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Endangered and Threatened Wildlife and Plants: Final Listing Determinations on Proposal To List 66 Reef-Building Coral Species and To Reclassify Elkhorn and Staghorn Corals; Final Rule

DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

50 CFR Part 223

[Docket No. 0911231415–4826–04]

RIN 0648–XT12

Endangered and Threatened Wildlife and Plants: Final Listing Determinations on Proposal To List 66 Reef-Building Coral Species and To Reclassify Elkhorn and Staghorn Corals

AGENCY: National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA), Commerce.

ACTION: Final rule.

SUMMARY: We, the National Marine Fisheries Service (NMFS), are publishing this final rule to implement our final determination to list the following 20 species as threatened: five in the Caribbean (*Dendrogyra cylindrus, Orbicella annularis, Orbicella faveolata, Orbicella franksi,* and *Mycetophyllia ferox*); and 15 in the Indo-Pacific (*Acropora globiceps, Acropora jacquelineae, Acropora lokani, Acropora pharaonis, Acropora retusa, Acropora rudis, Acropora speciosa, Acropora tenella, Anacropora spinosa, Euphyllia paradivisa, Isopora crateriformis, Montipora australiensis, Pavona diffluens, Porites napopora,* and *Seriatopora aculeata*) under the Endangered Species Act (ESA) of 1973, as amended. The two species currently listed as threatened (*Acropora cervicornis* and *Acropora palmata*) in the Caribbean still warrant listing as threatened. We also determined that a total of 43 proposed species do not warrant listing as endangered or threatened species, and three proposed species are not determinable under the ESA. We have reviewed the status of the species and efforts being made to protect the species, and public comments received on the proposed rule, and we have made our determinations based on the best scientific and commercial data available. We also solicit information that may be relevant to the designation of critical habitat for the 20 species newly listed under this final rule.

DATES: The effective date of this final rule is October 10, 2014. Responses to the request for information regarding a subsequent ESA section 4(d) Rule and critical habitat designation must be received by November 10, 2014.

ADDRESSES: Submit responses to the request for information regarding a subsequent ESA section 4(d) Rule and critical habitat designation to National Marine Fisheries Service, Pacific Islands Regional Office, NOAA Inouye Regional Center, 1845 Wasp Blvd., Building 176, Honolulu, HI 96818; or National Marine Fisheries Service, Southeast Regional Office, 263 13th Avenue South, Saint Petersburg, FL 33701.

FOR FURTHER INFORMATION CONTACT: Lance Smith, NMFS, Pacific Island Regional Office, 808–725–5131; Jennifer Moore, NMFS, Southeast Regional Office, 727–824–5312; or Marta Nammack, NMFS, Office of Protected Resources, 301–427–8469. A list of the literature cited in this rule is available at *http://coral.sero.nmfs.noaa.gov* and *http://www.fpir.noaa.gov/PRD/prd_coral.html.*

SUPPLEMENTARY INFORMATION:

Background

On October 20, 2009, the Center for Biological Diversity (CBD) petitioned us to list 83 reef-building corals as threatened or endangered under the Endangered Species Act (ESA) and designate critical habitat. The 83 species included in the petition were: *Acanthastrea brevis, Acanthastrea hemprichii, Acanthastrea ishigakiensis, Acanthastrea regularis, Acropora aculeus, Acropora acuminata, Acropora aspera, Acropora dendrum, Acropora donei, Acropora globiceps, Acropora horrida, Acropora jacquelineae, Acropora listeri, Acropora lokani, Acropora microclados, Acropora palmerae, Acropora paniculata, Acropora pharaonis, Acropora polystoma, Acropora retusa, Acropora rudis, Acropora speciosa, Acropora striata, Acropora tenella, Acropora vaughani, Acropora verweyi, Agaricia lamarcki, Alveopora allingi, Alveopora fenestrata, Alveopora verrilliana, Anacropora puertogalerae, Anacropora spinosa, Astreopora cucullata, Barabattoia laddi, Caulastrea echinulata, Cyphastrea agassizi, Cyphastrea ocellina, Dendrogyra cylindrus, Dichocoenia stokesii, Euphyllia cristata, Euphyllia paraancora, Euphyllia paradivisa, Galaxea astreata, Heliopora coerulea, Isopora crateriformis, Isopora cuneata, Leptoseris incrustans, Leptoseris yabei, Millepora foveolata, Millepora tuberosa, Montastraea annularis, Montastraea faveolata, Montastraea franksi, Montipora angulata, Montipora australiensis, Montipora calcarea, Montipora caliculata, Montipora dilatata, Montipora flabellata, Montipora lobulata, Montipora patula, Mycetophyllia ferox, Oculina varicosa, Pachyseris rugosa, Pavona bipartita, Pavona cactus, Pavona decussata, Pavona diffluens, Pavona venosa, Pectinia alcicornis, Physogyra lichtensteini, Pocillopora danae, Pocillopora elegans, Porites horizontalata, Porites napopora, Porites nigrescens, Porites pukoensis, Psammocora stellata, Seriatopora aculeata, Turbinaria mesenterina, Turbinaria peltata, Turbinaria reniformis,* and *Turbinaria stellulata.* Eight of the petitioned species occur in the Caribbean, and 75 of the petitioned species occur in the Indo-Pacific region. Most of the 83 species can be found in the United States, its territories (Puerto Rico, U.S. Virgin Islands, Navassa, Northern Mariana Islands, Guam, American Samoa, Pacific Remote Island Areas), or its freely associated states (Republic of the Marshall Islands, Federated States of Micronesia, and Republic of Palau), though many occur more frequently in other countries.

On February 10, 2010, we published a 90-day finding (75 FR 6616) that CBD had presented substantial information indicating the petitioned actions may be warranted for all of the petitioned species except for the Caribbean species *Oculina varicosa.* We also announced the initiation of a formal status review of the remaining 82 petitioned species, and we solicited input from the public on six categories of information: (1) Historical and current distribution and abundance of these species throughout their ranges (U.S. and foreign waters); (2) historical and current condition of these species and their habitat; (3) population density and trends; (4) the effects of climate change on the distribution and condition of these coral species and other organisms in coral reef ecosystems over the short and long term; (5) the effects of all other threats including dredging, coastal development, coastal point source pollution, agricultural and land use practices, disease, predation, reef fishing, aquarium trade, physical damage from boats and anchors, marine debris, and aquatic invasive species on the distribution and abundance of these coral species over the short- and long-term; and (6) management programs for conservation of these species, including mitigation measures related to any of the threats listed under No. 5 above.

The ESA requires us to make determinations on whether species are threatened or endangered ‘‘solely on the basis of the best scientific and commercial data available * * * after conducting a review of the status of the species * * * ’’ (16 U.S.C. 1533). Further, our implementing regulations specifically direct us not to take possible economic or other impacts of listing species into consideration (50 CFR 424.11(b)). We convened a Coral Biological Review Team (BRT) composed of seven Federal scientists from NMFS' Pacific Islands, Northwest, and Southeast Fisheries Science Centers, as well as the U.S. Geological Survey and National Park Service. The members of the BRT are a diverse group of scientists with expertise in coral biology, coral ecology, coral taxonomy, physical oceanography, global climate change, coral population dynamics and endangered species extinction risk evaluations. The BRT's comprehensive, peer-reviewed Status Review Report (SRR; Brainard *et al.*, 2011) incorporates and summarizes the best available scientific and commercial information as of August 2011 on the following topics: (1) Long-term trends in abundance throughout each species' range; (2) potential factors for any decline of each species throughout its range (human population, ocean warming, ocean acidification, overharvesting, natural predation, disease, habitat loss, *etc.*); (3) historical and current range, distribution, and habitat use of each species; (4) historical and current estimates of population size and available habitat; and (5) knowledge of various life history parameters (size/age at maturity, fecundity, length of larval stage, larval dispersal dynamics, *etc.*). The SRR evaluates the status of each species, identifies threats to the species, and estimates the risk of extinction for each of the species out to the year 2100. The BRT also considered the petition, comments we received as a result of the 90-day finding (75 FR 6616; February 10, 2010), and the results of the peer review of the draft SRR, and incorporated relevant information from these sources into the final SRR. Additionally, we developed a supplementary, peer-reviewed Draft Management Report (NMFS, 2012a) to identify information relevant to ESA factor 4(a)(1)(D), inadequacy of existing regulatory mechanisms, and protective efforts that may provide protection to the corals pursuant to ESA section 4(b).

The response to the petition to list 83 coral species is one of the broadest and most complex listing reviews we have ever undertaken. Given the petition's scale and the precedential nature of the issues, we determined that our decision-making process would be strengthened if we took additional time to allow the public, non-Federal experts, non-governmental organizations, state and territorial governments, and academics to review and provide information related to the SRR and the Draft Management Report prior to issuing our 12-month finding. Thus on April 17, 2012, we published a **Federal Register** notice announcing the availability of the SRR and the Draft Management Report, and specifically requested information on the following: (1) Relevant scientific information collected or produced since the completion of the SRR or any relevant scientific information not included in the SRR; and (2) relevant management information not included in the Draft Management Report, such as descriptions of regulatory mechanisms for greenhouse gas (GHG) emissions globally, and for local threats in the 83 foreign countries and the United States, its territories (Puerto Rico, U.S. Virgin Islands, Navassa, Northern Mariana Islands, Guam, American Samoa, Pacific Remote Island Areas), or its freely associated states (Republic of the Marshall Islands, Federated States of Micronesia, and Republic of Palau), where the 82 petitioned coral species collectively occur. Further, in June 2012, we held listening sessions and scientific workshops in the Southeast region and Pacific Islands region to engage the scientific community and the public in-person. During this public engagement period, which ended on July 31, 2012, we received over 42,000 letters and emails. Also, we were provided with or we identified approximately 400 relevant scientific articles, reports, or presentations that were produced since the SRR was finalized, or not originally included in the SRR. We compiled and synthesized all relevant information that we identified or received into the Supplemental Information Report (SIR; NMFS, 2012c). Additionally, we incorporated all relevant management and conservation information into the Final Management Report (NMFS, 2012b). Therefore, the 82 candidate coral species comprehensive status review consists of the SRR (Brainard *et al.*, 2011), the SIR (NMFS, 2012c), and the Final Management Report (NMFS, 2012b).

On December 7, 2012, we published a proposed rule (77 FR 73219) to list 12 of the petitioned coral species as endangered (five Caribbean and seven Indo-Pacific) and 54 coral species as threatened (two Caribbean and 52 Indo-Pacific), and we determined 16 coral species (all Indo-Pacific) did not warrant listing as threatened or endangered under the ESA. This was the final agency action for those species which we determined were not warranted for listing. We also determined that two currently listed Caribbean corals (*Acropora cervicornis* and *Acropora palmata*) warranted reclassification from threatened to endangered. The findings in the proposed rule were based on the information contained within the reports described above (SRR, SIR, and Final Management Report). During a 90-day comment period, we solicited comments from the public, other concerned governmental agencies, the scientific community, industry, foreign nations in which the species occur, and any other interested parties on our proposal. We later extended the public comment period by 30 days, making the full comment period 120 days. We received approximately 32,000 comments through electronic submissions, letters, and oral testimony from public hearings held in Dania Beach, FL; Key Largo, FL; Key West, FL; Rio Piedras, Puerto Rico; Mayaguez, Puerto Rico; Christiansted, St. Croix, U.S. Virgin Islands; Charlotte Amalie, St. Thomas, U.S. Virgin Islands; Hilo, Hawaii, HI; Kailua Kona, Hawaii, HI; Kaunakakai, Molokai, HI; Wailuku, Maui, HI; Lihue, Kauai, HI; Honolulu, Oahu, HI; Hagatna, Guam; Saipan, Commonwealth of the Northern Marianas Islands (CNMI); Tinian, CNMI; Rota, CNMI; Tutuila, American Samoa; and Washington, DC.

During the public comment period, we received numerous comments on the proposed listing and the sufficiency or accuracy of the available data used to support the proposed listing determinations. In particular, comments raised questions and provided varied, often conflicting, information regarding the following topics:

(1) The proposed species' listing statuses (*e.g.*, certain species proposed as endangered should be threatened);

(2) the sufficiency and quality, or lack thereof, of the species-specific information used for each species' proposed listing determination;

(3) the accuracy of the methods used to analyze the available information to assess extinction risk (including NMFS' "Determination Tool") and derive listing statuses for each of the proposed species;

(4) the ability of corals to adapt or acclimatize to ocean warming and acidification;

(5) the reliability, certainty, scale, and variability of future modeling and predictions of climate change; and

(6) the effect local management efforts have on coral resilience.

After considering these comments, we found that substantial disagreement existed regarding the sufficiency and accuracy of the available data used in support of the proposed determinations.

As a result, we determined it was necessary to solicit additional data from those scientists who were identified by public comments and others who may have additional data to assist in resolving the substantial disagreement. Therefore, pursuant to the ESA section 4(b)(6)(B)(i), we determined that a 6-month extension of the deadline for final determinations on the proposed rule was necessary (78 FR 57835; September 20, 2013). We completed our data collection effort in the fall of 2013, and the relevant information that we received or collected was considered in the formulation of this final rule. The data collection effort was the final step in our thorough process to assemble the best available information on the status of the species addressed in this final rule. As a result, this final rule represents a logical evolution from the proposed rule, including some changes in our overall decision-making framework and a holistic reconsideration of the key elements that contribute to a species' listing status, as described in detail throughout this rule. Consequently, most of the listing determinations have changed between the proposed and final rules.

Listing Species Under the Endangered Species Act

We are responsible for determining whether the 66 proposed coral species should be listed as threatened or endangered under the ESA, and whether the two species proposed for reclassification should be listed as endangered under the ESA (16 U.S.C. 1531 *et seq.*). Clonal, colonial organisms, such as corals, are vastly different in their biology and ecology than vertebrates, which are typically the focus of ESA status reviews. Therefore, concepts and terms that are typically applied to vertebrates have very distinct meanings when applied to corals. A 'rare' coral may have millions of colonies as compared to a 'rare' vertebrate, which may only have hundreds of individuals. To be considered for listing under the ESA, a group of organisms must constitute a ''species,'' which is defined in section 3 of the ESA to include ''any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature.'' In the case of reef-building corals, the decision that a species is a listable entity is often complicated by several aspects of their biology including individual delineation, taxonomic uncertainty, identification uncertainty, and life history (*e.g.*, colonialism and clonality).

Section 3 of the ESA further defines an endangered species as ''any species which is in danger of extinction throughout all or a significant portion of its range'' and a threatened species as one ''which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.'' Section 4(a)(1) of the ESA requires us to determine whether any species is endangered or threatened due to any one or a combination of the following five factors: (A) The present or threatened destruction, modification, or curtailment of its habitat or range; (B) overutilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) the inadequacy of existing regulatory mechanisms; or (E) other natural or manmade factors affecting its continued existence. We are required to make listing determinations based solely on the best scientific and commercial data available after conducting a review of the status of the species and after taking into account efforts being made by any state or foreign nation to protect the species.

This finding begins with an overview of coral biology, ecology, and taxonomy in the Corals and Coral Reefs section below, including whether each proposed species meets the definition of a ''species'' for purposes of the ESA. Specifically, are the proposed species determinable under the ESA given any discrepancies between their current morphologically-based taxonomy and any new genetic information that may result in taxonomic reclassification. Other relevant background information in this section includes the general characteristics of the habitats and environments in which the proposed species are found. The finding then summarizes information on factors adversely affecting and posing extinction risk to corals in general in the Threats Evaluation section. The Risk Analyses section then describes the framework applied to each of the species that resulted in final listing statuses for the proposed species. The Species-specific Information and Determinations section provides the best available species-specific information, which, coupled with the general portions of this final rule, provide the basis for the individual determinations for final listing status. Finally, we assessed efforts being made to protect the species and determined if these efforts are adequate to mitigate impacts and threats to the extent that a species does not meet one of the statutory statuses.

Given the precedential and complex nature of this rule-making process, we took extra steps to assemble the best available information for informing the final listing determinations. Efforts to acquire this information first included the formation of an expert scientific panel (BRT) that used the best available scientific information at that time in a structured decision-making process to inform and write the SRR. Further, this process provided numerous opportunities for public input, including a public comment period after the 90-day finding in 2010 (75 FR 6616; February 10, 2012), a unique public information-gathering period (77 FR 22749; April 17, 2012) prior to the release of the proposed rule in 2012, and a 120-day formal public comment period after the publication of the proposed rule. Finally, in a targeted data-solicitation effort to resolve substantial scientific disagreement in the public comments on the proposed rule, we published a 6-month extension in September 2013 to gather additional information to further inform our final decisions (78 FR 57835; September 20, 2013). Over the course of this multi-year process, we gathered and reviewed thousands of scientific papers, journal articles, reports, and presentations (bibliography and select documents available at *http://www.nmfs.noaa.gov/pr/species/invertebrates/corals.htm*). In addition, we held a total of 19 public hearings in 2012 and 2013 throughout the Southeast and Pacific Islands regions, and received and reviewed over 75,000 public comments during the information-gathering period in 2012 and the proposed rule public comment period in 2012–2013, combined. These efforts ensure that this final rule is based upon the best available information on the proposed species at this time, as explained in more detail below.

Summary of Comments Received

Below we address the comments received pertaining to the proposed listings or reclassifications of the 68 coral species in the December 7, 2012, proposed rule (77 FR 73219). During the 120-day public comment period from December 7, 2012, to April 6, 2013, we received 1,120 written and verbal responses (including public testimony during the 19 public hearings). This included 1,119 unique comments on the proposed listings or reclassifications and 32,000 action alert responses in support of the rule organized by the petitioner CBD, which substantively constitutes one unique comment, and. The public comments received covered a wide breadth of topics, many of which were significant and within the scope of this rule-making. We summarized the comments, and these summaries and our responses are organized according to the sections of the proposed rule on which those comments were based. We have considered all public comments, and we provide responses to all relevant issues raised by comments. We have not responded to comments outside the scope of this rulemaking, such as comments regarding the potential economic impacts of ESA listings, comments suggesting that certain types of activities be covered in any future regulations pursuant to ESA section 4(d) for threatened species, or whether ESA listings are appropriate for species threatened by climate change. As explained in the Background above, this final rule was extended by 6 months to resolve substantial scientific disagreement in the public comments on six topics related to the proposed listing.

Comments on Taxonomic Uncertainty in Reef-Building Corals

Comment 1: Many public comments on the proposed listing rule stated that species identification uncertainties and taxonomic uncertainties associated with many reef-building corals are problematic for the ESA listing determination process. Four comments specifically stated that the ability to determine the status of coral species under the ESA is impeded by the taxonomic uncertainty of many coral species. Two comments stated that genetic and genomic science is just beginning for corals, and as it develops it will likely show the current morphologically-based taxonomy is incorrect, completely changing current coral taxonomy. Therefore, management decisions based on the current taxonomy should be approached with caution. One comment stated that proper species identification, especially for the Indo-Pacific *Acropora* genus, is difficult and exacerbated by the use of outdated and inadequate information.

Most of these comments are based on species identification uncertainties and the conflicting taxonomic results between recent genetics studies and traditional morphology-based taxonomy, and comments identified two potential problems: (1) Species identification and taxonomic uncertainty prevents many reef-building coral taxa, especially in the Indo-Pacific, from being determinable species under the ESA; and (2) even if these taxa are determinable species under the ESA, the taxonomic uncertainty confounds the available information regarding the status of each species, thus it is not possible to determine the listing status of these species with adequate confidence.

Response: The comments correctly note that in some instances, lack of information, or ambiguity and uncertainty in available information, is so great that any listing determination on such a basis would be arbitrary. In our judgment, that is not the case for the proposed species, with a few exceptions noted below. The SRR concluded that the 68 species in the proposed rule were determinable, including the species for which the SRR found that splitting or lumping petitioned species was necessary based on genetic studies. For the proposed rule, we agreed with the SRR, and considered the 68 species to be determinable for purposes of conducting a status review and determining listing status under the ESA.

The public comments did not provide any studies or results, nor did we find any new studies or results, that significantly contradict the consideration of the traditional, morphologically described species as determinable species, with the exception of *Pocillopora.* We acknowledged in the proposed rule, however, that the taxonomic uncertainty for reef-building corals is not only real (Brainard *et al.,* 2011), but increasing in recent years as genetics studies have advanced (Stat *et al.,* 2012; Veron, 2013). In the case of *Pocillopora* species, the taxonomic uncertainty has recently increased substantially such that the three proposed species in this genus are not determinable under the ESA (see Comment 2). For the remaining 65 species, the best available scientific information continues to support their classification as species. The taxonomic uncertainty associated with each species is considered along with other types of uncertainty when determining the status of each species in the Species-specific Information and Determinations section. In this way, the species identification and taxonomic uncertainty for each species is acknowledged and incorporated into each of the 65 determinations in this final rule.

In this final rule, even though *Millepora foveolata* and *Montipora lobulata* were affirmed to be valid species, and there are few if any taxonomic uncertainty issues, the two species are so difficult to identify in the field that there is very little reliable information available for either species (Fenner, 2014b). Thus, as described in the Species-specific Information and Determinations below for *M. foveolata* and *M. lobulata*, the species identification uncertainty is so high for these species that there is not sufficient evidence to support listing determinations of threatened or endangered for either species. This is explained in more detail in each species' individual determination.

Comment 2: Related to Comment 1, one comment identified *Pocillopora* as a problematic taxon and provided a recent scientific paper describing new genetic evidence of taxonomic contradictions between genetic and morphologic results for *Pocillopora* species (Pinzón *et al.,* 2013).

Response: Based on information summarized in the SRR, the proposed rule split *P. elegans* into Indo-Pacific and Eastern Pacific nominal species, and proposed *P. elegans* (Indo-Pacific), *P. elegans* (Eastern Pacific), and *P. danae* for listing (*P. danae* only occurs in the Indo-Pacific). However, after considering new information on taxonomic uncertainty throughout the genus *Pocillopora* that has become available since the publication of the proposed rule, including the paper (Pinzón *et al.,* 2013) submitted by the commenter, we no longer consider the three *Pocillopora* species that were proposed for listing to be determinable under the ESA. A range-wide phylogeographic survey that included most currently recognized pocilloporid species found that reliance on colony morphology is broadly unreliable for species identification, and that several genetic groups have highly limited geographic distributions. The study concluded that ''a taxonomic revision informed foremost by genetic evidence is needed for the entire genus'' (Pinzón *et al.,* 2013). Similarly, a phylogeographic survey of several currently recognized pocilloporid species representing a range of atypical morphologies thought to be rare or endemic to remote locations throughout the Indo-Pacific found that: (1) The current taxonomy of Pocillopora based on colony morphology shows little correspondence with genetic groups; (2) colony morphology is far more variable than previously thought; and (3) there are numerous cryptic lineages (*i.e.,* two or more distinct lineages that are classified as one due to morphological similarities). The study concluded that ''the genus *Pocillopora* is in need of taxonomic revision using a combination of genetic, microscopic characters, and reproductive data to accurately delineate species'' (Marti-Puig *et al.,* 2013). Likewise, a more limited study of several currently recognized pocilloporid species in Moorea found that genetic groups do not correspond to colony morphology, and exhibit a wide range of morphological variation

(Forsman *et al.,* 2013). These studies demonstrate that colony morphology in pocilloporids is a poor indicator of taxonomic relationships, for the following reasons: (1) Morphologically similar colonies may not be the same species (*i.e.,* colonies of different species appear similar because of similar environmental conditions or other reasons); and (2) morphologically different colonies may be the same species (*i.e.,* colonies of the same species appear different because of different environmental conditions or other reasons).

While the current literature supports the taxonomic division of pocilloporids geographically into Indo-Pacific and Eastern Pacific groups, it indicates a high level of taxonomic uncertainty for all *Pocillopora* species that are found in both areas, such as *P. elegans.* Within these two geographic areas, colonies that resemble *P. elegans* may be different species, including possibly still undescribed species. That is, colonies may merely resemble *P. elegans* because of similar environmental conditions or other reasons, but actually may be different species. And the opposite type of taxonomic uncertainty also appears to be common, as colonies that do not resemble *P. elegans* may actually be *P. elegans.* That is, colonies that are *P. elegans* appear different because of different environmental conditions or other reasons (Forsman *et al.,* 2013; Marti-Puig *et al.,* 2013; Pinzón *et al.,* 2013). The recently appreciated taxonomic uncertainty is in addition to the historical morphological taxonomic uncertainty within the genus *Pocillopora* and for *P. elegans* specifically (Veron, 2013; Veron, 2014). While *P. danae* does not occur in the Eastern Pacific, similar taxonomic uncertainty problems occur for this species. That is, this species also had historical morphological taxonomic uncertainty (Veron, 2013), which has recently been compounded by genetic taxonomic uncertainty, leading Veron (2014) to conclude that the species likely requires a taxonomic revision. A new taxonomic revision of *Pocillopora* was published, in which *P. danae* was found to be a synonym of *P. verrucosa,* resulting in the traditional *P. danae* being included within *P. verrucosa* (Schmidt-Roach *et al.,* 2014). However, the overall taxonomic uncertainty within *Pocillopora,* including for *P. elegans* and *P. danae,* has not been resolved, and in fact continues to increase as more studies are conducted. Thus, at this time, *Pocillopora* species are not determinable under the ESA. Therefore, we are withdrawing our proposal to list *P. elegans* (Indo-Pacific) as threatened, *P. elegans* (Eastern Pacific) as endangered, and *P. danae* as threatened; these species are not considered further in this final rule.

Comment 3: Several comments objected to our agreement with the SRR's (Brainard *et al.,* 2011) lumping of *Montipora dilitata, M. flabellata,* and *M. turgescens* into a single species, as well as the lumping of *M. patula* and *M. verrilli* into a single species, based on the results of a single genetics study by Forsman *et al.* (2010).

Response: The objections in the public comments to lumping *Montipora dilitata/M. flabellata/M. turgescens* and *M. patula/M. verrilli* did not provide any new or supplemental information, nor did we find any new or supplemental information, contradicting the key study used by the SRR to consider these species as a group. We must use the best available science on which to base our determinations, and there is no indication that Forsman *et al.* (2010) is in error. However, as discussed in the response to Comment 1, we acknowledge that coral taxonomy is a rapidly growing field and that is creates uncertainty in determining a species under the ESA. This taxonomic uncertainty is considered in the individual Species-specific Information and Determination for the *Montipora.*

Comments on Reproductive Life History of Reef-Building Corals

Comment 4: There were only a few comments related to the reproductive life history of corals. One comment stated that coral reef connectivity data are sparse, and while the majority of published studies on coral larval dispersal report evidence of local seeding and replenishment of reefs, other models and studies report sporadic periods of longer distance dispersal and recruitment events. The commenter felt that the proposed rule did not adequately address coral population dynamics and connectivity in determining the status of the candidate coral species under the ESA. Another comment stated that there is almost no information on any of the species' trends or recruitment rates, and the limited information available is based on qualitative opinion, not quantitative data. The comment also pointed out that the proposed rule agreed that the term 'recruit' could be difficult to apply in the case of corals, which reproduce both sexually and asexually, and that the number of recruits per spawner depends on the age or size at which an entity is defined as a recruit. These comments assert that there is insufficient information on productivity and connectivity on which to base listing decisions.

Response: Coral reproduction and connectivity are addressed generally in the Reproductive Life History of Reef-building Corals section. As each proposed coral species has a different reproductive life history, we more comprehensively address each species' reproduction, connectivity, and recruitment (when that information was available) as they relate to each species' status under the ESA in the Species-specific Information and Determinations section. The public comments did not provide any studies or information on reproduction or connectivity for any species except for *Acropora cervicornis* (see Species-specific Information and Determinations section). Any supplemental information we found is included in Species-specific Information and Determinations section.

Comments on Distribution and Abundance of Reef Building Corals

Comment 5: We received several comments regarding the distribution and abundance of reef-building corals, mainly regarding the lack of species-specific information for many species' geographic distributions and population abundances. There were only a few comments related to determining the distribution and abundance of reef building corals, specifically on extrapolating individual corals to overall population abundance and distribution, on which to base a listing decision. One comment stated that coral population size and structure across the world's oceans is nearly impossible to determine with any accuracy because we use crude substitutes for individual animals in determining population and range information within a species. For example, there is a significant difference between using colony population and range estimates versus using polyp population and range estimates, which are essentially impossible to estimate. Another comment stated that it is not accurate to equate percent coral cover on reefs to population abundance (*i.e.,* numbers of individuals). Any loss of coral cover often is manifest by loss of coral tissue over large portions of still living colonies, without the loss of the individual. Furthermore, it is unclear whether the loss of many separate but genetically-identical colonies ('clones') equates to the loss of a single but genetically-distinct individual if some of the clone colonies survive. Another commenter noted that the distributions of the Indo-Pacific species are largely unknown due to their incredibly vast ranges encompassing numerous archipelagos that include thousands of islands and atolls. The commenter emphasized this point by noting that there are between 30,000 and 40,000 islands in Oceania which could potentially have populations of the proposed coral species. The comments described above collectively assert that listing decisions cannot be made due to the lack of species-specific information.

Response: We acknowledge that it is difficult to quantify and qualify distribution and abundance for individual coral species. The ambiguity associated with the delineation of the individual in reef-building corals is addressed in the Individual Delineation sub-section in the Corals and Coral Reefs section, including how we characterize the delineation of the individual for the species covered by this final rule. In response to public comments, we more adequately address each species' distribution and abundance as those characteristics relate to each species' determination status under the ESA in the Species-specific Information and Determinations section. The public comments provided some useful information on the distribution and abundance of specific coral species, and we also collected supplemental information on distribution and abundance that is included in the Species-specific Information and Determinations section.

Comments on Coral Reefs, Other Coral Habitats, and Overview of Candidate Coral Environments

Comment 6: Some comments asserted that the proposed rule focused too much on coral reefs rather than focusing on coral species. A couple of comments stated that corals thrive in places that are not coral reefs, even when nearby coral reefs are not thriving, underscoring the notion that reefs are not species. Another couple of comments stated that the focus on coral reefs and reef ecosystems, and the importance they have to reef-associated species, is improper for ESA listing analysis and added that NMFS cannot simply decide to treat reefs as a species under the ESA simply because evaluating reefs is easier.

Response: The proposed rule acknowledged that reef-building coral species are not reef-dependent and provided a description of non-reefal habitats. Public comments did not provide information on how to interpret non-reefal habitat in our analysis, but in the Coral Habitats sub-section of this final rule we clarify the relevance of non-reefal habitats in determining each species' status under the ESA (*e.g.,* providing variability in environmental conditions).

Further, in the Coral and Coral Reefs section (Individual Delineation and Species Identification sub-sections), we explain that we define a coral species as the ''physiological colony'' (*i.e.,* unit of the species that can be identified as an individual in the field) to ensure that we are evaluating the individual species and not coral reefs generally for determining ESA status. Public comments did not offer any information on how to define a coral species, but our explanations in the Individual Delineation and Species Identification sub-sections makes clear that we do not consider coral reefs as species in this final rule. However, it should be noted that defining an individual coral as the physiological colony in this final rule did not change how we interpreted abundance data for any species.

Comment 7: A few comments stated that the proposed rule lacked species-specific information for mesophotic habitats (deep, lower-light areas, usually between 30 and 100 m deep). One comment stated that the coral communities of many Indo-Pacific jurisdictions have received little attention, with vast areas of reef remaining unexplored, especially for corals occurring in the mesophotic zone, which likely harbors populations of species that can also be found at shallower depths. Another comment stated that recent data from NOAA-supported studies of mesophotic reefs found these extensive and poorly studied ecosystems serve as refugia for numerous shallow water coral species, yet no survey data from these ongoing studies were included in the proposed rule. We also received two papers (Bridge and Guinotte, 2013; Kahng *et al.,* 2014) that suggested the global diversity of some mesophotic corals may be underestimated and the biogeographic ranges of mesophotic corals are not fully explored.

Response: The proposed rule briefly described mesophotic habitats and acknowledged that the amount of mesophotic habitat available is unknown and likely greater than the amount of shallow reef habitat. The proposed rule also stated there is greater coral cover on mesophotic reefs in the Indo-Pacific than in the Caribbean. However, more information has become available on this habitat type since publication of the proposed rule. Two papers (Bridge and Guinotte, 2013; Kahng *et al.,* 2014) provided more information on the global diversity and biogeographic ranges of mesophotic corals and we have collected information on the magnitude and diversity of mesophotic habitat. The extent of mesophotic habitat is addressed in the Coral Habitats sub-section. Mesophotic habitat's potential function as refugia for corals from ocean warming is addressed in the Spatial and Temporal Refugia sub-section. Where mesophotic habitat information is available for an individual coral species we have included and considered that information in the Species-specific Information and Determinations section.

Comment 8: With regard to coral habitats being divided into only two global regions (*i.e.,* Caribbean and Indo-Pacific), a couple of comments stated that the Indo-Pacific region was too coarse. Specifically, the comments stated that the Hawaiian Islands should be considered its own region or sub-region with Hawaiian species evaluated separately, due to Hawaii's isolated nature and significant number of endemic species.

Response: We recognize that there may be numerous distinct sub-regions throughout the Caribbean and Indo-Pacific basins for some or all species, and that some coral species are endemic to Hawaii. However, under the ESA, we must evaluate the status of the species throughout their entire ranges. Invertebrate species, such as corals, cannot be divided further into Distinct Populations Segments (DPS) under the ESA, since DPS specifically refer only to vertebrate species. Therefore, we cannot identify sub-regions, such as Hawaii, as its own distinct geographic range and evaluate the status of more broadly distributed species only within that specific area. In addition, as described in the Risk Analyses—Statutory Standard sub-section of this final rule, we were not able to identify a significant portion of its range (SPOIR) for any of the proposed corals and therefore could not evaluate whether the status of the species within that portion of its range impacts the overall status of the species throughout its range.

Comment 9: We received a few comments regarding the consideration and inclusion of Traditional Ecological Knowledge (TEK), particularly from local island cultures (Hawaiian, Chamorro, and Samoan), as best available information for our listing determination process. One comment noted the importance of corals and coral reefs to island cultures in the Pacific Islands region, in particular to native Hawaiians. The comment criticized the lack of TEK in the SRR and proposed rule for the candidate corals, stating that coral biology and ecology is a fundamental part of TEK, and that their TEK is part of best available science.

Response: We agree that TEK provides an important and unique perspective on local ecosystems, their status, threats, and changes over time; when relevant information was made available to us, we incorporated it into the proposed rule. We also acknowledge that this information is not necessarily accessible in academic peer reviewed journals or text books. Therefore, we requested any additional TEK-related information on the biology, ecology, threats, and extinction risks of the 65 coral species on numerous occasions for inclusion within this final rule. While we received public comments and listened to several public testimonies from community members in both the Pacific Islands and Southeast regions that disagreed with our proposed listing determinations, we did not receive any TEK-related information or data on the biology, ecology, threats, or extinction risks for any of the 65 coral species within this final rule.

Comments on Threats Evaluation

Comment 10: We received a large number of public comments on the various threats to corals and coral reefs. In addition to the specific comments on the nine most important threats, one comment stated that there should be no doubt that corals and coral reefs throughout the world are in serious trouble and in decline due to the effects of anthropogenic stressors. Another commenter asked whether the mere threats from anthropogenic impacts are sufficient for ESA listing. Yet another commenter requested that recreational boating activities should be recognized as a specific threat, even though recreational boating activities may only present a relatively minor risk to coral species.

Response: As described in the proposed rule, there are nine threats considered to be the most significant to the current or expected future extinction risk of reef-building corals. The comments and responses on these nine threats (ocean warming, disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade) are addressed individually below. We acknowledged that recreational boating activities may present some risk to coral species and it was included in the description of the threat ‘‘Human-induced Physical Damage’’ in the SRR. However, we determined that threat's contribution to the extinction risk of corals, generally, is negligible to low.

We also recognized that anthropogenic threats are affecting coral species worldwide and may be sufficient for an ESA listing if the species meets the definition of threatened or endangered. That is, if the species is currently in danger of extinction or may become so in the foreseeable future due to any one or a combination of the five factors under Section 4 of the ESA (in which the various threats are categorized) then the species may be listed.

Comments on Global Climate Change—General Overview

Comment 11: We received many comments on the general treatment of global climate change in the proposed rule and supporting documents. The Global Climate Change—General Overview section in the proposed rule and the global climate change portion of the SRR describe past, current, and future GHG emissions and atmospheric concentrations and the associated past, current, and future general effects on coral reef ecosystems, based primarily on the International Panel on Climate Change's (IPCC) Fourth Assessment Report (AR4), The Physical Basis (IPCC, 2007) and supporting literature.

Some comments stated that we did not adequately account for the uncertainty in climate change modeling. A few comments stated that global temperature has been stable for the last ten years or that warming has slowed down since 2000. One commenter provided two recent papers (Guemas *et al.,* 2013; Hansen *et al.,* 2012) that showed global mean surface temperatures did not increase as much as had been predicted from 2000 to 2010.

Some comments stated that GHG emissions and global temperatures continue to rise unabated. One comment referenced two studies (Frieler *et al.,* 2012; van Hooidonk *et al.,* 2013b) that projected the frequency of coral reef bleaching under different levels of warming and emissions scenarios, indicating that significant and immediate GHG reductions are critical to prevent coral reefs from degradation and collapse. Another comment also referenced van Hooidonk *et al.* (2013b) and stated that targets for atmospheric carbon dioxide (CO_2) concentrations must be lower than 450 parts per million (ppm) to protect coral reef ecosystems. Yet another comment stated that scientific modeling indicates that within 40 to 50 years, reef decline will pass a tipping point, largely due to the increasing impacts of climate change, and may not be reversible over ecological time scales. Another comment pointed out that climate change also could likely increase corals' exposure to cold water stress, which studies have shown can cause extensive mortality of corals (Colella *et al.,* 2012; Schopmeyer *et al.,* 2012).

Response: We agree with commenters and acknowledge that there is uncertainty associated with climate change projections. Climate change projections over the foreseeable future are associated with three major sources of uncertainty: (1) The projected rate of increase for GHG concentrations; (2) strength of the climate's response to GHG concentrations; and (3) large natural variations. The recent warming slow-down is an example of a large natural variation that was not anticipated by previous models. However, AR4's projections were built upon scientifically accepted principles, which fairly simulated many large scale aspects of present-day conditions, providing the best available information on climate change at the time the proposed rule was published. The IPCC's Fifth Assessment Report (AR5), Climate Change 2013: The Physical Science Basis (IPCC, 2013), commonly referred to as the Working Group I Report (WGI) became available in September 2013, and supersedes AR4; accordingly, this final rule relies on the information provided in AR5's WGI. Despite the advance of climate change science in recent years, there is still complexity and uncertainty associated with projections of global climate change. However, the current state of climate change science is capable of producing informative projections that provide a rational basis for considering likely patterns in future climate change-related threats to reef-building corals. More detail on the overall complexity associated with projections of global climate change, major sources of uncertainty in climate change projections, and a summary of AR5's WGI, including the pathway that we consider the most impactful to corals, are addressed in Threats Evaluation—Global Climate Change Overview sub-section.

We also acknowledge the observed recent hiatus/slow-down in the rate of global surface air temperature increase, and we have accordingly provided a description of the hiatus/slowdown and its implications in the Threats Evaluation—Ocean Warming sub-section. In summary, despite unprecedented levels of GHG emissions in recent years, a slow-down in global mean surface air temperature warming has occurred since 1998, which AR5's WGI refers to as a ‘‘hiatus.’’ Despite this slowdown in warming, the period since 1998 is the warmest recorded and ‘‘Each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since

1850.'' The slow-down in global mean surface warming since 1998 is not fully explained by AR4 or AR5 WGI's models, but is consistent with the substantial decadal and interannual variability seen in the instrumental record and may result, in part, from the selection of beginning and end dates for such analyses.

Public comments provided supplemental information on several aspects of global climate change, as described above. We also collected information to inform how we assess the effects of global climate change to corals, including the IPCC Working Group II report on impacts, adaptation, and vulnerability. We maintain that global climate change is central to assessing extinction risk for the corals in this final rule. As described in more detail in the Threats Evaluation—Global Climate Change Overview sub-section below, the supplemental information underscores the complexity and uncertainty associated with projecting the extent and severity of effects of global climate change across the ranges of reef-building corals.

Comments on Ocean Warming (High Importance Threat, ESA Factor E)

Comment 12: We received several comments on general future projections of ocean warming levels. One commenter stated that climate change models applied in our assessment are too coarse to accurately predict the conditions reefs will experience in the future and that real conditions are impacted by bathymetry, water mixing, wind patterns, fresh water inputs, and other bio-geographic factors. The commenter concluded that existing projections for sea surface temperature are not sufficient to conclude the species face an existential threat. Other comments also criticized the use of AR4's worst-case scenario as the basis for determining the most likely future scenario with regard to ocean warming, and related topics such as the proposed rule's lack of consideration for the post-1998 hiatus in global warming.

Response: In the proposed rule, we discussed the numerous, complex spatial and temporal factors that compound uncertainty associated with projecting effects of ocean warming on corals in the future, and we have determined that ocean warming will not affect all species in all locations uniformly over the foreseeable future. We believe that different bio-geographic factors such as bathymetry, water mixing, wind patterns, and fresh water will likely impact conditions corals will experience over the foreseeable future. We also recognized that global climate change models are associated with uncertainty, as discussed in response to comment 11 above. However, in response to comments on ocean warming projections, such as criticism of the reliance of the proposed rule and supporting documents on AR4 (IPCC, 2007) and the lack of consideration of the ocean warming hiatus, we provide a review of the best available information on these topics, including AR5's WGI Report (IPCC, 2013), in the Threats Evaluation—Global Climate Change Overview, Representative Concentration Pathways (RCP) 8.5 Projections, and Ocean Warming sub-sections below. These data support the conclusion in the proposed rule that ocean warming is increasing in severity, and is likely to continue increasing in severity within the ranges of reef-building corals. However, a key difference between the proposed and final rule is that we now more fully consider the ability of each species' spatial and demographic traits to moderate exposure to threats, including warming, and place appropriate emphasis on the non-uniform nature of global threats at the regional and local levels that allows habitat heterogeneity to play a role in buffering a species against vulnerability to extinction. The significance of coral abundance and distribution, and habitat heterogeneity, to this final rule is described in more detail in the Corals and Coral Reefs, Risk Analyses and Species-specific Information and Determinations sections of this rule.

After reviewing the public comments and information provided in AR5's WGI our conclusion regarding the threat of ocean warming remains unchanged from the proposed rule. We maintain that ocean warming is a high importance threat in assessing global extinction risk for the corals in this final rule, while we also acknowledge that the interpretation of future climate change threats to corals is associated with complexity and uncertainty, and that effects on individual species of reef-building corals are difficult to determine as described in more detail in the Threats Evaluation—Global Climate Change Overview subsection below.

Comment 13: Many comments criticized the proposed rule for not accounting for spatial variability in ocean warming and overlooking regional and local variability in conditions leading to warming-induced bleaching, which may be more or less severe regionally or locally than the overall warming. For example, we received two comments requesting us to review the literature for information regarding current and projected regional differences in sea surface temperature anomalies and for variations in the responses of individual coral species across their ranges. Comments noted that coral species and their symbionts are not uniformly susceptible and/or resilient to climate change across their ranges. That variability results in heterogeneous responses of coral species to ocean warming both in different parts of the ranges and also at different rates in the future. Another comment provided information from van Hooidonk (2013b) regarding spatial and temporal variability of ocean warming within different regions. The commenter identified reef locations that appear to be less vulnerable to bleaching, including the southern Great Barrier Reef (GBR), the western Indian Ocean, Persian Gulf, Red Sea, Thailand, New Caledonia and French Polynesia, as well as other locations that appear to be more vulnerable to bleaching, including the western Pacific warm pool, northwestern Australia, west Papua New Guinea and the central Pacific islands of Tokelau. Another commenter stated that the corals at Flower Garden Banks National Marine Sanctuary seem to be less affected by elevated sea surface temperatures that are impacting corals in other parts of the wider Caribbean.

Response: We discussed spatial (*i.e.,* regional and/or local) variability of ocean warming impacts to corals in the proposed rule and we agree that ocean warming will not affect all species in all locations uniformly over the foreseeable future, and that different regions are predicted to experience the effects of ocean warming on different time scales and at different magnitudes than others. We provide a review of all the best available information on spatial variability in ocean warming, including any information provided via public comment or gathered ourselves since the proposed rule was published, in the Threats Evaluation—Global Climate Change Overview, RCP8.5 Projections, and Ocean Warming sub-sections below. These data support the conclusion in the proposed rule that ocean warming is increasing in severity, and likely to continue increasing in severity within the ranges of reef-building corals. This review also underscores the complexity and uncertainty associated with spatial variability in ocean warming across the ranges of reef-building corals. A key difference between the proposed and final rule is that we now more fully consider the ability of each species' spatial and demographic traits to moderate exposure to threats, including warming, and place appropriate emphasis on the non-uniform nature of global threats at the regional and local levels which allows habitat heterogeneity to play a role in buffering a species against vulnerability to extinction. The significance of coral abundance and distribution and habitat heterogeneity to this final rule is described in more detail in the Corals and Coral Reefs, Risk Analyses and Species-specific Information and Determinations sections of this rule.

Comment 14: Comments on the overview of ocean warming and coral reefs focused on projected effects of ocean warming on coral reef ecosystems, rather than on reef-building coral species. These comments comprise two distinct views. Some comments emphasized that coral reefs are likely to decline sharply in the future because of increasing GHG emissions, while other comments emphasized that recent reviews indicate a wide range of possible responses by coral species. For example, one commenter cited Frieler *et al.* (2012) and stated that the estimated frequency of coral bleaching at different levels of global warming showed that limiting warming to 1.5 °C above pre-industrial levels is unlikely to protect most of the world's reefs from degradation. The commenter further explained that even under the lowest of the IPCC AR5 emissions scenarios (RCP3–PD) and optimistic assumptions regarding thermal adaptation, approximately one-third (range from 9 to 60 percent) of the world's coral reefs will experience long-term degradation. Another commenter cited Donner (2009) and similarly stated that the projected increase in sea surface temperatures due to the physical commitment from the present accumulation of GHGs due to anthropogenic activity, as well as the amount of GHGs likely to be emitted, is sufficient to cause frequent and higher magnitude heat stress for the majority of the world's coral reefs by 2050. Another commenter provided information from Kiessling *et al.* (2004) and Carpenter *et al.* (2008) and asserted that if bleaching events become very frequent, many species may be unable to maintain breeding populations as repeated bleaching causes potentially irreversible declines, perhaps mimicking conditions that led to previous coral extinctions. In contrast, some commenters disagreed with our conclusion of the projected effects of ocean warming on corals and coral reef ecosystems in the proposed rule. As described above in Comment 13, many commenters pointed out several studies showing regional and local variability in responses of corals and coral reefs to ocean warming.

Response: We summarized the best available information on the interaction between ocean warming and corals reefs in the proposed rule, and concluded that ocean warming is a severe and increasing threat to corals. The public comments and supporting papers we received on the overview of ocean warming and coral reefs generally support the conclusion in the proposed rule that ocean warming is an important and increasing threat to coral reefs. However, the other comments underscore the uncertainty associated with projecting the effects of ocean warming on coral reefs in the future, and as described in our response to Comment 13, we also acknowledge that there is and will continue to be regional and local variability in responses of corals to ocean warming over the foreseeable future. We acknowledge that ocean warming will not act uniformly on all species at all times over the foreseeable future. Further, we recognize that the responses of each species to ocean warming will vary across their ranges over the foreseeable future. Additionally, as described in previous comment responses, a key difference between the proposed and final rule is that we now more fully consider the threat-buffering capacity of each species' unique characteristics, and place appropriate emphasis on the non-uniform nature of global threats at the regional and local levels which allows habitat heterogeneity to play a role in buffering a species against vulnerability to extinction.

Comment 15: We received comments on specific effects of ocean warming on reef-building corals that covered various topics, including the interactions of warming-induced bleaching with other threats. For example, one commenter noted that anthropogenic climate change (*e.g.,* ocean warming) weakens coral colonies and renders them more susceptible to disease, which is also covered in the Threats Evaluation—Disease sub-section below. Other commenters also emphasized the potential for ocean warming to act synergistically with other threats such as nutrification as well as overfishing. Another commenter provided information from Ferrier-Pagès *et al.* (2010) suggesting remarkable tolerance to global change, such as the potential to reduce bleaching vulnerability through increased feeding rates.

Response: In the proposed rule, we discussed how multiple threats stress corals simultaneously or sequentially, whether the effects are cumulative (the sum of individual stresses) or interactive (*e.g.,* synergistic or antagonistic). The comments and supporting papers we received on these topics provide supplemental information (such as synergistic effects of ocean warming with other threats), which has been incorporated and considered in our assessment, as described in more detail in the Threats Evaluation—Ocean Warming sub-section. The comments and supporting papers support the conclusion in the proposed rule that the impacts of ocean warming on reef-building corals are increasing in severity and likely to continue increasing in severity. This information also underscores the great complexity and high uncertainty associated with the various specific effects of ocean warming, including synergistic effects with other threats, across the ranges of reef-building corals. We continue to acknowledge that susceptibility of a species to a threat depends on the combination of: (1) Direct effects of the threat on the species; and (2) the cumulative and interactive (synergistic or antagonistic) effects of the threat with the effects of other threats on the species. In the proposed rule, we considered how the cumulative or interactive effects altered the rating assigned to a threat susceptibility in isolation. However, upon further consideration, we need to evaluate the extent to which one threat influences the susceptibility of an individual species to another threat with more species-specific information, in connection with all the other elements that influence a species' extinction risk. Generally, cumulative and interactive processes are complex and uncertain and existing information about threats interactions is only based on a few studies on a few species. Where possible, when we have species-specific or applicable genus-level information on cumulative or interactive effects, we have applied this information to that particular species' susceptibilities in a more integrated manner.

Comment 16: We received several comments on the capacity of reef-building corals for acclimatization and adaptation to ocean warming, covering various specific characteristics of reef-building corals that may contribute to such capacity. Mostly, commenters asserted that we did not adequately consider the ability of corals to acclimatize or adapt to changing temperatures. Several comments cited empirical evidence that corals have already adapted to ocean warming, thereby demonstrating the potential for acclimatization or adaptation. For example, one comment letter provided information from Pandolfi *et al.* (2011) and Cahill *et al.* (2013) stating that more recent analyses incorporating thermal tolerance of species indicate a wide range of outcomes including maintenance of comparable levels of cover to 2100 and beyond. Another commenter provided data from Maynard *et al.* (2008) and Guest *et al.* (2012) showing that many types of coral show surprisingly large (~0.5–1 °C) increases in thermal tolerance after a single mass bleaching event, due to either adaptation or acclimatization. In another comment letter, information provided from Jones and Berkelmans (2010) and Baker *et al.* (2004) show that the acclimatization potential of corals to increased temperatures is an active area of research, with a focus on identifying heat-resistant phenotypes. Another commenter pointed to the coral species that occur in the Arabian Gulf as an example of species adapting to warmer temperatures.

Response: In the proposed rule we acknowledged that there is some evidence to suggest that reef-building corals may have various mechanisms for acclimatization and adaptation to ocean warming. These topics were described in the Ocean Warming sub-section of the proposed rule, and we concluded that existing scientific information was inconclusive on how these processes may affect individual corals' extinction risk, given the projected intensity and rate of ocean warming. The public comments and supporting papers have been incorporated and considered in our assessment, as described in more detail in the Threats Evaluation—Ocean Warming sub-section and the Species-specific Information and Determinations section. However, the supplemental information does not alter the conclusion in the proposed rule that the capacity for acclimatization and adaptation of reef-building corals to ocean warming is inconclusive for corals generally at this time.

Comments on Disease (High Importance Threat, ESA Factor C)

Comment 17: One comment regarding the decline of Caribbean coral populations cited land-use changes as well as disease outbreaks (among other local threats) as the causes of Caribbean coral decline rather than climate change. Some comments also provided such information pertaining to specific species. For example, one comment stated that the genetic diversity of *Acropora cervicornis* in Florida may be sufficient to maintain viability and resilience to environmental perturbations and disease.

Response: The proposed rule described how disease had a major role in the initial decline of Caribbean coral populations as described in the Coral Reefs, Other Coral Habitats, and Overview of Candidate Coral Environments sections of the proposed rule. Further, in the Threats Evaluation—Disease section of this rule, we acknowledge diseases are of high importance with regard to extinction risk of corals. However, in assessing extinction risk over the foreseeable future, climate change-related threats are highly important to all reef-building corals. Any species-specific information provided on disease is included in the Species-specific Information and Determinations section later in this rule.

Comment 18: One commenter noted the explicit link between coral bleaching, disease, and the larger driving environmental factor of climate change by citing several studies that show anthropogenic climate change weakens coral colonies and renders them more susceptible to disease (Harvell *et al.,* 1999; Harvell *et al.,* 2002; Knowlton, 2001). Another commenter provided information from Muller and van Woesik (2012), stating that exceeding environmental disease thresholds will most likely become increasingly common in rapidly warming oceans, leading to more frequent coral-disease outbreaks. The study suggested that that the expression of some coral diseases occurs when (1) environmental thresholds are exceeded and (2) these environmental conditions either weaken the corals, which are then more susceptible to infection, or increase the virulence or abundance of pathogens. In other words, corals that experience bleaching are more likely to suffer from disease outbreaks and subsequent mortality.

Response: In the proposed rule, we described the importance of disease as a threat to corals and the potential for disease to act synergistically with other threats such as ocean warming. We also understand that assessing the threat of disease is highly complex, as the cause or causes of many coral diseases remains either unknown or poorly understood. Overall, the public comments we received underscored and supported the analysis in the SRR and the proposed rule. In addition to public comments, we collected a significant amount of information on disease that became available since the proposed rule published. Thus, we maintain that disease is a high importance threat to the extinction risks of the 65 corals in this final rule. All of the supplemental information received or otherwise collected has been detailed and summarized in the Threats Evaluation—Disease sub-section of this final rule. The extent to which the extinction risk of a particular coral species is impacted by disease is discussed in more detail in the Species-specific Information and Determinations section below.

Comments on Ocean Acidification (Medium-High Importance Threat, ESA Factor E)

Comment 19: We received public comments on the description of and future projections of ocean acidification, which provided information on the complexity of ocean chemistry on corals, and criticism of the use of the AR4's worst-case scenario as the basis for determining the most likely future scenario with regard to ocean acidification. For example, one commenter asserted that global projections of ocean acidification are too coarse and do not take into consideration competing and extremely localized factors that affect local CO_2 concentrations (*e.g.,* local atmospheric processes, local biological processes, local temperature, and upwelling from deeper waters). The commenter emphasized that despite acknowledging the multitude of local, regional, and seasonal factors that may cause local CO_2 concentrations to increase and pH to decrease, we opted instead to base our reef-scale threat analysis on generalized acidification predictions from global models. Other commenters also criticized our reliance on the IPCC's AR4 report as the basis for our threat evaluation of ocean acidification to corals.

Response: In the proposed rule we acknowledged that numerous, complex spatial and temporal factors compound uncertainty associated with projecting effects of ocean acidification on corals in the future. We also acknowledged that global climate change models are associated with uncertainty. We further acknowledge that the interpretation of future climate change threats to corals is complex and that effects on individual species of reef-building corals are difficult to determine, as described in more detail in the Threats Evaluation—Global Climate Change Overview subsection. However, we agree with commenters that ocean acidification will not affect all species in all locations uniformly over the foreseeable future, and that different locations will experience the effects of ocean acidification at different time scales and at different magnitudes than others. We provide a review of all the best available information, including a review of AR5's WGI (IPCC, 2013) in the Threats Evaluation—Global Climate Change Overview, RCP8.5 Projections, and Ocean Acidification sub-sections. Upon review of the information provided in AR5's WGI and public comments, our conclusion regarding the threat of ocean acidification remains unchanged from the proposed rule. We maintain that ocean acidification is increasing in severity, and is likely to continue increasing in severity, within the ranges of reef-building corals, and is a medium-high importance threat in assessing extinction risk for the 65 corals in this final rule. However, as described in earlier comment responses, a key difference between the proposed and final rule is that we now more fully consider the ability of each species' spatial and demographic traits to moderate the impacts of threats, and we place appropriate emphasis on the non-uniform nature of global threats at the regional and local levels which allows habitat heterogeneity to play a role in buffering a species against vulnerability to extinction.

Comment 20: We received a comment regarding variability in ocean acidification on coral reefs related to fluctuations in pH from localized factors such as seagrass beds. The commenter provided information from Manzello *et al.* (2012) indicating that local and regional biochemical processes buffer effects of ocean acidification in locations such as the Gulf of Mexico and South Atlantic. Manzello *et al.* (2012) reported that the photosynthetic uptake and sequestering of carbon dioxide by seagrasses and other macroalgae and the positive growth response by seagrasses to increasing dissolved carbon dioxide (Palacios and Zimmerman, 2007) may create ocean acidification refugia for corals. Comments on specific effects of ocean acidification on coral reefs and reef-building corals focused on capacity for acclimatization of corals to acidification, and evidence that some coral species are resistant to low pH.

Response: In the proposed rule, we discussed that numerous, complex spatial and temporal factors compound uncertainty associated with projecting effects of ocean acidification on corals and coral reefs in the future, and we agree with the comment that ocean acidification will not affect all species in all locations uniformly over the foreseeable future, and that different locations will experience the effects of ocean acidification at different time scales and at different magnitudes than others. In response to comments on spatial variability of ocean acidification, such as lack of consideration of localized increase in pH from adjacent seagrass beds, we provide a review of the best available information on spatial variability in ocean acidification, including any information provided by public comments as well as any information we gathered ourselves since the proposed rule was published, in the Threats Evaluation—RCP8.5 Projections and Ocean Acidification sub-sections. These data in our view still support the conclusion in the proposed rule that ocean acidification is increasing in severity, and likely to continue increasing in severity within the ranges of reef-building corals; however, as described in earlier comment responses, a key difference between the proposed and final rule is that we now more fully consider the threat moderation capacity of each species' spatial and demographic traits, and of habitat heterogeneity.

Comment 21: We received one comment that identified a couple of ocean acidification and coral reef calcification rate studies that were not included in the SRR and proposed rule. The commenter provided two studies: One showing that coral calcification increases with global warming (McNeil *et al.,* 2004), and another study showing that corals are already thriving in conditions similar to the ocean acidification conditions predicted by the IPCC for 2100 (Hofmann *et al.,* 2011).

Response: In the proposed rule and supporting documents we acknowledged that some exceptional areas exist where reef-building coral communities appear to be thriving under naturally high CO_2 concentrations. As described in the comment response above to Comment 19, we agree that ocean acidification will not act uniformly on all species in all locations over the foreseeable future. We provide a review of all the best information available on the threat of ocean acidification, including these studies, which we received in public comments, and any information we gathered ourselves in the Threats Evaluation—Ocean Acidification sub-section (*e.g.,* Shamberger *et al.,* in press). This supplemental information supports the proposed rule's conclusion that the threat of ocean acidification has already impacted corals and coral reefs and will become increasingly severe from now to 2100, with increasingly severe consequences for corals and coral reefs. However, as described in previous comment responses, a key difference between the proposed and final rule is that we now more fully consider the capacity of each species' spatial and demographic traits, and habitat heterogeneity, to buffer a species against vulnerability to extinction.

Comment 22: We received a detailed comment letter with supporting papers regarding specific effects of ocean acidification on reef-building corals, such as effects on reef accretion, effects on larvae and juvenile corals, and interactive or synergistic effects with other environmental variables. For example, the commenter pointed out several studies that underscore the potential impact of ocean acidification on reef calcification rates, noting that even under the most optimistic modeling scenario, 98 percent of reefs would be chemically stressed by 2050. The commenter also emphasized that corals may have a limited ability to adapt to ocean acidification based on an in-situ study of two corals in Florida Bay (Okazaki *et al.,* 2013).

Response: The comment letter and supporting papers support the conclusion in the proposed rule that ocean acidification is increasing in severity, and likely to continue increasing in severity, within the ranges of reef-building corals, resulting in various detrimental impacts. This information also underscores the complexity and uncertainty associated with the various specific effects of ocean acidification, including interactive or synergistic effects with other threats, across the ranges of reef-building corals as well as predicting adaptive capacity. The information provided by the commenter and the supporting papers regarding the specific effects of ocean acidification on corals and coral reefs have been incorporated and described in more detail in the Threats Evaluation—Ocean Acidification sub-section.

Comments on Trophic Effects of Fishing (Medium Importance Threat, ESA Factor A)

Comment 23: One comment provided supplemental information that was not included in the proposed rule regarding the role of herbivorous fish in terms of building and maintaining reef resilience. The commenter stated that ''overfishing also degrades coral reefs, particularly by depleting key functional groups, such as herbivores, that reduce turf algae on reefs and maintain optimal conditions for coral growth and recruitment'' and provided Keller *et al.* (2009) as a reference. Another commenter also described the importance of herbivorous functional groups, and stated that limiting or attempting to reduce harvest of predatory fish may cause ecological harm by unbalancing a healthy trophic chain.

Response: The proposed rule described the importance of trophic interactions which include reducing herbivorous fish species that control algal growth, limiting the size structure of fish populations, reducing species richness of herbivorous fish, and releasing corallivores from predator control. The supplemental information provided by public comments supports our conclusion in the proposed rule that healthy levels of herbivorous functional groups are essential to coral reef ecosystem resilience in light of climate change-related threats. Detailed information regarding the trophic effects of fishing can be found in the Threats Evaluation—Trophic Effects of Fishing sub-section as well as the Inadequacy of Existing Regulatory Mechanisms—Reef Resilience sub-section.

Comment 24: One commenter stated that fish landings have been stable for 30 years in St. Thomas, U.S. Virgin Islands, with many species increasing in size, indicating that overfishing is not occurring in this location or contributing to the status of the Caribbean species in that area. The commenter also pointed out numerous sources of sediments and nutrients, and coastal development projects in the U.S. Virgin Islands as the main contributors to coral reef decline rather than overfishing. Other commenters also disagreed that overfishing was contributing to coral reef decline in Hawaii and highlighted significant increases in tourism and in-water recreational activities as local drivers of reef decline in that area.

Response: Although not explicitly stated in the proposed rule, we agree that levels of fishing effort vary throughout the ranges of the 65 corals under consideration. We did acknowledge that exposure to this threat varies throughout the ranges of the proposed species and between the Caribbean and Indo-Pacific. In the proposed rule, we also recognized that management and regulation of commercial and recreational fisheries are inconsistent throughout the coral reef world. When evaluating the current and potential threat impacts from trophic effects of fishing, we are required to assess this threat throughout the entire ranges of the 65 coral species in this final listing. We understand that levels and impacts of overfishing differ depending on the particular location under evaluation; however, we maintain that the trophic effects of fishing represent a medium importance threat to the extinction risk of all 65 coral species in this final rule.

Comment 25: One commenter stated that we failed to consider human demography in terms of our analysis of fishing impacts to corals. The commenter noted that large swaths of area throughout Oceania are being depopulated in favor of more metropolitan countries, which reduces the level of human impacts to corals, including fishing pressure.

Response: The issues of human demography and population trends were covered explicitly in the SRR and considered in the proposed rule. While there may be some areas being depopulated, increased human population and consumption of natural resources are root causes for increases in fishing (particularly of herbivores) at many locations around the globe (Brainard *et al.,* 2011). Data from the World Bank show human population abundance and density have increased in all five coral reef regions since 1960 (*i.e.,* Indian Ocean, Caribbean, Southeast Asia, Pacific, and Middle East), with the greatest human population densities and increases in population density in the Southeast Asia and Indian Ocean regions. In these regions, current human population densities are 4–5 times greater than the global average and probably suggest the greatest local human-induced effects to corals and coral reefs. In the areas in closest proximity to coral reefs, the Southeast Asian, Indian Ocean and Middle East regions have the highest densities of people per reef area (Burke *et al.,* 2011). However, these data are regional averages. We do not dispute that human demography within any of these regions may be shifting to higher density in metropolitan areas, resulting in a decrease of human disturbance in some portions of these regions. The regional trend data suggest increasing risks to corals and coral reefs overall (Brainard *et al.,* 2011). However, because we must consider the extent to which a particular threat impacts each species throughout its entire range, we still maintain that overfishing is a medium importance threat to all 65 coral species in this final rule.

Comments on Sedimentation (Low-Medium Importance Threat, ESA Factors A and E)

Comment 26: We received some public comments on sedimentation as a threat to the 65 coral species in this final rule. Comments generally underscored the importance of sedimentation as a considerable local threat to corals and pointed out the potential of sedimentation to interact and potentially exacerbate other threats, as well as to reduce coral resilience. For example, we received a detailed comment asserting that prospects for recovery of certain reef sites in the Caribbean from acute episodes of hurricane damage or die-offs from bleaching and disease (brought on by ocean warming) are extremely poor without sustained recruitment, which may be prevented by sediment preempting larval attachment. Further, the commenter identified sedimentation (among other local threats) as a local threat with the capability of exacerbating bleaching and disease impacts, thereby reducing the resilience of corals. One commenter pointed out that mass mortality of *Acropora palmata* at Vega Baja, Puerto Rico, was caused in part by sedimentation. Another commenter stated that near shore marine-origin sediments have almost completely been replaced by terrestrial sediments due to a lack of land use controls, resulting in near total mortality of nearshore *Acropora* stands in the U.S. Virgin Islands. Other commenters identified the negative impacts of sedimentation to reefs on the Hawaiian Island of Molokai, emphasizing the issue of run-off from large rain events in certain areas. In general, these comments emphasize the importance of sedimentation as a threat to the 65 coral species in this final rule, with some asserting that this threat is as important, if not more important, than the higher rated threat of reef fishing.

Response: We acknowledge all of the public comments and information we received on the threat of sedimentation to the 65 coral species in this final rule. As summarized in the proposed rule, we also recognize the possibility for sedimentation to interact with other global and local threats and potentially reduce the resiliency of coral reef ecosystems and/or impede recovery. In addition to public comments, we also collected supplemental scientific information regarding the impacts of sedimentation to corals that became available after the proposed rule was published. The findings from these studies and more detailed information regarding the evaluation of sedimentation as a threat to coral reefs can be found in the Threats Evaluation—Sedimentation sub-section. We also acknowledge the concern that some comments expressed regarding the importance of this threat in comparison to other local threats. However, for corals in general, we maintain that sedimentation is a low-medium threat to the extinction risk of the 65 corals in this final rule. Any species-specific information we received on sedimentation is included in the Species-specific Information and Determinations section.

Comments on Nutrients (Low-Medium Importance Threat, ESA Factors A and E)

Comment 27: We received limited public comments on nutrient enrichment of nearshore waters (*i.e.,* eutrophication) and its impacts to coral reef ecosystems. Comments generally underscored the importance of nutrient enrichment as a considerable local threat to corals, and emphasized the potential of nutrient enrichment to interact and potentially exacerbate other threats, as well as reduce coral reef resiliency. For example, we received a detailed comment letter that provided studies regarding the impacts of nutrient enrichment to coral species. These studies, which became available after the proposed rule was published, provide evidence that nutrient enrichment can worsen thermal stress on inshore reef communities, and that management actions to reduce coastal nutrient enrichment can improve the resistance and resilience of vulnerable coastal coral reefs to ocean warming. Another comment detailed some of the impacts of nutrients in the U.S. Virgin Islands. For example, industrial effluent in St. Croix allegedly impacted fisheries in the area to the point where fishermen struggle to sell their catch due to perceived contamination. Further, a sewage pumping station in another area impacted nursery grounds for spiny lobsters. We received other comments regarding the negative impacts of nutrient enrichment in various locations in Florida and Hawaii from sewage outfalls and other land-based sources of pollution. In general, comments emphasized the importance of nutrients as a threat to the 65 coral species in this final rule, some asserting that this threat is as important, if not more, than the higher rated threat of reef fishing.

Response: In the proposed rule we described the threat nutrient enrichment poses to corals. The public comments and supporting papers regarding the impacts of nutrients to coral reef ecosystems have been considered and incorporated into our assessment, as described in more detail in the Threats Evaluation—Nutrients sub-section. We also acknowledge the concern that some comments expressed regarding the importance of this threat in comparison to other local threats. However, for corals in general, we maintain that nutrient enrichment is a low-medium threat to the extinction risk of the 65 corals in this final rule. Any species-specific information we received on nutrient enrichment is included in the Species-specific Information and Determinations section.

Comments on Sea-Level Rise (Low-Medium Threat, ESA Factor A)

Comment 28: We received one public comment that cited the Consensus Statement on Climate Change and Coral Reefs (drafted by a working group of eminent scientists and endorsed by hundreds of scientists to address the topic of climate change impacts on coral reefs; ICRS, 2012) as a source of estimates of sea-level rise by the end of this century. However, the comment did not expound upon the potential ramifications of these estimates. We did not receive any other public comments or gather new or supplemental information on the threat of sea-level rise to the 65 corals in this final rule.

Response: Although we received only one public comment on this topic, we collected supplemental information regarding the threat of sea-level rise to corals as a result of the IPCC's AR5. These findings are summarized in the Threats Evaluation—Sea-Level Rise sub-section.

Comments on Predation (Low Threat, ESA Factor C)

Comment 29: We received very few comments regarding the threat of predation to the 65 corals in this final rule. The majority of comments we received regarding predation were specific to individual species in Guam. For example, we received a detailed comment letter that included suggested changes to individual species vulnerability ratings to predation, as a result of local crown-of-thorns seastar (*Acanthaster planci*) predation levels. One commenter cautioned us in terms of inferring predation vulnerabilities for certain species from genus-level information. Other comments identified predation as a threat to corals, but provided no further information or scientific references.

Response: We acknowledge all of the public comments and information we received on the threat of predation to the 65 coral species in this final rule. The extent to which the extinction risk of a coral species is impacted by predation is discussed in more detail in the Species-specific Information and Determinations section, including any information we received from specific locations. We also agree that inferring susceptibility to threats from genus-level information is not always appropriate. However, that particular comment referenced a species we deemed Not Warranted for listing under the ESA, and are no longer considering. In addition to public comments, we collected information regarding the variable effects predation has on certain coral species. These studies are detailed and summarized in the Threats Evaluation—Predation sub-section. Overall, we maintain that predation is a low level threat to the extinction risk of corals in general.

Comments on Collection and Trade (Low Threat, ESA Factor B)

Comment 30: We received hundreds of comments that strongly criticized our characterization of the trade industry as a whole, stating that our analysis failed to use current science and/or commercial information about the coral trade. Commenters also asserted that we did not adequately consider aquaculture and mariculture industries as a potential alternative to alleviate pressures from wild collection practices. For example, we received a detailed comment regarding the mariculture industry in Indonesia, stating that in the last five years, the coral trade communities of Indonesia have developed coral mariculture with long-term objectives of reducing the wild harvest of coral species for the live coral trade. Another comment letter provided information from recent papers by Rhyne *et al.* (2012) and Wood *et al.* (2012) that report declining trade in wild-harvested Pacific corals and remarkable growth in the production and trade in cultured corals from Pacific countries. Overall, many comments asserted that a shift from wild collected corals to cultured corals is occurring as a result of increasing aquaculture and mariculture operations both within the United States and major source countries such as Indonesia.

Response: We agree with commenters that the SRR and proposed rule did not adequately describe the full scope of the marine ornamental trade industry and the contribution of captive culture in terms of alleviating pressures from wild collection. We agree that some significant progress has been made in terms of shifting from wild collection of corals to trade of aquacultured and/or maricultured corals as a result of both U.S. domestic production and production of corals in major source countries such as Indonesia. In addition to public comments we also collected a large amount of supplemental information on coral collection and trade. Specifically, we collected information about (1) the physical and ecological impacts of wild collection of coral colonies and/or fragments from their natural habitats; and (2) captive culture (*i.e.*, mariculture and aquaculture) including information on operations and the role of home aquaria as it relates to trade. All of the public comments and supporting papers have been considered and incorporated into our assessment as described in more detail in the Threats Evaluation—Collection and Trade sub-section. However, this information does not change our determination that the threat is of low importance to the extinction risk of corals, generally.

Comment 31: We also received numerous comments that strongly disagreed with our characterization and conclusion regarding the adequacy of regulatory mechanisms within the coral trade industry, particularly CITES and other laws in major source countries such as Indonesia. Many commenters assert that CITES and various regulations provide adequate restrictions and requirements for the ornamental trade of coral reef species, such that trade has much less of a negative impact on the extinction risk of the 65 coral species than was portrayed by the proposed rule and supporting documents. One commenter also described Indonesia's development of regulations for their mariculture industry that is helping to alleviate wild collection pressures.

Response: In the proposed rule we described that there are some protections afforded via CITES and various other national regulations in some countries where trade of coral reef species is prevalent. However, we agree that our evaluation of trade regulations was incomplete. There are numerous challenges in documenting trends in trade due to deficiencies of CITES import and export data, and the most recent information is conflicting. Some reports state that 98 percent of reef-building corals within the aquarium trade are still wild collected, with only two percent originating from maricultured sources (Thornhill, 2012). In contrast, another report shows that maricultured corals accounted for approximately 20 percent of the trade in 2010 (Wood *et al.*, 2012). Further, adequate tracking of wild and maricultured corals along the supply chain from ocean to aquarium is extremely difficult, yet necessary for determining the true dimensions and impacts of the industry (Cohen *et al.*, 2013). Additionally, the level of wild collection of reef-building corals may be underestimated due to an undocumented illegal trade and a significant amount of mortality along the supply chain from reef to aquarium (Thornhill, 2012). There are many other issues and discrepancies related to assessing the overall impacts of the trade and the adequacy of regulations like CITES; however, collection and trade was ultimately ranked as a low level threat to corals in general by the BRT and in the proposed rule. Further, no one species of coral was determined to be threatened or endangered solely due to the effects of the coral trade industry, and that is still true for the final determinations in this rule. Therefore, while we agree CITES provides some protections for corals in the trade industry, we maintain that the threat from collection and trade is low and does not dictate the listing status of any individual species. In addition to public comments, we collected some supplemental information on regulatory mechanisms for the global marine ornamental trade industry, including details regarding trade of both live and dead corals and other coral reef wildlife.

In light of the public comments and information we received regarding the ornamental trade industry, the Threat Evaluation—Collection and Trade sub-section discusses the trade and its impacts to corals in detail, including information regarding the physical and ecological impacts as a result of the collection process, advances in aquaculture and mariculture industries, as well as issues and trends in trade of both live and dead coral. Any species-specific information we received on collection and trade is included in the Species-specific Information and Determinations section.

Comments on Inadequacy of Existing Regulatory Mechanisms (ESA Factor D) and Conservation Efforts

Comment 32: We received several comments that critiqued our evaluation of local regulatory mechanisms and conservation efforts. Some comments asserted that we failed to adequately consider the beneficial effects of local management actions and conservation efforts with regard to building reef resilience in the face of climate change. For example, we received a comment letter that stated a broad consensus exists for management to increase marine ecosystem resilience to climate change by reducing local anthropogenic stressors and reduction of these stressors may boost the ability of species, communities, and ecosystems to tolerate climate-related stresses or recover after impacts have occurred. Another commenter emphasized the importance of local management for increasing coral reef resiliency, including management of land-use changes and water quality, as well as utilizing coral reef restoration techniques. Overall, these comments disagreed with our characterization regarding the effectiveness of local regulatory mechanisms and conservation efforts in the face of climate change related threats and urged us to consider the concept of reef resilience.

Response: We recognize that certain aspects of local management actions and conservation efforts need more explanation than was provided in the proposed rule and Management Report (NMFS, 2012b). This final rule provides that additional explanation, as summarized here. There is an emerging body of literature regarding the concept of reef resilience, defined as an ecosystem's capacity to absorb recurrent shocks or disturbances and adapt to change without compromising its ecological function or structural integrity (Hughes *et al.*, 2010; Obura, 2005). Recent evidence suggests that managing local scale disturbances for resilience will be crucial to maintaining complex, bio-diverse coral reef ecosystems given the predicted widespread impacts of climate change related threats (Anthony *et al.*, 2011).

Therefore, we recognize that effective local laws and regulations as well as conservation projects and programs may help reduce impacts to corals and coral reefs from threats on an ecosystem level, positively affecting the timeframe at which corals may become in danger of extinction by providing a protective temporal buffer (*i.e.*, resiliency) to individual coral species in the face of climate change related threats. Some evidence suggests that local management actions, particularly of fisheries (specifically, no-take marine reserves) and watersheds, can delay reef loss by at least a decade under ''business-as-usual'' rises in GHG emissions (Jackson *et al.*, 2014; Kennedy *et al.*, 2013; Marshall and Schuttenberg, 2006; Mumby and Steneck, 2011). However, many scientists strongly suggest that these local actions be combined with a low-carbon economy to prevent further degradation of reef structures and associated ecosystems (Kennedy *et al.*, 2013).

We cannot definitively say whether and to what degree the presence of regulations in a particular location is currently conferring resilience benefits for any particular species. Overall, we agree that local regulatory actions and conservation efforts to reduce threats are imperative for resiliency of coral reef ecosystems in the face of climate change. However, for purposes of evaluating the inadequacy of regulatory mechanisms as well as conservation efforts under the ESA, we are unable to definitively establish the current status and effectiveness of local regulation of impacts from local threats for any particular species in any given location, with the exception of local regulatory mechanisms for *Acropora palmata* and *A. cervicornis*, which were evaluated in detail in the 2005 status review for those species. Further, we maintain that global regulations to reduce impacts from climate change are inadequate at this time. For more detailed information about our evaluation of how local regulatory mechanisms relate to building coral reef resilience, please refer to the Threats Evaluation—Inadequacy of Existing Regulatory Mechanisms sub-section. Likewise, for more detailed information about our evaluation of conservation efforts please refer to the Conservation Efforts sub-section.

Comment 33: We received some comments that disagreed with our characterization of local regulatory mechanisms in general, asserting that certain local laws are sufficient for protection of corals, thus rendering additional protection via the ESA unnecessary. For example, we heard from several commenters who believe there are adequate regulations to prohibit the damage of reef-building corals, such that additional protections from the ESA are redundant. We also received comments that disagreed with our characterization of conservation efforts. For example, we received a comment that disagreed with our conclusion regarding conservation efforts, asserting that coral conservation actions already have, and will continue to, contribute to coral species recovery. Examples of conservation efforts that were not included in the Final Management Report (FMR; NMFS, 2012b) include ongoing coral reef restoration projects, specifically in Florida and the wider-Caribbean, as well as aquaculture and mariculture efforts both internationally (*e.g.*, Indonesia) and within the United States to try to alleviate wild collection pressure on coral reef ecosystems. Comments urged us to take these efforts into consideration for evaluating the status of the 65 corals in this final rule.

Response: We recognize that certain locations have effective local laws, regulations, and programs that address local threats and provide for the protection and conservation of coral species. For example, it is illegal to collect or harvest reef-building coral species in all U.S. states, territories, and commonwealths. Some laws even prohibit harming any reef-building coral species through activities such as boat groundings and impose penalties and fines for doing so. However, we must evaluate whether regulatory mechanisms are inadequate for corals across their entire ranges rather than in any one specific location. Likewise, our analysis of conservation efforts must also include the entirety of the species' ranges, and it must consider whether those efforts will result in recovering the species to the point of ameliorating threats throughout the species' range to such a degree that a species should be listed as threatened rather than endangered or even not at all. Therefore, we cannot solely consider whether regulations or conservation efforts in the United States or any other particular location are sufficient for reducing threats to corals. The importance of global climate change-related threats to the extinction risk of these corals makes it even more problematic to limit our assessment of conservation efforts and the adequacy of regulatory mechanisms to individual countries. For these corals, we are required to consider the adequacy of regulatory mechanisms for reducing GHG emissions and curbing the rate of global climate change.

For this final rule, we assessed regulatory mechanisms and conservation efforts in a more species-specific approach. To better capture the full breadth of existing regulatory mechanisms, in addition to the individual country descriptions in the Final Management Report, we re-characterized and summarized the presence of existing regulatory mechanisms throughout all the countries in the range of each individual species. The Inadequacy of Threats Evaluation—Existing Regulatory Mechanisms sub-section provides more detailed information on that range-wide evaluation process, as well as the Species Descriptions for the results. For more detailed information about our evaluation of the inadequacy of local management actions, please refer to the Threats Evaluations—Inadequacy of Existing Regulatory Mechanisms sub-section. For more detailed information about our evaluation of conservation efforts, please refer to the Conservation Efforts sub-section of this rule.

Comment 34: Several comments identified potential errors, omissions, and/or inaccurate characterizations within the Final Management Report (NMFS, 2012b). For example, we received a comment letter pointing out several omissions and inaccuracies regarding Federal management responsibilities for an extensive area of lands and waters in the Pacific Ocean. Many other comments provided additional laws, regulations, or conservation efforts that were not described in the Final Management Report or identified previously during the public engagement period during the summer of 2012. For example, one commenter requested our inclusion of Guam Public law 24–87 that ensures Guam's marine preserves are protected from recreational/commercial activities that may prove detrimental to fragile ecosystems. Another commenter pointed out that we omitted information regarding certain National Wildlife Refuges and National Parks that include coral reefs. We also received a public comment letter requesting us to consider information regarding Indonesia's Coral Reef Rehabilitation and Management Program as a conservation effort.

Response: We acknowledge that the Final Management Report had some minor errors and omissions. However, it should be noted that the Final Management Report was not intended to be an exhaustive document; rather, it aimed to capture the breadth of existing regulatory mechanisms and conservation efforts that may reduce threat impacts to corals and coral reefs. Due to the immense number of regulatory mechanisms that exist throughout the entire ranges of the 65 coral species (*i.e.*, 84 countries), the Management Report was not intended to identify every individual law and regulation that may have an effect on corals or their threats in every country within the species' ranges. However, any additional laws and regulations that were brought to our attention through the public comments were noted and considered in the analysis of inadequacy of existing regulatory mechanisms presented in this final rule under the Threats Evaluation—Inadequacy of Existing Regulatory Mechanisms sub-section.

Comments on Risk Analyses

Comment 35: We received many comments regarding the composition of the BRT. Some comments disagreed with the selection of BRT members, asserting that because all seven members of the BRT were Federal employees, non-Federal coral biologists with expertise in the field within specific regions (*e.g.*, Hawaii) were overlooked, thus casting doubt on the qualifications of the BRT members and the results of the status review. One comment suggested that the BRT member votes should have been weighted to reflect their level of expertise in the different types of corals undergoing review. Another comment stated that it would not be possible for certain members of the BRT to act in a neutral or unbiased manner because they are strong proponents of establishing Marine Monuments, sanctuaries, and MPAs for the protection of coral reef systems throughout the U.S. Pacific Islands. Yet another comment stated there was no independent verification from experts who did not have a stake in the Federal ESA listing processes.

Response: According to agency guidance, members of the BRT should have expertise in the particular species' biology, population dynamics or ecology, or other relevant disciplines (*e.g.*, ocean/environmental/climate processes, analytical techniques, population genetics, extinction risk, or pertinent threats). Additionally, NMFS must also consider team composition in light of the Federal Advisory Committee Act (FACA). Generally, any committee or group established for the purpose of providing consensus advice or recommendations to a Federal agency is subject to the procedural requirements of FACA. Biological Review Teams are subject to FACA because their assessments constitute group advice upon which NMFS may base its determinations as to whether to list species as endangered or threatened under the ESA. Based on the requirements of FACA, the team must therefore be composed of Federal officials and employees, and specific classes of state employees, unless specifically exempted. As such, the coral BRT was composed of seven Federal scientists from NMFS's Pacific Islands, Northwest, and Southeast Fisheries Science Centers and the U.S. Geological Survey and National Park Service. The members of the BRT are a diverse group of scientists with expertise in coral biology, coral ecology, coral taxonomy, physical oceanography, global climate change, and coral population dynamics. Additionally, the BRT consulted with numerous non-Federal scientists and subject matter experts during the status review, and had their work peer reviewed, to ensure the best available information was utilized in the SRR. These subject matter experts are detailed in the Acknowledgements of the SRR. Last, we provided extraordinary opportunities for non-Federal scientists to provide their expertise prior to the publication of the proposed rule, including two scientific workshops held in the summer of 2012. All information received was considered in the proposed rule.

Comment 36: We received numerous criticisms regarding the evaluation methods used by the BRT. Many comments criticized the Critical Risk Threshold voting method used by the BRT for developing extinction risk values for the 82 corals within the proposed rule. Some comments asserted that the voting process relied on subjective opinion rather than scientific facts, while other comments stated that the anonymous scoring system by the BRT could not truly be anonymous. Still, other comments pointed out critical errors or flaws in the BRT's methods. For example, one comment stated that ranking each coral species relative to the rankings of other coral species does not inform NMFS of the risk status of an individual coral species. Another comment stated the Critical Risk Threshold graphs have an inappropriate and misleading quantitative horizontal axis, which suggests higher threat levels than estimated by the BRT. A couple of comments questioned the assignment of levels of confidence in the outcomes of the BRT voting process given the lack of information on which those outcomes were based, noting there was not a high degree of certainty between the experts.

Response: The voting methods used by the BRT are consistent with previous agency listing determinations that utilized similar structured decision making techniques. This approach is typically used when quantitative modeling of extinction risk is not a viable option due to a lack of precise quantitative population data. The BRT's voting relied upon professional interpretation of the best available scientific information at the time, including qualitative assessments. This approach allowed the BRT to explicitly address various ranges of uncertainty within their voting. We also emphasize that the determinations in the proposed rule did not solely rely on information within the SRR and the voting outcomes of the BRT. As described previously in the proposed rule and throughout this final rule, numerous sources of information were considered and incorporated in the listing determination process, as described in explicit detail in the Risk Analyses and Species-specific Information and Determinations sections. Additionally, the ESA does not require quantitative precision when estimating extinction risk and determining whether a species warrants listing as threatened or endangered under the ESA. Rather, the decision must be reasonable and based solely on the best scientific and commercial information available at the time of the decision, even in light of considerable uncertainty.

Comment 37: We received several comments that criticized how the proposed rule and supporting documents inferred species' characteristics based on genus-level information (*i.e.*, the proposed rule assumed that information for other species in the genus applied to the proposed species in that genus). A few comments stated that the BRT only considered threats to the taxonomic class and therefore it conducted no individual species threat analysis for any of the candidate coral species. Most comments stated that genus-level info on response to threats, abundance, and other characteristics were improperly extrapolated to species because there are numerous examples in the literature in which ecological or physiological traits are not consistent across species within a genus.

Response: In the proposed rule, we relied on higher taxonomic level (*i.e.,* genus or family) information for threats susceptibilities when species-specific susceptibilities were not available. We acknowledge that there is intra-genus or intra-family variability in response to threats in many cases. In response to criticism of how the proposed rule and supporting documents inferred species' characteristics based on genus-level information, this final rule does not automatically assume that genus-level information for other species in the genus applies to the proposed species in that genus. Rather, a careful analysis of genus-level information is incorporated into the Species-specific Information and Determination sections below for each of the 21 genera in which the 65 species belong. That is, as a preface to the Species-specific Information and Determinations for species in a genus, this final rule includes a description of the available information for other species in the genus that are not part of this final rule, and an analysis of the degree of applicability of that information to the species included in this final rule. Further, in no case in this final rule do we extrapolate from family-level information.

Comment 38: We received multiple comments criticizing the definition of ''foreseeable future'' in the proposed rule and supporting documents out to the year 2100 because it is too far into the future. One comment stated that climate change projections beyond 50 years have a high degree of uncertainty and may be impacted by numerous unforeseen and unpredictable circumstances, and thus identifying the foreseeable future as out to the year 2100 is not appropriate. Another comment stated that our use of 2100 for the foreseeable future is contrary to previous decisions made by FWS and NMFS, and there have been no breakthroughs in climate modeling to justify our new position on the reliability of long-term climate modeling.

Response: Consistent with our practice for all species listing determinations, we established that the appropriate period of time corresponding to the foreseeable future is a function of the particular type of threats, the life-history characteristics, and the specific habitat requirements for the coral species under consideration.

The timeframe established for the foreseeable future considered the time necessary to provide for the conservation and recovery of each threatened species and the ecosystems upon which they depend. It was also a function of the reliability of available data regarding the identified threats and extends only as far as the data allow for making reasonable predictions about the species' response to those threats. In the proposed rule, we explained that our choice of the year 2100 as the ''foreseeable future'' for analysis of global climate change was based on AR4's use of 2100 as the end-point for most of its global climate change models. Similarly, most of AR5's WGI models also use 2100 as the end-point (some models go beyond 2100) and AR5's WGI reinforces our original rationale for defining the foreseeable future as the period of time from the present to the year 2100. For global climate change threats, there is strong support for considering the foreseeable future as the period from the present to 2100 in AR5's WGI and its cited literature (IPCC, 2013). However, we agree that the foreseeable future for purposes of other threats to the species and the species' responses thereto does not necessarily extend out to 2100. Therefore, in this final rule, we clarify that 2100 simply marks the outer temporal bounds for consideration of climate change-related threats, and does not frame our analysis across all threats or our ultimate listing determinations. Further discussion of the foreseeable future is presented in the Foreseeable Future subsections of the Threats Evaluation and Risk Analysis sections below.

Comment 39: There were many comments on the quantity and quality of information used to make listing decisions for the candidate coral species in the proposed rule. Several comments stated that the present biological data do not support the proposed listings. They stated that the available science was insufficient and not compelling enough to demonstrate the need to make a decision under the ESA. A few comments criticized the use of IUCN data as a surrogate for ''true scientific data'' on species distribution and abundance. Many comments stated that useful information was available, especially on coral trade and mariculture, but the BRT did not use it, which led to serious errors in the SRR. The study by Rhyne *et al.* (2012) was given as an example. Other comments stated that there was little data regarding individual species' population numbers and trends, so NMFS did not conduct the species-specific analyses required under the ESA. In general, the commenters indicated that the voting process by the BRT seemed very subjective, with the results coming from the individual scientists' perception of extinction rather than solid scientific data.

Response: The proposed rule and the SRR did conduct a species by species analysis of extinction risk for each of the candidate corals. However, in the proposed rule, the presentation of the information on which we based our determinations may have been unclear because of our use of the Determination Tool as an organizational mechanism to present the enormous amount of data. In response to criticism of the lack of sufficient species-specific information in the proposed rule and supporting documents on distribution, abundance, threat susceptibilities, and other information, this final rule clarifies and explains how the information relating to the taxonomic, field identification, distribution, abundance, life history, threat susceptibilities, and management information for each of the 65 coral species were evaluated in reaching the final listing determinations. The presentation of the information includes the information on which the proposed rule was based, information submitted by public comments, and information we gathered after the proposed rule published. The information was also analyzed in an integrated, non-formulaic framework instead of in a linear, formulaic framework as it was in the Determination Tool. The resulting information provides the basis for the 65 listing determinations in this final rule. In addition, while IUCN listings were used by the petitioner as one criterion for selecting coral species in the original 2009 petition, and IUCN maps were used in the 2011 SRR, no IUCN data or information is used in this final rule because it does not represent the current best available species-specific information. To explain more clearly the changes from the proposed to the final listings, we included an Overview of Methods and Key Changes Applied in Final Determination Framework sub-section within the Risk Analyses section to illustrate how all of the available information was considered for each species and how it contributed to each species' listing status. As a result, the 65 species-specific determinations below are based on the best available species-specific information and improves upon the proposed rule.

Comment 40: We received a couple of comments disagreeing with the characterization of the level of extinction risk inherent for a species due to its occurrence in the Caribbean. One comment stated that the BRT's determination that the entire Caribbean is sufficiently limited in geographic scale to be a factor that increases the extinction risk of all corals in the Caribbean is at odds with genetic data. The commenter provided references (Baums *et al.,* 2005b; Baums *et al.,* 2006a; Murdoch and Aronson, 1999; Vollmer and Palumbi, 2007) that show that, while it is clear that regional-scale processes such as bleaching and disease are acting on all these reefs simultaneously, no two reefs or areas respond the same to these disturbances. Another comment asserted that no threat to Caribbean *Acropora* is imminent, and therefore endangered listings are not supportable for these species.

Response: Geographic distribution is one of many factors we must evaluate to determine a species' status. We agree with commenters that an inherent increase in extinction risk solely due to occurrence in the Caribbean is not accurate; rather, the ratings in the Determination Tool regarding basin occupancy were an inadvertent function of comparing the Caribbean basin to the Indo-Pacific basin. That is, the automatic increase in extinction risk for species occurring in the smaller, more disturbed Caribbean was only relative in comparison to species occurring in the larger, less disturbed Indo-Pacific. In light of public comments, we determined that absolute range size in both the Caribbean and Indo-pacific was inadvertently under-estimated in the proposed rule. As a result, we now give consideration to geographic distribution in terms of absolute size rather than relative size in both the Caribbean and Indo-Pacific. We still maintain that the Caribbean is a highly disturbed basin that has experienced loss of resilience; however, the reconsideration of absolute distribution represents one piece of a more holistic approach to linking each species' characteristics to each species' status. The implications of occurrence in the Caribbean and more detailed descriptions of geographic ranges and how they may affect extinction risk are now provided in more detail for all species individually in the Risk Analyses and Species-specific Information and Determinations sections below.

We also explicitly incorporated consideration of regional and local variability in response to threats. We have also endeavored to provide a clearer discussion of how we assessed the vulnerability of each coral species, not just the Caribbean *Acropora,* to the major threats. The evolution of the

Determination Tool into a more comprehensive Determination Framework is described in the Risk Analyses section of this final rule below.

Comments on the Determination Tool

Comment 41: Commenters criticized that the Determination Tool equated species' characteristics to outcomes without adequate rationale. For example, one commenter stated that the Determination Tool suffers from a lack of transparency because we did not provide any information regarding how the rating values in the Determination Tool were assigned, who made the determinations, what their expertise was, or on what basis the decisions were made.

Several comments stated that the Determination Tool's decision points and resulting outcomes depended on species-specific information that was not available. For example, one commenter asserted that there is little to no experimental data provided in the proposed rule documentation to support the ratings used in the Determination Tool. Another commenter noted that there is almost no information on many of the species' abundances, geographic ranges, trends or recruitment rates, and that the ratings for these were based solely on qualitative opinion. Similarly, another commenter used ocean acidification as an example, stating that due to the large degree of uncertainty regarding the impacts of ocean acidification on coral species it is difficult to quantify the level of risk ocean acidification poses to the species. The commenter concluded by stating that assigning levels of ocean acidification-associated risk within the Determination Tool is a difficult proposition. Another commenter deemed the Determination Tool analysis and results arbitrary. The commenter stated that the analysis and results of the Determination Tool were based on the same faulty assumptions, extrapolations, assessments, and approximations of the seven BRT members and were based on very little, if any, species-specific spatial distribution or abundance data for a number of the proposed species.

Commenters claimed the Determination Tool was flawed and equated species' characteristics to listing outcomes too conservatively, especially for proposed endangered species. We received a detailed comment letter that outlined several criticisms of the Determination Tool and its four elements with regard to species outcomes. The Determination Tool was labeled faulty because it was deemed inherently biased towards listing. The commenter criticized that the first element in the Determination Tool was just a re-hash of the BRT's highly subjective ranking of threats and vulnerabilities. The commenter also asserted that nowhere in the four elements of the Determination Tool is there a discussion of imminence or a discussion of why we considered a species that meets any of the four factors to be ''on the brink'' of extinction. The commenter asserted that we not only failed to adhere to the legal standard of endangered, but we did so on extremely poor evidence. Further, the commenter criticized the results of the BRT voting as well as the Determination Tool for ranking each of the coral species' in a relative fashion, and as a result, asserted that our approach in determining extinction risk for each species was flawed.

Several comments pointed out additional perceived flaws in the Determination Tool. For example, one commenter stated that the Determination Tool dismissed the potential benefits of management efforts. Another commenter noted that the Determination Tool did not incorporate or consider projections of adaptation potential over the foreseeable future (*i.e.,* 2100). More specifically, the commenter asserted that the Determination Tool did not sufficiently consider the ability of corals to migrate (*i.e.,* undergo range expansion/shift) and adapt to changing conditions, especially when local stressors are well managed. One commenter also suggested that the Determination Tool conflicted with the SRR (*e.g.,* by giving too much weight to distribution when the range maps that the BRT relied upon were not precise). Similarly, commenters also criticized us for overemphasizing the importance of qualitative rankings for species' abundance (*e.g.,* common, uncommon, rare) in the Determination Tool, stating that a coral species' rarity does not necessarily correspond to its vulnerability to extinction.

Response: We acknowledge that several aspects of the process by which we produced our determinations in the proposed rule were not described or explained clearly enough. The Determination Tool in the proposed rule was a central aspect of a larger overall framework for making our decisions, as it organized and standardized our presentation of the risk factors, but we acknowledge that the larger determination framework was not sufficiently explained in the proposed rule. This lack of a clear explanation led to an overemphasis on and misunderstanding of the Determination Tool, which was one component of the determination framework. To better explain how the Determination Tool assessed risk and derived listing statuses we conclude that, as some public comments suggested, the Determination Tool was too linear and deterministic. We describe our final determination framework in greater detail in the Risk Analyses—Final Determination Framework sub-section below, and utilize a more holistic approach in considering all of the available information for each species. As described in that section, the non-formulaic approach used in this final rule, is more species-specific, and allowed us to address the concern that sufficient species-specific information was not available.

In summary, the Final Determination Framework in this final rule is composed of seven elements. The first element is describing the statutory standards for corals. The second, third, fourth, and fifth elements are identifying and analyzing all the appropriate species-specific and general characteristics that influence extinction risk for a coral species. The sixth element is relating a species' characteristics to a particular extinction risk at appropriate spatial and temporal scales. The seventh element is explicitly stating how each species' extinction risk meets the statutory listing definitions as applied to corals, resulting in an ultimate listing status. As a last consideration, we determine if any conservation efforts are abating the threats to the species such that it changes the individual species' listing status (*i.e.,* an endangered species' extinction risk is reduced such that it is threatened or that a threatened species is not warranted). This method of implementing our Final Determination Framework for every species individually is intended to be more transparent, by showing how complete use is made of available information to reach individual listing decisions.

We believe that there is still significant value in applying a standardized framework to each of the species to ensure consistency throughout the 65 individual determinations, but now do that in a narrative fashion in which there are no recipes or formulas for endangered, threatened, and not warranted species. This approach allows for the consideration of the system as a whole (*i.e.,* synergistically evaluating each species' demography, spatial characteristics, threat susceptibilities, and current and future environmental conditions independently of the other species), leading us to species-specific conclusions about vulnerability to extinction.

In response to the criticism that the Determination Tool did not appropriately evaluate the imminence of danger of extinction in proposing to list corals as endangered, in this final rule we more fully explain the biological characteristics and distinctions between endangered and threatened corals, and corals not warranting listing under the ESA, and relate each species' particular characteristics to one of those classifications. These characteristics and the distinctions between them as they relate to the three ESA classifications are explained in the Statutory Standards sub-section of the Risk Analyses section.

Comments on Significant Portion of Its Range (SPOIR)

Comment 42: We received one comment regarding the identification of a significant portion of its range to support not warranted determinations for the proposed coral species found in Hawaii. The commenter asserted that the species of corals proposed for listing in Hawaii are abundant, relatively healthy, and relatively insulated from impacts of the primary identified threats. As a result, the species will presumably persist in Hawaii, despite more immediate threats in other portions of their ranges, ultimately preventing the species from going extinct. Thus, the commenter argues that a significant portion of its range should be identified for these species, rendering the species not warranted for listing.

Response: The commenter misunderstands the function of the SPOIR analysis. As discussed in the Statutory Standard sub-section below, a SPOIR analysis is performed to ensure that a species that has been found not to be endangered or threatened based on the range-wide analysis is still considered for listing if any portions of its range meet the criteria of the SPOIR Final Policy. Therefore, the function of a SPOIR is not to avoid a listing but to still consider a listing. In any case, as described in the Risk Analyses section below, the results of our analysis of SPOIR are unchanged from the proposed rule, after considering all comments and supplemental information. At this time, no SPOIR is determinable for any of the proposed species. Thus, our analysis of each species at the range-wide level is determinative, and no portions of the range require further examination. Nevertheless, we agree with the general underlying premise of the comment, which is that if a species has significant areas of refugia or diversity of habitat, those are factors that provide additional buffering against extinction risk. We have incorporated that consideration in the final rule through our Final Determination Framework and species-specific evaluations.

Comments on Listing Determinations

Comment 43: We received numerous comments referring to the actual listing determinations of the 82 candidate coral species in the proposed rule. Many of those comments referred to specific coral species and to specific aspects of those species determinations. Those comments are discussed in detail in the Caribbean Species: Listing Determinations, Indo-Pacific Species: Listing Determinations, and Reclassification of *Acropora palmata* and *A. cervicornis* comment response sections below. The other comments regarding listing determinations centered on the lack of species-specific information on which the species determinations were based. Some comments were very skeptical that the assumptions being made from limited scientific information on individual coral species, which the proposed rule recognized, could justify the listing proposals. These commenters asserted that further studies and surveys should be performed to gather factual and relevant data on the status of the coral species, which could potentially change the assumptions used to make the listing determinations. Some comments specifically stated that a much better understanding of the global distribution and abundance of the species, including developing better species distribution maps, is critical to making an informed listing decision. Yet other comments stated that the proposed rule did not take into account the variability of response to threats that corals can have based on species, location, habitat type, and other factors that define an individual coral. Other comments suggested that NMFS was using global climate predictions as a substitute measure for species population and distribution information for listing purposes.

Response: We recognize that species-specific information was fairly limited for many of the proposed species. However, since the proposed rule was published, we have received or collected information for all species, including supplemental distribution and abundance information for 63 of the 65 species in this final rule as a result of the data collection effort by Veron (2014). In addition to updating all of the general information regarding coral reef biology, ecology, demography, and threat susceptibilities, we also incorporated this supplemental information in our discussions in the individual species-specific listing determinations in that section of this final rule. In light of the supplemental species-specific information, and the change to a more holistic and species-specific determination framework, we considered the ability of each species' distribution and abundance traits to affect vulnerability to extinction in the context of the statutory definitions of threatened and endangered for each species. In most cases, this consideration led to changes in listing status from the proposed rule. These species-specific assessments consider all of the public comments and available information for each species and provide a detailed description of what is and is not known for each species, including susceptibilities to all identified threats and vulnerability to extinction

Comment 44: We received several letters alerting us to an extensive ongoing effort by coral expert, Dr. J.E.N. ''Charlie'' Veron, to gather previously unpublished information for all reef-building corals of the world, including the 65 corals in this final rule. The resulting report (Veron, 2014) updates species-specific information on semi-quantitative (*i.e.,* survey data from 2,984 individual sites) and qualitative population abundance estimates (*i.e.,* Veron's subjective estimates covering a full range of habitats and most ecoregions the author has worked in), geographic distribution, principle habitat, and identification issues. Comments stated that given the lack of species-specific information on quantitative abundances and geographic distribution for most of our Indo-Pacific species, this effort proves extremely relevant to our listing decisions within this final rule.

Response: We agree with comments that information from Veron (2014) supplemented the existing species-specific information relied on in the proposed rule and that this information is relevant to the determinations made in this final rule. Thus, the supplemental information received in the report (Veron, 2014) was made available to the public on NOAA's Web site, and has been incorporated into the Species-specific Information and Determinations section for the 63 species covered in the report, Veron (2014) does not cover non-scleractinian corals in his report, and thus did not provide information for the *Millepora* species in this final rule).

Comments on Alternatives To Listing Under the ESA

Comment 45: We received several comments that suggested alternatives to ESA listing such as Candidate Conservation Agreements (CCAs), adding the proposed corals to the Species of Concern list, and extending the time period in which to make a determination to allow for the gathering of additional scientific data. One commenter suggested using CCAs, citing lack of species-specific information and other concerns as justification. Comments also asserted that because NOAA has no authority under the ESA to protect corals from climate change, CCAs could provide the same conservation benefits as ESA listings.

Response: While we acknowledge that CCAs provide conservation value for candidate species, no such agreements exist for any of the proposed species. Therefore, we are unable to determine a species' status on the basis of the conservation provided by a CCA. Further, in the Conservation Efforts section we determined that there are no conservation efforts currently or planned in the future that are expected to improve the overall status of any of the 65 coral species in this final rule, such that the additional protections provided by the ESA are not warranted.

We also considered the potential for utilizing the Species of Concern designation, which was suggested in lieu of ESA listings due to a lack of species-specific information and taxonomic uncertainty. This designation can be used if we decide a species is not warranted for listing under the ESA because we are unable to confidently assess the level of extinction risk, even qualitatively. Ultimately, based on the best available scientific information, we concluded that all 65 corals within this final rule are determinable species under the ESA. We also concluded that we have enough information to qualitatively assess the level of extinction risk and make listing determinations for most of the 65 species in this final rule with some degree of confidence. The species that are determined to be not warranted for listing due to a lack of sufficient information to assess their status are clearly described as such in the individual species determinations. Those species may be considered for inclusion on the Species of Concern list after this listing rule becomes final.

Extending the time period in which to make final species determinations in order to collect more scientific data is not permissible under the ESA. We are required to use the best scientific and commercial data available within the applicable statutory timeframes for responding to petitions, as the basis for our final determinations.

Comment 46: We received comments that criticized our proposed determinations due to their assumed inconsistency with other recent agency decisions, such as the Not Warranted bumphead parrotfish 12-month finding, and the negative Alaska deep-sea corals 90-day finding. Comments cited a lack of adequate species-specific information and taxonomic uncertainty as justification for the previous not warranted and negative determinations for bumphead parrotfish and Alaskan corals, and claimed that the proposed rule for the 68 reef-building corals suffers from the same level of uncertainty. Comments thus concluded that NOAA's decision to propose 68 reef-building corals for listing under the ESA is inconsistent with previous agency decisions and that there is a lack of adequate species-specific information to proceed with final listings.

Response: We respond to each petition based on the information presented within that petition and, if we conduct a status review, on the best scientific and commercial information available for each petitioned species at the time. We disagree that this final rule for 65 reef-building corals is inconsistent with our previous Not Warranted 12-month finding for the bumphead parrotfish. Primary threats to bumphead parrotfish, a coral reef-associated fish, were determined to be adult harvest and juvenile habitat loss. As a result of a thorough status review, the bumphead parrotfish received a Not Warranted determination largely due to its current abundance, life history, existing local management in the form of spear fishing regulations, and protections for mangrove habitat. Overall, the differences between bumphead parrotfish and the reef-building corals in this final rule are vast; however, we have complied with the requirements set forth under the ESA in each case.

Likewise, we disagree that this final rule is inconsistent with the negative 90-day finding for 44 Alaska deep-sea corals. The Alaska deep-sea coral species are non-reef building and exhibit many different characteristics than shallow-water tropical corals, which have been comparatively well researched. The Alaska corals were petitioned due to climate change related threats, as well as physical threats from commercial fisheries. NOAA considered these factors, but found that there are no empirical studies that have shown harmful effects of climate change related threats to these deep-sea corals or to similar corals in the area. Additionally, ocean acidification research cited in the petition was conducted on mostly tropical, reef-building corals that are very different from deep-sea corals; no inference could be made about the potential effects to the status of deep-sea corals from this information. Finally, there have been large swaths of fishing ground closures in Alaska since 2005 and NOAA determined that these closures were sufficient for protecting deep-water corals from bottom-contact fishing activities. Overall, differences between the Alaska deep-water corals and the reef-building corals in this final rule are vast; however, we have complied with the requirements set forth under the ESA in each case.

Comments on Caribbean Species: Listing Determinations

Comment 47: We received some comments that expressed disagreement with our proposed threatened determinations for some Caribbean species. For example, one comment disagreed with our proposed threatened listing of *Dichocoenia stokesi,* citing the following as justification: Large population numbers (even after the White Plague Type II epidemic), broad distribution among multiple habitat types (especially hard-bottom habitats), high relative abundance among all corals in the region, and the presently low prevalence of White Plague Type II. Another comment stated that *D. stokesi* is among the most common species in Florida, and that population estimates approached 100 million colonies in 2005, with no apparent downward trend. In addition, we received comments about the proposed threatened determination for *Agaricia lamarcki.* Comments argued that due to potentially larger populations not yet surveyed in deeper waters, the threatened status for *A. lamarcki* is not warranted. Many comments disagreed with the proposed endangered determinations for the *Orbicella* (formerly *Montastraea*) *annularis* complex (*i.e., O. annularis, O. faveolata,* and *O. franksi*). One comment provided information from van Woesik *et al.* (2012) as justification for listing *O. annularis* complex as threatened rather than endangered. Other comments submitted a technical report (Miller *et al.,* 2013) from the Nova Southeastern University on population abundance estimates and trends for the Caribbean coral species in the Florida Keys, in opposition to all proposed endangered listing determinations, including the proposed endangered determinations for the *Orbicella* species as well as

Dendrogyra cylindrus and *Mycetophyllia ferox.* Miller *et al.* (2013) provided recommended changes to the proposed listing statuses for each of the proposed Caribbean species using their population and distribution estimates as support. We received other comment letters that also noted the large population abundances of several of the Caribbean species, despite some local declines (*i.e., O. annularis* and *O. faveolata*). One comment also noted that for five of the Caribbean species (*i.e., O. franksi, D. cylindrus, M. ferox, D. stokesi,* and *A. lamarcki*) there is a complete lack of population data to support ESA listings. We also received information regarding the ecology of *O. annularis* and *O. faveolata* in opposition to their proposed endangered determinations, but supporting threatened listings. One comment argued that the total population number estimates of these two species are very large and that, in light of their broad depth ranges and multi-habitat distributions, these species are relatively resistant (in ecologic time) to extinction. Accordingly, the comment asserted that these species' potential listing is contrary to their ecology, especially in light of their remaining substantial population numbers both in Florida and throughout their range.

Response: Since the proposed rule was published, we received and collected supplemental information for all the Caribbean species, including updated distribution and abundance information. Therefore, we updated and expanded our individual species-specific descriptions in the Species-specific Information and Determinations section for all 65 reef-building corals within this final rule. These species-specific assessments consider the public comments and available information for each species, and explain what is and is not known for each species, including susceptibilities to the identified threats and overall vulnerability to extinction. Further, as described in earlier comment responses, we now more fully consider the ability of abundance, distribution and habitat heterogeneity to affect vulnerability to extinction in the context of the statutory definitions of threatened and endangered as applied to corals. The reconsiderations of the spatial and demographic factors contributed to changes in all the Caribbean species' statuses in this final rule. Thus, as described in detail in the Species-specific Information and Determinations section, based on the public comments, best available information, and the Final Determination Framework, we are revising our proposal to list *O. annularis, O. faveolata, O. franksi, D. cylindrus,* and *M. ferox* as endangered species. Our final determination for these species is to list them as threatened species. We have determined *D. stokesi* and *A. lamarcki* do not warrant listing.

Comments on Indo-Pacific Species: Listing Determinations

Comment 48: We received several comments regarding our proposed threatened and endangered determinations for various Indo-Pacific species. Several comments disagreed with our proposed threatened determinations for the Hawaiian *Montipora* clades (*M. dilitata/flabellata/turgescens* and *M. patula/verrilli*). As described in more detail below, comments disagreed with the status of these clades and suggested they be assessed individually rather than lumped into groups (see Comment 49 below for more details). Taxonomic uncertainty as it relates to the Genus *Montipora* and the decision to lump these two groups of species is addressed in more detail in the response to comments on taxonomic uncertainty (Comment 3 above). Comments also asserted that the *Montipora* clades not only have significantly large geographic ranges, but also include some of the most common coral species in Hawaii, thus rendering these clades not warranted for threatened listing. We received many other comments that disagreed with the proposed threatened determinations for a number of the Indo-Pacific coral species, but we did not receive any additional substantive information or data for consideration of those arguments.

One commenter provided information regarding the proposed endangered status of *Pocillopora elegans* in the Eastern Pacific. Evidence from southwestern Nicaragua suggests that *P. elegans* has undergone extensive mortality, with only a few fragmented and small colonies persisting. The data provided, while limited, supports a wider body of evidence suggesting particular vulnerability of *P. elegans* in the Eastern Pacific Ocean. However, as described above in Comments on Taxonomic Uncertainty in Reef-building Corals, new information on *Pocillopora* species has resulted in our determination that *P. elegans* is not determinable under the ESA.

The main argument against our proposed endangered determinations for Indo-Pacific species is a lack of adequate species-specific information to support an endangered status. For example, one comment letter noted the percentage of references used in the SRR that provided species-specific information for each of the proposed endangered species (*e.g.,* only two percent, 5.9 percent and 9.4 percent of the references used in the SRR provided species-specific information for *Acropora rudis, Acropora lokani,* and *Acropora jacquelineae,* respectively). We also received comments regarding the proposed endangered determinations for various *Acropora* species, particularly *A. lokani* and *A. jacquelineae.* For example, one comment emphasized the lack of adequate data for the proposed endangered determination of *A. jacquelineae,* citing questionable taxonomic status and lack of density estimates and distribution information. Likewise, another comment criticized the proposed endangered determination for *A. lokani,* stating that there is virtually no published information available for this species. Another comment letter recommended threatened designations for *A. jacquelineae, A. lokani,* and *A. rudis* rather than endangered, based on van Woesik *et al.* (2012), and stated that *Euphyllia paradivisa* absolutely does not warrant endangered status. We received other comments in disagreement with our proposed endangered determinations, but they did not include any other substantive information or data to consider.

Response: We recognize that species-specific information was limited for many of the Indo-Pacific species. Since the proposed rule was published, however, we have received or collected supplemental information for several species, including updated distribution and abundance information for 63 of the 65 species in this final rule as a result of the data collection effort by Veron (2014). As a result, we substantially updated and expanded our individual species-specific descriptions in the Species-specific Information and Determinations section for all 65 reef-building corals within this final rule. These species-specific assessments consider all of the public comments and available information for each species, and provide a detailed description of what is and is not known for each species, including vulnerabilities to all identified threats.

Comment 49: We received some comments that provided species-specific information for various Indo-Pacific species that is being applied in this final rule. The species-specific information we received predominantly relates to relative abundance and geographic distributions. We specifically received comments on abundance for the following Indo-

Pacific species: *Acropora aspera, Porites nigrescens, Acropora diversa,* and *Isopora cuneata.* We specifically received comments on distribution for the following Indo-Pacific species: *Alveopora allingi, Acropora palmerae, Acropora paniculata, Acropora jacquelineae, Acropora rudis, Euphyllia paradivisa, Acanthastrea brevis, Acanthastrea ishigakiensis, Acanthastrea regularis, Acropora globiceps, Acropora lokani, Acropora striata, Alveopora fenestrata, Alveopora verilliana, Astreopora cucullata, Barabattoia laddi, Euphyllia paraancora, Millepora tuberosa, Pavona diffluens, Pocillopora danae, Acropora verweyi,* and the *Montipora* clades that are discussed in more detail below. We received several detailed comment letters that provided species-specific information regarding the Hawaiian *Montipora* clades (*i.e., Montipora dilatata/flabellata/turgescens* and *Montipora patula/verrilli*). Several of the comments provided references to journal articles or other reports as new species-specific information. Some of those references were already available to NMFS and some constituted supplemental information we did not consider in the proposed rule. We received three comments specific to genetics of Indo-Pacific species specifically referring to *Pavona* species at mesophotic depths and to *Pocillopora* species. Species-specific comments regarding taxonomy were specific to *Acropora acuminata, Acropora paniculata,* and *Acropora polystoma.* Comments with species-specific information on threat vulnerabilities applied to *Acropora aculeus, Acropora aspera, Acropora paniculata, Acropora polystoma, Montipora patula, Montipora flabellata, Pocillopora elegans, Porites horizontalata,* and *Seriatopora aculeata.*

Response: Overall, most of the supplemental information we received for the Indo-Pacific species was specific to certain geographic locations; however, we must evaluate the status of the species throughout the entirety of their ranges. As described in earlier comment responses, we now more fully consider the ability of spatial and demographic traits, as well as the heterogeneous habitats occupied by all of the Indo-Pacific species, to affect vulnerability to extinction in the context of the statutory definitions of threatened and endangered for each species. For many of the Indo-Pacific species, their geographic ranges include waters between the east coast of Africa and French Polynesia. As described in detail in the Species-specific Information and Determinations section, based on the Final Determination Framework and supplemental information, we are maintaining our proposals to list *Acropora globiceps, Acropora pharaonis, Acropora retusa, Acropora speciosa, Acropora tenella, Isopora crateriformis, Montipora australiensis, Pavona diffluens, Porites napopora,* and *Seriatopora aculeata* as threatened in this final rule. Five Indo-Pacific coral species determinations changed from endangered in the proposed rule to threatened in the final rule: *Acropora jacquelineae, Acropora lokani, Acropora rudis, Anacropora spinosa,* and *Euphyllia paradivisa.* Forty Indo-Pacific coral species' determinations changed from threatened in the proposed rule to not warranted in the final rule: *Acanthastrea brevis, Acanthastrea hemprichii, Acanthastrea ishigakiensis, Acanthastrea regularis, Acropora aculeus, Acropora acuminata, Acropora aspera, Acropora dendrum, Acropora donei, Acropora horrida, Acropora listeri, Acropora microclados, Acropora palmerae, Acropora paniculata, Acropora polystoma, Acropora striata, Acropora vaughani, Acropora verweyi, Alveopora allingi, Alveopora fenestrata, Alveopora verrilliana, Anacropora puertogalerae, Astreopora cucullata, Barabattoia laddi, Caulastrea echinulata, Euphyllia cristata, Euphyllia paraancora, Isopora cuneata, Millepora tuberosa, Montipora angulata, Montipora calcarea, Montipora caliculata, Montipora dilatata/flabellata/turgescens, Montipora lobulata, Montipora patula/verrilli, Pachyseris rugosa, Pectinia alcicornis, Physogyra lichtensteini, Porites horizontalata,* and *Porites nigrescens.* Finally, *Millepora foveolata* changed from endangered in the proposed rule to not warranted in the final rule.

Last, as described in Comment 2, three coral species determinations changed from endangered or threatened in the proposed rule to not determinable in the final rule: *Pocillopora elegans* (eastern Pacific) warranted listing as endangered in the proposed rule but was considered not determinable in the final rule, and *Pocillopora danae* and *Pocillopora elegans* (Indo-Pacific) warranted listing as threatened in the proposed rule but were considered not determinable in the final rule.

Comments on Reclassification of *Acropora palmata* and *Acropora cervicornis*

Comment 50: Several comments disagreed with our proposal to reclassify the Caribbean species *A. cervicornis* and *A. palmata* from threatened to endangered. Most comments agreed with the current status of threatened for the Caribbean acroporid species. Many comments cited increasing abundances, recovering populations, and significant advances in active restoration projects as justification for not reclassifying them as endangered. One comment opposed the proposed reclassification, citing population numbers (Miller *et al.,* 2013), genetic diversity (Hemond and Vollmer, 2010), forward-looking population models and extinction models based on paleontological data (van Woesik *et al.,* 2012), and a better understanding of the causes of and resistance to mortality (Kline and Vollmer, 2011; Vollmer and Kline, 2008) as justification. Comments also stated that there has been no significant change in the population status of the acroporids since their initial listing in 2006, and populations are relatively stable and recovering in some areas. One commenter also emphasized that *A. cervicornis* in particular does not warrant endangered listing status due to its presence throughout its entire biogeographical range, population expansion northward in south Florida, and its ability to still reproduce sexually. One commenter asserted that reclassifying the Caribbean *Acropora* species to endangered is not warranted because the threats to these species are not imminent. Additionally, many comments cited the growing number of successful restoration projects throughout southeast Florida and the Caribbean (Hollarsmith *et al.,* 2012; Johnson *et al.,* 2011; Young *et al.,* 2012) that continue to aid in conservation of acroporids and help recover genetically viable populations. Overall, comments suggest the Caribbean acroporids should remain threatened under the ESA, and do not warrant reclassification to endangered status. However, we did receive one comment letter in support of the reclassifications for the Caribbean acroporids.

Response: As described previously, we have revised and provided a clearer explanation of our decision-making framework to further strengthen our final listing determinations. As with all other species in this final rule, we updated all of the general information regarding coral reef biology, ecology, demography, and threat susceptibilities relevant to the Caribbean acroporids, and thus we substantially updated and expanded our individual species-specific descriptions for these species in the Species-specific Information and Determinations section. Further, as previously described in earlier comment responses, we more fully consider in this final rule the ability of spatial and demographic traits, as well as habitat heterogeneity, to affect vulnerability of the Caribbean acroporids to extinction in the context of the statutory definitions of threatened and endangered for corals.

We also carefully considered the significant progress of active restoration projects in the state of Florida and the wider-Caribbean. We agree that these efforts confer conservation and potential recovery benefits for the species; however, these efforts, to date, are very limited in scale compared to the species ranges and should not be considered a panacea for conserving and recovering the Caribbean acroporids. The Conservation Efforts section of this rule provides more information on active coral reef restoration efforts. As described in detail in the Species-specific Information and Determinations section, based on the Final Determination Framework and supplemental information, we are changing our proposal to reclassify *A. palmata* and *A. cervicornis* as endangered species. *Acropora palmata* and *A. cervicornis* will remain listed as threatened species.

Comments on Effects of Listing

Comment 51: We received several comments that described potential negative effects that could result from ESA coral listings. These include regulatory burdens in the form of permit applications and other various paperwork, consultations and biological opinions, postponement of in-water maintenance activities, and increased costs associated with harbor improvement projects. We also received numerous comments expressing concern about impacts to cultural practices as a result of listing, including native artists' livelihoods, reef access by indigenous peoples, fishing, lime production, customary navigation and seafaring, and specifically native Hawaiian recreational and cultural practices, and the cultural needs and practices of American Samoa. One comment expressed concern that reclassifying *A. palmata* and *A. cervicornis* from threatened to endangered will impede ongoing restoration and recovery efforts. We received one comment encouraging NMFS to make sure we have adequate staff to carry out the additional workload associated with ESA Section 7 consultations for any coral species that are listed in this final rule.

Response: The ESA explicitly restricts the factors that can be considered in listing decisions. Listing decisions can be based solely on the best scientific and commercial data available, after conducting a status review and taking conservation measures into account. Therefore, comments relevant to the proposed listing include those comments that provide additional substantive information regarding whether a species is in danger of extinction or likely to become so in the foreseeable future (*e.g.,* the biology, status, and/or threats to the species, evaluation methodologies, effectiveness of conservation measures, accuracy and comprehensiveness of best available information, *etc.*). We are unable to consider other types of comments in a listing determination (*e.g.,* socio-economic or policy impacts). However, after we implement the final listings, we will work with our stakeholders and affected entities to reduce the impact of the listings while still providing for the conservation of the listed corals.

Comments on Critical Habitat

Comment 52: We received three comments related to critical habitat. One commenter offered to provide information to assist in the economic analysis required for critical habitat designation. A second commenter proposed the use of NOAA benthic habitat maps to define areas of critical habitat for listed corals and requested reconsideration of designated critical habitat for *Acropora palmata* and *Acropora cervicornis.* A third commenter requested to be consulted during critical habitat designation to ensure the operation of their facilities would not be affected.

Response: The comments summarized above do not provide substantive information to help inform the final species determinations. NMFS is required to designate critical habitat at the time of final rule publication, unless we determine that critical habitat is undeterminable at that time. Below, we discuss our determination that critical habitat is not currently determinable for the species being newly listed through this final rule. Designation of critical habitat will occur via a separate rule-making process once this final rule is published, which will include opportunities for public participation and input. As such, the comments described above are noted but are not responded to further in this final rule.

Comments on ESA Section 9 Take Prohibitions

Comment 53: We received 12 comments specific to ESA 4(d) rule-making, which is discussed in the Section 9 Take Prohibitions section of the proposed rule. Eight of these comments requested or suggested exemptions from Section 9 take prohibitions for specific activities that should be included in a 4(d) rule issued for threatened species listed in this final rule. Two comments recommended that lawful emissions of GHG should be included as an exception in any future 4(d) rule. Two other comments said the opposite, stating that NMFS should not consider GHG emissions in the context of the ESA.

Response: The comments described above did not provide substantive information to help inform the final listing determinations for the 65 coral species. NMFS is not required to issue a 4(d) rule for threatened species in conjunction with a final ESA listing. We will do so only if we determine it is necessary and advisable for the conservation of threatened species. If we make that finding for threatened species listed in this final rule, issuance of a 4(d) rule is a separate rule-making process that will include specific opportunities for public input. As such, the comments above are noted but not responded to further in this final rule.

Comments on Identification of Those Activities That Would Constitute a Violation of Section 9 of the ESA

Comment 54: We received numerous comments regarding concerns over the definition of ''take'' for corals under the ESA. Comments questioned how we would define ''take'' if corals are listed, considering their unique biological and ecological characteristics (*i.e.,* corals are colonial and clonal organisms). One commenter pointed out a lack of certainty regarding the threshold of ''take'' for coral larvae. Another commenter thought it was unclear how people would know if they are ''taking'' a listed coral and expressed concern about the ability to conduct cultural practices. A third commenter stated that, in the example of corals, the stated goals of the ESA are at odds with the best plan for the recovery of any coral species.

Response: We agree that defining ''take'' of corals under the ESA is both unique and challenging, because of the biology of reef-building corals. As described below under Corals and Coral Reefs—Individual Delineation, these species are both colonial (*i.e.,* capable of creating colonies from multiple genetically-identical polyps) and clonal (*i.e.,* capable of asexual reproduction to create genetic duplicates). The ESA take prohibitions only apply to endangered species immediately upon listing. No species in this final rule are being listed as endangered; therefore, we do not define activities that may result in take in this final rule, because take is not automatically prohibited for threatened species. Should we deem it necessary and advisable that extending any of the ESA section 9 prohibitions, including take prohibitions, is necessary for the conservation of any of the newly-list threatened coral, we will do so in a subsequent rule-making.

Comments on Policies on Role of Peer Review

Comment 55: We received two comments that criticized NMFS for not conducting peer review on the proposed rule. One commenter stated the following: ''The Department of Commerce issued guidelines to comply with the OMB mandate, publishing the final Guidelines for Ensuring and Maximizing the Quality, Objectivity, Utility, and Integrity of Disseminated Information in October 2002. As part of the NOAA guidelines, the agency must apply a higher standard to 'influential scientific information' ('ISI'), which is defined as scientific information the agency reasonably can determine will have or does have a clear and substantial impact on important public policies or private sector decisions.' Id. ISI is subject to the more stringent information standards in the OMB's Final Information Quality Bulletin for Peer Review (''OMB Peer Review Bulletin''), which requires peer review by qualified specialists in the relevant field (70 F.R. 2664; January 14, 2005).''

Response: The proposed rule itself was not peer reviewed. However, the supporting documents that formed the basis for the determinations in the proposed rule (*e.g.,* the SRR, FMR) were independently peer reviewed by subject matter experts. In addition, much of the information we received as a result of the public engagement and public comment periods and incorporated into this final rule was independently peer reviewed. During the public comment period and subsequent 6-month extension solicitation, we received critical review of the information on which the proposed rule was based from several coral reef experts. As a result, the information used to form the basis of our final listing determinations represents the best available scientific and commercial information to date on the 65 reef-building coral species within this final rule, and that we have complied with all applicable policies and guidance on peer review.

Comments Outside of the Scope of the Proposed Rule

We received numerous public comments in response to the proposed rule that are outside the scope of this rulemaking. Below are brief explanations to note the comments were received and explain why they are not considered relevant to the content of the proposed rule.

Comment 56: We received several comments regarding concerns over potential economic impacts as a result of listing coral species from various concerned parties. In addition, we received many comments criticizing the proposed rule as an inappropriate use of the ESA to protect corals in the face of global climate change. Some comments emphasized that the ESA is not designed to regulate GHGs and thus ESA listings are not a prudent use of time and resources. Comments also cited impacts to cultural practices related to marine resource use in opposition of ESA coral listings.

Response: Due to the statutory requirements of the ESA, comments relevant to the proposed listing include those comments that provide additional substantive information regarding any facet of the proposed rule (*e.g.,* the biology, status, and/or threats to the species, evaluation methodologies, accuracy and comprehensiveness of best available information, *etc.*). Comments not relevant to this rule making are those comments that are not related to the content of the proposed rule and/or comments that we are legally unable to consider in a listing determination (*e.g.,* economic impacts). While we are required to review and consider all comments, comments on issues outside the scope of the proposed rule, such as the comments described above, were noted, but are generally not responded to in this final rule.

Comment 57: Several commenters provided general support for the proposed listings but did not provide substantive information or specific comments on the content of the proposed rule.

Response: General support for the proposed action does not constitute submission of substantive information regarding any facet of the proposed rule. Therefore, these comments were noted but are not responded to in this final rule.

Comment 58: We received three comments pertaining directly to one or more of the 16 Not Warranted findings that were issued simultaneously with the proposed rule. One commenter questioned why some Caribbean species were determined to be Not Warranted while others are proposed because threats to all species appear to be the same. Another commenter stated that *Porites pukoensis* should have been proposed for listing based solely on the fact that it is endemic to Hawaii. A third commenter provided information on *Turbinaria reniformis'* tolerance to threats associated with climate change.

Response: A Not Warranted finding is a final decision for which public comments are not solicited. Therefore, comments on the not warranted findings are noted but not considered relevant to the content of the proposed rule and are not responded to directly in this final rule. We do note, however, that species determinations are based on more than just geographic range or existing threats alone and not warranted determinations were reached by considering all available information on species abundance, range, depth distribution, and threat vulnerabilities including susceptibility and exposure, as is described in more detail in the not warranted findings.

As also described in the proposed rule, a threatened coral is likely to become an endangered coral within the foreseeable future throughout all or a significant portion of its range. For threatened species, there is a temporal delay in extinction risk afforded by some characteristics of the species, such as broader distribution, larger populations, lower vulnerability to the most important threats, and better management. Threatened species are less vulnerable than endangered species, but still have characteristics that are likely to put them at elevated extinction risk within the foreseeable future. For each of the 65 species under consideration, we explain how a species' characteristics and its ability to provide buffering capacity to the identified threats influences its extinction risk over the foreseeable future. Some of the 65 species in this final rule meet the definition of threatened, as explained in the species sections below.

Basis of Listing Determinations

The following sections summarize all of the best available information on reef-building corals in general, which provides the baseline context and foundation for our species-specific listing determinations. While this general information illustrates that the most important threats are currently increasing in severity, and likely to continue increasing further in the foreseeable future, it also illustrates that the impacts from these threats, both currently and over the foreseeable future, are difficult to interpret and do not necessarily correlate to increased vulnerability to extinction due to the biological and physical variability and complexity of corals and their habitat. Accordingly, our Final Determination Framework and species determinations are based upon an analysis of the best available species-specific information evaluated within a worsening future environment.

In addition to the comments we received on the proposed rule that include new or supplemental information, we have continued to collect information that has either emerged since the publication of the proposed rule or that was published at the time of the proposed rule, but had been inadvertently overlooked. This latter category also includes literature cited in the SRR or SIR, but that was further examined to provide relevant information. Therefore, we consider ''supplemental information'' to be that which was not considered at the time of the proposed rule that expands upon the themes in the proposed rule, but does not fundamentally change a finding from the proposed rule. ''New information'' is considered to be that which is novel and results in a change to a finding in the proposed rule. To distinguish between the information on which the proposed rule was based from new or supplemental information, we will only cite the primary literature for new or supplemental information. For clarity, we will distinguish whether the information was identified via public comment or if we gathered it ourselves.

All the general information on reef-building corals, which provides the appropriate context for our species-specific determinations, is provided in the Corals and Coral Reefs and Threats Evaluation sections. The Risk Analyses section follows and describes our methods and final determination framework for making our determinations. Last, we provide the individual listing determinations in the Species-specific Information and Determinations section, which are based on all of the best available information for each coral species.

Corals and Coral Reefs

This section provides a summary of the best available information on the biology and habitat of reef-building corals as it pertains to this final rule. First, we briefly summarize the information from the proposed rule, which is based on the SRR and SIR. We also address all relevant comments received pertaining to the biology and habitats of reef-building corals. Further, we provide supplemental information relevant to biology and habitat of corals that we gathered during the period between the proposed and this final rule. This information provides part of the context in which we evaluate the species' status and illustrates the unique nature of this evaluation compared to typical NMFS' ESA listing determinations (*i.e.*, vertebrates).

As summarized in the proposed rule, corals are marine invertebrates in the phylum Cnidaria that occur as polyps, usually forming colonies of many clonal polyps on a calcium carbonate skeleton. The Cnidaria include true stony corals (class Anthozoa, order Scleractinia), the blue coral (class Anthozoa, order Helioporacea), and fire corals (class Hydrozoa, order Milleporina). All 68 proposed species are reef-building corals, because they secrete massive calcium carbonate skeletons that form the physical structure of coral reefs. Reef-building coral species collectively produce coral reefs over time in high-growth conditions, but these species also occur in non-reef habitats (*i.e.*, they are reef-building, but not reef-dependent). There are approximately 800 species of reef-building corals in the world.

Most corals form complex colonies made up of a tissue layer of polyps (a column with mouth and tentacles on the upper side) growing on top of a calcium carbonate skeleton, which the polyps produce through the process of calcification. *Millepora* fire corals are also reef-building species, but unlike the stony corals, they have near-microscopic polyps containing tentacles with stinging cells.

Individual Delineation

Comment 5 identified the lack of clarity on and complexity of the delineation of the ''individual'' with respect to corals and its influence in estimating population abundance. We agree that this is a complex issue and did not provide sufficient details on how we identified what an individual is and how the consideration of this issue factored into our estimates of abundances for each of the proposed species in the proposed rule. Thus, in this final rule, we provide details on how we considered individual delineation in the proposed rule and this final rule.

Reef-building corals are clonal organisms. A single larva will develop into a discrete unit (the primary polyp) that then produces modular units (*i.e.*, genetically-identical copies of the primary polyp) of itself, which are connected seamlessly through tissue and skeleton. These modular units may be solitary (*e.g.*, fungiid corals) or colonial. Most reef-building coral species are colonial, including all species covered in this final rule. Colony growth is achieved mainly through the addition of more polyps, and colony growth is indeterminate. The colony can continue to exist even if numerous polyps die, or if the colony is broken apart or otherwise damaged. The biology of such clonal, colonial species creates ambiguity with regard to delineation of the individual in reef-building corals, specifically: (1) Polyps versus colonies; (2) sexually-produced versus asexually-produced colonies; and (3) difficulty determining colony boundaries. Each source of ambiguity is addressed below, leading to a conclusion regarding the delineation of the ''individual'' for the species covered by this final rule, which was not specifically defined in the proposed rule. Though not specifically defined, we applied this same concept of the individual in the proposed rule.

The polyp could be considered as the smallest unit of the individual for reef-building corals. Each polyp in a coral colony consists of a column of tissue with a mouth and tentacles on the upper side, growing in a cup-like skeletal structure (the corallite) made of calcium carbonate that the polyp produces through calcification. The polyps are the building blocks of the colony, and most colony growth occurs by increasing the number of polyps and supporting skeleton. Polyps carry out the biological functions of feeding, calcification, and reproduction. However, because the polyps within a colony are modular units, and connected to one another physiologically (*i.e.*, via nerve net and gastrovascular cavity, and are the same sex), single polyps within a colony are not considered to be individuals for purposes of this final rule.

Alternatively, only colonies originating from sexually-produced larvae could be considered as the individual for reef-building corals. Colonies are founded by either sexually-produced larvae that settle and become the primary polyp of a colony, or asexually-produced fragments of pre-existing colonies that break off to form a new colony. Fragments from the same colony can fuse back together into the same colony if they are close enough to grow together. Fragmentation in branching species may lead to a large number of asexually-produced, genetically identical colonies, commonly resulting in a population made up of more asexually-produced colonies than sexually-produced colonies (Hughes, 1984). Sexually-produced colonies are important to the population by increasing the genetic diversity of the population, and colonies originating from asexually-produced fragments do not contribute to the effective population (*i.e.*, group of genetically unique individuals). Asexual reproduction, though it does not create new genetic individuals, is likely the more critical mode for some species, especially branching species, allowing them to grow, occupy space, and persist between relatively rare events of sexual reproduction. Sexually- and asexually-produced colonies often cannot be distinguished from one another in the field, but are identifiable as an individual, in most cases. Thus, we use the concept of the ''physiological colony'' as the entity that can be considered an individual. The physiological colony for reef-building colonial species is defined here as any colony of the species, whether sexually or asexually produced.

A physiological colony is generally autonomous from other colonies of the same species. However, colony morphology, partial colony mortality, and other colony growth characteristics (*e.g.*, formation of stands or thickets) can complicate the delineation of physiological colonies from one another in the field. For example, the overall colony morphology of many encrusting species (*e.g.*, some *Montipora* species) is largely dictated by the underlying substrate. In those cases, colony shape may not distinguish colonies from one another, and boundaries between separate encrusting colonies that have grown together may be difficult or impossible to make out visually. Partial mortality of colonies, especially larger colonies, can also mask the boundaries between colonies, because the algae-encrusted coral skeleton of a partially dead colony may appear to delineate two or more colonies. In addition, many reef-building coral species occur in stands or thickets that may be tens of meters or more in diameter (*e.g.*, some *Acropora* species), possibly consisting of multiple colonies or only one large colony, also masking the boundaries between colonies. In each of these instances, the actual number of genetically-distinct individuals can only be determined through genetic analysis. Those techniques have not been established for all coral species and are not feasible to conduct for every reef assessment. Therefore, most reef assessments for coral abundance also use the concept of the physiological colony as the unit for enumerating species.

Despite the challenges in individual delineation of clonal, colonial reef-building corals, this final rule considers the ''individual'' for each of the proposed species to be the physiological colony, as defined above. That is, polyps are not considered individuals, but sexually- and asexually-produced colonies are considered individuals because they are a type of physiological colony and are the unit that can be identified in the field. We acknowledge that there are limitations with this definition of the individual, including usually-unknown proportions of genetically-distinct individuals in a population and the difficulty with the determination of physiological colony boundaries. But defining the individual this way is the most supportable for this final rule based on the best available science. While we did not specifically name the individual as the physiological colony in the proposed rule, it is how we considered the individual in the proposed rule because the majority of the information on abundance is based on the physiological colony which can be readily identified and counted in field surveys. Thus, in our species determinations we use the physiological colony to inform how we estimate abundance of a coral species because that is how field surveys estimate coral abundance. Using the physiological colony to estimate abundance in the final rule does not change how we estimated abundance in the proposed rule, in which we also relied on information that uses the physiological colony to report abundance estimates. If we have information on the effective population size (*i.e.*, proportion of clonality) for a species, that information is also considered.

Taxonomic Uncertainty in Reef-Building Corals

To determine if the proposed corals meet the ESA definition of a species, we had to address issues related to the taxonomic uncertainty in corals (*e.g.*, reliance on morphological features rather than genetic and genomic science to delineate species) and corals' evolutionary history of reticulate processes (*i.e.*, individual lineages showing repeated cycles of divergence and convergence via hybridization). To address taxonomic uncertainty related to species delineation, except as described below where genetic information was available, the proposed rule considered the nominal species designation as listed in the petition, acknowledging that future research may result in taxonomic reclassification of some of the candidate species. Additionally, to address complex reticulate processes in corals, the BRT attempted to distinguish between a ''good species'' that has a hybrid history—meaning it may display genetic signatures of interbreeding and back-crossing in its evolutionary history—and a ''hybrid species'' that is composed entirely of hybrid individuals (as in the case of *Acropora prolifera*, discussed in the status review of acroporid corals in the Caribbean; *Acropora* Biological Review Team, 2005). The best available information indicates that, while several of the candidate species have hybrid histories, there is no evidence to suggest any of them are ''hybrid species'' (that is, all individuals of a species being F1 hybrids); thus, they were all considered to meet the definition of a ''species.''

Studies elucidating complex taxonomic histories were available for several of the genera addressed in the status review, and we were able to incorporate those into our species determinations. Thus, while we made species determinations for most of the 82 candidate coral species on the nominal species included in the petition, we made alternate determinations on the proper taxonomic classification for the candidate species *Montipora dilatata* and *M. flabellata; Montipora patula* and *Porites pukoensis* based on genetic studies. We decided to subsume a nominal species (morpho-species) into a larger clade whenever genetic studies failed to distinguish between them (*e.g., Montipora dilatata, M. flabellata,* and *M. turgescens* (not petitioned) and *Porites* Clade 1 *forma pukoensis*). Comment 3 objected to the lumping of the *Montipora* species based solely on one study. However, because the commenter did not provide any contrary information and we did not find any new or supplemental information suggesting that subsuming the *Montipora* species into a larger clade is incorrect, we are maintaining our determination that *M. dilitata/M. flabellata/M. turgescens* and *M. patula/M. verrilli* are considered species under the ESA.

In the proposed rule, *Pocillopora elegans* was split into two separate species because the two geographically-distant populations have different modes of reproduction. Additionally, the proposed rule examined the listing status of *P. danae.* After consideration of the information on taxonomic uncertainty, including from the proposed rule and supporting documents, Comment 2, and new information, we have determined that these three *Pocillopora* species (*P. elegans* (Eastern Pacific), *P. elegans* (Indo-Pacific), and *P. danae*), are not listable entities under the ESA. As explained in the response to Comment 2, new information on the three proposed *Pocillopora* species proposed for listing indicates an increasing level of taxonomic uncertainty to the point that these three species are not listable entities under the ESA at this time. Thus, this final rule considers 65 of the 68 species included in the proposed rule. However, even though these remaining 65 species are determinable under the ESA, some uncertainty regarding taxonomy and certain species identification remains. These uncertainties are addressed for each species in the Species-specific Information and Determinations sections.

In addition to these specific examples of species delineation, Comment 1 stated that taxonomic uncertainties associated with many reef-building coral species are problematic for the ESA listing determination process. We acknowledge the clear delineation among individuals that characterizes vertebrate species is often absent in reef-building coral species. This final rule addresses that ambiguity with the general introductions in this sub-section, then by providing species-specific information for each species. Therefore, the level of taxonomic uncertainty is addressed for each of the species in this final rule in the Species-specific Information and Determinations sub-sections below.

Species Identification

We received several comments related to the difficulty in coral species identification (see Comment 1). In the proposed rule we acknowledged the difficulty in identification and how that affected the ability to accurately infer abundances for individual species (see proposed rule Distribution and Abundance section). However, we did not discuss the species identification uncertainty on a species by species basis. In this sub-section, we more fully describe the challenge of species identification. In the Species-specific Information and Determinations section, we address the identification uncertainty for each species, and determine if that uncertainly affects the reliability of the distribution and abundance information described for each species, based on expert analysis (Fenner, 2014b).

In this final rule ''species identification'' refers to the assignment of a given individual to a species based on its appearance in the field or lab. In contrast, ''species delineation'' refers to the definition of reef-building corals as distinct species based on their scientific classification or taxonomy (covered in the previous sub-section). Many reef-building coral species are difficult to identify for many reasons, including: (1) The high biodiversity of reef-building corals; (2) the high morphological plasticity in many reef-building coral species; and (3) the different methods used for species identification. An example of all three factors working together (high biodiversity, morphological plasticity, different methods) is provided by massive *Porites* species: Many species occur together in the same habitats and locations, morphological plasticity is high for both colony shape and corallite structure, and experts disagree about how to distinguish the species (Forsman *et al.*, 2009; Veron, 2000).

Coral species identification is based on the assumption that the taxonomy is correct. The high biodiversity, high morphological plasticity, and different methodologies create species identification problems even when the taxonomy is correct. But if the taxonomy is not correct, the species identification problems described here are irrelevant because species with a high level of taxonomic uncertainty (*e.g.*, the *Pocillopora* species in this final rule) are not listable entities under the ESA. Both the species delineation and species identification problems are highly species-specific, and are addressed for each species in the Species-specific Information and Determinations section.

Reproductive Life History of Reef-Building Corals

As summarized in the proposed rule, corals use a number of diverse reproductive strategies that have been researched extensively; however, many individual species' reproductive modes remain poorly described. Most coral species use both sexual and asexual propagation. Sexual reproduction in corals is primarily through gametogenesis (*i.e.*, development of eggs and sperm within the polyps near the base). Some coral species have separate sexes (gonochoric), while others are hermaphroditic. Strategies for fertilization are either by ''brooding'' or ''broadcast spawning'' (*i.e.*, internal or external fertilization, respectively). Asexual reproduction in coral species most commonly involves fragmentation, where colony pieces or fragments are dislodged from larger colonies to establish new colonies, although the budding of new polyps within a colony can also be considered asexual reproduction. In many species of branching corals, fragmentation is a common and sometimes dominant means of propagation.

Depending on the mode of fertilization, coral larvae (called planulae) undergo development either mostly within the mother colony (brooders) or outside of the mother colony, adrift in the ocean (broadcast spawners). In either mode of larval development, larvae presumably experience considerable mortality (up to 90 percent or more) from predation or other factors prior to settlement and metamorphosis. Such mortality cannot be directly observed, but is inferred from the large amount of eggs and sperm spawned versus the much smaller number of recruits observed later. Coral larvae are relatively poor swimmers; therefore, their dispersal distances largely depend on the duration of the pelagic phase and the speed and direction of water currents transporting the larvae. The documented maximum larval life span is 244 days (*Montastraea magnistellata*), suggesting that the potential for long-term dispersal of coral larvae, at least for some species, may be substantially greater than previously understood and may partially explain the large geographic ranges of many species.

The spatial and temporal patterns of coral recruitment have been studied extensively. Biological and physical factors that have been shown to affect spatial and temporal patterns of coral recruitment include substrate availability and community structure, grazing pressure, fecundity, mode and timing of reproduction, behavior of larvae, hurricane disturbance, physical oceanography, the structure of established coral assemblages, and chemical cues. Additionally, factors other than dispersal may influence recruitment, and several other factors may influence reproductive success and reproductive isolation, including external cues, genetic precision, and conspecific signaling.

In general, on proper stimulation, coral larvae settle and metamorphose on appropriate substrates. Some evidence indicates that chemical cues from crustose coralline algae, microbial films, and/or other reef organisms or acoustic cues from reef environments stimulate settlement behaviors. Calcification begins with the forming of the basal plate. Buds formed on the initial corallite develop into daughter corallites. Once larvae are able to settle onto appropriate hard substrate, metabolic energy is diverted to colony growth and maintenance. Because newly settled corals barely protrude above the substrate, juveniles need to reach a certain size to limit damage or mortality from threats such as grazing, sediment burial, and algal overgrowth. In some species, it appears that there is virtually no limit to colony size beyond structural integrity of the colony skeleton, as polyps apparently can bud indefinitely.

Comment 4 identified the lack of information on coral population dynamics and connectivity; however, it did not provide any supplemental information, other than for *Acropora* *cervicornis,* which will be considered in that species' determination. Therefore, the section above is a summary of the information on coral reproductive life history from the proposed rule as it contributes to the extinction risk analyses for the proposed corals. In our species determinations, we consider life history characteristics that may contribute to extinction risk. For example, species with high recruitment rates or fast growth rates may have the ability to more quickly recover from disturbances. Additionally, long-lived species with large colony size can sustain partial mortality (fission) and still have potential for persistence and regrowth. However, detailed life history information is not available for all of the species considered in this final rule, though it is used when available.

Distribution and Abundance of Reef-Building Corals

The proposed corals are distributed throughout the wider-Caribbean (*i.e.,* the tropical and sub-tropical waters of the Caribbean Sea, western Atlantic Ocean, and Gulf of Mexico; herein referred to collectively as ''Caribbean''), the Indo-Pacific biogeographic region (*i.e.,* the tropical and sub-tropical waters of the Indian Ocean, the western and central Pacific Ocean, and the seas connecting the two in the general area of Indonesia), and the tropical and sub-tropical waters of the eastern Pacific Ocean. In our species determinations, spatial and demographic traits inform our evaluation of a species' current status and its capacity to respond to changing conditions over the foreseeable future. One important demographic trait is absolute abundance, which is a function of local density (either quantitative or qualitative) and range size. Absolute abundance is more informative than a relative description of abundance for corals such as ''rare,'' because even a coral species described as ''rare'' may still have millions of individual colonies or more (*i.e.,* few individuals per unit area spread across a very large area). Similarly, the spatial trait of geographic distributions are not considered on a relative scale (*i.e.,* narrow, moderate, wide as we did in the proposed rule), but rather considered on an absolute scale, which for even the smallest species distribution encompasses millions of square miles.

As described in the Individual Delineation sub-section, determining abundance of the proposed corals presents a unique challenge because corals are clonal, colonial invertebrates, and colony growth occurs by the addition of new polyps. In addition, colonies can exhibit partial mortality in which a subset of the polyps in a colony dies, but the colony persists. Colonial species present a special challenge in determining the appropriate unit to evaluate for status. In addition, new coral colonies, particularly in branching species, can be added to a population by fragmentation (breakage from an existing colony of a branch that reattaches to the substrate and grows) as well as by sexual reproduction (see above, and Fig. 2.2.1 in SRR). Fragmentation results in multiple, genetically identical colonies (ramets) while sexual reproduction results in the creation of new genetically distinct individuals (genotypes or genets).

In the proposed rule, quantitative abundance estimates were available for only a few of the candidate species. In the Indo-Pacific, many reports and long-term monitoring programs describe coral percent cover only to genus level because of the substantial diversity within many genera and difficulties in field identification among congeneric species. In the Caribbean, most of the candidate species are either too few in numbers to document meaningful trends in abundance from literature reports (*e.g., Dendrogyra cylindrus*), or commonly identified only to genus (*Mycetophyllia* and *Agaricia* spp.), or potentially misidentified as another species. At the time of the proposed rule, the only comprehensive abundance data in the Caribbean were for the three *Orbicella* species, partially because they historically made up a predominant part of live coral cover. Even for these species, the time series data are often of very short duration (they were not separated as sibling species until the early 1990s and many surveys continue to report them as ''*Orbicella annularis* complex'') and cover a very limited portion of the species range (*e.g.,* the time series only monitors a sub-section of a single national park). In general, the available quantitative abundance data were so limited or compromised due to factors such as small survey sample sizes, lack of species-specific data, *etc.,* that they were considerably less informative for evaluating the risk to species than other data, and were therefore generally not included as part of the individual species extinction risk evaluations.

Comment 47 provided quantitative abundance estimates from Florida for all of the proposed corals in the Caribbean. In addition, we gathered supplemental information providing quantitative abundance estimates and distribution for individual species in the Caribbean and Indo-Pacific. These data are included and described in the individual extinction risk assessments for those species in the Species-specific Information and Determinations section.

Unlike quantitative abundance data, qualitative abundance characterizations (*e.g.,* rare, common), were available for all species (Veron, 2000), and were considered in the proposed rule's individual species extinction risk evaluations. These estimates are the subjective opinion of the author and are meant to indicate relative abundance between the categories. That is, a rare species has fewer individuals as compared to an uncommon one, and an uncommon species has fewer individuals than a common one. These estimates are also meant to describe the author's opinion of the qualitative abundance of the species throughout its range, and not necessarily an estimate of the abundance at an individual location. Since the proposed rule was published, semi-quantitative (*i.e.,* survey data from 2,984 individual sites) and updated non-quantitative (*i.e.,* the author's subjective estimates covering a full range of habitats and most ecoregions the author has worked in) abundance estimates were provided for 63 of the 65 corals covered in this final rule (Veron, 2014). In addition to the semi-quantitative and non-quantitative estimates, Veron (2014) provided occupancy of each species within the approximately 150 ecoregions he has defined. An ecoregion is defined as an area that is internally cohesive (*i.e.,* areas with similar habitats share similar species complements), but externally distinct from neighboring regions (*http://coral.aims.gov.au/*). Ecoregions are widely used in biogeography because they incorporate a substantial amount of background knowledge, are a good platform for statistical analysis, and allow the pooling and comparison of different datasets from the same ecoregion. Ecoregions are not equal in size and thus occupancy in the same number of ecoregions by two different species does not indicate the same range size. Rather, the number of ecoregions occupied is a good indication of the diversity of habitats and geographic distribution in which a species may be found. These data are included in the individual extinction risk assessments for those species in the Species-specific Information and Determinations section.

As previously described in the Individual Delineation section, clonal, colonial organisms, such as corals, are vastly different in their biology and ecology than vertebrates, which are typically the focus of ESA status reviews. Therefore, concepts and terms that are typically applied to vertebrates have very distinct meanings when applied to corals. A 'rare' coral may still have millions of colonies as compared to a 'rare' vertebrate, which may only have hundreds of individuals.

Coral Habitats

As summarized in the Coral Reefs, Other Coral Habitats, and Overview of Candidate Coral Environments section of the proposed rule, a ''coral reef'' is a complex three-dimensional structure occurring from the surface to approximately 30 to 40 meters of depth resulting from the skeletal growth of reef-building corals that provides habitat, food, and shelter for numerous marine species. As such, coral reefs foster exceptionally high biodiversity and provide the following essential functional roles: Primary production and recycling of nutrients in relatively nutrient poor (oligotrophic) seas, calcium carbonate deposition yielding reef construction, sand production, modification of near-field or local water circulation patterns, and habitat for secondary production, including fisheries. These functional roles yield important ecosystem services in addition to direct economic benefits to human societies such as traditional and cultural uses, food security, tourism, and potential biomedical compounds. Coral reefs protect shorelines, coastal ecosystems, and coastal inhabitants from high seas, severe storm surge, and tsunamis.

The three broad categories of coral reefs are fringing reefs, barrier reefs, and atolls. Fringing reefs are mostly close to coastlines, and usually have a high component of non-carbonate sediment. Barrier reefs are offshore and are composed of wave-resistant consolidated limestone. Atolls are usually a wall of reefs partially or completely enclosing a central lagoon. There are not sharp differences that clearly mark boundaries between reef types. For example, fringing reefs gradually become barrier reefs with increasing distance from shore. Also, the shape of both barrier reefs and atolls is largely determined by the bathymetry of the substratum, producing many irregularly shaped reefs that are intermediary between the two types. Isolated reefs that do not fit any of these descriptions are referred to as platform reefs (Veron, 2000).

Despite the differences between the reef categories, most fringing reefs, barrier reefs, atolls, and platform reefs consist of a reef slope, a reef crest, and a back-reef, which in turn are typically characterized by distinctive habitats. The reef slope is the seaward side of the coral reef between the reef crest and the deep ocean, and generally includes upper fore-reefs or upper slopes (approximately 5–10 to 10–20 m depth), mid-slopes that often occur as terraces or shelves (approximately 10–20 to 20–30 m depth), and deep fore-reefs, lower slopes, or walls (approximately 30–40 m depth) that transition to mesophotic areas (greater than 30–40 m depth). The reef crest (approximately 0 to 5–10 m depth) forms the boundary between the reef slope and back-reef, and generally includes a consolidated ridge or rim where the waves break, and a lower reef crest on the seaward side of the algal ridge often made of up of buttresses and surge channels (*i.e.,* spur-and-groove structures). The back-reef lies between the reef crest and land (or middle of the lagoon, in the case of atolls). The back-reef generally includes reef flats (approximately 0 to 1–5 m depth) and lagoons (approximately 1–5 to over 30 m depth), interlaced with tide pools, channels, patch reefs, and other features. The characteristics of these habitat types vary greatly by reef categories, locations, latitudes, frequency of disturbance, *etc.,* and there is also much habitat variability within each habitat type, together constituting the habitat heterogeneity of coral reefs, as described further below.

Fringing reefs occur adjacent to coastlines, and subsequently the habitats associated with their reef slopes and back-reefs may be quite different than on barrier reefs or atolls. The reef slopes of many fringing reefs that are protected from strong wave action (*e.g.,* on leeward sides of islands) consist of unconsolidated material sloping gently towards deeper water, while those of fringing reefs in more exposed areas (*e.g.* windward sides of islands) are usually more consolidated. On many fringing reefs, even on the reef slope, natural turbidity and sedimentation may be high due to proximity to land. Fringing reefs typically have narrow back-reefs consisting of a reef flat abutting the reef crest, and possibly tide pools, channels, or small lagoons between the reef flat and shore (Goreau, 1959; Veron, 2000). Barrier reefs typically form tens to hundreds of kilometers from coastlines, their reef slopes are composed of consolidated limestone that may plunge steeply to deeper water, and natural turbidity and sedimentation are very low due to distance from land. Thus the characteristics of their reef slope habitats can be quite different than on fringing reefs. Barrier reefs are exposed to very strong wave action, and their reef crests can vary from high, consolidated algal ridges to unconsolidated shingle ramparts to low and wide indistinct crests. In addition, barrier reefs typically have immense back-reefs consisting of reef flats abutting the reef crest, and large lagoons that may vary from clear and sandy near the reef to turbid and muddy near land, and include various features such as patch reefs and islands (Maxwell, 1968). Atolls occur in oceanic waters far from land, and may be hundreds of kilometers across. Their reef slopes often form vertical walls dropping into abyssal waters, and their back-reefs consist of large, clear lagoons (Veron, 2000; Wells, 1951). Environmental conditions vary greatly between the habitat types found on the reefs slopes, reef crests, and back-reefs of the world's coral reefs. In addition, much variability also occurs within each habitat type. For example, Maxwell (1968) describes six geomorphological types of reef crests, and how the different environmental conditions provide ''coral zones'' unique to each type of reef crest. The physical diversity of coral reef habitat is illustrated by Kuchler (1986), who notes that the scientific literature on the GBR alone used over 20 terms for the reef slope or its habitats, over 50 terms for the reef crest or its habitats, and over 100 terms for the reef flat and lagoon and their habitats.

In conclusion, five main points are important regarding coral habitat on coral reefs (as opposed to non-reefal and mesophotic habitats) for this final rule: (1) Regardless of reef category, reefs generally consist of reef slopes, reef crests, and back-reefs, each of which have distinct habitats, but those habitats can be highly variable between reef types and locations; (2) spatial variability in coral habitat conditions is very high between habitat types, as well as within the habitat types described above (*i.e.,* deep fore-reefs, walls, mid-slopes, upper reef slopes, lower reef crests, algal ridges, reef flats, and lagoons), producing highly variable environmental conditions across both large and small spatial scales at any given point in time; (3) temporal variability in coral habitat conditions is also very high, both cyclically (*e.g.,* from tidal, seasonal, annual, and decadal cycles) and episodically (*e.g.,* storms, temperature anomalies, *etc.*); (4) together this spatial and temporal variability in environmental conditions across multiple scales produces the very high habitat heterogeneity of coral reefs; and (5) while most coral species in this final rule are more common in certain reef habitat types, they are typically found in many different habitat types.

Reef-building corals have specific habitat requirements, including hard substrate, narrow mean temperature range, adequate light, and adequate water flow. These habitat requirements most commonly occur on the shallow tropical and subtropical coral reefs described above, but also occur in non-reefal and mesophotic areas. All of the proposed species require hard substrates. Thus, in this final rule, ''non-reefal habitats'' refers to hard substrates where reef-building corals can grow, including marginal habitats where conditions prevent reef development (*e.g.,* turbid or high-latitude or upwelling-influenced areas) and recently available habitat (*e.g.,* lava flows). The term ''mesophotic habitats'' refers to hard substrates deeper than 30 m. Coral reefs, non-reefal areas, and mesophotic areas are not necessarily sharply delineated from one another, thus one may gradually blend into another. We anticipate the total area of non-reefal and mesophotic habitats is greater than the total area of shallow coral reef habitats within the ranges of the corals in this final rule.

Comments 6 and 7 suggested that we did not consider non-reefal habitats and mesophotic habitats adequately in our proposed rule. However, these comments did not provide any new or supplemental information on how to interpret the importance of these habitats in our extinction risk analysis. Comment 7 includes two studies that provide supplemental information on the extent of mesophotic reefs. In addition to the public comment received on the diversity and complexity of coral reef habitats, supplemental information has become available on non-reefal and mesophotic habitats since the publication of the proposed rule. The following sub-sections on non-reefal and mesophotic habitats are intended to illustrate the diversity of reef-building coral habitats, but are not intended to provide an exhaustive list of them.

Non-reefal habitats include marginal habitats (Perry and Larcombe, 2003), as well as newly available natural habitats such as the hard substrates created by lava flows (Grigg and Maragos, 1974), tsunamis (scoured bedrock or transported boulders (Goto *et al.,* 2010)), or other episodic processes. Non-reefal habitats are defined as areas where environmental conditions prevent reef formation but reef-building corals are present. Marginal habitats are much more common than newly-available natural habitats. Marginal habitats are very diverse, as they occur where seawater temperatures or light levels are sub-optimal (*i.e.,* inadequate for high skeletal growth but still allowing reef-building corals to survive), and thus include environments that are turbid (Blakeway *et al.,* 2013; Browne *et al.,* 2012), very warm (Riegl and Purkis, 2012; Riegl *et al.,* 2011), or cold because of high latitude (Dalton and Roff, 2013; Lybolt *et al.,* 2011) or upwelling (Alvarado *et al.,* 2011; Manzello *et al.,* 2008), and other environments (Couce *et al.,* 2012; Done, 1982; Perry and Larcombe, 2003). Some coral species can also live on soft substrates, such as *Manicina areolata* in the Caribbean, staghorns (*Acropora*) that must begin on hard substrate but can then grow over soft substrates, and *Catalaphyllia jardini,* which is common in some soft substrates in Australia. Such habitat is not necessarily indicative of low-diversity coral assemblages, as shown by turbid sites, which have been documented to support over 160 species of reef-building corals (Perry and Larcombe, 2003), and fresh lava flows, which have been documented to support fully recovered coral communities only 20 years after the flow (Grigg and Maragos, 1974). Marginal habitats expands the diversity of environmental conditions that can support some reef-building corals and therefore may provide refugia from some threats affecting shallow coral reef habitat, as described in the Spatial and Temporal Refugia sub-section below.

Since 2012, research on mesophotic habitats has demonstrated that many reef-building corals have greater depth distributions than previously reported. Twenty-two of the proposed species have been reported from mesophotic depths (*i.e.,* 30 m or more) and several more reported at 25 m. For other species, their biogeographic ranges may be underestimated due to lack of mesophotic exploration. These studies demonstrate that some species in shallow coral reef habitats readily extend to mesophotic depths if water clarity and temperatures remain favorable (Kahng *et al.,* 2014). For example, investigations in American Samoa (Bare *et al.,* 2010), the Hawaiian Archipelago (Kahng *et al.,* 2010; Rooney *et al.,* 2010), and the Mariana Archipelago (Rooney *et al.,* 2012), have revealed extensive mesophotic coral reef ecosystems. While classically considered to be limited to 100 m, mesophotic reefs have been observed as deep as 130 m in some of these areas, including at depths in excess of 150 m in the Au'au Channel of Hawaii (Blyth-Skyrme *et al.,* 2013). Likewise, investigations on Australia's GBR found extensive mesophotic habitats both along the continental shelf-edge and on submerged reefs inside the lagoon of the GBR, both of which support previously unknown communities of reef-building corals (Bridge *et al.,* 2012a; Bridge and Guinotte, 2013; Bridge *et al.,* 2012b). As noted in one of these recent papers, several coral species (including *Acropora aculeus, A. jacquelineae,* and *A. tenella*) are common and geographically widespread in deeper waters (30–60 m; Bridge *et al.,* 2013b). Other recent studies in Curaçao (Bongaerts *et al.,* 2013), Bermuda (Locke *et al.,* 2013), and Hawaii (Luck *et al.,* 2013) reveal extensive mesophotic habitats and reef-building coral communities. These studies expand the known potential habitats for reef-building corals, but species diversity and abundances have not been well-documented due to the relative inaccessibility of these habitats to divers.

In summary, the magnitude of habitats potentially supporting reef-building coral species is extremely large, and much larger than the 0.2 percent of the marine environment provided in the SRR. Globally, some reef-building corals can occur in shallow coral reef, non-reefal, and/or mesophotic habitats. These three types of general habitats combined provide the overall physical environment of many species, and supplemental information on non-reefal and mesophotic habitats indicates that their magnitude is larger than previously understood.

Inter-Basin Comparisons

As described in the proposed rule, the Caribbean and Indo-Pacific basins contrast greatly both in size and in condition. The Caribbean basin is geographically small and partially enclosed, has high levels of connectivity, and has relatively high human population densities. The wider-Caribbean occupies five million square km of water and has approximately 55,000 km of coastline, including approximately 5,000 islands. Shallow coral reefs occupy approximately 25,000 square km (including ≈2,000 square km within U.S. waters), or about 10 percent of the total shallow coral reefs of the world. The amount of non-reefal and mesophotic habitat that could potentially be occupied by corals in the Caribbean is unknown, but is potentially greater than the area of shallow coral reefs in the Caribbean.

The Caribbean region has experienced numerous disturbances to coral reef systems throughout recorded human history. Fishing has affected Caribbean reefs since before European contact, and continues to be a threat. Beginning in the early 1980s, a series of basin-scale disturbances has led to altered community states, and a loss of resilience (*i.e.,* inability of corals and coral communities to recover after a disturbance event). Massive, Caribbean-wide mortality events from disease conditions of both the keystone grazing urchin *Diadema antillarum* and the dominant branching coral species *Acropora palmata* and *Acropora cervicornis* precipitated widespread and dramatic changes in reef community structure. None of the three important keystone species (*Acropora palmata, Acropora cervicornis,* and *Diadema antillarum*) have shown much recovery over decadal time scales. In addition, continuing coral mortality from periodic acute events such as hurricanes, disease outbreaks, and bleaching events from ocean warming have added to the poor state of Caribbean coral populations and yielded a remnant coral community with increased dominance by weedy brooding species, decreased overall coral cover, and increased macroalgal cover. Additionally, iron enrichment in the Caribbean may predispose the basin to algal growth. Further, coral growth rates in the Caribbean have been declining over decades.

Caribbean-wide meta-analyses suggest that the current combination of disturbances, stressful environmental factors such as elevated ocean temperatures, nutrients and sediment loads, and reduced observed coral reproduction and recruitment have yielded a loss of resilience, even to natural disturbances such as hurricanes.

Coral cover (percentage of reef substrate occupied by live coral) across the region has declined from approximately 50 percent in the 1970s to approximately 10 percent in the early 2000s (*i.e.,* lower densities throughout the range, not range contraction), with concurrent changes between subregions in overall benthic composition and variation in dominant species. However, supplemental information suggests that this estimate of coral cover decline in the Caribbean is an oversimplification. In the Caribbean, quantitative surveys of a few dozen sites from before the early 1980s suggest the regional mean for coral cover was 30–40 percent around 1980 (Gardner *et al.,* 2003; Schutte *et al.,* 2010). Supplemental information based on more complete sampling effort (*i.e.,* meta-analysis of 35,000 quantitative reef surveys from 1969 to 2012) indicates higher levels of ''current'' percent live coral cover in the Caribbean than described in the proposed rule. For example, a recent study found that average coral cover throughout the wider-Caribbean declined by 66 percent from an overall average of 41 percent between 1969–1983 to 14 percent today, slightly higher than the 10 percent reported earlier. The earlier reports were based on less thorough sampling of the available data, and were also dominated by data from the Florida Keys, U.S. Virgin Islands, and Jamaica, which may not be representative of the entire Caribbean (Jackson *et al.* 2014).

In conclusion, the supplemental information regarding live coral cover does not dispute that there has been a long-term overall decline in live coral cover in the Caribbean and that those declines are likely ongoing and likely to continue in the future as a result of a multitude of global and local threats at all spatial scales. These wide-scale changes in coral populations and communities have affected habitat complexity and may have already reduced overall reef fish abundances. These trends are expected to continue. However, as the above information illustrates, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that may not be indicative of conditions throughout the basin.

Ocean basin size and diversity of habitats (*e.g.,* reef-flats, forereef, mesophotic, non-reefal), as well as some vast expanses of ocean area with only very local, spatially-limited, direct human influences, have provided substantial buffering of Indo-Pacific corals from many of the threats and declines manifest across the Caribbean. The Indo-Pacific (Indian and Pacific Oceans) is enormous and hosts much greater coral diversity than the Caribbean region (~700 coral species compared with 65 coral species). The Indo-Pacific region encompasses the tropical and sub-tropical waters of the Indian Ocean, the western and central Pacific Ocean, and the seas connecting the two in the general area of Indonesia. This vast region occupies at least 60 million square km of water (more than ten times larger than the Caribbean), and includes 50,000 islands and over 40,000 km of continental coastline, spanning approximately 180 degrees of longitude and 60 degrees of latitude. There are approximately 240,000 square km of shallow coral reefs in this vast region, which is more than 90 percent of the total coral reefs of the world. In addition, the Indo-Pacific includes abundant non-reefal habitat, as well as vast but scarcely known mesophotic areas that provide coral habitat. The amount of non-reefal and mesophotic habitat that could potentially be occupied by corals in the Indo-Pacific is unknown, but is likely greater than the area of shallow coral reefs in the Indo-Pacific (NMFS, 2012b; SIR Section 4.3).

While the reef communities in the Caribbean may have poor resilience, the reefs in the central Pacific (*e.g.,* American Samoa, Moorea, Fiji, Palau, and the Northwestern Hawaiian Islands) appear to remain much more resilient despite major bleaching events from ocean warming, hurricanes, and crown-of-thorns seastar predation outbreaks. That is, even though the reefs have experienced significant impacts, corals have been able to recover, as described below. Several factors likely result in greater resilience in the Indo-Pacific than in the Caribbean: (1) The Indo-Pacific is more than 10-fold larger than the Caribbean, including many remote areas; (2) the Indo-Pacific has approximately 10-fold greater diversity of reef-building coral species than the Caribbean; (3) broad-scale Caribbean reef degradation likely began earlier than in the Indo-Pacific; (4) iron enrichment in the Caribbean may predispose it to algal growth versus lack of broad-scale iron enrichment in the Indo-Pacific; (5) there is greater coral cover on mesophotic reefs in the Indo-Pacific than in the Caribbean; and (6) there is greater resilience to algal phase shifts in the Indo-Pacific than in the Caribbean.

Even given the relatively higher resilience in the Indo-Pacific as compared to the Caribbean, one meta-analysis of overall coral status throughout the Indo-Pacific indicates that substantial loss of coral cover (*i.e.,* lower densities throughout the range, but not range contraction) has already occurred in most subregions. As of 2002–2003, the Indo-Pacific had an overall average of approximately 20 percent live coral cover, down from approximately 50 percent since the 1970s. However, supplemental information refines this estimate. Data from 154 surveys of reefs across the Pacific performed between 1980 and 1982 had mean live coral cover of 42.5 percent (Bruno and Selig, 2007). Coral cover in the Indian Ocean declined from approximately 40 percent prior to the 1998 bleaching event to approximately 22 percent; subsequently, mean coral cover increased to approximately 30 percent by 2005 (Ateweberhan *et al.,* 2011) Live coral cover likely had already declined in all regions before 1980, but region-wide quantitative data is generally lacking. For example, local surveys before 1980 from several parts of the Indo-Pacific documented live coral cover of 50 to 70 percent (Gomez *et al.,* 1981).

Unlike the Caribbean, no recent region-wide reports of current, overall live coral cover are available for the Indo-Pacific as a whole. However, recent reports from parts of the region have found current live coral cover higher than the 20 percent for the region reported earlier, and stable or increasing live coral cover. For example, monitoring data collected annually from 47 sites on the GBR from 1995 to 2009 averaged 29 percent live coral cover. More importantly, this study found no evidence of consistent, system-wide decline in coral cover since 1995. Instead, fluctuations in coral cover at sub-regional scales (10–100 km), driven mostly by changes in fast-growing Acroporidae, occurred as a result of localized disturbance events and subsequent recovery (Osborne *et al.,* 2011). However, another recent study based on 2,258 surveys of 214 GBR reefs over 1985–2012, showed declines in live coral cover from 28 percent to 14 percent, a loss of half of the initial coral cover. In the Philippines, a study of 317 sites from 1981 to 2010 averaged 36 percent live coral cover, and showed an overall increase from 29 percent in 1981 to 37 percent in 2010 (Magdaong *et al.,* 2013). A study of 366 sites from 1977 to 2005 in the Indian Ocean documented large initial decline from approximately 35 percent live coral cover to approximately 15 percent at most sites following the 1998 bleaching event, followed by partial recovery to approximately 25 percent, and then stability of live coral cover (Ateweberhan *et al.,* 2011). Likewise, a study in Western Australia from 2005 to 2009, following the 2005 bleaching event, documented declines to 10 percent live coral cover as a result of the event and then subsequent recovery to 30 percent (Ceccarelli *et al.,* 2011). A study in the Andaman Islands from 2010 to 2012 following the 2010 bleaching also documented substantial recovery of live coral cover (Marimuthu *et al.,* 2012; Osborne *et al.,* 2011).

These recent studies illustrate the dynamic nature of live coral cover, especially recovery from the 1998 bleaching event. It is likely that the overall basin-wide live coral cover in both the Caribbean and the Indo-Pacific has declined over decadal and centurial time scales, but with fluctuations on shorter time scales and within smaller geographic scales. This is significant because coral decline doesn't occur in every location at every time scale. Rather, there are periods of decline and recovery over shorter time periods in various locations throughout the larger basins. This has broad implications when analyzing the temporal and spatial elements of a coral species' extinction risk.

Disagreements over the methods of how to measure live coral cover have led to different results in studies measuring changes in live coral cover over time. For example, one study (Bellwood *et al.,* 2004) reported approximately 50 percent declines in live coral cover on GBR over the last several decades, but another study disagreed (Sweatman *et al.,* 2011), making the case for considerably smaller declines, using a different method. Both studies provided detailed support for their methods and findings (Hughes *et al.,* 2011; Sweatman and Syms, 2011). Studies supporting both results have since been published (De'ath *et al.,* 2012; Osborne *et al.,* 2011), and such disagreements illustrate the complexity of determining trends in live coral cover.

In conclusion, the supplemental information regarding live coral cover does not dispute that there has been a long-term overall decline in live coral cover in both the Caribbean and Indo-Pacific, and that those declines are likely ongoing and likely to continue in the future due to a multitude of global and local threats at all spatial scales. Further, both basins have experienced conditions leading to coral mortality and prevention of full recovery; however, the Caribbean has been more greatly impacted. While basin-wide averages are useful for large-scale comparisons, they do not describe conditions at finer, regional scales. For example, decreases in overall live coral cover have occurred since 2002 in some areas, such as on the GBR, while increases have occurred in other areas, such as in American Samoa. As the supplemental information further illustrates, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context. Live coral cover trends are complex, dynamic, and highly variable across space and time. Thus their interpretation requires the appropriate spatial-temporal context (*i.e.,* entire range or each species now and through foreseeable future), and an understanding of the various physical, biological, and ecological processes at work within coral communities and coral reef ecosystems.

In the proposed rule, we provided a summary of conditions in the eastern Pacific to illustrate the contrast to the conditions in Indo-Pacific and Caribbean. This description was relevant because the range of one of our candidate species, *Pocillopora elegans* (eastern Pacific), was restricted to the eastern Pacific. Because we are no longer considering the three proposed *Pocillopora* species in this final rule, a detailed description of the eastern Pacific is not necessary.

Spatial and Temporal Refugia

Comment 7 suggested that certain habitats (*e.g.,* mesophotic) may provide refugia for shallow water corals. Therefore, we provide the following discussion of temporal and spatial refugia. Some of these concepts were discussed in the Threats Evaluation section of the proposed rule as they relate to exposure of corals to the various threats and how exposure influences extinction risk. The above information on coral habitats illustrates the enormous heterogeneity of the environments that many of these species inhabit. Each species occurs in a patchwork of variable habitat conditions at any given point in time, with certain combinations of variables at certain locations producing favorable conditions that may provide refugia from threats such as ocean warming. Habitat conditions are highly variable over time in different ways, including cyclically (*e.g.,* from tidal, seasonal, annual, and decadal cycles), episodically (*e.g.,* storms, temperature anomalies, *etc.*), and linearly (*e.g.,* gradual thermal regime changes, which will both degrade and improve habitat, depending on location and initial conditions). The dynamic nature of reef-building coral habitats may provide refugia for some corals from some threats, both spatially and temporally (Fine *et al.,* 2013; McClanahan *et al.,* 2011; Riegl and Piller, 2003).

Some habitats have natural features that reduce stress from extremely high temperatures or light levels (*i.e.,* the most common causes of coral bleaching), which may provide spatial refugia for some reef-building coral species from ocean warming and other threats. Deeper water may be cooler depending on the amount of mixing, and is exposed to less light (*i.e.,* irradiance). Mesophotic habitats are very extensive, and recent investigations provide evidence that mesophotic habitat functions as refugia for some reef-building corals. A review of mesophotic habitat on Australia's GBR concluded that reef-building corals in mesophotic habitat are less likely to be affected by warming-induced bleaching events than their counterparts on nearby shallow reefs (Bridge *et al.,* 2012a). Mesophotic habitat may also be important for recovery of corals disturbed coral reefs by providing sources of propagules to recolonize shallow reefs following disturbances (Bridge and Guinotte, 2013). A 37-year record from the eastern Pacific across the two most severe El Niño events on record (1982–83 and 1997–98) shows how an exceptionally thermally-sensitive reef-building fire coral, *Millepora intricata,* twice survived catastrophic bleaching in a deeper water refuge (>11 m depth). During both events, *M. intricata* was extirpated across its range in shallow water but showed recovery within several years, while two other fire corals without deep-water populations were driven to regional extinction (Smith *et al.,* in press).

The refuge value of mesophotic habitats is limited, however. Only about one-quarter of all reef-building coral species occur at mesophotic depths (Bongaerts *et al.,* 2012) and only 22 of our proposed species. Also, there is limited connectivity between mesophotic and shallow coral habitats, at least for some species, suggesting that the actual likelihood of mesophotic corals repopulating shallow reef habitats is low for those species. For example, genetic connectivity between mesophotic and shallow populations is high in *Seriatopora hystrix* on the GBR (van Oppen *et al.,* 2011) and *Millepora intricata* in the eastern Pacific (Smith *et al.,* in press), but low for *Montastraea cavernosa* in the Caribbean (Brazeau *et al.,* 2013).

Marginal habitats are also extensive, and recent investigations provide evidence that marginal habitat also functions as refugia for some reef-building corals. Marginal habitats include turbid (Blakeway *et al.,* 2013; Browne *et al.,* 2012), very warm (Riegl and Purkis, 2012; Riegl *et al.,* 2011), cold (Dalton and Roff, 2013; Lybolt *et al.,* 2011), soft substrate, and other environments (Couce *et al.,* 2012; Done, 1982; Perry and Larcombe, 2003) with sub-optimal coral growth conditions. A study of future coral habitat suitability under ocean warming and acidification suggests that marginal habitats may provide important refugia for some reef-building corals (Couce *et al.,* 2013b), though not all coral species can survive in these habitats. The study found that the IPCC AR4's higher emission scenarios are all likely to result in: (1) Range expansion at the high-latitude boundaries; (2) no decreased suitability in currently marginal eastern Equatorial Pacific locations as well as in the Atlantic generally; and (3) severe temperature-driven impacts in the western Equatorial Pacific (Coral Triangle) and surrounding regions. These findings led to the conclusion that marginal habitat is likely to function as a patchwork of refuge habitats for some reef-building corals in both the Indo-Pacific and Atlantic as ocean warming and acidification increase over the twenty-first century.

Aside from mesophotic and marginal habitats, other types of habitats may provide refuge for reef-building corals from ocean warming and other threats. Some of these have long been known to reduce thermal stress, such as those habitats with highly-fluctuating conditions, strong currents from wind or tides, and shading from frequent cloud cover or complex bathymetry, as described in the proposed rule and supporting documents. Supplemental information suggests other oceanographic features may also provide refuge from ocean warming both currently and the foreseeable future, such as: (1) Large-scale upwelling in both the Pacific (Karnauskas and Cohen, 2012) and Caribbean (Bayraktarov *et al.,* 2012); (2) the similar but smaller-scale phenomenon of internal tidal bores that transport cooler, deeper water to warmer, shallower areas (Storlazzi *et al.,* 2013); (3) and the wakes of relatively cool water left by the passage of tropical cyclones (Carrigan, 2012). Most of the refugia described above are with regard to ocean warming, but some of these habitat types provide refugia potential from ocean acidification, such as highly-fluctuating habitats which limit pH minima via tidal flux (Shaw *et al.,* 2012), and from disease and sedimentation, such as high-energy habitats which provide flushing that reduces conditions conducive to disease and removes sediment. Seagrass beds provide beneficial changes in ocean chemistry to seawater on adjacent reefs, providing local refugia to ocean acidification (Manzello *et al.,* 2012). Depth also provides some refugia potential from disease, as most studies show a negative correlation between depth and coral disease incidence. However, some studies show no such correlation, and disease incidence can be comparable between mesophotic and shallow depths (Brandt *et al.,* 2012).

Thermal regime changes from ocean warming will have opposite effects on habitat, depending on location: In locations already near the thermal maxima of reef-building corals, warming will degrade habitat, but in locations currently too cool for these species, warming will improve habitat, if other habitat features conducive to reef growth are also present, such as hard substrate and appropriate light and water chemistry conditions. Geological evidence from past global warming periods shows a pattern of poleward expansion of some reef-building coral ranges, coupled with decline in equatorial areas (Kiessling *et al.,* 2012) and expansion into temperate areas (Woodroffe *et al.,* 2010). Predicted ocean warming in the twenty-first century is expected to result in a similar pattern of poleward expansion, thus newly-colonized areas may provide temporary refugia for some species (van Hooidonk *et al.,* 2013b). For example, models suggest that such expansion of reef-building corals could occur at the rate of 1–4 km per year in Japan (Yara *et al.,* 2011). As temperatures increase to the optimal range for reef-building corals in these northerly and southerly areas, however, the simultaneous increase in ocean acidification may negate the suitability of these areas (van Hooidonk *et al.,* 2014; Yara *et al.,* 2012). While it may appear that there is no long-term, large-scale refugia from both ocean warming and ocean acidification (van Hooidonk *et al.,* 2014), on a finer regional and/or reef-scale, there is still a large amount of refugia in the form of heterogeneous habitat, including mesophotic, non-reefal, and marginal habitats, that provide a buffer to corals from threats into the foreseeable future.

Corals and Coral Reefs Conclusion

The above general information on reef-building coral biology and habitat leads to several important overall points that apply both currently and over the foreseeable future. With regard to reef-building coral biology, first, delineations between individual colonies of the same species, and between species, can be highly uncertain, creating ambiguity with regard to the status of species—specific sources of uncertainty include unclear individual delineations, taxonomic uncertainty, and species identification uncertainty. Thus, in our species determinations we use the physiological colony to inform how we estimate abundance of a coral species because that is how field surveys estimate coral abundance. Using the physiological colony to estimate abundance in the final rule does not change how we estimated abundance in the proposed rule, in which we also relied on information that uses the physiological colony to report abundance estimates. If we have new or supplemental information on the effective population size (*e.g.,* proportion of clonality) for a species, that information is also considered. Second, while corals can reproduce both sexually and asexually, abundance estimates are based solely on the physical number of coral colonies that does not recognize mode of reproduction. Dispersal and recruitment patterns are highly variable across space and time, leading to complex and poorly understood population dynamics and connectivity. In our species determinations, we consider life history characteristics that may contribute to extinction risk. For example, species with high recruitment rates or fast growth rates may have the ability to more quickly recover from disturbances. Additionally, long-lived species with large colony size can sustain partial mortality (fission) and still have potential for persistence and regrowth. Third, all species considered in this final rule occur in multiple habitat types and have considerable distributions that encompass at least thousands of islands and multiple habitat types, which influences absolute abundances—the absolute distributions and absolute abundances of these species are key components of their vulnerability to extinction. Therefore, in our species determinations, the spatial and demographic traits of absolute abundance and absolute distribution inform our evaluation of a species' current status and its capacity to respond to changing conditions over the foreseeable future.

Additionally, because of variability between species, some generalities cannot be assumed to apply equally to each species. Therefore, in our species determinations we consider the complex nature of coral biology and assume that for all species, responses to threats will be variable between individual coral colonies and even between different portions of the same colony. The best available species-specific information for each of the 65 species is provided in the Species-specific Information and Determinations sub-sections below.

With regard to reef-building coral habitat, first, the heterogeneity of reef-building coral habitat varies greatly both spatially and temporally. That is, the habitat of a given species varies spatially (*i.e.,* even the smallest ranges of the species included in this final rule encompass thousands of islands and multiple habitat types) and temporally (*i.e.,* varies over time in response to disturbances and recoveries). Second, some habitat types are understudied (*e.g.,* mesophotic and marginal) so data about their contribution to the distribution and abundance of individual coral species are limited, as well as the possibility of refugia from particular threats being underestimated. Third, a diversity of habitats likely helps some species capacity to acclimatize and adapt to changing conditions, especially extreme habitats. For example, while some colonies die during the stressful conditions common to extreme habitats, other colonies at the same reef survive and acclimatize, potentially leading to adaptation. The magnitude and diversity of reef-building coral habitats creates high physical heterogeneity across the ranges of these species, providing habitat refugia from threats. Some of these refuge habitats may already be occupied by the species; others could become occupied as their suitability changes, assuming the species are able to reproduce and successfully recruit into these areas. The habitat heterogeneity and refugia lead to variable micro-climates at a reef scale that leads to variable responses by reef-building corals to threats, both spatially and over time, which adds complexity to assessing the status of species in a worsening environment.

Overall, in our species determinations, we recognize that the exposure and response of a coral species to global threats varies spatially and temporally based on variability in the species' habitat and distribution. All species considered in this final rule occur in multiple habitat types, or reef environments, and have distributions that encompass diverse physical environmental conditions that influence how that species responds to global threats. As such, the concept of heterogeneous habitat influences extinction risk for all species in this final rule because each species experiences a wide variety of conditions throughout its range which allows for variable responses to global and local threats.

Threats Evaluation

Section 4(a)(1) of the ESA and NMFS' implementing regulations (50 CFR 424) state that the agency must determine whether a species is endangered or threatened because of any one or a combination of five factors: (A) Present or threatened destruction, modification, or curtailment of habitat or range; (B) overutilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) inadequacy of existing regulatory mechanisms; or (E) other natural or manmade factors affecting its continued existence. In the proposed rule, our evaluation of the five factors was informed by the SRR and SIR for factors A–C and E; and the Final Management Report for factor D. We identified factors acting directly as stressors to the 82 coral species (*e.g.,* sedimentation and elevated ocean temperatures) as distinct from the sources responsible for those factors (*e.g.,* land management practices and climate change) and qualitatively evaluated the impact each threat has on the candidate species' extinction risk over the foreseeable future.

The proposed rule qualitatively ranked each threat as high, medium, low, or negligible (or combinations of two; *e.g.,* ''low-medium'') importance in terms of their contribution to extinction risk of all coral species across their ranges. These qualitative rankings considered: (1) The severity of the threat; (2) the geographic scope of the threat; (3) the level of certainty that corals in general (given the paucity of species-level information) are affected by each threat; (4) the projections of potential changes in the threat; and (5) the impacts of the threat on each species. Global climate change directly influences two of the three highest ranked threats, ocean warming and ocean acidification, and indirectly (through ocean warming) influences the remaining highest ranked threat, disease.

We identified nine threats (see Table 1) as posing either current or future extinction risk to the proposed corals. However, the SRR identified 19 threats that affect corals. The ten threats not included in Table 1 did not rank highly in their contribution to extinction risk, although they do adversely affect the species. Ocean warming, ocean acidification, and disease are overarching threats of high or medium-high importance when evaluating the extinction risk of the proposed species. These impacts are currently occurring, and are expected to worsen, posing increasingly severe effects on the species considered in this final rule. Other threats are of medium or medium-low importance when evaluating extinction risk because their effects are largely indirect and/or local to regional in spatial scale. These include trophic effects of fishing, sea-level rise, and water quality issues related to sedimentation and nutrients. The remaining threats can be locally acute, but because they affect limited geographic areas, they are of low importance when evaluating extinction risk. Examples in this category are predation or collection for the ornamental trade industry. These threats are more significant to certain species, such as those with naturally low abundance and/or those at severely depleted population levels. However, none of the species in this final rule can be characterized as such.

Table 1. The nine most important threats contributing to extinction risk for corals in general and ordered according to importance. The threat is paired with its corresponding ESA section 4 factor in the last column.

Threat	Importance	Section 4 factor
Ocean Warming	High	E.
Disease	High	C.
Ocean Acidification	Medium-High	E.
Trophic Effects of Fishing	Medium	A.
Sedimentation	Low-Medium	A and E.
Nutrients	Low-Medium	A and E.
Sea-Level Rise	Low-Medium	A.
Predation	Low	C.
Collection and Trade	Low	B.

Some comments (*e.g.,* Comment 26) suggested that local threats, such as sedimentation, are more important locally to species' extinction risk than the higher rated threats. In the proposed rule, we acknowledged that some of the local threats have been the cause of mass coral mortality in particular locations. Further, supplemental information provides evidence that local threats, such as overfishing and disease, have actually been more significant drivers of past coral reef species decline, particularly in the Caribbean (Jackson *et al.,* 2014). However, we must evaluate all threats that pose an extinction risk to the proposed species over the foreseeable future. Given the predicted impacts of climate-related threats over the foreseeable future, we maintain the relative importance ranking of the threats to reef-building corals generally. However, we acknowledge that lower importance threats also pose significant risk to individual species in certain locations.

Foreseeable Future

In the proposed rule, we established that the appropriate period of time corresponding to the foreseeable future is a function of the particular types of threats, the life-history characteristics, and the specific habitat requirements for the coral species under consideration. The timeframe corresponding to the foreseeable future takes into account the time necessary to provide for the conservation and recovery of each threatened species (*e.g.,* recruitment rate, growth rate, *etc.*) and the ecosystems upon which they depend, but is also a function of the reliability of available data regarding the identified threats and extends only as far as the data allow for making reasonable predictions about the species' response to those threats. As is discussed further in the Foreseeable Future and Current and Future Environmental Conditions subsections of the Risk Analysis section below, the period of time over which individual threats and responses may be projected varies according to the nature of the threat and the type of information available about that threat and the species' likely response. As described below, the more vulnerable a coral species is to the high importance threats (*i.e.,* ocean warming, diseases, ocean acidification), the more likely the species is at risk of extinction, either now or within the foreseeable future. The threats related to global climate change (*e.g.,* bleaching from ocean warming, ocean acidification) pose the greatest potential extinction risk to corals and have been evaluated with sufficient certainty out to the year 2100.

Comment 38 provides a summary of the comments we received on the determination of foreseeable future in the proposed rule and supporting documents as extending out to the year 2100. Many comments criticized the use of 2100 because they considered it to be too far into the future. We do not agree that 2100 is too far in the future to be considered foreseeable as it pertains to projections regarding climate-change related threats. As described in detail in the Global Climate Change—General Overview section, the IPCC Fifth Assessment Report (AR5), Climate Change 2013: The Physical Science Basis (IPCC, 2013), commonly referred to as the Working Group I Report (WGI), is a continuation of AR4. Most of AR5 WGI's models also use 2100 as the end-point (some models go beyond 2100) and the supplemental information included in AR5 reinforces our original basis for defining the foreseeable future as the period of time from the present to the year 2100 (IPCC, 2013). That is, the foreseeable future is not defined as the year 2100, but rather as the time period from the present to the year 2100, with increasing uncertainty in climate change projections over that time period. So while precise conditions during the year 2100 are not reasonably foreseeable, the general trend in conditions during the period of time from now to 2100 including the period 2081 to 2100 is reasonably foreseeable as a whole, although less so through time. Because the time period of the present to the year 2100 is strongly supported as a reasonably foreseeable timeframe in the climate science projections in AR5's WGI, and because the climate-related impacts to coral reefs may be substantial within that timeframe, our conclusion that 2100 is the appropriate timeframe for purposes of analyzing climate change-related threats remains unchanged.

Nine Most Important Threats to Reef-Building Corals

As described above and shown in Table 1, we considered nine threats to be the most important to the current or expected future extinction risk of reef-building corals: Ocean warming, disease, ocean acidification, trophic effects of reef fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade. Vulnerability of a coral species to a threat is a function of susceptibility and exposure, considered at the appropriate spatial and temporal scales. In this finding, the spatial scale is the current range of the species, and the temporal scale is from now through the foreseeable future. Susceptibility refers to the response of coral colonies to the adverse conditions produced by the threat. Susceptibility of a coral species to a threat is primarily a function of biological processes and characteristics, and can vary greatly between and within taxa. Susceptibility depends on direct effects of the threat on the species, and it also depends on the cumulative (*i.e.*, additive) and interactive (*i.e.*, synergistic or antagonistic) effects of multiple threats acting simultaneously on the species. Exposure refers to the degree to which the species is likely to be subjected to the threats throughout its range, so the overall vulnerability of a coral species to threats depends on the proportion of colonies that are exposed to the threats. Thus, the exposure of a species to threats, on a range-wide scale, is a function of physical processes and characteristics that affect the frequency or degree to which individual colonies experience the threats and the ability of its spatial and demographic traits to affect its overall vulnerability. A species may not necessarily be highly vulnerable to a threat even when it is highly susceptible to the threat, if exposure is low over the appropriate spatial and temporal scales. Consideration of the appropriate spatial and temporal scales is particularly important, because of potential high variability in some threats over the large spatial scales. The nine most important threats are summarized below, including general descriptions of susceptibility and exposure. Species-specific threat susceptibilities are described in the Species-specific Information and Determinations section.

Global Climate Change—General Overview

Several of the most important threats contributing to the extinction risk of corals are related to global climate change. The main concerns regarding impacts of global climate change on coral reefs generally, and on the proposed corals in particular, are the magnitude and the rapid pace of change in GHG concentrations (*e.g.*, carbon dioxide (CO_2) and methane) and atmospheric warming since the Industrial Revolution in the mid-19th century. These changes are increasing the warming of the global climate system and altering the carbonate chemistry of the ocean (ocean acidification), which affects a number of biological processes in corals, including secretion of their skeletons. The description and analysis of global climate change in the proposed rule and supporting documents were based largely on the IPCC AR4, The Physical Science Basis (IPCC, 2007) and supporting literature. Supplemental information gathered during the public engagement period shows that global temperatures continue to increase and that temperature patterns differ regionally.

As summarized in Comment 11, we received many comments on our analysis of global climate change in the proposed rule. Some commenters asserted that we did not adequately portray the level of uncertainty associated with the available climate change models. Others provided information that global GHG emissions and global temperatures continue to rise unabated. Additionally, significant supplemental information has become available on global climate change since the proposed rule, specifically, AR5's WGI (IPCC, 2013), and its companion report, Climate Change 2014: Impacts, Adaptation, and Vulnerability, commonly referred to as the Working Group II Report (WGII; IPCC, 2014).

The IPCC has summarized the major sources of uncertainty associated with AR5's WGI projections of global climate change as: (1) The projected rate of increase for GHG concentrations; (2) strength of the climate's response to GHG concentrations; and (3) large natural variations. The warming rate slow-down (or ''hiatus'' discussed in the Threats Evaluation—Ocean Warming section) since 1998 is an example of a large natural variation that was not predicted by the models at that time. However, AR4's projections are built on scientifically sound principles, and they fairly simulate many large-scale aspects of present-day conditions, and thereby provided the best available information on climate change at the time the proposed rule was published. Overall uncertainty is not necessarily any greater in AR5 than in AR4, but rather the uncertainty is understood better and expressed more clearly in AR5's WGI (IPCC, 2007; IPCC, 2013; Knutti and Jan Sedlácek, 2012). AR5's WGI represents the largest synthesis of global climate change physical science ever compiled, and a substantial advance from AR4. WGI is divided into four sections that examine observations, drivers, understanding, and projections of changes to the global climate system. The primary results of these four sections relevant to this rule are summarized below; then a summary of the potential impacts to corals resulting from the IPCC climate change scenario that we consider to be the most impactful to corals is provided in the RCP8.5 Projections section below, with a focus on ocean warming and acidification, two of the most important threats to corals.

The first section of WGI considers observations of changes in the climate system, which refers to description of past climate patterns, and the certainty associated with the same. The overall conclusion of this section is that warming of the climate system is unequivocal and since the 1950s, many of the observed changes are unprecedented over decades to millennia. With regard to ocean warming, it is ''virtually certain'' that the upper ocean (0–700 m) warmed from 1971 to 2010. With regard to ocean acidification, it is ''very likely'' that the pH of surface ocean waters has decreased as a result of ocean uptake of anthropogenic CO_2 from the atmosphere. With regard to sea-level rise, it is ''virtually certain'' that the global mean sea level rose by 19 cm from 1901 to 2010 (IPCC, 2013).

The second section of WGI considers drivers of changes in the climate system, which refers to explanations of factors forcing climate patterns. Natural and anthropogenic substances and processes that alter the Earth's energy budget are drivers of climate change. In AR5, radiative forcing (RF, measured in watts per square meter, W/m^2) quantifies energy fluxes caused by changes in these drivers relative to the year 1750. Increasing RF leads to surface warming, and decreasing RF leads to surface cooling. The concentration of CO_2 in the atmosphere is the dominant anthropogenic driver. Higher atmospheric CO_2 results in: Ocean warming via the greenhouse effect, ocean acidification via oceanic uptake of CO_2, and rising sea levels via ice melting and thermal expansion. Patterns in solar activity and major volcanic eruptions are the two dominant natural drivers. Solar activity can either increase or decrease RF, whereas major volcanic eruptions only decrease RF. Current total RF relative to 1750 is positive, and has led to an uptake of energy by the climate system. The largest contribution to current total RF is the increasing atmospheric concentration of CO_2 since 1750, most of which has been anthropogenic CO_2 emitted since 1860, and the mean rate of increase in CO_2 is unprecedented in the past 20,000 years. Current CO_2 levels (~400 ppm) will result in continued warming even if anthropogenic emissions went to zero now (this is referred to as ''commitment'' to future warming from the CO_2 build-up already in the atmosphere), but reducing emissions now would strongly influence the levels of future warming (IPCC, 2013).

The third section of WGI describes past climate patterns to understand the changes in the climate system. It is ''extremely likely'' that human activities caused more than half of the observed increase in global average surface temperature from 1951 to 2010. Anthropogenic GHGs have ''very likely'' made a substantial contribution to upper-ocean warming (above 700 m) observed since the 1970s. It is also ''very likely'' that oceanic uptake of anthropogenic CO_2 has reduced surface water pH. The anthropogenic ocean warming observed since the 1970s has contributed to global sea-level rise over this period through ice melting and thermal expansion (IPCC, 2013).

The fourth section of WGI uses projected changes in the climate system to model potential patterns of future climate. WGI uses a new set of four representative concentration pathways (RCP) that provide a standard framework for consistently modeling future climate change. These replace the old Special Report on Emissions Scenarios (SRES) system used in prior assessments. The new RCPs are named according to increases in radiative forcing (RF) relative to the 1986–2005 average by the year 2100 of 2.6, 4.5, 6.0, and 8.5 W/m^2, RCP2.6, RCP4.5, RCP6.0, and RCP8.5. The four new pathways have atmospheric CO_2 equivalents of 421 (RCP2.6), 538 (RCP4.5), 670 (RCP6.0), and 936 ppm (RCP 8.5) in 2100, and follow very different trajectories to reach those endpoints. The purpose of the RCPs was to explicitly explore the impact of different climate policies in addition to the no-climate-policy scenarios explored in the earlier scenarios (Van Vuuren *et al.*, 2011). The four new pathways were developed with the intent of providing a wide range of total climate forcing to guide policy discussions and specifically include one mitigation pathway leading to a very low forcing level (RCP2.6), two stabilization pathways (RCP4.5 and RCP6), and one pathway with continued high GHG emissions (RCP8.5).

The RCP method more strongly represents the physical processes underlying climate change, and various factors affecting GHG emissions globally, than previous methods. WGI adjusts the likely global surface warming that would result from a doubling of atmospheric CO_2 to 1.5–4.5 °C (compared to AR4's estimate of 2.0–4.5 °C), due to improved understanding of the climate system, the extended temperature record in the atmosphere and ocean, and new estimates of radiative forcing to GHG concentrations. Taken together, the four new pathways project wide ranges of increases in ocean warming, ocean acidification, and sea level rise globally throughout the 21st century with conditions seen in RCP 2.6–6.0 requiring significant changes in anthropogenic GHG emissions (IPCC, 2013).

The proposed rule and supporting documents assumed that AR4's highest-emission scenario A1FI was the most likely to occur for two reasons: (1) Recent annual GHG emission growth rates had exceeded the GHG emission growth rates in A1F1 (except 2009 when the global recession slowed growth); and (2) there were no indications that major reductions in GHG emissions would occur in the near to mid-term future (decades) through national or international policies or major changes in the global fossil fuel economy (Brainard *et al.*, 2011). Recent annual GHG emission growth rates (except 2009) exceed the GHG emission growth rates in RCP8.5 (Le Quéré *et al.*, 2013). While the President's Climate Action Plan and intensified international climate negotiations may change global emissions trajectories, we make the conservative assumption to evaluate RCP8.5, and its projections for ocean warming and ocean acidification, in our assessment of extinction risk for the corals in the final rule. RCP8.5 is the scenario with the highest GHG emissions rate and subsequent future GHG levels; thus it would be the most impactful to corals through ocean warming and ocean acidification. However, should another of the IPCC RCPs ultimately be realized, the negative impacts to corals would be lower.

As described above, we received and collected significant supplemental information regarding our consideration of global climate change in the proposed rule. Additional observations, data, and testing have produced better models and a greater understanding of the uncertainty inherent in climate change projections. Annual GHG emission rates continue to climb to record levels, and the last decade has been the warmest on record, underscoring the proposed rule's conclusions about climate change threats to reef-building corals. We conclude that the supplemental information supports the central premise of the proposed rule that global climate change-related threats have already caused widespread impacts to corals and coral reefs and these impacts will become increasingly severe from now to 2100, with correspondingly severe consequences for corals and coral reefs. However, we acknowledge that the interpretation of future climate change threats to corals and coral reefs is associated with complexity and uncertainty, and that precise effects on individual species of reef-building corals are difficult to determine. Species-specific threat susceptibilities of each of the 65 species in this final rule to the threats resulting from global climate change are described in the Species-specific Information and Determinations section below.

RCP8.5 Projections

Because we have determined that RCP8.5 is the most impactful pathway to corals, we provide a summary of RCP8.5's projections over the foreseeable future for ocean warming and ocean acidification (IPCC, 2013). Where possible, projections are provided for the near-term (to mid-century) and long-term (to 2100), and globally and regionally (Indo-Pacific and Caribbean). Implications for coral reefs are also described.

Ocean Warming. Under RCP8.5, annual averaged, globally averaged, surface ocean temperature is projected to increase by approximately 0.7 °C by 2030 and 1.4 °C by 2060 compared to the 1986–2005 average, with the 10 to 90 percent range increasing over that time period to approximately +/−0.7 °C by 2060 (IPCC, 2013; WGI Figure 11.19). Projected changes in annual mean ocean temperature between 60 °N and 60 °S latitude in 2081–2100 are shown in WGI Figure 12.12. Under RCP8.5, annual mean surface ocean temperature between 60 °N and 60 °S latitude is projected to increase by approximately 3.5 °C by 2081–2100 compared to the 1986–2005 average (IPCC, 2013; WGI Figure 12.12). A different graph using the same data shows global annual mean surface ocean temperature is projected to increase by approximately 3.5 °C by 2081–2100 compared to the 1986–2005 average, with 5 to 95 percent range of +/−1–1.5 °C (IPCC, 2013; Figure AI.SM8.5.4). Thus, RCP8.5 projects that global annual mean ocean surface temperatures will increase by approximately 0.4–1 °C by 2030, approximately 0.7–2 °C by 2060, and approximately 2–5 °C by 2081–2100 (IPCC, 2013).

Projected changes in Indo-Pacific annual median ocean surface temperatures (*i.e.*, WGI's West Indian Ocean, North Indian Ocean, Southeast Asia, North Australia, and Pacific Islands regions), and Caribbean annual median land and ocean combined surface temperatures, compared to the 1986–2005 average are shown in the figures in WGI's Annex I's Supplementary Material for RCP8.5 for these six WGI regions, which together cover the ranges of the species included in this final rule. The figures include graphs in the upper right showing the projected median temperature increase to 2100 under RCP8.5, the 25 to 75 percent range, and the 5 to 95 percent range. The figures also includes maps of each region showing projected changes spatially under RCP8.5 for the time periods 2016–2035, 2046–2065, and 2081–2100, and for the 25 percent, 50 percent, and 75 percent projections under RCP8.5 for each of these time periods. For the Caribbean, the range of projections spanned by the 25, 50, and 75 percent range maps are: For 2016–2035, increases of 0.5–1.0 °C; for 2046–2065, increases of 1.0–3.0 °C; and for 2081–2100, increases of 2.0–4.0 °C. Spatial variability in the projections consists mostly of larger increases in the Greater Antilles and Jamaica, and lower increases in the Lesser Antilles and the Bahamas (Figure AI.SM8.5.44). The percent ranges in the projections described above are from the maps and are for the 25 to 75 percent range, however range of projections within the 5 to 95 percent range are considerably greater, as shown in the bar-and-whisker graph in the upper right of each figure (IPCC, 2013).

For the Indo-Pacific (WGI's West Indian Ocean, North Indian Ocean, Southeast Asia, North Australia, and Pacific Islands regions), the range of projections spanned by the 25, 50, and 75 percent range maps are: For 2016–2035, increases of 0.0–1.0 °C; for 2046–2065, increases of 1.0–3.0 °C; and for 2081–2100, increases of 2.0–5.0 °C. Spatial variability in the projections consists mostly of larger increases in the Red Sea, Persian Gulf, and the Coral Triangle, and lower increases in the central and eastern Indian Ocean and south-central Pacific (Figures AI.SM8.5.92, 116, 124, 132, and 140). The percent ranges in the projections described above are from the maps and are for the 25 to 75 percent range, however range of projections within the 5 to 95 percent range are considerably greater, as shown in the bar-and-whisker graph in the upper right of each figure (IPCC, 2013).

To summarize ocean warming projections, RCP8.5 projects annual median ocean surface temperature increases for the Indo-Pacific, and annual median land and ocean combined surface temperature increases for the Caribbean. Projected median temperatures, and associated 25 to 75 percent range and 5 to 95 percent range, are provided for the time periods of 2016–2035, 2046–2065, and 2081–2100. We interpret these projections as follows: (1) Global annual median ocean surface temperatures are likely to rise approximately 2–5 °C by 2081–2100, exacerbating the impacts of ocean warming on reef-building corals; (2) these global mean projections are not necessarily representative of ocean surface temperature conditions throughout the ranges and habitats of the species in this final rule through the foreseeable future, due to spatial variability and statistical range of the RCP8.5 ocean warming projections described above for the Indo-Pacific and Caribbean regions; and (3) ocean surface temperature conditions in the foreseeable future within the ranges of the species in this final rule are assumed to vary spatially at the coarse spatial scales shown in WGI for the Indo-Pacific and Caribbean regions, and more so at finer spatial scales, and to fall within the statistical ranges projected for the Indo-Pacific and Caribbean regions.

Ocean Acidification. Under RCP8.5, mean surface pH in the tropics (20 °N to 20 °S) is projected to decline from the current pH of approximately 8.05 to approximately 7.95 by 2050, and to approximately 7.75 by 2100, or a reduction of 0.31 (statistical range of 0.30 to 0.32) by 2100 (IPCC, 2013; WGI Figure 6.28a). Projected changes in global surface pH in the 2090s compared to the 1990s under RCP8.5 are shown in the map in WGI Figure 6.28b. In the tropical Indo-Pacific, decreases of 0.25 to 0.40 are projected, with the lower decreases in the central and eastern Pacific, and the higher decreases in the GBR area and the northern Philippines, while most of the Caribbean is projected to decrease in pH by 0.30 to 0.35. The pH reductions associated with RCP8.5 are projected to result in declining aragonite saturation states, as shown in WGI Figure 6.29. Projected median surface aragonite saturation states of the world's oceans are shown for 2050 and 2100 in Figure 6.29d and f respectively, and by depth for the Atlantic and Pacific Oceans in 2100 in Figure 6.29c and e respectively. Surface aragonite saturation states in the tropical Indo-Pacific and Caribbean are projected to decline from current levels of over 3, to less than 2.5 by 2100, with similar spatial patterns as for pH reductions (IPCC, 2013; WGI Figure 6.29). Statistical range is not provided for aragonite saturation state, but we assume it to be similar to that associated with pH projections. As shown in Figures 6.28 and 6.29, spatial variability is projected under RCP8.5 for both pH and aragonite saturation state reductions over the foreseeable future within the ranges of the species included in this final rule (IPCC, 2013).

We interpret RCP8.5's ocean acidification projections as follows: (1) Mean surface pH in the tropics is projected to decline by approximately 0.31 to approximately 7.75 by 2100, with a subsequent large decline in aragonite saturation state in surface tropical waters, exacerbating the impacts of ocean acidification on reef-building corals; (2) surface pH and aragonite saturation state conditions throughout the ranges of the species in this final rule through the foreseeable future are not necessarily represented by these mean projections, due to the spatial variability within the Indo-Pacific and Caribbean regions, and the statistical range of the RCP8.5 ocean acidification projections; and (3) surface pH and aragonite saturation state conditions in the foreseeable future within the ranges of the species in this final rule are assumed to vary spatially at the coarse spatial scales shown in WGI for the Indo-Pacific and Caribbean regions, and more so at finer spatial scales, and to fall within the statistical ranges projected for the Indo-Pacific and Caribbean regions.

Implications for Coral Reef Ecosystems. AR5's WGII Report describes the effects of WGI's climate change projections on the world's ecosystems, including coral reefs. The report includes a description of ''Projected Impacts'' on coral reefs of all four WGI pathways combined, and a general overview of projected impacts to coral reefs. While this information does not specifically describe projected impacts of RCP8.5 to coral reefs by 2100, it strongly suggests that the projected impacts of ocean warming and ocean acidification will increase (IPCC, 2014). Likewise, the recent U.S. National Climate Assessment (NCA) report describes the effects of projected climate change on United States ecosystems, including coral reefs. Chapter 24 of the report includes a brief and general description of projected climate change without specifically examining any particular pathway (Doney *et al.*, 2014). As with WGII, while the NCA report does not specifically describe projected impacts of RCP8.5 to coral reefs by 2100, it strongly suggests that the projected impacts of ocean warming and ocean acidification will increase on United States coral reefs.

Recent papers specifically address future changes in Indo-Pacific and Caribbean coral reef ecosystems resulting from RCP8.5's projections of combined ocean warming and ocean acidification, including Couce *et al.* (2013a) and van Hooidonk *et al.* (2014). Couce *et al.* (2013a) uses RCP8.5's ocean warming and ocean acidification projections to develop predictions of ''average change in suitability'' of coral reef habitat by 2070, concluding that declines in conditions will be driven primarily by ocean warming, and vary spatially within the ranges of the species included in this final rule. Couce *et al.* (2013) predicts marked declines in environmental suitability for shallow coral reef habitats across the equatorial western Pacific and adjacent areas (*e.g.*, Coral Triangle) by 2070, and generally less favorable conditions elsewhere on Indo-Pacific and Caribbean coral reefs. Some coral reef areas show little or no change in environmental suitability by 2070, including portions of the western Indian and central Pacific Oceans, likely because seawater temperatures are moderated by physical factors such as higher latitudes or upwelling but aragonite saturation states are suitable (Couce *et al.*, 2013a; Fig. 1e). Many species included in this final rule occur in areas of the western Indian and central Pacific Oceans predicted to have little or no change in environmental suitability by 2070. Notably, the paper concluded the detrimental effect of higher ocean warming appears to strongly outweigh the impacts of lower aragonite saturation states for tropical shallow water coral reefs (Couce *et al.*, 2013a).

van Hooidonk *et al.* (2014) also applies RCP8.5's ocean warming and ocean acidification projections to predict ''when severe coral bleaching events start to occur annually, and of changes in aragonite saturation state'' over the 21st century. The paper concludes that 90 percent of all coral reefs are projected to experience severe bleaching annually by 2055, that five percent declines in calcification are projected for all reef locations by 2034, with the predicted changes in conditions varing spatially across the geographic ranges of the species included in this final rule. These authors predicted that the most rapid increases in ocean warming will occur in the western equatorial Pacific, the slowest in the Indian Ocean, eastern Pacific Ocean, and high latitude areas, and intermediate elsewhere (van Hooidonk *et al.*, 2014; Fig 1a). The most rapid declines in aragonite saturation state are predicted for the same general areas as the slowest warming, the slowest declines in aragonite saturation state in roughly the same areas as the most rapid warming, and intermediate elsewhere in the Indo-Pacific and in the Caribbean (van Hooidonk *et al.*, 2014; Fig 1d). One of the paper's conclusions is that there are no real refugia for coral reefs to the combined threats of higher ocean warming and lower aragonite saturation states (van Hooidonk *et al.*, 2014).

Several points to consider when interpreting Couce *et al.* (2013a) and van Hooidonk *et al.* (2014) are: (1) The different results and conclusions are likely due to the different methods, and illustrate the sensitivity and variability in predicting the impacts of projected changes in climate on coral reefs; (2) both papers used very coarse spatial scales (1° × 1° cells, or >10,000 km^2 at the Equator), thus each cell can include many different reefs that collectively represent diverse coral communities and habitats, which in turn can affect the local spatial and temporal patterns of coral responses to ocean warming and acidification; (3) both papers predict high spatial variability in future conditions across coral reefs, and both show the western equatorial Pacific as having the most degraded future conditions, and parts of the Indian Ocean, central Pacific, and some outlying areas as having less degraded future conditions; and (4) neither paper analyzed the impacts of future climate change on individual coral species.

In conclusion, RCP8.5 projects impacts to global coral reef ecosystems over the foreseeable future from the combined effects of increased ocean temperature and ocean acidification, the effects of which are likley to be compounded by increasing coral disease, trophic effects of fishing, land-based sources of pollution, and other threats to corals. However, projecting species-specific responses to global threats is complicated by several physical and biological factors: (1) Global projections of changes to ocean temperatures and acidification over the foreseeable future are associated with three major sources of uncertainty (GHG emissions assumptions, strength of the climate's response to GHG concentrations, and large natural variations); (2) there is spatial variability in projected environmental conditions across the ranges of the species in this final rule at any given point in time; and (3) species-specific responses depend on many biological characteristics, including, at a minimum, distribution, abundance, life history, susceptibility to threats, and capacity for acclimatization. The available species-specific information on how species in this final rule respond to climage change is limited. Therefore, analysis of the biological characteristics on a case-by-case basis is emphasized in considering a species' vulnerability to extinction.

Ocean Warming (High Importance Threat, ESA Factor E)

Ocean warming is considered under ESA Factor E—other natural or manmade factors affecting the continued existence of the species—because the effect of the threat results from human activity and affects individuals of the species directly, and not their habitats. In the proposed rule, we described the threat from ocean warming as follows. Mean seawater temperatures in reef-building coral habitat in both the Caribbean and Indo-Pacific have increased during the past few decades, and are predicted to continue to rise between now and 2100. As also described in the proposed rule, the frequency of warm-season temperature extremes (warming events) in reef-building coral habitat in both the Caribbean and Indo-Pacific has increased during the past two decades, and it is also predicted to increase between now and 2100.

Ocean warming is one of the most important threats posing extinction risks to the proposed coral species; however, individual susceptibility varies among species. The primary observable coral response to ocean warming is bleaching of adult coral colonies, wherein corals expel their symbiotic zooxanthellae in response to stress. For many corals, an episodic increase of only 1 °C–2 °C above the normal local seasonal maximum ocean temperature can induce bleaching. Corals can withstand mild to moderate bleaching; however, severe, repeated, or prolonged bleaching can lead to colony death. Coral bleaching patterns are complex, with several species exhibiting seasonal cycles in symbiotic dinoflagellate density. Thermal stress has led to bleaching and associated mass mortality in many coral species during the past 25 years. In addition to coral bleaching, other effects of ocean warming detrimentally affect virtually every life-history stage in reef-building corals. Impaired fertilization, developmental abnormalities, mortality, impaired settlement success, and impaired calcification of early life phases have all been documented. In the proposed rule, we relied heavily on AR4 in evaluating extinction risk from ocean warming because it contained the most thoroughly documented and reviewed assessments of future climate and represented the best available scientific information on potential future changes in the earth's climate system. Emission rates in recent years have met or exceeded levels predicted by AR4's worst-case scenarios, resulting in all scenarios underestimating the projected climate condition.

Exposure of colonies of a species to ocean warming can vary greatly across its range, depending on colony location (*e.g.,* latitude, depth, bathymetry, habitat type, *etc.*) and physical processes that affect seawater temperature and its effects on coral colonies (*e.g.,* winds, currents, upwelling shading, tides, *etc.*). Colony location can moderate exposure of colonies of the species to ocean warming by latitude or depth, because colonies in higher latitudes and/or deeper areas are usually less affected by warming events. Deeper areas are generally less affected typically because lower irradiance reduces the likelihood of warming-induced bleaching. Also, some locations are blocked from warm currents by bathymetric features, and some habitat types reduce the effects of warm water, such as highly fluctuating environments. Physical processes can moderate exposure of colonies of the species to ocean warming in many ways, including processes that increase mixing (*e.g.,* wind, currents, tides), reduce seawater temperature (*e.g.,* upwelling, runoff), or increase shading (*e.g.* turbidity, cloud cover). Exposure of colonies of a species to ocean warming will likely vary annually and decadally, while increasing over time, because: (1) Numerous annual and decadal processes that affect seawater temperatures will continue to occur in the future (*e.g.,* inter-decadal variability in seawater temperatures and upwelling related to El-Niño Southern Oscillation); and (2) ocean warming is predicted to substantially increase by 2100.

Multiple threats stress corals simultaneously or sequentially, whether the effects are cumulative (the sum of individual stresses) or interactive (*e.g.,* synergistic or antagonistic). Ocean warming is likely to interact with many other threats, especially considering the long-term consequences of repeated thermal stress, and that ocean warming is expected to continue to increase over the foreseeable future. Increased seawater temperature can lower resistance to coral diseases and reduce coral health and survivorship. Coral disease outbreaks often have either accompanied or immediately followed bleaching events, and also follow seasonal patterns of high seawater temperatures. The effects of greater ocean warming (*e.g.,* increased bleaching, which kills or weakens colonies) are expected to interact with the effects of higher storm intensity (*e.g.,* increased breakage of dead or weakened colonies), resulting in an increased rate of coral declines. Likewise, ocean acidification and nutrients may reduce thermal thresholds to bleaching, increase mortality, and slow recovery.

There is also mounting evidence that warming ocean temperatures can have direct impacts on early life stages of corals, including abnormal embryonic development at 32 °C and complete fertilization failure at 34 °C for one Indo-Pacific *Acropora* species. In addition to abnormal embryonic development, symbiosis establishment, larval survivorship, and settlement success have been shown to be impaired in Caribbean brooding and broadcasting coral species at temperatures as low as 30 °C–32 °C. Further, the rate of larval development for spawning species is appreciably accelerated at warmer temperatures, which suggests that total dispersal distances could also be reduced, potentially decreasing the likelihood of successful settlement and the replenishment of extirpated areas.

Finally, warming will continue causing increased stratification of the upper ocean because water density decreases with increasing temperature. Increased stratification results in decreased vertical mixing of both heat and nutrients, leaving surface waters warmer and nutrient-poor. While the implications for corals and coral reefs of these increases in warming-induced stratification have not been well studied, it is likely that these changes will both exacerbate the temperature effects described above (*e.g.,* increase bleaching and decrease recovery) and decrease the overall net productivity of coral reef ecosystems (*e.g.,* fewer nutrients) throughout the tropics and subtropics.

Overall, there is ample evidence that climate change (including that which is already committed to occur from past GHG emissions and that which is reasonably certain to result from continuing and future emissions) will follow a trajectory that will have a major impact on corals. There has been a recent research emphasis on the processes of acclimatization and adaptation in corals, but in the proposed rule we determined that, taken together, the body of research was inconclusive as to how these processes may affect individual corals' extinction risk, given the projected intensity and rate of ocean warming. As detailed in Comments 12–16, we received numerous comments related to ocean warming threats to corals that focused on the following aspects: (1) General future projections of ocean warming levels; (2) accounting for spatial variability; (3) the future decline of coral reefs because of increasing GHG emissions; (4) the possibility of wide ranging responses by coral reef ecosystems; (5) the specific effects of ocean warming on reef-building corals; and (6) the capacity of reef-building corals for acclimatization and adaptation to ocean warming.

With regard to the future projections of global climate change, the proposed rule and supporting documents assumed that AR4's highest-emission scenario A1FI was the most likely. As discussed in Global Climate Change—General Overview, we assume that for corals RCP8.5 is the most impactful pathway for present to the year 2100. Ocean warming projections and implications for coral reefs are described above in the RCP8.5 Projections section.

Comment 12 also criticized our lack of consideration of the post-1998 hiatus in global warming. The proposed rule did not consider this phenomenon as the issue was only emerging during the time the proposed rule was drafted. However, because supplemental information has become available since that time, we consider it here. Despite unprecedented levels of GHG emissions in recent years, a slow-down in global mean surface air temperature warming has occurred since 1998, which AR5's WGI refers to as a ''hiatus.'' Despite this slowdown in warming, the period since 1998 is the warmest recorded and ''Each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850.''

The slow-down in global mean surface warming since 1998 is not fully explained by AR4 or AR5 WGI's models, but is consistent with the substantial decadal and interannual variability seen in the instrumental record and may result, in part, from the selection of beginning and end dates for such analyses. Possible factors in the slow-down may include the following: Heat absorption by the deep ocean (Guemas *et al.,* 2013; Levitus *et al.,* 2012) facilitated by stronger than normal trade winds (England *et al.,* 2014), volcanic eruptions over the last decade (Santer *et al.,* 2014), La Niña-like decadal cooling that produces multi-year periods of slower warming than the long-term anthropogenic forced warming trend (Benestad, 2012; Easterling and Wehner, 2009; Kosaka and Xie, 2013), inherent variability within the climate system that cannot currently be modeled, and potentially other factors (IPCC, 2013). As explained above, the major sources of uncertainty in climate change projections such as AR4 or AR5's WGI are: (1) The projected rate of increase for GHG concentrations; (2) strength of the climate's response to GHG concentrations; and (3) large natural variations. The slow-down in warming since 1998 is an example of a large natural variation that could not be predicted, at least by the models at that time.

Comment 12 identified several sources of spatial variability in ocean warming and requested our consideration of additional information. The proposed rule acknowledged both spatial and temporal variability in ocean warming and considered the effect that variability would have on the proposed corals. However, we acknowledge that supplemental information has since become available, and we consider it here. Regional and local variability in ocean warming conditions may lead to warming-induced bleaching that is more or less severe regionally or locally than globally. A hot spot of ocean warming occurs in the equatorial western Pacific where regional warming is higher than overall warming in the Indo-Pacific, exposing corals and coral reefs in this area to a higher risk of warming-induced bleaching. The hot spot overlaps the Coral Triangle (Couce *et al.,* 2013b; Lough, 2012; Teneva *et al.,* 2012; van

Hooidonk *et al.,* 2013b). Several other areas in the Indo-Pacific have been identified as having lower than average warming, including the western Indian Ocean, Thailand, the southern GBR, central French Polynesia, and the eastern equatorial Pacific, potentially resulting in relatively lower risk of warming-induced coral bleaching in these areas (Couce *et al.,* 2013b; van Hooidonk *et al.,* 2013b). Spatial variability in ocean warming is lower in the much smaller Caribbean, and there are fewer areas there with lower than average warming (Buddemeier *et al.,* 2011). The regional and local heterogeneity in ocean warming likely results in high variability in coral responses across spatial scales (Selig *et al.,* 2010).

There are several types of temporal variability in ocean warming on coral reefs. First, the rate of ocean warming itself changes over time. For example, ocean warming has increased in the Indo-Pacific since 1950, but at different rates at different times (Lough, 2012). Second, different periods of ocean warming can result in variability in warming-induced bleaching at the same location. For example, a study in Thailand showed significant differences in the susceptibility of coral taxa to bleaching events between the years 1998 and 2010 and among coral species at the same site (Sutthacheep *et al.,* 2013). Spatial variability in ocean warming between sites also results in temporal variability in ocean warming impacts, as the different areas are subsequently affected at different rates into the future (van Hooidonk *et al.,* 2013b). For example, a recent study found that Australian subtropical reef-building coral communities are affected by ocean warming more slowly than tropical reef-building coral communities, resulting in slower rates of changes in the subtropical than tropical communities (Dalton and Roff, 2013). These studies underscore the temporal variability of ocean warming and warming-induced bleaching across the ranges of reef-building coral species, complicating the interpretation of the effects of ocean warming on any given coral species across its range and over time.

Mesophotic and marginal habitats serving as refugia from ocean warming are relatively new and potentially important considerations for the vulnerability of coral species to ocean warming. Mesophotic habitats continue to be explored, with new surveys finding larger habitat areas and greater depth distributions for some reef-building corals (Blyth-Skyrme *et al.,* 2013; Bridge and Guinotte, 2012). Supplemental information demonstrates the potential for mesophotic habitat to provide refugia from ocean warming (Bridge *et al.,* 2013a; Smith *et al.,* in press), although it does not always do so (Neal *et al.,* 2013). Marginal habitats, such as high latitude sites, upwelling regions, and turbid areas like the GBR inner shelf, also may provide refugia from ocean warming for some species in some conditions (Browne *et al.,* 2012; Couce *et al.,* 2013b; Dalton and Roff, 2013), but not others (Lybolt *et al.,* 2011). Taken together, mesophotic and marginal habitats may represent a network of refugia from ocean warming for some species.

Comment 14 emphasized both that coral reefs are likely to decline sharply in the future because of increasing GHG emissions (*e.g.,* Carpenter *et al.,* 2008; Donner, 2009; Frieler *et al.,* 2012; Kiessling and Baron-Szabo, 2004) and that a wide range of responses by coral reef ecosystems are possible. Studies provided by commenters, and others on recent modeling results (Frieler *et al.,* 2012; van Hooidonk and Huber, 2012; van Hooidonk *et al.,* 2013b) and scientific opinion statements (Birkeland *et al.,* 2013; ICRS, 2012) suggest disastrous effects of ocean warming, in combination with other threats, on coral reef ecosystems. For example, even in AR5 WGI's best-case pathway (RCP2.6) where CO_2 equivalent concentrations peak at 455 ppm, one model suggests that 95 percent of coral reefs will experience annual bleaching conditions by the end of the century (van Hooidonk *et al.* 2013b). Another model suggests that preserving more than 10 percent of coral reefs worldwide would require limiting warming to less than 1.5 °C above pre-industrial levels. Even assuming high adaptive capacity of corals and the more optimistic AR5 pathways, the model suggests that one-third of the world's coral reefs are projected to be subject to long-term degradation (Frieler *et al.,* 2012). In addition, the combined effects of ocean warming and ocean acidification would produce even more severe impacts on coral reefs globally (van Hooidonk *et al.,* 2013a; Yara *et al.,* 2012).

These and other studies predict the irreversible disappearance of coral reefs on a global scale in the next few decades. However, other recent studies suggest that coral reef degradation resulting from global climate change threats alone is likely to be a more spatially, temporally, and taxonomically heterogeneous process. These studies indicate that coral reef ecosystems, rather than disappear entirely as a result of future impacts, will likely persist, but with unpredictable changes in the composition of coral species and ecological functions (Hughes *et al.,* 2012; Pandolfi *et al.,* 2011). Many factors contribute to the heterogeneous responses of coral reefs to climate change threats, including complexity associated with coral reef habitat, as well as the biology of reef-building coral species themselves. As described in the Corals and Coral Reefs section, the exceptional complexity, extent, and diversity of coral reef habitat increases the uncertainty associated with coarse modeling of reef responses to climate change threats. Likewise, many aspects of reef-building coral biology contribute to complex responses to ocean warming, including species-level processes such as capacity for acclimatization and adaptation (Palumbi *et al.,* 2014), the potential for range expansion (Yamano *et al.,* 2011; Yara *et al.,* 2011), and community-level processes such as changes in competition and predation (Cahill *et al.,* 2013; Hughes *et al.,* 2012). These different processes occur simultaneously, and contribute to highly-variable, complex, and uncertain responses of reef-building coral species and in turn coral reefs to climate changes threats like ocean warming. Moreover, management of local threats can increase resilience of coral reefs to ocean warming and other global climate change threats (Jackson *et al.,* 2014; Pandolfi *et al.,* 2011), as described further in the Threats Evaluation—Inadequacy of Existing Regulatory Mechanisms section.

Comment 15 focused on the specific effects of ocean warming on reef-building corals. The proposed rule described the known specific effects of ocean warming as well as the threats that act simultaneously or sequentially, and whether the effects are cumulative (the sum of individual stresses) or interactive (*e.g.,* synergistic or antagonistic). The rapidly growing literature on synergistic effects of ocean warming-induced bleaching with other threats demonstrates that bleaching is exacerbated by nutrients (Cunning and Baker, 2013; Vega Thurber *et al.,* 2013; Wiedenmann *et al.,* 2013), disease is exacerbated by warm temperatures and bleaching (Ban *et al.,* 2013; Bruno *et al.,* 2007; Muller and van Woesik, 2012; Rogers and Muller, 2012), ocean warming and acidification may impact corals in opposite but converging ways (van Hooidonk *et al.,* 2013a; Yara *et al.,* 2012), and bleaching is exacerbated by a variety of physical factors (Yee and Barron, 2010) or can be reduced by biological factors (Connolly *et al.,* 2012; Fabricius *et al.,* 2013). Other information on species-specifics effects of ocean warming is provided in the

Species-specific Information and Determinations section below.

Comment 15 focused on the potential capacity of reef-building corals for acclimatization and adaptation to ocean warming and provided several new studies (Cahill *et al.,* 2013; Guest *et al.,* 2012; Jones and Berkelmans, 2010) and some that we considered in the proposed rule (Baker *et al.,* 2004; Maynard *et al.,* 2008; Pandolfi *et al.,* 2011). Identified mechanisms include symbiont shuffling (Baker, 2012; Cunning *et al.,* 2013; Ortiz *et al.,* 2013; Silverstein *et al.,* 2012), symbiont shading by host pigments or tissue (Mayfield *et al.,* 2013; Smith *et al.,* 2013a), host genotype expression (Baums *et al.,* 2013; Granados-Cifuentes *et al.,* 2013; Meyer *et al.,* 2011), and host protein expression (Barshis *et al.,* 2013; Voolstra *et al.,* 2011). As described in the Corals and Coral Reefs section, the dynamic association of host coral and symbiotic zooxanthellae and microbes provides potential for acclimatization or adaptation of some reef-building coral species to environmental changes.

Many recent studies provide evidence that certain reef-building coral communities have acclimated or adapted to ocean warming, at least to some degree. The bleaching and mortality of some colonies of a coral species on a reef, followed by the recovery of hardier colonies, is the process by which acclimatization and adaptation of a species to ocean warming occurs. Examples of bleaching, mortality, and recovery provide information about the capacity for acclimatization and adaptation. Several such examples were provided in the proposed rule and supporting documents (Diaz-Pulido *et al.,* 2009; Hueerkamp *et al.,* 2001; Kayanne *et al.,* 2002). More recently, many relevant studies have become available on the effects of the 1998 bleaching event. For example, in comparisons of 1998 and 2010 bleaching events and recovery in southeast Asia, some coral species demonstrated more resistance to bleaching in 2010, suggesting acclimatization or adaptation to thermal stress (Sutthacheep *et al.,* 2013). In a study on an isolated reef in Australia, recovery of coral cover occurred within 12 years of the 1998 bleaching event (Gilmour *et al.,* 2013). In contrast, studies in the U.S. Virgin Islands and Florida demonstrated little if any recovery in the 10 to 12 years following the 1998 bleaching event (Rogers and Muller, 2012; Ruzicka *et al.,* 2013).

A recent analysis comparing observed versus predicted coral bleaching events suggests that corals may have already responded adaptively to some warming since the Industrial Revolution because observed bleaching responses are lower than predicted by the warm temperature anomalies (Logan *et al.,* 2013). A recent study of fast-growing, shallow water coral species demonstrated that acclimatization and adaptive responses allowed them to inhabit reef areas with water temperatures far above their expected tolerances (Palumbi *et al.,* 2014). Similar to the mechanisms of coral acclimatization and adaptation described above, there is a rapidly growing body of literature on the responses of corals to ocean warming (Ateweberhan *et al.,* 2013; Baker *et al.,* 2013; Bellantuono *et al.,* 2012; Castillo *et al.,* 2012; Coles and Riegl, 2013; Penin *et al.,* 2013). These studies help explain the capacity for reef-building corals to acclimatize and adapt to ocean warming and warming-induced bleaching and suggest some limited capacity. However, any such capacity is highly dependent on species, location, habitat type, and many other factors. Available species-specific information on vulnerability to ocean warming and warming-induced bleaching, including evidence of acclimatization or adaptation, is provided in the Species-specific Information and Determination sections below.

After considering this supplemental information in addition to that which was available for the proposed rule, our conclusion regarding ocean warming remains unchanged from the proposed rule, in that we consider ocean warming to be of high importance in contributing to extinction risk for the 65 corals in this final rule. However, we acknowledge that the interpretation of future ocean warming and warming-induced impacts to corals and coral reefs is associated with complexity and uncertainty, and that precise effects on individual species of reef-building corals are especially difficult to determine. The impact of ocean warming may be mediated by several factors and the extent to which the extinction risk of a coral species is impacted by ocean warming depends on its particular level of susceptibility, combined with its spatial and demographic characteristics in the context of worsening environmental conditions out to 2100, which is discussed in detail for each species in the Species-specific Information and Determinations section.

Disease (High Importance Threat, ESA Factor C)

Disease is considered under ESA Factor C—disease or predation. In the proposed rule we described the threat of disease as follows. Disease adversely affects various coral life history events by, among other processes, causing adult mortality, reducing sexual and asexual reproductive success, and impairing colony growth. A diseased state results from a complex interplay of factors including the cause or agent (*e.g.,* pathogen, environmental toxicant), the host, and the environment. All coral disease impacts are presumed to be attributable to infectious diseases or to poorly-described genetic defects. Coral disease often produces acute tissue loss. Other manifestations of disease in the broader sense, such as coral bleaching from ocean warming, are incorporated under other factors (*e.g.,* manmade factors such as ocean warming as a result of climate change).

Coral diseases are a common and significant threat affecting most or all coral species and regions to some degree, although the scientific understanding of individual disease causes in corals remains very poor. The incidence of coral disease appears to be expanding geographically in the Indo-Pacific, and there is evidence that corals with massive morphology species are not recovering from disease events in certain locations. The prevalence of disease is highly variable between sites and species. Increased prevalence and severity of diseases is correlated with increased water temperatures, which may correspond to increased virulence of pathogens, decreased resistance of hosts, or both. Moreover, the expanding coral disease threat may result from opportunistic pathogens that become damaging only in situations where the host integrity is compromised by physiological stress or immune suppression. Overall, there is mounting evidence that warming temperatures and coral bleaching responses are linked (albeit with mixed correlations) with increased coral disease prevalence and mortality. Complex aspects of temperature regimes, including winter and summer extremes, may influence disease outbreaks. Bleaching and coral abundance seem to increase the susceptibility of corals to disease contraction. Further, most recent research shows strong correlations between elevated human population density in close proximity to coral reefs and disease prevalence in corals.

Although disease causes in corals remain poorly understood, some general patterns of biological susceptibility are beginning to emerge. There appear to be predictable patterns of immune capacity across coral families, corresponding with trade-offs with their life history traits, such as reproductive output and growth rate. Both Acroporidae and Pociloporidae have low immunity to disease. However, both of these families have intermediate to high reproductive outputs. Both Faviidae and Mussidae are intermediate to high in terms of disease immunity and reproductive output. Finally, while Poritidae has high immunity to disease, it has a low reproductive output.

The effects of coral disease depend on exposure of the species to the threat, which varies spatially across the range of the species and temporally over time. Exposure to coral disease is moderated by distance of some coral habitats from the primary causes of most disease outbreaks, such as stressors resulting from sedimentation and nutrient over-enrichment. Exposure to coral disease can also be moderated by depth of many habitats, with deep habitats generally being less affected by disease outbreaks associated with stressors resulting from ocean warming. Disease exposure in remote areas and deep habitats appears to be low but gradually increasing. Exposure to coral disease will increase as factors that increase disease outbreaks (*e.g.,* warming events) expand over time.

As explained above, disease may be caused by threats such as ocean warming and bleaching, nutrients, and toxins. However, interactive effects between independently-arising disease and other threats are also important, because diseased colonies are more susceptible to the effects of some other threats. For example, diseased or recovering colonies may become more quickly stressed than healthy colonies by land-based sources of pollution (sedimentation, nutrients, and toxins), may more quickly succumb to predators, and may more easily break during storms or as a result of other physical impacts.

Comments 17 and 18 discussed the importance of disease as a threat to corals and provided a few scientific studies (Harvell *et al.,* 1999; Harvell *et al.,* 2002; Muller and van Woesik, 2012; Rogers and Muller, 2012) to emphasize this importance. Muller and van Woesik (2012) examined spatial epidemiology in the Caribbean to test if pathogens are contagious and spread from infected to susceptible hosts. They found no evidence of clustering for these diseases, so they did not follow a contagious disease model. They suggest the expression of coral disease is a two-step model: Environmental thresholds are exceeded, then those conditions either weaken the coral or increase the virulence of the pathogen (Muller and van Woesik, 2012).

We also gathered supplemental information on the threat of disease since the proposed rule was published. Burge *et al.* (2014) summarized the current understanding of interactions among coral disease, elevated temperature, and bleaching. This supplemental information provides further insight of coral disease impacts at the individual level and the local aggregation level, and provides future predictions for the role of coral disease at the population level.

At the individual level, recent studies examine both underlying factors and mechanistic explanations for the contraction and expansion of coral disease. For example, one study investigated microbial community dynamics in the mucus layer of corals to understand how the surface microbial community responds to changes in environmental conditions and under what circumstances it becomes vulnerable to overgrowth by pathogens. They found that a transient thermal anomaly can cause the microbial community to shift from a stable state dominated by antibiotic microbes to a stable state dominated by pathogens. Beneficial microbes may not be able to resume dominance after a temperature disturbance until the environment becomes considerably more favorable for them (Mao-Jones *et al.,* 2010). Another study conducted a meta-analysis to determine whether the presence of particular microbial taxa correlates with the state of coral health and found distinct differences in the microbial taxa present in diseased and healthy corals (Mouchka *et al.,* 2010). A third study investigated three variables commonly associated with immunity in hard and soft corals spanning ten families on the GBR. They found that all three variables (phenlyoxidase activity, size of melanin containing granular cells, and fluorescent protein concentrations) were significant predictors of susceptibility (Palmer *et al.,* 2010). Many other studies have focused on bacterial or eukaryotic pathogens as the source of coral disease; however, a more recent study examined the role of viruses and determined that a specific group of viruses is associated with diseased Caribbean corals (Soffer *et al.,* 2013).

Several studies provide further evidence of disease outbreaks that were significantly correlated with bleaching events. The bleaching occurred first, then several months to a year later, there were significant increases in disease prevalence in bleached areas (Ban *et al.,* 2013; Brandt and McManus, 2009; Bruno *et al.,* 2007; Croquer *et al.,* 2006; Croquer and Weil, 2009; Miller *et al.,* 2009). The specific interactions between the two phenomena varied among disease-bleaching combinations. Results from one of these studies suggest the hypothesized relationship between bleaching and disease events may be weaker than previously thought, and more likely to be driven by common responses to environmental stressors, rather than directly facilitating one another.

Ateweberhan *et al.* (2013) reviewed and summarized interactions between important threats to corals. They note that disease can interact not only with ocean warming and bleaching events, but may also be exacerbated by sedimentation, nutrients, overfishing, and destructive practices on coral reefs. From a broad, population-wide perspective, Yakob and Mumby (2011) provide an important alternative context in which to demonstrate that high population turnover within novel ecosystems (those that are different from the past and created by climate change) may enhance coral resistance to disease. They emphasize the need to move away from future projections based on historical trends and start to account for novel behavior of ecosystems under climate change.

After considering this supplemental information in addition to that which was available for the proposed rule, our conclusion regarding disease remains unchanged from the proposed rule, in that we consider coral disease to be of high importance in contributing to extinction risk for the 65 corals in this final rule. The impact of disease may be mediated by several factors and the extent to which the extinction risk of a coral species is impacted by disease depends on its particular level of susceptibility, combined with its spatial and demographic characteristics in the context of worsening environmental conditions out to 2100, which is discussed in detail for each species in the Species-specific Information and Determinations section.

Ocean Acidification (Medium-High Importance Threat, ESA Factor E)

Ocean acidification is considered under ESA Factor E—other natural or manmade factors affecting the continued existence of the species—because the effect is a result of human activity and affects individuals of the coral species more so than their habitats. In the proposed rule we described that ocean acidification is a result of global climate change caused by increased GHG accumulation in the atmosphere. Reef-building corals produce skeletons made of the aragonite form of calcium carbonate; thus, reductions in aragonite saturation state caused by ocean acidification pose a major threat to these species and other marine calcifiers. Ocean acidification has the potential to cause substantial reduction in coral calcification and reef cementation. Further, ocean acidification adversely affects adult growth rates and fecundity, fertilization, pelagic planula settlement, polyp development, and juvenile growth. The impacts of ocean acidification can lead to increased colony breakage and fragmentation and mortality. Based on observations in areas with naturally low pH, the effects of increasing ocean acidification may also include potential reductions in coral size, cover, diversity, and structural complexity.

As CO_2 concentrations increase in the atmosphere, more CO_2 is absorbed by the oceans, causing lower pH and reduced availability of carbonate ions, which in turn results in lower aragonite saturation state in seawater. Because of the increase in CO_2 and other GHGs in the atmosphere since the Industrial Revolution, ocean acidification has already occurred throughout the world's oceans, including in the Caribbean and Indo-Pacific, and is predicted to considerably increase between now and 2100, as described above in the RCP8.5 Projections section. Along with ocean warming and disease, we considered ocean acidification to be one of the most important threats posing extinction risks to coral species between now and the year 2100; however, individual susceptibility varies among the proposed species.

Numerous laboratory and field experiments have shown a relationship between elevated CO_2 and decreased calcification rates in some corals and other calcium carbonate secreting organisms. However, because only a few species have been tested for such effects, it is uncertain how most will fare in increasingly acidified oceans. In addition to laboratory studies, recent field studies have demonstrated a decline in linear growth rates of some coral species, suggesting that ocean acidification is already significantly reducing growth of corals on reefs. However, this has not been widely demonstrated across coral species and reef locations, suggesting species-specific effects and localized variability in aragonite saturation state. A potential secondary effect is that ocean acidification may reduce the threshold at which bleaching occurs. Overall, the best available information demonstrates that most corals exhibit declining calcification rates with rising CO_2 concentrations, declining pH, and declining aragonite saturation state, although the rate and mode of decline can vary among species. Recent studies also discuss the physiological effects of ocean acidification on corals and their responses. Corals are able to regulate pH within their tissues, maintaining higher pH values in their tissues than the pH of surrounding waters. This is an important mechanism in naturally highly-fluctuating environments (*e.g.,* many backreef pools have diurnally fluctuating pH) and suggests that corals have some adaptive capacity to acidification. However, as with ocean warming, there is high uncertainty as to whether corals will be able to adapt quickly enough to the projected changes in aragonite saturation state.

In addition to the direct effects on coral calcification and growth, ocean acidification may also affect coral recruitment, reef cementation, and other important reef-building species like crustose coralline algae. Studies suggest that the low pH associated with ocean acidification may impact coral larvae in several ways, including reduced survival and recruitment. Ocean acidification may influence settlement of coral larvae on coral reefs more by indirect alterations of the benthic community, which provides settlement cues, than by direct physiological disruption. A major potential impact from ocean acidification is a reduction in the structural stability of corals and reefs, which results both from increases in bioerosion and decreases in reef cementation. As atmospheric CO_2 rises globally, reef-building corals are expected to calcify more slowly and become more fragile. Declining growth rates of crustose coralline algae may facilitate increased bioerosion of coral reefs from ocean acidification. Studies demonstrate that ocean acidification will likely have a great impact on corals and reef communities by affecting community composition and dynamics, exacerbating the effects of disease and other stressors (*e.g.,* temperature), contributing to habitat loss, and affecting symbiont function. Some studies have found that an atmospheric CO_2-level twice as high as pre-industrial levels will start to dissolve coral reefs; this level could be reached as early as the middle of this century. Further, the rate of acidification may be an order of magnitude faster than what occurred 55 million years ago during the Paleocene-Eocene Thermal Maximum (*i.e.,* the period in which global temperatures rose 5 to 9 °C, providing a context in which to understand climate change).

While CO_2 levels in the surface waters of the ocean are generally in equilibrium with the lower atmosphere, there can be considerable variability in seawater pH across reef-building coral habitats, resulting in colonies of a species experiencing high spatial variability in exposure to ocean acidification. The spatial variability in seawater pH occurs from reef to global scales, driven by numerous physical and biological characteristics and processes, including: Seawater temperature; proximity to land-based runoff and seeps; proximity to sources of oceanic CO_2; salinity; nutrients; photosynthesis; and respiration. In cooler waters, CO_2 absorption is higher, driving pH and aragonite saturation state lower, thus relatively cool coral habitats are more susceptible to acidification, such as those at higher latitudes, in upwelling areas, and in deeper environments. On coral reefs, wave and wind-induced mixing typically maintain roughly similar temperatures in the shallow photic zone preferred by most reef-building corals, thus the deeper environments that are more susceptible to acidification are generally below this photic zone.

Land-based runoff decreases salinity and increases nutrients, both of which can raise pH. Local sources of oceanic CO_2 like upwelling and volcanic seeps lower pH. Photosynthesis in algae and seagrass beds draws down CO_2, raising pH. High variability over various time-scales is produced by numerous processes, including diurnal cycles of photosynthesis and respiration, seasonal variability in seawater temperatures, and decadal cycles in upwelling. Temporal variability in pH can be very high diurnally in highly-fluctuating or semi-enclosed habitats such as reef flats and back-reef pools, due to high photosynthesis during the day (pH goes up) and high respiration during the night (pH goes down). In fact, pH fluctuations during one 24-hr period in such reef-building coral habitats can exceed the magnitude of change expected by 2100 in open ocean subtropical and tropical waters. As with spatial variability in exposure to ocean warming, temporal variability in exposure to ocean acidification is a combination of high variability over short time-scales together with long-term increases. While exposure of the proposed coral species to ocean acidification varies greatly both spatially and temporally, it is expected to increase for all species across their ranges between now and 2100.

Ocean acidification likely interacts with other threats, especially considering that ocean acidification is expected to continue to increase over the foreseeable future. For example, ocean acidification may reduce the threshold at which bleaching occurs, increasing the threat posed by ocean warming. One of the key impacts of ocean acidification is reduced calcification, resulting in reduced skeletal growth and skeletal density, which may lead to numerous interactive effects with other threats. Reduced skeletal growth compromises the ability of coral colonies to compete for space against algae, which grows more quickly as nutrient over-enrichment increases, especially if not held in check by herbivores. Reduced skeletal density weakens coral skeletons, resulting in greater colony breakage from natural and human-induced physical damage.

As discussed in Comments 18–21, we received numerous comments related to the threat to corals from ocean acidification including: (1) The overview and future projections of ocean acidification; (2) variability in ocean acidification; and (3) specific effects of ocean acidification on reef-building corals.

Comment 17 stated that we oversimplified the complexity and variability in the future projections of ocean acidification, and criticized our reliance on AR4 as the basis for our threat evaluation. In the proposed rule, we acknowledged the uncertainty associated with projections of ocean acidification from global climate change. However, while there are many sources of uncertainty in climate change projections, and likewise for ocean acidification, the ocean acidification projections in AR4 and AR5's WGI represent the best available information. The proposed rule and supporting documents assumed that AR4's highest-emission scenario A1F1 was the most likely to occur. Now that AR5's WGI is available, we consider the most impactful pathway to coral is WGI's RCP8.5, which includes ocean acidification projections. These projections are described above in the RCP8.5 Projections section, along with two independent analyses of the effects of ocean acidification projections in RCP8.5 on coral reefs in the 21st century. As noted in the RCP8.5 Projections section, there is uncertainty in these ocean acidification projections for coral reefs.

Comment 18 specifically cites Manzello *et al.* (2012) and Palacios and Zimmerman (2012; 2007) to illustrate that variability in ocean acidification on coral reefs can be buffered by local and regional biogeochemical processes within seagrass beds. Additionally, biogeochemical processes within coral reef communities (Andersson *et al.,* 2013) may buffer the effects of decreasing pH. Other scientific studies identify mechanisms that can exacerbate changes in seawater pH around coral reefs from ocean acidification, such as diurnal variability that can amplify CO_2 in seawater around coral reefs (Shaw *et al.,* 2013). On larger scales, a recent study demonstrated that some coastal areas of the Gulf of Mexico and South Atlantic were buffered against ocean acidification because of the input of fresh, alkaline surface waters carrying dissolved inorganic carbon (Wang *et al.,* 2013). Variability in ocean acidification at basin and global scales is influenced largely by upwelling and latitude, with more acidification in areas of high upwelling and lower temperatures. The interaction of ocean acidification with ocean warming produces basin-level patterns of higher and lower habitat suitability for reef-building corals (Couce *et al.,* 2013b; van Hooidonk *et al.,* 2013a; Yara *et al.,* 2012).

Comments 19 and 20 underscore specific effects to corals from ocean acidification identified in the proposed rule, including: (1) Effects on reef accretion; (2) effects on larvae and juvenile corals; (3) interactive effects with other environmental variables; and (4) miscellaneous effects. Recent research identifies impacts of ocean acidification on reef accretion due to reduced coral calcification (Chan and Connolly, 2013) and impacts on crustose coralline algae (Doropoulos and Diaz-Pulido, 2013). Recent research has also found that impacts of ocean acidification on brooded larvae of *Pocillopora damicornis* were higher when the larvae were released earlier (Cumbo *et al.,* 2013) and that nutritionally replete juvenile corals were less susceptible to ocean acidification than nutritionally deprived juveniles (Drenkard *et al.,* 2013).

Many recent studies have investigated the interactive effects of ocean acidification with other environmental variables. The opposing effects of ocean warming and ocean acidification were discussed in a study that demonstrated low light conditions can exacerbate ocean acidification effects. Low-light conditions can provide a refuge for reef-building corals from thermal and light stress, but this study suggests that lower light availability will potentially increase the susceptibility of key coral species to ocean acidification (Suggett *et al.,* 2013). Another study predicts that increasing storms predicted by climate change, together with ocean acidification, are likely to increase collapse of table corals (Madin *et al.,* 2012). Salinity extremes on a nearshore coral community did not affect the sensitivity of reef-building corals to ocean acidification (Okazaki *et al.,* 2013). Finally, several studies have investigated the simultaneous effects of ocean warming and ocean acidification, most of which have found harmful synergistic effects (Ateweberhan *et al.,* 2013; Dove *et al.,* 2013; Kroeker *et al.,* 2013), but not all (Wall *et al.,* 2013). However, impacts of ocean acidification are more rapid in cool water, such as in mesophotic habitat (Cerrano *et al.,* 2013) and temperate areas (Yara *et al.,* 2012).

Several other recent papers also provide information on the impacts of ocean acidification on reef-building corals. A study of the effects of ocean acidification on primary polyps with and without zooxanthellae found that polyps with zooxanthellae had higher tolerance to ocean acidification, suggesting that coral species that acquire symbionts from the environment will be more vulnerable to ocean acidification than corals that maternally acquire symbionts (*i.e.,* brooding species; Ohki *et al.,* 2013). A study of *Porites* corals at a field site with naturally low pH found that the corals were not able to acclimatize enough to prevent the impacts of local ocean acidification on their skeletal growth and development, despite spending their entire lifespan in low pH seawater (Crook *et al.,* 2013). A study of the effects of ocean acidification on different coral species in different environments found that effects were highly species-dependent, and furthermore, that effects within a species depended on the environment (Kroeker *et al.,* 2013).

After considering this supplemental information in addition to that which was available for the proposed rule, our conclusion regarding ocean acidification remains unchanged from the proposed rule, in that we consider ocean acidification to be of medium-high importance in contributing to extinction risk for the 65 corals in this final rule. However, we acknowledge that the interpretation of future ocean acidification and acidification-induced impacts to corals and coral reefs is associated with complexity and uncertainty and that the effects on individual species of reef-building corals are especially difficult to determine. The impact of ocean acidification may be mediated by several factors and the extent to which the extinction risk of a coral species is impacted by ocean acidification depends on its particular level of susceptibility, combined with its spatial and demographic characteristics in the context of worsening environmental conditions out to 2100, which is discussed in detail for each species in the Species-specific Information and Determinations section.

Trophic Effects of Fishing (Medium Importance Threat, ESA Factor A)

Trophic effects of fishing are considered under ESA Factor A—the present or threatened destruction, modification, or curtailment of its habitat or range—because the main effect of concern is to limit availability of habitat for corals. In the proposed rule we described the threat of the trophic effects of reef fishing as follows. Fishing, particularly overfishing, can have large scale, long-term ecosystem-level effects that can change ecosystem structure from coral-dominated reefs to algal-dominated reefs (''phase shifts''). Even fishing pressure that doesn't rise to the level of overfishing potentially can alter trophic interactions that are important in structuring coral reef ecosystems. These trophic interactions include reducing population abundance of herbivorous fish species that control algal growth, limiting the size structure of fish populations, reducing species richness of herbivorous fish, and releasing corallivores from predator control. Thus, an important aspect of maintaining resilience in coral reef ecosystems is to sustain populations of herbivores, especially the larger scarine herbivorous wrasses such as parrotfish.

On topographically complex reefs, population densities can average well over a million herbivorous fishes per km^2, and standing stocks can reach 45 metric tons per km^2. In the Caribbean, parrotfishes can graze at rates of more than 150,000 bites per square meter per day, and thereby remove up to 90–100 percent of the daily primary production (*e.g.,* algae). Under these conditions of topographic complexity with substantial populations of herbivorous fishes, as long as the cover of living coral is high and resistant to mortality from environmental changes, it is very unlikely that the algae will take over and dominate the substrate. However, if herbivorous fish populations, particularly large-bodied parrotfish, are heavily fished and a major mortality of coral colonies occurs, then algae can grow rapidly and prevent the recovery of the coral population. The ecosystem can then collapse into an alternative stable state, a persistent phase shift in which algae replace corals as the dominant reef species. Although algae can have negative effects on adult coral colonies (*e.g.,* overgrowth, bleaching from toxic compounds), the ecosystem-level effects of algae are primarily from inhibited coral recruitment. Filamentous algae can prevent the colonization of the substrate by planula larvae by creating sediment traps that obstruct access to a hard substrate for attachment. Additionally, macroalgae can suppress the successful colonization of the substrate by corals through occupation of the available space, shading, abrasion, chemical poisoning, and infection with bacterial disease.

Overfishing can have further impacts on coral mortality via trophic cascades. In general larger fish are targeted, resulting in fish populations of small individuals. For parrotfishes, the effect of grazing by individuals greater than 20 cm in length is substantially greater than that by smaller fish. Up to 75 individual parrotfishes with lengths of about 15 cm are necessary to have the same reduction in algae and promotion of coral recruitment as a single individual 35 cm in length. Species richness of the herbivorous fish population is also very beneficial to maintaining available substrate potentially leading to enhanced coral populations. Because of differences in their feeding behaviors, several species of herbivorous fishes with complementary feeding behaviors can have a substantially greater positive effect than a similar biomass of a single species on reducing the standing stock of macroalgae, of increasing the cover of crustose coralline algae, and increasing live coral cover.

Exposure to the trophic effects of fishing in the Caribbean may be moderated by distance of some coral habitats from fishing effort. Exposure to the trophic effects of fishing in the Indo-Pacific is likely more moderated by distance than in the Caribbean, due to a greater proportion of reef-building coral habitats located in remote areas away from fishing effort. Exposure to the trophic effects of reef fishing may also moderated by depth of many habitats in both regions, but again more so in the Indo-Pacific than in the Caribbean. Deep habitats are generally less affected by the trophic effects of fishing, especially in the Indo-Pacific. Exposure to the trophic effects of fishing will increase as the human population increases over time.

The trophic effects of fishing are likely to interact with many other threats, especially considering that fishing impacts are likely to increase within the ranges of many of the proposed corals over the foreseeable future. For example, when carnivorous fishes are overfished, corallivore populations may increase, resulting in greater predation on corals. Further, overfishing appears to increase the frequency of coral disease. Fishing activity usually targets the larger apex predators. When predators are removed, corallivorous butterfly fishes become more abundant and can transmit disease from one coral colony to another as they transit and consume from each coral colony. With increasing abundance, they transmit disease to higher proportions of the corals within the population.

Comments 21–23 focused on the following aspects of the trophic effects of reef fishing: (1) The importance of the threat to coral reefs; (2) higher importance localized threats; and (3) consideration of human demography.

Comment 21 highlighted Keller *et al.* (2009), which provides additional support for the importance herbivores play in the maintenance of recruitment habitat. Further, recent information shows that one of the most detrimental effects of unsustainable fishing pressure is the alteration of trophic interactions that are particularly important in structuring coral reef ecosystems (Jackson *et al.,* 2012; Jackson *et al.,* 2014; Ruppert *et al.,* 2013). These trophic interactions include reducing population abundance of herbivorous fish species that control algal growth, limiting the size structure of fish populations, reducing species richness of herbivorous fish, and releasing corallivores from predator control. Thus, an important aspect of maintaining resilience in coral reef ecosystems is to sustain functional populations of herbivores, especially the larger parrotfish and other key functional herbivorous fish (Hughes *et al.,* 2010; Jackson *et al.,* 2012; Jackson *et al.,* 2014; Kennedy *et al.,* 2013). Further, Jackson *et al.* (2014) considers overfishing (associated with high human densities) to be one of the major causes of the region-wide decline in Caribbean corals while acknowledging that climate threats are likely to be major sources of mortality in the future. In addition to direct overfishing of primary consumers such as parrotfish, recent studies found that overfishing of top reef predators such as sharks and other predatory fish, such as large groupers in the Caribbean, can have an impact that cascades down the food chain, potentially contributing to mesopredator release, and ultimately altering the numbers of primary consumers available to control algal growth (Jackson *et al.,* 2012; Jackson *et al.,* 2014; Ruppert *et al.,* 2013).

After considering this supplemental information in addition to that which was available for the proposed rule, our conclusion regarding the trophic effects of fishing remains unchanged from the proposed rule. Trophic effects of fishing are a medium importance threat in assessing global extinction risk for the 65 corals in this final rule. Because the main effect of trophic effects of reef fishing is habitat alteration, there are no species-specific levels of exposure and susceptibility. However, the extent to which an individual species' recruitment is affected is discussed in more detail in the Species-specific Information and Determinations section, when species-specific information is available.

Sedimentation (Low-Medium Importance Threat, ESA Factors A and E)

Sedimentation is considered under ESA Factor A—the present or threatened destruction, modification, or curtailment of its habitat or range—and ESA Factor E—other natural or manmade factors affecting the continued existence of the species—because the effect of the threat, resulting from human activity, is both to limit the availability of habitat for corals and to directly impact individuals of coral species. In the proposed rule we described the threat of sedimentation as follows. Human activities in coastal and inland watersheds introduce sediment into the ocean by a variety of mechanisms, including river discharge, surface runoff, groundwater seeps, and atmospheric deposition. Humans also introduce sewage into coastal waters through direct discharge, treatment plants, and septic leakage. Elevated sediment levels are generated by poor land use practices and coastal and nearshore construction.

The most common direct effect of sedimentation is deposition of sediment on coral surfaces as sediment settles out from the water column. Corals with certain morphologies (*e.g.,* mounding) can passively reject settling sediments. In addition, corals can actively displace sediment by ciliary action or mucous production, both of which require energetic expenditures. Corals with large calices (skeletal component that holds the polyp) tend to be better at actively rejecting sediment. Some coral species can tolerate complete burial for several days. Corals that are unsuccessful in removing sediment will be smothered and die. Sediment can also induce sublethal effects, such as reductions in tissue thickness, polyp swelling, zooxanthellae loss, and excess mucus production. In addition, suspended sediment can reduce the amount of light in the water column, making less energy available for coral photosynthesis and growth. Sedimentation also impedes fertilization of spawned gametes and reduces larval settlement and survival of recruits and juveniles.

Although it is difficult to quantitatively predict the extinction risk that sedimentation poses to the corals under consideration, human activity has resulted in quantifiable increases in sediment inputs in some reef areas. Continued increases in coastal human populations combined with poor land use and nearshore development practices will likely increase sediment delivery to reef systems. Nearshore sediment levels will also likely increase with sea-level rise. Greater inundation of reef flats can erode soil at the shoreline and resuspend lagoon deposits, producing greater sediment transport and potentially leading to leeward reefs being flooded with turbid lagoon waters or buried by off-bank sediment transport. Sediment stress and turbidity also can induce bleaching, although some corals may be more tolerant of elevated short-term levels of sedimentation.

Exposure to sedimentation can be moderated by distance of some coral habitats from areas where sedimentation is chronically or sporadically heavy, resulting in some habitats being unaffected or very lightly affected by sedimentation. Exposure to sedimentation for particular species may also be moderated by depth of habitats. Exposure to sedimentation is expected to increase as human activities that produce sedimentation expand over time.

Sedimentation is also likely to interact with many other threats, such as other land-based sources of pollution and warming-induced bleaching, especially considering that sedimentation is likely to increase across the ranges of many of the 65 species over the foreseeable future. For example, when coral communities that are chronically affected by sedimentation experience a warming-induced bleaching event, a disease outbreak, or a toxic spill, the consequences for those corals can be much more severe than in communities not affected by sedimentation.

Comment 25 underscored the importance of sedimentation as a considerable local threat to corals, and highlighted the potential of sedimentation to interact and potentially exacerbate other threats. A few commenters provided references (Bonkosky *et al.,* 2009; Hernández-Delgado *et al.,* 2012; Hernandez-Delgado *et al.,* 2011) that discussed sedimentation as a threat to corals.

We also gathered supplemental studies on the threat of sedimentation since the proposed rule was published. Three points in particular from the proposed rule were affirmed by the supplemental studies. Sedimentation can have interactive effects with other stressors including disease and climate factors such as bleaching susceptibility and reduced calcification (Ateweberhan *et al.,* 2013; Suggett *et al.,* 2013). MPAs provide little protection against indirect stressors like sedimentation from upland activities (Halpern *et al.,* 2013). The effects of sedimentation can be variable for different coral species and may depend on other environmental conditions (Blakeway *et al.,* 2013; Suggett *et al.,* 2013).

After considering this supplemental information in addition to that which was available for the proposed rule, our conclusion regarding sedimentation remains unchanged from the proposed rule. Sedimentation is a low to medium importance threat in assessing global extinction risk for the 65 corals in this final rule. The impact of sedimentation may be mediated by several factors and the extent to which the extinction risk of a coral species is impacted by sedimentation depends on its particular level of susceptibility combined with it spatial and demographic characteristics in the context of worsening environmental conditions out to 2100, which is considered for each species in the Species-specific Information and Determinations section.

Nutrients (Low-Medium Importance Threat, ESA Factors A and E)

Nutrient enrichment is considered under ESA Factor A—the present or threatened destruction, modification, or curtailment of its habitat or range—and ESA Factor E—other natural or manmade factors affecting the continued existence of the species—because the effect of the threat, resulting from human activity, is both to limit the availability of habitat for corals and directly impact individuals of coral species. In the proposed rule we described the threat of nutrient over-enrichment as follows. Elevated nutrients affect corals through two main mechanisms: Direct impacts on coral physiology and indirect effects through nutrient-stimulation of other community components (*e.g.,* macroalgal turfs and seaweeds, and filter feeders) that compete with corals for space on the reef. Increased nutrients can decrease calcification; however, nutrients may also enhance linear extension, while reducing skeletal density. Either condition results in corals that are more prone to breakage or erosion, but individual species do have varying tolerances to increased nutrients. The main vectors of anthropogenic nutrients are point-source discharges (such as rivers or sewage outfalls) and surface runoff from modified watersheds. Natural processes, such as *in situ* nitrogen fixation and delivery of nutrient-rich deep water by internal waves and upwelling also bring nutrients to coral reefs.

Exposure to nutrients can be moderated by distance of some coral habitats from areas where nutrients are chronically or sporadically heavy (*e.g.,* heavily populated areas). However, nutrient over-enrichment can still result from sparsely populated areas; and these nutrients can be quickly transported large distances. Therefore, distance is less of a moderating factor for nutrients than for sedimentation. Similarly, although nutrient exposure may also be moderated by the depth of some habitats, nutrient impacts extend deeper than sedimentation impacts. Exposure to nutrients is expected to increase as human activities that produce nutrients expand over time.

Nutrients are likely to interact with many other threats, especially considering that nutrient over-enrichment is likely to increase across the ranges of many of the 65 corals over the foreseeable future. For example, when coral communities that are chronically affected by nutrients experience a warming-induced bleaching event, a disease outbreak, or a toxic spill, the consequences for corals can be much more severe than in communities not affected by nutrients.

Comment 26 supported and reiterated the effects nutrients can have on corals. Some of the individual commenters provided studies (Bonkosky *et al.,* 2009; Connolly *et al.,* 2012; Cunning and Baker, 2013; Fabricius *et al.,* 2013; Hernandez-Delgado *et al.,* 2011; Hernández-Delgado *et al.,* 2008; Méndez-Lázaro *et al.,* 2012; Wiedenmann *et al.,* 2013) to reinforce their support. Bonkosky *et al.* (2009) provided further evidence that elevated turbidity and nutrient enrichment from human waste discharge has an extensive impact on coral reef ecosystems. In response to contradictory results from other studies as to whether nutrients increase thermal stress or increase resistance to higher temperature for corals, Fabricius *et al.* (2013) exposed corals to both elevated nutrients and heat stress. They found higher mortality occurred in the elevated nutrient-heat stress treatments versus heat-stressed alone and controls. Wiedenmann *et al.* (2013) found that unfavorable ratios of dissolved inorganic nutrients in the water column led to phosphate starvation of symbiotic algae, reducing thermal tolerance. Cunning and Baker (2013) found higher nutrient loads can lead to higher densities of symbionts, and corals with higher densities of symbionts were more susceptible to bleaching.

We also gathered supplemental information on how elevated nutrients interact with other threats, including coral bleaching and disease. One study tested the interactive effects of nutrient loading with both bleaching and disease and found that coral disease prevalence and severity as well as coral bleaching were increased in nutrient enriched plots (Vega Thurber *et al.,* 2013). Ateweberhan *et al.* (2013) note that most studies on the subject of nutrient enrichment and high temperatures also present evidence of negative effects on calcification due to higher nutrient levels, although both positive and negative effects have been reported. Nutrient enrichment can also interact with the threat of coral disease by encouraging the proliferation of disease-causing microorganisms and bioeroders, such as boring sponges, and intensifying the growth of fleshy macroalgae that harbor and spread coral diseases (Ateweberhan *et al.,* 2013; Vega Thurber *et al.,* 2013).

After considering this supplemental information in addition to that which was available for the proposed rule, our conclusion regarding nutrient over-enrichment remains unchanged from the proposed rule. Nutrients are a low to medium importance threat in assessing global extinction risk for the 65 corals in this final rule. The impact of elevated nutrients may be mediated by several factors and the extent to which the extinction risk of a coral species is impacted by nutrient enrichment depends on its particular level of susceptibility, combined with its spatial and demographic characteristics in the context of worsening environmental conditions out to 2100, which is considered for each species in the Species-specific Information and Determinations section.

Sea-Level Rise (Low-Medium Threat, ESA Factor A)

Sea-level rise is considered under ESA Factor A—the present or threatened destruction, modification, or curtailment of its habitat or range—because the effect of the threat is to the availability of corals' habitat and not directly to the species themselves. In the proposed rule we described the threat of sea-level rise as follows. The effects of sea-level rise may act on various coral life history events, including larval settlement, polyp development, and juvenile growth, and can contribute to adult mortality and colony fragmentation, mostly due to increased sedimentation and decreased water quality (reduced light availability) caused by coastal inundation. The best available information suggests that sea level will continue to rise due to thermal expansion and the melting of land and sea ice. Theoretically, any rise in sea-level could potentially provide additional habitat for corals living near the sea surface. Many corals that inhabit the relatively narrow zone near the ocean surface have rapid growth rates when healthy, which allowed them to keep up with sea-level rise during the past periods of rapid climate change associated with deglaciation and warming. However, depending on the rate and amount of sea-level rise, rapid rises can lead to reef drowning. Rapid rises in sea level could affect many of the proposed coral species by both submerging them below their common depth range and, more likely, by degrading water quality through coastal erosion and potentially severe sedimentation or enlargement of lagoons and shelf areas. Rising sea level is likely to cause mixed responses in the 65 corals depending on their depth preferences, sedimentation tolerances, growth rates, and the nearshore topography. Reductions in growth rate due to local stressors, bleaching, infectious disease, and ocean acidification may prevent the species from keeping up with sea-level rise (*i.e.,* from growing at a rate that will allow them to continue to occupy their preferred depth range despite sea-level rise).

The rate and amount of future sea-level rise remains uncertain. Until the past few years, sea-level rise was predicted to be in the range of only about one half meter by 2100. However, more recent estimated rates are higher, based upon evidence that the Greenland and Antarctic ice sheets are much more vulnerable than previously thought. While there is large variability in predictions of sea-level rise, AR4 likely underestimated the rates under all scenarios.

Fast-growing branching corals were able to keep up with the first 3 m of sea-level rise during the warming that led to the last interglacial period. However, whether the 65 corals in this final rule will be able to survive 3 m or more of future sea-level rise will depend on whether growth rates are reduced as a result of other risk factors, such as local environmental stressors, bleaching, infectious disease, and ocean acidification. Additionally, lack of suitable new habitat, limited success in sexual recruitment, coastal runoff, and coastal hardening will compound some corals' ability to survive rapid sea-level rise.

This threat is expected to disproportionately affect shallow areas adjacent to degraded coastlines, as ocean inundation results in higher levels of sedimentation from the newly-inundated coastlines to the shallow areas. Exposure to sea-level rise will be moderated by horizontal and vertical distances of reef-building coral habitats from inundated, degraded coastlines. Exposure to sea-level rise will increase over time as the rate of rise increases.

Sea-level rise is likely to interact with other threats, especially considering that sea-level rise is likely to increase across the ranges of the 65 corals over the foreseeable future. In particular, the inundation of developed areas (*e.g.,* urban and agricultural areas) and other areas where shoreline sediments are easily eroded by sea-level rise is likely to degrade water quality of adjacent coral habitat through increased sediment and nutrient runoff and the potential release of toxic contamination.

Comment 27 supported the Consensus Statement on Climate Change and Coral Reefs, which specifies that sea-levels have already risen and that future rising sea-levels will be accompanied by increased sedimentation levels. We received no additional supplemental information on this threat.

We also gathered supplemental information to update the analysis presented in the proposed rule. In the proposed rule, we noted that AR4 likely underestimated rates of projected sea-level rise. AR5's WGI represents a substantial advance from AR4. The first section of WGI considers observations of climate system change, which refers to descriptions of past climate patterns. WGI concludes it is virtually certain that the global mean sea level rose by 19 cm from 1901 to 2010. The anthropogenic ocean warming observed since the 1970s has contributed to global sea-level rise over this period through ice melting and thermal expansion. Projections for future sea-level-rise in RCP8.5 for the period 2081 to 2100 are 0.53 to 0.97 meter higher than the period 1986 to 2005. In addition, WGI concluded that it is virtually certain that global mean sea-level rise will continue beyond 2100. WGI also reported that it is very likely that in the twenty-first century and beyond, sea-level change will have a strong regional pattern (IPCC, 2013).

After considering this supplemental information in addition to that which was previously available, our conclusion regarding sea-level rise remains unchanged from the proposed rule. Sea-level rise is a low to medium importance threat in assessing global extinction risk for the 65 corals in this final rule. The impact of sea-level-rise may be mediated by some factors and the extent to which the extinction risk of a coral species is impacted by sea-level-rise depends on its particular level of susceptibility, combined with its spatial and demographic characteristics in the context of worsening environmental conditions out to 2100, which is considered for each species in the Species-specific Information and Determinations section.

Predation (Low Threat, ESA Factor C)

Predation is considered under ESA Factor C—disease or predation. In the proposed rule we described the threat of predation as follows. Predation on some coral genera by many corallivorous species of fish and invertebrates (*e.g.,* snails and seastars) is a chronic, though occasionally acute, energy drain. It is a threat that has been identified for most coral life stages. Thus, predation factored into the extinction risk analysis for each of the 65 corals. Numerous studies have documented the quantitative impact of predation by various taxa on coral tissue and skeleton. Predators can indirectly affect the distribution of corals by preferentially consuming faster-growing coral species, thus allowing slower-growing corals to compete for space on the reef. The most notable example of predation impacts in the Indo-Pacific are from large aggregations or outbreaks of crown-of-thorns seastar. The specific cause of crown-of-thorns seastar outbreaks is unknown. Crown-of-thorns seastar can reduce living coral cover to less than one percent during outbreaks, changing coral community structure, promoting algal colonization, and affecting fish population dynamics.

Exposure to predation by corallivores is moderated by presence of predators of the corallivores. For example, corallivorous reef fish prey on corals, and piscivorous reef fish and sharks prey on the corallivores; thus, high abundances of piscivorous reef fish and sharks moderate coral predation. Abundances of piscivorous reef fish and sharks vary spatially because of different ecological conditions and human exploitation levels. Exposure to predation is also moderated by distance from physical conditions that allow corallivore populations to grow. For example, in the Indo-Pacific, high nutrient runoff from continents and high islands improves reproductive conditions for crown-of-thorns seastar, thus coral predation by crown-of-thorns seastar is moderated by distance from such conditions. Predation can also be moderated by depth of many habitats because abundances of many corallivorous species decline with depth. Exposure to predation can increase over time as conditions change, but may be moderated by distance and depth for certain species, which depends upon the distribution and abundances of the species.

Predation of coral colonies can increase the likelihood of the colonies being infected by disease, and likewise diseased colonies may be more likely to be preyed upon. There are likely other examples of cumulative and interactive effects of predation with other threats to corals.

Comment 28 suggested predation and exposure values for some individual species, but did not provide supplemental information on the threat. We also gathered supplemental information that supports and reiterates the analysis presented in the proposed rule. Bonaldo *et al.* (2011) documented spatial and temporal variation in coral predation by parrotfishes on the Great Barrier Reef. Lenihan *et al.* (2011) assessed the degree to which the performance of recently recruited branching corals was influenced by several factors, including corallivory. They found that partial predation by corallivorous fishes is an important but habitat-modulated constraint for branching corals and, overall, corallivory had variable effects on corals of different genera. Last, De'ath *et al.* (2012) documented that 42 percent of the decline in coral cover on the GBR is attributable to crown-of-thorns seastar predation.

After considering this supplemental information in addition to that which was available for the proposed rule, our conclusion regarding predation remains unchanged from the proposed rule. Predation is a low importance threat in assessing global extinction risk for the 65 corals in this final rule. The impact of predation may be mediated by several factors and the extent to which the extinction risk of a coral species is impacted by predation depends on its particular level of susceptibility combined with its spatial and demographic characteristics in the context of worsening environmental conditions out to 2100, which is considered for each species in the Species-specific Information and Determinations section.

Collection and Trade (Low Threat, ESA Factor B)

Collection and trade is considered under ESA Factor B—overutilization for commercial, recreational, scientific, or educational purposes. In the proposed rule, we described the threat of collection and trade as follows.

Globally, 1.5 million live stony coral colonies are reported to be collected from at least 45 countries each year, with the United States consuming the largest portion of live corals (64 percent) and live rock (95 percent) for the aquarium trade. The imports of live corals taken directly from coral reefs (not from aquaculture) increased by 600 percent between 1988 and 2007, while the global trade in live coral increased by nearly 1,500 percent. Harvest of stony corals is usually highly destructive, and results in removing and discarding large amounts of live coral that go unsold and damaging reef habitats around live corals. While collection is a highly spatially-focused impact, it can result in significant impacts and was considered to contribute to individual species' extinction risk. However, we ultimately ranked this threat as low overall because of species-specific factors (*i.e.,* some species are preferentially affected) as well as distance and depth factors that create barriers to human access.

As described in Comments 29 and 30, we received a significant amount of supplemental information via public comments and gathered supplemental information on three aspects of the threat of collection and trade on reef-building corals and coral reef ecosystems: (1) Wild collection of corals, including information about the physical and ecological impacts of wild collection of coral colonies and/or fragments from their natural habitats; (2) captive culture including information regarding the development of mariculture and aquaculture operations, as well as the role of home aquaria as they relate to trade, including all commercial, recreational, and educational coral-raising operations in marine environments as well as in captivity; and (3) the global marine ornamental trade industry, including detailed information regarding trade of both live and dead corals and other coral reef wildlife.

For the purposes of this final rule, collection and trade refers to the physical process of taking corals from their natural habitat on coral reefs for the purpose of sale in the ornamental trade industry. We define wild collection as the physical removal or capture of coral colonies, fragments, and polyps from their natural habitat. This section also discusses the use of captive breeding techniques via aquaculture and mariculture for the purposes of trade. Captive culture techniques are increasingly used to supply the aquarium trade industry and potentially reduce the amount of corals collected from the wild to meet demand (Thornhill, 2012; Wood *et al.,* 2012). We define aquaculture as the land-based ('ex situ') propagation or grow out of corals. Examples of this include corals grown in home aquaria or terrestrial coral farms. We define mariculture as the ocean-based ('in situ') propagation or grow out of corals. Examples of this include corals grown in coral farms and nursery areas in marine environments. The phrase ''captive culture'' is used interchangeably to refer to captive breeding of corals, both via aquaculture or mariculture techniques.

The ecological and socio-economic impacts of the ornamental trade industry for corals are numerous, and can include overharvesting, collateral damage to coral reef habitat, and potential introduction of exotic species (Rhyne *et al.,* 2012). Wild collection of stony corals is usually highly destructive, resulting in removing and discarding large amounts of live coral that often go unsold for various reasons. Additionally, collection techniques can be physically damaging to reef habitat around live corals. In a recent, thorough review of ecological impacts and practices of the coral reef wildlife trade, Thornhill (2012) identifies and describes five overarching potential impacts: (1) Effects on target population such as over-exploitation and local population extirpations; (2) habitat impacts such as reduced coral cover, diversity, and rugosity; (3) effects on associated species such as decreased abundance, biomass, and diversity of reef fish, invertebrates, and other species due to loss or destruction of habitat; (4) ecosystem impacts such as increased degradation and erosion leading to reduced resilience; and (5) socio-economic impacts such as user group conflict between tourists, fishers, *etc.*

Collection and trade of coral colonies can also increase the likelihood of the colonies being infected by disease, as a result of both the directed and incidental breakage of colonies, which are then more easily infected (Brainard *et al.,* 2011). Further, destructive practices for collection of other coral reef wildlife, such as the use of cyanide for capturing reef fish, can also have deleterious effects on coral reef habitat in general. Currently, cyanide fishing is practiced in 15 countries, many of which are major marine wildlife trade exporters (Thornhill, 2012). There are likely many other examples of cumulative and interactive effects of collection and trade that pose a threat to corals. Given the paucity of data for the coral reef wildlife trade, it is difficult to accurately estimate mortality rates directly resulting from collection practices (Thornhill, 2012).

The rapid increase of coral reef species entering markets in the United States and Europe and the sustainability of the aquarium trade in terms of driving collection of wild specimens have been of great concern to governments, scientists, conservationists, and conscientious aquarium hobbyists alike (Olivotto *et al.,* 2011; Rhyne and Tlusty, 2012). However, production of marine wildlife for home aquaria (*i.e.,* the aquarium hobbyist trade) through captive culture is an increasingly growing sector of the ornamental trade industry. Recently, advances in both aquaculture and mariculture propagation techniques show promise in shifting the demand of the ornamental trade industry away from wild-collected corals to corals reared via captive-culture techniques. Such techniques are possible since many corals, especially fast-growing branching corals, are capable of asexual reproduction via a process known as fragmentation or ''fragging'' (Brainard *et al.,* 2011; Rhyne *et al.,* 2012). According to CITES import and export reports, maricultured corals accounted for approximately 20 percent of total live trade in 2010 (Wood *et al.* 2012), but other studies suggest that captive-cultured corals account for only 2 percent of the live coral trade (Thornhill, 2012).

Globally, there are approximately two million aquarium hobbyists involved in a complex trade network that sells an estimated 50 million corals every year to use (Rhyne *et al.,* 2012). According to the Florida Department of Agriculture and Consumer Services, there are 87 certified aquaculture facilities listing corals as a product in Florida alone. The study hypothesized that a notable decline in U.S. imports of corals occurred after 2006 as a result of increased domestic coral production as well as the global economic downturn. Import reports do not account for this ''hidden'' domestic production, and statistical tracking of this type of coral production is lacking (Rhyne *et al.,* 2012). In addition to increasing domestic production of corals, some major source countries such as Indonesia are increasing production via mariculture activities to reduce wild collection pressure on coral reefs, and supporting coral farming as a potential alternative to fishing for reef fish and collection of wild corals (Pomeroy *et al.,* 2006). For example, according to 2009 U.S. import reports, 26 percent of *Acropora* species were identified under CITES codes which indicated that these colonies were produced via captive-culture techniques (Rhyne *et al.,* 2012). However, since CITES codes are self-determined by exporter countries, there may be some inconsistencies in how those codes are applied (Wood *et al.,* 2012). As of 2008, there were 55 coral farms scattered throughout the different provinces of Indonesia (Timotius *et al.,* 2009); however, this number may be increasing since Indonesia's government has mandated companies and traders involved in the coral trade to utilize captive culture techniques in hopes of eventually phasing out wild collection of corals.

There are a number of challenges associated with developing aquaculture or mariculture operations for coral species, including technical capacity and know-how, high capital investments and operating costs, and high levels of production risk (Ferse *et al.,* 2012; Pomeroy *et al.,* 2006). Culturing corals has not been an easy task, predominantly due to the lack of knowledge regarding reproductive and larval biology for most traded species (Olivotto *et al.,* 2011). Further, most mariculture operations tend to focus predominantly on fast-growing corals, while successful propagation techniques for the popular slow-growing, large-polyp species have not yet been developed (Wood *et al.,* 2012). There is also the increasingly popular trend of using ocean-based coral nurseries for the purposes of propagating coral fragments to a suitable size and subsequently out-planting those coral fragments on degraded reefs to aid in reef restoration efforts. These types of activities are also considered in the Conservation Efforts section of the rule.

The export of marine organisms for the ornamental trade industry is a global industry. As described in the proposed rule, it is estimated that 1.5 million live stony coral colonies are collected from at least 45 countries each year, with an estimated 11 to 12 million coral pieces (*i.e.,* fragments from larger colonies) traded every year (Brainard *et al.,* 2011; Wabnitz, 2003). In addition to live stony corals, approximately 13 to 40 million reef fish, four million pounds of dead coral skeleton, and nine to 10 million other invertebrates are extracted from coral reef ecosystems across the world (Thornhill, 2012). For corals, trade can be broken down into several categories, including: Coral rock (*i.e.,* rock and substrate that may have live settled coral polyps among other marine organisms), live wild coral, live maricultured coral, and dead coral skeleton. Yet, numbers of corals traded in these categories are very difficult to accurately estimate for a variety of reasons. First, corals are colonial, vary in size, and can be fragmented into many smaller pieces. Additionally, reporting of trade volume is inconsistent and varies between reporting pieces and weight, and live rock and corals are often confused with each other and misreported (Thornhill, 2012). Currently, Indonesia is the primary source country of live corals; it exports approximately one million corals annually and represents an estimated 91 percent of the global supply market as of 2005 (Bruckner and Borneman, 2006; Thornhill, 2012; Timotius *et al.,* 2009). Other major exporters of scleractinian corals include Fiji, Solomon Islands, Tonga, and Australia. The largest importers of coral reef wildlife include the United States, European Union, and Japan. The United States accounted for an average of 61 percent of global imports from 2000–2010 (Wood *et al.,* 2012). Imports of live corals into the United States taken directly from coral reefs (not from aquacultured or maricultured sources) increased by 600 percent between 1988 and 2007, while the global imports of live coral increased by nearly 1,500 percent (Brainard *et al.,* 2011; Thornhill, 2012; Tissot *et al.,* 2010). Import and export data shows overall increasing trends for trade of live coral pieces between 2000–2009, with a slight dip in 2010 (Wood *et al.,* 2012). In addition, undocumented, illegal live coral trade is estimated to represent approximately 25 percent of the legal trade level, although these numbers are difficult to estimate considering the secretive nature of the illegal trade (Jones, 2008; Thornhill, 2012).

The international coral trade was established by 1950 and was dominated by the Philippines until 1977 when a national ban on wild collection and export was introduced (Wood *et al.,* 2012). It was then that Indonesia surpassed the Philippines to provide the majority of corals to the market. In the 1980s and 1990s, the international coral trade still focused on the trade of dead coral skeletons for home décor and curios. In recent years, the focus has shifted to live corals for the marine reef aquarium trade due to increased interest in home aquaria and advances in coral husbandry in North America and Europe, as well as the advent of modern air cargo methods (Rhyne *et al.,* 2012; Thornhill, 2012; Wood *et al.,* 2012). As stated previously, there is a complex global trade network of approximately two million aquarium hobbyists that sells upwards of 50 million coral reef animals every year (Rhyne *et al.,* 2012). Collection of corals for display in public aquaria for educational purposes represents a small portion of the coral reef wildlife trade, and public aquaria likely produce as many corals as they consume by using captive-culture techniques (Thornhill, 2012).

There has been some significant progress in captive culture of coral species using aquaculture and/or mariculture for the purposes of trade. Still, commercial-scale production of most species currently suffers several technical bottlenecks, including the long and often arduous supply chain from ocean to aquarium (*e.g.,* capture, collection, handling, and transport), which often results in mortality ranging from a few percent up to 80 percent. For example, in an analysis of confiscated coral shipments, a majority of the corals were found in poor condition. On the way to their final destination, coral colonies may experience significant temperature drops in the shipping water, poor water quality, and physical damage from repeated handling of the shipping boxes and bags resulting in mortality of a large proportion of colonies through subsequent bacterial infections (Jones, 2008). These non-reported rates of biomass loss may significantly underestimate the ecological impacts of the trade as more corals are collected to make up the losses (Cohen *et al.,* 2013; Thornhill, 2012). Distinguishing between specimens collected under regulated conditions from those collected using illegal or destructive fishing practices is very difficult (Cohen *et al.,* 2013; Wabnitz, 2003).

Traceability and tracking of cultured corals versus wild-collected corals is extremely difficult as there is no morphological or biological difference between them, making distinction almost impossible (Olivotto *et al.,* 2011). For example, a coral can be broken into fragments and labeled as cultured, when in fact it was collected from the wild. There is some evidence to suggest that culture of live corals has the potential to affect trends in the trade industry by reducing wild collection and provide an economically and financially feasible alternative livelihood for local communities in the Indo-Pacific. Even so, coral mariculture development in the Indo-Pacific is still in its infancy and requires a number of conditions to be met in order for these operations to be commercially profitable, sustainable, and traceable (Cohen *et al.,* 2013; Pomeroy *et al.,* 2006). It is also important to note that not all species lend themselves to culture. In fact, only a small number of coral genera have the ability to be commercially cultured (Rhyne *et al.,* 2012). According to some sources, approximately 98 percent of live corals in the ornamental trade are still collected from the wild, with only 2 percent originating from captive bred sources such as coral farms and nurseries (Ferse *et al.,* 2012; Thornhill, 2012), but, according to a different analysis of import reports between 2000 and 2010, captive cultured corals made up approximately 20 percent of total imports, and these originated almost entirely from Indonesia (Wood *et al.,* 2012). Therefore, there are still significant data deficiencies and a large amount of uncertainty as to how much of an impact captive cultured corals are having on the ornamental trade.

Significant supplemental information was received in public comments on the proposed rule or otherwise gathered on collection and trade of coral species. As previously described in the SRR and proposed rule, there are numerous ecological impacts from the physical process of removing corals and other wildlife from the reef. Trade practices that rely on the collection of wild individuals may damage or destroy adult and juvenile reef corals. Additionally, removal of reef fish and other organisms for trade purposes may also result in ecological impacts to reef ecosystems (Brainard *et al.,* 2011). The ten most popular coral genera involved in the ornamental trade by volume are: *Acropora* (Indo-Pacific only), *Euphyllia, Goniopora, Trachyphyllia, Plerogyra, Montipora, Heliofungia, Lobophyllia, Porites,* and *Turbinaria* (Jones, 2008; Thornhill, 2012), all of which represent 31 of the coral species considered in this final rule. *Acropora* species are in the highest demand followed by the large polyp species such as *Euphyllia* (Jones, 2008). Culturing corals through aquaculture and/or mariculture techniques is becoming an increasingly popular tool to help move the aquarium trade away from collection of wild corals. Still, these techniques are fairly new and in need of many improvements before being considered a viable solution in shifting market demand from wild-collected to captive cultured corals. As it currently stands, the amount of unreported, illegal, and unregulated collection, combined with the large amount of biomass loss along the supply chain raises serious questions as to the sustainability of the ornamental trade (Cohen *et al.,* 2013). Overall, collection and trade of coral reef wildlife is considered to contribute to some individual species' extinction risk.

In our previous analysis, collection and trade were generally considered to be a threat to coral reefs, as well as particular individual coral species, but extinction risk as a result of collection and trade activities for the 65 corals proposed for ESA listing was considered to be ''low'' (Brainard *et al.,* 2011). After considering this supplemental information in addition to that which was available for the proposed rule, our conclusion regarding the threat of collection and trade remains unchanged from the proposed rule. Collection and trade is a low importance threat in assessing global extinction risk for the 65 corals in this final rule, and even less so for the seven Caribbean species due to undesirable appearance and growth characteristics for trade. The impact of collection and trade may be mediated by several factors and the extent to which the extinction risk of a coral species is impacted by collection and trade depends on its particular level of susceptibility, combined with its spatial and demographic characteristics in the context of worsening environmental conditions out to 2100, which is considered for each species in the Species Information and Determinations section. Information regarding the adequacy of regulations related to the marine ornamental trade such as CITES and other laws can be found in the Local Regulatory Mechanisms section of the Final Management Report (NMFS, 2012b). Additionally, coral restoration projects using ocean-based, nursery-reared corals are also becoming increasingly popular as a complement to existing management tools. Information related to the roles that coral farms, coral nurseries, and aquaria (both public and private) play in coral reef conservation is discussed in the Conservation Efforts sub-section of the rule.

Inadequacy of Existing Regulatory Mechanisms (ESA Factor D)

Regulatory mechanisms are considered under Factor D—Inadequacy of Existing Regulatory Mechanisms. As previously described in the proposed rule, we developed a Draft Management Report to assess the contribution of ''inadequacy of regulatory mechanisms'' to the extinction risk of corals. The Draft Management Report identified: (1) Existing regulatory mechanisms relevant to threats to the 82 candidate coral species; and (2) conservation efforts with regard to the status of the 82 candidate coral species. This Draft was peer reviewed and released with the SRR in April 2012, with a request for any information that we may have omitted. We incorporated all of the information we received into the Final Management Report, which formed the basis of our evaluation of this factor's effect on the extinction risk of the 82 candidate coral species in the proposed rule.

The Final Management Report identified existing regulatory mechanisms that were relevant to the threats to coral species. It was organized in two sections: (1) Existing regulatory mechanisms that are relevant to addressing global-scale threats to addressing other threats to corals. The proposed rule summarized the information from that report as follows.

Greenhouse gas emissions are regulated through multi-state agreements, at the international level, and through statutes and regulations, at the national, state, or provincial level. One of the key international agreements relevant to attempts to control GHG emissions, the Copenhagen Accord, was developed in 2009 by the Conference of Parties to the United Nations Framework Convention on Climate Change. The Copenhagen Accord identifies specific information provided by Parties on quantified economy-wide emissions targets for 2020 and on nationally appropriate mitigation actions to the goal of capping increasing average global temperature at 2 °C above pre-industrial levels. Overall, the proposed rule concluded that existing regulatory mechanisms with the objective of reducing GHG emissions were inadequate to prevent the impacts to corals and coral reefs from ocean warming, ocean acidification, and other climate change-related threats. After an in-depth analysis of international agreements to curb GHG emissions and their respective progress, it appeared unlikely that Parties would be able to collectively achieve, in the near term, climate change avoidance goals outlined via international agreements. Additionally, none of the major global initiatives appeared to be ambitious enough, even if all terms were met, to reduce GHG emissions to the level necessary to minimize impacts to coral reefs and prevent what are predicted to be severe consequences for corals worldwide. The evidence suggested that existing regulatory mechanisms at the global scale in the form of international agreements to reduce GHG emissions were insufficient to prevent widespread impacts to corals.

Existing regulatory mechanisms directly or indirectly addressing the localized threats identified in the proposed rule (*i.e.,* those threats not related to GHGs and global climate change) are primarily national and local fisheries, coastal, and watershed management laws and regulations in the 84 countries within the collective ranges of the 82 coral species. Because of the large number of threats, and the immense number of regulatory mechanisms in the 84 countries, we concluded in the proposed rule that a regulation-by-regulation assessment of adequacy was not possible. Furthermore, with the exception of *Acropora palmata* and *A. cervicornis* in the Caribbean, there was not enough information available to determine the effects of specific regulatory mechanisms on individual coral species, given the lack of information on specific locations of individual species (the adequacy of existing local regulatory mechanisms relevant to threats impacting the Caribbean acroporids was evaluated in detail in those species' 2005 status review, and that information is incorporated into this rule's final findings for those species). However, general patterns included: (1) Fisheries management regimes regulate reef fishing in many parts of the collective ranges of the proposed coral species, albeit at varying levels of success; (2) laws addressing land-based sources of pollution are less effective than those regulating fisheries; (3) coral reef and coastal marine protected areas have increased several-fold in the last decade, reducing some threats through regulation or banning of fishing, coastal development, and other activities contributing to localized threats; and (4) the most effective regulatory mechanisms address the threats other than climate change. We generally concluded that because the local threats have impacted and continue to impact corals across their ranges, collectively, the existing regulations were not preventing or controlling local threats. Further, there was insufficient information to determine if an individual species was impacted by inadequacy of individual existing regulations.

We received public comments and supplemental information on the inadequacy of existing regulatory mechanisms. As a result, we incorporated any information we received into this final rule, which supplemented the basis for our final analysis and determination of the inadequacy of existing regulatory mechanisms in each species determination.

Comments 31–33 provided supplemental information, which we incorporated into this final rule. Specifically, we received information on how local management actions potentially confer resilience benefits to coral reef ecosystems. The public comments and supplemental information on the inadequacy of existing regulatory mechanisms are discussed below in three sections: (1) Updates to adequacy of global regulatory mechanisms; (2) updates to adequacy of local regulatory mechanisms; and (3) local management as it applies to reef resilience.

Since the release of the Final Management Report, there have been two additional conferences of the Parties to the United National Framework Convention on Climate Change. In 2012, the Parties met in Doha, Qatar, and they met again in Warsaw, Poland in 2013. The resulting decisions from both meetings were primarily to continue ongoing efforts to reach a new agreement for emissions reductions to be adopted at the 2015 meeting in Paris, and to have those implemented by 2020. The new agreement would maintain the same overall goal as the Copenhagen Accord, to cap additional warming at 2 °C. Within the United States, President Barack Obama released the President's Climate Action Plan in June 2013. The plan is three-pronged, including proposed actions for mitigation, adaptation, and international leadership. The actions listed for mitigation include completing carbon pollution standards for new and existing power plants, accelerating clean energy permitting, increasing funding for clean energy innovation and technology, increasing fuel economy standards, increasing energy efficiency in homes businesses and factories, and reducing other GHG emissions including hydrofluorocarbons and methane. The plan states that the United States is still committed to reducing GHG emissions 17 percent below 2005 levels by 2020 if all other major economies agree to similar reductions. Additional efforts made domestically related to climate change are more focused on facilitating adaptation to the impending changes to the environment due to climate change in order to maintain the country's natural and economic resources, but do not directly address the emission of GHGs.

As described in the proposed rule, existing regulatory mechanisms directly or indirectly addressing all of the localized threats identified in the SRR (*i.e.,* those threats not related to GHGs and global climate change) are primarily national and local fisheries, coastal, and watershed management laws and regulations in the 84 countries within the collective ranges of the 65 coral species. This final rule incorporates any information we received via public comment regarding recent local regulatory mechanisms or local regulatory mechanisms that were either previously mischaracterized or inadvertently omitted. This includes some additions of various local laws as well as supplemental information regarding regulations pertaining to collection and trade of coral species. In addition, to better capture the breadth and scope of existing regulatory mechanisms on a species-by-species basis, we evaluated the presence and scope of five different categories of regulatory mechanisms in each of the 84 countries throughout the ranges of the 65 corals in this final rule. These categories of laws include: General protection of corals, reef fishing, marine protected areas, wild collection, and pollution.

For each coral species, we considered the relevant national laws, regulations, and other similar mechanisms that may reduce any of the threats described in our threat analyses for all countries in which the coral species has confirmed records of occurrence. To find each country where our 65 coral species have confirmed occurrence we used Veron's updated report on the listed coral species and their occurrence in various ecoregions (Veron, 2014). In considering countries' regulatory mechanisms, we give strongest weight to statutes and their implementing regulations and to management direction that stems from those laws and regulations.

In analyzing local regulatory mechanisms available for each coral species, five general categories emerged: General coral protection, coral collection control, fishing controls, pollution controls, and managed areas. General coral protection regulatory mechanisms include overarching environmental laws that may protect corals from damage, harm, and destruction, and specific coral reef management laws. In some instances, these general coral protection regulatory mechanisms are limited in scope because they apply only to certain areas or only regulate coral reef damage and do not prohibit it completely.

Coral collection regulatory mechanisms include specific laws that prohibit the collection, harvest, and mining of corals. In some instances, these coral collection regulatory mechanisms are limited in scope because they apply only to certain areas or are regulated but not prohibited.

Pollution control regulatory mechanisms include oil pollution laws, marine pollution laws, ship-based pollution laws, and coastal land use and development laws. In some instances, pollution regulatory mechanisms are limited in scope because they apply only to certain areas or to specific sources of pollution.

Fishing regulatory mechanisms include fisheries regulations that pertain to reefs or regulations that prohibit explosives, poisons and chemicals, electrocution, spearfishing, specific mesh sizes of nets, or other fishing gear. In some instances, fishing regulatory mechanisms are limited in scope because they apply only to certain areas, or not all reef-damaging fishing methods are prohibited, or reef-damaging fishing methods are regulated but not prohibited.

Managed area regulatory mechanisms include the capacity to create national parks and reserves, sanctuaries, and marine protected areas. In some instances, managed area regulatory mechanisms are limited in scope, primarily because the managed area provides limited protection for coral reefs, only small percentages of the countries' coral reefs are protected within the managed areas, or the managed areas are not well administered.

The management results for each species can be found in the Species-Specific Information and Determination section of this rule. It should be noted that while some of these regulatory mechanisms were categorized as ''limited in scope,'' it does not necessarily mean they are inadequate under ESA section 4(a)(1) Factor D.

We received a significant amount of information regarding the role of local management actions in building resilience into reef ecosystems. This section describes the emerging body of literature regarding the concept of reef resilience, defined as an ecosystem's capacity to absorb recurrent shocks or disturbances and adapt to change without compromising its ecological function or structural integrity. Until recently, the main drivers of coral reef decline included overfishing of herbivorous fish and nutrient loading from agriculture and other land-based sources of pollution. These stressors caused widespread changes in reef ecosystems over the past couple of centuries, and ultimately led to ecological shifts from coral-dominated systems to systems overrun by fleshy algae. These localized disturbances are now being compounded by climate change related threats, including increasingly frequent coral bleaching events as a result of ocean warming.

Many factors contribute to coral reef ecosystem resilience, including ecosystem condition, biological diversity, connectivity between areas, and local environmental conditions (Marshall and Schuttenberg, 2006; Obura, 2005). Implementing local actions that either protect or strengthen these resilience-conferring factors has the potential to help coral reef ecosystems survive predicted increases in the frequency, duration, and severity of mass coral bleaching events (Obura, 2005) and may help reduce the extinction risk of some individual coral species.

In terms of local management actions, many acute disturbances such as coral bleaching are out of the direct control of reef managers and cannot be mitigated directly. Actions that can be taken to build reef resilience and enhance reef recovery include reducing physical disturbance and injury as a result of recreational activities, managing local watersheds and coastal areas to prevent sedimentation and nutrient run-off, and reducing fishing pressures on important herbivorous fish (Jackson *et al.,* 2014; Kennedy *et al.,* 2013; Marshall and Schuttenberg, 2006; Mumby and Steneck, 2011). For example, a recent study shows that eutrophication can increase thermal stress on inshore reef communities and management actions to reduce coastal eutrophication can improve the resistance and resilience of vulnerable coastal coral reefs to ocean warming (Fabricius *et al.,* 2013). Additionally, herbivorous fish play a crucial role in the recovery of coral reefs after major disturbance events. Severe warming and increases in ocean acidification alone can reduce resilience of coral reef ecosystems, particularly if those systems are already subject to overfishing of the key functional groups of herbivorous reef fishes and nutrient loading (Anthony *et al.,* 2011; Bellwood *et al.,* 2004). Elevated populations of herbivores have the potential to confer resilience benefits by encouraging greater niche diversification and creating functional redundancy. For example, it has been demonstrated that two complementary herbivore species were more successful at controlling algal blooms than a single species on its own, and management of herbivorous fish can help in reef regeneration after episodes of bleaching or disease that are impossible to locally regulate (Bellwood *et al.,* 2004; Burkepile and Hay, 2008; Roff and Mumby, 2012). Conversely, even unexploited populations of herbivorous fishes do not guarantee reef resilience; therefore, some reefs could lose resilience even under relatively low fishing pressure (Cheal *et al.,* 2010). Therefore, the entire suite of local threats and disturbances should be minimized through local management actions to ensure that reef resilience and recovery are also maximized. Establishing MPA networks is generally accepted as one of the more common management tools to help reduce impacts to coral reefs and build resilience (Burke *et al.,* 2011; Keller *et al.,* 2009).

In a 2013 global review of 10,280 MPAs, it was found that approximately 2.93 percent of the world's oceans have MPA coverage; however, coverage does not necessarily equate to protection. Marine protected areas have often failed to prevent ongoing local threats such as overfishing due to management and/or design failure, as well as lack of local support, poor compliance, and inadequate resources to promote educational awareness and enforcement (Hughes *et al.,* 2007; Hughes *et al.,* 2010; Spalding *et al.,* 2013). A study by the World Resources Institute found that only 6 percent of the world's reefs occur in effectively managed MPAs (Burke *et al.,* 2011). Further, scientists are just beginning to understand spatial patterns of coral responses to disturbance. Efforts to identify coral reef areas with the greatest resilience are crucial for siting MPAs. This information has the potential to assist in future MPA design and management so that resistant patches of coral reef can be protected to ensure continued connectivity and subsequent recovery of nearby reefs that are less resistant. These strategies of tailoring management efforts across the marine environment depending on various responses to disturbance are still in their infancy, but it may eventually prove essential in adaptive management of reef resources in the face of future climate change-related disturbances (Mumby and Steneck, 2011). For these reasons, while MPAs are an important tool in response to the global degradation of coral reefs, they should not be considered a panacea (Hughes *et al.,* 2007).

In general, recent evidence suggests that management of local scale disturbances is essential to maintaining an adequate coral population density for successful reproduction and maintenance of genetic diversity and is therefore crucial to maintaining complex, bio-diverse coral reef ecosystems, given the predicted widespread impacts of climate change related threats (*e.g.,* Anthony *et al.,* 2011). The presence of effective local laws and regulations has the potential to help reduce impacts to coral reefs from threats on an ecosystem level, potentially extending the timeframe at which individual coral species may be in danger of extinction by providing a protective temporal buffer (*i.e.,* resiliency). Some evidence suggests that local management actions, particularly of fisheries (specifically, no-take marine reserves) and watersheds, can enhance the ability of species, communities, and ecosystems to tolerate climate change-related stressors, and potentially delay reef loss by at least a decade under ''business-as-usual'' rises in GHG emissions (Keller *et al.,* 2008; Kennedy *et al.,* 2013). In the Caribbean especially, local regulation of fisheries for herbivorous fish species (specifically parrotfish) is deemed one of the most important local actions to safeguard coral reefs in the face of looming climate change threats (Jackson *et al.,* 2014). It also has been strongly suggested that local management be combined with a low-carbon economy to prevent further degradation of reef structures and associated ecosystems (Birkeland *et al.,* 2013; Kennedy *et al.,* 2013).

After considering this supplemental information in addition to that which was available for the proposed rule, our conclusion regarding the inadequacy of regulatory mechanisms addressing global threats to corals from GHG emissions remains unchanged from the proposed rule. That is, without any substantive changes in emissions reduction pledges from any major economies and without any noteworthy additional efforts to actually reduce GHG emissions, the supplemental information considered in this final rule regarding regulatory mechanisms does not change the previous analysis. We reach the same conclusions regarding local regulatory mechanisms as described in the proposed rule, with the exceptions of *Acropora palmata* and *A. cervicornis.* For these species, we have incorporated into this final rule, the analysis of adequacy of regulatory mechanisms included in the 2005 status review and 2006 listing of these species as threatened. Those documents concluded that existing regulatory mechanisms are inadequate to address local and global threats affecting these species, and as such are contributing to the threatened status of these species.

Because the local threats have impacted and continue to impact corals across their ranges, we still generally conclude that, collectively, the existing regulations are not currently preventing or controlling local threats across the entire range of any of the 65 species. We still do not have sufficient information to determine if an individual species' extinction risk is exacerbated by inadequacy of individual existing regulations. On the other hand, the best available information suggests that local management may confer resilience benefits for coral reefs on an ecosystem level, which could extend the timeframe at which individual coral species may be at risk of extinction by providing a protective temporal buffer in the face of climate change-related threats. That is, implementing effective local management actions may allow for coral to persist while awaiting significant global progress to curb GHGs. Overall, we maintain that in the absence of effective global regulatory mechanisms to reduce impacts from climate change to corals, the inadequacy of existing regulatory mechanisms at global and local scales poses an extinction risk threat to all of the corals that are vulnerable to climate-related threats.

Threats Evaluation Conclusion

The above information on threats to reef-building corals leads to several important overall points that apply both currently and over the foreseeable future. First, the period of time over which individual threats and responses may be projected varies according to the nature of the threat and the type of information available about that threat and the species' likely response. The threats related to global climate change pose the greatest potential extinction risk to corals and have been evaluated with sufficient certainty out to the year 2100. Second, we expect an overall increase in threats, especially those related to global climate change as projected by RCP8.5 to 2100. Third, RCP8.5's projections of conditions on coral reefs within the ranges of the species covered by this rule over the foreseeable future are based on spatially-coarse analyses associated with high uncertainty, in particular at local spatial scales. Finally and most importantly, determining the effects of global threats on an individual coral species over the foreseeable future is complicated by the combination of: (1) Uncertainty associated with projected ocean warming and acidification threats; (2) regional and local variability in global threats; (3) large distributions and high habitat heterogeneity of the species in this final rule; and (4) limited species-specific information on responses to global threats.

Thus, in our species determinations, we recognize that the best available information indicates the impacts of climate change will likely increase in the foreseeable future. However, there are limitations to using this global, coarse-scale information for determining vulnerability to extinction for individual coral species. Climate change projections over the foreseeable future are associated with three major sources of uncertainty; (1) The projected rate of increase for GHG concentrations; (2) strength of the climate's response to GHG concentrations; and (3) large natural variations. The recent warming slow-down is an example of a large natural variation that was not anticipated by previous models. Reports that discuss the future impacts of climate change on coral reefs indicate variability in both the models underlying these changes and the extent of potential impacts to the coral ecosystem. Recognizing uncertainty and spatial variability in climate change projections, and the spatial variability in environmental conditions on coral habitat, in our species determinations we emphasize the role that heterogeneous habitat and spatial and demographic traits play in evaluating extinction risk. We also consider in our determinations that each species in this final rule experiences a wide variety of conditions throughout its range that helps mitigate the impacts of global and local threats to some degree. Finally, we don't consider projections of impacts to coral reef ecosystems to definitively represent impacts to individual coral species, because coral reef communities typically consist of dozens to hundreds of reef-building coral species, each of which may respond differently to environmental and ecological changes. In addition, reef-building corals are not limited to occupying only coral reefs.

Risk Analyses

Many factors can contribute to an individual species' extinction risk. The process of extinction usually occurs in phases, first affecting individual populations or sub-populations, and then progressing to the species level. Extinction can occur as a result of stochastic processes that affect birth and death and mortality from catastrophic events. A species' biological traits can influence extinction risk both in terms of vulnerability to environmental perturbations and effects on population dynamics. Extinction risk is also influenced by depensatory effects, which are self-reinforcing processes (*i.e.,* positive feedbacks) that accelerate species loss as its population density declines.

The proposed rule described our framework for evaluating extinction risk and making listing determinations in the Risk Analyses section. There were multiple steps in our process of evaluating the listing status of each species. The initial step in developing the framework consisted of evaluating the ESA definitions of ''endangered'' and ''threatened'' and how those definitions apply to corals. The application of those definitions was based on the background of the Context for Extinction Risk and General Threats sections of the proposed rule.

We then considered the elements that contribute to the extinction risk of corals in the Risk Analyses section of the proposed rule. The following is a list of the specific elements within their respective categories: (1) Vulnerability to threats, including each of the nine most important threats, based on a species' susceptibility and exposure to each of the threats; (2) demography, including abundance, trends in abundance, and relative recruitment rate; and (3) spatial structure, including overall distribution, which is a combination of geographic and depth distributions, and ocean basin. In order to evaluate the best available information for each of the 82 candidate corals and consider all elements in each of these categories, we developed a Determination Tool to organize and consistently interpret the information in the SRR, FMR, and SIR and apply it to the definitions of threatened, endangered, and not warranted species developed for corals, in a decision framework that we developed to specifically apply to corals.

In the proposed rule, we linked the major elements of our Risk Analyses, vulnerability to threats, demography, and spatial structure, to the ESA listing categories. We described endangered species as having a current extinction risk; they are highly vulnerable to one or more of the high importance threats and have either already been seriously adversely affected by one of these threats, as evidenced by a declining trend and high susceptibility to that threat, or they lack a buffer to protect them from serious adverse effects from these threats in the future. We described threatened species as not currently being in danger of extinction, but are likely to become so within the foreseeable future. They are highly or moderately vulnerable to one or more of the high importance threats or highly vulnerable to one or more of the lower importance threats, but have either not yet exhibited effects in their populations or they have the buffering protection of more common abundance or wider overall distribution. We described not warranted species as not being in danger of extinction currently and not likely to become so within the foreseeable future because they have: Low vulnerability to the high importance threats, or low or moderate vulnerability to all the lower importance threats, and common abundance or wide overall distribution.

The proposed rule described the basis for our determination of the foreseeable future for the purposes of projecting climate-related threats in the Threats Evaluation and Risk Analyses sections, and was supported by several other sections (*e.g.,* Global Climate Change—Overview). Consistent with our practice for all species listing determinations, we established that the appropriate period of time corresponding to the foreseeable future is a function of the particular type of threats, the life-history characteristics, and the specific habitat requirements for the coral species under consideration. The timeframe established for the foreseeable future considered the time necessary to provide for the conservation and recovery of each threatened species and the ecosystems upon which they depend. It was also a function of the reliability of available data regarding the identified threats and extends only as far as the data allow for making reasonable predictions about the species' response to those threats. We agreed with the BRT's assessment that the threats related to climate change had been sufficiently characterized and predicted through the end of this century. Therefore, in the proposed rule, we determined the year 2100 to be the appropriate outer limit of foreseeability as to climate change-related threats.

In the proposed rule, we evaluated each species throughout its entire range, because no SPOIRs were identified, and that assessment has not changed in the final rule as described further below in the Statutory Standards sub-section. While we did receive additional qualitative information on the abundances and distributions of the 65 proposed species, nothing in that data indicated that any portions of the range of any of the species warranted further evaluation under the applicable standards of the final SPOIR Policy, as discussed in the Statutory Standards sub-section below. The last step in developing the proposed listing determinations was to evaluate ''Conservation Efforts'' to determine if they would change the basis for listing a species by alleviating threats or recovering populations. We concluded that conservation efforts on global and local scales did not change the status determined using our decision framework for any of the 82 candidate species.

Comments 32–34 and 37–42 focused on four aspects of the listing determination process in the proposed rule: (1) The Determination Tool, (2) the foreseeable future, (3) the SPOIR analysis, and (4) conservation efforts. The comments we received identified deficiencies in the proposed rule's Determination Tool, leading to a change in our approach from a formulaic framework to describe extinction risk, to a non-formulaic framework to describe vulnerability to extinction. That is, the final determination framework integrates different types of information in a holistic manner that better represents all the available information, including complexity and uncertainty, than was possible using the linear Determination Tool in the proposed rule. In this section, we explain the final determination framework process that we used to determine each of the species' statuses, how it is different from the proposed rule, and how new and supplemental information was incorporated.

In the proposed rule we described our determination approach in the Risk Analyses and Detailed Description of Determination Tool Elements sections, in which we discussed the elements that affect a coral's extinction risk. Below we describe how that determination approach has been adapted for this final rule and applied to the Statutory Standards, in light of and in response to public comments.

Final Determination Framework

Overview of Key Changes Applied in Final Determinations. We received many comments questioning the accuracy of the methods used to analyze the available information to assess extinction risk and derive listing statuses for each of the proposed species, including how the Determination Tool was used. After considering these comments, and as discussed above, our findings in the proposed rule were influenced by how we believed coral species would react to environmental changes now and over the foreseeable future. Given the current effects and projections of climate change impacts to the marine environment into the foreseeable future and the information we had at the time of the proposed rule on coral response to existing and predicted environmental stressors, we determined that many of the coral species met the definition of ''endangered species'' or ''threatened species.'' In explaining how the Determination Tool assessed risk and derived listing statuses we concluded that, as some public comments suggested, the Determination Tool was too linear and deterministic. This led to listing determinations in the proposed rule that were based, in large part, on applying the endangered and threatened standard to relative characteristics instead of applying the endangered and threatened standard to each individual species independently to determine their listing status.

In this rule, we have changed our determinations for many of the species for two general reasons: (1) Informed by public comments, we refined the way we apply the available information to determine vulnerability to extinction; and (2) we received via public comments, or gathered ourselves, information that expanded our existing knowledge.

We received and gathered specific information about spatial, demographic, and other characteristics of individual coral species, and the public comments provided general scientific criticism about how we weighed these factors. In the proposed rule, we gave greater consideration to susceptibility to threats but did not fully recognize the extent to which spatial, demographic, and other characteristics of corals can moderate vulnerability to extinction. After considering all of the available information and public comments, in this final rule we continue to recognize the threats that the species face, but we also place more emphasis on buffers against those threats and revisit the predicted population responses of individual species to the threats, giving full consideration to their current spatial, demographic, and other characteristics. For example, we took into account that many of the species, when viewed on their own rather than in relation to other coral species or vertebrate species, have more substantial absolute abundances than the prior methodology accounted for.

We also took into account that in many instances coral species occupy a wide range of habitats, including areas that can act as refugia from warming, which moderate the predicted impacts across coarse-scale areas. As explained generally above, and in regard to individual species below, the species in this final rule will be negatively impacted by future conditions, but in light of our consideration of factors and characteristics discussed above, we find they are not currently in danger of extinction and do not meet the definition of endangered. We do, however, conclude that some species are likely to become in danger of extinction within the foreseeable future and thus meet the definition of threatened. We also find that listing is not warranted for some species that were previously proposed for listing.

In this final rule, we acknowledge that there are no recipes or formulas for endangered, threatened, or not warranted coral species, especially given the variability in coral species' biology and ecology, and the variability in available information from species to species. Accordingly, the final framework allows for consideration of each coral's circumstances as a whole (simultaneously evaluating each species' demography, spatial characteristics, threat susceptibilities, and current and future environmental conditions independently of the other species), leading us to species-specific conclusions about vulnerability to extinction.

The final determination framework used in this final rule is composed of seven elements. The first element is describing the statutory standards. The second, third, fourth, and fifth elements are identifying and analyzing all the appropriate species-specific and general characteristics that influence extinction risk for a coral species. The sixth element is relating a species' characteristics to a particular extinction risk at appropriate spatial and temporal scales. The seventh element is explicitly stating how each species' extinction risk meets the statutory listing definitions as applied to corals, resulting in an ultimate listing status. A final consideration in evaluating listing status is whether current or planned conservation efforts improve the overall status of any of the 65 species such that the additional protections of the ESA are not warranted.

In moving to an integrated, non-formulaic framework, some of our key assumptions about vulnerability to extinction changed due to analyzing the different aspects of each species' characteristics independently (on an absolute scale), instead of being rated with the other proposed corals species (on a relative scale). We rely on the following guiding principles extracted from each of the sections in the first part of this rule, providing the context and background information for the species determinations, in order to determine each species' listing status:

- Clonal, colonial organisms, such as corals, are vastly different in their biology and ecology than many other species listed by NMFS under the Endangered Species Act.
- In our species determinations, we give appropriate consideration to the complex nature of coral biology and variability in responses to threats between individual coral colonies and even between different portions of the same colony.
- In our species determinations, absolute abundance and absolute distribution inform our evaluation of a species' current status and its capacity to respond to changing conditions over the foreseeable future.
- The concept of heterogeneous habitat influences extinction risk for all species in this final rule because each species experiences a wide variety of conditions throughout its range, which allows for variable responses to global and local threats.
- We recognize that the best available information indicates the impacts of climate change will likely increase in the foreseeable future. However, there are limitations to using this global, coarse-scale information for determining vulnerability to extinction for individual coral species.
- In our species determinations, we don't consider projections of impacts to coral reef ecosystems to definitively represent impacts to individual coral species, because coral communities typically consist of dozens to hundreds of coral species, each of which may respond differently to environmental and ecological changes.
- Recognizing the uncertainty and spatial variability in climate change projections, and the spatial variability in environmental conditions on coral habitat, in our species determinations we emphasize the role that heterogeneous habitat and absolute demographic and spatial characteristics play in evaluating extinction risk.

We have ordered the informational categories in the Species-specific Information and Determinations sections below for clarity in describing the species-specific elements and their interaction in contributing to each species' vulnerability to extinction as follows: (1) Spatial Information—overall distribution and ocean basin, habitat; (2) Demographic Information—abundance, trends in abundance, relative recruitment rate; and (3) Susceptibility to threats based on a species' susceptibility to each of the nine threats. Further, when information is available that does not fall into one of the categories or elements identified above, but is relevant to extinction risk, we provide it under the Other Biological Information category. In each species determination, we refer back to the specific guiding principles that played a role in how we consider the species-specific information and the sections in which they are described in more detail.

Statutory Standards

The definitions of endangered and threatened species under section 3 of the ESA, wherein (1) an ''endangered species'' is defined as ''any species which is in danger of extinction throughout all or a significant portion of its range'', and (2) a ''threatened species'' is defined as ''any species which is likely to become an endangered species in the foreseeable future throughout all or a significant portion of its range,'' formed the basis of our determination framework. Considered at both the spatial and temporal scales applicable to each of those listing statuses, an endangered species *currently* faces an extinction risk throughout *all or a significant portion of its range* and a threatened species is likely to become endangered throughout *all or a significant portion of its range within the foreseeable future.* In other words, the primary statutory difference between a threatened and endangered species is the timing of when a species may be in danger of extinction, either presently (endangered) or in the foreseeable future (threatened). Further, as discussed below, no significant portions of their ranges could be determined for any of our proposed species; thus, the only spatial scale we consider is each species' entire range.

Court opinions produced in litigation challenging the listing of the polar bear as threatened provides a thorough discussion of the ESA's definitions and the Services' broad discretion to determine on a case-by-case basis whether a species is in danger of extinction (*see, In Re Polar Bear Endangered Species Act Listing and § 4(d) Rule Litigation,* 794 F. Supp.2d 65 (D.D.C. 2011); *aff'd,* 709 F.3d 1 (D.C. Cir. 2013); 748 F. Supp.2d 19 (D.D.C. 2010)). The Court determined that the phrase ''in danger of extinction'' is ambiguous. The Court held that there is a temporal distinction between endangered and threatened species in terms of the proximity of the ''danger'' of extinction, noting that the definition of ''endangered species'' is phrased in the present tense, whereas a threatened species is ''likely to become'' so in the future. However, the Court also ruled that neither the ESA nor its legislative history compels the interpretation of ''endangered'' as a species being in ''imminent'' risk of extinction. Thus, in the context of the ESA, a key statutory difference between a threatened and endangered species is the timing of when a species may be in danger of extinction, either now (endangered) or in the foreseeable future (threatened). The Court ruled that although imminence of harm is clearly one factor that the Services weigh in their decision-making process, it is not necessarily a limiting factor, and that Congress did not intend to make any single factor controlling when drawing the distinction between endangered and threatened species. In many cases, the Services might appropriately find that the imminence of a particular threat is the dispositive factor that warrants listing a species as 'threatened' rather than 'endangered,' or vice versa. To be listed as endangered does not require that extinction be certain or probable, and that it is possible for a species validly listed as ''endangered'' to actually persist indefinitely. Due to the ambiguous nature of the statutory terms, we have defined ''endangered'' and ''threatened'' at the end of the Foreseeable Future sub-section below in the context of the particular species (corals) being considered for listing.

Significant Portion of its Range (SPOIR). The ESA's definitions of ''endangered species'' and ''threatened species'' refer to two spatial scales, providing that a species may be imperiled ''throughout all'' of or ''in a significant portion of'' its range. 16 U.S.C. 1532(6); (20). NMFS has interpreted the ''significant portion of its range'' language in a policy that has recently been finalized. *See* ''Final Policy on Interpretation of the Phrase 'Significant Portion of its Range' in the Endangered Species Act's Definitions of 'Endangered Species' and 'Threatened Species' '' (79 FR 37578; July 1, 2014) (''Final Policy''). In developing our proposed rule, our analysis was informed by the Draft Policy that was published in December 2011 (76 FR 76987; December 9, 2011). As we explained in the proposed rule, we were unable to identify any portions of the species' ranges that might require closer analysis as potential SPOIRs, due in large part to a lack of species-specific information regarding abundance, geographic distribution, diversity, and productivity (77 FR 73247).

The Final Policy, which we must now apply, differs in two key respects from the Draft Policy. Neither changes the ultimate result in this case, which is that no SPOIRs can be identified. First, the Final Policy specifies that no portions of a species' range can be ''significant,'' and thus no SPOIR analysis need be done, where the range-wide status analysis leads to a conclusion that listing the entire species as threatened or endangered is warranted. (Under the Draft Policy, even if a species were found to warrant listing as ''threatened,'' the agency still needed to consider whether any portions of the range may be significant). Second, the final policy defines ''significant'' to include not only those portions where the individuals are so biologically significant that without them the entire species would meet the definition of ''endangered'' (the standard in the Draft Policy), but also those portions whose loss would render the species ''threatened.''

In this case, our framework evaluates each species throughout its range to determine extinction risk. If a species is determined to be threatened or endangered based on the rangewide analysis, no further evaluation is warranted. However, if a species is found to be not warranted at the spatial scale of its entire range, we must consider if a SPOIR exists that may be both highly biologically important and at higher extinction risk, such that its loss would render the entire species endangered or threatened. An evaluation is required only where there is information to suggest that a particular portion of the range is likely to be both ''significant'' as defined in the policy and to qualify as endangered or threatened (79 FR 37586).

As described in the proposed rule, the BRT did not identify any portions of the range for any of the 82 coral species as being potentially ''significant'' or at a higher extinction risk. Because there was a general lack of species-specific data regarding quantitative abundance, distribution, diversity, and productivity of coral species, we were not able to identify any portions of any of the species' ranges that could be considered unusually biologically significant. Further, we had no information to indicate that particular local threats were more severe in a particular portion of an individual species' range.

No supplemental information was received in response to the proposed rule that provides support for identification of a SPOIR for any of the proposed species. While we did receive supplemental information on the qualitative abundances and distributions for some species, nothing in that data suggests that any particular portion of any proposed species range is unusually biologically significant. We do not have any information that would help elucidate whether any species is at higher exposure to threats in a particular area of its range (*i.e.,* where threats may be so acute or concentrated that current conditions are likely to render the species there at significantly higher risk of extinction than the overall species). Thus, we did not identify any SPOIR for any species, and so our determination as to each species is based on the best available information about the species' status throughout its range.

Foreseeable Future. The ''foreseeable future'' is integral to the definition of a threatened species. It is the timeframe over which we evaluate a species' extinction risk if it is not currently in danger of extinction. As described in the proposed rule, the identification of the foreseeable future is unique to every listing decision. It is based on the particular type of threats, the life-history characteristics, and the specific habitat requirements for the species under consideration.

For this Final Rule, we clarify that the ''foreseeable future'' is that period of time over which we are able to make reliable projections about all of the significant threats affecting the species and the species' likely response to those threats. Projections need not be ''certain'' to be reliable, so long as we are able to make predictions with a reasonable degree of confidence based on available information. In the proposed rule, we identified the year 2100 as marking the outer limit of the foreseeable future based upon the ability to make projections about the primary threats to corals—those stemming from global climate change—over that period (77 FR 73226). However, in identifying 2100 as the limit of the foreseeable future for purpose of analyzing those threats, we did not intend to establish that year as the only relevant benchmark for analyzing all threats to the species or the species' response thereto.

Because neither the ESA nor implementing regulations define ''foreseeable future,'' the term is ambiguous, and Congress has left broad discretion to the Secretary to determine what period of time is reasonable for each species. This does not require identifying a specific year or period of time to frame our analysis, particularly where there is inadequate specific data to do so. *See* ''Memorandum Opinion: The Meaning of 'Foreseeable Future' in Section 3(20) of the Endangered Species Act'' (M–37021, Department of the Interior Office of the Solicitor, January 16, 2009). The appropriate timescales for analyzing various threats will vary with the data available about each threat. In making our final listing determinations we must synthesize all available information and forecast the species' status into the future only as far as we reliably are able based on the best available scientific and commercial information and best professional judgment.

In the case of corals, we can make reasonable assessments as to the most significant environmental factors facing the coral species between now and 2100. We have explained that this time period, which is consistently used by most current global models and the IPCC reports, allows for reliable and reasonable projections about climate change-related threats. As described in the Threats Evaluation—Foreseeable Future and Global Climate Change Overview sections above, 2100 was selected as the limit of foreseeability for climate change-related threats based on AR4's and AR5 WGI's use of 2100 as the end-point for most of its global climate change models (IPCC, 2013). Public comments asserted that the models used in climate predictions are too uncertain to reliably predict climate conditions out to 2100. However, as we have explained in our response to Comment 38 and elsewhere in this final rule, supplemental information supports, and we reaffirm our choice of, identifying 2100 as the timeframe over which we can make reliable predictions about climate change-related threats.

However, global climate change is not the only relevant threat to the species, and the range of available data differs as to these other threats (such as predation, sedimentation, *etc.*). Further, in reaching our conclusions and ultimate listing determinations, we need to assess how the species will react to the various stressors identified in this rule. For example, to the extent it was available, we considered a significant amount of information on the current spatial and demographic features of the species, based on various types of information which support varying degrees of projection into the future. Thus, while the year 2100 is a reliable end-point for projecting climate change-related threats, it is not valid across the range of threats for the species and should not be misunderstood as driving our forecasts of the species' statuses.

For all of these species, we concluded based on the best available scientific and commercial information that their spatial, demographic, or other characteristics buffer them against current endangerment of extinction. However, over the foreseeable future, the ability of spatial and demographic traits to provide a buffer against the danger of extinction is expected to diminish as colonies within particular areas are impacted due to climate change and other negative stressors. We considered, at a species level, whether these predicted conditions may cause the species to become in danger of extinction within the foreseeable future. However, there are varying degrees of certainty about the responses of corals to stressors. We can be confident that certain mitigating elements of the life history for some of these species will not change, such as their ability to reproduce asexually or the ability to persist in a range of depths. But we are less confident in other aspects, such as precisely where and when local extirpations may occur.

For this final rule, then, we make clear that our listing determinations are reached on the totality of the best available information about the threats to the species and the species' likely response to them over time. Our determinations reflect our consideration of that information, as well as application of our professional judgment regarding how far into the future we can reliably project either the underlying threats or the species' response. However, in light of the number of variables pertaining to the stressors and buffering traits among the corals species evaluated, and the limited availability and incomplete nature of quantitative data on these species, a quantitative assessment of these projections is not possible. Therefore our assessment of the foreseeable future is necessarily qualitative. Given the biological traits and life history strategies of the corals evaluated in this rule, including their relatively long life-spans, the period of time over which we are able to make reliable projections is the next several decades. This general timeframe thus frames our listing determinations. Although we recognize that climate related threats will persist beyond this horizon, we find it both infeasible on the information available and unnecessary to attempt to identify the foreseeable future across the full range of threats to the species and the species' response with more precision.

In the proposed rule, we considered how the temporal scales were appropriately factored into our evaluations of whether a species was in danger of extinction now, likely to become in danger of extinction in the foreseeable future, or not warranted for listing. For example, two major factors determining the immediacy of the danger of extinction for corals are the relatively high degree of certainty of impacts from high importance threats and a species' current or future capacity to resist adverse effects. Under the proposed rule's Determination Tool approach, endangered species were species with a current high extinction risk; they were highly vulnerable to one or more of the high importance threats and had either already been seriously adversely affected by one of these threats, as evidenced by a declining trend, and high susceptibility to that threat, or they lacked a buffer to protect them from serious adverse effects from these threats in the future. While a threatened species under the proposed rule might be impacted by the same threats as an endangered species, it was less exposed or less susceptible, providing greater buffering capacity to those same threats when compared to an endangered species.

In response to public comments critical of our equating species' listing statuses with outcomes of the determination tool, here we more fully explain the biological characteristics and distinctions between endangered and threatened corals, and corals not warranting listing under the ESA. Under the final rule's determination framework, an endangered species is at such risk of extinction, that it is currently ''in danger'' of extinction throughout its range. As such, an endangered coral species is of such low abundance or is so spatially fragmented that the species is currently in danger of extinction. Several processes may contribute to the danger of extinction (*e.g.,* depensatory process, catastrophic events). Depensatory processes include reproductive failure from low density of reproductive individuals and genetic processes such as inbreeding. A coral species with these characteristics would be vulnerable to background environmental variation if a large proportion of the existing population were concentrated in an area that experienced an environmental anomaly leading to high mortality. Similarly, an endangered coral species could be of such low abundance that one catastrophic event or a series of severe, sudden, and deleterious environmental events could cause mortality of a large enough proportion of the existing population that the remaining population would be unable to reproduce and/or recover. A coral species that meets the endangered standard is not necessarily characterized by a single factor (*e.g.,* abundance number, density, spatial distribution, or trend value) but could also be characterized by combinations of factors encompassing multiple life history characteristics and other important ecological features, as described above. Different combinations of such factors may result in endangered status from species to species.

Under the final rule's determination framework, a threatened coral species also is at a risk of extinction due to its spatial and demographic characteristics and threat susceptibilities; however those traits still provide sufficient buffering capacity against being in danger of extinction currently. In other words, the species has an abundance and distribution sufficient for it to be not currently of such low abundance or so spatially fragmented to be in danger of extinction, but is likely to become so within the foreseeable future throughout it range. Similar to an endangered species, a coral species that meets the threatened standard is not necessarily characterized by a single factor (*e.g.,* abundance number, density, spatial distribution, or trend value) but could also be characterized by combinations of factors encompassing multiple life history characteristics and other important ecological features, as described above. Different combinations of such factors may result in threatened status from species to species.

Thus, there is a temporal distinction between endangered and threatened species in terms of the proximity of the danger of extinction based on the sufficiency of characteristics to provide buffering capacity against threats that cause elevated extinction risk. It is worth noting that this temporal distinction is broad, and a threatened species could likely become an endangered species anytime within the foreseeable future.

Under the final rule's determination framework, a coral species that is not warranted for listing has spatial and demographic traits and threat susceptibilities that, when considered in combination, provide sufficient buffering capacity against being in danger of extinction within the foreseeable future throughout its range. In other words, it has sufficient abundance and distribution, when considering the species' threat susceptibilities and future projections of threats, it is not likely to become of such low abundance or so spatially fragmented to be in danger of extinction within the foreseeable future throughout its range. A not warranted species also may not be susceptible to the threats at a sufficient level to cause any major change in the species abundance.

In summary, the basic structure of our final determination framework is formed by the relevant spatial and temporal scales over which each coral species' extinction risk is evaluated. An endangered coral species is *currently* in danger of extinction throughout its entire range. A threatened species is *likely to become* endangered throughout its entire range within the foreseeable future.

Spatial Structure

We consider spatial elements that increase a species' risk of extinction, alone or in combination with other threats, under ESA Factor E—other natural or manmade factors affecting the continued existence of the species. Spatial structure is important at a variety of scales. At small spatial scales within a single population, issues of gamete density and other Allee effects can have significant impacts on population persistence. At large spatial scales, geographic distribution can buffer a population or a species from environmental fluctuations or catastrophic events by ''spreading the risk'' among multiple populations. We explicitly described how exposure to individual threats varies at different spatial scales in the Threats Evaluation section above. Generally, having a larger geographic or depth distribution provides more potential area to occupy. However, if populations become too isolated gene flow and larval connectivity may be reduced, making the species less likely to recover from mortality events. Thus, a robust spatial structure includes larger geographic distributions with adequate connectivity to maintain proximity of populations and individuals within the range. We consider geographic distribution and depth distribution (and connectivity, when we have that information) in describing the overall distribution for each species.

We also consider the ocean basin in which a species exists. As described in the Corals and Coral Reefs—Inter-basin Comparisons, the Indo-Pacific occupies at least 60 million square km of water (more than ten times larger than the Caribbean), and includes 50,000 islands and over 40,000 km of continental coastline, spanning approximately 180 degrees of longitude and 60 degrees of latitude. Thus, occupying only a small portion of the Indo-Pacific basin can still be a geographically large distribution for an individual coral species. In contrast, the Caribbean basin is relatively geographically small and partially enclosed, but biologically well-connected. The Caribbean also has relatively high human population densities with a long history of adversely affecting coral reef systems across the basin. In the proposed rule we determined that if a species is restricted to the Caribbean, its overall range was considered narrow and its extinction risk was significantly increased, which greatly contributed to an endangered or threatened determination. Comment 40 criticizes our characterization of the Caribbean in this manner, stating that the BRT's determination that the entire Caribbean is sufficiently limited in geographic scale to be a factor that increases the extinction risk of all corals in the Caribbean is at odds with genetic data. The commenter provided references to support the conclusion that, while it is clear that regional-scale processes such as bleaching and disease are acting on all these reefs in the Caribbean basin simultaneously, all reefs should not be presumed to respond the same to these disturbances. Upon consideration of the comment and the fact that the Determination Tool ratings regarding basin occupancy were an inadvertent function of comparing the Caribbean basin to Indo-Pacific basin (*i.e.,* the automatic increase in extinction risk for species occurring in the smaller, more disturbed Caribbean was only relative in comparison to species occurring in the larger, less disturbed Indo-Pacific) we re-evaluated our characterization of the Caribbean. We now consider the absolute (non-relative) size of the basin and the amount of heterogeneity in the system; therefore, we no longer conclude that presence within the Caribbean basin automatically increases extinction risk (because many of the Caribbean coral species occupy a large portion of habitat compared to the total habitat available to them and the heterogeneous nature of that habitat). In general, we still consider distribution in the Caribbean to be problematic, but will now consider the influence of a Caribbean distribution on extinction risk on a species-by-species basis. For example, if a species has a Caribbean-wide geographic distribution and large depth distribution, and isn't susceptible to or exposed to threats now or through the foreseeable future, then a Caribbean basin distribution alone doesn't automatically increase the species' extinction risk. In the Species-specific Information and Determinations section of this final rule, we describe the extent to which an individual species' extinction risk is influenced by its specific geographic, depth, and habitat distributions within each basin.

Demography

Demographic elements that cause a species to be at heightened risk of extinction, alone or in combination with threats under other listing factors, are considered under ESA Factor E—other natural or manmade factors affecting the continued existence of the species. In the proposed rule, we used species-specific qualitative abundance estimates, coded as ''common,'' ''uncommon,'' or ''rare'' for the candidate species because it was the only abundance metric that was available for all of the 82 candidate species. As mentioned above in the Distribution and Abundance of Reef-building Corals sub-section, these qualitative estimates are the subjective opinion of particular authors on their particular survey data and are meant to indicate relative abundance between the categories. That is, a rare species has fewer individuals as compared to an uncommon one, and an uncommon species has fewer individuals than a common one. These estimates are also meant to describe an author's opinion of the qualitative abundance of the species throughout its range, but not an estimate of the abundance at an individual location. In general, ''rare'' or ''uncommon'' species are more vulnerable than ''common'' ones, although some species are naturally rare and have likely persisted in that rare state for tens of thousands of years or longer. However, naturally rare species can be at greater risk of extinction than naturally more common species when confronted with global threats to which they are vulnerable. In our final determination framework, rarity or uncommonness may increase extinction risk, but alone it does not automatically contribute to a finding of an endangered or threatened status.

Trends in abundance directly demonstrate how a particular species responds under current or recent-past conditions. Generally, a continuing downward trend likely increases extinction risk, while stabilization or a continuing upward trend likely decreases extinction risk. Trend data for the 65 species are scarce, but we describe the extent to which an individual species' extinction risk is influenced by its trend data when the information is available.

Productivity is another important indicator of extinction risk. Productivity is defined here as the tendency of the population to increase in abundance and is often expressed as ''recruits per spawner,'' although the term ''recruit'' can be difficult to apply in the case of corals, which reproduce both sexually and asexually (see Individual Delineation sub-section). Some of the proposed coral species are long-lived, with low or episodic productivity, making them vulnerable to trends of increased mortality or catastrophic mortality events. Overall, recruitment rate estimates for the proposed species are scarce, but in cases where estimates were available analysis of how that species' extinction risk is influenced by its relative recruitment rate is considered in the Species-specific Information and Determinations section below.

Susceptibility to Threats

Susceptibility of a coral species to a threat is primarily a function of biological processes and characteristics, and can vary greatly between and within taxa. Susceptibility of a species to a threat depends on the combination of: (1) Direct effects of the threat on the species; and (2) the cumulative and interactive (synergistic or antagonistic) effects of the threat with the effects of other threats on the species. In the proposed rule, we considered how the cumulative or interactive effects altered the rating assigned to a threat susceptibility in isolation. However, upon further consideration, we need to evaluate the extent to which one threat influences the susceptibility of an individual species to another threat with more species-specific information, in connection with all the other elements that influence a species' extinction risk. Generally, cumulative and interactive processes are complex and uncertain and existing information about threats interactions is only based on a few studies on a few species. Where possible, when we have species-specific cumulative or interactive effects information, we have applied this information to that particular species' susceptibilities in a more integrated manner. Species-specific threat susceptibilities are described in the Species-specific Information and Determinations section.

The three most important threats that contribute to the proposed coral species' extinction risk are ocean warming, disease, and ocean acidification. We considered these threats to be the most significant threats posing extinction risk to the proposed coral species currently and out to the year 2100. Threats of lower importance (trophic effects of reef fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade) also contributed to our findings on extinction risk, but to a lesser extent.

Current and Future Environmental Conditions

The general information described in the preceding sections of this final rule illustrates that the most important threats are currently increasing and likely to increase further in the foreseeable future (Threats Evaluation), but that the impacts from these threats currently and in the foreseeable future are difficult to interpret and do not necessarily correlate to an increased vulnerability to extinction due to the biological and physical complexity of corals and their habitat (Corals and Corals Reefs, Threats Evaluation).

The information on corals, coral reefs, coral habitat, and threats to reef-building corals in a changing climate leads to several important points that apply both currently and over the foreseeable future. First, the foreseeable future for purposes of our ultimate listing determinations is described qualitatively and encompasses the next several decades. For purposes of analyzing the specific threats related to climate change, we have identified the foreseeable time period over which we can make reliable projections to extend over the period from now to the year 2100. There is increased uncertainty over that time period as conditions that are analyzed closer to the year 2100 become less foreseeable. That is, the general trend in conditions during the period of time from now to 2100 is reasonably foreseeable as a whole, but conditions become more difficult to accurately predict through time. Second, there is an overall increasing trend of threat severity, especially for threats related to global climate change as projected by RCP8.5 to 2100. Third, while some models suggest disastrous effects of RCP8.5 on coral reefs by 2100, such projections are based on spatially coarse analyses associated with high uncertainty, especially at local spatial scales. In sum, determining the effects of global threats on an individual coral species over the foreseeable future is complicated by the combination of: (1) Uncertainty associated with projected ocean warming and acidification threats; (2) regional and local variability in global threats; (3) large distributions and high habitat heterogeneity of the species in this final rule; and (4) limited species-specific information on responses to global threats.

Vulnerability to Extinction

The vulnerability of a species to extinction is a complex function of physiology, life history, morphology, spatial distribution, and interaction with threats (the biological context). The biological context for a species' vulnerability to threats dictates the ecological interactions that ultimately determine how a species responds to threats, such as competition and predation (the ecological context). For example, a species that suffers high mortality from a bleaching event also may be able to recover quickly because its high dispersal and skeletal growth enable efficient recolonization and strong competition. Thus, the initial response to threats does not necessarily mean the species is vulnerable.

Vulnerability of a coral species to extinction also depends on the proportion of colonies that are exposed to threats and their different responses to those threats. In the proposed rule there was little variation between species for exposure to a given threat in the assigned ratings (*e.g.,* exposure to ocean warming was rated the same for all 82 species, which should not automatically be the case because for species that have drastically different distributions and abundances). For this final rule, a coral species' vulnerability to extinction is now evaluated to be holistically influenced by its demographic and spatial characteristics, threat susceptibilities, and current and future environmental conditions. We believe this more complete and integrated treatment of the factors that influence a coral's vulnerability to extinction will lead to a more accurate characterization of whether or not a species currently faces an extinction risk throughout its entire range.

Species Status

After analyzing all of the relevant species-specific demographic and spatial characteristics, threat susceptibilities, and general information on current and future environmental conditions, we relate those characteristics to the particular species' status. This is the key component of the determination that explains how certain species characteristics translate to a particular extinction risk at appropriate spatial and temporal scales. These determinations are heavily influenced by the quantity and quality of species-specific information, especially the species' demographic and distribution characteristics. We received many public comments regarding the lack of quantity and quality of information available for each of the species; those commenters asserted that our species determinations were therefore unfounded. By specifically considering all the currently available species-specific information (both information that we used in the proposed rule and the considerable amount of information that has become available since the proposed rule), we are able to produce more robust evaluations of the information and species determinations. Recognizing the uncertainty and spatial variability of climate change projections and the limited species-specific information on how species in this final rule respond to climate change, we emphasize a species' demographic and spatial characteristics in how its vulnerability to extinction is affected now and through the foreseeable future.

In finalizing a species determination we translate the species' status directly into a listing category using the statutory standards. In the proposed rule, we satisfied this step by using an organizational process called the outcome key, based on ratings in the Determination Tool. The key was intended to identify the general species characteristics and combinations that equate to a particular listing status. However, the outcome key in the proposed rule was too formulaic, and did not explain our comprehensive consideration of the species characteristics that influenced their listing status, and was also based on relative ratings from the Determination Tool. Therefore, the presentation of our final determination framework is more clearly articulated in this final rule by explicitly describing the considerations for each the 65 species in narrative format and how they relate to the statutory standards

In summary, the determination framework used in this final rule is composed of seven elements. The first element is describing the statutory standards. The second, third, fourth, and fifth elements are identifying and analyzing all the appropriate species-specific and general characteristics that influence extinction risk for a coral species. The sixth element is relating a species' characteristics to a particular extinction risk at appropriate spatial and temporal scales. The seventh element is explicitly stating how each species' extinction risk meets the statutory listing definitions as applied to corals, resulting in an ultimate listing status. A final consideration in evaluating listing status is whether current or planned conservation efforts improve the overall status of any of the 65 species such that the additional protections of the ESA are not warranted. We explicitly apply the determination framework to each species in our narrative evaluations. This approach provides consistency across all of the 65 final listing determinations, but also produces individual determinations that are independent of the other 65 coral species.

Conservation Efforts

The effect conservation efforts have on an individual species' listing status is the last consideration in making a final determination. Because many conservation efforts are not species-specific, we provide our analysis of the effectiveness of conservation efforts for corals generally prior to making individual species determinations. Our conclusions regarding conservation efforts in this section apply to all of the proposed species. However, in some cases, we are able to identify species-specific conservation efforts and therefore evaluate them separately in the Species-specific Information and Determinations section.

Section 4(b)(1)(A) of the ESA requires the Secretary, when making a listing determination for a species, to take into account those efforts, if any, being made by any State or foreign nation to protect the species. In evaluating the efficacy of protective efforts, we rely on the Services' joint ''Policy for Evaluation of Conservation Efforts When Making Listing Decisions'' (''PECE;'' 68 FR 15100; March 28, 2003). The PECE requires us to consider whether any conservation efforts recently adopted or implemented, but not yet proven to be successful, will result in improving the species' status to the point at which listing is not warranted, or contribute to a threatened rather than endangered status.

For the proposed rule, we developed a Management Report that identified existing conservation efforts relevant to both global and local threats to corals. A draft of this report was peer reviewed and made available to the public with the SRR in April 2012. At that time, we requested any new or inadvertently overlooked existing information. The information that we received was incorporated into the Final Management Report (NMFS, 2012b), which formed the basis of our initial PECE evaluation. The information, analysis, and conclusions regarding conservation efforts in the proposed rule and supporting documents apply to this final rule, unless otherwise noted below.

Comments 30–32 focus on our consideration of conservation efforts in the proposed rule. In response to public comments on the proposed rule, we incorporated into our analyses in the final rule relevant information on conservation efforts that are new or that may have been inadvertently omitted or mischaracterized. Thus, this final rule incorporates information we received as a result of the public comment period, identifies existing conservation efforts that are relevant to the threats to the 65 coral species in this final rule, both for global-scale threats to corals linked to GHG emissions and other threats to corals. In particular, we received supplemental information regarding coral reef restoration efforts in Florida and the wider-Caribbean. We also received supplemental information regarding efforts to utilize captive-culture techniques to supplement the coral reef wildlife trade industry and reduce collection pressure on wild coral species. Specifically, we received information regarding Indonesia's mariculture operations as well as efforts in the United States to commercially and recreationally farm corals. This information on coral reef restoration, captive culture efforts for trade purposes, and local conservation efforts as it applies to reef resilience is described further below.

We received some supplemental information regarding the ongoing coral reef restoration efforts being made in South Florida as well as the wider-Caribbean, predominantly for staghorn and elkhorn corals (*Acropora cervicornis* and *A. palmata,* respectively). We briefly mentioned active coral restoration in the proposed rule as an important conservation action for corals, but did not describe these efforts in great detail. Coral reef restoration efforts encompass a variety of activities, and they are increasingly utilized to enhance, restore, and recover coral reef ecosystems and species (Bowden-Kerby *et al.,* 2005; Bruckner and Bruckner, 2001; Lirman *et al.,* 2010b). These activities may include post-ship grounding ''triage'' (*e.g.,* stabilizing substrate and salvaging corals and sponges), active predator and algae removal, larval seeding, and active restoration via coral propagation and outplanting activities. As a result of the 2009 American Recovery and Reinvestment Act, Federal funding through NOAA enabled a network of coral nurseries to expand throughout south Florida and the U.S. Virgin Islands to help recover threatened staghorn and elkhorn corals. These types of in-water coral nurseries have proven successful for propagating corals and serving as genetic repositories to help replenish and restore denuded reefs (Schopmeyer *et al.,* 2012; Young *et al.,* 2012). In 2012 alone, it was estimated these nurseries housed 30,000 corals, with more than 6,000 corals outplanted to surrounding reefs (The Nature Conservancy, 2012). Further, successful spawning of these outplanted corals has been reported on several occasions since the first event occurred in 2009 (Coral Restoration Foundation, 2013). Still, it should be emphasized that coral reef restoration should not be expected to recover entire reef tracts or species; rather, coral reef restoration can serve as a complementary tool to other management strategies such as fisheries management, coastal zone and watershed management, marine protected areas, and others. In a comprehensive review of restoration activities conducted in Florida and the wider-Caribbean, Young *et al.* (2012) found that most practitioners recommended that active restoration activities always be conducted in conjunction with robust local and regional management strategies to minimize the impacts of global and local threats. This is because coral reef restoration efforts can prove futile if the initial elements of degradation have not been mitigated (Jaap, 2000; Precht and Aronson, 2006; Young *et al.,* 2012).

As described above in the Threats Evaluation—Collection and Trade section of this rule, we received a significant amount of information regarding the potential conservation benefits of increasing international and domestic commercial and recreational production of corals via significant advances in captive-culture techniques (*i.e.,* mariculture and aquaculture). Specifically, we received supplemental information regarding the mariculture efforts conducted in Indonesia to reduce the amount of corals collected in the wild, thereby potentially reducing the threat of the marine ornamental trade industry on corals and coral reefs. As the largest exporter of corals in the world, shifting from wild-collected corals to captive cultured corals is an important conservation effort for preserving the integrity of wild reefs and coral species in Indonesia. However, there are still many challenges and obstacles related to captive culture of corals that are detailed in the Threats Evaluation, Trade and Collection section above. Any relevant information regarding this topic has also been incorporated into the analysis of conservation efforts in this final rule.

We received information regarding the role of local management actions and conservation efforts with regard to reef resilience. Conservation projects and programs such as international agreements and memoranda of understanding, coral reef monitoring, voluntary protected areas, restoration activities, and outreach and education initiatives, among others, play an integral role in building and maintaining resilience within coral reef ecosystems as well as raising public awareness. More detailed information regarding local actions as they relate to reef resilience are described above in the Threats Evaluation, Inadequacy of Existing Regulatory Mechanisms section of this final rule.

As described above, we received supplemental information about local conservation efforts since the publication of the proposed rule. However, we did not receive any supplemental information that changes our previous conclusions regarding global conservation efforts to slow climate change-related impacts. After considering this supplemental information in addition to that which was available for the proposed rule, our conclusions regarding conservation efforts remain unchanged. Overall, the numerous coral reef conservation projects are increasing and strengthening resiliency within coral reef ecosystems on a local level, and can provide a protective temporal buffer for corals in the face of climate change related threats. Coral reef restoration activities, particularly of the Caribbean acroporid species, are expected to assist in recovery efforts, but they cannot be considered a panacea. In the absence of effective global efforts to reduce impacts from climate change, there are no conservation efforts currently or planned in the future that are expected to improve the overall status of any of the listed species in this final rule, such that the additional protections provided by the ESA are not warranted.

Species-Specific Information and Determinations

Introduction

This section summarizes the best available information for each of the 65 species of coral considered in this final rule. The best available information is comprised of the proposed rule and its supporting documents, and information that we either gathered ourselves or received as a result of public comments. To distinguish between the information on which the proposed rule was based from new or supplemental information, we will only cite the primary literature for new or supplemental information. For clarity, we will distinguish whether the information was identified via public comment or if we gathered it ourselves.

Spatial, demographic, and other relevant biological information, threat susceptibilities, and information on regulatory mechanisms are all presented for each species. Because species-specific information is limited for many of the proposed species, genus-level information is highly relevant to our determinations. Therefore, we provide relevant information for each genus prior to providing the specific information for species within that genus. Specifically, genus-level information on threat susceptibilities is relevant to species when the available genus-level information can be appropriately applied to the species. Therefore, in each genus description, we provide a section that summarizes genus-level threat susceptibility information that was provided in the SRR and SIR, as well as in the public comments and supplemental information. Threat susceptibility conclusions are then provided considering the applicability of the genus-level information to an unstudied species within that genus. These conclusions will be applied, as appropriate, in the appropriate species descriptions.

Caribbean Species Determinations

Genus Agaricia

Introduction

There are seven species in the genus *Agaricia,* all of which occur in the Caribbean (Veron, 2000). Colonies are composed of plates, which are flat, horizontal, or upright. The latter are usually contorted and fused. Some species such as *A. humilis* and *Agaricia fragilis* tend to be small and somewhat circular in shape while others like *Agaricia lamarcki* and *Agaricia grahamae* can form large, plating colonies.

Spatial Information

The SRR and SIR provided the following genus-level information on *Agaricia*'s distribution, habitat, and depth range: *Agaricia* can be found at depths of 50 to 100 m on mesophotic reefs.

The public comments did not provide any new or supplemental information on *Agaricia's* distribution, habitat, and depth range. Supplemental information we found includes the following. Bongaerts *et al.* (2013) studied the depth distribution and genetic diversity of five agariciid species (*A. humilis, A. agaricites, A. lamarcki, A. grahamae,* and *Helioseris cucullata* [= *Leptoseris cucullata*]) and their symbiotic zooxanthellae in Curaçao. They found a distinct depth distribution among the species. *Agaricia humilis* and *A. agaricites* were more common at shallow depths, and *A. lamarcki, A. grahamae,* and *H. cucullata* were more common at deeper depths. They also found genetic segregation between coral host-symbiont communities at shallow and mesophotic depths.

Demographic Information

The SRR and SIR provided the following genus level information on *Agaricia's* abundance and population trends: Coral specimens collected in 2010 from a mesophotic reef at Pulley Ridge, Florida suggest that corals, such as *Agaricia spp.,* that appear live in video images may actually be covered with algae rather than live coral tissue.

The public comments did not provide any new or supplemental information on *Agaricia's* abundance or population trends. Supplemental information we found on *Agaricia's* population trends includes the following: Stokes *et al.* (2010) reported a decrease in cover of *Agaricia* spp. in the Netherlands Antilles between 1982 and 2008 at all depths surveyed (10 to 30 m). An analysis of Caribbean monitoring data from 1970 to 2012 found that large, plating *Agaricia* spp. were one of the species groups that suffered the greatest proportional losses (Jackson *et al.,* 2014).

Other Biological Information

The SRR and SIR provided the following information on the life history of the genus *Agaricia.* In general, *Agaricia* spp. are gonochoric brooders. Several species such as *Agaricia agaricites, A. tenuifolia,* and *A. humilis* are known to use chemical cues from crustose coralline algae to mediate settlement.

The public comments did not provide new or supplemental information on the life history of the genus *Agaricia.* Supplemental information we found on *Agaricia's* life history includes the following: *Agaricia* spp. can be one of the dominant taxonomic groups found in recruitment studies (Bak and Engel, 1979; Rogers *et al.,* 1984; Shearer and Coffroth, 2006).

Susceptibility to Threats

The SRR and SIR did not provide any genus level information on the susceptibility of *Agaricia* to ocean warming, and the public comments did not provide any new or supplemental information. Supplemental information we found on the susceptibility of the genus *Agaricia* to ocean warming includes the following: *Agaricia* is considered highly susceptible to bleaching. *Agaricia* spp. were the most susceptible to bleaching of the corals monitored during an unanticipated bleaching event at a remote, uninhabited island (Navassa), with higher bleaching prevalence at deeper sites (Miller *et al.,* 2011a). During the 1998 bleaching event in Belize, *A. tenuifolia,* a dominant coral, was nearly eradicated from the Channel Cay reef complex (Aronson *et al.,* 2002). During the 2005 bleaching event, nearly all *Agaricia* spp. were bleached at long-term monitoring sites in Buck Island National Monument, and they remained bleached comparatively longer than other species monitored (Clark *et al.,* 2009). Manzello *et al.* (2007) characterized *Agaricia* as having high susceptibility to bleaching in their study identifying bleaching indices and thresholds in the Florida Reef Tract, the Bahamas, and St. Croix, U.S. Virgin Islands. A long-term study in the Florida Keys found that bleaching prevalence was increased four to seven times by nutrient-enrichment in *Agaricia* spp., the only genus that showed such a response (Vega Thurber *et al.,* 2014). This study indicated that the temperature threshold for bleaching may have been lowered by the nutrient enrichment. Notably, after removal of the nutrient enrichment, bleaching prevalence returned to background levels. Thus, we conclude that, absent species-specific information, species in the genus *Agaricia* should be considered highly susceptible to ocean warming-induced bleaching.

The SRR and SIR did not provide any genus level information on the susceptibility of *Agaricia* to disease, and the public comments did not provide any new or supplemental information. Supplemental information we found on the susceptibility of the genus *Agaricia* to disease includes the following. A study of coral diseases across the wider-Caribbean during the summer and fall of 2005 found the genus *Agaricia,* along with seven other major reef-building genera, to be particularly susceptible to coral diseases including white plague type II, Caribbean ciliate infection, and to be infected with multiple diseases at the same time (Croquer and Weil, 2009). *Agaricia agaricites* decreased 87 percent in mean cover from the disease outbreak following the 2005 bleaching event in the U.S. Virgin Islands (Miller *et al.,* 2009). Thus, we conclude that, absent species-specific information, species in the genus *Agaricia* should be considered highly susceptible to diseases.

The SRR and SIR provided the following information on the susceptibility of *Agaricia* to acidification. No specific research has addressed the effects of acidification on the genus *Agaricia.* However, most corals studied have shown negative relationships between acidification and growth, and acidification is likely to contribute to reef destruction in the future. While ocean acidification has not been demonstrated to have caused appreciable declines in coral populations so far, it is considered a significant threat to corals by 2100.

The public comments did not provide any new or supplemental information on the susceptibility of *Agaricia* to acidification. Supplemental information we found on the susceptibility of the genus *Agaricia* to acidification includes the following. Crook *et al.* (2012) surveyed coral populations near submarine springs close to the Mesoamerican Reef in Mexico where water aragonite saturation state was naturally low due to groundwater seepage. *Agaricia* spp. were found near the springs, but only in waters with an aragonite saturation state greater than 2.5, indicating these species may be less tolerant than other coral species that were able to grow in under-saturated waters. Thus, we conclude that, absent species-specific information, species in the genus *Agaricia* should be considered to have some susceptibility to acidification.

The SRR and SIR provided genus level information on the susceptibility of *Agaricia* to sedimentation. The typically small calices of *Agaricia* spp. are not efficient at rejecting sediment, and species with horizontally-oriented plates or encrusting morphologies could be more sediment-susceptible than species with vertically-oriented plates as evidenced by fine sediment suspended in hurricanes that caused higher mortality in platy corals than hemispherical or non-flat ones. The public comments did not provide any new or supplemental information on the susceptibility of the genus *Agaricia* to sedimentation, and we did not find any new or supplemental information. Thus, we conclude that, absent species-specific information, species in the genus *Agaricia* should be considered to have some susceptibility to sedimentation.

The SRR and SIR did not provide any genus level information on the susceptibility of *Agaricia* to nutrients, and the public comments did not provide any new or supplemental information. Supplemental information we found on the susceptibility of *Agaricia* spp. to nutrients includes the following. Treatment of *A. tenuifolia* with low (5 mg per l) and high (25 mg per l) doses of organic carbon resulted in 73 to 77 percent mortality, respectively, compared to 10 percent mortality of controls (Kuntz *et al.* 2005). Treatment of *A. tenuifolia* with nitrate (7.5 μM), ammonium (25 μM), and phosphate (2.5 μM) caused about 50 percent mortality compared to 10 percent in controls (Kuntz *et al.* 2005). Thus, we conclude that, absent species-specific information, species in the genus *Agaricia* should be considered to have high susceptibility to nutrient enrichment based on this study in combination with the Vega Thurber *et al.* (2014) study that found increased bleaching in the presence of chronic nutrient enrichment.

The SRR and SIR did not provide any information on the susceptibility of *Agaricia* spp. to any other threats. The public comments did not provide any new or supplemental information, and we did not find any new or supplemental information on the susceptibility of *Agaricia* to any other threats.

Genus Conclusion

The studies cited above indicate that *Agaricia* spp. are highly susceptible to warming. In at least one location, a bleaching event resulted in 100 percent mortality of one *Agaricia* species. The genus also appears to be highly susceptible to diseases that can result in high rates of mortality and to be highly susceptible to impacts of nutrients. However, as described below, there is a fair amount of species-specific information for individual *Agaricia* species; therefore, we generally do not rely on the genus-level information to inform species level determinations. When necessary the appropriate inference is described in the species-specific information.

Agaricia lamarcki

Introduction

The SRR and SIR provided the following information on *A. lamarcki*'s morphology and taxonomy. *Agaricia lamarcki* has flat, unifacial, or encrusting plates that are commonly arranged in whorls. It is identifiable by its morphology and the presence of white stars at the mouths. *Agaricia lamarcki* does not appear to have taxonomic problems.

The public comments did not provide new or supplemental information, and we did not find any new or supplemental information on *A. lamarcki's* morphology or taxonomy.

Spatial Information

The SRR and SIR provided the following information on *A. lamarcki's* distribution, habitat, and depth range. *Agaricia lamarcki* can be found in the western Atlantic off south Florida as far north as Palm Beach County, in the Gulf of Mexico including the Flower Garden Banks, and throughout the Caribbean including the Bahamas. *Agaricia lamarcki* is rare in shallow reef environments of 3 to 15 m, but is common at deeper depths of 20 to 100 m where it can be one of the dominant coral species. It is found in shaded or reduced light environments, on slopes and walls, and on mesophotic reefs in Curaçao, Florida, Jamaica, Puerto Rico, and the U.S. Virgin Islands.

The public comments did not provide new or supplemental information on *A. lamarcki*'s distribution, habitat, or depth range. Supplemental information we found on *A. lamarcki*'s distribution includes the following. Veron (2014) confirms the presence of *A. lamarcki* in seven out of 11 possible ecoregions in the western Atlantic and greater Caribbean that contain corals, and he strongly predicts the presence of *A. lamarcki* in the ecoregion surrounding the Flower Garden Banks based on published record or confirmed occurrence in surrounding ecoregions. The three ecoregions in which it is not reported are off the coasts of Bermuda, Brazil, and the southeast U.S. north of south Florida. We did not find any new or supplemental information on *A. lamarcki*'s habitat or depth range.

Demographic Information

The SRR and SIR provided the following information on *A. lamarcki*'s abundance and population trends. *Agaricia lamarcki* is reported as common. In the Netherlands Antilles, *A. lamarcki* increased in abundance or remained stable on reefs 30 to 40 m in depth from 1973 to 1992.

The public comments provided supplemental information on *A. lamarcki*'s abundance. Population estimates of *A. lamarcki* in the Florida Keys extrapolated from stratified random samples were 3.1 ± 1.3 million (standard error (SE)) colonies in 2005 and 0.2 ± 0.2 million colonies in 2012. No colonies were observed in 2009, but fewer deep sites (>20 m) were surveyed in 2009 and 2012 compared to 2005. Most colonies observed were 20 to 30 cm in diameter, and partial mortality was highest (50 percent) in the largest size class (30 to 40 cm). *Agaricia lamarcki* ranked 35th in abundance out of 47 species in 2005 and 37th out of 40 species in 2012. In the Dry Tortugas, Florida, where more deep sites were surveyed, *A. lamarcki* ranked 12th out of 43 species in 2006, with population estimates extrapolated to 14.3 ± 2.6 million colonies. It ranked 22nd out of 40 species in 2008 with populations estimates extrapolated to 2.1 ± 0.5 million colonies. Most of the colonies in 2006 were 10 to 30 cm in diameter, but colonies greater than 90 cm were observed. Partial mortality was highest in the 30 to 40 cm size class (approximately 35 percent) in 2006 and highest in the 20 to 30 cm size class (approximately 20 percent) in 2008. In 2008, most of the colonies were 0 to 10 cm in size, and the largest colonies observed were in the 50 to 60 cm size class (Miller *et al.,* 2013). Because population estimates were extrapolated from random samples, differences in population numbers between years are more likely a function of sampling effort rather than population trends over time. The public comments did not provide new or supplemental information on *A. lamarcki*'s population trends.

Supplemental information we found on *A. lamarcki*'s abundance and population trends includes the following. Between 1977 and 1987, colonies of *A. lamarcki* in monitored plots in Jamaica decreased from 34 to 31 colonies, indicating the net production by sexual and asexual means was not enough to compensate for mortality of the originally present colonies (Hughes, 1988). More than 40 percent of the colonies present in 1987 were derived from asexual fission of the original colonies present in 1977, and none of the six sexual recruits survived until the end of the study period (Hughes, 1988). In the U.S. Virgin Islands, *A. lamarcki* was the eleventh most common coral in terms of cover out of 55 species, and average cover across 18 monitoring sites was 1.2 ± 0.3 (SE) percent in 2012 (Smith, 2013).

All information on *A. lamarcki*'s abundance and population trends can be summarized as follows. Based on population estimates, there are at least tens of millions of *A. lamarcki* colonies present in the Florida Keys and Dry Tortugas combined. Absolute abundance is higher than the estimate from these two locations given the presence of this species in many other locations throughout its range. Population trends indicate this species may be declining in some areas, but because some of the trend data is lumped by genus or genus plus morphology, there is uncertainty that the trends represent *A. lamarcki* specifically. Thus, we conclude that *A. lamarcki* has likely declined in some areas and the population numbers at least in the tens of millions of colonies.

Other Biological Information

The SRR and SIR provided the following information on *A. lamarcki*'s life history. No information on the reproductive strategy of *A. lamarcki* is available, but congeners are gonochoric brooders. Larval settlement occurs primarily at deeper depths (26 to 37 m), but the species has also been found at shallower depths. Recruitment rates of *A. lamarcki* are low (*e.g.,* only one of 1,074 *Agaricia* recruits at the Flower Garden Banks may have been *A. lamarcki*), and net gains from sexual recruitment may be negligible at a decadal time scale. Population numbers may be maintained through asexual fission of larger colonies into smaller daughter colonies. Growth rates are slow; radial growth measurements from Jamaica ranged from zero to 1.4 cm per year and averaged approximately 0.5 cm per year. Growth rates are a bit slower, ranging from zero to 1.0 cm per year, at depths greater than 20 m. Maximum colony size is approximately two meters. *Agaricia lamarcki* is a relatively long-lived species, and individual colonies may persist for greater than a century. Based on monitoring in Jamaica, the half-life (mortality of half of monitored colonies) of *A. lamarcki* is 17 years. Mortality rates are size-specific (ranging from 10 to 25 percent), and partial mortality rates are high (ranging from 22 to 90 percent). Overall, demographic characteristics are low recruitment, high colony survival, and high partial mortality.

The public comments did not provide new or supplemental information on *A. lamarcki* life history. Supplemental information we found on *A. lamarcki* life history includes the following. Darling *et al.* (2012) performed a trait-based analysis to categorize coral species into four life history strategies: Generalist, weedy, competitive, and stress-tolerant. The classifications were primarily separated by colony morphology, growth rate, and reproductive mode. *Agaricia lamarcki* was classified as a ''weedy'' species, thus likely more tolerant of environmental stress.

The SRR, SIR, and the public comments did not provide new or supplemental biological information for *A. lamarcki.* Supplemental biological information we found about *A. lamarcki* includes the following. Out of five agariciid species sampled at a single reef in Curaçao, *A. lamarcki* was the only species that harbored multiple symbiont profiles across depth distribution; the other four species had only a single symbiont profile across depth. The symbiont community associated with *A. lamarcki* at 40 m depth was significantly different from those at both 10 m and 25 m (Bongaerts *et al.,* 2013).

Susceptibility to Threats

The threat susceptibility information from the SRR and SIR was interpreted in the proposed rule for *A. lamarcki*'s vulnerabilities to threats as follows: Moderate vulnerability to ocean warming, disease, acidification, trophic effects of fishing, sedimentation, and nutrients; and low vulnerability to sea level rise and collection and trade. No conclusions on *A. lamarcki*'s vulnerability to predation were made due to lack of available information on its susceptibility to this threat.

The SRR and SIR provided the following information on the susceptibility of *A. lamarcki* to ocean warming. *Agaricia lamarcki* is susceptible to bleaching from both high and low temperature anomalies. In laboratory studies, *A. lamarcki* had almost complete disruption of photosynthesis at 32 °C to 34 °C. Bleaching can be extensive; however, it may not result in mortality in *A. lamarcki.*

Van Woesik *et al.* (2012) developed a coral resiliency index to evaluate extinction risk due to bleaching, based on biological traits and processes. Evaluations were performed at the genus level. They rated the resiliency of *Agaricia* as −2 out of a range of −6 to 7 observed in other coral genera. Less than or equal to −3 was considered highly vulnerable to extinction, and greater than or equal to 4 was considered highly tolerant. Thus, *Agaricia* was rated closer to the vulnerable end of the spectrum, though not highly vulnerable. This study was in the SIR, but the findings specific to *Agaricia* were not included. The public comments (comment 47) indicated the results of this study should be considered in the listing status of *A. lamarcki.*

The public comments did not provide any new or supplemental information on the susceptibility of *A. lamarcki* to ocean warming. Supplemental information we found on the susceptibility of *A. lamarcki* to ocean warming includes the following. During the 2005 bleaching event, greater than

80 percent of *A. lamarcki* colonies bleached at 12 sites in Puerto Rico (Waddell and Clarke, 2008). In the U.S. Virgin Islands, an average of 59 percent of *A. lamarcki* colonies (n = 11) bleached, and nine percent paled during the 2010 bleaching event (Smith *et al.,* 2013b). *Agaricia lamarcki* had high resistance to both hot and cold water anomalies that impacted the Florida Keys in 2005 and 2010, respectively, as indicated by their low tissue mortality compared to other coral species monitored (Lirman *et al.,* 2011).

All sources of information are used to describe *A. lamarcki*'s susceptibility to ocean warming as follows. *Agaricia lamarcki* has some susceptibility to ocean warming as evidenced by extensive bleaching during warm water temperature anomalies but observed low bleaching-related mortality. The available information does not support a more precise description of susceptibility.

The SRR and SIR did not provide any species-specific information on susceptibility of *A. lamarcki* to ocean acidification. The public comments did not provide new or supplemental information on the susceptibility of *A. lamarcki* to acidification, and we did not find any new or supplemental information.

All sources of information are used to describe *A. lamarcki's* susceptibility to acidification as follows. There is uncertainty about how *A. lamarcki* will respond to ocean acidification, but there is genus-level evidence that *Agaricia* are not among the more tolerant species from areas of water with naturally lower aragonite saturation state. Thus, *A. lamarcki* likely has some susceptibility to ocean acidification, but the available information does not support a more precise description of susceptibility.

The SRR and SIR provided the following information on *A. lamarcki*'s susceptibility to disease. White plague infections in *A. lamarcki* have been observed in Florida, Colombia, and St. Lucia, though no incidence of disease was observed in the Florida Keys in 1996 to 1998. Ciliate infections have been documented in *A. lamarcki,* and tumors may affect this species. The ecological and population impacts of disease have not been established for *A. lamarcki.*

The public comments did not provide any new or supplemental information on the susceptibility of *A. lamarcki* to disease, and we did not find any new or supplemental information on *A. lamarcki's* susceptibility to disease.

All source of information are used to describe *A. lamarcki*'s susceptibility to disease as follows. *Agaricia lamarcki* is susceptible to several diseases, including white plague, which has one of the fastest progression rates recorded in the Caribbean. However, there is no information on the population level effects of disease on *A. lamarcki* (*e.g.,* rates of infection, percentage of population affected, and amounts of tissue loss). Genus-level information indicates high susceptibility to a disease outbreak following a bleaching event, indicating A. *lamarcki* is likely highly susceptible to disease.

The SIR and SRR did not provide any species-specific information on the trophic effects of fishing on *A. lamarcki.* The public comments did not provide new or supplemental information, and we did not find new or supplemental information on the trophic effects of fishing on *A. lamarcki.* However, due to the level of reef fishing conducted in the Caribbean, coupled with *Diadema* die-off and lack of significant recovery, competition with algae can adversely affect coral recruitment. Thus, *A. lamarcki* likely has some susceptibility to the trophic effects of fishing because of low recruitment rates, though the available information does not support a more precise description of susceptibility.

The SRR and SIR provided the following information on susceptibility of *A. lamarcki* to sedimentation. *Agaricia lamarcki* could be susceptible to sedimentation based on calix and colony morphology. This conclusion was based on genus-level information on susceptibility to sedimentation. The public comments did not provide new or supplemental information on the susceptibility of *A. lamarcki* to sedimentation, and we did not find new or supplemental information.

All sources of information are used to describe *A. lamarcki*'s susceptibility to sedimentation as follows. There is no species-specific information on the susceptibility of *A. lamarcki* to sedimentation. However, based on genus-level information, colony morphology and skeletal structure of *A. lamarcki* indicate it is likely poor at removing sediment. Thus, *A. lamarcki* likely has some susceptibility to sedimentation, but the available information does not support a more precise description of susceptibility.

The SRR and SIR did not provide any information on the susceptibility of *A. lamarcki* to nutrients, and the public comments did not provide any new or supplemental information. Supplemental information we gathered at the genus-level indicates that *A. lamarcki* is likely highly susceptible to nutrient enrichment.

The SRR and SIR did not provide species-specific information on the effects of sea level rise on *A. lamarcki.* The SRR described sea level rise as an overall low to medium threat for all coral species. The public comments did not provide new or supplemental information on *A. lamarcki*'s susceptibility to sea level rise, and we did not find any new or supplemental information. Thus, we conclude that *A. lamarcki* has some susceptibility to sea level rise, but the available information does not provide a more precise description of susceptibility.

The SRR and SIR provided the following information on the susceptibility of *A. lamarcki* to collection and trade. Only light trade has been recorded with gross exports averaging fewer than 10 pieces of coral annually between 2000 and 2005. The public comments did not provide new or supplemental information on the susceptibility of *A. lamarcki* to collection and trade. Supplemental information we found confirms that collection and trade of *A. lamarcki* remained low between 2000 and 2012 with gross exports averaging fewer than 10 pieces of coral annually (data available at *http://trade.cites.org/*). Thus, we conclude that *A. lamarcki* has low susceptibility to collection and trade.

The SRR and SIR provided the following information on the susceptibility of *A. larmarcki* to predation. Predation effects on *A. lamarcki* are unknown. The public comments did not provide any new or supplemental information, and we did not find any new or supplemental information on the susceptibility of *A. lamarcki* to predation. We conclude that while *A. lamarcki* likely has some susceptibility to predation, available information is lacking, and we cannot say whether it is a threat.

Regulatory Mechanisms

In the proposed rule, we relied on information from the Final Management Report for evaluating the existing regulatory mechanisms for controlling threats to all corals. However, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *A. lamarcki.* Public comments were critical of that approach, and we therefore attempt to analyze regulatory mechanisms and conservation efforts on a species basis, where possible, in this final rule. Records confirm that *Agaricia lamarcki* occurs in eight Atlantic ecoregions that encompass 26 kingdom's and countries' EEZs. The 26 kingdoms and countries are Antigua &

Barbuda, Bahamas, Barbados, Belize, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, French Antilles, Grenada, Guatemala, Haiti, Kingdom of the Netherlands, Honduras, Jamaica, Mexico, Nicaragua, Panama, St. Kitts & Nevis, St. Lucia, St. Vincent & Grenadines, Trinidad and Tobago, United Kingdom (British Overseas Territories), United States (including U.S. Caribbean Territories), and Venezuela. The regulatory mechanisms relevant to *A. lamarcki,* described first as a percentage of the above kingdoms and countries that utilize them to any degree, and second as a percentage of those countries and kingdoms whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (31 percent with 12 percent limited in scope), coral collection (50 percent with 27 percent limited in scope), pollution control (31 percent with 15 percent limited in scope), fishing regulations on reefs (73 percent with 50 percent limited in scope), managing areas for protection and conservation (88 percent with 31 percent limited in scope). The most common regulatory mechanisms in place for *A. lamarcki* are reef fishing regulations and area management for protection and conservation. However, half of the reef fishing regulations are limited in scope and may not provide substantial protection for the species. General coral protection and collection laws, along with pollution control laws, are much less common regulatory mechanisms for the management of *A. lamarcki.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic traits, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that the factors that increase the extinction risk for *A. lamarcki* include the widespread decline in environmental conditions in the Caribbean, potential losses to disease, severe effects of bleaching, and limited sediment tolerance. Factors that reduce extinction risk include occurrence primarily at great depth, where disturbance events are less frequent, and life history characteristics that have allowed the species to remain relatively persistent compared to other deep corals despite low rates of sexual recruitment.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species' abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *A. lamarcki,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Although it is geographically located in the heavily disturbed Caribbean, *A. lamarcki's* predominant occurrence at depths of 20 to 100 m reduces its exposure to disturbance events that have resulted in the decreased resilience of reefs in the Caribbean and moderates vulnerability to extinction over the foreseeable future. *Agaricia lamarcki's* life history characteristics of large colony size and long life span have enabled it to remain relatively persistent despite slow growth and low recruitment rates, thus moderating vulnerability to extinction. Although we concluded that *A. lamarcki* is likely highly susceptible to disease, population level effects of disease have not been documented in *A. lamarcki* thus far, indicating the currently low vulnerability to extinction from this threat. Additionally, although *A. lamarcki* has been observed to have high levels of warming-induced bleaching, bleaching-related mortality appears to be low, indicating that vulnerability to extinction from ocean warming is currently low. Deeper areas of *A. lamarcki's* range will usually have lower temperatures than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. *Agaricia lamarcki's* habitat includes shaded or reduced light environments, slopes, walls, and mesophotic reefs. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that are predicted, on local and regional scales, to experience highly variable thermal regimes and ocean chemistry at any given point in time. *Agaricia lamarcki's* absolute abundance has been estimated as at least tens of millions of colonies in the Florida Keys and Dry Tortugas combined and is higher than the estimate from these two locations due to the occurrence of the species in many other areas throughout its range. Its abundance, life history characteristics, and depth distribution, combined with spatial variability in ocean warming and acidification across the species' range, moderate vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform, and there will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule, using the determination tool formula approach, *A. lamarcki* was proposed for listing as threatened because of: Moderate vulnerability to ocean warming (E), disease (C), and acidification (E); low relative recruitment rate (E); moderate overall distribution (based on narrow geographic distribution and wide depth distribution (E); restriction to the Caribbean (E); and inadequacy of regulatory mechanisms (D).

In this final rule, we changed the listing determination for *A. lamarcki* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *A. lamarcki'* spatial structure, demography, threat susceptibilities, and management none of the five ESA listing factors, alone or in combination, are causing this species to be likely to become endangered throughout its range within the foreseeable future, and thus it is not warranted for listing at this time because:

(1) *Agaricia lamarcki's* predominant occurrence at depths of 20 to 100 m in heterogeneous habitats, including shaded or reduced light environments, on slopes and walls, and on mesophotic reefs, throughout the Caribbean basin reduces exposure to any given threat event or adverse condition that does not occur uniformly throughout the species' range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future; and

(2) *Agaricia lamarcki's* absolute abundance is at least tens of millions of colonies based on estimates from two locations. Absolute abundance is higher than estimates from these locations since *it* occurs in many other locations throughout its range. This provides buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future if global threats continue and worsen in severity, and the species' exposure to the threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, *A. lamarcki* is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *A. lamarcki* is not warranted for listing at this time under any of the listing factors, and we withdraw our proposal to list the species as threatened.

Genus Mycetophyllia

There are five species in the genus *Mycetophyllia* that all occur in the western Atlantic and Caribbean (Veron, 2000). Most species of *Mycetophyllia* can be difficult to distinguish in the field, and many studies report data to the genus level rather than species. Therefore, all information reported for the genus appears in this section, and information reported specifically for *M. ferox* is presented in the species section.

Demographic Information

The SRR, SIR, and the public comments did not provide information on *Mycetophyllia* abundance or population trends. Supplemental information we found on *Mycetophyllia's* abundance and population trends includes the following. Percent cover of *Mycetophyllia* spp. between 2001 and 2006 was less than approximately 0.02 percent on St. John (233 sites surveyed) and St. Croix (768 sites surveyed), U.S. Virgin Islands and La Parguera, Puerto Rico (Waddell and Clarke, 2008). Similarly, cover of *Mycetophyllia* spp. on the mesophotic Hind Bank in the U.S. Virgin Islands was 0.02 ± 0.01 percent in 2007 (Smith *et al.,* 2010). Cover of *Mycetophyllia* spp. was 0.1 percent between 2002 and 2004 on four islands in the Bahamas Archipelago (Roff *et al.,* 2011). Between 2005 and 2007, *Mycetophyllia* spp. comprised 0.1 percent or less of the coral cover and occurred in densities of 1.0 colony per 10 m^2 in parts of southeast Florida and the Florida Keys (Wagner *et al.,* 2010). In Roatan, Honduras, *Mycetophyllia* sp. cover in permanent photo-stations increased between 1996 and 1998 from 0.57 percent to 0.77 percent but subsequently decreased to 0.26 percent in 2003 and 0.15 percent in 2005 (Riegl *et al.,* 2009).

Susceptibility to Threats

The SRR, SIR, and public comments did not provide information on *Mycetophyllia's* susceptibility to threats. Supplemental information we found on *Mycetophyllia's* susceptibility to ocean warming includes the following. During the 1995 bleaching event in Belize, 24 percent of 21 colonies monitored *Mycetophyllia* bleached (McField, 1999). In Roatan, Honduras, 11 percent [*sic*]of 10 monitored *Mycetophyllia* sp. colonies bleached and 11 percent [*sic*] partially bleached during the 1998 bleaching event; mortality of *Mycetophyllia* colonies was 11 percent (Riegl *et al.,* 2009).

Bleaching of *Mycetophyllia* was 62 percent across all 28 locations surveyed in Puerto Rico during the 2005 temperature anomaly (Waddell and Clarke, 2008). Additionally, a post-bleaching outbreak of white plague resulted in a massive collapse of *Mycetophyllia* colonies at most reefs on the east, south, and west coasts of Puerto Rico and reproductive failure during the 2006 mass spawning (Waddell and Clarke, 2008). Off Mona and Desecheo Islands, Puerto Rico in 2005, paling occurred in 65 percent of *Mycetophyllia* colonies, and bleaching occurred in 10 percent (Bruckner and Hill, 2009).

In surveys conducted between August and October 2005 to 2009 from the lower Florida Keys to Martin County, average mortality of *Mycetophyllia* spp. was 0.6 ± 6.4 percent, which was the eighth highest out of 25 of the most abundant species (Lirman *et al.,* 2011). During the 2010 cold-water event, average mortality of *Mycetophyllia* spp. across 76 sites from the lower Florida Keys to Martin County was 15.0 ± 28.3 percent, which was the eleventh highest of the 25 most abundant species (Lirman *et al.,* 2011).

During the 2005 bleaching event, *Mycetophyllia* spp. were among the most severely affected of 22 coral species reported to have bleached across 91 of 94 sites in northeast St. Croix, U.S. Virgin Islands (Wilkinson and Souter, 2008). In the U.S. Virgin Islands, the one colony of *Mycetophyllia* sp. observed at 18 sites, bleached during 2005. Six colonies were subsequently monitored after the 2010 mild bleaching event with average of eight percent bleaching (Smith *et al.,* 2013b).

Supplemental information we found on the susceptibility of *Mycetophyllia* to disease includes the following. White plague (Nugues, 2002) and red band disease (Waddell, 2005) have been reported to infect *Mycetophyllia* species. In 2004, prevalence of disease in *Mycetophyllia* was approximately two to three percent in Mexico (Harvell *et al.,* 2007).

Mycetophyllia ferox

Introduction

The SRR and SIR provided the following information on *M. ferox's* morphology and taxonomy. *Mycetophyllia ferox* forms a thin, encrusting plate that is weakly attached. *Mycetophyllia ferox* is taxonomically distinct. Maximum colony size is 50 cm.

Public comments did not provide new or supplemental information on *M. ferox's* taxonomy or morphology. Supplemental information we found on *M. ferox's* taxonomy and morphology includes the following. Zlatarski and Estalella (1982) reported 14 out of 25 *Mycetophyllia* colonies collected from Cuba were intermediate between *M. ferox,* and *M. lamarkiana,* and parts of two colonies were comparable to *M. ferox* or *M. lamarkiana,* illustrating potential morphological plasticity between species.

Spatial Information

The SRR and SIR provided the following information on *M. ferox's* distribution, habitat, and depth range. *Mycetophyllia ferox* occurs in the western Atlantic and throughout the wider Caribbean. It has not been reported in the Flower Garden Banks (Gulf of Mexico) or in Bermuda. It has been reported in reef environments in water depths of 5 to 90 m, including shallow and mesophotic habitats.

The public comments did not provide new or supplemental information on *M. ferox's* distribution, habitat, or depth range. Supplemental information we found on *M. ferox's* distribution includes the following. Veron (2014) confirms the occurrence of *M. ferox* in seven out of a possible 11 ecoregions in the Caribbean and western Atlantic that contain corals. The four ecoregions where it is not reported are the Flower Garden Banks, off the coasts of Bermuda, Brazil, and the southeast U.S. north of south Florida. We did not find any supplemental information on *M. ferox's* habitat or depth range.

Demographic Information

The SRR and SIR provided the following information on *M. ferox's* abundance and population trends. *Mycetophyllia ferox* is usually uncommon or rare, constituting less than 0.1 percent of all coral species at generally less than one percent of the benthic cover. Density of *M. ferox* in southeast Florida and the Florida Keys was approximately 0.8 colonies per 10 m^2 between 2005 and 2007. There is indication that the species was much more abundant in the upper Florida Keys in the 1970s. In a survey of 97 stations in the Florida Keys, *M. ferox* declined in occurrence from 20 stations in 1996 to four stations in 2009. At 21 stations in the Dry Tortugas, *M. ferox* declined in occurrence from eight stations in 2004 to three stations in 2009.

The public comments provided the following supplemental information on *M. ferox's* abundance. In stratified random surveys in the Florida Keys, *M. ferox* ranked 39th most abundant out of 47 in 2005, 43rd out of 43 in 2009, and 40th out of 40 in 2012. Extrapolated population estimates were 1.0 ± 0.7 (SE) million in 2005, 9,500 ± 9,500 (SE) colonies in 2009, and 7,000 ± 7,000 (SE) in 2012 . These abundance estimates are based on random surveys, and differences between years are more likely a result of sampling effort rather than population trends. The most abundant size class was 10 to 20 cm diameter that equaled the combined abundance of the other size classes. The largest size class was 30 to 40 cm. Average partial mortality per size class ranged from nearly 0 to 50 percent and was greatest in the 20 to 30 cm size class (Miller *et al.,* 2013).

In the Dry Tortugas, Florida, *M. ferox* ranked 35th most abundant out of 43 species in 2006 and 30th out of 40 in 2008. Population estimates were 0.5 ± 0.4 (SE) million in 2006 and 0.5 ± 0.2 million (SE) in 2008. The number of colonies in 2006 was similar between the 0 to 10 cm and 10 to 20 cm size classes, and the largest colonies were in the 20 to 30 cm size class. Greatest partial mortality was around 10 percent. Two years later, in 2008, the highest proportion of colonies was in the 20 to 30 cm size class, and the largest colonies were in the 40 to 50 cm size class. The greatest partial mortality was about 60 percent in the 30 to 40 cm size class, however the number of colonies at that size were few (Miller *et al.,* 2013).

Supplemental information we found on *M. ferox's* abundance and population trends confirms *M. ferox's* low percent cover, encounter rate, and density. In a survey of Utila, Honduras between 1999 and 2000, *M. ferox* was observed at eight percent of 784 surveyed sites and was the 36th most commonly observed out of 46 coral species; other *Mycetophyllia* species were seen more commonly (Afzal *et al.,* 2001). In surveys of remote southwest reefs of Cuba, *M. ferox* was observed at one of 38 reef-front sites, with average abundance was 0.004 ± 0.027 (standard deviation (SD)) colonies per 10 m transect; this was comparatively lower than the other three *Mycetophyllia* species observed (Alcolado *et al.,* 2010). Between 1998 and 2004, cover of *M. ferox* ranged between 0.3 and 0.4 percent in three of six sites monitored in Colombia (Rodriguez-Ramirez *et al.,* 2010). In Barbados, *M. ferox* was observed on one of seven reefs surveyed, and the average cover was 0.04 percent (Tomascik and Sander, 1987).

Benthic cover of *M. ferox* in the Red Hind Marine Conservation District off St. Thomas, U.S. Virgin Islands, which includes mesophotic coral reefs, was 0.003 ± 0.004 percent in 2007, accounting for 0.02 percent of coral cover, and ranking 20th highest in cover out of 21 coral species (Nemeth *et al.,* 2008; Smith *et al.,* 2010). In the U.S. Virgin Islands between 2001 and 2012, cover of *M. ferox* appeared in 12 of 33 survey sites and accounted for 0.01 percent of the benthos, and 0.07 percent of the coral cover, ranking as 13th most common (Smith, 2013).

In 1981, *M. ferox* was observed on one of four reefs surveyed in the upper Florida Keys at 0.1 percent cover (Burns, 1985). In surveys of the Florida Keys between 1996 and 2003, cover of *M. ferox* was 0.022, 0.005, and less than 0.001 percent on patch reefs, deep offshore reefs, and shallow offshore reefs, respectively (Somerfield *et al.,* 2008). At permanent monitoring stations in the Florida Keys, the number of stations where *M. ferox* was present declined between 1996 and 2003 (Waddell, 2005). Between 2005 and 2010, *M. ferox* was one of 42 species surveyed and was found the least abundant being observed at densities of 0.02 and 0.01 colonies per 10 m^2 on mid-channel reefs and fore-reefs, respectively, on the Florida reef tract (Burman *et al.,* 2012).

All information on *M. ferox's* abundance and population trends can be summarized as follows. *Mycetophyllia ferox* has been reported to occur on 3 to 50 percent of reefs surveyed and is one of the least common coral species observed. On reefs where *M. ferox* is found, it generally occurs at abundances of less than one colony per 10 m^2 and percent cover of less than 0.1 percent. Based on population estimates, there are at least hundreds of thousands of *M. ferox* colonies present in the Florida Keys and Dry Tortugas combined. Absolute abundance is higher than the estimate from these two locations given the presence of this species in many other locations throughout its range. Low encounter rate and percent cover coupled with the tendency to include *Mycetophyllia* spp. at the genus level make it difficult to discern population trends of *M. ferox* from monitoring data. However, reported losses of *M. ferox* from monitoring stations in the Florida Keys and Dry Tortugas (63 to 80 percent loss) indicate population decline in these locations. Based on declines in Florida, we conclude *M. ferox* has likely declined throughout its range.

Other Biological Information

The SRR and SIR provided the following information on *M. ferox's* life history. *Mycetophyllia ferox* is a hermaphroditic brooding species. Colony size at first reproduction is greater than 100 cm^2. Recruitment of *M. ferox* appears to be very low, even in studies from the 1970s.

The public comments did not provide new or supplemental information on *M. ferox's* life history. Supplemental information we found on *M. ferox's* life history includes the following. *Mycetophyllia ferox* has a lower fecundity compared to *M. aliciae, M. lamarckiana* and *M. danaana* (Morales Tirado, 2006). Over a 10 year period, no colonies of *M. ferox* were observed to recruit to an anchor-damaged site in the U.S. Virgin Islands although adults were observed on the adjacent reef (Rogers and Garrison, 2001). Darling *et al.* (2012) performed a biological trait-based analysis to categorize coral species into four life history strategies: Generalist, weedy, competitive, and stress-tolerant. *Mycetophyllia ferox* was classified as a ''weedy'' species, thus likely more tolerant of environmental stress.

Susceptibility to Threats

The threat susceptibility information from the SRR and SIR was interpreted in the proposed rule for *M. ferox'*s vulnerabilities to threats as follows: High vulnerability to disease and nutrient enrichment; moderate vulnerability to ocean warming, acidification, trophic effects of fishing, and sedimentation; and low vulnerability to sea level rise, predation, and collection and trade.

The SRR and SIR provided the following information on *M. ferox'*s susceptibility to ocean warming. No bleached *M. ferox* colonies were observed in Florida or Barbados in a wide-scale survey during the 2005 mass-bleaching event, although the number of colonies was small.

The public comments did not provide new or supplemental information on the susceptibility of *M. ferox* to ocean warming. Supplemental information we found on the susceptibility of *M. ferox* to ocean warming includes the following. In surveys of the lower Florida Keys and Dry Tortugas during the 1998 bleaching event, approximately 20 percent of *M. ferox* colonies bleached; out of the 14 species reported to have experienced bleaching of at least 50 percent of the colony, *M. ferox* was one of the least affected (Waddell, 2005). Approximately 50 percent of *M. ferox* colonies bleached at 12 locations in Puerto Rico during the 2005 bleaching event (Waddell and Clarke, 2008). During the 2005 Caribbean bleaching event, neither of the two colonies of *M. ferox* monitored at six sites in Barbados bleached; an average of 71 percent of all coral colonies bleached at those six sites during the event (Oxenford *et al.,* 2008).

All sources of information are used to describe *M. ferox'*s susceptibility to ocean warming as follows. The bleaching reports available specifically for *M. ferox* and at the genus level indicate similar trends of relatively low bleaching observed in 1995, 1998, and 2010 (less than 25 percent) and higher levels (50 to 65) or no bleaching in the more severe 2005 bleaching event. Reproductive failure and a disease outbreak were reported for the genus after the 2005 bleaching event. Although bleaching of most coral species is spatially and temporally variable, understanding the susceptibility of *M. ferox* is somewhat confounded by the species' low sample size in any given survey due to its low encounter rate. We conclude that *M. ferox* has some susceptibility to ocean warming. However, the available information does not support a more precise description of susceptibility to this threat.

The SRR and SIR provided the following information on the susceptibility of *M. ferox* to acidification. No specific research has addressed the effects of acidification on the genus *Mycetophyllia.* However, most corals studied have shown negative relationships between acidification and growth, and acidification is likely to contribute to reef destruction in the future. While ocean acidification has not been demonstrated to have caused appreciable declines in coral populations to date, it is considered to become a significant threat to corals by 2100.

The public comments did not provide new or supplemental information on the susceptibility of *M. ferox* to acidification, and we did not find any new or supplemental information.

All sources of information are used to describe *M. ferox'*s susceptibility to acidification as follows. There is uncertainty about how *M. ferox* will respond to ocean acidification. Based on the negative effects of acidification on growth of most corals, *M. ferox* likely has some susceptibility to acidification. The available information does not support a more precise description of susceptibility.

The SRR and SIR provided the following information on *M. ferox'*s susceptibility to disease. *Mycetophyllia ferox* is susceptible to white plague. Diseased *M. ferox* colonies were reported in the upper Florida Keys in the mid-1970s; between 24 and 73 percent of *M. ferox* colonies were infected per site. At one reef site, 20 to 30 percent of the *M. ferox* colonies died from disease during a one-year period.

The public comments did not provide new or supplemental information on the susceptibility of *M. ferox* to disease. Supplemental information we found on the susceptibility of *M. ferox* to disease includes the following. Porter *et al.* (2001) report the loss of *M. ferox* from many of the permanent monitoring stations (160 stations at 40 sites) in the Florida Keys between 1996 and 1998 due to coral disease.

All sources of information are used to describe *M. ferox'*s susceptibility to disease as follows. From reports in the Florida Keys, *M. ferox* appears to be highly susceptible to disease, specifically white plague, and reports of high losses and correlation with higher temperatures date back to the mid-1970s (Dustan, 1977). Although heavy impacts of disease on *M. ferox* have not been reported in other locations, an outbreak of white plague was credited with causing heavy mortality at the genus level in Puerto Rico after the 2005 bleaching event. We conclude that the susceptibility of *M. ferox* to disease is high.

The SIR and SRR did not provide any species-specific information on the trophic effects of fishing on *M. ferox.* The public comments did not provide new or supplemental information, and we did not find new or supplemental information on the trophic effects of fishing on *M. ferox.* However, due to the level of reef fishing conducted in the Caribbean, coupled with *Diadema* die-off and lack of significant recovery, competition with algae can adversely affect coral recruitment. Thus, *M. ferox* likely has some susceptibility to the trophic effects of fishing given its low recruitment rates. The available information does not support a more precise description of susceptibility.

The SRR and SIR provided the following information on the susceptibility of *M. ferox* to nutrient enrichment. *Mycetophyllia ferox* appeared to be absent at fringing reef sites in Barbados impacted by sewage pollution.

The public comments did not provide any new or supplemental information on the susceptibility of *M. ferox* to nutrient enrichment, and we did not find any new or supplemental information.

All sources of information are used to describe *M. ferox'*s susceptibility to nutrient enrichment as follows. *Mycetophyllia ferox* may be susceptible to nutrient enrichment as evidenced by its absence from eutrophic sites in one location. However, there is uncertainty about whether the absence is a result of eutrophic conditions or a result of uncommon or rare occurrence. Therefore, we conclude that *M. ferox* likely has some susceptibility to nutrient enrichment. However, the available information does not support a more precise description of susceptibility.

The SRR and SIR did not provide any species or genus information on the susceptibility of *M. ferox* to sedimentation but provided the following. Land-based sources of pollution (including sediment) often act in concert rather than individually and are influenced by other biological (*e.g.,* herbivory) and hydrological factors. Collectively, land-based sources of pollution are unlikely to produce extinction at a global scale; however, they may pose significant threats at local scales and reduce the resilience of corals to bleaching.

The public comments did not provide new or supplemental information on the susceptibility of *M. ferox* to sedimentation, and we did not find any new or supplemental information. We conclude that *M. ferox* has some level of susceptibility to sedimentation, but the available information does not support a more precise description of susceptibility.

The SRR and SIR provided the following information on the susceptibility of *M. ferox* to predation. *Mycetophyllia ferox* has not been susceptible to predation. Public comments did not provide new or supplemental information on *M. ferox's* susceptibility to predation, and we did not find any new or supplemental information. We conclude that *M. ferox* has low susceptibility to predation.

The SRR and SIR did not provide species-specific information on the effects of sea level rise on *M. ferox.* The SRR described sea level rise as an overall low to medium threat for all coral species. The public comments did not provide new or supplemental information on *M. ferox's* susceptibility to sea level rise, and we did not find any new or supplemental information. Thus, we conclude that *M. ferox* has some susceptibility to sea level rise, but the available information does not provide a more precise description of susceptibility.

The SRR and SIR provided the following information on *M. ferox's* susceptibility to collection and trade. *Mycetophyllia ferox* is not reported to be an important species for trade. Exports of *M. ferox* were ten pieces in 2000, two in 2003, and five in 2007.

The public comments did not provide new or supplemental information on the susceptibility of *M. ferox* to collection and trade. Supplemental information we found confirmed low collection and trade of *M. ferox* with gross exports between 2000 and 2012 averaging fewer than two corals per year (data available at *http://trade.cites.org/*). Thus, we conclude that *M. ferox* has low susceptibility to collection and trade.

Regulatory Mechanisms

In the proposed rule, we relied on information from the Final Management Report for evaluating the existing regulatory mechanisms for controlling threats to all corals. However, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *M. ferox.* Public comments were critical of that approach, and we therefore attempt to analyze regulatory mechanisms and conservation efforts on a species basis, where possible, in this final rule. Records confirm that *M. ferox* occurs in seven Atlantic ecoregions that encompass 26 kingdom's or countries' EEZs. The 26 kingdoms and countries are Antigua & Barbuda, Bahamas, Barbados, Belize, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, French Antilles, Grenada, Guatemala, Haiti, Honduras, Jamaica, Kingdom of the Netherlands, Mexico, Nicaragua, Panama, St. Kitts & Nevis, St. Lucia, St. Vincent & Grenadines, Trinidad and Tobago, United Kingdom (British Overseas Territories), United States (including U.S. Caribbean Territories), and Venezuela. The regulatory mechanisms relevant to *M. ferox,* described first as a percentage of the above kingdoms and countries that utilize them to any degree, and, second as the percentages of those kingdoms and countries whose regulatory mechanisms may be limited in scope, are as follows general coral protection (31 percent with 12 percent limited in scope), coral collection (50 percent with 27 percent limited in scope), pollution control (31 percent with 15 percent limited in scope), fishing regulations on reefs (73 percent with 50 percent limited in scope), managing areas for protection and conservation (88 percent with 31 percent limited in scope). The most common regulatory mechanisms in place for *M. ferox* are reef fishing regulations and area management for protection and conservation. However, half of the reef-fish fishing regulations are limited in scope and may not provide substantial protection for the coral species. General coral protection and collection laws, along with pollution control laws, are much less common regulatory mechanisms for the management of *M. ferox.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic traits, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that the factors that increase the extinction risk for *M. ferox* include disease, rare abundance, and observed declines in abundance.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species' abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *M. ferox,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. *Mycetophyllia ferox* has declined due to disease in at least a portion of its range and has low recruitment, which limits its capacity for recovery from mortality events and exacerbates vulnerability to extinction. Despite the large number of islands and environments that are included in the species' range, geographic distribution in the highly disturbed Caribbean exacerbates vulnerability to extinction over the foreseeable future because *M. ferox* is limited to an area with high, localized human impacts and predicted increasing threats. Its depth range of five to 90 meters moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower temperatures than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Its habitat includes shallow and mesophotic reefs which moderates vulnerability to extinction over the foreseeable future because the species occurs in numerous types of reef environments that are predicted, on local and regional scales, to experience highly variable thermal regimes and ocean chemistry at any given point in time. *Mycetophyllia ferox* is usually uncommon to rare throughout its range. Its absolute abundance has been estimated as at least hundreds of thousands of colonies in the Florida Keys and Dry Tortugas combined and is higher than the estimate from these two locations due to the occurrence of the species in many other areas throughout its range. Its abundance, combined with spatial variability in ocean warming and acidification across the species' range, moderate vulnerability to extinction because the threats are non-uniform, and there will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule, using the determination tool formula approach, *M. ferox* was proposed for listing as endangered because of: High vulnerability to disease (C); moderate vulnerability to ocean warming (E) and acidification (E); high vulnerability to nutrient over-enrichment (A and E); rare general range-wide abundance (E); decreasing trend in abundance (E); low relative recruitment rate (E); moderate overall distribution (based on narrow geographic distribution and wide depth distribution (E); restriction to the Caribbean (E); and inadequacy of regulatory mechanisms (D).

In this final rule, we changed the listing determination for *M. ferox* from endangered to threatened. We made this determination based on a more species-specific and holistic approach, including consideration of the buffering capacity of this species' spatial and demographic traits, and the best available information above on *M. ferox's* spatial structure, demography, threat susceptibilities, and management. This combination of factors indicates that *M. ferox* is likely to become endangered throughout its range within the foreseeable future, and thus warrants listing as threatened at this time, because:

(1) *Mycetophyllia ferox* is highly susceptible to disease (C) and susceptible to ocean warming (ESA Factor E), acidification (E), trophic effects of fishing (A), nutrients (A, E), and sedimentation (A, E). These threats are expected to continue and increase into the future. In addition, the species is at heightened extinction risk due to inadequate existing regulatory mechanisms to address global threats (D);

(2) *Mycetophyllia ferox* has experienced significant declines in Florida and has likely experienced decline in other locations in its range;

(3) *Mycetophyllia ferox* has a usually uncommon to rare occurrence throughout its range, which heightens the potential effect of localized mortality events and leaves the species vulnerable to becoming of such low abundance within the foreseeable future that it may be at risk from depensatory processes, environmental stochasticity, or catastrophic events, as explained in more detail in the Corals and Coral Reefs and Risk Analyses sections;

(4) *Mycetophyllia ferox* is geographically located in the highly disturbed Caribbean where localized human impacts are high and threats are predicted to increase as described in the Threats Evaluation section. A range constrained to this particular geographic area that is likely to experience severe and increasing threats indicates that a high proportion of the population of this species is likely to be exposed to those threats over the foreseeable future; and

(5) *Mycetophyllia ferox*'s low recruitment limits the capacity for recovery from threat-induced mortality events throughout the range over the foreseeable future.

The combination of these characteristics and future projections of threats indicates that the species is likely to be in danger of extinction within the foreseeable future throughout its range and warrants listing as threatened at this time due to factors A, C, D, and E.

The available information above on *M. ferox*'s spatial structure, demography, threat vulnerabilities, and management also indicate that the species is not currently in danger of extinction and thus does not warrant listing as Endangered because:

(1) While *Mycetophyllia ferox*'s distribution within the Caribbean increases its risk of exposure to threats as described above, its depth distribution is five to 90 m and its habitat includes various shallow and mesophotic reef environments. This moderates vulnerability to extinction currently because the species is not limited to one habitat type but occurs in numerous types of reef environments that will experience highly variable thermal regimes and ocean chemistry on local and regional scales at any given point in time, as described in more detail in the Coral Habitat and Threats Evaluation sections. There is no evidence to suggest that the species is so spatially fragmented that depensatory processes, environmental stochasticity, or the potential for catastrophic events currently pose a high risk to the survival of the species; and

(2) *Mycetophyllia ferox*'s absolute abundance is at least hundreds of thousands of colonies based on estimates from two locations. Absolute abundance is higher than estimates from these locations since *M. ferox* occurs in many other locations throughout its range. This absolute abundance allows for variation in the responses of individuals to threats to play a role in moderating vulnerability to extinction for the species to some degree, as described in more detail in the Corals and Coral Reefs section. Its absolute abundance indicates it is currently able to avoid high mortality from environmental stochasticity, and mortality of a high proportion of its population from catastrophic events.

The combination of these characteristics indicates that the species does not exhibit the characteristics of one that is currently in danger of extinction, as described previously in the Risk Analyses section, and thus does not warrant listing as endangered at this time.

Range-wide, multitudes of conservation efforts are already broadly employed that are likely benefiting *M. ferox.* However, considering the global scale of the most important threats to the species, and the ineffectiveness of conservation efforts at addressing the root cause of global threats (*i.e.,* GHG emissions), we do not believe that any current conservation efforts or conservation efforts planned in the future will result in affecting the species' status to the point at which listing is not warranted.

Genus Dendrogyra

The SRR and SIR provided the following information on morphology and taxonomy of *Dendrogyra. Dendrogyra cylindrus* is the only species in the genus *Dendrogyra.* It is easily identifiable, and there is no taxonomic confusion. The public comments did not provide new or supplemental information on the morphology or taxonomy of *D. cylindrus*, and we did not find any new or supplemental information.

Dendrogyra cylindrus

Introduction

The SRR and SIR provided the following information on the morphology of *D. cylindrus. Dendrogyra cylindrus* forms cylindrical columns on top of encrusting bases. Colonies are generally grey-brown in color and may reach three meters in height. Tentacles remain extended during the day, giving columns a furry appearance.

Spatial Information

The SRR and SIR provided the following information on *D. cylindrus*'s distribution, habitat, and depth range. *Dendrogyra cylindrus* is present in the western Atlantic and throughout the greater Caribbean. The SRR reports a single known colony in Bermuda that is in poor condition. *Dendrogyra cylindrus* inhabits most reef environments in water depths ranging from one to 25 m.

The public comments did not provide new or supplemental information on *D. cylindrus*'s distribution, habitat, or depth range. Supplemental information we found on *D. cylindrus*'s distribution, habitat, and depth range include the following. *Dendrogyra cylindrus* is absent from the southwest Gulf of Mexico (Tunnell, 1988). There is fossil evidence of the presence of *D. cylindrus* off Panama less than 1000 years ago, but it has been reported as absent today (Florida Fish and Wildlife Conservation Commission, 2013). Veron (2014) confirms the presence of *D. cylindrus* in seven out of a potential 11 ecoregions in the western Atlantic and wider-Caribbean that are known to contain corals. The four ecoregions in which it is not reported are the Flower Garden Banks and off the coasts of Bermuda, Brazil, and the southeast U.S. north of south Florida. Although *D. cylindrus*'s depth range is 1 to 25 m, it is most common between five and 15 m depth (Acosta and Acevedo, 2006; Cairns, 1982; Goreau and Wells, 1967).

All information on *D. cylindrus*'s distribution can be summarized as follows. *Dendrogyra cylindrus* is distributed throughout most of the greater Caribbean in most reef environments between 1 to 25 m depth. It currently appears to be absent from Panama where it historically occurred within the last 1000 years.

Demographic Information

The SRR and SIR provided the following information on *D. cylindrus*'s abundance and population trends. *Dendrogyra cylindrus* is uncommon but conspicuous with scattered, isolated colonies. It is rarely found in aggregations. *Dendrogyra cylindrus* has been reported to be common on Pleistocene reefs around Grand Cayman, but rare on modern reefs. In monitoring studies, cover is generally less than one percent. Between 2005 and 2007, mean density of *D. cylindrus* was approximately 0.5 colonies per 10 m^2 in the Florida Keys. In a study of *D. cylindrus* demographics at Providencia Island, Colombia, a total of 283 *D. cylindrus* colonies were detected in a survey of 1.66 km^2 for and overall density of 172.0 ± 177.0 (SE) colonies per km^2.

The public comments provided supplemental information on *D. cylindrus*'s abundance but not on population trends. In stratified random samples of the Florida Keys, *D. cylindrus* ranked least common out of 47 coral species in 2005 and 41 out of 43 species in 2009. Based on random surveys stratified by habitat type, extrapolated abundance for the Florida Keys was 23,000 ± 23,000 (SE) colonies in 2005 and 25,000 ± 25,000 (SE) colonies in 2009. Because these population estimates were based on random sampling, differences between years is more likely a function of sampling effort rather than an indication of population trends. All *D. cylindrus* colonies reported in 2005 were in the 70 to 80 cm diameter size class with less than two percent partial mortality. Four years later in 2009, all reported colonies were greater than 90 cm. No *D. cylindrus* colonies were encountered in 600 surveys from Key Biscayne to Key West, Florida in 2012, with the authors noting sampling design was not optimized for this species. This species was not reported in the Dry Tortugas in 2006 and 2008, and rarely encountered during pilot studies conducted over several years (1999 to 2002) ranking 49th out of 49 coral species (Miller *et al.,* 2013).

Supplemental information we found on *D. cylindrus*'s abundance and population trends confirms the uncommon occurrence, rare encounter rate, low percent cover, and low density. During surveys of Utila, Honduras between 1999 and 2000, *D. cylindrus* was sighted in 19.6 percent of 784 surveys and ranked 26th most common in abundance out of 48 coral species (Afzal *et al.,* 2001). In surveys of the upper Florida Keys in 2011, *D. cylindrus* was the second rarest out of 37 coral species and encountered at one percent of sites (Miller *et al.,* 2011b).

In stratified random surveys from Palm Beach County to the Dry Tortugas, Florida between 2005 and 2010, *D. cylindrus* was seen only on the ridge complex and mid-channel reefs at densities of 1.09 and 0.1 colonies per 10 m^2, respectively (Burman *et al.,* 2012). Average number of *D. cylindrus* colonies in remote reefs off southwest Cuba was 0.013 ± 0.045 colonies per 10 m transect, and the species ranked sixth rarest out of 38 coral species (Alcolado *et al.,* 2010).

Out of 283 *D. cylindrus* colonies at Providencia Island, Colombia, 70 were fragments resulting from asexual fragmentation, and no sexual recruits were observed. Size class distribution was skewed to smaller size classes less than 60 cm in height, and average colony height was 73.8 ± 46.0 cm (Acosta and Acevedo, 2006).

Dendrogyra cylindrus's average percent cover was 0.002 on patch reefs and 0.303 in shallow offshore reefs in annual surveys of 37 sites in the Florida Keys between 1996 and 2003 (Somerfield *et al.,* 2008). At permanent monitoring stations in the U.S. Virgin Islands, *D. cylindrus* has been observed in low abundance at 10 of 33 sites and, where present, ranged in cover from less than 0.05 percent to 0.22 percent (Smith, 2013). In Dominica, *D. cylindrus* comprised less than 0.9 percent cover and was present at 13.3 percent of 31 surveyed sites (Steiner, 2003). At seven fringing reefs off Barbados, *D. cylindrus* was observed on one reef, and cover was 2.7 ± 1.4 percent (Tomascik and Sander, 1987). In monitored photo-stations in Roatan, Honduras, cover of *D. cylindrus* increased slightly from 1.35 percent in 1996 to 1.67 percent in 1999 and then declined to 0.44 percent in 2003 and 0.43 percent in 2005 (Riegl *et al.,* 2009). In the U.S. Virgin Islands, seven percent of 26 monitored colonies experienced total colony mortality between 2005 and 2007, though the very low cover of *D. cylindrus* (0.04 percent) remained relatively stable during this time period (Smith *et al.,* 2013b).

All sources of information on *D. cylindrus*'s abundance and population trends can be summarized as follows. Based on population estimates, there are at least tens of thousands of *D. cylindrus* colonies present in the Florida Keys. Absolute abundance is higher than the estimate from this location given the presence of this species in many other locations throughout its range. Although there is evidence of potentially higher population levels in some areas of the Caribbean during the Pleistocence, *D. cylindrus* is currently uncommon to rare. Few studies report *D. cylindrus* population trends, and the low abundance and infrequent encounter rate in monitoring programs result in small samples sizes. The low coral cover of this species renders monitoring data difficult to extrapolate to realize trends. Therefore, we conclude that *D. cylindrus* is naturally uncommon to rare and that trends are unknown.

Other Biological Information

The SRR and SIR provided the following information on *D. cylindrus's* life history. *Dendrogyra cylindrus* is a gonochoric (separate sexes) broadcast spawning species with relatively low annual egg production for its size. The combination of gonochoric spawning with persistently low population densities is expected to yield low rates of successful fertilization and low larval supply. Sexual recruitment of this species is low, and reported juvenile colonies in the Caribbean are lacking. *Dendrogyra cylindrus* can propagate by fragmentation following storms or other physical disturbance. Average growth rates of 1.8 to 2.0 cm per year in linear extension have been reported in the Florida Keys compared to 0.8 cm per year in Colombia and Curaçao. Partial mortality rates are size-specific with larger colonies having greater rates. Frequency of partial mortality can be high (65 percent of 185 colonies surveyed in Colombia), while the amount of partial mortality per colony is generally low (average of 3 percent of tissue area affected per colony).

The public comments did not provide new or supplemental information on *D. cylindrus*'s life history. Supplemental information we found on *D. cylindrus*'s life history includes the following. Spawning observations have been made several nights after the full moon of August in the Florida Keys (Neely *et al.,* 2013; Waddell and Clarke, 2008).

Darling *et al.* (2012) performed a biological trait-based analysis to categorize coral species into four life history strategies: Generalist, weedy, competitive, and stress-tolerant. The classifications were primarily separated by colony morphology, growth rate, and reproductive mode. *Dendrogyra cylindrus* was classified as a ''competitive'' species, thus likely more vulnerable to environmental stress.

The SRR and SIR provided the following other biological information for *D. cylindrus. Dendrogyra cylindrus* appears to be sensitive to cold temperatures. Feeding rates (removal of suspended particles in seawater) are low relative to most other Caribbean corals, indicating it is primarily a tentacle feeder rather than a suspension feeder. However, *D. cylindrus* has a relatively high photosynthetic rate, and stable isotope values suggest it receives substantial amounts of photosynthetic products from its zooxanthellae.

The public comments did not provide new or supplemental biological information for *D. cylindrus.* Supplemental information we found confirms that *D. cylindrus* is sensitive to cold temperatures and is summarized as follows. In laboratory studies of cold shock, *D. cylindrus* had the highest zooxanthellae expulsion rate of three species tested at 12 degrees C (Muscatine *et al.,* 1991). During the 2010 cold water event in the Florida Keys, *D. cylindrus* was one of the most affected coral species with 100 percent mortality on surveyed inshore reefs (Kemp *et al.,* 2011).

Susceptibility to Threats

The threat susceptibility information from the SRR and SIR was interpreted in the proposed rule for *D. cylindrus's* vulnerabilities to threats as follows: High vulnerability to disease; moderate vulnerability to ocean warming, acidification, trophic effects of fishing, sedimentation, and nutrient enrichment; and low vulnerability to sea level rise, predation, and collection and trade.

The SRR and SIR provided the following information on the susceptibility of *D. cylindrus* to ocean warming. There are conflicting characterizations of bleaching susceptibility of *D. cylindrus* in the literature. The species was bleaching-resistant during the 1983 mass-bleaching event in Florida. Characterizations of the 2005 mass-bleaching event in southern Florida and in the U.S. Virgin Islands noted that no bleached *D. cylindrus* colonies were observed, but during the same event in Barbados 100 percent of 15 *D. cylindrus* colonies bleached.

Van Woesik *et al.* (2012) developed a coral resiliency index based on biological traits and processes to evaluate extinction risk due to bleaching. Evaluations were performed at the genus level. They rated the resiliency of *D. cylindrus* as 3 out of a range of −6 to 7 observed in other coral genera. Less than or equal to −3 was considered highly vulnerable to extinction, and greater than or equal to 4 was considered highly tolerant. Thus, *D. cylindrus* was rated as moderately tolerant. While this study was included in the SIR, species-specific findings for *Dendrogyra* were not included. The public comments (Comment 47) indicated the results of this study should be considered in the listing status of *D. cylindrus.*

The public comments did not provide new or supplemental information on the susceptibility of *D. cylindrus* to ocean warming. Supplemental information we found confirms the variable susceptibility of *D. cylindrus* to ocean warming and bleaching. *Dendrogyra cylindrus* was among 42 species reported not to have bleached at various locations in the western Atlantic (British Virgin Islands, Jamaica, and Mona Island) during the 1987 bleaching event, while the authors noted these species were reported bleached at other locations or other areas by others (Williams and Bunkley-Williams, 1990). None of the 18 *D. cylindrus* colonies monitored in Roatan, Honduras experienced bleaching or mortality in the 1998 event where bleaching ranged from zero to 89 percent in the 22 species monitored (Riegl *et al.*, 2009). Across 12 locations in Puerto Rico, 100 percent of *D. cylindrus* colonies bleached during the 2005 temperature anomaly (Waddell and Clarke, 2008). However, Bruckner and Hill (2009) report less severe *D. cylindrus* bleaching during the 2005 event in Puerto Rico; approximately 25 percent paled and 10 percent bleached on reefs off Mona and Desecheo Islands, which was relatively low compared to some other species such as *Orbicella faveolata,* which had approximately 60 percent bleached colonies. At Dairy Bull Reef in Jamaica, 50 percent of *D. cylindrus* colonies bleached during the 2005 bleaching event, but no mortality was reported for this species (Quinn and Kojis, 2008). An average of 33 percent of the monitored *D. cylindrus* colonies in the U.S. Virgin Islands bleached in 2005, and 67 percent paled. None of the monitored colonies bleached or paled during the less severe 2010 bleaching event (Smith *et al.*, 2013b).

All sources of information are used to describe *D. cylindrus*'s susceptibility to ocean warming as follows. There are conflicting characterizations of the susceptibility of *D. cylindrus* to bleaching. Some locations experienced high bleaching of up to 100 percent of *D. cylindrus* colonies during the 2005 Caribbean bleaching event while others had a smaller proportion of colonies bleach (10 to 50 percent). Reports of low mortality after less severe bleaching indicate potential resilience, though mortality information is absent from locations that reported high bleaching frequency. Although bleaching of most coral species is spatially and temporally variable, understanding the susceptibility of *D. cylindrus* is further confounded by the species' rarity and, hence, low sample size in any given survey. We conclude that although *D. cylindrus* appears to have resistance to bleaching from warmer temperatures in some portions of its range under some circumstances, it is likely to have some susceptibility to ocean warming, given the high rates of bleaching observed at times. However, the available information does not support a more detailed description of susceptibility.

The SRR and SIR provided the following information on the susceptibility of *D. cylindrus* to acidification. No specific research has addressed the effects of acidification on the genus *Dendrogyra.* However, most corals studied have shown negative relationships between acidification and growth, and acidification is likely to contribute to reef destruction in the future. While ocean acidification has not been demonstrated to have caused appreciable declines in coral populations so far, it is considered a significant threat to corals by 2100.

The public comments did not provide new or supplemental information on the susceptibility of *D. cylindrus* to acidification, and we did not find any new or supplemental information.

All sources of information are used to describe *D. cylindrus's* susceptibility to acidification as follows. *Dendrogyra cylindrus* likely has some susceptibility to acidification, but the available information does not support a more precise description of susceptibility to this threat.

The SRR and SIR provided the following information on the susceptibility of *D. cylindrus* to disease. *Dendrogyra cylindrus* is susceptible to black band disease and white plague, though impacts from white plague are likely more extensive because of rapid progression rates. The large colony size suggests that individual colonies are less likely to suffer complete mortality from a given disease exposure, but low colony density suggests that even small degrees of mortality increase extinction risk.

The public comments did not provide new or supplemental information on the susceptibility of *D. cylindrus* to disease. Supplemental information we found on the susceptibility of *D. cylindrus* to disease includes the following. In a January 2002 survey at Providencia Island, Colombia, 4.2 percent of *D. cylindrus* colonies (n=185) exhibited white plague type II (Acosta and Acevedo, 2006). The prevalence of diseased *D. cylindrus* colonies was approximately three percent in Mexico from 2002 to 2004 (Ward *et al.*, 2006). Though white diseases were reported to cause colony mortality in some coral species in the U.S. Virgin Islands after the 2005 Caribbean bleaching event, none of the monitored *D. cylindrus* colonies exhibited signs of white disease (Smith *et al.*, 2013b).

All sources of information are used to describe *D. cylindrus's* susceptibility to disease as follows. Disease appears to be present in about three to four percent of the population in some locations. Because no studies have tracked disease progression in *D. cylindrus,* the effects of disease are uncertain at both the colony and population level. However, the reported low partial mortality and large colony size suggest that individual colonies are less likely to suffer complete colony mortality from a given disease exposure. Therefore, we conclude that *D. cylindrus* has some susceptibility to disease, but the available information does not support a more precise description of susceptibility to this threat.

The SIR and SRR did not provide any species-specific information on the trophic effects of fishing on *D. cylindrus.* The public comments did not provide new or supplemental information, and we did not find new or supplemental information on the trophic effects of fishing on *D. cylindrus.* However, due to the level of reef fishing conducted in the Caribbean, coupled with *Diadema* die-off and lack of significant recovery, competition with algae can adversely affect coral recruitment. This effect coupled with the species' low recruitment rate indicates it likely has some susceptibility to the trophic effects of fishing. The available information does not support a more precise description of its susceptibility.

The SRR and SIR provided the following information on the susceptibility of *D. cylindrus* to sedimentation. The rate of sand removal from *D. cylindrus* tissues in laboratory conditions was intermediate among 19 Caribbean coral species tested.

The public comments did not provide new or supplemental information on the susceptibility of *D. cylindrus* to sedimentation. Supplemental information we found includes the following. *Dendrogyra cylindrus,* along with *Acropora* spp. and *Meandrina meandrites*, was found in fossil assemblages only on the reef tract and not on the lagoonal patch reefs around Grand Cayman, suggesting that this species may be ineffective at sediment rejection like the other two species or may be intolerant of turbidity (Hunter and Jones, 1996).

All sources of information are used to describe *D. cylindrus*'s susceptibility to sedimentation as follows. *Dendrogyra cylindrus* appears to be moderately capable of removing sediment from its tissue. However, *D. cylindrus* may be more sensitive to turbidity due to its high reliance on nutrition from photosynthesis and as evidenced by the geologic record. Therefore, we conclude that *D. cylindrus* has some susceptibility to sedimentation, but the available information does not support a more precise description of susceptibility to this threat.

The SRR and SIR provided the following information on the susceptibility of *D. cylindrus* to nutrient enrichment. Along a eutrophication gradient in Barbados, *D. cylindrus* was found at a single site, one of those farthest removed from pollution. The public comments did not provide new or supplemental on the susceptibility of *D. cylindrus* to nutrient enrichment, and we did not find any new or supplemental information.

All sources of information are used to describe *D. cylindrus*'s susceptibility to nutrient enrichment as follows. *Dendrogyra cylindrus* may be susceptible to nutrient enrichment as evidenced by its absence from eutrophic sites in one location. However, there is uncertainty about whether its absence is a result of eutrophic conditions or a result of its naturally uncommon or rare occurrence. Therefore, we conclude that *D. cylindrus* likely has some susceptibility to nutrient enrichment. However, the available information does not support a more precise description of its susceptibility to this threat.

The SRR and SIR provided the following information on the susceptibility of *D. cylindrus* to predation. The corallivorous fireworm *Hermodice carunculata* has been observed feeding on diseased colonies of *D. cylindrus*, but generally, predation is not observed to cause noticeable mortality on *D. cylindrus,* despite its rarity.

The public comments did not provide new or supplemental information on *D. cylindrus*'s susceptibility to predation. Supplemental information we found includes the following. The sea urchin, *Diadema antillarum*, has been reported to cause partial mortality at the base of *D. cylindrus* colonies (Acosta and Acevedo, 2006).

All sources of information are used to describe *D. cylindrus*'s susceptibility to predation as follows. The low amounts of observed mortality indicate *D. cylindrus* has low susceptibility to predation.

The SRR and SIR did not provide species-specific information on the effects of sea level rise on *D. cylindrus.* The SRR described sea level rise as an overall low to medium threat for all coral species. The public comments did not provide new or supplemental information on *D. cylindrus*'s susceptibility to sea level rise, and we did not find any new or supplemental information. Thus, we conclude that *D. cylindrus* has some susceptibility to sea level rise, but the available information does not support a more precise description of susceptibility to this threat.

The SRR and SIR provided information on *D. cylindrus*'s susceptibility to collection and trade. Overall trade reports indicate very low rates of international trade of *D. cylindrus.* It is possible that historical curio collecting of *D. cylindrus* may have significantly reduced populations off Florida.

The public comments did not provide new or supplemental information of the susceptibility of *D. cylindrus* to collection and trade. Supplemental information we found confirms what was provided by the SRR and SIR. Prior to its ban in the 1980s, collection of *D. cylindrus* for curios was once widespread off the coast of Florida (Florida Fish and Wildlife Conservation Commission, 2013). From 2000 to 2012, international trade of this species was low with gross exports ranging from zero to nine corals per year (average less than two per year; data available at *http://trade.cites.org*).

All sources of information are used to describe *D. cylindrus*'s susceptibility to collection and trade as follows. In the past, collection and trade may have had a large effect on the population in some locations like Florida. However, collection and trade likely does not have a large impact on the population currently. Therefore, we conclude that the susceptibility of *D. cylindrus* to collection and trade is currently low.

Regulatory Mechanisms

In the proposed rule, we relied on information from the Final Management Report for evaluating the existing regulatory mechanisms for controlling threats to all corals. However, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *D. cylindrus.* Public comments were critical of that approach, and we therefore attempt to analyze regulatory mechanisms and conservation efforts on a species basis, where possible, in this final rule. Records confirm that *D. cylindrus* occurs in seven Atlantic ecoregions that encompass 26 kingdom's and countries' EEZs. The 26 kingdoms and countries are Antigua & Barbuda, Bahamas, Barbados, Belize, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, French Antilles, Grenada, Guatemala, Haiti, Kingdom of the Netherlands, Honduras, Jamaica, Mexico, Nicaragua, Panama, St. Kitts & Nevis, St. Lucia, St. Vincent & Grenadines, Trinidad and Tobago, United Kingdom (British Caribbean Territories), United States (including U.S. Caribbean Territories), and Venezuela. The regulatory mechanisms relevant to *D. cylindrus,* described first as a percentage of the above kingdoms and countries that utilize them to any degree, and, second as the percentages of those kingdoms and countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (31 percent with 12 percent limited in scope), coral collection (50 percent with 27 percent limited in scope), pollution control (31 percent with 15 percent limited in scope), fishing regulations on reefs (73 percent with 50 percent limited in scope), managing areas for protection and conservation (88 percent with 31 percent limited in scope). The most common regulatory mechanisms in place for *D. cylindrus* are reef fishing regulations and area management for protection and conservation. However, half of the reef fishing regulations are limited in scope and may not provide substantial protection for the species. General coral protection and collection laws, along with pollution control laws, are much less common regulatory mechanisms for the management of *D. cylindrus.*

Dendrogyra cylindrus is listed as threatened on the State of Florida endangered and threatened species list. The state has an action plan for conservation of the species with several objectives including stabilizing or increasing the existing population, the current area of occupancy, and the number of sexually mature individuals and evaluating the reproductive potential of the population over the next decade (Florida Fish and Wildlife Conservation Commission, 2013). However, the management plan recognizes that there are threats to *D. cylindrus* that need to be addressed outside the scope of the plan in order to improve the status of this species.

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its demographic and spatial characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that the factors that increase the extinction risk for *D. cylindrus* include the overall low population density and low population size, gonochoric spawning mode and lack of observed sexual recruitment, and susceptibility to observed disease mortality. The SRR acknowledged that, given the apparent naturally rare status of this species, some undescribed adaptations to low population density may exist in this species, particularly with regard to overcoming fertilization limitation between spawned gametes from gonochoric parent colonies that are at great distance from one another. Nonetheless, the pervasiveness of threats characterizing the Caribbean region was deemed to represent substantial extinction risk given this species' low population size.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species' abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *D. cylindrus,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. *Dendrogyra cylindrus* is susceptible to a number of threats, but there is little evidence of population declines thus far. Despite the large number of islands and environments that are included in the species' range, geographic distribution in the highly disturbed Caribbean exacerbates vulnerability to extinction over the foreseeable future because *D. cylindrus* is limited to an area with high, localized human impacts and predicted increasing threats. *Dendrogyra cylindrus* inhabits most reef environments in water depths ranging from 1 to 25 m which moderates vulnerability to extinction over the foreseeable future because the species occurs in numerous types of reef environments that are predicted, on local and regional scales, to experience highly variable thermal regimes and ocean chemistry at any given point in time. It is naturally rare. Estimates of absolute abundance are at least tens of thousands of colonies in the Florida Keys, and absolute abundance is higher than estimates from this location due to the occurrence of the species in many other areas throughout its range. It is a gonochoric broadcast spawner with observed low sexual recruitment. Its low abundance, combined with its geographic location, exacerbates vulnerability to extinction because increasingly severe conditions within the species' range are likely to affect a high proportion of its population at any given point in time, and low sexual recruitment is likely to inhibit recovery potential from mortality events, further exacerbating its vulnerability to extinction.

Listing Determination

In the proposed rule, using the determination tool formula approach, *D. cylindrus* was proposed for listing as endangered because of: High vulnerability to disease (C); moderate vulnerability to ocean warming (E) and acidification (E); rare general range-wide abundance (E); low relative recruitment rate (E); narrow overall distribution (based on narrow geographic distribution and moderate depth distribution (E); restriction to the Caribbean (E); and inadequacy of regulatory mechanisms (D).

In this final rule, we changed the listing determination for *D. cylindrus* from endangered to threatened. We made this determination based on a more species-specific and holistic approach, including consideration of the buffering capacity of this species' spatial and demographic traits, and the best available information above on *D. cylindrus*'s spatial structure, demography, threat susceptibilities, and management. This combination of factors indicates that *D. cylindrus* is likely to become endangered throughout its range within the foreseeable future, and thus warrants listing as threatened at this time, because:

(1) *Dendrogyra cylindrus* is susceptible to ocean warming (ESA Factor E), disease (C), acidification (E), nutrient enrichment (A and E), sedimentation (A and E), and trophic effects of fishing (A). These threats are expected to continue and increase into the future. In addition, the species is at heightened extinction risk due to inadequate existing regulatory mechanisms to address global threats (D).

(2) *Dendrogyra cylindrus* is geographically located in the highly disturbed Caribbean where localized human impacts are high and threats are predicted to increase as described in the Threats Evaluation section. A range constrained to this particular geographic area that is likely to experience severe and increasing threats indicates that a high proportion of the population of this species is likely to be exposed to those threats over the foreseeable future;

(3) *Dendrogyra cylindrus* has an uncommon to rare occurrence throughout its range, which heightens the potential effect of localized mortality events and leaves the species vulnerable to becoming of such low abundance within the foreseeable future that it may be at risk from depensatory processes, environmental stochasticity, or catastrophic events, as explained in more detail in the Corals and Coral Reefs and Risk Analyses sections; and

(4) *Dendrogyra cylindrus*'s low sexual recruitment limits its capacity for recovery from threat-induced mortality events throughout its range over the foreseeable future.

The combination of these characteristics and future projections of threats indicates the species is likely to be in danger of extinction within the foreseeable future throughout its range and warrants listing as threatened at this time due to factors A, C, D, and E.

The available information above on *D. cylindrus* spatial structure, demography, threat susceptibilities, and management also indicate that the species is not currently in danger of extinction and thus does not warrant listing as Endangered because:

(1) There is little evidence of *D. cylindrus* population declines (*i.e.*, the species continues to be naturally rare);

(2) *Dendrogyra cylindrus* shows evidence of resistance to bleaching from warmer temperatures in some portions of its range under some circumstances (*e.g.*, Roatan, Honduras); and

(3) While *D. cylindrus*'s distribution within the Caribbean increases its risk of exposure to threats as described above, its habitat includes most reef environments in water depths ranging from one to 25 m. This moderates vulnerability to extinction currently because the species is not limited to one habitat type but occurs in numerous types of reef environments that will experience highly variable thermal regimes and ocean chemistry on local and regional scales at any given point in time, as described in more detail in the Coral Habitat and Threats Evaluation sections.

The combination of these characteristics indicates that the species does not exhibit the characteristics of one that is currently in danger of extinction, as described previously in the Risk Analyses section, and thus does not warrant listing as endangered at this time.

Last, *D. cylindrus* is listed as threatened on the State of Florida endangered and threatened species list, and an action plan for conservation has recently been developed. Implementation of the action plan will no doubt have benefits to the species, but it is too soon to evaluate its effectiveness for conserving the species. Further, considering the global scale of the most important threats to the species, and the ineffectiveness of conservation efforts at addressing the root cause of global threats (*i.e.*, GHG emissions), we do not believe that any current conservation efforts or conservation efforts planned in the future will result in affecting the species' status to the point at which listing is not warranted.

Genus Dichocoenia

The SRR and SIR provided the following information on *Dichocoenia*'s morphology and taxonomy. There are potentially two species in the genus *Dichocoenia: Dichocoenia stokesi* and *Dichocoenia stellaris. Dichocoenia stellaris* has been described as differing from *D. stokesi* by its pancake-like colony morphology and dominance of smaller, circular calices. Some coral taxonomists consider there to be only one species, *D. stokesi*, as specimens have all variations of skeletal shape and valley length. The public comments did not provide any new or supplemental information on *Dichocoenia*'s taxonomy or morphology, and we did not find any new or supplemental information.

Most studies over the last several decades describe *D. stokesi* and do not separately report data for colonies with *D. stellaris* morphology. Because *D. stokesi* was petitioned for listing and *D. stellaris* was not, we considered all information on *D. stokesi* and did not consider information on *D. stellaris*, despite some uncertainty of whether or not these are the same species. If *D. stokesi* is accepted to include all sizes of calices, it is easy to identify; if not then species delineations are somewhat arbitrary. We did not find any supplemental information on *Dichocoenia*'s taxonomy.

Dichocoenia stokesi

Introduction

Dichocoenia stokesi forms mounding-spherical colonies that are usually orange-brown but sometimes green.

Spatial Information

The SRR and SIR provided the following information on *D. stokesi*'s distribution, habitat, and depth range. *Dichocoenia stokesi* is located in the western Atlantic, Gulf of Mexico (including the Florida Middle Grounds and Flower Garden Banks), and throughout the Caribbean. It is also reported in Bermuda, though it is rare. *Dichocoenia stokesi* occurs in most reef environments within its range, including mesophotic reefs, back- and fore-reef environments, rocky reefs, lagoons, spur-and-groove formations, channels, and occasionally at the base of reefs. It has been reported in water depths ranging from two to 72 m.

The public comments did not provide any new or supplemental information on *D. stokesi*'s distribution, habitat, or depth range. Supplemental information we found includes the following. Veron (2014) confirmed the occurrence of *D. stokesi* in nine out of 11 ecoregions in the western Atlantic and wider-Caribbean known to contain corals. The two ecoregions in which it is not reported are off the coasts of Brazil, and the southeast U.S. north of south Florida. Kahng *et al.* (2010) report that *D. stokesi* is relatively abundant and dominates the coral community on mesophotic reefs greater than 40 m depth in the northern Gulf of Mexico but not in Belize, Puerto Rico, U.S. Virgin Islands, Jamaica, Curacao, Florida, Bermuda, Bahamas, or Barbados.

All information on *D. stokesi'*s distribution can be summarized as follows. *Dichocoenia stokesi* is distributed throughout most of the greater Caribbean in most reef environments within its range, including mesophotic reefs.

Demographic Information

The SRR and SIR provided the following information on *D. stokesi* abundance. *Dichocoenia stokesi* is characterized as usually uncommon. In surveys of southeast Florida and the

Florida Keys between 2005 and 2007, *D. stokesi* comprised between 1.8 and 7.0 percent of all coral colonies observed and was present at a density of approximately 1.7 colonies per 10 m^2, which was the ninth most abundant out of an observed 43 coral species.

The public comments provided the following supplemental information on *D. stokesi's* abundance. In stratified random surveys conducted by Miller *et al.* (2013) in the Florida Keys, *D. stokesi* ranked as the 8th most abundant species or higher in 2005, 2009, and 2012. Extrapolated abundance was 97.8 ± 13.1 (SE) million colonies in 2005, 53.8 ± 9.7 (SE) million colonies in 2009, and 81.6 ± 10.0 (SE) million colonies in 2012. Because population estimates were based on random sampling, differences between years are more likely a function of sampling effort rather than an indication of population trends. Most colonies were 30 cm or less in size, and size class distributions remained similar among the three sample periods (2005, 2009, and 2012). Larger colonies typically exhibited more partial mortality, which ranged between 20 and 80 percent for colonies larger than 10 cm.

In the Dry Tortugas, *D. stokesi* was ranked 12th and 14th most common in 2006 and 2008, respectively. Extrapolated colony abundance was 12.1 ± 4.1 (SE) million colonies in 2006 and 7.1 ± 1.1 (SE) million colonies in 2008. All *D. stokesi* colonies observed were 40 cm or less in 2006, and 20 cm or less in 2008. Partial mortality was higher in larger colonies and ranged from approximately 20 to 65 percent in colonies larger than 10 cm (Miller *et al.*, 2013).

Supplemental information we found on *D. stokesi's* abundance includes the following. In surveys of Utila, Honduras between 1999 and 2000, *D. stokesi* was the eighth most common species and was sighted in 52.6 percent of 784 surveys (Afzal *et al.,* 2001). *Dichocoenia stokesi* has been observed in low abundance at 17 of 33 monitoring sites in the U.S. Virgin Islands and is the 33rd most common species by percent cover (Smith, 2013). Off southeast Florida, *D. stokesi* comprised 6.8 percent of the coral population between 9 and 32 m depth and was ranked the 5th most abundant coral species out of 27 coral species encountered (Goldberg, 1973). In surveys of Conch Reef in the Florida Keys in 1995, juvenile *D. stokesi* comprised between approximately two and six percent of the overall juvenile coral population, and the highest proportion occurred at 14 m and decreased with depth (Edmunds *et al.,* 2004). Off South Caicos Island, *D. stokesi* was most frequently encountered on shallow pavement (9 m) and comprised 15 percent of all coral colonies counted; however on the deeper spur and groove (18 m) and fore-reef (27 m), it comprised 2 and 0.7 percent of colonies counted, respectively (Steiner, 1999). Bak and Meesters (1999) report that about 50 percent of *D. stokesi* colonies surveyed in Florida and Curacao were in the 10 to 20 cm size class.

Between 1996 and 2003, average cover of *D. stokesi* per habitat type ranged from 0.02 to 0.12 percent in the Florida Keys and was highest on patch reefs (Somerfield *et al.,* 2008). Of three sites surveyed in Bermuda, cover of *D. stokesi* was 0.02 ± 0.03 percent at one site (Dodge *et al.,* 1982). In surveys off Colombia from 1998 to 2004, *D. stokesi* cover ranged from 0.02 to 0.6 percent, but the species was only present in nine out of 32 sites (Rodriguez-Ramirez *et al.,* 2010). In the Bahamas Archipelago, cover of *D. stokesi* was on average 0.01 to 0.02 percent in 2002 to 2004 (Roff *et al.,* 2011). In Dominica, *D. stokesi* was observed in 47 percent of 31 sites surveyed and comprised less than one percent cover (Steiner, 2003). *Dichocoenia stokesi* was present on four out of seven fringing reefs off Barbados and comprised between 0.1 and 0.6 percent cover (Tomascik and Sander, 1987).

On remote reefs off southwest Cuba, *D. stokesi* was observed on 30 reef front sites at densities of 0.052 ± 0.096 (SD) colonies per 10 m transect, but was not observed at any of the 38 surveys of the reef crest (Alcolado *et al.,* 2010). In 1,176 sites surveyed in southeast Florida and the Florida Keys between 2005 and 2010, density of *D. stokesi* ranged from 0.07 to 2.35 colonies per 10 m^2 on reef zones where they were found, and this species was the eighth most abundant species out of 42 coral species encountered (Burman *et al.,* 2012).

The SRR and SIR provided the following information on population trends of *D. stokesi.* A comparison of survey data from 19 sites in Spaanse Water, Curacao in 1961 and 1992 indicated an 80 percent decrease in relative abundance of *D. stokesi* between the two survey periods. In surveys of the Florida Keys between 1995 and 2002 during and after a disease outbreak, the average number of *D. stokesi* colonies per 314-m^2 site decreased from 44.3 to 11.2, a decline of almost 75 percent. The maximum number of *D. stokesi* colonies per site decreased from 95 to 43, and the minimum number of colonies per site decreased from ten to one. There was a shift in the size class distribution between 1998 and 2002 with a decrease in the frequency of smaller size classes and a shift from dominance by smaller size classes to a more even distribution across small to larger size classes. Two *D. stokesi* recruits were found after the disease but did not survive to the following year. No colonies greater than 25 cm were observed in 1998, four years later (2002) many colonies greater than 25 cm were observed up to 55 cm.

The public comments did not provide new or supplemental information on *D. stokesi's* population trends, and we did not find any new or supplemental information.

All information on *D. stokesi's* abundance and population trends can be summarized as follows. *Dichocoenia stokesi* has been characterized as usually uncommon but is usually reported as one of the top 10 most abundant species where estimates are available. Based on population estimates, there are at least tens of millions of *D. stokesi* colonies present in both the Florida Keys and Dry Tortugas. Absolute abundance is higher than the estimate from these two locations given the presence of this species in many other locations throughout its range. The characterization of its occurrence as usually uncommon gives the impression of a lower population abundance than is indicated by population estimates. Density estimates range from 0.05 to 2.35 colonies per 10 m^2. The sometimes low density and small colony size result in low percent cover estimates, generally between 0.01 and less than 1 percent, and make it difficult to track population trends from percent cover data. Trend data indicate *D. stokesi* has decreased in abundance in at least two locations (*i.e.,* the Florida Keys, and a bay in Curacao). Presence of juveniles in several locations indicates recruitment is occurring. Recovery from severe population declines in the Florida Keys after a disease event was not reported seven years later. Thus, we conclude that population decline has occurred in some locations and that the species' absolute abundance is greater than hundreds of millions of colonies.

Other Biological Information

The SRR and SIR provided the following information on *D. stokesi's* life history. *Dichocoenia stokesi* is a gonochoric broadcast spawner with an overall sex ratio of 2 to 1 (male to female) in southeast Florida where a small portion of hermaphroditic colonies (approximately 18 percent) were observed. Minimum size at reproduction was 160 cm^2, and two potential spawning events per year were inferred: one in late August/early September and a second in October. Recruitment levels, inferred from the presence of juveniles, is intermediate compared to other Caribbean coral species. Very low densities of *Dichocoenia* juveniles (approximately one percent of total juvenile colonies) have been observed in the Netherlands Antilles. Mean *D. stokesi* juvenile density among 566 sites surveyed during 1999 to 2009 averaged 0.11 per m^2 but reached as high as one juvenile per m^2 in certain habitats. The annual growth rate of *D. stokesi* has been reported as 2 to 7 mm per year in diameter and 2 to 5.2 mm per year in height.

The public comments did not provide new or supplemental information on the life history of *D. stokesi.* Supplemental information we found on the life history of *D. stokesi* includes the following. Chiappone and Sullivan (1996) reported density of juvenile *D. stokesi* range from 0.02 to 0.26 per m^2 at five out of nine sites surveyed in the Florida Keys between 1993 and 1994. Darling *et al.* (2012) performed a biological trait-based analysis to categorize coral species into four life history strategies: Generalist, weedy, competitive, and stress-tolerant. The classifications were primarily separated by colony morphology, growth rate, and reproductive mode. *Dichocoenia stokesi* was classified as a ''stress-tolerant'' species, thus likely more tolerant of environmental stress.

The SRR and SIR provided the following other biological information about *D. stokesi.* The mounding morphology and large corallite diameter of *D. stokesi* enhance turbulence near the surface of colonies. This should, in turn, enhance mass transfer, which affects photosynthesis and respiration in *D. stokesi* as well as prey capture and nutrient uptake. Thresholds for uptake of inorganic nitrogen in *D. stokesi* have been reported to be fairly low (150 nM), giving it a potential advantage in nutrient-poor conditions.

The public comments did not provide new or supplemental information on *D. stokesi's* biology. Supplemental information we found on *D. stokesi's* biology includes the following. At 76 sites surveyed in the Florida Keys during the 2010 cold-water event, approximately 15 percent of *D. stokesi* paled, and approximately one percent bleached. Mortality was approximately four percent (The Nature Conservancy, 2010).

Susceptibility to Threats

The threat susceptibility information from the SRR and SIR was interpreted in the proposed rule for *D. stokesi's* vulnerabilities to threats as follows: High vulnerability to disease; moderate vulnerability to ocean warming, acidification, trophic effects of fishing, and sedimentation; and low vulnerability to sea level rise, predation, and collection and trade.

The SRR and SIR provided the following information on the susceptibility of *D. stokesi* to ocean warming. Of the 28 coral species that bleached along the Florida reef tract from Martin County through the lower Florida Keys from 2005 to 2007, *D. stokesi* had the lowest bleaching prevalence. During the 2005 Caribbean mass-bleaching event, it ranked 16th of 21 species in bleaching prevalence in Barbados and was observed to be bleaching-tolerant in the U.S. Virgin Islands.

Van Woesik *et al.* (2012) developed a coral resiliency index based on biological traits and processes to evaluate extinction risk due to bleaching. Evaluations were performed at the genus level. They rated the resiliency of *Dichocoenia* as 0 out of a range of −6 to 7 observed in other coral genera. Less than or equal to −3 was considered highly vulnerable to extinction, and greater than or equal to 4 was considered highly tolerant. Thus, *Dichocoenia* was rated in the middle.

The public comments did not provide new or supplemental information on the susceptibility of *D. stokesi* to ocean warming. Supplemental information we found on the susceptibility of *D. stokesi* to ocean warming includes the following. During the 1998 bleaching event, an average of 20 percent of *D. stokesi* colonies were greater than 50 percent bleached in the lower Florida Keys and Dry Tortugas; however, this was the lowest of 14 species that bleached (Waddell, 2005). Of the 22 species monitored off Roatan, Honduras, *D. stokesi* was one of eight species that did not bleach during the 1998 bleaching event (Riegl *et al.,* 2009).

During the 2005 temperature anomaly, *D. stokesi* colonies were fully bleached around La Parguera, Puerto Rico but were less frequently bleached at other locations around Puerto Rico (Waddell and Clarke, 2008). Off of Mona and Desecheo Islands, Puerto Rico, about 25 percent of *D. stokesi* paled and about 10 percent bleached; in the 16 coral species surveyed, bleaching ranged from less than five percent to approximately 60 percent of colonies (Bruckner and Hill, 2009). During the 2005 bleaching event, approximately 30 percent of *D. stokesi* colonies on six reefs bleached in Barbados, and *D. stokesi* around Grand Cayman experienced total bleaching (Wilkinson and Souter, 2008). None of the monitored *D. stokesi* colonies in the U.S. Virgin Islands bleached, and 67 percent paled during the 2005 bleaching event (Smith *et al.,* 2013b). In the Florida Keys, *D. stokesi* ranked 19th out of 25 species in amount of mortality during the 2005 bleaching event (Lirman *et al.,* 2011).

All sources of information are used to describe *D. stokesi's* susceptibility to ocean warming as follows. Reported bleaching of *D. stokesi* ranges from zero to about 60 percent. While reported bleaching of *D. stokesi* is temporally and spatially variable, compared to other Caribbean coral species, *D. stokesi* appears to be among the less susceptible to temperature-induced bleaching. Additionally, a report from the Florida Keys indicates that bleaching-induced mortality of *D. stokesi* was among the lowest compared to other Caribbean coral species. Thus, we conclude that *D. stokesi* has some susceptibility to ocean warming. However, the available information does not support a more precise description of susceptibility.

The SRR and SIR provided the following information on the susceptibility of *D. stokesi* to acidification. No specific research has addressed the effects of acidification on the genus *Dichocoenia.* However, most corals studied have shown negative relationships between acidification and growth, and acidification is likely to contribute to reef destruction in the future. While ocean acidification has not been demonstrated to have caused appreciable declines in coral populations so far, it is considered a significant threat to corals by 2100.

The public comments did not provide new or supplemental information on the susceptibility of *D. stokesi* to acidification, and we did not find any new or supplemental information.

All sources of information are used to describe *D. stokesi's* susceptibility to acidification as follows. There is uncertainty about how *D. stokesi* will respond to ocean acidification, but based on the negative effects of acidification on growth of most corals, *D. stokesi* likely has some susceptibility to acidification. The available information does not support a more precise description of susceptibility.

The SRR and SIR provided the following information on *D. stokesi's* susceptibility to disease. Black band disease, dark spot syndrome, and white plague have been reported to affect *D. stokesi.* In an outbreak of white plague in St. Lucia in 1997, six surveyed colonies of *D. stokesi* were infected, and average tissue mortality was about 65 percent. In surveys in Dominica between 2000 and 2002, *D. stokesi* was one of four coral species most commonly affected by disease, and white plague predominantly affected larger-sized colonies. Of 17 species affected by white plague in the Florida Keys, *D. stokesi* was the most susceptible.

The public comments did not provide new or supplemental information on the susceptibility of *D. stokesi* to disease. Supplemental information we found on the susceptibility of *D. stokesi* to disease includes the following. In 1991, an outbreak of white plague was observed on Mona Island, Puerto Rico that affected 14 species, with the highest prevalence among small, massive corals including *D. stokesi,* many of which died within one to two weeks (Waddell, 2005). In Mexico, disease was prevalent on approximately one percent of *D. stokesi* colonies surveyed in 2004 (Ward *et al.,* 2006).

During an outbreak of white plague type II in the Florida Keys in 1995, mortality of *D. stokesi* averaged 26 percent and ranged from 0 to 38 percent (Richardson *et al.,* 1998). The disease routinely caused whole colony mortality within two to three days due to its infection of small coral colonies (usually less than 10 cm in diameter) and aggressive progression rate (up to 2 cm per day; Richardson, 1998). Between 1996 and 1998, out of 160 monitoring stations at 40 sites in the Florida Keys, the number of stations with *D. stokesi* colonies affected by disease increased through time with two stations affected in 1996, 22 in 1997, and 45 in 1998 (Porter *et al.,* 2001). However, no white plague was observed in *D. stokesi* in 2002 at the sites with the reported outbreak in 1995 (Richardson and Voss, 2005).

Disease surveys at St. Croix, U.S. Virgin Islands during the summer of 2001 revealed that *D. stokesi* had the highest prevalence of white plague type II out of seven species infected and the highest disease-related mortality (Kaczmarsky *et al.,* 2005). The prevalence of white plague type II on *D. stokesi* was 41 percent at one location and 60 percent at a second site. Of 107 *D. stokesi* colonies, 38 were infected, and 26 percent of the infected colonies, or 9.4 percent of the sample population, died within two months (Kaczmarsky *et al.,* 2005). After the 2005 bleaching event, 100 percent of monitored *D. stokesi* colonies in the U.S. Virgin Islands were infected with disease in 2006, but none of the colonies experienced total colony mortality (Smith *et al.,* 2013b).

All sources of information are used to describe *D. stokesi's* susceptibility to disease as follows. Although *D. stokesi* is susceptible to several diseases, the most severe impacts have been the result of white plague. Low prevalence of diseased *D. stokesi* colonies have been reported from some locations, but outbreaks of white plague have caused rapid and substantial mortality in some other sites. Outbreaks in Puerto Rico and St. Lucia, while affecting *D. stokesi,* do not appear to have caused as severe mortality as in the Florida Keys and U.S. Virgin Islands. Thus, we conclude that *D. stokesi* has high susceptibility to disease.

The SIR and SRR did not provide any species-specific information on the trophic effects of fishing on *D. stokesi.* The public comments did not provide any new or supplemental information on the trophic effects of fishing on *D. stokesi,* and we did not find any new or supplemental information. However, due to the level of reef fishing conducted in the Caribbean, coupled with *Diadema* die-off and lack of significant recovery, competition with algae can adversely affect coral recruitment. Based on D. *stokesi's* inferred recruitment rates, we conclude that it likely has low susceptibility to trophic effects of fishing.

The SRR and SIR provided the following information on susceptibility of *D. stokesi* to sedimentation. A laboratory study examining oil/sediment rejection indicated that out of 19 Caribbean coral species examined, *D. stokesi* was intermediate in the rate of sediment removal from its tissues. In laboratory experiments, *D. stokesi* exhibited significant increases in respiration after 3 days of exposure to turbidity levels of 28 to 30 NTU, which are within allowable levels as regulated by the State of Florida for coastal construction projects. While light levels and photosynthesis were not affected, after six days of exposure to 14 to 16 NTU of turbidity, gross photosynthesis to respiration ratios were less than one in this species, and excessive mucus production was observed.

The public comments did not provide new or supplemental information on the susceptibility of *D. stokesi* to sedimentation. Supplemental information we found on the susceptibility of *D. stokesi* to sedimentation includes the following. The large calices, number of septa, and calical relief of *D. stokesi* give this species the capability to remove both fine sediment and larger grain sizes through polyp distension (Hubbard and Pocock, 1972).

All sources of information are used to describe *D. stokesi's* susceptibility to sedimentation as follows. *Dichocoenia stokesi* is more tolerant of sedimentation than other coral species as it has the ability to remove both larger grain size and finer sediment. However, prolonged exposure (several days) to turbidity has been shown to cause physiological stress. We conclude that *D. stokesi* has some susceptibility to sedimentation. However, the available information does not support a more precise description of susceptibility.

The SRR and SIR did not provide any species or genus information on the susceptibility of *D. stokesi* to nutrients but provided the following. Land-based sources of pollution (including nutrients) often act in concert rather than individually and are influenced by other biological (*e.g.,* herbivory) and hydrological factors. Collectively, land-based sources of pollution are unlikely to produce extinction at a global scale; however, they may pose significant threats at local scales and reduce the resilience of corals to bleaching.

The public comments did not provide new or supplemental information on the susceptibility of *D. stokesi* to nutrients, and we did not find any new or supplemental information. Based on our knowledge that nutrients in general have a negative effect on corals, we conclude that *D. stokesi* has some level of susceptibility to nutrients, but the available information does not support a more precise description of susceptibility.

The SRR and SIR provided the following information on the susceptibility of *D. stokesi* to predation. *Dichocoenia stokesi* is minimally affected by predation. Sponges such as *Chondrilla nucula* and *Ectoplaysia ferox* can overgrow and cause tissue loss in *D. stokesi,* especially if unchecked by spongivores. *Dichocoenia stokesi* had the highest density of boring bivalves (average 7.5 bivalves per colony) of the three coral species examined.

The public comments provided supplemental information on *D. stokesi's* susceptibility to predation. Predation by *Coralliophila* snails was recorded on 1.8 percent of the 502 *D. stokesi* colonies assessed for condition in 2012 surveys in the Florida Keys (Miller *et al.,* 2013). We did not find any new or supplemental information on the susceptibility of *D. stokesi* to predation.

All sources of information confirm that predation does not appear to significantly affect *D. stokesi.* Thus, we conclude that *D. stokesi* has low susceptibility to predation.

The SRR and SIR provided the following information on the susceptibility of *D. stokesi* to collection and trade. Collection and trade are not considered a threat to *D. stokesi.* The public comments did not provide new or supplemental information. Supplemental information we found on collection and trade includes the following. Collection and trade of *D. stokesi* appear to be low and primarily for scientific purposes. Gross exports between 2000 and 2012 averaged 35 corals per year (data available at *http://trade.cites.org*). Thus, we conclude that *D. stokesi* has low susceptibility to collection and trade.

The SRR and SIR did not provide species-specific information on the effects of sea level rise on *D. stokesi.* The SRR described sea level rise as an overall low to medium threat for all coral species. The public comments did not provide new or supplemental information on *D. stokesi*'s susceptibility to sea level rise, and we did not find any new or supplemental information. Thus, we conclude that *D. stokesi* has some susceptibility to sea level rise, but the available information does not provide a more precise description of susceptibility.

Regulatory Mechanisms

In the proposed rule, we relied on information from the Final Management Report for evaluating the existing regulatory mechanisms for controlling threats to all corals. However, we did not provide any species-specific information on the regulatory mechanism or conservation efforts for *D. stokesi.* Public comments were critical of that approach, and we therefore attempt to analyze regulatory mechanisms and conservation efforts on a species basis, where possible, in this final rule. Records confirm that *Dichocoenia stokesi* occurs in nine Atlantic ecoregions that encompass 26 kingdom's and countries' EEZs. The 26 kingdoms and countries are Antigua & Barbuda, Bahamas, Barbados, Belize, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, French Antilles, Grenada, Guatemala, Haiti, Kingdom of the Netherlands, Honduras, Jamaica, Mexico, Nicaragua, Panama, St. Kitts & Nevis, St. Lucia, St. Vincent & Grenadines, Trinidad and Tobago, United Kingdom (British Overseas Territories), United States (including U.S. Caribbean Territories), and Venezuela. The regulatory mechanisms relevant to *D. stokesi,* described first as a percentage of the above countries and kingdoms that utilize them to any degree, and second as the percentages of those countries and kingdoms whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (31 percent with 12 percent limited in scope), coral collection (50 percent with 27 percent limited in scope), pollution control (31 percent with 15 percent limited in scope), fishing regulations on reefs (73 percent with 50 percent limited in scope), managing areas for protection and conservation (88 percent with 31 percent limited in scope). The most common regulatory mechanisms in place for *D. stokesi* are reef-fish fishing regulations and area management for protection and conservation. However, half of the reef-fish fishing regulations are limited in scope and may not provide substantial protection for the species. General coral protection and collection laws, along with pollution control laws, are much less common regulatory mechanisms for the management of *D. stokesi.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic traits, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that the factors that increase the potential extinction risk for *D. stokesi* include documented population-level impacts from disease. Factors that reduce potential extinction risk are relatively high abundance and persistence across many habitat types, including nearshore and mesophotic reefs. Residency in a wide range of habitat types suggests the species has a wide tolerance to environmental conditions and, therefore, better capacity to deal with changing environmental regimes.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species' abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *D. stokesi,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Although it is geographically located in the heavily disturbed Caribbean, *D. stokesi* occurs in a wide range of habitats, including mesophotic reefs, back- and fore-reef environments, rocky reefs, lagoons, spur-and-groove formations, channels, and occasionally at the base of reefs. This distribution in a wide range of environments suggests the species will be better able to withstand changing environmental conditions and moderates vulnerability to extinction over the foreseeable future because the numerous types of reef environments in which the species occurs are predicted, on local and regional scales, to experience highly variable thermal regimes and ocean chemistry at any given point in time. It has been reported in water depths ranging from 2 to 72 m. Deeper areas of *D. stokesi*'s range will usually have lower temperatures than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. The species is highly susceptible to disease, and outbreaks have resulted in high colony mortality in some locations in its range. However, *D. stokesi*'s abundance has been estimated as at least tens of millions of colonies in both the Florida Keys and Dry Tortugas and is higher than the estimate from these two locations due to the occurrence of the species in many other areas throughout its range. Additionally, sexual recruitment, as evidenced by presence of juvenile colonies, is comparatively higher than many other Caribbean coral species, enhancing recovery potential from mortality events, thus moderating vulnerability to extinction. The combination of wide habitat occupancy, abundance, life history characteristics, and depth distribution, combined with spatial variability in ocean warming and acidification across the species' range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform, and there will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule, using the determination tool formula approach, *D. stokesi* was proposed for listing as threatened because of: High vulnerability to disease (C); moderate vulnerability to ocean warming (E) and acidification (E); moderate overall distribution (based on narrow geographic distribution and wide depth distribution (E); restriction to the

Caribbean (E); and inadequacy of regulatory mechanisms (D).

In this final rule, we changed the listing determination for *D. stokesi* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *D. stokesi*'s spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to be likely to become endangered throughout its range within the foreseeable future, and thus it is not warranted for listing at this time because:

(1) *Dichocoenia stokesi*'s distribution in depths of two to 72 m in heterogeneous habitats, including mesophotic reefs, back- and fore-reef environments, rocky reefs, lagoons, spur-and-groove formations, channels, and occasionally at the base of reefs, throughout the Caribbean basin reduces exposure to any given threat event or adverse condition that does not occur uniformly throughout the species' range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future;

(2) *Dichocoenia stokesi* is usually reported in the top ten most abundant coral species in the Caribbean, and its total absolute abundance is at least tens of millions of colonies based on estimates from two locations. Absolute abundance is higher than estimates from these locations since *it* occurs in many other locations throughout its range. This provides buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response;

(3) *Dichocoenia stokesi* occurs in most reef habitats, including mesophotic reefs, back- and fore-reef environments, rocky reefs, lagoons, spur-and-groove formations, channels, and occasionally at the base of reefs, indicating wide tolerance of environmental conditions and better capacity to deal with changing environmental regimes; and

(4) Presence of juvenile *D. stokesi* colonies indicates that recruitment is likely occurring, enhancing recovery potential from mortality events.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. This species' extinction risk may increase in the future if global threats continue and worsen in severity and the species' exposure to the threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, *D. stokesi* is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *D. stokesi* is not warranted for listing at this time under any of the listing factors, and we withdraw our proposal to list the species as threatened.

Genus Orbicella (formerly Montastraea)

Introduction

The SRR and SIR provided the following information on the taxonomy and morphology of the genus *Montastraea*. The genus *Montastraea* contained four Caribbean species: *M. cavernosa, M. annularis, M. faveolata,* and *M. franksi.* Prior to the 1990s, *M. annularis, M. faveolata,* and *M. franksi* were considered one species, *M. annularis.* However, *M. annularis* was broken into the three sibling species based on behavioral, biochemical, and morphological criteria. These three species are often grouped into the *M. annularis* species complex. Subsequent reproductive and genetic studies have generally supported the partitioning of the complex into three species. *Montastraea faveolata* is the most genetically distinct while *M. annularis* and *M. franksi* are less so.

The public comments provided the following new information on *Montastraea*'s taxonomy. In 2012, the genus *Montastraea* was split, and *M. annularis, M. faveolata,* and *M. franksi* were assigned to the genus *Orbicella* (Budd *et al.,* 2012). From this point forward, we will refer to the genus and species by their current taxonomic classification in the genus *Orbicella.* We did not find any new or supplemental information on *Orbicella*'s taxonomy or morphology.

Some studies report on the species complex rather than individual species since visual distinction can be difficult from video or photographic surveys or in small colonies where morphology is more difficult to discern. This section will report information on the species complex and on *O. annularis* from studies pre-dating 1994 when the species was split into three nominal species.

Spatial Information

The SRR and SIR provide the following information on *Orbicella*'s distribution, habitat, and depth range. The species complex has been found at depths to 90 m. It is dominant on mesophotic reefs in Puerto Rico and the U.S. Virgin Islands at depths of 30 to 45 m, and it is found at depths up to 70 to 90 m in these locations.

The public comments did not provide new or supplemental information on *Orbicella*'s distribution, habitat, or depth range. Supplemental information we found on *Orbicella's* depth range includes the following. All three species occupy a large depth range. Although there is depth overlap in species occurrence, there is larger variance and overlap in species abundances in shallow versus deep water (Pandolfi and Budd, 2008). *Orbicella faveolata* tends to have the shallowest depth distribution, and *O. franksi* tends to have the deepest (Pandolfi and Budd, 2008; Weil and Knowlton, 1994). At three study sites in Belize, *O. faveolata* was the most abundant member of the species complex between 2 and 5 m depth; *O. annularis* was the most abundant at depths of 10 to 15 m, and *O. franksi* was the most abundant at depths of 20 to 30 m (Pandolfi and Budd, 2008). *Orbicella annularis* species complex can be relatively abundant at mesophotic depths in the Bahamas, Belize, Jamaica, Puerto Rico, U.S. Virgin Islands, and Curacao (Kahng *et al.,* 2010).

Demographic Information

The SRR and SIR provided the following information on abundance and population trends of the *Orbicella annularis* species complex. The species complex has historically been a dominant component on Caribbean coral reefs, characterizing the so-called ''buttress zone'' and ''annularis zone'' in the classical descriptions of Caribbean reefs. The species complex is the major reef-builder in the greater Caribbean, since the die-off of *Acropora* spp., due to their large size and high abundance.

Numerous examples of population decline of the *Orbicella annularis* species complex were described, and the results are summarized as follows. Decline in the Florida Keys between the late 1970s and 2003 was approximately 80 to 95 percent, with further losses during the 2012 cold weather event. Decadal-scale declines across the remote islands of Navassa, Mona, and Desecheo in the central Caribbean impacted 85 percent of colonies found there. In the U.S. Caribbean (U.S. Virgin Islands and Puerto Rico), an 80 to 90 percent decline has been reported over the past two decades. Percent cover was reportedly stable in Curacao in the mid-1970s, an 85 percent increase in partial mortality occurred between 1998 and 2005. Between 1975 and 1998 at Glovers Reef in Belize, a 38 to 75 percent decline in relative cover occurred with a further 40 percent decline since. Colonies in Colombia were stable between 1998 and 2003 although demographic changes imply some degree of decline. Surveys of population structure across five countries found a significant increase in small ramets (tissue isolates that are genetically identical but physiologically separate from the parent colony) less than 500 cm^2 (211 percent for *O. annularis,* 168 percent for *O. faveolata,* 137 percent for *O. franksi*), while the proportion of large (1,500- 30,000 cm^2), completely live colonies declined by 51 to 57 percent.

The public comments did not provide new or supplemental information on *Orbicella*'s abundance and population trends. Supplemental information we found on *Orbicella*'s abundance and population trends is provided as follows. In a survey of 185 sites in five countries (Bahamas, Bonaire, Cayman Islands, Puerto Rico, and St. Kitts and Nevis) between 2010 and 2011, *Orbicella annularis* species complex exhibited mean tissue mortality of 29 to 66 percent, which was higher than other species exhibiting mean 8 to 17 percent tissue mortality. Total mortality of *O. annularis* species complex were observed (five to seven percent of the total); however mortality of large colonies mostly resulted in multiple smaller ramets Mortality was attributed primarily to outbreaks of white plague and yellow band disease, which emerged as corals began recovering from mass bleaching events. This was followed by increased predation and removal of live tissue by damselfish to cultivate algal lawns (Bruckner, 2012a).

In 1998 *O. annularis* species complex covered more of the benthos than any other coral taxon at nine monitored sites off Mona and Desecheo Islands, Puerto Rico: 47 percent on reefs off Desecheo Island and 32 percent off Mona Island. In 2008 live cover of *O. annularis* species complex ranged from 0 to 14 percent with 95 percent decline off Desecheo Island and 78 percent decline off Mona Island. This was accompanied with large changes in the size frequency distribution and extent of partial mortality, with size structure remaining constant. The amount of living tissue declined by 55 percent due to partial mortality affecting medium and large colonies, with an increase in the number of colonies with small (less than 10 cm diameter) tissue remnants. Sponges and macroalgae colonized newly exposed area, and sponges appeared to be preventing re-sheeting of tissue remnants. No *Orbicella* spp. recruits were observed during the ten year study (Bruckner and Hill, 2009).

Surveys at three reefs in western Curacao in 1998 found 46 percent of all corals were *O. annularis* species complex. In 2005, *O. annularis* species complex remained the dominant coral species but declined in abundance to 38 percent of the overall coral population (decreases in abundance occurred in *O. faveolata* and *O. annularis,* but not *O. franksi*). In 1998 mean diameter of *O. annularis* species complex colonies were 62 cm and less than 10 percent of all *O. annularis* species complex colonies were less than 30 cm in diameter. Partial mortality of *O. annularis* species complex increased 85 percent between 1997 and 2005 with losses of *O. annularis* and *O. faveolata* (partial mortality 42 to 48 percent and total mortality 6 percent for the two species combined) larger than *O. franksi.* The most significant losses were due to yellow band disease and white plague. No recruits of *O. annularis* species complex were observed between 1997 and 2005 in transects or on skeletons of tagged colonies exposed through mortality from disease (Bruckner and Bruckner, 2006a).

McClanahan and Muthiga (1998) surveyed 20 patch reefs in Glovers Reef atoll off Belize between 1996 and 1997 and compared their results to surveys of 16 patch reefs in the same general area conducted between 1970 and 1971. They found that *O. annularis* species complex experienced an overall 62 percent decrease in cover. Average cover of *O. annularis* species complex was seven percent in 1996 and 1997.

The *O. annularis* species complex often makes up the largest proportion of coral cover on Caribbean reefs. In surveys conducted on four reefs in Biscayne National Park, Florida in 1981, cover of *O. annularis* species complex ranged between approximately 25 and 50 percent on three of the reefs, and no *O. annularis* species complex colonies were observed in transects on the fourth reef (Burns, 1985). In stratified random surveys in 2007–2008, *O. annularis* species complex was the dominant coral by percent cover in the Red Hind Marine Conservation District off St. Thomas, U.S. Virgin Islands, at depths of 34 to 47 m. *Orbicella annularis* species complex averaged 15 percent cover (range zero to 48 percent) and made up 92 percent of the 25 percent average coral cover (Nemeth *et al.,* 2008).

In a survey of 185 sites in five countries (Bahamas, Bonaire, Cayman Islands, Puerto Rico, and St. Kitts and Nevis) in 2010 to 2011, density of *O. annularis* species complex ranged from 0.3 to 2.7 colonies per m^2 and comprised between 9 and 30 percent of all corals greater than 4 cm diameter. The mean diameter ranged from 44 to 89 cm, and the size structure (planar surface area) had a bell shaped distribution, with only a few colonies less than 500 cm^2 or greater than 10,000 cm^2 (Bruckner, 2012a).

In surveys of juvenile corals (less than 4 cm diameter) on nine reefs in the Florida Keys between 1993 and 1994, density of *O. annularis* species complex ranged between 0.02 and 0.04 juvenile corals per m^2 on six of the nine reefs. Density of *O. annularis* species complex juveniles was correlated with non-juvenile *O. annularis* species complex density and with depth. The majority of non-juveniles were smaller than the reproductive size of 100 cm^2 (Chiappone and Sullivan, 1996).

Surveys in Bonaire in 2008 showed that the *O. annularis* species complex dominated coral cover in depths less than 20 m and cover was similar to that reported in 1982. However, all sites surveyed in 2008 showed signs of disease and partial mortality in a large number of the massive colonies, and many were reduced to a patchwork of live tissue and dead areas colonized by algae (Stokes *et al.,* 2010).

At 25 sites surveyed in Bonaire in 2011, *O. annularis* species complex was the dominant coral taxa occupying approximately 20 to 25 percent of the benthos and making up 46 percent of the total live coral cover. It was dominant in terms of abundance, making up approximately 27 percent of all corals. *Orbicella annularis* was significantly more abundant than *O. franksi* and *O. faveolata* on the northern reefs but not on southern reefs. Most colonies were between 30 and 80 cm diameter with size structure of *O. annularis* species complex in a bell shaped distribution around this range; there were few colonies less than 20 cm and few very large colonies greater than 200 cm, with a small peak at the 150 to 199 cm range. There was a notable absence of colonies less than 10 cm diameter (as measured by the skeleton, not live tissue) and an absence of recruits. A total of 73 out of 1602 colonies (4.5 percent) had completely died. Surviving colonies (n=1529) had a mean of 28 percent partial mortality. On average, each colony was divided into 6.6 tissue remnants. Several sites contained a high abundance of large, unblemished *O. annularis* species complex colonies (Bruckner, 2012c).

Between 1999 and 2009, overall cover of *O. annularis* species complex in the Florida Keys declined, but differed by habitat type (Ruzicka *et al.,* 2013). Percent cover declined on the deep and shallow fore-reefs but remained stable on patch reefs (Ruzicka *et al.,* 2013). The 2010 cold-water event reduced cover of *O. annularis* species complex from 4.4 percent to 0.6 percent on four patch reefs in the upper and middle Florida Keys. Greater than 50 percent of *O. annularis* species complex colonies across all size classes suffered lethal or severe mortality, and 93 percent of all *O. annularis* species complex colonies surveyed suffered complete or partial mortality. The species complex suffered the highest mortality of all coral species affected (Colella *et al.,* 2012). A comparison of 1995 and 2005 surveys of *O. annularis* species complex at 13 patch reefs in the Florida Keys reported ten sites had between 5 and 40 percent more dead areas (Gischler, 2007).

Density of juvenile *O. annularis* species complex increased from 0.07 juveniles per m^2 prior to 2008, to 0.15 juveniles per m^2 and continued at 0.12 juveniles per m^2 in 2009 at 4 km area on the south side of St. John, U.S. Virgin Islands that has been monitored for 16 years. These densities were driven by seven to nine colonies per year, and the increased density did not extend outside the initial survey area when expanded to other areas around St. John. While not possible to distinguish the species in the field, the authors conclude juveniles were most likely *O. annularis* due to the abundance of *O. annularis* on adjacent reefs and the rarity of the presence of the other two species in water less than 9 m (Edmunds *et al.,* 2011).

At Yawzi Point, St. John, U.S. Virgin Islands, the percentage of total coral cover declined by more than 50 percent between 1987 to 1998, from 45 percent to 20 percent. In 1988, 94 percent of the coral cover at Yawzi was *O. annularis* species complex mostly *O. annularis* (97 percent), with a few colonies of *O. faveolata (6 percent).* Despite a reduction in total cover, *O. annularis* species complex remained spatially dominant in 1998 at 96 percent of the coral cover (Edmunds, 2002). Coral cover at this site again declined an additional 65 percent between 1999 and 2011 to seven percent cover, with *O. annularis* species complex remaining dominant at 77 percent of the coral cover (Edmunds, 2013).

At Tektite Reef, St. John, U.S. Virgin Islands, total coral cover increased from 32 percent in 1987 to 43 percent in 1998 but then decreased to 29 percent in 2011 (Edmunds, 2002; Edmunds, 2013). In 1988, 79 percent of the species complex was *O. annularis,* with lesser amounts of *O. faveolata* (one percent) and *O. franksi* (21 percent) (Edmunds, 2002). Greater than 72 percent of coral was *O. annularis* species complex in all survey years (Edmunds, 2013).

Surveys of the Flower Garden Banks between 1974 and 1980 found cover of *O. annularis* species complex between approximately 23 and 40 percent in areas less than 36 m depth (Bright *et al.,* 1984). *Orbicella annularis* species complex was the dominant coral between 2002 and 2003 at 32 percent cover (Aronson *et al.,* 2005). In random surveys between 2002 and 2006, *O. annularis* species complex (predominantly *O. franksi*) was the dominant coral in the Flower Garden Banks comprising between 27 and 40 percent benthic cover (Hickerson *et al.,* 2008). In permanent photo quadrats (8 m^2 total), cover of *O. annularis* species complex (as measured by planar surface area of individual colonies) fluctuated between approximately 20 and 45 percent cover in the East Flower Gardens between 1992 and 2006 with periods of sharp increase and decrease in cover (Hickerson *et al.,* 2008). Cover in west Flower Gardens was between 22 and 40 percent over the same time period and had less annual variability and a generally increasing or stable trend through time (Hickerson *et al.,* 2008).

Surveys of five sites in the Mexican Yucatan in 1985 and 2005 revealed a decrease in relative cover of *O. annularis* species complex. At four out of the five sites, cover of *O. annularis* species complex decreased from between approximately 50 and 60 percent in 1985 to between approximately 10 and 25 percent in 2005. The fifth site had a less dramatic decrease in relative cover from approximately 35 percent to 30 percent cover during this 20-year interval. Disease appeared to be the main cause of decline, but hurricanes may have also played a role (Harvell *et al.,* 2007).

Size transition matrices were derived from *Orbicella* growth, mortality, and recruitment rates between 1998 and 2003 from four sites in the lower Florida Keys. Forecasting 15 years into the future predicted a steady decline in all size classes except the smallest (less than 5 cm) due to insufficient recruitment to offset mortality and low growth rates of the smaller size classes. Mortality rates were assumed at approximately 40 percent for the smallest size class declining to about 5 percent for the largest (Smith and Aronson, 2006).

All information on *Orbicella*'s abundance and population trends can be summarized as follows. The *O. annularis* species complex historically dominated fore-reef sites throughout the Caribbean both in abundance and cover and formed dense assemblages of large, hundreds-of-years old colonies and few small colonies (Bruckner, 2012a). However, recent declines in *O. annularis* species complex cover have been reported. Major declines range from approximately 50 to 95 percent in locations including Puerto Rico, Belize, the Florida Keys, Mexico, and the U.S. Virgin Islands, and lower levels of decline (5 to 33 percent) have been reported at individual sites within some of these same locations. There have also been reports of more stable percent cover trends (*e.g.,* Bonaire) and periods of increase (*e.g.,* Flower Garden Banks). Observed declines in total coral cover in the Caribbean, since the major decline of *Acropora* spp. in the 1980s, have often been a result of the decline of the *O. annularis* species complex since the taxa can make up a large proportion of the total coral cover. Despite decreases, the *O. annularis* species complex continues to be reported as the dominant coral taxa, albeit at times its relative dominance has decreased to a lower percentage of the total coral cover (*e.g.,* Curacao, U.S. Virgin Islands).

Other Biological Information

The SRR and SIR provided the following information on *Orbicella* life history. *Orbicella* spp. have growth rates of approximately 1 cm per year, ranging from 0.06 to 1.2 cm per year. They grow more slowly in deeper water and in less clear water. Large colonies have lower total mortality rates than juvenile and small colonies.

All three species of the *O. annularis* complex are hermaphroditic broadcast spawners, with spawning concentrated on six to eight nights following the full moon in late August, September, or early October. *Orbicella faveolata* is largely reproductively incompatible with *O. franksi* and *O. annularis,* and it spawns about one to two hours earlier. Fertilization success measured in the field was generally below 15 percent for all three species being closely linked to the number of colonies concurrently spawning. In Puerto Rico, minimum size at reproduction for the *O. annularis* species complex was 83 cm^2.

Successful recruitment by the *O. annularis* species complex species has seemingly always been rare. Only a single recruit of *Orbicella* was observed over 18 years of intensive observation of 12 m^2 of reef in Discovery Bay, Jamaica. Many other studies throughout the Caribbean also report negligible to absent recruitment of the species complex.

The public comments did not provide new or supplemental information on the life history of *Orbicella.* Supplemental information we found on the life history of *Orbicella* includes the following. *Orbicella franksi* spawns an average of 110 minutes before *O. annularis,* and 120 minutes before *O. faveolata* (Fogarty *et al.,* 2012a). Gametes can disperse over 500 m in 100 minutes, and *O. franksi* sperm viability decreases after two hours (Levitan *et al.,* 2004). *Orbicella franksi* and *O. annularis* gametes are compatible, though other mechanisms associated with the temporal isolation of spawning, including gamete aging, dilution, and dispersal, make hybridization less likely (Knowlton *et al.,* 1997; Levitan *et al.,* 2004). All three species are largely self-incompatible (Knowlton *et al.,* 1997; Szmant *et al.,* 1997). Size at sexual maturity is generally about 200 cm^2 (Szmant-Froelich, 1985). Colonies that were fragmented experimentally to sizes smaller than 100 cm^2 were generally found to have lower fecundity indicating that frequent fragmentation and partial mortality can affect reproductive capacity (Szmant-Froelich 1985).

Smith and Aronson (2006) reported 18 *Orbicella* recruits between 1998 and 2003 in 384 permanent monitoring quadrats (237 m^2) in the lower Florida Keys. The ability of the species complex to dominate with such low recruitment rates has been described as a storage effect whereby large, old colonies are able to persist and maintain the population until favorable conditions for recruitment occur (Edmunds and Elahi, 2007). However, potential problems may exist for species employing storage effects if favorable conditions for recruitment occur so infrequently that they fall outside the life span of the cohort (Foster *et al.,* 2013).

All sources of information are used to summarize *Orbicella*'s life history as follows. *Orbicella* species have slow growth rates, late reproductive maturity, and low recruitment rates. Colonies can grow very large and live for centuries. Large colonies have lower total mortality than small colonies, and partial mortality of large colonies can result in the production of ramets. The historical absence of small colonies and few observed recruits, even though large numbers of gametes are produced on an annual basis, suggests that recruitment events are rare and were less important for the survival of the *O. annularis* species complex in the past (Bruckner, 2012a). Large colonies in the species complex maintain the population until conditions favorable for recruitment occur; however, poor conditions can influence recruitment periodicity. While the life history strategy of the *O. annularis* species complex has allowed the taxa to remain abundant, we conclude that the buffering capacity of this life history strategy has been reduced by recent population declines and partial mortality, particularly in large colonies.

The SRR, SIR, and public comments did not provide other biological information on the *Orbicella annularis* species complex. Supplemental biological information we found on *Orbicella* is provided as follows. The *Orbicella annularis* species complex is sensitive to cold water. In laboratory experiments, *O. annularis* species complex released zooxanthellae when shocked with cold water between 12 and 18 degrees C, and the response decreased with increasing temperature (Muscatine *et al.,* 1991).

Susceptibility to Threats

The SRR and SIR provided the following information on *Orbicella*'s susceptibility to ocean warming. The *Orbicella annularis* species complex is moderately to highly susceptible to bleaching. The composition of zooxanthellae in at least some areas changes in response to bleaching. Bleaching has been shown to prevent reproduction in the following season after recovering normal pigmentation. Particularly well documented mortality following severe mass bleaching in 2005 highlights the immense impact thermal stress events and their aftermath can have on the *Orbicella annularis* species complex. A significant correlation was found between bleaching in 2005 and the prevalence of yellow band disease and white plague affecting the *Orbicella* species complex. Additionally, in laboratory experiments, mortality due to yellow band disease increased with increasing temperatures.

The public comments did not provide new or supplemental information on the susceptibility of *Orbicella* to ocean warming. Supplemental information we found on *Orbicella*'s susceptibility to ocean warming confirms and expands the information in the SRR and SIR. The *O. annularis* species complex often has one of the highest bleaching levels among reported species. Extended recovery times have been reported, and disease outbreaks have often followed bleaching events. On Carysfort Reef in the Florida Keys, greater than 90 percent of *O. annularis* species complex colonies were bleached in March 1988 after the 1987 Caribbean bleaching event; however, no colony mortality was observed between 1986 and 1988 (Fitt *et al.,* 1993). Colonies of the *O. annularis* species complex in the Florida Keys that remained bleached seven months following the 1987 bleaching event experienced reproductive failure during the reproductive season following the bleaching event. Colonies that recovered after bleaching events were able to follow a normal reproductive cycle, but bleached colonies of *O. annularis* species complex were unable to complete gametogenesis (Szmant and Gassman, 1990). Compared to recovered colonies, bleached colonies had lower tissue biomass, lower carbon-to-nitrogen ratios, and reduced growth, indicating the energy reserves needed for successful reproduction were not available (Szmant and Gassman, 1990).

During the 1987 bleaching event, 90 percent of all *O. annularis* species complex colonies surveyed at 30 m in the Cayman Islands were bleached. Bleaching was less severe at 46 m with 14 percent of *O. annularis* species complex colonies bleached. Five months after bleaching was first observed in the Cayman Islands, 54 percent of bleached *O. annularis* species complex colonies had not recovered. *Orbicella annularis* species complex had the slowest recovery of the 28 coral species observed to bleach (Ghiold and Smith, 1990).

In a 1995 bleaching event in Belize, *O. annularis* species complex was the most affected coral taxon with 76 percent of the 2,126 surveyed colonies affected. Seven percent of the 904 colonies surveyed six months after the bleaching event remained bleached. Twenty-six percent of tagged *O. annularis* species complex colonies (n=19) exhibited partial mortality due to bleaching or post-bleaching infection by black band disease (McField, 1999).

In 20 surveys across 302 sites throughout the wider Caribbean, *O.*

annularis species complex and *Agaricia tenuifolia* were the taxa most impacted by the 1998 bleaching event (Ginsburg and Lang, 2003; Kramer, 2003). Subsequent disease outbreaks were also recorded in *O. annularis* and *O. faveolata* off Curaçao, the Cayman Islands, Costa Rica, and some of the Virgin Islands after the bleaching event. Bleaching and disease related mortality heavily impacted the *O. annularis* species complex (Ginsburg and Lang, 2003).

During the 2005 bleaching event, approximately 70 percent of *O. annularis* species complex colonies bleached both in sites less than 10 m in depth and in sites greater than 15 m in depth on the west and southwest coasts of Barbados (Oxenford *et al.,* 2008). Bleaching was observed in 2005 at 86 of 94 sites (91 percent) surveyed in Buck Island Reef, U.S. Virgin Islands. Ninety-four percent of the cover of *O. annularis* species complex bleached (Clark *et al.,* 2009).

The 2005 bleaching event resulted in a 51 percent decrease in the cover of *O. annularis* species complex at five sites in the U.S. Virgin Islands between 2005 and 2007. Bleaching occurred in 16 of the 21 species of coral at the five sites with maximum tissue area bleached between 98 to 99.5 percent for the *O. annularis* species complex. Mortality after the bleaching event occurred primarily from a subsequent regional outbreak of coral disease, predominantly white plague, not the bleaching itself. The highest rate of mortality of the 19 species affected by the white plague was the *Orbicella annularis* species complex with 94.5 percent of disease lesions occurring on *Orbicella annularis* species complex. Total coral cover declined from 21 percent to 10 percent, and species-specific changes in coral cover affected the relative abundance of coral species on the reef. Overall relative abundance of *O. annularis* species complex declined from an initial average of 79 to 59 percent of live coral cover (Miller *et al.,* 2009).

Stratified random surveys on back-reefs and fore-reefs between one and 30 m depth off Puerto Rico (Mona and Desecho Islands, La Parguera, Mayaguez, Boqueron, and Rincon) in 2005 and 2006 revealed bleaching was most severe in *O. annularis* species complex with 94 percent of colonies bleached. After bleaching, a disease outbreak occurred, and *O. annularis* species complex suffered extensive partial and total mortality. Coral cover declined between 40 and 60 percent and was primarily driven by mortality of *O. annularis* species complex. Additionally, the severe tissue loss and prolonged bleaching stress resulted in reproductive collapse of *O. annularis* species complex during the 2006 mass spawning cycle (Waddell and Clarke, 2008).

The 2005 bleaching affected greater than 95 percent of *O. annularis* species complex in Mona and Desecheo Islands, Puerto Rico and was followed by a disease outbreak that both caused extensive mortality (Bruckner and Hill, 2009). A study of 36 sites across six countries (Grenada, Curaçao, Panamá, Puerto Rico, Cayman Islands, and Bermuda) and three depth habitats (less than 4 m, 5 to 12 m, and greater than 15 m) found a significant correlation between the 2005 bleaching and prevalence of yellow band disease and white plague in *O. annularis* species complex (Croquer and Weil, 2009). *Orbicella annularis* species complex bleached at all depths surveyed in Grenada (23 to 52 percent of colonies), Puerto Rico (21 to 40 percent), and Cayman Islands (16 to 44 percent). The species complex did not experience bleaching in Curacao or Bermuda, both locations reported very low bleaching across all genera examined (Croquer and Weil, 2009). Bleaching of *O. annularis* species complex varied by depth in Panama with bleaching occurring in 11 percent of colonies in depths less than 4 m and in15 percent of colonies in depths between 5 and 12 m, but no bleaching occurred in deep depths greater than 15 m (Croquer and Weil, 2009). Smith *et al.* (2013b) described species responses to the 2005 and 2010 bleaching events in St. Thomas, St. Croix, and St. John, U.S. Virgin Islands. The response of the *O. annularis* species complex (mostly *O. faveolata* and *O. franksi* with the likelihood of small numbers of *O. annularis*) to the 2005 bleaching event was high to moderate initial response of bleaching prevalence, high disease prevalence, high mortality, a large decline in coral cover, and increasing or stable colony abundance. Average bleaching was 66 percent, and paling was 27 percent in 2005. Disease prevalence in *O. annularis* complex was 17 percent after the 2005 bleaching event. In the milder 2010 bleaching event, 35 percent of *O. annularis* species complex colonies bleached, and 47 percent of *O. annularis* species complex colonies paled. Less than one percent of *O. annularis* species complex colonies suffered total mortality, but percent cover decreased from seven percent cover of *O. annularis* species complex in 2005 before bleaching to less than three percent in 2007. By 2010, there was a slight increase in percent cover to about four percent. *Orbicella annularis* species complex lost a large proportion of colonies in the largest size class and showed a significant increase in colony abundance, likely due to the increase in abundance of colonies in smaller size classes resulting from partial mortality of larger colonies.

Van Woesik *et al.* (2012) developed a coral resiliency index based on biological traits and processes to evaluate extinction risk due to bleaching. Evaluations were performed at the genus level, but genera were separated between the Caribbean and Indo-Pacific. They rated the resilience score for the *O. annularis* species complex as four out of a range of -6 to 7 observed in other coral genera. Less than or equal to -3 was considered highly vulnerable to extinction, and greater than or equal to 4 was considered highly tolerant. Thus, *O. annularis* species complex was rated as highly tolerant. However, Smith *et al.* (2013b) concluded that large faviids, such as the *O. annularis* species complex, seem very susceptible to long-term population declines because of their poor response to stress response when bleaching, disease, and mortality were considered. The *O. annularis* species complex was found to be likely less equipped to recovery after bleaching because they tend to grow slowly, have lower fecundity, and are more susceptible to mortality when small (Smith *et al.,* 2013b). While the van Woesik *et al.* (2012) study was in the SIR, the findings specific to *Orbicella* were not included. The public comments indicated the results of this study should be considered in the listing status of the three species in the *Orbicella* species complex.

All sources of information are used to describe *Orbicella*'s susceptibility to ocean warming as follows. The *O. annularis* species complex is highly susceptible to ocean warming. Bleaching often occurs in 76 to 94 percent of *O. annularis* species complex colonies during bleaching events, and *Orbicella* spp. are one of the taxa most affected by high temperatures. Colonies in deeper water have been reported to bleach less severely. Recovery from bleaching can take longer for the species complex than for other coral species, and prolonged stress from bleaching has been cited as a possible reason for reproductive failure following bleaching events. Mortality from temperature anomalies is often due to subsequent disease outbreaks. Thus, we conclude that the *O. annularis* species complex is highly susceptible to ocean warming.

The SRR and SIR provided the following information on *Orbicella*'s susceptibility to acidification. The only study conducted regarding the impact of acidification on this genus is a field study that did not find any change in *O. faveolata* calcification in field-sampled colonies from the Florida Keys up through 1996. Preliminary experiments testing effects of acidification on fertilization and settlement success of *O. annularis* species complex show results that are consistent with the significant impairments demonstrated for *A. palmata*.

The public comments did not provide new or supplemental information on the susceptibility of the *Orbicella* species complex to acidification. Supplemental information we found on the susceptibility of the *Orbicella* species complex to acidification includes the following. In laboratory experiments, reproduction of *O. faveolata* was negatively impacted by increasing carbon dioxide, and impairment of fertilization was exacerbated at lower sperm concentrations (Albright, 2011b). Fertilization success was reduced by 25 percent at 529 µatm (43 percent fertilization) and 40 percent at 712 µatm (34 percent fertilization) compared to controls at 435 µatm (57 percent fertilization; Albright, 2011a). Additionally, growth rate of *O. faveolata* was reduced under lower pH conditions (7.6) compared to higher pH conditions (8.1) after 120 days of exposure (Hall *et al.,* 2012).

All sources of information are used to describe *Orbicella*'s susceptibility to acidification as follows. Laboratory studies indicate that *Orbicella* is susceptible to ocean acidification both through reduced fertilization of gametes and reduced growth of colonies. Thus, we conclude that the *Orbicella* species complex is highly susceptible to ocean acidification.

The SRR and SIR provided the following information on *Orbicella*'s susceptibility to disease. White plague and yellow band (also called yellow blotch) disease have caused profound population decline of the *Orbicella annularis* species complex both with and without prior bleaching.

The public comments did not provide new or supplemental information on the susceptibility of *Orbicella* spp. to disease. Supplemental information we found on *Orbicella*'s susceptibility to disease confirms and expands the information in the SRR and SIR. *Orbicella* spp. are susceptible to black band disease and dark spot syndrome (Alcolado *et al.,* 2010). Additionally, an unknown disease was observed in the Red Hind Marine Conservation District in the U.S. Virgin Islands and affected 39 percent of *O. annularis* species complex colonies (Smith *et al.,* 2010). White plague is one of the most aggressive coral diseases in the Caribbean with progression rates of 1 to 10 cm per day (Bruckner and Hill, 2009). Tissue loss from yellow band disease is slow, averaging 0.5 to 1 cm per month, though tissue loss can be significant over the long term since colonies can remain infected for years and can have multiple lesions per colony (Bruckner and Bruckner, 2006b).

In the Florida Keys, the prevalence of white plague increased between 1996 and 2002. No *O. annularis* species complex colonies with white plague were reported within monitoring stations in 1996, but infected colonies appeared in 32 stations in 2002 (Waddell, 2005). *Orbicella annularis* species complex had the highest prevalence (up to 12 percent) of the 21 species affected by white plague in Puerto Rico between 1998 and 2008 (Bruckner and Hill, 2009). In Mexico, *O. annularis* species complex had the highest disease prevalence in surveys during 2004 (27 percent, Ward *et al.,* 2006). Surveys in four locations (Netherlands Antilles, Grenada, Turks and Caicos, and U.S. Virgin Islands) between 1997 and 1998 revealed that prevalence of yellow band in *O. annularis* species complex ranged from 18 to 91 percent.

Tagged colonies with yellow band disease in Puerto Rico lost an average of 32 percent of their tissue over four years, and the percent of partial mortality appeared to increase with colony size (Bruckner and Bruckner, 2006b). Eight percent of infected colonies died completely (most were 50 cm or less in size), and larger colonies lost between 60 and 85 percent of their tissue (Bruckner and Bruckner, 2006b). Eighty-five percent of colonies with yellow band disease tagged in 1999 still had active signs of the disease in 2003 (Bruckner and Bruckner, 2006b). In 1999, yellow band disease affected up to 50 percent of all *O. annularis* species complex colonies at permanent sites in Puerto Rico, including many of the largest (2 to 3 m diameter and height) and presumably oldest colonies (Waddell and Clarke, 2008).

In Curacao, yellow band disease affected from three to 49 percent of all *O. annularis* species complex colonies within transects conducted on western reefs between 1997 and 2005. The highest prevalence of yellow band disease occurred in 1997 and 1998. Thirty-one to 49 percent of *O. annularis* species complex colonies were affected in eastern Curacao, and 24 percent were affected in western Curacao. The numbers of new infections declined from 2000 to 2005. Yellow band disease affected larger corals more frequently than small corals. Over 21 percent of the colonies tagged with yellow band disease between 1997 and 1999 were still infected in 2005. Of the remainder, 44 percent died, 2 percent were affected by other diseases, and 32 percent no longer had signs of yellow band disease but had large amounts (most greater than 90 percent) of partial mortality (Bruckner and Bruckner, 2006a).

Disease prevalence in *O. annularis* species complex (*O. annularis* and *O. faveolata*) at three reefs off Mexico increased from between zero and four percent in 1996 and 1998 to between 26 and 37 percent in 2001. The increase was due to the proliferation of yellow band disease, though black band disease and white plague were also present. Partial mortality also increased over this same period from 20 to 35 percent of *O. annularis* species complex colonies at one site and from 35 to 52 percent at another (Jordan-Dahlgren *et al.,* 2005).

At 253 sites surveyed in 2009 in St. Croix and St. John, U.S. Virgin Islands and La Parguera, Puerto Rico, the average number of healthy *O. annularis* species complex colonies was 182 (± 33 SE) per 100 m^2. Yellow band was present on an average of about one percent of colonies (Muller and van Woesik, 2012).

All sources of information are used to describe *Orbicella*'s susceptibility to disease as follows. Disease can affect a large proportion of the *Orbicella* spp. population (3 to 91 percent), particularly during outbreaks following bleaching events, and can cause extensive mortality. Partial mortality can be high (32 to greater than 90 percent) and can result in multiple ramets. White plague and yellow band disease have had the greatest effect and can disproportionately affect larger colonies in the species complex. Total colony mortality is less likely for larger colonies than for smaller colonies, and partial mortality can lead to changes in colony size distribution as observed in Puerto Rico, U.S. Virgin Islands, and a study in Bahamas, Bonaire, Cayman Islands, and St. Kitts and Nevis. Thus, we conclude that the *O. annularis* species complex is highly susceptible to disease.

The SIR and SRR did not provide any information on the trophic effects of fishing on *Orbicella*. The public comments did not provide new or supplemental information, and we did not find new or supplemental information on the trophic effects of fishing on *Orbicella*. However, as described above in Caribbean Genera and Species—Introduction, due to the level of reef fishing conducted in the Caribbean, coupled with *Diadema* die-off and lack of significant recovery, competition with algae can adversely affect coral recruitment. This effect coupled with *Orbicella*'s low recruitment rate indicates it likely has some susceptibility to the trophic effects of fishing. The available information does not support a more precise description of its susceptibility.

The SRR and SIR provided the following information on the susceptibility of *Orbicella* to sedimentation. *Orbicella* has shown a decline in growth at sediment impacted sites in Puerto Rico and during periods of construction in Aruba. Along a gradient of continental influence in the southern Gulf of Mexico, density and calcification rate of *O. annularis* decreased with increasing turbidity and sedimentation while extension rate increased with increasing turbidity and sedimentation.

The public comments did not provide new or supplemental information on the susceptibility of *Orbicella* to sedimentation. Supplemental information we found on the susceptibility of the *Orbicella annularis* species complex confirms the information in the SRR and SIR. The *Orbicella annularis* species complex appears to be moderately capable of removing sediment from the colony surface. Colonies receiving single applications of 200 or 400 mg sediment per cm^2 showed no evidence of damage while 800 mg per cm^2 caused mortality (Rogers, 1983). Sedimentation has been found to negatively affect *O. annularis* species complex primary production, growth rates, and abundance (Pastorok and Bilyard, 1985). An observed difference in average colony size at two sites in Puerto Rico led Loya (1976) to conclude turbidity negatively affects growth of *O. annularis* species complex since colony size was half as large at the sediment-impacted site (23 cm versus 9 cm).

All sources of information are used to describe *Orbicella*'s susceptibility to sedimentation as follows. Although the species complex is moderately capable of removing sediment from the colony surface, sedimentation negatively affects primary production, growth rates, calcification, colony size, and abundance. Thus, we conclude that the *O. annularis* species complex is highly susceptible to sedimentation.

The SRR and SIR provided the following information on the susceptibility of *Orbicella* to nutrient enrichment. *Orbicella* had an increasing growth rate with improving environmental conditions in Barbados. Additionally, decreasing growth rate of *Orbicella* over a 30-year period was attributed to deterioration of water quality.

The public comments did not provide new or supplemental information on the susceptibility of *Orbicella* to nutrient enrichment. Supplemental information we found on the susceptibility of the *Orbicella* species complex confirms and expands the information in the SRR and SIR. Two growth forms of *O. annularis* species complex, columnar (likely *O. faveolata*) and lobate (likely *O. annularis*) were found to have increasing average growth rates with improving environmental conditions away from a eutrophication gradient in Barbados (Tomascik, 1990). Although nutrient concentration was negatively correlated with growth, suspended particulate matter resulting from eutrophication, rather than the nutrients themselves, was postulated to be the cause of observed decreased growth rates (Tomascik and Sander, 1985). A general pattern of decreasing growth rates of the columnar growth form between 1950 and 1983 may be directly related to the deterioration of water quality along the west coast of the island (Tomascik, 1990). Additionally, *Orbicella* spp. did not recruit to settlement plates on the most eutrophic reef, and recruitment of *Orbicella* spp. increased at sites with decreasing eutrophication along the eutrophication gradient (Tomascik, 1991). Field experiments indicate that nutrient enrichment significantly increases yellow band disease severity in *O. annularis* and *O. franksi* through increased tissue loss (Bruno *et al.,* 2003).

All sources of information are used to describe *Orbicella*'s susceptibility to nutrient enrichment as follows. The *Orbicella annularis* species complex is susceptible to nutrient enrichment through reduced growth rates, lowered recruitment, and increased disease severity. Thus, we conclude that the *O. annularis* species complex is highly susceptible to nutrient enrichment.

The SRR and SIR provided the following information on the susceptibility of *Orbicella* to predation. Predators of the *O. annularis* species complex include the corallivorous snail *Coralliophila abbreviata* and some species of parrotfish including *Sparisoma viride* and *S. aurofrenatum*. Additionally, damselfish remove live coral tissue to build algal gardens. The large decline of *Acropora* spp. in the Caribbean, likely resulted in greater impacts by damselfishes on other high-dimension corals, including the *O. annularis* species complex.

Public comments did not provide new or supplemental information on the susceptibility of *Orbicella* to predation. Supplemental information we found on the susceptibility of the *Orbicella* species complex includes the following. Surveys of six sites in Navassa found between zero and 33 percent of *O. annularis* species complex colonies (average 17 percent across all sites) were affected by *C. abbreviata* (Miller *et al.,* 2005). The *O. annularis* species complex was the preferred target of parrotfish across all reef habitats in a study on the Belize barrier reef. Incidence of parrotfish grazing was highest on *O. annularis* (over 55 percent of colonies), followed by *O. franksi* and *O. faveolata,* respectively (Rotjan, 2007). In most habitats, a few colonies of *Orbicella* spp. were more heavily grazed by parrotfishes, while the majority showed little or no parrotfish grazing (Rotjan and Lewis, 2006).

All sources of information are used to describe *Orbicella*'s susceptibility to predation as follows. The *O. annularis* species complex is susceptible to several predators. Current effects of predation appear to be low. Thus, we conclude the *O. annularis* species complex has low susceptibility to predation.

The SRR and SIR did not provide information on the effects of sea level rise on *Orbicella*. The SRR described sea level rise as an overall low to medium threat for all coral species. The public comments did not provide new or supplemental information on *Orbicella*'s susceptibility to sea level rise, and we did not find any new or supplemental information. Thus, we conclude that *Orbicella* has some susceptibility to sea level rise, but the available information does not support a more precise description of susceptibility to this threat.

The SRR and SIR provided the following information on the susceptibility of the *Orbicella* species complex to collection and trade. The *Orbicella* complex species have a very low occurrence in the CITES trade databases. Hence, collection and trade is not considered a significant threat to the *Orbicella annularis* complex species. The public comments did not provide new or supplemental information on the susceptibility of the *Orbicella* species complex to trade. Supplemental information we found on the susceptibility of species in the *Orbicella* complex to collection and trade is described in each of the individual species sections.

Genus Conclusion

The *O. annularis* species complex is distributed throughout the Caribbean and occupies a variety of habitats across a large depth range, including mesophotic depths to 90 m. Over the last twenty years, major declines of approximately 50 to 95 percent have occurred. In addition, changes in size frequency distribution have sometimes accompanied decreases in cover, resulting in fewer large colonies that impact the buffering capacity of the species complex's life history strategy. Despite decline, the *O. annularis* species complex continues to be reported as the dominant coral taxon, sometimes at a lower percentage of the total coral cover.

The species complex has highly susceptibility to ocean warming, acidification, disease, sedimentation, and nutrients; some susceptibility to trophic effects of fishing and sea level rise; and low susceptibility to predation. Susceptibility to collection and trade is described in each of the individual species sections.

Orbicella faveolata

Introduction

The SRR and SIR provided the following information on *O. faveolata*'s morphology. *Orbicella faveolata* grows in heads or sheets, the surface of which may be smooth or have keels or bumps. The skeleton is much less dense than in the other two *Orbicella* species. Colony diameter can reach up to 10 m with a height of 4 to 5 m. The public comments did not provide new or supplemental information on *O. faveolata*'s morphology, and we did not find any new or supplemental information.

Spatial Information

The SRR and SIR provided the following information on the distribution, habitat and depth range of *O. faveolata. Orbicella faveolata* occurs in the western Atlantic and throughout the Caribbean, including Bahamas, Flower Garden Banks, and the entire Caribbean coastline. There is conflicting information on whether or not it occurs in Bermuda. *Orbicella faveolata* has been reported in most reef habitats and is often the most abundant coral between 10 and 20 m in fore-reef environments. The depth range of *O. faveolata* has been reported as 0.5 to 40 m, though the species complex has been reported to depths of 90 m, indicating *O. faveolata's* depth distribution is likely deeper than 40 m. *Orbicella* species are a common, often dominant component of Caribbean mesophotic reefs, suggesting the potential for deep refugia for *O. faveolata.*

The public comments did not provide new or supplemental information on *O. faveolata's* distribution, habitat, or depth range. Supplemental information we found includes the following. Veron (2014) confirmed the occurrence of *O. faveolata* in five out of his 11 ecoregions in the west Atlantic and greater Caribbean known to contain corals and strongly predicted its presence in an additional three ecoregions (off Colombia and Venezuela; Jamaica and Cayman Islands; and Florida and the Bahamas). Many studies have confirmed the presence of *O. faveolata* in these additional three ecoregions (Bayraktarov *et al.,* 2012; Bruckner, 2012a; Burman *et al.,* 2012). The ecoregions where Veron (2014) reported the absence of *O. faveolata* are off the coasts of Brazil, Bermuda, and the southeastern U.S. north of southern Florida (Veron, 2014). Smith (2013) reported that *O. faveolata* is found in the U.S. Virgin Islands across all depths to about 45 m.

Demographic Information

The SRR and SIR provided the following information on *O. faveolata'*s abundance and population trends. *Orbicella faveolata* is considered common.

The public comments did not provide new or supplemental information on *O. faveolata'*s population trends but provided the following supplemental information on *O. faveolata'*s abundance. Extrapolated population estimates from stratified random samples in the Florida Keys were 39.7 ± 8 million (SE) colonies in 2005, 21.9 ± 7 million (SE) colonies in 2009, and 47.3 ± 14.5 million (SE) colonies in 2012. The greatest proportion of colonies tended to fall in the 10 to 20 cm and 20 to 30 cm size classes in all survey years, but there was a fairly large proportion of colonies in the greater than 90 cm size class. Partial mortality of the colonies was between 10 and 60 percent surface across all size classes. In the Dry Tortugas, Florida, *O. faveolata* ranked seventh most abundant out of 43 coral species in 2006 and fifth most abundant out of 40 in 2008. Extrapolated population estimates were 36.1 ± 4.8 million (SE) colonies in 2006 and 30 ± 3.3 million (SE) colonies in 2008. The size classes with the largest proportion of colonies were 10 to 20 cm and 20 to 30 cm, but there was a fairly large proportion of colonies in the greater than 90 cm size class. Partial mortality of the colonies ranged between approximately two percent and 50 percent. Because these population abundance estimates are based on random surveys, differences between years may be attributed to sampling effort rather than population trends (Miller *et al.,* 2013).

Supplemental information we found on *O. faveolata'*s abundance and population trends includes the following. In a survey of 31 sites in Dominica between 1999 and 2002, *O. faveolata* was present at 80 percent of the sites at one to ten percent cover (Steiner, 2003). In a 1995 survey of 16 reefs in the Florida Keys, *O. faveolata* ranked as the coral species with the second highest percent cover (Murdoch and Aronson, 1999). On 84 patch reefs (3 to 5 m depth) spanning 240 km in the Florida Keys, *O. faveolata* was the third most abundant coral species comprising seven percent of the 17,568 colonies encountered and was present at 95 percent of surveyed reefs between 2001 and 2003 (Lirman and Fong, 2007). In surveys of 280 sites in the upper Florida Keys in 2011, *O. faveolata* was present at 87 percent of sites visited (Miller *et al.,* 2011b). In 2003 on the East Flower Garden Bank, *O. faveolata* comprised ten percent of the 76.5 percent coral cover on reefs 32 to 40 m, and partial mortality due to bleaching, disease, and predation were rare at monitoring stations (Precht *et al.,* 2005).

Colony density ranges from approximately 0.1 to 1.8 colonies per 10 m^2 and varies by habitat and location. In surveys along the Florida reef tract from Martin County to the lower Florida Keys, density of *O. faveolata* was approximately 1.6 colonies per 10 m^2 (Wagner *et al.,* 2010). On remote reefs off southwest Cuba, density of *O. faveolata* was 0.12 ± 0.20 (SD) colonies per 10 m transect on 38 reef-crest sites and 1.26 ± 1.06 colonies per 10 m transect on 30 reef-front sites (Alcolado *et al.* 2010). In surveys of 1,176 sites in southeast Florida, the Dry Tortugas, and the Florida Keys between 2005 and 2010, density of *O. faveolata* ranged between 0.17 and 1.75 colonies per 10 m^2 and was highest on mid-channel reefs followed by offshore patch reefs and fore-reefs (Burman *et al.,* 2012). Along the east coast of Florida, density was highest in areas south of Miami at 0.94 colonies per 10 m^2 compared to 0.11 colonies per 10 m^2 in Palm Beach and Broward Counties (Burman *et al.,* 2012).

Orbicella faveolata is the sixth most abundant species by percent cover in permanent monitoring stations in the U.S. Virgin Islands. The species complex had the highest abundance and included all colonies where species identification was uncertain. Therefore, *O. faveolata* is likely more abundant. Population estimates in the 49 km^2 Red

Hind Marine Conservation District are at least 16 million colonies (Smith, 2013).

Population trend data exists for several locations. At nine sites off Mona and Desecheo Islands, Puerto Rico, no species extirpations were noted at any site over ten years of monitoring between 1998 and 2008 (Bruckner and Hill, 2009). Both *O. faveolata* and *O. annularis* sustained the large losses during the period. The number of colonies of *O. faveolata* decreased by 36 and 48 percent at Mona and Desecheo Islands, respectively (Bruckner and Hill, 2009). In 1998, 27 percent of all corals at six sites surveyed off Mona Island were *O. faveolata* colonies, but decreased to approximately 11 percent in 2008 (Bruckner and Hill, 2009). At Desecheo Island, 12 percent of all coral colonies were *O. faveolata* in 2000 compared to seven percent in 2008.

In a survey of 185 sites in five countries (Bahamas, Bonaire, Cayman Islands, Puerto Rico, and St. Kitts and Nevis) between 2010 and 2011, size of *O. faveolata* colonies was significantly greater than *O. franksi* and *O. annularis.* The total mean partial mortality of *O. faveolata* at all sites was 38 percent. The total live area occupied by *O. faveolata* declined by a mean of 65 percent, and mean colony size declined from 4005 cm^2 to 1413 cm^2. At the same time, there was a 168 percent increase in small tissue remnants less than 500 cm^2, while the proportion of completely live large (1,500 to 30,000 cm^2) colonies decreased. *Orbicella faveolata* colonies in Puerto Rico were much larger and sustained higher levels of mortality compared to the other four countries. Colonies in Bonaire were also large but experienced much lower levels of mortality. Mortality was attributed primarily to outbreaks of white plague and yellow band disease, which emerged as corals began recovering from mass bleaching events. This was followed by increased predation and removal of live tissue by damselfish to cultivate algal lawns (Bruckner, 2012a).

All information on *O. faveolata's* abundance and population trends can be summarized as follows. *Orbicella faveolata* is a common species throughout the greater Caribbean. Based on population estimates, there are at least tens of millions of colonies present in each of several locations including the Florida Keys, Dry Tortugas, and the U.S. Virgin Islands. Absolute abundance is higher than the estimate from these three locations given the presence of this species in many other locations throughout its range. Population decline has occurred over the past few decades with a 65 percent loss in *O. faveolata* cover across five countries. Losses of *O. faveolata* from Mona and Descheo Islands, Puerto Rico include a 36 to 48 percent reduction in abundance and a decrease of 42 to 59 percent in its relative abundance (*i.e.,* proportion relative to all coral colonies). High partial mortality of colonies has led to smaller colony sizes and a decrease of larger colonies in some locations such as the Bahamas, Bonaire, Puerto Rico, Cayman Islands, and St. Kitts and Nevis. Partial colony mortality is lower in some areas such as the Flower Garden Banks. We conclude that *O. faveolata* has declined but remains common and likely has at least tens of millions of colonies throughout its range. Additionally as discussed in the genus section, we conclude that the buffering capacity of *O. faveolata's* life history strategy that has allowed it to remain abundant has been reduced by the recent population declines and amounts of partial mortality, particularly in large colonies.

Other Biological Information

The SRR and SIR provided the following information on *O. faveolata's* life history. In many life history characteristics, including growth rates, tissue regeneration, and egg size, *O. faveolata* is considered intermediate between *O. annularis* and *O. franksi.* Spatial distribution may affect fecundity on the reef, with deeper colonies of *O. faveolata* being less fecund due to greater polyp spacing.

The public comments did not provide new or supplemental information on the life history of *O. faveolata.* Supplemental information we found on *O. faveolata's* life history includes the following. Reported growth rates of *O. faveolata* range between 0.3 and 1.6 cm per year (Cruz-Piñón *et al.,* 2003; Tomascik, 1990; Villinski, 2003; Waddell, 2005). Graham and van Woesik (2013) report that 44 percent of small colonies of *O. faveolata* in Puerto Morelos, Mexico, resulting from partial colony mortality produced eggs at sizes smaller than maturation. The number of eggs produced per unit area of smaller fragments was significantly less than in larger size classes. Szmant and Miller (2005) reported low post-settlement survivorship for *O. faveolata* transplanted to the field with only three to 15 percent remaining alive after 30 days. Post-settlement survivorship was much lower than the 29 percent observed for *A. palmata* after seven months (Szmant and Miller, 2005). Darling *et al.* (2012) performed a biological trait-based analysis to categorize coral species into four life history strategies: Generalist, weedy, competitive, and stress-tolerant. The classifications were primarily separated by colony morphology, growth rate, and reproductive mode. *Orbicella faveolata* was classified as a ''generalist'' species, thus likely less vulnerable to environmental stress.

The SRR and SIR provided the following other biological information on *O. faveolata.* Surveys at an inshore patch reef in the Florida Keys that experienced temperatures less than 18 degrees C for 11 days revealed species-specific cold-water susceptibility and survivorship. *Orbicella faveolata* was one of the more susceptible species with 90 percent of colonies experiencing total colony mortality, including some colonies estimated to be more than 200 years old (Kemp *et al.,* 2011). In surveys from Martin County to the lower Florida Keys, *O. faveolata* was the second most susceptible coral species experiencing an average of 37 percent partial mortality (Lirman *et al.,* 2011).

The public comments did not provide any new or supplemental biological information on *O. faveolata.* Supplemental biological information we found on *O. faveolata* includes the following. Samples (n = 182) of *O. faveolata* from the upper and lower Florida Keys and Mexico showed three well-defined populations based on five genetic markers, but the populations were not stratified by geography, indicating they were shared among the three regions (Baums *et al.,* 2010). Of ten *O. faveolata* colonies observed to spawn at a site off Bocas del Toro, Panama, colonies sorted into three spatially arranged genotypes (Levitan *et al.,* 2011).

Orbicella faveolata larvae are sensitive to ultraviolet radiation during the motile planula stage through the onset of larval competence (Aranda *et al.,* 2011). Of six Caribbean coral species exposed to high solar irradiation, *O. faveolata* and *Stephanocoenia intersepta* had the most severe decline in photochemical efficiency resulting in severe tissue loss and mortality (Fournie *et al.,* 2012).

Experiments exposing *O. faveolata* to high temperatures (up to 35 degrees C) revealed that the corals produced heat shock proteins at temperatures between 33 and 35 degrees C even for very short exposures (2 h) but did respond at temperatures between 27 and 31 degrees C when exposed from 2 hours to one week (Black *et al.,* 1995).

Thornhill *et al.* (2006) repeatedly sampled symbiont composition of colonies of six coral species in the Bahamas and the Florida Keys in 1998 and 2000 to 2004, during and after the 1997–98 bleaching event. Symbioses in *O. faveolata* remained stable at virtually all sites in the Bahamas and the Florida Keys. Individual colonies usually showed fidelity over time to one particular *Symbiodinium* partner, and changing symbiont types was rare, thus indicating acclimation to warming temperatures may not occur by symbiont shuffling.

Susceptibility to Threats

The threat susceptibility information from the SRR and SIR was interpreted in the proposed rule for *O. faveolata'*s vulnerabilities to threats as follows: High vulnerability to ocean warming, disease, acidification, sedimentation, and nutrient enrichment; moderate vulnerability to the trophic effects of fishing; and low vulnerability to sea level rise, predation, and collection and trade.

The SRR and SIR provided the following information on the susceptibility of *O. faveolata* to ocean warming. Recent work in the Mesoamerican reef system indicated that *O. faveolata* had reduced thermal tolerance in locations with increasing human populations and over time, implying increasing local threats. At sites in Navassa, *O. faveolata* and *Agaricia* spp. were the most susceptible to bleaching. Approximately 90 percent of *O. faveolata* colonies (n = 334) bleached at deeper sites (>18 m), and approximately 60 percent of *O. faveolata* colonies (n = 20) bleached at shallower sites (<10 m) in 2006. During a moderate bleaching event in Colombia in 2010, 100 percent of *O. faveolata* colonies bleached at a site in Gayraca Bay, and 50 percent of *O. faveolata* colonies were dead and completely overgrown by algae in 2011 (Bayraktarov *et al.,* 2012).

The public comments did not provide new or supplemental information on the susceptibility of *O. faveolata* to ocean warming. Supplemental information we found on the susceptibility of *O. faveolata* to ocean warming includes the following. Stratified random surveys on back-reefs and fore-reefs between one and 30 m depth off Puerto Rico (Mona and Desecho Islands, La Parguera, Mayaguez, Boqueron, and Rincon) in 2005 and 2006 revealed severe bleaching in *O. faveolata* with approximately 90 percent of colonies bleached (Waddell and Clarke, 2008). Surveys from 2005 to 2007 along the Florida reef tract from Martin County to the lower Florida Keys indicated that *O. faveolata* had the 13th highest bleaching prevalence out of 30 species observed to bleach (Wagner *et al.,* 2010). During a 2009 bleaching event on Little Cayman, of the ten coral species that bleached, *O. faveolata* had the third highest bleaching prevalence with approximately 37 percent of colonies bleached (van Hooidonk *et al.,* 2012).

Coral cores from 92 colonies of *O. faveolata* from the Mesoamerican Reef around Belize and Honduras indicate that the bleaching event in 1998 was unprecedented in the prior century despite periods of higher temperatures and solar irradiance (Carilli *et al.,* 2010). The authors of the study concluded that bleaching in 1998 likely stemmed from reduced thermal tolerance due to the synergistic impacts of chronic local stressors stemming from land-based sources of pollution (Carilli *et al.,* 2010). Coral cores collected from four sites in Belize indicate that *O. faveolata* that experienced higher chronic stress were more severely affected by bleaching and had a much slower recovery after the severe 1998 bleaching event (Carilli *et al.,* 2009). Coral growth rates at sites with higher local anthropogenic stressors remained suppressed for at least eight years, while coral growth rates at sites with lower stress recovered in two to three years (Carilli *et al.,* 2009). Based on samples of *O. faveolata* and *O. franksi* collected from the Mesoamerican Barrier Reef, calcification of these two species is projected to cease at 35 degrees C in this location, even without an increase in acidification (Carricart-Ganivet *et al.,* 2012). Collections from Chinchorro Bank indicate that calcification of *O. faveolata* decreased 20 percent over the period of 1985 to 2009 where there was a 0.6 degree C increase in sea surface temperature (equivalent to 2.4 degrees C per century; Carricart-Ganivet *et al.,* 2012).

Polato *et al.* (2010) raised *O. faveolata* larvae derived from three to four colonies from Florida and Mexico under mean and elevated (1 to 2 degrees above summer mean) temperatures. Both locations had misshapen embryos at the elevated temperature, but the percentage was higher in the embryos from Florida. They found conserved and location-specific variation in gene expression in processes related to apoptosis (programmed cell death), cell structuring, adhesion and development, energy and protein metabolism, and response to stress.

Voolstra *et al.* (2009) exposed *O. faveolata* embryos to temperatures of 27.5, 29, and 31.5 degrees C directly after fertilization and measured differences in gene expression after 12 and 48 hours. They found a higher number of misshapen embryos after 12 hours at 29 and 31.5 degrees C in comparison to embryos kept at 27.5 degrees C. However, after 48 hours, the proportion of misshapen embryos decreased for embryos kept at 29 and 31.5 degrees C, and increased for embryos kept at 27.5 degrees C. Increased temperatures may lead to oxidative stress, apoptosis, and a structural reconfiguration of the cytoskeletal network. However, embryos responded differently depending on exposure time and temperature level. Embryos showed expression of stress-related genes at a temperature of 29 degrees C but seemed to be able to counteract the initial response over time. Embryos at 31.5 degrees C displayed continuous expression of stress genes.

During the 2005 bleaching event, larger colonies of *O. faveolata* experienced more intensive bleaching than smaller colonies at inshore patch reefs of the Florida Keys (Brandt, 2009). *Orbicella faveolata* was one of the most affected species with approximately 80 percent of colonies (n = 77) bleached and, out of eight species that bleached, had the fourth highest bleaching prevalence (Brandt, 2009). *Orbicella faveolata* colonies with greater bleaching intensities later developed white plague disease (Brandt and McManus, 2009). White plague affected approximately ten percent of *O. faveolata* colonies and resulted in less than five percent tissue loss in all but two infected corals which experienced greater than five percent tissue loss (Brandt and McManus, 2009).

All sources of information are used to describe *O. faveolata's* susceptibility to ocean warming as follows. *Orbicella faveolata* is highly susceptible to elevated temperatures. In lab experiments, elevated temperatures resulted in misshapen embryos and differential gene expression in larvae that could indicate negative effects on larval development and survival. Bleaching susceptibility is generally high with 37 to 100 percent of *O. faveolata* colonies reported to bleach during several bleaching events. Chronic local stressors can exacerbate the effects of warming temperatures, which can result in slower recovery from bleaching, reduced calcification, and slower growth rates for several years following bleaching. Additionally, disease outbreaks affecting *O. faveolata* have been linked to elevated temperature as they have occurred after bleaching events. We conclude that *O. faveolata* is highly susceptible to elevated temperature.

The SRR and SIR provided the following information on *O. faveolata'*s susceptibility to acidification. A field study did not find any change in *O. faveolata's* calcification in field-sampled colonies from the Florida Keys up through 1996.

The public comments did not provide new or supplemental information on the susceptibility of *O. faveolata* to acidification. Supplemental information we found on the susceptibility of *O. faveolata* to acidification includes the following. In laboratory experiments, reproduction of *O. faveolata* was negatively impacted by increasing CO_2, and impairment of fertilization was exacerbated at lower sperm concentrations (Albright, 2011b). Fertilization success was reduced by 25 percent at 529 µatm (43 percent fertilization) and 40 percent at 712 µatm (34 percent fertilization) compared to controls at 435 µatm (57 percent fertilization; Albright, 2011a). Additionally, growth rate of *O. faveolata* was reduced under lower pH conditions (7.6) compared to higher pH conditions (8.1) after 120 days of exposure (Hall *et al.,* 2012).

All sources of information are used to describe *O. faveolata's* susceptibility to acidification as follows. Laboratory studies indicate that *O. faveolata* is susceptible to ocean acidification both through reduced fertilization of gametes and reduced growth of colonies. Thus, we conclude that *O. faveolata* is highly susceptible to ocean acidification.

The SRR and SIR did not provide any species-specific information on the susceptibility of *O. faveolata* to disease. The public comments also did not provide new or supplemental information on the susceptibility of *O. faveolata* to disease. Supplemental information we found on the susceptibility of *O. faveolata* to disease confirms the information on the *Orbicella* species complex and includes the following. Disease affected corals in Puerto Rico after the 2005 bleaching event, and *O. faveolata* was the species most affected (Bruckner and Hill, 2009). A 1998 outbreak of white plague on three surveyed reefs in St. Lucia affected 19 percent of *O. faveolata* colonies, and *O. faveolata* was the species most affected (Nugues, 2002). Larger colonies in St. Lucia were more likely to get infected, but they were less likely to suffer complete mortality (Nugues, 2002). Tissue mortality of marked *O. faveolata* colonies was 51 percent, and no colonies showed regrowth during the 8 month study period (Nugues, 2002). Disease surveys conducted between August and December 1999 at 19 reef sites from six geographic areas across the wider Caribbean (Bermuda, Puerto Rico, Bonaire, Venezuela, Colombia, and Jamaica) revealed that *O. faveolata* showed the second highest incidence of disease at 4.7 to 10.4 percent across geographic locations (Weil *et al.,* 2002).

Surveys at five sites along the west coast of Dominica between 2000 and 2002 revealed that *O. faveolata* was one of the species most susceptible to disease. Of the 12 species infected by white plague in 2000, *O. faveolata* ranked second highest in disease prevalence (18.4 percent of infected colonies were *O. faveolata*); it ranked third in 2001 out of 14 species (12.7 percent) and second in 2002 out of 13 species (18.8 percent). In addition, white plague infected the larger size classes of *O. faveolata.* Although only one colony experienced total colony mortality, *O. faveolata* had the highest amount of tissue loss in each year and in the three years combined (Borger and Steiner, 2005).

Yellow band disease in *O. faveolata* increased in abundance between 1999 and 2004 on reefs near La Parguera and Desecheo and Mona Islands, Puerto Rico (Waddell, 2005). Yellow band disease mean lesion growth rates on *O. faveolata* in La Parguera, Puerto Rico had a significant positive correlation with mean yearly surface water temperatures between 1998 and 2010 (Burge *et al.,* 2014). In Curacao colonies of *O. faveolata* infected with yellow band disease lost 90 percent of their tissue between 1997 and 2005 (Bruckner and Bruckner, 2006a). Only the unaffected parts of colonies continued to grow, and only the smallest lesions caused by disease healed (Bruckner and Bruckner, 2006a). Partial mortality was higher in 2005 (average of 40 percent) than in 1998 (Bruckner and Bruckner, 2006a). Outbreaks of white plague occurred in 2001 and 2005 and infected *O. faveolata* and *O. annularis* with the highest frequency (Bruckner and Bruckner, 2006a).

Yellow band disease significantly affects *O. faveolata* reproductive output. Fecundity of diseased lesions was significantly lower than transition and healthy-looking tissues on diseased colonies. Diseased lesions had 99 percent fewer eggs compared to un-diseased control colonies. Fecundity in transition areas was 24 percent less than healthy-looking areas of diseased colonies and was significantly lower (50 percent) than in un-diseased control colonies. Healthy-looking tissues of diseased colonies had 27 percent lower fecundity compared to un-diseased control colonies. Furthermore, in colonies that had recovered from disease, small tissue remnants (less than 100 cm^2) had 84 percent lower fecundity compared to un-diseased controls, and large tissue remnants (400 to 1000 cm^2) had 64 percent lower fecundity compared to un-diseased controls (Weil *et al.,* 2009).

All sources of information are used to describe *O. faveolata's* susceptibility to disease as follows. *Orbicella faveolata* is often among the coral species with the highest disease prevalence and tissue loss. Outbreaks have been reported to affect ten to 19 percent of *O. faveolata* colonies, and yellow band disease and white plague have the greatest effect. Disease often affects larger colonies, and reported tissue loss due to disease ranges from five to 90 percent. Additionally, yellow band disease results in lower fecundity in diseased and recovered colonies of *O. faveolata.* Therefore, we conclude that *O. faveolata* is highly susceptible to disease.

The SIR and SRR did not provide any species-specific information on the trophic effects of fishing on *O. faveolata.* The public comments did not provide new or supplemental information, and we did not find supplemental information on the trophic effects of fishing on *O. faveolata.* However, due to the level of reef fishing conducted in the Caribbean, coupled with *Diadema* die-off and lack of significant recovery, competition with algae can adversely affect coral recruitment. Thus, *O. faveolata* likely has some susceptibility to the trophic effects of fishing given its low recruitment rates. However, the available information does not support a more precise description of susceptibility to this threat.

The SRR and SIR did not provide species-specific information on the susceptibility of *O. faveolata* to sedimentation, and the public comments did not provide new or supplemental information on its susceptibility to this threat. Supplemental information we found confirms the information on the susceptibility of the *Orbicella* species complex to sedimentation and includes the following. In St. Lucia, rates of partial mortality of *O. annularis* and *O. faveolata* were higher close to river mouths where sediments were deposited than they were farther from the river mouths, indicating the sensitivity of these two species to sedimentation (Nugues and Roberts, 2003).

All sources of information are used to describe *O. faveolata's* susceptibility to sedimentation as follows. Sedimentation can cause partial mortality of *O. faveolata,* and genus-level information indicates that sedimentation negatively affects primary production, growth rates, calcification, colony size, and abundance. Therefore, we conclude that *O. faveolata* is highly susceptible to sedimentation.

The SRR, SIR, and public comments did not provide information on the susceptibility of *O. faveolata* to nutrient enrichment, and we did not find any new or supplemental information on the susceptibility of *O. faveolata* to nutrient enrichment.

All sources of information are used to describe *O. faveolata's* susceptibility to nutrient enrichment as follows. Although there is no species-specific information, the *Orbicella* species complex is susceptible to nutrient enrichment through reduced growth rates, lowered recruitment, and increased disease severity. Therefore, based on genus-level information, we conclude that *O. faveolata* is likely highly susceptible to nutrient enrichment.

The SRR and SIR provided the following information on the susceptibility of *O. faveolata* to predation. Under laboratory conditions, black band disease was transmitted to healthy *O. faveolata* fragments in the presence of the butterflyfish *Chaetodon capistratus* but not in aquaria without the fish present, suggesting that the fish acts as a disease vector (Aeby and Santavy, 2006).

The public comments did not provide new or supplemental information on the susceptibility of *O. faveolata* to predation. Supplemental information we found on the susceptibility of *O. faveolata* to predation includes the following. In surveys of the Florida Keys in 2012, two percent of *O. faveolata* colonies were affected by predation by the corallivorous snail *C. abbreviata* (Miller *et al.,* 2013). Parrotfish consume *O. annularis* and *O. faveolata* more intensively than other coral species, but tissue regeneration capabilities appear to be high enough to counterbalance loss from predation (Mumby, 2009).

All sources of information are used to describe *O. faveolata's* susceptibility to predation as follows. *Orbicella faveolata* is affected by a number of predators, but losses appear to be minimal. We conclude that *O. faveolata* has low susceptibility to predation.

The SRR and SIR did not provide information on the effects of sea level rise on *O. faveolata.* The SRR described sea level rise as an overall low to medium threat for all coral species. The public comments did not provide new or supplemental information on *O. faveolata's* susceptibility to sea level rise, and we did not find any new or supplemental information. Thus, we conclude that *O. faveolata* has some susceptibility to sea level rise, but the available information does not support a more precise description of susceptibility to this threat.

The SRR and SIR did not provide species-specific information on the susceptibility of *O. faveolata* to collection and trade, and the public comments did not provide new or supplemental information on its susceptibility to this threat. Supplemental information we found confirms the information in the SRR and SIR that collection and trade is not a significant threat for the *Orbicella* species complex. Over the last decade, collection and trade of this species has been primarily for scientific research rather than commercial purposes. Gross exports for collection and trade of *O. faveolata* between 2000 and 2012 averaged 271 specimens (data available at *http://trade.cites.org*). We conclude that *O. faveolata* has low susceptibility to collection and trade.

Regulatory Mechanisms

In the proposed rule, we relied on information from the Final Management Report for evaluating the existing regulatory mechanisms for controlling threats to all corals. However, we did not provide any species-specific information on the regulatory mechanism or conservation efforts for *O. faveolata.* Public comments were critical of that approach, and we therefore attempt to analyze regulatory mechanisms and conservation efforts on a species basis, where possible, in this final rule. Records confirm that *O. faveolata* occurs in five Atlantic ecoregions, and studies and observations have confirmed the presence of *O. faveolata* in an additional three ecoregions (Burman *et al.,* 2012). These eight ecoregions encompass 26 kingdom's and countries' EEZs. The 26 kingdoms and countries are Antigua & Barbuda, Bahamas, Barbados, Belize, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, French Antilles, Grenada, Guatemala, Haiti, Kingdom of the Netherlands, Honduras, Jamaica, Mexico, Nicaragua, Panama, St. Kitts & Nevis, St. Lucia, St. Vincent & Grenadines, Trinidad and Tobago, United Kingdom (British Caribbean Territories and possibly Bermuda), United States (including U.S. Caribbean Territories), and Venezuela. The regulatory mechanisms relevant to *O. faveolata,* described first as a percentage of the above kingdoms and countries that utilize them to any degree, and second as the percentages of those kingdoms and countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (31 percent with 12 percent limited in scope), coral collection (50 percent with 27 percent limited in scope), pollution control (31 percent with 15 percent limited in scope), fishing regulations on reefs (73 percent with 50 percent limited in scope), managing areas for protection and conservation (88 percent with 31 percent limited in scope). The most common regulatory mechanisms in place for *O. faveolata* are reef fishing regulations and area management for protection and conservation. However, half of the reef fishing regulations are limited in scope and may not provide substantial protection for the species. General coral protection and collection laws, along with pollution control laws, are much less common regulatory mechanisms for the management of *O. faveolata.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic traits, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that the factors that increase the extinction risk for *O. faveolata* are its extremely low productivity (growth and recruitment), documented dramatic recent declines, and its restriction to the highly disturbed/degraded wider Caribbean region.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species' abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *O. faveolata,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. The species has undergone major declines mostly due to warming-induced bleaching and disease. There is evidence of synergistic effects of threats for this species including disease outbreaks following bleaching events and reduced thermal tolerance due to chronic local stressors stemming from land-based sources of pollution. *Orbicella faveolata* is highly susceptible to a number of threats, and cumulative effects of multiple threats have likely contributed to its decline and exacerbate vulnerability to extinction. Despite high declines, the species is still common and remains one of the most abundant species on Caribbean reefs. Its life history characteristics of large colony size and long life span have enabled it to remain relatively persistent despite slow growth and low recruitment rates, thus moderating vulnerability to extinction. However, the buffering capacity of these life history characteristics is expected to decrease as colonies shift to smaller size classes as has been observed in locations in its range. Its absolute population abundance has been estimated as at least tens of millions of colonies in each of several locations including the Florida Keys, Dry Tortugas, and the U.S. Virgin Islands and is higher than the estimate from these three locations due to the occurrence of the species in many other areas throughout its range. Despite the large number of islands and environments that are included in the species' range, geographic distribution in the highly disturbed Caribbean exacerbates vulnerability to extinction over the foreseeable future because *O. faveolata* is limited to an area with high, localized human impacts and predicted increasing threats. Its depth range of 0.5 to at least 40 m, possibly up to 90 m, moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower temperatures than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. *Orbicella faveolata* occurs in most reef habitats, including both shallow and mesophotic reefs, which moderates vulnerability to extinction over the foreseeable future because the species occurs in numerous types of reef environments that are predicted, on local and regional scales, to experience highly variable thermal regimes and ocean chemistry at any given point in time. Its abundance, life history characteristics, and depth distribution, combined with spatial variability in ocean warming and acidification across the species' range, moderate vulnerability to extinction because the threats are non-uniform, and there will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule, using the determination tool formula approach, *O. faveolata* was proposed for listing as endangered because of: High vulnerability to ocean warming (E), disease (C), and ocean acidification (E); high vulnerability to sedimentation (A and E) and nutrient over-enrichment (A and E); decreasing trend in abundance (E); low relative recruitment rate (E); moderate overall distribution (based on narrow geographic distribution and wide depth distribution) (E); restriction to the Caribbean (E); and inadequacy of regulatory mechanisms (D).

In this final rule, we changed the listing determination for *O. faveolata* from endangered to threatened. We made this determination based on a more species-specific and holistic approach, including consideration of the buffering capacity of this species' spatial and demographic traits, and the best available information above on *O. faveolata's* spatial structure, demography, threat susceptibilities, and management. This combination of factors indicates that *O. faveolata* is likely to become endangered throughout its range within the foreseeable future, and thus warrants listing as threatened at this time, because:

(1) *Orbicella faveolata* is highly susceptible to ocean warming (ESA Factor E), disease (C), ocean acidification (E), sedimentation (A, E), and nutrients (A, E) and susceptible to trophic effects of fishing (A). These threats are expected to continue and increase into the future. In addition, the species is at heightened extinction risk due to inadequate existing regulatory mechanisms to address global threats (D);

(2) *Orbicella faveolata* is geographically located in the highly disturbed Caribbean where localized human impacts are high and threats are predicted to increase as described in the Threats Evaluation section. A range constrained to this particular geographic area that is likely to experience severe and increasing threats indicates that a high proportion of the population of this species is likely to be exposed to those threats over the foreseeable future;

(3) *Orbicella faveolata* has experienced substantial declines in abundance and percent cover over the past two decades; and

(4) *Orbicella faveolata's* slow growth rate and low sexual recruitment limit its capacity for recovery from threat-induced mortality events throughout its range over the foreseeable future. Additionally, shifts to smaller size classes via fission and partial mortality of older, larger colonies, have reduced the buffering capacity of *O. faveolata's* life history strategy.

The combination of these characteristics and future projections of threats indicates that the species is likely to be in danger of extinction within the foreseeable future throughout its range, and warrants listing as threatened at this time due to factors A, C, D, and E.

The available information above on *O. faveolata's* spatial structure, demography, threat susceptibilities, and management also indicate that the species is not currently in danger of extinction and thus does not warrant listing as Endangered because:

(1) While *Orbicella faveolata's* distribution within the Caribbean increases its risk of exposure to threats as described above, its known depth distribution is between 0.5 and 45 m, with occurrence by the complex as deep as 90 m, and its habitat includes various shallow and mesophotic reef environments. This moderates vulnerability to extinction currently because the species is not limited to one habitat type but occurs in numerous types of reef environments that will experience highly variable thermal regimes and ocean chemistry on local and regional scales at any given point in time, as described in more detail in the Coral Habitat and Threats Evaluation sections. There is no evidence to suggest that the species is so spatially fragmented that depensatory processes, environmental stochasticity, or the potential for catastrophic events currently pose a high risk to the survival of the species; and

(2) Although *O. faveolata's* abundance has declined, it still has a common occurrence and remains one of the most dominant corals in the Caribbean. Its absolute abundance is at least tens of millions of colonies based on estimates from three locations. Absolute abundance is higher than estimates from these locations since *it* occurs in many other locations throughout its range. This absolute abundance allows for variation in the responses of individuals to threats to play a role in moderating vulnerability to extinction for the species to some degree, as described in more detail in the Corals and Coral Reefs section. There is no evidence of depensatory processes such as reproductive failure from low density of reproductive individuals and genetic processes such as inbreeding affecting this species. Thus, its absolute abundance indicates it is currently able to avoid high mortality from

environmental stochasticity, and mortality of a high proportion of its population from catastrophic events.

The combination of these characteristics indicates that the species does not exhibit the characteristics of one that is currently in danger of extinction, as described previously in the Risk Analyses section, and thus does not warrant listing as endangered at this time.

Range-wide, multitudes of conservation efforts are already broadly employed that are likely benefiting *O. faveolata.* However, considering the global scale of the most important threats to the species, and the ineffectiveness of conservation efforts at addressing the root cause of global threats (*i.e.,* GHG emissions), we do not believe that any current conservation efforts or conservation efforts planned in the future will result in affecting the species' status to the point at which listing is not warranted.

Orbicella franksi

Introduction

The SRR and SIR provided the following information on *O. franksi's* morphology. *Orbicella franksi* is distinguished by large, unevenly arrayed polyps that give the colony its characteristic irregular surface. Colony form is variable, and the skeleton is dense with poorly developed annual bands. Colony diameter can reach up to 5 m with a height of up to 2 m. The public comments did not provide new or supplemental information on *O. franksi's* morphology, and we did not find any new or supplemental information.

Spatial Information

The SRR and SIR provided the following information on *O. franksi's* distribution, habitat, and depth range. *Orbicella franksi* is distributed in the western Atlantic and throughout the Caribbean Sea including in the Bahamas, Bermuda, and the Flower Garden Banks. *Orbicella franksi* tends to have a deeper distribution than the other two species in the *Orbicella* species complex.

It occupies most reef environments and has been reported from water depths ranging from 5 to 50 m, with the species complex reported to 90 m. *Orbicella* species are a common, often dominant, component of Caribbean mesophotic reefs, suggesting the potential for deep refugia for *O. franksi.*

The public comments did not provide new or supplemental information on *O. franksi's* distribution, habitat, or depth range. We did not find new or supplemental information on *O. franksi's* habitat or depth range. Supplemental information we found on *O. franksi's* distribution includes the following. Veron (2014) confirmed the occurrence of *O. franksi* in six out of his 11 ecoregions in the western Atlantic and greater Caribbean known to contain corals and strongly predicted its presence in an additional three ecoregions (off Colombia/Venezuela, Cuba/Cayman Islands, and Jamaica). Other studies confirm the presence of *O. franksi* in three other ecoregions (Alcolado *et al.,* 2010; Bayraktarov *et al.,* 2012; Bruckner, 2012c; Weil *et al.,* 2002). The two ecoregions where *O. franksi* has not been found are off the coasts of Brazil and the southeastern U.S. north of southern Florida (Veron, 2014).

Demographic Information

The SRR and SIR provided the following information on *O. franksi's* abundance and population trends. *Orbicella franksi* is reported as common.

The public comments provided the following supplemental information on *O. franksi's* abundance and population trends. In surveys throughout the Florida Keys, *O. franksi* in 2005 ranked 26th most abundant out of 47 coral species, 32nd out of 43 in 2009, and 33rd out of 40 in 2012. Extrapolated population estimates from stratified random surveys were 8.0 ± 3.5 million (SE) colonies in 2005, 0.3 ± 0.2 million (SE) colonies in 2009, and 0.4 ± 0.4 million (SE) colonies in 2012. The authors note that differences in extrapolated abundance between years were more likely a function of sampling effort rather than an indication of population trends. In 2005, the greatest proportions of colonies were in the smaller size classes of 10 to 20 cm and 20 to 30 cm. Partial colony mortality ranged from zero to approximately 73 percent and was generally higher in larger colonies (Miller *et al.,* 2013).

In the Dry Tortugas, Florida, *O. franksi* ranked fourth highest in abundance out of 43 coral species in 2006 and eighth out of 40 in 2008. Extrapolated population estimates were 79 ± 19 million (SE) colonies in 2006 and 18.2 ± 4.1 million (SE) colonies in 2008. The authors note the difference in estimates between years was more likely a function of sampling effort rather than population decline. In the first year of the study (*i.e.,* 2006), the greatest proportion of colonies were in the size class 20 to 30 cm with twice as many colonies as the next most numerous size class, and a fair number of colonies in the largest size class of greater than 90 cm. Partial colony mortality ranged from approximately ten to 55 percent. Two years later in 2008 no size class was found to dominate, and proportion of colonies in the medium to large size classes (60 to 90 cm) appeared to be less than in 2006. The number of colonies in the largest size class of greater than 90 cm remained consistent. Partial colony mortality ranged from approximately 15 to 75 percent (Miller *et al.,* 2013).

Supplemental information we found on *O. franksi's* abundance and population trends includes the following. In a 1995 survey of 16 reefs in the Florida Keys, *O. franksi* has the highest percent cover of all species (Murdoch and Aronson, 1999). In a survey of 31 sites in Dominica between 1999 and 2002, *O. franksi* was present in seven percent of the sites at less than one percent cover (Steiner, 2003). In 2003 on the east Flower Garden Bank, *O. franksi* comprised 46 percent of the 76.5 percent coral cover on reefs 32 to 40 m in depth, and partial coral mortality due to bleaching, disease, and predation was rare in survey stations (Precht *et al.,* 2005).

Reported density is variable by location and habitat and is reported to range from 0.02 to 1.05 colonies per 10 m^2. In surveys of 1,176 sites in southeast Florida, the Dry Tortugas, and the Florida Keys between 2005 and 2010, density of *O. franksi* ranged between 0.04 and 0.47 colonies per 10 m^2 and was highest on the offshore patch reef and fore-reef habitats (Burman *et al.,* 2012). In south Florida, density was highest in areas south of Miami at 0.44 colonies per 10 m^2 compared to 0.02 colonies per 10 m^2 in Palm Beach and Broward Counties (Burman *et al.,* 2012). Along the Florida reef tract from Martin County to the lower Florida Keys, density of *O. franksi* was approximately 0.9 colonies per 10 m^2 (Wagner *et al.,* 2010). On remote reefs off southwest Cuba, colony density was 0.083 ± 0.17 (SD) per 10 m transect on 38 reef-crest sites and 1.05 ± 1.02 colonies per 10 m transect on 30 reef-front sites (Alcolado *et al.,* 2010). The number of *O. franksi* colonies in Cuba with partial colony mortality were far more frequent than those with no mortality across all size classes, except for one (*i.e.,* less than 50 cm) that had similar frequency of colonies with and without partial mortality (Alcolado *et al.,* 2010).

In the U.S. Virgin Islands, *O. franksi* is the second most abundant species by percent cover at permanent monitoring stations. However, because the species complex, which is the most abundant by cover, was included as a category when individual *Orbicella* species could not be identified with certainty, it is likely that *O. franksi* is the most abundant. Population estimates of *O. franksi* in the 49 km² Red Hind Marine Conservation District are at least 34 million colonies (Smith, 2013).

Abundance in Curacao and Puerto Rico and appears to be stable over an eight to ten year period. In Curacao, abundance was stable between 1997 and 2005, with partial mortality similar or less in 2005 compared to 1998 (Bruckner and Bruckner, 2006a). Abundance was also stable between 1998–2008 at nine sites off Mona and Desecheo Islands, Puerto Rico. In 1998, 4 percent of all corals at six sites surveyed off Mona Island were *O. franksi* colonies in 1998 and approximately five percent in 2008; at Desecheo Island, about two percent of all coral colonies were *O. franksi* in both 2000 and 2008 (Bruckner and Hill, 2009).

On the other hand, colony size has decreased over the past several decades. A survey of 185 sites (2010 and 2011) in five countries (Bahamas, Bonaire, Cayman Islands, Puerto Rico, and St. Kitts and Nevis) reported the size of *O. franksi* and *O. annularis* colonies as significantly smaller than *O. faveolata.* The total mean partial mortality of *O. franksi* was 25 percent. Overall, the total live area occupied by *O. franksi* declined by a mean of 38 percent, and mean colony size declined from 1356 cm² to 845 cm². At the same time there was a 137 percent increase in small tissue remnants less than 500 cm², along with a decline in the proportion of large (1,500 to 30,000 cm²), completely alive colonies. Mortality was attributed primarily to outbreaks of white plague and yellow band disease, which emerged as corals began recovering from mass bleaching events. This was followed by increased predation and removal of live tissue by damselfish to cultivate algal lawns (Bruckner, 2012a).

All information on *O. franksi's* abundance and population trends can be summarized as follows. Based on population estimates, there are at least tens of millions of colonies present in both the Dry Tortugas and U.S. Virgin Islands. Absolute abundance is higher than the estimate from these two locations given the presence of this species in many other locations throughout its range. The frequency and extent of partial mortality, especially in larger colonies of *O. franksi,* appear to be high in some locations such as Florida and Cuba, though other locations like the Flower Garden Banks appear to have lower amounts of partial mortality. A decrease in *O. franksi* percent cover by 38 percent, and a shift to smaller colony size across five countries, suggest that population decline has occurred in some areas; colony abundance appears to be stable in other areas. We conclude that while population decline has occurred, *O. franksi* is still common with the number of colonies at least in the tens of millions. Additionally, as discussed in the genus section, we conclude that the buffering capacity of *O. franksi's* life history strategy that has allowed it to remain abundant has been reduced by the recent population declines and amounts of partial mortality, particularly in large colonies.

Other Biological Information

The SRR and SIR provided the following information on *O. franksi's* life history. The growth rate for *O. franksi* is reported to be slower, and spawning is reported to be about one to two hours earlier than *O. annularis* and *O. faveolata.*

The public comments did not provide new or supplemental information on *O. franksi's* life history. Supplemental information we found on *O. franksi's* life history includes the following. Of 361 colonies of *O. franksi* tagged in Bocas del Toro, Panama, larger colonies were noted to spawn more frequently than smaller colonies between 2002 and 2009 (Levitan *et al.,* 2011). Darling *et al.* (2012) performed a biological trait-based analysis to categorize coral species into four life history strategies: Generalist, weedy, competitive, and stress-tolerant. The classifications were primarily separated by colony morphology, growth rate, and reproductive mode. *Orbicella franksi* was classified as a ''generalist'' species, thus likely less vulnerable to environmental stress.

The SRR and SIR provided the following other biological information on *O. franksi.* Low tissue biomass can render specific colonies of *O. franksi* susceptible to mortality from stress events, such as bleaching or disease. This suggests that differential mortality among individuals, species, and reefs from stress events such as bleaching or disease may be at least partially a function of differential colony biomass (indicating overall coral health) as opposed to genetic or physiologic differences among corals or their symbionts.

In a 2010 cold-water event that affected south Florida, *O. franksi* ranked as the 14th most susceptible coral species out of 25 of the most abundant coral species. Average partial mortality was eight percent in surveys from Martin County to the lower Florida Keys after the 2010 cold-water event compared to 0.4 percent average mortality during summer surveys between 2005 and 2009.

The public comments did not provide new or supplemental biological information on *O. franksi.* Supplemental biological information we found on *O. franksi* includes the following. Of 351 *O. franksi* colonies observed to spawn at a site off Bocas del Toro, Panama, 324 were unique genotypes. Over 90 percent of *O. franksi* corals on this reef were the product of sexual reproduction, and 19 genetic individuals had asexually propagated colonies made up of two to four spatially adjacent ramets each. Individuals within a genotype spawned more synchronously than individuals of different genotypes. Additionally, within 5m, colonies nearby spawned more synchronously than farther spaced colonies, regardless of genotype. At distances greater than 5m, spawning was random between colonies (Levitan *et al.,* 2011).

In a study of symbiont composition of repeatedly sampled colonies of six species in the Bahamas and the Florida Keys (1998, and 2000 to 2004), major changes in symbiont dominance over time were observed at certain Florida Keys reefs in *O. annularis* and *O. franksi.* Some colonies of *O. annularis* and *O. franksi* exhibited shifts in their associations attributed to recovery from the stresses of the 1997–98 bleaching event. Most transitions in symbiont identity ended in 2002, three to five years after the 1997–98 bleaching event (Thornhill *et al.,* 2006).

Susceptibility to Threats

The threat susceptibility information from the SRR and SIR was interpreted in the proposed rule for *O. franksi's* vulnerability to threats as follows: High vulnerability to ocean warming, disease, acidification, sedimentation, and nutrient enrichment; moderate vulnerability to the trophic effects of fishing; and low vulnerability to sea level rise, predation, and collection and trade.

The SRR and SIR did not provide species-specific information on the susceptibility of *O. franksi* to ocean warming. The public comments did not provide new or supplemental information on the susceptibility of *O. franksi* to ocean warming. Supplemental information we found on the susceptibility of *O. franksi* to ocean warming includes the following. A high percentage of *O. franksi* colonies experience bleaching during warm water temperature anomalies. Stratified random surveys on back-reefs and fore-reefs between one and 30 m depth off Puerto Rico (Mona and Desecho Islands, La Parguera, Mayaguez, Boqueron, and Rincon) in 2005 and 2006 revealed severe bleaching in *O. franksi* with approximately 90 percent of colonies bleached (Waddell and Clarke, 2008). Surveys from 2005 to 2007 along the Florida reef tract from Martin County to the lower Florida Keys indicated *O. franksi* had the tenth highest bleaching prevalence out of 30 species observed to bleach (Wagner *et al.,* 2010). During a moderate bleaching event in Colombia in 2010, 88 percent of *O. franksi* bleached, and 12 percent paled at a site in Gayraca Bay (Bayraktarov *et al.,* 2012). In 2011, 75 percent of *O. franksi* were dead and completely overgrown by algae (Bayraktarov *et al.,* 2012). Based on samples of *O. franksi* and *O. faveolata* collected from the Mesoamerican Barrier Reef, calcification of these two species is projected to cease at 35 degrees C in this location in the absence of acidification (Carricart-Ganivet *et al.,* 2012).

All sources of information are used to describe *O. franksi's* susceptibility to ocean warming as follows. Available information indicates that *O. franksi* is highly susceptible to warming temperatures with a reported 88 to 90 percent bleaching frequency. Reported bleaching-related mortality from one study is high at 75 percent. There is indication that symbiont shuffling after bleaching in *O. franksi.* We conclude that *O. franksi* is highly susceptible to ocean warming.

The SRR and SIR did not provide any species-specific information on the susceptibility of *O. franksi* to acidification, and the public comments did not provide new or supplemental information on its susceptibility to this threat. We did not find any new or supplemental information on the susceptibility of *O. franksi* to acidification. Although there is no species-specific information on the susceptibility of *O. franksi* to ocean acidification, genus information indicates that the species complex has reduced growth and fertilization success under acidic conditions. Thus, we conclude *O. franksi* likely has high susceptibility to ocean acidification.

The SRR and SIR did not provide any species-specific information on the susceptibility of *O. franksi* to disease. The public comments did not provide new or supplemental information on the susceptibility of *O. franksi* to disease. Supplemental information we found on the susceptibility of *O. franksi* to disease includes the following. Disease surveys conducted between August and December 1999 at 19 reef sites from six geographic areas across the wider Caribbean (Bermuda, Puerto Rico, Bonaire, Venezuela, Colombia, and Jamaica) revealed that *O. franksi* had the third highest incidence of disease at 1.1 to 5.6 percent across geographic locations (Weil *et al.,* 2002). Between 1998 and 2000, *O. franksi* was one of six coral species identified in the Virgin Islands as most susceptible to disease (Waddell, 2005). In 2004 in Mexico, disease prevalence was highest in *O. franksi* with 41 percent of colonies infected, followed by 34 percent of *O. annularis* colonies and 31 percent of *O. faveolata* colonies (Ward *et al.,* 2006). In Curacao colonies of *O. franksi* infected with yellow band disease lost an average of 30 percent of their tissue between 1997 and 2005, but some tagged colonies exhibited re-sheeting over disease lesions (Bruckner and Bruckner, 2006a).

All sources of information are used to describe *O. franksi's* susceptibility to disease as follows. *Orbicella franksi* is often reported as among the species with the highest disease prevalence. Although there are few quantitative studies of the effects of disease on *O. franksi,* there is evidence that partial mortality can average about 25 to 30 percent and that disease can cause shifts to smaller size classes. Thus, we conclude that *O. franksi* is highly susceptible to disease.

The SIR and SRR did not provide any species-specific information on the trophic effects of fishing on *O. franksi.* The public comments did not provide new or supplemental information, and we did not find new or supplemental information on the trophic effects of fishing on *O. franksi.* However, due to the level of reef fishing conducted in the Caribbean, coupled with *Diadema* die-off and lack of significant recovery, competition with algae can adversely affect coral recruitment. Thus, *O. franksi* likely has some susceptibility to the trophic effects of fishing given its low recruitment rates.

The SRR, SIR, and public comments did not provide information on the susceptibility of *O. franksi* to sedimentation, and we did not find any new or supplemental information. All sources of information are used to describe *O. franksi's* susceptibility to sedimentation as follows. Genus information indicates sedimentation negatively affects primary production, growth rates, calcification, colony size, and abundance. Therefore, we conclude that *O. franksi* is highly susceptible to sedimentation.

The SRR, SIR, and public comments do not provide information on the susceptibility of *O. franksi* to nutrient enrichment. Supplemental information we found on the susceptibility of *O. franksi* to nutrient enrichment includes the following. Field experiments indicate that nutrient enrichment significantly increases yellow band disease severity in *O. annularis* and *O. franksi* through increased tissue loss (Bruno *et al.,* 2003).

All sources of information are used to describe *O. franksi's* susceptibility to nutrient enrichment as follows. Genus level information indicates *O. franksi* is likely susceptible to nutrient enrichment through reduced growth rates and lower recruitment. Additionally, nutrient enrichment has been shown to increase the severity of yellow band disease in *O. franksi.* Thus, we conclude that *O. franksi* is highly susceptible to nutrient enrichment.

The SRR and SIR do not provide species-specific information on the susceptibility of *O. franksi* to predation. Likewise, the public comments do not provide new or supplemental information on the susceptibility of *O. franksi* to predation. Supplemental information we found on the susceptibility of *O. franksi* to predation includes the following. Incidence of parrotfish grazing on the Belize barrier reef was second highest on *O. franksi.* However, in most habitats, the majority of *Orbicella* spp. showed little or no parrotfish grazing while only a few colonies were more heavily grazed, indicating low impact to the species overall (Rotjan, 2007).

All sources of information are used to describe *O. franksi's* susceptibility to predation as follows. Genus-level information indicates *O. franksi* is affected by a number of predators, but both species-level and genus-level impacts appear to be minimal. We conclude that *O. franksi* has low susceptibility to predation.

The SRR and SIR did not provide information on the effects of sea level rise on *O. franksi.* The SRR described sea level rise as an overall low to medium threat for all coral species. The public comments did not provide new or supplemental information on *O. franksi's* susceptibility to sea level rise, and we did not find any new or supplemental information. Thus, we conclude that *O. franksi* has some susceptibility to sea level rise, but the available information does not support a more precise description of susceptibility to this threat.

The SRR and SIR do not provide species-specific information on the susceptibility of *O. franksi* to collection and trade, and the public comments do not provide new or supplemental information on its susceptibility to this threat. Supplemental information we found confirms the information in the

SRR and SIR that collection and trade is not a significant threat for the *Orbicella* species complex. Over the last decade, collection and trade of *O. franksi* has been primarily for scientific research rather than commercial purposes. Annual gross exports for collection and trade of *O. franksi* between 2000 and 2012 averaged 40 specimens (data available at *http://trade.cites.org*). Thus, we conclude that *O. franksi* has low susceptibility to collection and trade.

Regulatory Mechanisms

In the proposed rule, we relied on information from the Final Management Report for evaluating the existing regulatory mechanisms for controlling threats to all corals. However, we did not provide any species-specific information on the regulatory mechanism or conservation efforts for *O. franksi.* Public comments were critical of that approach, and we therefore attempt to analyze regulatory mechanisms and conservation efforts on a species basis, where possible, in this final rule. Records confirm that *O. franksi* occurs in six Atlantic ecoregions, and studies have confirmed the presence of *O. franksi* in an additional three ecoregions. These nine ecoregions encompass 26 kingdoms' and countries' EEZs, and the 26 kingdoms and countries are Antigua & Barbuda, Bahamas, Barbados, Belize, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, French Antilles, Grenada, Guatemala, Haiti, Kingdom of the Netherlands, Honduras, Jamaica, Mexico, Nicaragua, Panama, St. Kitts & Nevis, St. Lucia, St. Vincent & Grenadines, Trinidad and Tobago, United Kingdom (British Caribbean Territories and Bermuda), United States (including U.S. Caribbean Territories), and Venezuela. The regulatory mechanisms relevant to *O. franksi,* described first as a percentage of the above kingdoms and countries that utilize them to any degree, and second as the percentage of those kingdoms and countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (31 percent with 12 percent limited in scope), coral collection (50 percent with 27 percent limited in scope), pollution control (31 percent with 15 percent limited in scope), fishing regulations on reefs (73 percent with 50 percent limited in scope), managing areas for protection and conservation (88 percent with 31 percent limited in scope). The most common regulatory mechanisms in place for *O. franksi* are reef fishing regulations and area management for protection and conservation. However, half of the reef fishing regulations are limited in scope and may not provide substantial protection for the species. General coral protection and collection laws, along with pollution control laws, are much less common regulatory mechanisms for the management of *O. franksi.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic traits, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that the factors that increase the extinction risk for *O. franksi* are extremely low productivity (growth and recruitment), documented dramatic recent declines, and its restriction to the highly disturbed and degraded wider Caribbean region. All of these factors combined to yield a very high estimated extinction risk. It had a marginally lower risk estimate than the other two *O. annularis* complex species because of greater distribution in deep and mesophotic depth habitats, which are expected to experience lesser exposure to some surface-based threats.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species' abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *O. franksi,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. The species has undergone declines most likely from disease and warming-induced bleaching. There is evidence of synergistic effects of threats for this species including increased disease severity with nutrient enrichment. *Orbicella franksi* is highly susceptible to a number of threats, and cumulative effects of multiple threats have likely contributed to its decline and exacerbate vulnerability to extinction. Despite declines, the species is still common and remains one of the most abundant species on Caribbean reefs. Its life history characteristics of large colony size and long life span have enabled it to remain relatively persistent despite slow growth and low recruitment rates, thus moderating vulnerability to extinction. However, the buffering capacity of these life history characteristics is expected to decrease as colonies shift to smaller size classes as has been observed in locations in its range. Its absolute population abundance has been estimated as at least tens of millions of colonies in both a portion of the U.S. Virgin Islands and the Dry Tortugas and is higher than the estimate from these two locations due to the occurrence of the species in many other areas throughout its range. Despite the large number of islands and environments that are included in the species' range, geographic distribution in the highly disturbed Caribbean exacerbates vulnerability to extinction over the foreseeable future because *O. franksi* is limited to an area with high, localized human impacts and predicted increasing threats. Its depth range of five to at least 50 m, possibly up to 90 m, moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower temperatures than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. *Orbicella franksi* occurs in most reef habitats, including both shallow and mesophotic reefs, which moderates vulnerability to extinction over the foreseeable future because the species occurs in numerous types of reef environments that are predicted, on local and regional scales, to experience highly variable thermal regimes and ocean chemistry at any given point in time. Its abundance, life history characteristics, and depth distribution, combined with spatial variability in ocean warming and acidification across the species' range, moderate vulnerability to extinction because the threats are non-uniform, and there will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule, using the determination tool formula approach, *O. franksi* was proposed for listing as endangered because of: High vulnerability to ocean warming (E) disease (C), and ocean acidification (E); high vulnerability to sedimentation (A and E) and nutrient over-enrichment (A and E); decreasing trend in abundance (E); low relative recruitment rate (E); moderate overall distribution (based on narrow geographic distribution and wide depth distribution (E); restriction to the Caribbean (E); and inadequacy of regulatory mechanisms (D).

In this final rule, we changed the listing determination for *O. franksi* from endangered to threatened. We made this determination based on a more species-specific and holistic approach, including consideration of the buffering capacity of this species' spatial and demographic traits, and the best available information above on *O. franksi's* spatial structure, demography, threat susceptibilities, and management. This combination of factors indicates that *O. franksi* is likely to become endangered throughout its range within the foreseeable future, and thus warrants listing as threatened at this time, because:

(1) *Orbicella franksi* is highly susceptible to ocean warming (ESA Factor E), disease (C), nutrients (A, E), ocean acidification (E), and sedimentation (A, E) and susceptible to trophic effects of fishing (A). These threats are expected to continue and increase into the future. In addition, the species is at heightened extinction risk due to inadequate existing regulatory mechanisms to address global threats (D);

(2) *Orbicella franksi* is geographically located in the highly disturbed Caribbean where localized human impacts are high and threats are predicted to increase as described in the Threats Evaluation section. A range constrained to this particular geographic area that is likely to experience severe and increasing threats indicates that a high proportion of the population of this species is likely to be exposed to those threats over the foreseeable future;

(3) *Orbicella franksi* has experienced a decline in benthic cover over the past two decades; and

(4) *Orbicella franksi's* slow growth rate and low sexual recruitment limits its capacity for recovery from threat-induced mortality events throughout its range over the foreseeable future. Additionally, shifts to smaller size classes via fission and partial mortality of older, larger colonies, have reduced the buffering capacity of *O. franksi's* life history strategy.

The combination of these characteristics and future projections of threats indicates that the species is likely to be in danger of extinction within the foreseeable future throughout its range, and warrants listing as threatened at this time due to factors A, C, D, and E.

The available information above on *O. franksi* spatial structure, demography, threat susceptibilities, and management also indicate that the species is not currently in danger of extinction and thus does not warrant listing as Endangered because:

(1) While *Orbicella franksi's* distribution within the Caribbean increases its risk of exposure to threats as described above, its known depth distribution is between 5 and 50 m, with occurrence by the species complex as deep as 90 m, and its habitat includes various shallow and mesophotic reef environments. This moderates vulnerability to extinction currently because the species is not limited to one habitat type but occurs in numerous types of reef environments that will experience highly variable thermal regimes and ocean chemistry on local and regional scales at any given point in time, as described in more detail in the Coral Habitat and Threats Evaluation sections. There is no evidence to suggest that the species is so spatially fragmented that depensatory processes, environmental stochasticity, or the potential for catastrophic events currently pose a high risk to the survival of the species;

(2) Although *O. franksi* has declined in percent cover and colony size, there is evidence that population abundance has remained stable in some locations over a decadal time scale; and

(3) *Orbicella franksi* has a common occurrence and remains one of the most dominant corals in the Caribbean. It has an absolute abundance of at least tens of millions of colonies based on estimates from two locations. Absolute abundance is higher than estimates from these locations since *it* occurs in many other locations throughout its range. This absolute abundance allows for variation in the responses of individuals to threats to play a role in moderating vulnerability to extinction for the species to some degree, as described in more detail in the Corals and Coral Reefs section. There is no evidence of depensatory processes such as reproductive failure from low density of reproductive individuals and genetic processes such as inbreeding affecting this species. Thus, its absolute abundance indicates it is currently able to avoid high mortality from environmental stochasticity, and mortality of a high proportion of its population from catastrophic events.

The combination of these characteristics indicates that the species does not exhibit the characteristics of one that is currently in danger of extinction, as described previously in the Risk Analyses section and thus does not warrant listing as endangered at this time.

Range-wide, multitudes of conservation efforts are already broadly employed that are likely benefiting *O. franksi.* However, considering the global scale of the most important threats to the species, and the ineffectiveness of conservation efforts at addressing the root cause of global threats (*i.e.,* GHG emissions), we do not believe that any current conservation efforts or conservation efforts planned in the future will result in affecting the species' status to the point at which listing is not warranted.

Orbicella annularis

Introduction

The SRR and SIR provided the following information on *O. annularis*' morphology. *Orbicella annularis* colonies grow in columns that exhibit rapid and regular upward growth. In contrast to the other two *Orbicella* species, margins on the sides of columns are typically dead. Live colony surfaces usually lack ridges or bumps. The public comments did not provide new or supplemental information on *O. annularis*' morphology, and we did not find any new or supplemental information.

Spatial Information

The SRR and SIR provided the following information on the distribution, habitat and depth range of *O. annularis. Orbicella annularis* is common throughout the western Atlantic and greater Caribbean including the Flower Garden Banks but may be absent from Bermuda. Two personal communications were cited: one confirming its rarity in Bermuda, and the other stating *O. annularis* had not been seen in Bermuda. *Orbicella annularis* is reported from most reef environments in depths of 0.5 to 20 m. The *Orbicella* species complex is a common, often dominant component of Caribbean mesophotic reefs, suggesting the potential for deep refugia across a broader depth range, but *O. annularis* is generally described with a shallower distribution.

The public comments did not provide new or supplemental information on *O. annularis*' distribution, habitat, or depth range. Supplemental information we found includes the following. Veron (2014) confirmed the occurrence of *O. annularis* in nine out of his 11 ecoregions in the western Atlantic and greater Caribbean known to contain corals, but indicated one of these ecoregions (Bermuda) has published records of occurrence that need further investigation. Locke (2013) indicated early records of *O. annularis* in Bermuda may be incorrect since this species was historically undifferentiated from *O. franksi* and *O. faveolata.* The two ecoregions in which it is not found are off the coasts of Brazil and the southeastern U.S. north of southern Florida (Veron, 2014).

Demographic Information

The SRR and SIR provided the following information on *O. annularis*' abundance and population trends. *Orbicella annularis* has been described as common overall. Demographic data collected in Puerto Rico over nine years straddling the 2005 bleaching event showed that population growth rates were stable in the pre-bleaching period (2001–2005) but declined one year after the bleaching event. Population growth rates declined even further two years after the bleaching event but returned to stasis the following year.

The public comments provided the following supplemental information on *O. annularis*' abundance and population trends. In the Florida Keys, abundance of *O. annularis* ranked 30 out of 47 coral species in 2005, 13 out of 43 in 2009, and 12 out of 40 in 2012. Extrapolated population estimates from stratified random samples were 5.6 million ± 2.7 million (SE) in 2005, 11.5 million ± 4.5 million (SE) in 2009, and 24.3 million ± 12.4 million (SE) in 2012. Size class distribution was somewhat variable between survey years, with a larger proportion of colonies in the smaller size classes in 2005 compared to 2009 and 2012 and a greater proportion of colonies in the largest size class (>90 cm) in 2012 compared to 2005 and 2009. Partial colony mortality was lowest less than 10 cm (as low as approximately 5 percent) up to approximately 70 percent in the larger size classes. In the Dry Tortugas, Florida, abundance of *O. annularis* ranked 41 out of 43 in 2006 and 31 out of 40 in 2008. The extrapolated population estimate was 0.5 million ± 0.3 million (SE) colonies in 2008. Differences in population estimates between years may be attributed to sampling effort rather than population trends (Miller *et al.,* 2013).

Supplemental information we found on *O. annularis*' abundance and population trends includes the following. In Utila, Honduras, *O. annularis* was present at 80 percent of sites surveyed between 1999 and 2000 and was the second most common coral species (Afzal *et al.,* 2001). In a survey of 31 sites in Dominica between 1999 and 2002, *O. annularis* was present at 20 percent of the sites at one to ten percent cover (Steiner, 2003).

Colony density varies by habitat and location, and range from less than 0.1 to greater than one colony per 10 m^2. In surveys of 1,176 sites in southeast Florida, the Dry Tortugas, and the Florida Keys between 2005 and 2010, density of *O. annularis* ranged between 0.09 and 0.84 colonies per 10 m^2 and was highest on mid-channel reefs followed by inshore reefs, offshore patch reefs, and fore-reefs (Burman *et al.,* 2012). Along the east coast of Florida, density was highest in areas south of Miami (0.34 colonies per 10 m^2) compared to Palm Beach and Broward Counties (0.04 colonies per 10 m^2, Burman *et al.,* 2012). In surveys between 2005 to 2007 along the Florida reef tract from Martin County to the lower Florida Keys, density of *O. annularis* was approximately 1.3 colonies per 10 m^2 (Wagner *et al.,* 2010). Off southwest Cuba on remote reefs, *O. annularis* density was 0.31 ± 0.46 (SD) per 10 m transect on 38 reef-crest sites and 1.58 ± 1.29 colonies per 10 m transect on 30 reef-front sites. Colonies with partial mortality were far more frequent than those with no partial mortality which only occurred in the size class less than 100 cm (Alcolado *et al.,* 2010).

Population trends are available from a number of studies. In a study of sites inside and outside a marine protected area in Belize, *O. annularis* cover declined significantly over a ten year period (1998/99 to 2008/09) (Huntington *et al.,* 2011). In a study of ten sites inside and outside of a marine reserve in the Exuma Cays, Bahamas, cover of *O. annularis* increased between 2004 and 2007 inside the protected area and decreased outside the protected area (Mumby and Harborne, 2010). Between 1996 and 2006, *O. annularis* declined in cover by 37 percent in permanent monitoring stations in the Florida Keys (Waddell and Clarke, 2008), and, cover of *O. annularis* in permanent monitoring stations between 1996 and 1998 on a reef in the upper Florida Keys declined 71 percent (Porter *et al.,* 2001).

Orbicella annularis is the third most abundant coral by percent cover in permanent monitoring stations in the U.S. Virgin Islands. A decline of 60 percent was observed between 2001 and 2012 primarily due to bleaching in 2005. However, most of the mortality was partial mortality, and colony density in monitoring stations did not change (Smith, 2013).

At nine sites off Mona and Desecheo Islands, Puerto Rico, no species extirpations were noted at any site over 10 years of monitoring between 1995 and 2008. However, *O. faveolata* and *O. annularis* sustained the largest losses with the number of colonies of *O. annularis* decreasing by 19 and 20 percent at Mona and Desecheo Islands, respectively. In 1998, eight percent of all corals at six sites surveyed off Mona Island were *O. annularis* colonies, dipping to approximately 6 percent in 2008. At Desecheo Island, 14 percent of all coral colonies were *O. annularis* in 2000 and 13 percent in 2008 (Bruckner and Hill, 2009).

Surveys of a degraded and a less degraded site in a marine protected area in Cartagena, Colombia, revealed that while large, old colonies of *O. annularis* were present, colonies had experienced high partial mortality that caused high fission rates and a dominance of small, non-reproductive ramets. Ramets that were non-reproductive or less fertile (less than 46 cm^2) accounted for 72 percent and 55 percent of the population at the surveyed sites, and only one percent and six percent of the ramets at the sites were large enough (200 cm^2) to be fully reproductive. In addition to the small ramet size, the lack of sexual recruitment led the authors to conclude that both populations were in decline, especially at the more degraded reef where mortality was higher and ramets were smaller, as individual colonies seemed to be growing old without being replaced (Alvarado-Chacon and Acosta, 2009).

In a survey of 185 sites in five countries (Bahamas, Bonaire, Cayman Islands, Puerto Rico, and St. Kitts and Nevis) in 2010 to 2011, size of *O. annularis* and *O. franksi* colonies was significantly less than *O. faveolata.* Total mean partial mortality of *O. annularis* colonies at all sites was 40 percent. Overall, the total area occupied by live *O. annularis* declined by a mean of 51 percent, and mean colony size declined from 1927 cm^2 to 939 cm^2. There was a 211 percent increase in small tissue remnants less than 500 cm^2, while the proportion of completely live large (1,500–30,000 cm^2) colonies declined. *Orbicella annularis* colonies in Puerto Rico were much larger with large amounts of dead sections. In contrast, colonies in Bonaire were also large with greater amounts of live tissue. The presence of dead sections was attributed primarily to outbreaks of white plague and yellow band disease, which emerged as corals began recovering from mass bleaching events. This was followed by increased predation and removal of live tissue by damselfish algal lawns (Bruckner, 2012a).

Hughes and Tanner (2000) documented the demographics of *O. annularis* in Jamaica from 1977 to 1993. At the beginning of the study, 86 colonies were present within monitored stations. The number of colonies increased 40 to 42 percent between 1986 and 1987 due to fission (occurring at the same time as a decline in cover) and subsequently declined steadily to 40 colonies by 1993. Rates of survival, population growth, and recruitment declined over time, and the size structure became increasingly dominated by smaller size classes (Hughes and Tanner, 2000). Mortality increased sharply between 1990 and 1993 due to the presence of smaller, more vulnerable colonies formed by partial mortality of larger colonies (Hughes, 1996). The persistence of large colonies had the greatest effect on population growth, and simulations indicated that the levels of recruitment needed to maintain population levels at 1977 levels increased sharply over time (Hughes and Tanner, 2000). Simulations with no sexual recruitment indicated that the population dynamics in the most recent period (1987 to 1993) forecasted a population of zero within approximately 25 years. Simulation using the population dynamics observed between 1982 to 1987 would result in a slower decline while the dynamics observed between 1977 and 1982 would result in population growth (Hughes and Tanner, 2000).

Cover of *O. annularis* at Yawzi Point, St. John, U.S. Virgin Islands declined from 41 percent in 1988 to approximately 12 percent by 2003 with a rapid decline beginning with the aftermath of Hurricane Hugo in 1989 and continuing between 1994 and 1999 during a time of two hurricanes (1995) and a year of unusually high sea temperature (1998), and remaining statistically unchanged between 1999 and 2003. Colony abundances declined from 47 to 20 colonies per m^2 between 1988 and 2003, due mostly to the death and fission of medium to large colonies (≥151 cm^2). Meanwhile, the population size class structure shifted between 1988 and 2003 to a higher proportion of smaller colonies in 2003 (60 percent less than 50 cm^2 in 1988 versus 70 percent in 2003) and lower proportion of large colonies (6 percent greater than 250 cm^2 in 1988 versus 3 percent in 2003). The changes in population size structure indicated a population decline coincident with the period of apparent stable coral cover. Population modeling forecasts the 1988 size structure would not be reestablished by recruitment and a strong likelihood of extirpation of *O. annularis* at this site within 50 years (Edmunds and Elahi, 2007).

Orbicella annularis colonies were monitored between 2001 and 2009 at Culebra Island, Puerto Rico. The population was in demographic equilibrium (high rates of survival and stasis) before the 2005 bleaching event but suffered a significant decline in growth rate (mortality and shrinkage) for two consecutive years after the bleaching event. Partial tissue mortality due to bleaching caused dramatic colony fragmentation that resulted in a population made up almost entirely of small colonies by 2007 (97 percent were less than 50 cm^2). Three years after the bleaching event, the population stabilized at a number of colonies reduced by about half, with fewer medium to large size colonies and more smaller colonies (Hernández-Pacheco *et al.,* 2011).

All information on *O. annularis'* abundance and population trends can be summarized as follows. Historically, *O. annularis* was considered to be one of the most abundant species in the Caribbean (Weil and Knowlton, 1994). Percent cover has declined between 37 to 90 percent over the past several decades at reefs at Jamaica, Belize, Florida Keys, Bahamas, Bonaire, Cayman Islands, Curacao, Puerto Rico, U.S. Virgin Islands, and St. Kitts and Nevis. Based on population estimates, there are at least tens of millions of *O. annularis* colonies present in the Florida Keys and Dry Tortugas combined. Absolute abundance is higher than the estimate from these two locations given the presence of this species in many other locations throughout its range. *Orbicella annularis* remains common in occurrence. Abundance has decreased in some areas between 19 to 57 percent, and shifts to smaller size classes have occurred in locations such as Jamaica, Colombia, Bahamas, Bonaire, Cayman Islands, Puerto Rico, U.S. Virgin Islands, and St. Kitts and Nevis. At some reefs, a large proportion of the population is comprised of non-fertile or less-reproductive size classes. Several population projections indicate population decline in the future is likely at specific sites, and local extirpation is possible within 25 to 50 years at conditions of high mortality, low recruitment, and slow growth rates. We conclude that while substantial population decline has occurred in *O. annularis,* it is still common throughout the Caribbean and remains one of the dominant species numbering at least in the tens of millions of colonies. Additionally, as discussed in the genus section, we conclude that the buffering capacity of *O. annularis'* life history strategy that has allowed it to remain abundant has been reduced by the recent population declines and amounts of partial mortality, particularly in large colonies.

Other Biological Information

The SRR and SIR provided the following information on *O. annularis'* life history. *Orbicella annularis* is reported to have slightly smaller egg size and potentially smaller size/age at first reproduction that the other two species of the *Orbicella genus.*

The public comments did not provide new or supplemental information on the life history of *O. annularis.* Supplemental information we found on *O. annularis'* life history includes the following. The reported growth rate of *O. annularis* is 0.4 to 1.2 cm per year (Cruz-Piñón *et al.,* 2003; Tomascik, 1990). Darling *et al.* (2012) performed a biological trait-based analysis to categorize coral species into four life history strategies: Generalist, weedy, competitive, and stress-tolerant. The classifications were primarily separated by colony morphology, growth rate, and reproductive mode. *Orbicella annularis* was classified as a ''stress-tolerant'' species, thus likely less vulnerable to environmental stress.

The SRR and SIR provided the following other biological information for *O. annularis.* Eight percent of *O. annularis* genotypes across three sites in Belize were clones. Low tissue biomass can render specific colonies of *O. annularis* susceptible to mortality from stress events, such as bleaching or disease. This suggests that differential mortality among individuals, species, and reefs from stress events such as bleaching or disease may be at least partially a function of differential colony biomass (indicating overall coral health) as opposed to genetic or physiologic differences among corals or their symbionts.

In a 2010 cold-water event that affected south Florida, mortality of *O. annularis* was higher than any other coral species in surveys from Martin County to the lower Florida Keys. Average partial mortality was 56 percent during the cold-water event compared to 0.3 percent from 2005 to 2009. Surveys at a Florida Keys inshore patch reef, which experienced temperatures less than 18 degrees C for 11 days, revealed *O. annularis* was one of the most susceptible coral species with all colonies experiencing total colony mortality.

The public comments did not provide new or supplemental biological information on *O. annularis.*

Supplemental biological information we found includes the following. Of 117 colonies of *O. annularis* observed to spawn at a reef site off Bocas del Toro, Panama, there were 21 distinct genotypes, meaning that 82 percent of the colonies were clones (Levitan *et al.,* 2011). Individuals within a genotype spawned more synchronously than individuals of different genotypes. Colonies nearby spawned more synchronously regardless of genotype, out to about 5 m. When colonies were farther away, spawning was random.

Of 137 *O. annularis* colonies sampled in Honduras, 118 were distinct genotypes, meaning that 14 percent of the colonies were clones. Over 90 percent of genotypes were represented by a single colony, and 8 percent of the genotypes were represented by two or three colonies. One genotype had 14 colonies. Distance between clones ranged between 0.15 m to 6.94 m (Foster *et al.,* 2007).

Genetic sampling of 698 *O. annularis* colonies from 18 reefs within five countries in the Caribbean (Belize, Bahamas, Columbia, Curacao, and Honduras) revealed 466 distinct genotypes (approximately 33 percent clones). Genotypic diversity varied across the species' range from genetically diverse populations in Colombia, where every colony was unique, to genetically depauperate populations in Belize and Curacao, where a few genetic clones dominated. The contribution of clones to the local abundance of *O. annularis* increased in areas with greater hurricane frequency. Sites with higher genotypic diversity were dominated by larger colonies, and sites that experienced more frequent hurricanes were composed of smaller colonies than sites with less frequent hurricanes (Foster *et al.,* 2013).

Tissue samples of 1,424 *O. annularis* colonies at 26 reefs in 16 regions of the Caribbean (Bahamas, Cuba, Dominican Republic, Puerto Rico, British Virgin Islands, Dominica, Barbados, Tobago, Venezuela, Netherlands Antilles, Colombia, Nicaragua, Jamaica, Cayman Islands, Belize, and Honduras) produced 943 distinct genotypes (34 percent clones). Three coarse population clusters of *O. annularis* were detected: eastern (Lesser Antilles, Venezuela, and Netherlands Antilles), western (Bahamas, Cuba, Belize, and Cayman Islands), and central (Jamaica, Honduras, Nicaragua, Colombia, Puerto Rico, British Virgin Islands, and Dominican Republic). No barrier to gene flow based on absolute geographic distance was apparent (Foster *et al.,* 2012).

In a study of symbiont composition of repeatedly sampled colonies of six species in the Bahamas and the Florida Keys in 1998 and 2000 to 2004, major changes in symbiont dominance with time were observed in *O. annularis* and *O. franksi* at certain reefs in the Florida Keys. Some colonies of *O. annularis* and *O. franksi* exhibited shifts in their associations attributed to recovery from the stresses of the 1997–1998 bleaching event. Most transitions in symbiont identity ended in 2002, three to five years after the 1997–98 bleaching event (Thornhill *et al.,* 2006).

All other biological information can be summarized as follows. Asexual fission and partial mortality can lead to multiple ramets. The percentage of unique genotypes is variable by location and is reported to range between 18 and 86 percent (14 to 82 percent are clones). Colonies in areas with higher disturbance from hurricanes tend to have more clonality. Genetic data indicate that there is some population structure in the eastern, central, and western Caribbean with population connectivity within areas but not across. Although *O. annularis* is still abundant, it may exhibit high clonality in some locations.

Susceptibility to Threats

The threat susceptibility information from the SRR and SIR was interpreted in the proposed rule for *O. annularis'* vulnerabilities to threats as follows: High vulnerability to ocean warming, disease, acidification, sedimentation, and nutrient enrichment; moderate vulnerability to the trophic effects of fishing; and low vulnerability to sea level rise, predation, and collection and trade.

The SRR and SIR provided the following information on the susceptibility of *O. annularis* to ocean warming. Simulation models using demographic data collected in Puerto Rico over nine years straddling the 2005 bleaching forecasted extinction of the population within 100 years at a bleaching frequency of once every five to ten years.

The public comments did not provide new or supplemental information on the susceptibility of *O. annularis* to ocean warming. Supplemental information we found on the susceptibility of *O. annularis* to ocean warming includes the following. Surveys from 19 locations throughout the Caribbean indicated the bleaching event of 1995–96 was most extensive in the central and western Caribbean but only slight in the Lesser Antilles and Bermuda. Mortality of *O. annularis* from bleaching ranged from 2 to 30 percent at eight locations six months after the onset of bleaching (Alcolado *et al.,* 2001).

Eight of 15 colonies of *O. annularis* monitored in Jamaica from 1994 to 1997 bleached in 1995. Bleaching affected polyp tissue depth, skeletal extension rate, reproduction, and density band formation, but the rate of recovery of each of these characteristics varied. Tissue depth recovered within 4 to 8 weeks after normal color returned, and growth rates returned to pre-bleaching levels once color and tissue depth returned. However, one year post bleaching, reproductive failure occurred in severely bleached colonies (bleached for 4 months and pale for an additional 3 months), and colonies that bleached mildly (bleached for 2 months with pale color for an additional 1 to 3 months) experienced reduced reproduction. Reproductive output of bleached colonies continued to be reduced two years after bleaching (Mendes and Woodley, 2002).

Stratified random surveys on back-reefs and fore-reefs between one and 30 m depth off Puerto Rico (Mona and Desecho Islands, La Parguera, Mayaguez, Boqueron, and Rincon) in 2005 and 2006 revealed severe bleaching in *O. annularis* with greater than 95 percent of colonies bleached (Waddell and Clarke, 2008). Surveys from 2005 to 2007 along the Florida reef tract from Martin County to the lower Florida Keys indicated that *O. annularis* had the seventh highest bleaching prevalence out of 30 species observed (Wagner *et al.,* 2010). During a 2009 bleaching event on Little Cayman, of the ten coral species that bleached, *O. annularis* had the second highest bleaching prevalence with approximately 45 percent of colonies bleached (van Hooidonk *et al.,* 2012).

Surveys at Culebra Island, Puerto Rico revealed extensive bleaching in 2005 with all of the *O. annularis* colonies in monitored transects bleached, and many of the surviving colonies remained pale in color after a year. Cover of *O. annularis* was reduced from 28 percent prior to the bleaching event in 2005 to 8 percent in 2009 (Hernández-Pacheco *et al.,* 2011).

In Barbados, the prevalence and abundance of the zooxanthellae *Symbiodinium trenchi* (D1a) increased in colonies of *O. annularis* in the weeks leading up to and during the 2005 bleaching event, and disproportionately dominated *O. annularis* colonies that did not bleach. In the 2-year period following the bleaching event, *S. trenchi* was displaced by other strains of *Symbiodinium* that were more competitive under less stressful conditions. The authors concluded that it was unclear whether the rise and fall of *S. trenchi* was ecologically beneficial or whether its increased prevalence was an indicator of weakening coral health (LaJeunesse *et al.,* 2009).

Across the U.S. Virgin Islands, average bleaching of *O. annularis* was 66 percent, and paling was 16 percent, during the 2005 bleaching event. Disease prevalence of *O. annularis* was 5 percent after the 2005 bleaching. In the milder 2010 bleaching event, 58 percent of *O. annularis* colonies bleached, and 28 percent of *the* colonies paled. No *O. annularis* colonies suffered total mortality, but percent cover decreased from the 2.5 percent cover in 2005 before bleaching to about one percent in 2010. There was a reduction in the proportion of larger sized colonies and an increase in the proportion of smaller sized colonies due to fission of larger colonies. The authors concluded that the susceptibility to disease increased the impact of bleaching, making *O. annularis* less tolerant overall to ocean warming (Smith *et al.,* 2013b).

All sources of information are used to describe *O. annularis'* susceptibility to ocean warming as follows. *Orbicella annularis* is highly susceptible to bleaching with 45 to 100 percent of colonies observed to bleach. Reported mortality from bleaching ranges from two to 71 percent. Recovery after bleaching is slow with paled colonies observed for up to a year. Reproductive failure can occur a year after bleaching, and reduced reproduction has been observed two years post bleaching. There is indication that symbiont shuffling can occur prior to, during, and after bleaching events and result in bleaching resistance in individual colonies. We conclude that *O. annularis* is highly susceptible to ocean warming.

The SRR and SIR did not provide any species-specific information on the susceptibility of *O. annularis* to acidification, and the public comments did not provide new or supplemental information on its susceptibility to this threat. We did not find any new or supplemental information on the susceptibility of *O. annularis* to acidification. Although there is no species-specific information on the susceptibility of *O. annularis* to ocean acidification, genus information indicates the species complex has reduced growth and fertilization success under acidic conditions. Thus, we conclude *O. annularis* likely has high susceptibility to ocean acidification.

The SRR and SIR did not provide any species-specific information on the susceptibility of *O. annularis* to disease. The public comments did not provide new or supplemental information on the susceptibility of *O. annularis* to disease. Supplemental information we found on the susceptibility of *O. annularis* to disease confirms the information on the *Orbicella* species complex and includes the following. Surveys at five sites along the west coast of Dominica between 2000 and 2002 revealed *O. annularis* was one of the species most susceptible to disease. Of the 12 species infected by white plague in 2000, *O. annularis* ranked third highest in disease prevalence (14.1 percent of infected colonies were *O. annularis*). It ranked second in 2001 out of 14 species (20.3 percent) and third in 2002 out of 13 species (12.7 percent). Although only one colony experienced total colony mortality, *O. annularis* had the third highest amount of tissue loss in the three years combined (11,717 cm^2). Black band disease affected *O. annularis* in 2000 but not in any of the other survey years (Borger and Steiner, 2005).

In a 1998 outbreak of white plague in St. Lucia, three percent of *O. annularis* were affected, which was the lowest prevalence of disease of six species studied (Nugues, 2002). In surveys after the 2010 bleaching event and the passage of a hurricane, 93 percent of diseased colonies (111 of 119 colonies) surveyed in radial transects in Brewers Bay, U.S. Virgin Islands were *O. annularis* (Brandt *et al.,* 2013). Yellow band disease in *O. annularis* increased in prevalence between 1999 and 2004 on reefs near La Parguera and Desecheo and Mona Islands, Puerto Rico (Waddell, 2005).

Disease surveys conducted between August and December 1999 at 19 reef sites from six geographic areas across the wider Caribbean (Bermuda, Puerto Rico, Bonaire, Venezuela, Colombia, and Jamaica) revealed that *O. annularis* showed the highest incidence of disease at 5.5 to 12.6 percent across geographic locations. Yellow band disease showed higher incidences in Bonaire and Venezuela where a high proportion of recently dead ramets of *O. annularis* that most probably died from the disease were observed (Weil *et al.,* 2002).

In Curacao, colonies of *O. annularis* infected with yellow band disease lost 90 percent of their tissue between 1997 and 2005. Only the unaffected parts of colonies continued to grow, and only the smallest lesions healed. Partial mortality was higher in 2005 (average of 40 percent) than in 1998. Outbreaks of white plague occurred in 2001 and 2005 and infected *O. faveolata* and *O. annularis* with the highest frequency (Bruckner and Bruckner, 2006a).

All sources of information are used to describe *O. annularis'* susceptibility to disease as follows. Most studies report *O. annularis* as among the species with the highest disease prevalence. Disease can cause extensive loss in coral cover, high levels of partial colony mortality, and changes in the relative proportions of smaller and larger colonies, particularly when outbreaks occur after bleaching events. Thus, we conclude that *O. annularis* is highly susceptible to disease.

The SRR and SIR provided the following information on the susceptibility of *O. annularis* to the trophic effects of fishing. Interactions between *O. annularis* and four types of benthic algae (encrusting calcified red algae, fleshy brown macroalgae, upright calcareous green algae, and a mixed assemblage of turf algae) indicate that each alga exerts its own characteristic suite of effects on the coral holobiont, and that micro-scale dynamics have the potential to drive changes in reef community composition. Negative impacts spanned the range from micro-scale changes in microbial communities and oxygen drawdown to colony-scale effects such as damage to adjacent polyps and lowered fecundity of the adjacent colony. The public comments did not provide new or supplemental information on the susceptibility of *O. annularis* to the trophic effects of fishing, and we did not find any new or supplemental information.

All sources of information are used to describe *O. annularis'* susceptibility to the trophic effects of fishing as follows. Due to the level of reef fishing conducted in the Caribbean, coupled with *Diadema* die-off and lack of significant recovery, competition with algae can adversely affect coral recruitment. In addition, competition with algae can lead to micro-scale to colony-level negative impacts to *O. annularis.* Thus, we conclude that *O. annularis* has some susceptibility to the trophic effects of fishing. The available information does not support a more precise description of susceptibility to this threat.

The SRR and SIR did not provide species-specific information on the susceptibility of *O. annularis* to sedimentation, and the public comments did not provide new or supplemental information on its susceptibility to this threat. Supplemental information we found confirms the information on the susceptibility of the *Orbicella* species complex to sedimentation and includes the following. In St. Lucia, rates of partial mortality of *O. annularis* and *O. faveolata* were higher close to river mouths where sediments were deposited than they were farther from the river mouths, indicating sensitivity of these two species to sedimentation (Nugues and Roberts, 2003). Additionally, at five study sites in Puerto Rico, the cover of *O. annularis* decreased significantly with a high content of terrigenous sediments (Torres and Morelock, 2002).

All sources of information are used to describe *O. annularis'* susceptibility to sedimentation as follows. Sedimentation can cause partial mortality and decreased coral cover of *O. annularis.* In addition, genus information indicates sedimentation negatively affects primary production, growth rates, calcification, colony size, and abundance. Therefore, we conclude that *O. annularis* has high susceptibility to sedimentation.

The SRR, SIR, and public comments do not provide information on the susceptibility of *O. annularis* to nutrient enrichment. Supplemental information we found on the susceptibility of *O. annularis* to nutrient enrichment includes the following. Field experiments indicate that nutrient enrichment significantly increases yellow band disease severity in *O. annularis* and *O. franksi* through increased tissue loss (Bruno *et al.,* 2003). In laboratory experiments, dissolved organic carbon caused significantly higher mortality of *O. annularis* after 30 days of exposure compared to controls while nutrients (phosphate, nitrate, and ammonia) did not (Kline *et al.,* 2006; Kuntz *et al.,* 2005). Dissolved organic carbon levels that resulted in significantly higher mortality compared to controls were 12.5 mg per L glucose, and 25 mg per L lactose, starch, galactose, and glucose, which were all levels reported for impacted reefs (Kline *et al.,* 2006; Kuntz *et al.,* 2005).

All sources of information are used to describe *O. annularis'* susceptibility to nutrient enrichment as follows. Elevated nutrients cause increased disease severity in *O. annularis.* Genus level information indicates elevated nutrients also cause reduced growth rates and lowered recruitment. Therefore, we conclude that *O. annularis* has high susceptibility to nutrients.

The SRR and SIR do not provide species-specific information on the susceptibility of *O. annularis* to predation. Likewise, the public comments do not provide information on the susceptibility of *O. annularis* to predation. Supplemental information we found on the susceptibility of *O. annularis* to predation includes the following. Predation by the corallivorous snail *C. abbreviata* was present on 2.5 percent of *O. annularis* colonies surveyed in the Florida Keys in 2012 (Miller *et al.,* 2013). Parrotfish consume *O. annularis* and *O. faveolata* more intensively than other coral species, but tissue regeneration capabilities appear to be high enough to counterbalance loss from predation (Mumby, 2009).

All sources of information are used to describe *O. annularis'* susceptibility to predation as follows. *Orbicella annularis* is affected by a number of predators, but losses appear to be minimal. We conclude that *O. annularis* has low susceptibility to predation.

The SRR and SIR did not provide information on the effects of sea level rise on *O. annularis.* The SRR described sea level rise as an overall low to medium threat for all coral species. The public comments did not provide new or supplemental information on *O. annularis'* susceptibility to sea level rise, and we did not find any new or supplemental information. Thus, we conclude that *O. annularis* has some susceptibility to sea level rise, but the available information does not support a more precise description of susceptibility to this threat.

The SRR and SIR did not provide species-specific information on the susceptibility of *O. annularis* to collection and trade, and the public comments did not provide new or supplemental information on its susceptibility to this threat. Supplemental information we found confirms the information in the SRR and SIR that collection and trade is not a significant threat for the *Orbicella* species complex. Over the last decade, collection and trade of this species has been primarily for scientific research rather than commercial purposes. Annual gross exports for collection and trade of *O. annularis* between 2000 and 2012 averaged 1,178 specimens (data available at *http://trade.cites.org*). Thus, we conclude that *O. annularis* has a low susceptibility to collection and trade.

Regulatory Mechanisms

In the proposed rule, we relied on information from the Final Management Report for evaluating the existing regulatory mechanisms for controlling threats to all corals. However, we did not provide any species-specific information on the regulatory mechanism or conservation efforts for *O. annularis.* Public comments were critical of that approach, and we therefore attempt to analyze regulatory mechanisms and conservation efforts on a species basis, where possible, in this final rule. Records confirm that *O. annularis* occurs in nine Atlantic ecoregions that encompass 26 kingdom's and countries' EEZs. The 26 kingdoms and countries are Antigua & Barbuda, Bahamas, Barbados, Belize, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, French Antilles, Grenada, Guatemala, Haiti, Kingdom of the Netherlands, Honduras, Jamaica, Mexico, Nicaragua, Panama, St. Kitts & Nevis, St. Lucia, St. Vincent & Grenadines, Trinidad and Tobago, United Kingdom (British Caribbean Territories and possibly Bermuda), United States (including U.S. Caribbean Territories), and Venezuela. The regulatory mechanisms relevant to *O. annularis,* described first as a percentage of the above kingdoms and countries that utilize them to any degree, and second as the percentage of those kingdoms and countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (31 percent with 12 percent limited in scope), coral collection (50 percent with 27 percent limited in scope), pollution control (31 percent with 15 percent limited in scope), fishing regulations on reefs (73 percent with 50 percent limited in scope), managing areas for protection and conservation (88 percent with 31 percent limited in scope). The most common regulatory mechanisms in place for *O. annularis* are reef fishing regulations and area management for protection and conservation. However, half of the reef fishing regulations are limited in scope and may not provide substantial protection for the species. General coral protection and collection laws, along with pollution control laws, are much less common regulatory mechanisms for the management of *O. annularis.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic traits, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that the factors that increase the extinction risk for *O. annularis* include very low productivity (growth and recruitment), documented dramatic declines in abundance, restriction to the degraded reefs of the wider Caribbean region, and preferential occurrence in shallow habitats (yielding potentially greater exposure to surface-based threats.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species' abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *O. annularis,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. The species has undergone major declines mostly due to warming-induced bleaching and disease. Several population projections indicate population decline in the future is likely at specific sites and that local extirpation is possible within 25 to 50 years at conditions of high mortality, low recruitment, and slow growth rates. There is evidence of synergistic effects of threats for this species including disease outbreaks following bleaching events and increased disease severity with nutrient enrichment. *Orbicella annularis* is highly susceptible to a number of threats, and cumulative effects of multiple threats have likely contributed to its decline and exacerbate vulnerability to extinction. Despite high declines, the species is still common and remains one of the most abundant species on Caribbean reefs. Its life history characteristics of large colony size and long life span have enabled it to remain relatively persistent despite slow growth and low recruitment rates, thus moderating vulnerability to extinction. However, the buffering capacity of these life history characteristics is expected to decrease as colonies shift to smaller size classes as has been observed in locations in its range. Its absolute population abundance has been estimated as at least tens of millions of colonies in the Florida Keys and Dry Tortugas combined and is higher than the estimate from these two locations due to the occurrence of the species in many other areas throughout its range. Despite the large number of islands and environments that are included in the species' range, geographic distribution in the highly disturbed Caribbean exacerbates vulnerability to extinction over the foreseeable future because *O. annularis* is limited to an area with high, localized human impacts and predicted increasing threats. *Orbicella annularis* occurs in most reef habitats 0.5 to 20 m in depth which moderates vulnerability to extinction over the foreseeable future because the species occurs in numerous types of reef environments that are predicted, on local and regional scales, to experience highly variable thermal regimes and ocean chemistry at any given point in time. Its abundance and life history characteristics combined with spatial variability in ocean warming and acidification across the species' range, moderate vulnerability to extinction because the threats are non-uniform, and there will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule, using the determination tool formula approach, *O. annularis* was proposed for listing as endangered because of: High vulnerability to ocean warming (E) disease (C), and ocean acidification (E); high vulnerability to sedimentation (A and E) and nutrient over-enrichment (A and E); decreasing trend in abundance (E); low relative recruitment rate (E); narrow overall distribution (based on narrow geographic distribution and moderate depth distribution (E); restriction to the Caribbean; and inadequacy of regulatory mechanisms (D).

In this final rule, we changed the listing determination for *O. annularis* from endangered to threatened. We made this determination based on a more species-specific and holistic approach, including consideration of the buffering capacity of this species' spatial and demographic traits, and the best available information above on *O. annularis'* spatial structure, demography, threat susceptibilities, and management. The combination of these factors indicates that *O. annularis* is likely to become endangered throughout its range within the foreseeable future, and thus warrants listing as threatened at this time, because:

(1) *Orbicella annularis* is susceptible to ocean warming (ESA Factor E), disease (C), sedimentation (A, E), nutrients (A, E), and ocean acidification (E) and susceptible to trophic effects of fishing (A). These threats are expected to continue and increase into the future. In addition, the species is at heightened extinction risk due to inadequate existing regulatory mechanisms to address global threats (D);

(2) *Orbicella* is geographically located in the highly disturbed Caribbean where localized human impacts are high and threats are predicted to increase as described in the Threats Evaluation section. A range constrained to this particular geographic area that is likely to experience severe and increasing threats indicates that a high proportion of the population of this species is likely to be exposed to those threats over the foreseeable future;

(3) *Orbicella annularis* has undergone declines in abundance and percent cover over the past two decades;

(4) *Orbicella annularis'* slow growth rate and low sexual recruitment limit its capacity for recovery from threat-induced mortality events throughout its range over the foreseeable future. Additionally, shifts to smaller size classes via fission and partial mortality of older, larger colonies, have reduced the buffering capacity of *O. annularis'* life history strategy; and

(5) Several population projections and simulations predict continued population declines and local extirpation at specific sites within the foreseeable future.

The combination of these characteristics and future projections of threats indicates that the species is likely to be in danger of extinction within the foreseeable future throughout its range, and warrants listing as threatened at this time due to factors A, C, D, and E.

The available information above on *O. annularis'* spatial structure, demography, threat susceptibilities, and management also indicate that the species is not currently in danger of extinction and thus does not warrant listing as Endangered because:

(1) While *Orbicella annularis'* distribution within the Caribbean increases its risk of exposure to threats as described above, its habitat includes most reef environments in water depths ranging from 0.5 to 20 m. This moderates vulnerability to extinction currently because the species is not limited to one habitat type but occurs in numerous types of reef environments will experience highly variable thermal regimes and ocean chemistry on local and regional scales at any given point in time, as described in more detail in the Coral Habitat and Threats Evaluation sections. There is no evidence to suggest that the species is so spatially fragmented that depensatory processes, environmental stochasticity, or the potential for catastrophic events currently pose a high risk to the survival of the species;

(2) Although *O. annularis'* abundance has declined, it still has a common

occurrence and remains one of the most dominant corals in the Caribbean. Its absolute abundance is at least tens of millions of colonies based on estimates from two locations. Absolute abundance is higher than estimates from these locations since *it* occurs in many other locations throughout its range. This absolute abundance allows for variation in the responses of individuals to threats to play a role in moderating vulnerability to extinction for the species to some degree, as described in more detail in the Corals and Coral Reefs section. There is no evidence of depensatory processes such as reproductive failure from low density of reproductive individuals and genetic processes such as inbreeding affecting this species. Thus, its absolute abundance indicates it is currently able to avoid high mortality from environmental stochasticity, and mortality of a high proportion of its population from catastrophic events; and

(3) Some evidence shows that symbiont shuffling can occur prior to, during, and after bleaching events and result in bleaching resistance in individual colonies. This indicates *O. annularis* may have some buffering capacity against warming-induced bleaching.

The combination of these characteristics indicates that the species does not exhibit the characteristics of one that is currently in danger of extinction, as described previously in the Risk Analyses section and thus does not warrant listing as endangered at this time.

Range-wide, multitudes of conservation efforts are already broadly employed that are likely benefiting *O. annularis.* However, considering the global scale of the most important threats to the species, and the ineffectiveness of conservation efforts at addressing the root cause of global threats (*i.e.,* GHG emissions), we do not believe that any current conservation efforts or conservation efforts planned in the future will result in affecting the species' status to the point at which listing is not warranted.

Genus Acropora (Caribbean)

Acropora is the only genus considered in this rule that has species from both the Caribbean and the Indo-Pacific. Genus-level information for the Indo-Pacific species is described later under the section heading Genus *Acropora* (Indo-Pacific). Colonies in the Caribbean are all branching. There are over 300 nominal species in the genus *Acropora,* but in the Caribbean, there are only two species and one hybrid. *Acropora cervicornis* and *A. palmata* can interbreed to form the hybrid *A. prolifera* (Brainard *et al.,* 2011). *Acropora cervicornis* shows genetic evidence of introgression or back-crossing with the hybrid *A. prolifera* while *A. palmata* does not (Brainard *et al.,* 2011). The reason may be that *A. palmata* eggs are more resistant to fertilization in comparison to *A. cervicornis* eggs, as evidenced by an order of magnitude higher sperm needed to maximize conspecific fertilization, lower rates of heterospecific fertilization, and reduced viability after four hours (Fogarty *et al.,* 2012c).

Caribbean acroporiids are easily distinguishable and heavily studied. Therefore, this final rule does not provide an exhaustive discussion of the spatial, demographic, and threat vulnerabilities at the genus level. That information is described below for each species.

Acropora cervicornis

Introduction

Acropora cervicornis is characterized by antler-like colonies with straight or slightly curved, cylindrical branches. The diameter of branches ranges from 0.25 to 5 cm (Lirman *et al.,* 2010a), and linear branch growth rates have been reported to range between 3 and 11.5 cm per year (*Acropora* Biological Review Team, 2005). The species can exist as isolated branches, individual colonies up to about 1.5 m diameter, and thickets comprised of multiple colonies that are difficult to distinguish (*Acropora* Biological Review Team, 2005).

Spatial Information

Information on *A. cervicornis'* distribution, habitat, and depth range that we considered in the proposed rule includes the following. *Acropora cervicornis* is distributed throughout the Caribbean, in the southwestern Gulf of Mexico, and in the western Atlantic. The fossil record indicates that during the Holocene, *A. cervicornis* was present as far north as Palm Beach County in southeast Florida (Lighty *et al.,* 1978), which is also the northern extent of its current distribution (Goldberg, 1973).

Acropora cervicornis naturally occurs on spur and groove, bank reef, patch reef, and transitional reef habitats, as well as on limestone ridges, terraces, and hardbottom habitats (Cairns, 1982; Davis, 1982; Gilmore and Hall, 1976; Goldberg, 1973; Jaap, 1984; Miller *et al.,* 2008; Wheaton and Jaap, 1988). It commonly grows in water ranging from five to 20 m in depth and has rarely been found to 60 m (Davis, 1982; Jaap, 1984; Jaap *et al.,* 1989; Schuhmacher and Zibrowius, 1985; Wheaton and Jaap, 1988). At the northern extent of its range, it grows in deeper water (16 to 30 m; Goldberg, 1973). Historically, staghorn coral was one of the primary constructors of mid-depth (10 to 15 m) reef terraces in the western Caribbean, including Jamaica, the Cayman Islands, Belize, and some reefs along the eastern Yucatan peninsula (Adey, 1978). In the Florida Keys, *A. cervicornis* occurs in various habitats but is most prevalent on patch reefs as opposed to their former abundance in deeper fore-reef habitats (Miller *et al.,* 2008). There is no evidence of range constriction, though loss of *A. cervicornis* at the reef level has occurred (*Acropora* Biological Review Team, 2005).

The public comments did not provide new or supplemental information on *A. cervicornis'* habitat or depth range. The public comments provided the following supplemental information on the distribution of *A. cervicornis.* Precht and Aronson (2004) postulate that coincident with climate warming, *A. cervicornis* only recently re-occupied its historic range after contracting to south of Miami, Florida during the late Holocene. They based this idea on the presence of large thickets off Ft. Lauderdale, Florida which were discovered in 1998 and had not been reported in the 1970s or 1980s (Precht and Aronson, 2004). However, because the presence of *A. cervicornis* in Palm Beach County, north of Ft. Lauderdale, was reported in the early 1970s (though no thicket formation was reported; Goldberg, 1973), there is uncertainty associated with whether these thickets were present prior to their discovery or if they recently appeared coincident with warming.

We did not find any new or supplemental information on habitat or depth range. Supplemental information we found on *A. cervicornis'* distribution is consistent with information considered in the proposed rule and includes the following. Veron (2014) confirms the presence of *A. cervicornis* in seven out of a potential 11 ecoregions in the western Atlantic and greater Caribbean that are known to contain corals. The four ecoregions in which it is not found are the Flower Garden Banks and off the coasts of Bermuda, Brazil, and the southeast U.S. north of south Florida. The proportion of reefs with *A. cervicornis* present decreased dramatically after the Caribbean-wide mass mortality in the 1970s and 1980s, indicating the spatial structure of the species has been affected by extirpation from many localized areas throughout its range (Jackson *et al.,* 2014).

Demographic Information

Information on *A. cervicornis'* abundance and population trends that we considered in the proposed rule includes the following. *Acropora cervicornis* has been described as sometimes common (Veron, 2000) and uncommon (Carpenter *et al.,* 2008). *Acropora cervicornis* historically was one of the dominant species on most Caribbean reefs, forming large, monotypic thickets and giving rise to the nominal distinct zone in classical descriptions of Caribbean reef morphology (Goreau, 1959). Massive, Caribbean-wide mortality, apparently primarily from white band disease (Aronson and Precht, 2001), spread throughout the Caribbean in the mid-1970s to mid-1980s and precipitated widespread and radical changes in reef community structure (Brainard *et al.,* 2011). In addition, continuing coral mortality from periodic acute events such as hurricanes, disease outbreaks, and mass bleaching events has added to the decline of *A. cervicornis* (Brainard *et al.,* 2011). In locations where quantitative data are available (Florida, Jamaica, U.S. Virgin Islands, Belize), there was a reduction of approximately 92 to greater than 97 percent between the 1970s and early 2000s (*Acropora* Biological Review Team, 2005).

Fossil evidence from the Dominican Republic indicates that Holocene *A. cervicornis* was capable of thriving for thousands of years under highly variable temperature and salinity conditions and suggests that the recent decline in *A. cervicornis* is anomalous (Greer *et al.,* 2009). Additional fossil evidence from Belize indicates that the recent decline of *A. cervicornis* is without precedent during the late Holocene (Aronson and Precht, 2001). In contrast, two 500 year gaps in the fossil record, around 3 and 4.5 thousand years ago where dated *A. cervicornis* fragments were not observed in samples from the Florida Keys, suggests that the recent decline may not be without precedent (Shinn *et al.,* 2003). However, this study was based on radiocarbon dating of *A. cervicornis* fragments, for which the time of transport and deposition are not known, so there is uncertainty of whether these gaps represent the absence of *A. cervicornis* or variable storm depositional history (Shinn *et al.,* 2003).

Since the 2006 listing of *A. cervicornis* as threatened, continued population declines have occurred in some locations with certain populations of both species decreasing up to an additional 50 percent or more (Colella *et al.,* 2012; Lundgren and Hillis-Starr, 2008; Muller *et al.,* 2008; Rogers and Muller, 2012; Williams *et al.,* 2008).

Public comments provided the following supplemental information on *A. cervicornis'* abundance and population trends. There are some small pockets of remnant robust populations such as in southeast Florida (Vargas-Angel *et al.,* 2003), Honduras (Keck *et al.,* 2005; Riegl *et al.,* 2009), and Dominican Republic (Lirman *et al.,* 2010a). Additionally, Lidz and Zawada (2013) observed 400 colonies of *A. cervicornis* along 70.2 km of transects near Pulaski Shoal in the Dry Tortugas where the species had not been seen since the cold water die-off of the 1970s. Cover of *A. cervicornis* increased on a Jamaican reef from 0.6 percent in 1995 to 10.5 percent in 2004 (Idjadi *et al.,* 2006).

Riegl *et al.* (2009) monitored *A. cervicornis* in photo plots on the fringing reef near Roatan, Honduras from 1996 to 2005. *Acropora cervicornis* cover was 0.42 percent in 1996, declined to 0.14 percent in 1999 after the Caribbean bleaching event in 1998 and mortality from run-off associated with a Category 5 hurricane, and decreased further to 0.09 percent in 2005. *Acropora cervicornis* colony frequency decreased 71 percent between 1997 and 1999. In sharp contrast, offshore banks near Roatan had dense thickets of *A. cervicornis* with 31 percent cover in photo-quadrats in 2005 and appeared to survive the 1998 bleaching event and hurricane, most likely due to bathymetric separation from land and greater flushing. Modeling showed that under undisturbed conditions, retention of the dense *A. cervicornis* stands on the banks off Roatan is likely with a possible increased shift towards dominance by other coral species. However, the authors note that because their data and the literature seem to point to extrinsic factors as driving the decline of *A. cervicornis,* it is unclear what the future may hold for this dense population (Riegl *et al.,* 2009).

Miller *et al.* (2013) extrapolated population abundance of *A. cervicornis* in the Florida Keys and Dry Tortugas from stratified random samples across habitat types. Population estimates of *A. cervicornis* in the Florida Keys were 10.2 ± 4.6 (SE) million colonies in 2005, 6.9 ± 2.4 (SE) million colonies in 2007, and 10.0 ± 3.1 (SE) million colonies in 2012. In the Dry Tortugas population estimates were 0.4 ± 0.4 (SE) million colonies in 2006 and 3.5 ± 2.9 (SE) million colonies in 2008, though the authors note their sampling scheme in the Dry Tortugas was not optimized for *A. cervicornis.* Because these population estimates were based on random sampling, differences in abundance estimates between years may be more likely a function of sampling effort rather than population trends. In both the Florida Keys and Dry Tortugas, most of the population was dominated by small colonies less than 30 cm diameter. In the Florida Keys, partial mortality was highest in 2005, with up to 80 percent mortality observed, and lowest in 2007 with a maximum of 30 percent. In 2012, partial mortality ranged from 20 to 50 percent across most size classes.

Supplemental information we found on *A. cervicornis'* abundance and population trends includes the following. *Acropora cervicornis* was observed in 21 out of 301 stations between 2011 and 2013 in stratified random surveys designed to detect *Acropora* colonies along the south, southeast, southwest, and west coasts of Puerto Rico, and it was observed at an additional 16 sites outside of the surveyed area (García Sais *et al.,* 2013). The largest colony was 60 cm, and density ranged from 1 to 10 colonies per 15 m^2 (García Sais *et al.,* 2013).

While cover of *A. cervicornis* increased from 0.6 percent in 1995 to 10.5 percent in 2004 (Idjadi *et al.,* 2006) and 44 percent in 2005 on a Jamaican reef, it collapsed after the 2005 bleaching event and subsequent disease to less than 0.5 percent in 2006 (Quinn and Kojis 2008). A cold water die-off in the Florida Keys in January 2010 resulted in the complete mortality of all *A. cervicornis* colonies at 45 of the 74 reefs surveyed (61 percent), spanning the lower to upper Florida Keys (Schopmeyer *et al.,* 2012). Walker *et al.* (2012) report increasing size of two thickets (expansion of up to 7.5 times the original size of one of the thickets) monitored off southeast Florida and also noted that cover within monitored plots concurrently decreased by about 50 percent, highlighting the dynamic nature of *A. cervicornis* distribution via fragmentation and re-attachment.

New information we found on population trends includes the following. A report on the status and trends of Caribbean corals over the last century indicates that cover of *A. cervicornis* has remained relatively stable (though much reduced) throughout the region since the large mortality events of the 1970s and 1980s. The frequency of reefs at which *A. cervicornis* was described as the dominant coral has remained stable. The number of reefs with *A. cervicornis* present declined during the 1980s (from approximately 50 to 30 percent of reefs), remained relatively stable through the

1990s, and decreased to approximately 20 percent of the reefs 2000–2004, and approximately 10 percent 2005–2011 (Jackson *et al.,* 2014).

We summarize all sources of information on *A. cervicornis'* abundance and population trends as follows. Based on population estimates, there are at least tens of millions of colonies present in the Florida Keys and Dry Tortugas combined. Absolute abundance is higher than the estimate from these two locations given the presence of this species in many other locations throughout its range. The effective population size is smaller than indicated by abundance estimates due to the tendency for asexual reproduction. There is no evidence of range constriction or extirpation at the island level. However the species is absent at the reef level. Populations appear to consist mostly of isolated colonies or small groups of colonies compared to the vast thickets once prominent throughout its range, with thickets still a prominent feature at only a handful of known locations. Across the Caribbean, percent cover appears to have remained relatively stable since the population crash in the 1980s. Frequency of occurrence has decreased since the 1980s. There are examples of increasing trends in some locations (Dry Tortugas and southeast Florida), but not over larger spatial scales or longer time frames. Population model projections from Honduras at one of the only known-remaining thickets indicate the retention of this dense stand under undisturbed conditions. If refuge populations are able to persist, it is unclear whether they would be able to repopulate nearby reefs as observed sexual recruitment is low. Thus, we conclude that the species has undergone substantial population decline and decreases in the extent of occurrence throughout its range. Percent benthic cover and proportion of reefs where *A. cervicornis* is dominant have remained stable since the mid-1980s and since the listing of the species as threatened in 2006. We also conclude that population abundance is at least tens of millions of colonies, but likely to decrease in the future with increasing threats.

Other Biological Information

Information on *A. cervicornis'* life history that we considered in the proposed rule includes the following. *Acropora cervicornis* is a hermaphroditic broadcast spawning species. The spawning season occurs several nights after the full moon in July, August, or September, but may be split over the course of more than one lunar cycle (Szmant, 1986; Vargas-Angel *et al.,* 2006). The estimated size at sexual maturity is 17 cm branch length, and large colonies produce proportionally more gametes than small colonies (Soong and Lang, 1992). Basal and branch tip tissue is not fertile (Soong and Lang, 1992). Sexual recruitment rates are low, and this species is generally not observed in coral settlement studies. However, laboratory studies have found that certain species of crustose-coralline algae facilitate larval settlement and post-settlement survival (Ritson-Williams *et al.,* 2010).

Reproduction occurs primarily through asexual fragmentation that produces multiple colonies that are genetically identical (Tunnicliffe, 1981). The combination of branching morphology, asexual fragmentation, and fast growth rates can lead to persistence of large areas dominated by *A. cervicornis.*

The public comments did not provide new or supplemental information on *A. cervicornis'* life history. Supplemental information we found on life history includes the following. Darling *et al.* (2012) performed a biological trait-based analysis to categorize coral species into four life history strategies: Generalist, weedy, competitive, and stress-tolerant. The classifications were primarily separated by colony morphology, growth rate, and reproductive mode. *Acropora cervicornis* was classified as a ''competitive'' species, thus likely more vulnerable to environmental stress.

All information on *A. cervicornis'* life history can be summarized as follows. The combination of rapid skeletal growth rates and frequent asexual reproduction by fragmentation can enable effective competition and can facilitate potential recovery from disturbances when environmental conditions permit. However, low sexual reproduction can lead to reduced genetic diversity and limits the capacity to repopulate sites.

Other biological information on *A. cervicornis* that we considered in the proposed rule includes the following. Vollmer and Palumbi (2007) examined 22 populations of *A. cervicornis* from nine regions in the Caribbean (Panama, Belize, Mexico, Florida, Bahamas, Turks and Caicos, Jamaica, Puerto Rico, and Curaçao) and concluded that populations greater than 500 km apart are genetically differentiated with low gene flow across the greater Caribbean. Fine-scale genetic differences have been detected at reefs separated by as little as 2 km, suggesting that gene flow in *A. cervicornis* may not occur at much smaller spatial scales (Garcia Reyes and Schizas, 2010; Vollmer and Palumbi, 2007). This fine-scale population structure was greater when considering genes of *A. palmata* introgressed in *A. cervicornis* due to back-crossing of the hybrid *A. prolifera* with *A. cervicornis* (Garcia Reyes and Schizas, 2010; Vollmer and Palumbi, 2007).

Populations in Florida and Honduras are genetically distinct from each other and other populations in the U.S. Virgin Islands, Puerto Rico, Bahamas, and Navassa (Baums *et al.,* 2010), indicating little to no larval connectivity. However, some potential connectivity between the U.S. Virgin Islands and Puerto Rico was detected and also between Navassa and the Bahamas (Baums *et al.,* 2010).

Florida populations of *A. cervicornis* have high levels of both genetic diversity and connectivity, with evidence suggesting the western Caribbean has historically been the source of genetic variation for Florida (Hemond and Vollmer, 2010). Colonies of *A. cervicornis* in Florida mostly harbored zooxanthellae Clade A, but colonies from inshore and mid-channel reefs, which experience higher sedimentation and temperature fluctuations than reefs further offshore, had a higher prominence of Clades C and D, revealing the influence of habitat on zooxanthellae associations (Baums *et al.,* 2010).

The public comments did not provide new or supplemental biological information on *A. cervicornis,* and we did not find any new or supplemental biological information. All information on *A. cervicornis'* biology can be summarized as follows. Connectivity over distances of greater than 500 km is limited, and there is evidence of restricted gene flow over much smaller spatial scales. Genetic diversity appears to be relatively high in some areas like the Florida Keys.

Susceptibility to Threats

Information on threat susceptibilities was interpreted in the proposed rule for *A. cervicornis'* vulnerabilities to threats as follows: High vulnerability to ocean warming, disease, acidification, sedimentation, and nutrient enrichment; moderate vulnerability to the trophic effects of fishing and predation; and low vulnerability to sea level rise and collection and trade.

Information on *A. cervicornis'* susceptibility to disease that we considered in the proposed rule includes the following. Disease is believed to be the primary cause of the region-wide decline of *A. cervicornis* beginning in the late 1970s (Aronson and Precht, 2001) and continues to have a large impact on the species. White band disease is generally associated with the majority of disease-related mortalities, but several other diseases affect *A. cervicornis*. Ritchie and Smith (1995; 1998) described white band disease type II which is linked with a bacterial infection by *Vibrio carchariae* (Ritchie and Smith, 1998), also referred to as *V. charchariae* and *V. harveyi* (Gil-Agudelo *et al.,* 2006). Williams and Miller (2005) reported an outbreak of a transmissible disease that caused rapid tissue loss on *A. cervicornis* in the Florida Keys in 2003. The disease manifested as irregular, multifocal tissue lesions with apparently healthy tissue remaining in between, a description similar to *A. palmata* afflicted with white pox. Additionally ciliate infections have been reported by Croquer *et al.* (2006) at several locations in the Caribbean.

Few studies follow the progression of disease in individual colonies over time, but there are reports of instantaneous levels of disease at various locations. The *Acropora* Biological Review Team (2005) reported that in the 1997 to 2000 AGRRA surveys, at least 6 percent of *A. cervicornis* colonies were diseased, with greater prevalence documented from the Turks and Caicos (21 percent), Cayman Islands (20 percent), U.S. Virgin Islands (13 percent), and Cuba (8 percent). No disease was recorded on *A. cervicornis* in Jamaica, Mexico, Netherlands Antilles, Panama, and Venezuela during the 1997 to 2000 AGRRA surveys (*Acropora* Biological Review Team, 2005). Between 2001 and 2002, disease was detected at all monitored thickets off Ft. Lauderdale, Florida with mortality ranging from 0.1 to 7.5 percent per site and a mean of 1.8 percent of colony surface area affected (Vargas-Angel *et al.,* 2003). Evidence of white band disease was observed on 5.3 percent of *A. cervicornis* colonies in February 2010 at Cabezos del Cayo, Dominican Republic (Lirman *et al.,* 2010a). During a disease outbreak in the Florida Keys in 2003, 72 percent of the 20 tagged *A. cervicornis* colonies were infected; 28 percent of these suffered complete mortality while many more colonies ended up as remnants of live tissue (less than 10 percent of colony alive; Williams and Miller, 2005).

The public comments provided the following supplemental information on the susceptibility of *A. cervicornis* to disease. No disease was detected in stratified random surveys in the Florida Keys in 2007 (Miller *et al.,* 2013). Vollmer and Kline (2008) found that six percent of *A. cervicornis* genotypes (three out of 49) were resistant to white band disease during *in situ* transmission assays in Bocas del Toro, Panama.

Supplemental information we found on the susceptibility of *A. cervicornis* to disease includes the following. In Honduras, diseases were present in 32 percent of colonies (n = 181) monitored annually from 1996 to 2005 (Riegl *et al.,* 2009). Between zero and 30 percent of *A. cervicornis* colonies monitored in the middle Florida Keys were affected by disease from 2011 to 2012 (Lunz, 2013). About five percent were affected by rapid tissue loss during each quarterly monitoring period (Lunz, 2013).

All information on the susceptibility of *A. cervicornis* to disease can be summarized as follows. *Acropora cervicornis* is highly susceptible to disease as evidenced by the mass-mortality event in the 1970s and 1980s. Although disease is both spatially and temporally variable, about five to six percent of *A. cervicornis* colonies appear to be affected by disease at any one time, though incidence of disease has been reported to range from zero to 32 percent and up to 72 percent during an outbreak. There is indication that some colonies may be resistant to white band disease. *Acropora cervicornis* is also susceptible to several diseases including one that causes rapid tissue loss from multi-focal lesions. Because few studies track diseased colonies over time, determining the present-day colony and population level effects of disease is difficult. One study that monitored individual colonies during an outbreak found that disease can be a major cause of both partial and total colony mortality (Williams and Miller, 2005). Thus, we conclude that *A. cervicornis* is highly susceptible to disease.

Information on *A. cervicornis'* susceptibility to ocean warming that we considered in the proposed rule includes the following. *Acropora cervicornis* was one of the most heavily affected species during a 1987 to 1988 bleaching event in the Cayman Islands with 100 percent of colonies bleached on the deep reef terrace (18 to 29 m depth) and 83 percent bleached on the shallow reef terrace (Ghiold and Smith, 1990). In Puerto Rico, about 75 percent of *A. cervicornis* colonies bleached at 12 monitored sites during the 2005 Caribbean bleaching event (Waddell and Clarke, 2008). At Culebra Island, Puerto Rico approximately 90 percent of the *A. cervicornis* colonies had partial or total mortality during and after the 2005 bleaching event, and bleaching stress and mortality are believed to have resulted in the reproductive failure to subsequently spawn in 2006 (Waddell and Clarke, 2008).

Repeat sampling of colonies in the Florida Keys and Bahamas in 1998, and seasonally between March 2000 and August 2004, showed that colonies of *A. cervicornis* were stable with their associations with *Symbiodinium* type A3 but sometimes had mixed symbiosis with *Symbiodinium* type (B1) (Thornhill *et al.,* 2006). The associations with *Symbiodinium* type (B1) were always short-lived (gone by next sampling period) and did not appear to be correlated with seasonal fluctuations or to follow the 1997 to 1998 bleaching event (Thornhill *et al.,* 2006). Most of the mixed symbiosis events were limited to a single colony except for one sampling period in August 2001 when all colonies at one of the Bahamian sites had mixed symbionts.

The public comments did not provide new or supplemental information on the susceptibility of *A. cervicornis* to ocean warming. Supplemental information we found on the susceptibility of *A. cervicornis* to ocean warming includes the following. In Roatan, Honduras, Riegl *et al.* (2009) monitored *A. cervicornis* and found none were bleached fully during the 1998 bleaching event, with the fourth highest partial bleaching frequency, and the highest mortality of 22 species monitored. During the 2005 bleaching event with 17 species observed, only *A. cervicornis* and *A. palmata* bleached 100 percent (all colonies bleached completely white) at two reefs in Jamaica with 90 percent mortality at one site and 10 percent at the other (Quinn and Kojis, 2008).

Van Woesik *et al.* (2012) developed a coral resiliency index based on biological traits and processes to evaluate extinction risk due to bleaching. Evaluations were performed at the genus level with genera separated between the Caribbean and Indo-Pacific. They reported *A. cervicornis* as highly vulnerable to extinction due to bleaching.

All information on the susceptibility of *A. cervicornis* to ocean warming can be summarized as follows. *Acropora cervicornis* is highly susceptible to bleaching in comparison to other coral species, and mortality after bleaching events is variable. Algal symbionts did not shift in *A. cervicornis* after the 1998 bleaching event, indicating the ability of this species to acclimatize to rising temperatures may not occur through this mechanism. Data from Puerto Rico and Jamaica following the 2005 Caribbean bleaching event indicate that temperature anomalies can have a large impact on total and partial mortality and reproductive output. Thus, we conclude that *A. cervicornis* is highly susceptible to ocean warming.

Information on *A. cervicornis'* susceptibility to acidification that we considered in the proposed rule includes the following. Renegar and Riegl (2005) performed laboratory experiments to examine the effect of nutrients and carbon dioxide on *A. cervicornis* growth. They found significantly reduced growth under carbon dioxide levels of 700 to 800 μatm, predicted to occur this century, compared to controls. In addition, when elevated carbon dioxide was combined with increased nitrate and phosphate, growth rates were further reduced. The effect of combined nitrate, phosphate, and carbon dioxide appeared to be antagonistic at lower nutrient concentrations and additive at higher concentrations (compared to those nutrients paired with carbon dioxide separately). All corals in the combined nitrate, phosphate, and carbon dioxide treatment experienced total mortality, indicating the severe stress this combination induced.

The public comments did not provide new or supplemental information on the susceptibility of *A. cervicornis* to acidification. Supplemental information we found on the susceptibility of *A. cervicornis* to acidification includes the following. Enochs *et al.* (2014) examined the effects of carbon dioxide and light intensity on *A. cervicornis.* They found that carbon dioxide levels projected to occur by the end of the century from ocean acidification caused reduced calcification and skeletal density but no change in linear extension, surface area, or volume. High light intensity did not ameliorate reductions in calcification, and the authors concluded that the high light intensity necessary to reach saturation of photosynthesis and calcification in *A. cervicornis* may limit the effectiveness of this potentially protective mechanism.

All information on the susceptibility of *A. cervicornis* to acidification can be summarized as follows. *Acropora cervicornis* is susceptible to acidification through reduced growth, calcification, and skeletal density, and the effects of increased carbon dioxide combined with increased nutrients appear to be much worse than either stressor alone, and caused 100 percent mortality in some combination in one laboratory study. Therefore, we conclude that *A. cervicornis* is highly susceptible to acidification.

There is no species-specific information on the trophic effects of fishing on *A. cervicornis.* However, due to the level of reef fishing conducted in the Caribbean, coupled with *Diadema* die-off and lack of significant recovery, recruitment habitat is limited. Thus, we conclude that *A. cervicornis* has some susceptibility to the trophic effects of fishing due to its low recruitment rates. However, the available information does not support a more precise description of susceptibility to this threat.

All information on *A. cervicornis'* susceptibility to sedimentation that we considered in the proposed rule includes the following. Exposure to drilling mud reduced calcification rates and protein concentrations in *A. cervicornis,* and exposure to equivalent concentrations of kaolin produced no drop in proteins and a lower drop in calcification rate, indicating the toxic effects of drilling mud are not due solely to increases in turbidity (Kendall *et al.,* 1983).

Acropora cervicornis has poor capacity to remove coarser sediments (250–2000 μm) and only slightly more capacity for removing finer sediments (62–250 μm; Hubbard and Pocock, 1972). Water movement (turbulence) and gravity are probably more important in removing sediments from this species than its capabilities of sloughing sediments in still water (Porter, 1987). In field experiments in Puerto Rico, *A. cervicornis* was less sensitive to single applications (200 mg per cm^2, 400 mg per cm^2, and 800 mg per cm^2) of coarse sediment (mean grain size 0.5 mm) than *A. palmata* and *Orbicella annularis,* likely due to morphology that facilitated passive sediment removal, though some bleaching near the base of the colonies did occur (Rogers, 1983).

Lab experiments testing the effects of sedimentation and phosphate on *A. cervicornis* indicated that sediment-clearing rates declined with increased exposure from less than two hours to up to 24 hours after four weeks of treatment. Treatments resulted in degenerative changes to tissue, zooxanthellae, and gonad development and were more severe in sediment and sediment plus phosphate treatments in comparison to controls and phosphate alone (Hodel and Vargas-Angel, 2007).

Acropora cervicornis is sensitive to turbidity because it is highly reliant on sunlight for nutrition (Lewis, 1977; Porter, 1976). Rogers (1979) shaded a 20 m^2 area of reef as a partial simulation of conditions from turbidity and found that *A. cervicornis* was the first species to respond by bleaching. Three weeks after shading was initiated, most colonies of *A. cervicornis* were bleached. After shading was terminated at five weeks, at the sixth week, most branches were dead and covered with algae with growth tips deteriorating or grazed away, but a few branches recovered. After seven weeks, there were more algae on the branches and further disintegration of branch tips.

Fossil material collected from Bocas del Toro, Panama indicated that *A. cervicornis* declined in lagoonal areas prior to 1960, coincident with intensive land clearing, and continued to decline offshore after 1960, with community structure more tolerant of turbid conditions (Cramer *et al.*, 2012).

The public comments did not provide new or supplemental information on *A. cervicornis'* susceptibility to sedimentation, and we did not find any new or supplemental information. All information on the susceptibility of *A. cervicornis* to sedimentation can be summarized as follows. *Acropora cervicornis* is susceptible to sedimentation through its sensitivity to turbidity, and increased run-off from land clearing has resulted in mortality of this species. In addition, laboratory studies indicate the combination of sedimentation and nutrient enrichment appears to be worse than the effects of either of these two stressors alone. Thus, we conclude that *A. cervicornis* has high susceptibility to sedimentation.

Information on *A. cervicornis'* susceptibility to nutrient enrichment that we considered in the proposed rule includes the following. Renegar and Riegl (2005) performed laboratory experiments to examine the effect of nutrients and carbon dioxide on *A. cervicornis* growth. Under the nutrient treatments alone, *A. cervicornis* experienced significantly lower growth rates under the higher nitrate and higher phosphate treatments, though not under the lower levels, and the combined nitrate and phosphate treatment produced significantly lower growth under both the low and high levels. All corals in the combined nitrate, phosphate, and carbon dioxide treatment experienced total mortality, indicating the severe stress this combination induced.

Lab experiments testing the effects of sedimentation and phosphate on *A. cervicornis* indicated that degenerative changes to tissue, zooxanthellae, and gonad development were more severe in sediment plus phosphate treatments in comparison to controls and phosphate alone (Hodel and Vargas-Angel, 2007).

The public comments did not provide new or supplemental information on the susceptibility of *A. cervicornis* to nutrient enrichment, and we did not find any new or supplemental information on its susceptibility to this threat. All information on the susceptibility of *A. cervicornis* to nutrient enrichment can be summarized as follows. Elevated nutrients can cause decreased growth in *A. cervicornis.* The combined effects of nutrients with other stressors such as elevated carbon dioxide and sedimentation appear to be worse than the effects of nutrients alone, and can cause colony mortality in some combinations. Thus, we conclude that *A. cervicornis* is highly susceptible to nutrient enrichment.

Information on *A. cervicornis'* susceptibility to predation that we considered in the proposed rule includes the following. Known predators of *A. cervicornis* include the corallivorous snail *Coralliophila abbreviata* and the polychaete fireworm *Hermodice carunculata.* Fireworms engulf growing branch tips and devour the live tissue; removal of tissue from growing branch tips of *A. cervicornis* may negatively affect colony growth. Corallivorous snails have also been shown to transmit a disease that causes rapid tissue loss in *A. cervicornis* (Williams and Miller, 2005). Several species of fish including, threespot damselfish *Stegastes planifrons* and yellowtail damselfish *Microspathodon chrysurus*, do not directly feed on coral but remove live tissue to cultivate algal gardens.

In all thickets monitored off Ft. Lauderdale, Florida between 2001 and 2002, densities of fireworms ranged between 18 and 86 individuals per hectare, with predation scars affecting less than 0.2 percent of the *A. cervicornis* cover (Vargas-Angel *et al.*, 2003). Within the survey quadrats, fireworm scar sizes ranged from 1.0 to 8.0 cm, and densities ranged from 0 to 30 per m^2 (Vargas-Angel *et al.*, 2003). Evidence of fireworm predation was observed on 20.3 percent of colonies in Cabezos del Cayo, Dominican Republic in 2010 (Lirman *et al.*, 2010a). Yellowtail damselfish and three-spot damselfish were present on *A. cervicornis* colonies at a density of 0.50 and 0.96 fish per m^2, respectively, in the Dry Tortugas National Park, near Garden Key, Florida in 2004 (Wilkes *et al.*, 2008).

The public comments provided the following supplemental information on the susceptibility of *A. cervicornis* to predation. In stratified random samples in the Florida Keys, damselfish algal gardens were detected on 1.9 percent of colonies in 2007 and 2.6 percent of colonies in 2012. Snail predation was detected on 1.3 percent of colonies in 2012 (Miller *et al.*, 2013).

Supplemental information we found on the susceptibility of *A. cervicornis* to predation includes the following. In Cabezos del Cayo, Dominican Republic, 30 percent of colonies occurred within established damselfish territories, and corallivorous snails were found on 11.3 percent of *A. cervicornis* colonies in 2010 (Lirman *et al.*, 2010a). In permanent monitoring plots in the middle Florida Keys between 2011 and 2012, about ten percent of fate-tracked *A. cervicornis* colonies were affected by fireworm predation, about five percent were affected by damselfish, and about five percent were affected by corallivorous snails (Lunz, 2013).

All information on the susceptibility of *A. cervicornis* to predation can be summarized as follows. Predators can have a negative impact on *A. cervicornis* through both tissue removal and the spread of disease. Predation pressure appears spatially variable. Removal of tissue from growing branch tips of *A. cervicornis* may negatively affect colony growth, but the impact is unknown as most studies do not report on the same colonies through time, inhibiting evaluation of the longer-term impact of these predators on individual colonies and populations. We conclude that *A. cervicornis* is highly susceptible to predation.

Information on *A. cervicornis'* susceptibility to collection and trade that we considered in the proposed rule includes the following. Over the last decade, collection and trade of this species has been low.

The public comments did not provide new or supplemental information on the susceptibility of *A. cervicornis* to collection and trade. Supplemental information we found includes the following. Over the last decade, collection and trade of this species has been primarily for scientific research rather than commercial purposes. Gross exports averaged approximately 2,500 pieces of coral per year between 2000 and 2012 (data available at *http://trade.cites.org*). We conclude that *A. cervicornis* has low susceptibility to collection and trade.

There is no species-specific information on the susceptibility of *A. cervicornis* to sea level rise. The SRR described sea level rise as an overall low to medium threat for all coral species. The public comments did not provide new or supplemental information on *A. cervicornis'* susceptibility to sea level rise, and we did not find any new or supplemental information. Thus, we conclude that *A. cervicornis* has some susceptibility to sea level rise, but the available information does not support a more precise description of susceptibility to this threat.

Regulatory Mechanisms

In the proposed rule, we relied on information from the Final Management Report for evaluating the existing regulatory mechanisms for controlling threats to all corals. However, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *A. cervicornis.* Public comments were critical of that approach, and we therefore attempt to analyze regulatory mechanisms and conservation efforts on a species basis, where possible, in this final rule. We also incorporate here, the evaluation of threats to this species conducted in the 2005 status review. Records confirm that *A. cervicornis* occurs in seven Atlantic ecoregions that encompass 26 kingdom's and countries' EEZs. The 26 kingdoms and countries are Antigua & Barbuda, Bahamas, Barbados, Belize, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, French Antilles, Grenada, Guatemala, Haiti, Kingdom of the Netherlands, Honduras, Jamaica, Mexico, Nicaragua, Panama, St. Kitts & Nevis, St. Lucia, St. Vincent & Grenadines, Trinidad and Tobago, United Kingdom (British Caribbean Territories), United States (including U.S. Caribbean Territories), and Venezuela. The regulatory mechanisms relevant to *A. cervicornis,* described first as a percentage of the above kingdoms and countries that utilize them to any degree, and second as the percentages of those kingdoms and countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (31 percent with 12 percent limited in scope), coral collection (50 percent with 27 percent limited in scope), pollution control (31 percent with 15 percent limited in scope), fishing regulations on reefs (73 percent with 50 percent limited in scope), managing areas for protection and conservation (88 percent with 31 percent limited in scope). The most common regulatory mechanisms in place for *A. cervicornis* are fishing regulations and area management for protection and conservation. However, half of the fishing regulations are limited in scope and may not provide substantial protection for the species. General coral protection and collection laws, along with pollution control laws, are much less common regulatory mechanisms for the management of *A. cervicornis.* The 2005 status review and 2006 listing concluded that existing regulatory mechanisms are inadequate to control both global and local threats, and are contributing to the threatened status of the species, and we incorporate that analysis here.

Additionally, the public comments suggested that we did not fully consider the effects that conservation efforts have on the status of *A. cervicornis.* Therefore, conservation efforts are described as follows. Conservation efforts have been underway for *A. cervicornis* for a number of years. Of 60 *Acropora* restoration efforts identified in 14 Caribbean countries, 88 percent used *A. cervicornis* including efforts in Belize, Colombia, Curaçao, Dominican Republic, Guadalupe, Honduras, Jamaica, Mexico, Puerto Rico, Turks and Caicos, U.S. Virgin Islands, and the Florida Keys (Young *et al.*, 2012). The most popular method is to use coral nurseries to propagate *A. cervicornis* for restoration (Johnson *et al.*, 2011; Young *et al.*, 2012). Fast growth rates, branching morphology, and asexual reproduction through fragmentation make *A. cervicornis* an ideal candidate for active propagation. The use of coral nursery techniques has been shown to be effective and only temporarily affect wild donor colonies from which fragments are taken to initially stock nurseries (Lirman *et al.*, 2010b). Survivorship is high (greater than 70 percent) in nurseries during the first year, but mortality due to storms, temperature anomalies, predation, and water quality have been reported (Young *et al.*, 2012). Survival rates are variable after transplanting, ranging between 43 and 95 percent during the first year (Hollarsmith *et al.*, 2012; Young *et al.*, 2012). Mortality rates of non-nursery raised transplanted *A. cervicornis* after five years were similar to those of reference or wild colonies (Garrison and Ward, 2008).

In conclusion, there are many conservation efforts aimed at increasing abundance and diversity of *A. cervicornis* throughout the Caribbean. These efforts are important, but not enough to ensure conservation unless combined with efforts to reduce the underlying threats and causes of mortality (Young *et al.*, 2012). Thus, while conservation efforts will likely enhance recovery and conservation of *A. cervicornis* at small spatial scales, they are unlikely to affect the overall status of the species, given the global nature of threats.

Vulnerability to Extinction

In 2006, *A. cervicornis* was listed as threatened, *i.e.*, likely to become in danger of extinction within the next 30 years, due to: (1) Recent drastic declines in abundance of the species that have occurred throughout its geographic range and abundances at historic lows; (2) the potential constriction of broad geographic ranges due to local extirpations resulting from a single stochastic event (*e.g.*, hurricanes, new disease outbreak); (3) limited sexual recruitment in some areas and unknown levels in most; and (4) occurrence of the Allee effect (in which fertilization success declines greatly as adult density declines).

The species was not listed as endangered, *i.e.*, currently in danger of extinction, because: (1) It was showing limited, localized recovery; (2) range-wide, the rate of decline appeared to have stabilized and was comparatively slow as evidenced by persistence at reduced abundances for the past two decades; (3) it was buffered against major threats by the large number of colonies, large geographic range, and asexual reproduction; and (4) as shown by the geologic record, the species has persisted through climate cooling and heating fluctuation periods over millions of years, whereas other corals have gone extinct.

In 2012, *A. cervicornis* was proposed for listing as endangered because information available since the original 2006 listing as threatened suggested: (1) Population declines have continued to occur, with certain populations of both species decreasing up to an additional 50 percent or more since the time of listing; (2) there are documented instances of recruitment failure in some populations; (3) minimal levels of thermal stress (*e.g.*, 30 degrees C) have been shown to impair larval development, larval survivorship, and settlement success of *A. palmata;* (4) near-future levels of acidification have been demonstrated to impair fertilization, settlement success, and post-settlement growth rates in *A. palmata;* (5) on average 50 percent of the colonies are clones, meaning the effective number of genetic individuals is half the total population size; (6) the species' ranges are not known to have contracted, but with continued declines local extirpations are likely, resulting in a reduction of absolute range size. Furthermore, we took into account that the BRT identified restriction to the Caribbean as a spatial factor increasing extinction risk, though, among other things, exposure to high levels of human disturbance that result in pollution and breakage impacts. Also, while asexual reproduction (fragmentation) provides a source for new colonies (albeit clones) that can buffer natural demographic and environmental variability remains true, we believed that reliance on asexual reproduction is not sufficient to prevent extinction of the species. Last, the previous status review and listing determination underestimated the global climate change-associated impacts to *A. palmata* and *A. cervicornis,* based on our current knowledge of trends in emissions, likely warming scenarios, and ocean acidification. In particular, in the previous determination, we identified ocean acidification only as a factor that ‘‘may be contributing’’ to the status of two species, in comparison to our current understanding that ocean acidification is one of the three highest order threats affecting extinction risk for corals.

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic traits, threat susceptibilities, and consideration of the baseline environment and future projections of threats. Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species' abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *A. cervicornis,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. The species has undergone substantial population decline and decreases in the extent of occurrence throughout its range due mostly to disease. Although localized mortality events have continued to occur, percent benthic cover and proportion of reefs where *A. cervicornis* is dominant have remained stable over its range since the mid-1980s. There is evidence of synergistic effects of threats for this species including worse effects of nutrients in combination with acidification and sedimentation. *Acropora cervicornis* is highly susceptible to a number of threats, and cumulative effects of multiple threats are likely to exacerbate vulnerability to extinction. Despite the large number of islands and environments that are included in the species' range, geographic distribution in the highly disturbed Caribbean exacerbates vulnerability to extinction over the foreseeable future because *A. cervicornis* is limited to an area with high, localized human impacts and predicted increasing threats. *Acropora cervicornis* commonly occurs in water ranging from 5 to 20 m in depth, though occurs in deeper depths of 16–30 m at the northern extent of its range, and has been rarely found to 60 m in depth. It occurs in spur and groove, bank reef, patch reef, and transitional reef habitats, as well as on limestone ridges, terraces, and hardbottom habitats. This habitat heterogeneity moderates vulnerability to extinction over the foreseeable future because the species occurs in numerous types of reef environments that are predicted, on local and regional scales, to experience highly variable thermal regimes and ocean chemistry at any given point in time. Its absolute population abundance has been estimated as at least tens of millions of colonies in the Florida Keys and Dry Tortugas combined and is higher and is higher than the estimate from these two locations due to the occurrence of the species in many other areas throughout its range. *Acropora cervicornis* has low sexual recruitment rates, which exacerbates vulnerability to extinction due to decreased ability to recover from mortality events when all colonies at a site are extirpated. In contrast, its fast growth rates and propensity for formation of clones through asexual fragmentation enables it to expand between rare events of sexual recruitment and increases its potential for local recovery from mortality events, thus moderating vulnerability to extinction. Its abundance and life history characteristics, combined with spatial variability in ocean warming and acidification across the species' range, moderate vulnerability to extinction because the threats are non-uniform, and there will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule, using the determination tool formula approach, *A. cervicornis* was proposed for listing as endangered because of: High vulnerability to ocean warming (E), ocean acidification (E) and disease (C); high vulnerability to sedimentation (A and E) and nutrient over-enrichment (A and E); uncommon abundance (E); decreasing trend in abundance (E); low relative recruitment rate (E); narrow overall distribution (E); restriction to the Caribbean (E); and inadequacy of regulatory mechanisms (D).

In this final rule, we changed the listing determination for *A. cervicornis* from endangered to threatened. We made this determination based on a more species-specific and holistic approach, including consideration of the buffering capacity of this species' spatial and demographic traits, and the best available information above on *A. cervicornis'* spatial structure, demography, threat susceptibilities, and management. The combination of these factors indicates that *A. cervicornis* is likely to become endangered throughout its range within the foreseeable future, and thus warrants listing as threatened at this time, because:

(1) *Acropora cervicornis* is highly susceptible to ocean warming (ESA Factor E), disease (C), ocean acidification (E), sedimentation (A, E), nutrients (A, E), and predation (C) and susceptible to trophic effects of fishing (A), depensatory population effects from rapid, drastic declines and low sexual recruitment (E), and anthropogenic and natural abrasion and breakage (A, E). These threats are expected to continue and increase into the future. In addition, the species is at heightened extinction risk due to inadequate existing regulatory mechanisms to address both local and global threats (D);

(2) *Acropora cervicornis* is geographically located in the highly disturbed Caribbean where localized human impacts are high and threats are predicted to increase as described in the Threats Evaluation section. A range constrained to this particular geographic area that is likely to experience severe and increasing threats indicates that a high proportion of the population of this species is likely to be exposed to those threats over the foreseeable future; and

(3) *Acropora cervicornis'* abundance is still a fraction of what it was before the mass mortality in the 1970s and 1980s, and its presence on reefs throughout its range has continued to decrease over the last decade.

The combination of these characteristics and future projections of threats indicates that the species is likely to be in danger of extinction within the foreseeable future throughout its range and warrants listing as threatened at this time due to factors A, C, D, and E.

The available information above on *A. cervicornis'* spatial structure, demography, threat susceptibilities, and management also indicate that the species is not currently in danger of extinction and thus does not warrant listing as Endangered because:

(1) While *A. cervicornis'* distribution within the Caribbean increases its risk of exposure to threats as described above, its habitat includes spur and groove, bank reef, patch reef, and transitional reef habitats, as well as limestone ridges, terraces, and hardbottom habitats in water depths ranging from 5 to 60 m. This moderates vulnerability to extinction currently because the species is not limited to one habitat type but occurs in numerous types of reef environments that will experience highly variable thermal regimes and ocean chemistry on local and regional scales at any given point in time, as described in more detail in the Coral Habitat and Threats Evaluation sections;

(2) *Acropora cervicornis'* absolute abundance is at least tens of millions of colonies based on estimates from two locations. Absolute abundance is higher than estimates from these locations since *A. cervicornis* occurs in many other locations throughout its range, including a few small pockets of robust remnant populations. This absolute abundance allows for variation in the responses of individuals to threats to play a role in moderating vulnerability to extinction for the species to some degree, as described in more detail in the Corals and Coral Reefs section;

(3) Recent information indicates that percent cover and proportions of Caribbean sites where *A. cervicornis* is dominant have stabilized;

(4) *Acropora cervicornis* shows evidence of limited population expansion in some portions of its range under some circumstances (*e.g.,* Dry Tortugas, southeast Florida); and

(5) *Acropora cervicornis* has fast growth rates and high capacity to produce clones through asexual fragmentation, which can aid in recovery from mortality events.

The combination of these characteristics indicates that the species does not exhibit the characteristics of one that is currently in danger of extinction, as described previously in the Risk Analyses section, and thus does not warrant listing as endangered at this time. Therefore, we withdraw our proposal to list *A. cervicornis* as endangered.

Progress has been made with *A. cervicornis*-specific conservation and restoration projects, albeit small-scale, and these projects are likely to increase in the future. Within some countries, *A. cervicornis*-specific conservation and restoration projects show promise for enhancing species recovery at very small spatial scales and for facilitating the persistence of the species in some areas in the face of continuing threats. Range-wide, a multitude of conservation efforts are already broadly employed specifically for *A. cervicornis.* However, considering the global scale of the most important threats to the species, and the ineffectiveness of conservation efforts at addressing the root cause of global threats (*i.e.,* GHG emissions), we do not believe that any current conservation efforts or conservation efforts planned in the future will result in affecting the species' status to the point at which listing is not warranted.

A. palmata

Introduction

Acropora palmata colonies have frond-like branches, which appear flattened to near round, and typically radiate out from a central trunk and angle upward. Branches are up to 50 cm wide and range in thickness from 4 to 5 cm. Individual colonies can grow to at least 2 m in height and 4 m in diameter (*Acropora* Biological Review Team, 2005). Colonies of *A. palmata* can grow in nearly mono-specific, dense stands and form an interlocking framework known as thickets.

Spatial Information

Information on *A. palmata's* distribution, habitat, and depth range that we considered in the proposed rule includes the following. *Acropora palmata* is distributed throughout the western Atlantic, Caribbean, and Gulf of Mexico. The northern extent of the range in the Atlantic is Broward County, Florida where it is relatively rare (only a few known colonies), but fossil *A. palmata* reef framework extends into Palm Beach County, Florida. There are two known colonies of *A. palmata,* which were discovered only recently in 2003 and 2005, at the Flower Garden Banks, located 161 km off the coast of Texas in the Gulf of Mexico (Zimmer *et al.,* 2006).

Acropora palmata often grows in thickets in fringing and barrier reefs (Jaap, 1984; Tomascik and Sander, 1987; Wheaton and Jaap, 1988) and formed extensive barrier-reef structures in Belize (Cairns, 1982), the greater and lesser Corn Islands, Nicaragua (Lighty *et al.,* 1982), and Roatan, Honduras, and built extensive fringing reef structures throughout much of the Caribbean (Adey, 1978). *Acropora palmata* commonly grows in turbulent water on the fore-reef, reef crest, and shallow spur-and-groove zone (Cairns, 1982; Miller *et al.,* 2008; Rogers *et al.,* 1982; Shinn, 1963) in water ranging from 1 to 5 m depth. Early studies termed the reef crest and adjacent seaward areas from the surface to five or six meters depth the ''palmata zone'' because of the domination by the species (Goreau, 1959; Shinn, 1963). Maximum depth of framework construction ranges from 3 to 12 m, and colonies generally do not form thickets below a depth of 5 m (Lighty *et al.,* 1982). Although *A. palmata's* predominant habitat is reef crests and shallow fore-reefs less than 12 m depth, it also occurs in back-reef environments and in depths up to 30 m.

Extensive stands of dead colonies throughout the range occurred after mass mortalities during the 1970s and 1980s (see Demographic Information Below). There is no evidence of overall range constriction from the mass mortalities, but local extirpations are likely (Jackson *et al.,* 2014), resulting in a reduction of absolute range size.

The public comments did not provide new or supplemental information on *A. palmata's* habitat or depth range but provided the following supplemental information on its distribution. Precht and Aronson (2004) suggested that the recent expansion of *A. palmata* to the Flower Garden Banks (Zimmer *et al.,* 2006) is possibly due to climate warming.

Supplemental information we found on *A. palmata's* distribution is consistent with prior information. Veron (2014) confirms the occurrence of *A. palmata* in eight of a potential 11 ecoregions in the western Atlantic and wider-Caribbean that are known to contain corals. The three ecoregions in which *A. palmata* is not found are off the coasts of Bermuda, Brazil, and the southeast U.S. north of south Florida. The presence of the species in the Flower Garden Banks may represent a recent re-occupation of its historic range since fossil evidence indicates this species occupied the Flower Garden Banks during the early Holocene but disappeared in the middle Holocene due to sea level rise and possibly cooling temperatures (Precht *et al.,* 2014). Finally, the spatial structure of the species has been affected by extirpation from many localized areas throughout its range (Jackson *et al.,* 2014).

Supplemental information we found on *A. palmata's* habitat and depth includes the following. Goreau (1959) described ten habitat zones on a Jamaican fringing reef from inshore to the deep slope, finding *A. palmata* in eight of the ten zones. *Acropora palmata* was very abundant in the reef crest zones, but also common in several other zones further inshore (the reef flat, rear, channel or lagoon, and inshore zones), and rare on the reef slope to 15 meters depth. Although *A. palmata* is currently much less common throughout its range than it was prior to the mid-1980s, it still occurs in multiple habitats and to depths of one to 30 m. For example, a 2005 study of Bonaire back-reefs found *A. palmata* at three of six sites, including within inshore and lagoon habitats, ranging from seven to 15 m depth. In 2003, aggregations of *A. palmata* were reported from patch reefs at 10 to 20 m depth within the lagoon of Serrano Bank (Sanchez and Pizarro, 2005).

Demographic Information

Information on *A. palmata's* abundance and population trends that we considered in the proposed rule includes the following. *Acropora palmata* has been described as usually common (Veron, 2000) and uncommon (Carpenter *et al.,* 2008). *Acropora palmata* was historically one of the dominant species on Caribbean reefs, forming large, monotypic thickets and giving rise to the nominal distinct zone in classical descriptions of Caribbean reef morphology (Goreau, 1959). Mass mortality, apparently from white-band disease (Aronson and Precht, 2001), spread throughout the Caribbean in the mid-1970s to mid-1980s and precipitated widespread and radical changes in reef community structure (Brainard *et al.,* 2011). This mass mortality occurred throughout the range of the species within all Caribbean countries and archipelagos, even on reefs and banks far from localized human influence (Aronson and Precht, 2001; Wilkinson, 2008). In addition, continuing coral mortality from periodic acute events such as hurricanes, disease outbreaks, and mass bleaching events added to the decline of *A. palmata* (Brainard *et al.,* 2011). In locations where historic quantitative data are available (Florida, Jamaica, U.S. Virgin Islands), there was a reduction of greater than 97 percent between the 1970s and early 2000s (*Acropora* Biological Review Team, 2005).

Since the 2006 listing of *A. palmata* as threatened, continued population declines have occurred in some locations with certain populations of *A. palmata* and *A. cervicornis* decreasing up to an additional 50 percent or more (Colella *et al.,* 2012; Lundgren and Hillis-Starr, 2008; Muller *et al.,* 2008; Rogers and Muller, 2012; Williams *et al.,* 2008). In addition, Williams *et al.* (2008) reported recruitment failure between 2004 and 2007 in the upper Florida Keys after a major hurricane season in 2005; less than five percent of the fragments produced recruited into the population.

The public comments provided the following supplemental information on *A. palmata's* abundance and population trends. Several studies describe *A. palmata* populations that are showing some signs of recovery or are in good condition including in the Turks and Caicos Islands (Schelten *et al.,* 2006), U.S. Virgin Islands (Grober-Dunsmore *et al.,* 2006; Mayor *et al.,* 2006; Rogers and Muller, 2012), Venezuela (Zubillaga *et* *al.,* 2008), and Belize (Macintyre and Toscano, 2007).

Extrapolated population estimates of *A. palmata* from stratified random samples across habitat types in the Florida Keys were 0.6 ± 0.5 million (SE) colonies in 2005, 1.0 ± 0.3 million (SE) colonies in 2007, and 0.5 ± 0.3 million colonies in 2012. Because these population estimates are based on random sampling, differences between years may be a function of sampling effort rather than an indication of population trends. Relative to the abundance of other corals in the Florida Keys region, *A. palmata* was among the least abundant, ranking among corals that are naturally rare in abundance. No colonies of *A. palmata* were observed in surveys of the Dry Tortugas in 2006 and 2008. The size class distribution of the Florida Keys population included both small and large individuals (> 260 cm), but after 2005 the majority of the colonies were smaller in size. These smallest corals (0 to 20 cm) had approximately zero to two percent partial mortality during all three survey years. Partial mortality across all other size classes was approximately 20 to 70 percent in 2005, 5 to 50 percent in 2007, and 15 to 90 percent in 2012 (Miller *et al.,* 2013).

Supplemental information we found on *A. palmata's* abundance includes the following. Relatively abundant *A. palmata* communities have been documented from various locations, including Cuba (Alcolado *et al.,* 2010; González-Díaz *et al.,* 2010), Colombia (Sanchez and Pizarro, 2005), Venezuela (Martínez and Rodríguez Quintal, 2012), Navassa (Bruckner, 2012b), Jamaica (Jackson *et al.,* 2014), and the U.S. Virgin Islands (Muller *et al.,* 2014). Density estimates from sites in Cuba range from 0.14 colonies per m^2 (Alcolado *et al.,* 2010) to 0.18 colonies per m^2 (González-Díaz *et al.,* 2010). Maximum *A. palmata* density at ten sites in St. John, U.S. Virgin Islands was 0.18 colonies per m^2 (Muller *et al.,* 2014).

Mayor *et al.* (2006) reported the abundance of *A. palmata* in Buck Island Reef National Monument, St. Croix, U.S. Virgin Islands. They surveyed 617 sites from May to June 2004 and extrapolated density observed per habitat type to total available habitat. Within an area of 795 ha, they estimated 97,232–134,371 (95% confidence limits) *A. palmata* colonies with any dimension of connected live tissue greater than one meter. Mean densities (colonies ≥ 1 m) were 0.019 colonies per m^2 in branching coral-dominated habitats and 0.013 colonies per m^2 in other hard bottom habitats.

Puerto Rico contains the greatest known extent of *A. palmata* in the U.S. Caribbean. Between 2006 and 2007, a survey of 431 random points in habitat suitable for *A. palmata* in six marine protected areas in Puerto Rico revealed a variable density of zero to 52 *A. palmata* colonies per 100 m^2 (0.52 colonies per m^2), with average density of 3.3 colonies per 100 m^2 (0.03 colonies per m^2). Total loss of *A. palmata* was evidenced in 13.6 percent of the random survey areas where only dead standing colonies were present (Schärer *et al.,* 2009).

In stratified random surveys along the south, southeast, southwest, and west coasts of Puerto Rico designed to locate *Acropora* colonies, *A. palmata* was observed at five out of 301 stations with sightings outside of the survey area at an additional two stations (García Sais *et al.,* 2013). *Acropora palmata* colonies were absent from survey sites along the southeast coast. Maximum density was 18 colonies per 15 m^2 (1.2 colonies per m^2), and maximum colony size was 2.3 m in diameter (García Sais *et al.,* 2013).

Zubillaga *et al.* (2005) report densities of 3.2 colonies of *A. palmata* per 10 m^2 (0.32 colonies per m^2) in Los Roques National Park, Venezuela. At ten sites surveyed in the national park in 2003 to 2004, density ranged from 0 to 3.4 colonies per 10 m^2 (0 to 0.34 colonies per m^2) with four of the sites showing only standing dead colonies (Zubillaga *et al.,* 2008). In the six sites with live colonies, small (0.1 to 50 cm^2) and medium-sized (50 to 4,550 cm^2) colonies predominated over larger-sized (4,550 to16,500 cm^2) colonies.

At Los Colorados reef in northwestern Cuba, a 2006 study at 12 reef crest sampling stations reported average *A. palmata* densities of 0.18 colonies per m^2, and that *A. palmata* made up 8.7 percent of the total live coral colonies at the study sites. The study also reported that the nearby Baracoa and Rincon de Guanabo reefs had similar *A. palmata* densities (González-Díaz *et al.,* 2010). The size of *A. palmata* colonies indicates some recruitment in Cuba, but not the proportions of sexual versus asexual recruits. In a 2005 study of 280 *A. palmata* colonies at four sites on the north coast of Cuba, 30.4 percent were less than 10 cm in diameter (González-Díaz *et al.,* 2008). In a 2006 study of approximately 1,100 *A. palmata* colonies at three sites on the north coast of Cuba, diameter and height size-classes were measured (<2, 3–5, 6–7, 8–10, 11–80, and >80 cm). For the three sites combined, there were approximately 25 to 100 colonies in each of the four smaller size classes (Perera-Pérez *et al.,* 2012).

Supplemental information we found on *A. palmata's* population trends includes the following. At eight of 11 sites in St. John, U.S. Virgin Islands, colonies of *A. palmata* increased in abundance, between 2001 and 2003, particularly in the smallest size class, with the number of colonies in the largest size class decreasing (Grober-Dunsmore *et al.,* 2006). Colonies of *A. palmata* monitored monthly between 2003 and 2009 in Haulover Bay on St. John, U.S. Virgin Islands suffered bleaching and mortality from disease but showed an increase in abundance and size at the end of the monitoring period (Rogers and Muller, 2012). The overall density of *A. palmata* colonies around St. John did not significantly differ between 2004 and 2010 with six out of the ten sites showing an increase in colony density. Size frequency distribution did not significantly change at seven of the 10 sites, with two sites showing an increased abundance of large-sized (> 51 cm) colonies (Muller *et al.,* 2014).

In Colombia, *A. palmata* was present at four of the 32 plots (three of the six reefs) monitored annually from 1998 to 2004. Coverage of *A. palmata* ranged from 0.8 to 2.4 percent. Over the eight-year period, the species was stable at two reefs and declined at the other reef, likely in response to a hurricane in 1999 (Rodriguez-Ramirez *et al.,* 2010). MacIntyre and Toscano (2007) report the return of ''numerous large colonies'' of *A. palmata* on the shallow fore-reef at the southern limit of Carrie Bow Cay, Belize though no quantitative data were presented.

Colonies monitored in the upper Florida Keys showed a greater than 50 percent loss of tissue as well as a decline in the number of colonies, and a decline in the dominance by large colonies between 2004 and 2010 (Vardi *et al.,* 2012; Williams and Miller, 2012). Elasticity analysis from a population model based on data from the Florida Keys has shown that the largest individuals have the greatest contribution to the rate of change in population size (Vardi *et al.,* 2012). Between 2010 and 2013 *A. palmata* in the middle and lower Florida Keys had mixed trends. Population densities remained relatively stable at two sites and decreased at two sites by 21 and 28 percent (Lunz, 2013).

Acropora palmata monitored in Curaçao between 2009 and 2011 decreased in abundance, increased in colony size, with stable tissue abundance following hurricane damage (Bright *et al.,* 2013). The authors explained that the apparently conflicting trends of increasing colony size but similar tissue abundance likely resulted from the loss of small-sized colonies that skewed the distribution to larger size classes, rather than colony growth.

Simulation models using data from matrix models of *A. palmata* colonies from specific sites in Curaçao (2006–2011), the Florida Keys (2004–2011), Jamaica (2007–2010), Navassa (2006 and 2009), Puerto Rico (2007 and 2010), and the British Virgin Islands (2006 and 2007) indicate that most of these studied populations will continue to decline in size and extent by 2100 if background environmental conditions remain unchanged (Vardi, 2011). In contrast, the studied populations in Jamaica were projected to increase in abundance, and studied populations in Navassa were projected to remain stable. Studied populations in the British Virgin Islands were predicted to decrease slightly from their initial very low levels. Studied populations in Florida, Curaçao, and Puerto Rico were predicted to decline to zero by 2100. Because the study period did not include physical damage (storms), the population simulations in Jamaica, Navassa, and the British Virgin Islands may have contributed to the differing projected trends at sites in these locations.

New information we found on population trends includes the following. A report on the status and trends of Caribbean corals over the last century indicates that cover of *A. palmata* has remained relatively stable at approximately one percent throughout the region since the large mortality events of the 1970s and 1980s. The report also indicates that the number of reefs with *A. palmata* present steadily declined from the 1980s to 2000–2004, then remained stable between 2000–2004 and 2005–2011. *Acropora palmata* was present at about 20 percent of reefs surveyed in both the 5-year period of 2000–2004 and the 7-year period of 2005–2011. *Acropora palmata* was dominant on approximately five to ten percent of hundreds of reef sites surveyed throughout the Caribbean during the four periods of 1990–1994, 1995–1999, 2000–2004, and 2005–2011 (Jackson *et al.,* 2014).

All information on *A. palmata'*s abundance and population trends is summarized as follows. Based on population estimates there are at least hundreds of thousands of *A. palmata* colonies present in both the Florida Keys and St. Croix, U.S. Virgin Islands. Absolute abundance is higher than estimates from these two locations given the presence of this species in many other locations throughout its range. The effective population size is smaller than indicated by abundance estimates due to the tendency for asexual reproduction. Across the Caribbean, percent cover appears to have remained relatively stable since the population crash in the 1980s. Frequency of occurrence has decreased since the 1980s, indicating potential decreases in the extent of occurrence and effects on the species' range. However, the proportions of Caribbean sites where *A. palmata* is present and dominant have recently stabilized. There are locations such as the U.S. Virgin Islands where populations of *A. palmata* appear stable or possibly increasing in abundance and some such as the Florida Keys where population number appears to be decreasing. In some cases when size class distribution is not reported, there is uncertainty of whether increases in abundance indicate growing populations or fragmentation of larger size classes into more small-sized colonies. From locations where size class distribution is reported, there is evidence of recruitment, but not the proportions of sexual versus asexual recruits. The best evidence of recovery would come from multi-year studies showing an increase in the overall amount of living tissue of this species, growth of existing colonies, and an increase in the number of small corals arising from sexual recruitment (Rogers and Muller, 2012). Simulation models predict by 2100 that *A. palmata* will become absent at specific sites in several locations (Florida, Curacao, and Puerto Rico), decrease at specific sites in the British Virgin Islands, remain stable at specific sites in Navassa, and increase at specific sites in Jamaica. These simulations are based on the assumption that conditions experienced during the monitoring period, ranging from one to seven years depending on location, would remain unchanged in the future. We conclude there has been a significant decline of *A. palmata* throughout its range, with recent population stability at low percent coverage. We also conclude that absolute abundance is at least hundreds of thousands of colonies, but likely to decrease in the future with increasing threats.

Other Biological Information

Information on *A. palmata'*s life history that we considered in the proposed rule includes the following. Growth rates, measured as skeletal extension of the end of branches, range from 4 to 11 cm per year (*Acropora* Biological Review Team, 2005) but in Curaçao have been reported to be slower today than they were several decades ago (Brainard *et al.,* 2011).

Acropora palmata is a hermaphroditic broadcast spawning species that reproduces after the full moon of July, August, and/or September (*Acropora* Biological Review Team, 2005). The estimated size at sexual maturity is 1600 cm^2, and growing edges and encrusting base areas are not fertile (Soong and Lang, 1992). Larger colonies have higher fecundity per unit area, as do the upper branch surfaces (Soong and Lang, 1992). Although self-fertilization is possible, *A. palmata* is largely self-incompatible (Baums *et al.,* 2005a; Fogarty *et al.,* 2012b).

Reproduction occurs primarily through asexual fragmentation that produces multiple colonies that are genetically identical (Bak and Criens, 1982; Highsmith, 1982; Lirman, 2000; Miller *et al.,* 2007; Wallace, 1985). Storms can be an important mechanism to produce fragments to establish new colonies (Fong and Lirman, 1995). Fragmentation is an important mode of reproduction in many reef-building corals, especially for branching species such as *A. palmata* (Highsmith, 1982; Lirman, 2000; Wallace, 1985). However, in the Florida Keys where populations have declined, there have been reports of failure of asexual recruitment due to high fragment mortality after storms (Porter *et al.,* 2012; Williams and Miller, 2010; Williams *et al.,* 2008).

Sexual recruitment rates are low, and this species is generally not observed in coral settlement studies. Laboratory studies have found that certain species of crustose-coralline algae facilitate larval settlement and post-settlement survival (Ritson-Williams *et al.,* 2010). Rates of post-settlement mortality after nine months are high based on settlement experiments (Szmant and Miller, 2005).

The public comments did not provide new or supplemental information on *A. palmata'*s life history. Supplemental information we found on *A. palmata'*s life history includes the following. Split spawning (spawning over a two month period) has been reported from the Florida Keys (Fogarty *et al.,* 2012b). Laboratory experiments have shown that some individuals (*i.e.,* genotypes) are sexually incompatible (Baums *et al.,* 2013) and that the proportion of eggs fertilized increases with higher sperm concentration (Fogarty *et al.,* 2012b). Experiments using gametes collected in Florida had lower fertilization rates than those from Belize, possibly due to genotype incompatibilities (Fogarty *et al.,* 2012b).

Darling *et al.* (2012) performed a biological trait-based analysis to categorize coral species into four life history strategies: Generalist, weedy, competitive, and stress-tolerant. The classifications were primarily separated by colony morphology, growth rate, and reproductive mode. *Acropora palmata* was classified as a ''competitive'' species, thus likely more vulnerable to environmental stress.

All information on *A. palmata'*s life history can be summarized as follows. The combination of rapid skeletal growth rates and frequent asexual reproduction by fragmentation can enable effective competition within, and domination of, reef-building coral communities in high-energy environments such as reef crests. Rapid skeletal growth rates and frequent asexual reproduction by fragmentation facilitate potential recovery from disturbances when environmental conditions permit (Highsmith, 1982; Lirman, 2000). However, low sexual reproduction can lead to reduced genetic diversity and limits the capacity to repopulate sites.

Other biological information on *A. palmata* that we considered in the proposed rule includes the following. Genetic samples from 11 locations throughout the Caribbean indicate that *A. palmata* populations in the eastern Caribbean (St. Vincent and the Grenadines, U.S. Virgin Islands, Curaçao, and Bonaire) have had little or no genetic exchange with populations in the western Atlantic and western Caribbean (Bahamas, Florida, Mexico, Panama, Navassa, and Puerto Rico) (Baums *et al.,* 2005b). While Puerto Rico is more closely connected with the western Caribbean, it is an area of mixing with contributions from both regions (Baums *et al.,* 2005b). Models suggest that the Mona Passage between the Dominican Republic and Puerto Rico acts as a filter for larval dispersal and gene flow between the eastern Caribbean and western Caribbean (Baums *et al.,* 2006b).

The western Caribbean is characterized by genetically depauperate populations with lower densities (0.13 ± 0.08 colonies per m^2), while denser (0.30 ± 0.21 colonies per m^2), genotypically rich stands characterize the eastern Caribbean (Baums *et al.,* 2006a). Baums *et al.* (2006a) concluded that the western Caribbean had higher rates of asexual recruitment and that the eastern Caribbean had higher rates of sexual recruitment. They postulated these geographic differences in the contribution of reproductive modes to population structure may be related to habitat characteristics, possibly the amount of shelf area available.

Genotypic diversity is highly variable. At two sites in the Florida Keys, only one genotype per site was detected out of 20 colonies sampled at each site (Baums *et al.,* 2005b). In contrast, all 15 colonies sampled in Navassa had unique genotypes (Baums *et al.,* 2006a). Some sites have relatively high genotypic diversity such as in Los Roques, Venezuela (118 unique genotpyes out of 120 samples; Zubillaga *et al.,* 2008) and in Bonaire and Curacao (18 genotypes of 22 samples and 19 genotypes of 20 samples, respectively; Baums *et al.,* 2006a). In the Bahamas, about one third of the sampled colonies were unique genotypes, and in Panama between 24 and 65 percent of the sampled colonies had unique genotypes, depending on the site (Baums *et al.,* 2006a).

The public comments did not provide new or supplemental biological information on *A. palmata.* Supplemental biological information we found includes the following. A genetic study found significant population structure in Puerto Rico locations (Mona Island, Desecheo Island, La Parguerain, La Parguera) both between reefs and between locations; population structure in La Parguera suggests restriction of gene flow between some reefs in close proximity (Garcia Reyes and Schizas, 2010). A more-recent study provided additional detail on the genetic structure of *A. palmata* in Puerto Rico, as compared to Curacao, the Bahamas, and Guadeloupe that found unique genotypes in 75 percent of the samples with high genetic diversity (Mège *et al.,* 2014). The recent results support two separate populations of *A. palmata* in the eastern Caribbean and western Caribbean; however, there is less evidence for separation at Mona Passage, as found by Baums *et al.* (2006b).

All biological information on *A. palmata* can be summarized as follows. Genotypic diversity is variable across the range with some populations showing evidence of higher input from sexual recruitment versus others that rely more heavily on asexual recruitment for population maintenance. There are many areas with many unique genotypes. Connectivity and mixing appear limited across larger geographic scales with eastern Caribbean populations relatively isolated from western Caribbean populations, with evidence of population structure at a local scale in some locations.

Susceptibility to Threats

Information on threat susceptibilities was interpreted in the proposed rule for *A. palmata'*s vulnerability to threats as follows: High vulnerability to ocean warming, disease, acidification, sedimentation, and nutrient enrichment; moderate vulnerability to the trophic effects of fishing and predation; and low vulnerability to sea level rise and collection and trade.

Information on *A. palmata'*s susceptibility to disease that we considered in the proposed rule includes the following. Disease is believed to be the primary cause of the region-wide decline of *A. palmata* beginning in the late 1970s and continues to have a large effect on the species. White band disease was generally associated with the majority of disease-related mortalities in *A. palmata* from the 1970s to 1990s (Aronson and Precht, 2001). White pox has been described as having severe impacts on *A. palmata,* and most monitoring information after 2000 indicates that lesion patterns resembling white pox have higher prevalence than patterns resembling white band disease (*Acropora* Biological Review Team, 2005). In the Florida Keys, the causative agent of white pox was identified as a bacterium linked to human sewage and potential vectors/reservoirs such as corallivores (Patterson *et al.,* 2002; Sutherland *et al.,* 2011).

The effects of white pox appear to be exacerbated by higher temperatures. In Hawksnest Bay, U.S. Virgin Islands during the 2005 bleaching event, the prevalence of white pox had a positive linear relationship with temperature, with mortality increasing with bleaching, indicating a decreased resilience to disease when colonies were stressed (Muller *et al.,* 2008).

Disease is temporally and spatially variable and is often reported as an instantaneous measure of prevalence (percent of colonies affected by disease) that provides only a snapshot in time. For instance, in Puerto Rico disease affected an average of 6.7 percent of colonies from December 2006 to October 2007 (Schärer *et al.,* 2009). In St. Croix U.S. Virgin Islands, white band disease affected three percent of the colonies surveyed in Buck Island Reef National Monument between May and June 2004 (Mayor *et al.,* 2006).

Studies of permanently marked colonies, or monitoring plots, show longer-term trends of disease and mortality over time. From January 2003 to December 2009, 90 percent of the 69 monitored *A. palmata* colonies in Haulover Bay, St. John, U.S. Virgin Islands exhibited signs of disease, and the most significant cause of whole colony mortality (Rogers and Muller, 2012). Of colonies monitored in the

Florida Keys from 2004 to 2011, disease was the second highest cause of tissue mortality after physical damage from storms (33 percent of all mortality attributed to disease, Williams and Miller, 2012).

The public comments did not provide new or supplemental information on the susceptibility of *A. palmata* to disease, and we did not find any new or supplemental information. Information on the susceptibility of *A. palmata* to disease can be summarized as follows. *Acropora palmata* is highly susceptible to disease as evidenced by the mass-mortality event in the 1970s and 1980s. White pox seems to be more common today than white band disease. The effects of disease are spatially and temporally (both seasonally and inter-annually) variable. Results from longer-term monitoring studies in the U.S. Virgin Islands and the Florida Keys indicate that disease can be a major cause of both partial and total colony mortality. Thus, we conclude that *A. palmata* is highly susceptible to disease.

Information on *A. palmata's* susceptibility to ocean warming that we considered in the proposed rule includes the following. High temperatures can cause bleaching and mortality of *A. palmata.* In St. Croix, U.S. Virgin Islands, colonies differentially bleached in Buck Island National Monument during the 2005 Caribbean-wide mass bleaching event; colonies in the shallower back reef bleached earlier and suffered greater tissue loss than those located elsewhere (Lundgren and Hillis-Starr, 2008). Data from two sites in Jamaica, found 100 percent of *A. palmata* colonies bleached at both sites in 2005, with greater than 50 percent of the colonies suffering partial mortality (Quinn and Kojis, 2008). At one site, bleached colonies had complete mortality only occasionally, and 15 percent of bleached colonies died at the second site (Quinn and Kojis, 2008). In Trunk Bay and Saltpond, St. John, U.S. Virgin Islands, almost half of the colonies that bleached in 2005 suffered partial or complete mortality (44 percent of 27 colonies and 40 percent of 107 colonies, respectively, Rogers *et al.,* 2006). Negligible bleaching of *A. palmata* was observed during a 2006 bleaching event in Navassa that affected corals at deeper depths (between 18 and 37 m) more significantly than at shallower depths (<10 m), likely due to decreased water motion at the deeper sites (Miller *et al.,* 2011a). Repeated sampling of the same colonies in the Florida Keys and Bahamas in 1998 and seasonally between March 2000 and August 2004 showed that colonies of *A. palmata* did not change their association with *Symbiodinium* type A3 throughout the study period that included the 1997–98 bleaching event (Thornhill *et al.,* 2006).

High water temperatures also affect *A. palmata* reproduction. *Acropora palmata* embryos and larvae exhibited more developmental abnormalities, lower survivorship, and decreased settlement at 30 degrees and 31.5 degrees C compared to those at 28 degrees C (Randall and Szmant, 2009).

The public comments did not provide new or supplemental information on the susceptibility of *A. palmata* to ocean warming. Supplemental information we found includes the following. *Acropora palmata* larvae exhibited faster development and faster swimming speed at 30 and 31.5 degrees C compared to controls at 27 and 28 degrees C (Baums *et al.,* 2013). The authors suggested these changes could decrease average larval dispersal distances, and cause earlier larval settlement, thereby affecting gene flow among populations (Baums *et al.,* 2013).

A 14-year study was conducted at nine sites around Little Cayman from 1999 to 2012 of live coral cover, juvenile densities, and size structure of coral colonies to determine response to the 1998 bleaching event inside versus outside of marine protected areas. Over the first half of the study, bleaching and disease caused live cover to decrease from 26 percent to 14 percent in all corals, with full recovery seven years later with no differences inside versus outside of marine protected areas. The numbers of *A. palmata* colonies in regularly-observed size-classes did not decrease during this study, which the authors suggested may indicate resistance to bleaching and disease. The study concluded that the health of the coral assemblage and the similarity of responses inside and outside the marine protected area suggested that negligible anthropogenic disturbance at the local scale was a key factor underlying the observed resilience (Manfrino *et al.,* 2013).

Van Woesik *et al.* (2012) developed a coral resiliency index based on biological traits and processes to evaluate extinction risk due to bleaching. Evaluations were performed at the genus level, but genera were separated between the Caribbean and Indo-Pacific. They indicated that *A. palmata* is highly vulnerable to extinction.

All information on the susceptibility of *A. palmata* to ocean warming can be summarized as follows. High water temperatures affect *A. palmata* through bleaching, lowered resistance to disease, and effects on reproduction. Temperature-induced bleaching and mortality following bleaching are temporally and spatially variable. Bleaching associated with the high temperatures in 2005 had a large impact on *A. palmata* with 40 to 50 percent of bleached colonies suffering either partial or complete mortality in several locations. Algal symbionts did not shift in *A. palmata* after the 1998 bleaching event indicating the ability to adapt to rising temperatures may not occur through this mechanism. However, *Acropora palmata* showed evidence of resistance to bleaching from warmer temperatures in some portions of its range under some circumstances (Little Cayman). Through the effects on reproduction, high temperatures can potentially decrease larval supply and settlement success, decrease average larval dispersal distances, and cause earlier larval settlement, thereby affecting gene flow among populations. Therefore, we conclude that *A. palmata* is highly susceptible to ocean warming.

Information on *A. palmata's* susceptibility to acidification that we considered in the proposed rule includes the following. Ocean acidification has a negative impact on early life stages of *A. palmata.* Compared to controls at 400 μatm, carbon dioxide levels of 560 and 800 μatm, predicted to occur this century, reduced the rate of fertilization and settlement (combined 52 and 73 percent, respectively) and post-settlement growth (39 and 50 percent, respectively) of *A. palmata* in lab experiments, and impairment of fertilization was exacerbated at lower sperm concentrations (Albright *et al.,* 2010).

The public comments did not provide new or supplemental information on the susceptibility of *A. palmata* to acidification. Supplemental information we found on its susceptibility to this threat includes the following. No effects on the progression or timing of larval development, or embryo and larval size were detected at elevated carbon dioxide levels of 700 μatm or 1000 μatm (Medina-Rosas *et al.,* 2013).

All information on the susceptibility of *A. palmata* to acidification can be summarized as follows. Ocean acidification will likely impact fertilization, settlement success, and post-settlement growth of *A. palmata.* Therefore, we conclude that *A. palmata* is highly susceptible to acidification.

There is no species-specific information on the trophic effects of fishing on *A. palmata.* However, due to the level of reef fishing conducted in the Caribbean, coupled with *Diadema* die-off and lack of significant recovery, recruitment habitat is limited. Therefore, the trophic effects of reef fishing adversely affects *A. palmata's* recruitment habitat. Thus, we conclude that *A. palmata* has some susceptibility to the trophic effects of reef fishing due to low natural recruitment rates. However, the available information does not support a more precise description of susceptibility to this threat.

Information on *A. palmata's* susceptibility to sedimentation that we considered in the proposed rule includes the following. The morphology of *A. palmata* contributes to its sensitivity to sedimentation as it is poorer at removing sediment compared to mounding corals such as *Orbicella annularis* and *Diploria strigosa* (Abdel-Salam *et al.,* 1988). Out of five species tested, *A. palmata* was the least tolerant of sediment exposure; single applications of 200 mg per cm^2 to colonies caused coral tissue death as sediments accumulated on the flattened, horizontal surfaces (Rogers, 1983). It is generally unable to remove coarser sediments and only weakly able to remove finer sediments (*Acropora* Biological Review Team, 2005). Water movement and gravity are probably more important in removing sediments from this species than their capabilities of sloughing sediments in stagnant water (*Acropora* Biological Review Team, 2005). Because *A. palmata* is highly dependent on sunlight for nutrition, it is also sensitive to suspended sediments that reduce water clarity (Porter, 1976).

The public comments did not provide new or supplemental information on *A. palmata's* susceptibility to sedimentation. Supplemental information we found on the susceptibility of *A. palmata* to sedimentation includes the following. In Vega Baja, Puerto Rico, *A. palmata* mortality increased to 52 percent concurrent with pollution and sedimentation associated with raw sewage and beach nourishment, respectively, between December 2008 and June 2009 (Hernandez-Delgado *et al.,* 2011). Mortality presented as patchy necrosis-like and white pox-like conditions that impacted local reefs following anthropogenic disturbances and was higher inside the shallow platform (52 to 69 percent) and closer to the source of pollution (81 to 97 percent) compared to the outer reef (34 to 37 percent; Hernandez-Delgado *et al.,* 2011).

All information on the susceptibility of *A. palmata* to sedimentation can be summarized as follows. *Acropora palmata* is sensitive to sedimentation due to its poor capability of removing sediment and its high reliance on clear water for nutrition, and sedimentation can cause tissue mortality. We conclude that *A. palmata* is highly susceptible to sedimentation.

Information on *A. palmata's* susceptibility to nutrient enrichment that we considered in the proposed rule includes the following. There are few studies of the effects of nutrients on *A. palmata.* Field experiments indicate that the mean net rate of uptake of nitrate by *A. palmata* exceeds that of ammonium by a factor of two and that *A. palmata* does not uptake nitrite (Bythell, 1990).

The public comments did not provide new or supplemental information on the susceptibility of *A. palmata* to nutrient enrichment. Supplemental information we found on the susceptibility to this threat includes the following. In Vega Baja, Puerto Rico, *A. palmata* mortality increased to 52 percent concurrent with pollution and sedimentation associated with raw sewage and beach nourishment, respectively, between December 2008 and June 2009 (Hernandez-Delgado *et al.,* 2011). Mortality presented as patchy necrosis-like and white pox-like conditions that impacted local reefs following anthropogenic disturbances and was higher inside the shallow platform (52 to 69 percent) and closer to the source of pollution (81 to 97 percent) compared to the outer reef (34 to 37 percent; Hernandez-Delgado *et al.,* 2011).

All information on the susceptibility of *A. palmata* to nutrient enrichment can be summarized as follows. *Acropora palmata* is sensitive to nutrients as evidenced by increased mortality after exposure to raw sewage. We conclude that *A. palmata* is highly susceptible to nutrient enrichment.

Information on *A. palmata's* susceptibility to predation that we considered in the proposed rule includes the following. There are several known predators of *A. palmata* including the corallivorous snail *Coralliophila abbreviata* (Baums *et al.,* 2003) and the polychaete worm *Hermodice carrunculata.* Incidental corallivores that affect *A. palmata* include several species of fish such as stoplight parrotfish *Sparisoma viride* and three-spot damselfish *Stegastes planifrons. Stegastes planifrons* does not directly feed on the coral but removes live tissue to cultivate algal gardens. Likewise, parrotfish are primarily herbivores and may be feeding on endolithic algae in coral tissue (Bruckner *et al.,* 2000). Monitoring in the Florida Keys indicates that parrotfish bites on *A. palmata* usually heal in a matter of weeks to months (*Acropora* Biological Review Team, 2005). Predators have been identified as potential vectors and reservoirs of disease (Sutherland *et al.* 2011).

The corallivorous snail *C. abbreviata* is the main predator, removing up to 16 cm^2 of tissue per day (Brawley and Adey 1982), and there is evidence that they concentrate on remnant *Acropora* populations following decline (*Acropora* Biological Review Team, 2005). Severity of predation is variable, and *Coralliophila* seem to be extremely rare or absent on *Acropora* spp. in certain areas such as the Dry Tortugas, Florida and Bocas del Toro, Panama (*Acropora* Biological Review Team, 2005). In St. John, U.S. Virgin Islands, snail predation affected a total of six percent of the colonies across 29 sites, but at individual sites, predation affected up to 60 percent of the colonies (Grober-Dunsmore *et al.,* 2006). In Los Roques, Venezuela snail predation was the most common cause of partial mortality (4 to 20 percent), and it affected 0.72 to 10.6 percent of the colonies (Zubillaga *et al.,* 2008). Surveys of 235 sites throughout the Florida Keys in 2007 revealed that about five percent of the *A. palmata* colonies assessed for condition were affected via predation by snails and damselfish (Miller *et al.,* 2008). In Puerto Rico, infestations of corallivorous snails were observed on three percent of all *A. palmata* colonies surveyed and ranged from 0.9 to 10.6 percent per site (Schärer *et al.,* 2009).

The public comments did not provide new or supplemental information on the susceptibility of *A. palmata* to predation. Supplemental information we found on the susceptibility of *A. palmata* to predation includes the following. Of the 50 percent tissue loss experienced during monitoring in the Florida Keys between 2004 and 2010, snail predation accounted for 15 percent after storm damage (42 percent) and disease (33 percent; Williams and Miller, 2012). The honeycomb cowfish *Acanthostracion polygonius* has been observed biting *A. palmata* and causing tissue lesions; it is unknown whether the fish is actively feeding on the coral tissue or if lesions are a by-product of its foraging mode (Williams and Bright, 2013). Lesions healed rapidly (less than six weeks) and did not contribute to significant losses of live tissue (Williams and Bright, 2013).

All information on the susceptibility of *A. palmata* to predation can be summarized as follows. Predators can have an impact on *A. palmata* both through tissue removal and the potential to spread disease. Predation pressure is spatially variable and almost non-existent in some locations. However, the effects of predation can become more severe if colonies decrease in abundance and density, as predators focus on the remaining living colonies. Therefore, we conclude that *A. palmata* has high susceptibility to predation.

Information on *A. palmata's* susceptibility to sea level rise that we considered in the proposed rule includes the following. In-place colonies of *A. palmata* have been used in the geologic record for reconstructing Holocene sea level because this species only develops monospecific thickets in waters less than 5 m deep and is generally limited to depths of 10 m or less (Blanchon, 2005; Blanchon *et al.,* 2009). A sustained sea level rise of more than 14 mm per year is likely to displace *A. palmata* from its thicket-forming, framework-building depth range (≤5 m) into its remaining habitat range where a mixed framework is likely to develop (Brainard *et al.,* 2011). In the Yucatan region of Mexico during the warming that led to the last interglacial period, *A. palmata* was able to keep up with the first 3 m of rapid sea-level rise; continued sea-level rise led to the demise of the original fore-reef crests inhabited by *A. palmata,* the retreat of *A. palmata* to a more inland site, and back-stepping of the reef crest as sea level rose an additional 2 to 3 m (total of 6 m over an ecological time scale; Brainard *et al.,* 2011).

The public comments did not provide new or supplemental information on *A. palmata's* susceptibility to sea level rise, and we did not find any new or supplemental information. All information on the susceptibility of *A. palmata* to sea level rise can be summarized as follows. The fast growth rate of *A. palmata* could accommodate deeper water. We conclude that *A. palmata* has a low susceptibility to sea level rise.

Information on *A. palmata's* susceptibility to collection and trade that we considered in the proposed rule includes the following. Over the last decade, collection and trade of this species has been low. The public comments did not provide new or supplemental information on the susceptibility of *A. palmata* to collection and trade. Supplemental information we found includes the following. Gross exports averaged 2,120 pieces of coral per year between 2000 and 2012 and have primarily been for scientific purposes (data available at *http://trade.cites.org*). We conclude that *A. palmata* has low susceptibility to collection and trade.

Regulatory Mechanisms

In the proposed rule, we relied on information from the Final Management Report for evaluating the existing regulatory mechanisms for controlling threats to all corals. However, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *A. palmata.* Public comments were critical of that approach, and we therefore attempt to analyze regulatory mechanisms and conservation efforts on a species basis, where possible, in this final rule. We also incorporate here, the evaluation of threats to this species conducted in the 2005 status review. Records confirm that *A. palmata* occurs in eight Atlantic ecoregions that encompass 26 kingdom's and countries' EEZs. The 26 kingdoms and countries are Antigua & Barbuda, Bahamas, Barbados, Belize, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, French Antilles, Grenada, Guatemala, Haiti, Kingdom of the Netherlands, Honduras, Jamaica, Mexico, Nicaragua, Panama, St. Kitts & Nevis, St. Lucia, St. Vincent & Grenadines, Trinidad and Tobago, United Kingdom (British Caribbean Territories), United States (including U.S. Caribbean Territories), and Venezuela. The regulatory mechanisms relevant to *A. palmata,* described first as a percentage of the above kingdoms and countries that utilize them to any degree, and second as the percentages of those kingdoms and countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (31 percent with 12 percent limited in scope), coral collection (50 percent with 27 percent limited in scope), pollution control (31 percent with 15 percent limited in scope), fishing regulations on reefs (73 percent with 50 percent limited in scope), managing areas for protection and conservation (88 percent with 31 percent limited in scope). The most common regulatory mechanisms in place for *A. palmata* are fishing regulations and area management for protection and conservation. However, half of the fishing regulations are limited in scope. General coral protection and collection laws, along with pollution control laws, are much less common regulatory mechanisms for the management of *A. palmata.* The 2005 status review and 2006 listing concluded that existing regulatory mechanisms are inadequate to control both global and local threats, and are contributing to the threatened status of the species, and we incorporate that analysis here.

Additionally, the public comments suggested that we did not fully consider the effects that conservation efforts have on the status of *A. palmata.* Therefore, conservation efforts are described as follows. Conservation efforts have been underway for *A. palmata* for a number of years. Of 60 *Acropora* restoration efforts identified in 14 Caribbean countries, 52 percent used *A. palmata,* including efforts in Belize, British Virgin Islands, Colombia, Curacao, Dominican Republic, Guadalupe, Jamaica, Mexico, Puerto Rico, Turks and Caicos, U.S. Virgin Islands, and Florida (Young *et al.,* 2012). SECORE, a conservation organization comprised of public aquariums, zoos, and researchers, holds annual workshops to accommodate sexual fertilization of *A. palmata* eggs collected from the wild, with the intent of rearing larvae for development of ex situ populations for conservation (Petersen *et al.,* 2008). However, to date, *A. palmata* colonies produced through in vitro fertilization have rarely been planted into the wild for restoration (but see Roik *et al.,* 2011; Szmant and Miller, 2005).

Restoration efforts involving *A. palmata* more typically re-attach fragments after physical disturbance such as storms or ship groundings (Bruckner and Bruckner, 2001; Garrison and Ward, 2008) or grow colonies in coral nurseries (Becker and Mueller, 2001; Bowden-Kerby and Carne, 2012; Johnson *et al.,* 2011) to outplant. Fast growth rates, branching morphology, and asexual reproduction through fragmentation make *A. palmata* an ideal candidate for active propagation, and there are a number of offshore nurseries that are producing corals for use in restoration and re-establishment of degraded populations. High survivorship (>70 percent) of coral fragments has been found within coral nurseries during the first year of propagation (Young *et al.,* 2012). Survival rates after transplanting are variable, ranging between 43 and 95 percent during the first year, and decreasing in some studies using non-nursery raised fragments to 0 to 20 percent after five years (Young *et al.,* 2012).

In conclusion, there are many conservation efforts aimed at increasing abundance and genetic diversity of *A. palmata* throughout the Caribbean. These efforts are important, but not enough to ensure conservation unless combined with efforts to reduce the underlying threats and causes of mortality (Young *et al.,* 2012). While conservation efforts will likely enhance recovery and conservation of *A. palmata* at small spatial scales, they are unlikely to affect the status of the species, given the global nature of threats.

Vulnerability to Extinction

In 2006, *A. palmata* was listed as threatened, *i.e.,* likely to become in danger of extinction within the next 30 years, due to: (1) Recent drastic declines in abundance of the species that have occurred throughout its geographic range and abundances at historic lows; (2) the potential constriction of broad geographic ranges due to local extirpations resulting from a single stochastic event (*e.g.,* hurricanes, new disease outbreak); (3) limited sexual recruitment in some areas and unknown levels in most; and (4) occurrence of the Allee effect (in which fertilization success declines greatly as adult density declines).

The species was not listed as endangered, *i.e.,* currently in danger of extinction, because: (1) It was showing limited, localized recovery; (2) range-wide, the rate of decline appeared to have stabilized and was comparatively slow as evidenced by persistence at reduced abundances for the past two decades; (3) it was buffered against major threats by the large number of colonies, large geographic range, and asexual reproduction; and (4) as shown by the geologic record, the species has persisted through climate cooling and heating fluctuation periods over millions of years, whereas other corals have gone extinct.

In 2012, *A. palmata* was proposed for listing as endangered because information available since the original 2006 listing as threatened suggested: (1) Population declines have continued to occur, with certain populations of both species decreasing up to an additional 50 percent or more since the time of listing; (2) there are documented instances of recruitment failure in some populations; (3) minimal levels of thermal stress (*e.g.,* 30 degrees C) have been shown to impair larval development, larval survivorship, and settlement success of *A. palmata;* (4) near-future levels of acidification have been demonstrated to impair fertilization, settlement success, and post-settlement growth rates in *A. palmata;* (5) on average 50 percent of the colonies are clones, meaning the effective number of genetic individuals is half the total population size; (6) the species' ranges are not known to have contracted, but with continued declines local extirpations are likely, resulting in a reduction of absolute range size. Furthermore, we took into account that the BRT identified restriction to the Caribbean as a spatial factor increasing extinction risk, though, among other things, exposure to high levels of human disturbance that result in pollution and breakage impacts. Also, while asexual reproduction (fragmentation) provides a source for new colonies (albeit clones) that can buffer natural demographic and environmental variability remains true, we believed that reliance on asexual reproduction is not sufficient to prevent extinction of the species. Last, the previous status review and listing determination underestimated the global climate change-associated impacts to *A. palmata* and *A. cervicornis,* based on our current knowledge of trends in emissions, likely warming scenarios, and ocean acidification. In particular, in the previous determination, we identified ocean acidification only as a factor that ''may be contributing'' to the status of two species, in comparison to our current understanding that ocean acidification is one of the three highest order threats affecting extinction risk for corals.

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic traits, threat susceptibilities, and consideration of the baseline environment and future projections of threats. Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species' abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *A. palmata,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. The species has undergone substantial population decline and decreases in the extent of occurrence throughout its range due mostly to disease. Although localized mortality events have continued to occur, percent benthic cover and proportion of reefs where *A. palmata* is dominant have remained stable over its range since the mid-1980s. There is evidence of synergistic effects of threats for this species including disease outbreaks following bleaching events. *Acropora palmata* is highly susceptible to a number of threats, and cumulative effects of multiple threats are likely to exacerbate vulnerability to extinction. Despite the large number of islands and environments that are included in the species' range, geographic distribution in the highly disturbed Caribbean exacerbates vulnerability to extinction over the foreseeable future because *A. palmata* is limited to an area with high localized human impacts and predicted increasing threats. *Acropora palmata* occurs in turbulent water on the back reef, fore reef, reef crest, and spur and groove zone in water ranging from 1 to 30 m in depth. This moderates vulnerability to extinction over the foreseeable future because the species occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Its absolute population abundance has been estimated as at least hundreds of thousands of colonies in both Florida and a portion of the U.S. Virgin Islands and is higher than the estimate from these two locations due to the occurrence of the species in many other areas throughout its range. *Acropora palmata* has low sexual recruitment rates, which exacerbates vulnerability to extinction due to decreased ability to recover from mortality events when all colonies at a site are extirpated. In contrast, its fast growth rates and propensity for formation of clones through asexual fragmentation enables it to expand between rare events of sexual recruitment and increases its potential for local recovery from mortality events, thus moderating vulnerability to extinction. Its abundance and life history characteristics, combined with spatial variability in ocean warming and acidification across the species' range, moderate vulnerability to extinction because the threats are non-uniform, and there will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule, using the determination tool formula approach, *A. palmata* was proposed for listing as endangered because of: High vulnerability to ocean warming (E), ocean acidification (E) and disease (C); high vulnerability to sedimentation (A and E) and nutrient over-enrichment (A and E); uncommon abundance (E); decreasing trend in abundance (E); low relative recruitment rate (E); narrow overall distribution (E); restriction to the Caribbean (E); and inadequacy of regulatory mechanisms (D).

In this final rule, we changed the listing determination for *A. palmata* from endangered to threatened. We made this determination based on a more species-specific and holistic approach, including consideration of the buffering capacity of this species' spatial and demographic traits, and the best available information above on *A. palmata's* spatial structure, demography, threat susceptibilities, and management. The combination of these factors indicates that *A. palmata* is likely to become endangered throughout its range within the foreseeable future, and thus warrants listing as threatened at this time, because:

(1) *Acropora palmata* is highly susceptible to ocean warming (ESA Factor E), disease (C), ocean acidification (E), sedimentation (A, E), nutrients (A, E), and predation (C) and susceptible to trophic effects of fishing (A), depensatory population effects from rapid, drastic declines and low sexual recruitment (C), and anthropogenic and natural abrasion and breakage (A, E). These threats are expected to continue and increase into the future. In addition, the species is at heightened extinction risk due to inadequate existing regulatory mechanisms to address local and global threats (D);

(2) *Acropora palmata* is geographically located in the highly disturbed Caribbean, where localized human impacts are high and threats are predicted to increase as described in the Threats Evaluation section. A range constrained to this particular geographic area that is likely to experience severe and increasing threats indicates that a high proportion of the population of this species is likely to be exposed to those threats over the foreseeable future; and

(3) *Acropora palmata*'s abundance is still a fraction of what it was before the mass mortality in the 1970s and 1980s, and recent population models forecast the extirpation of the species from some locations over the foreseeable future.

The combination of these characteristics and future projections of threats indicates that the species is likely to be in danger of extinction within the foreseeable future throughout its range and warrants listing as threatened at this time due to factors A, C, D, and E.

The available information above on *A. palmata*'s spatial structure, demography, threat susceptibilities, and management also indicate that the species is not currently in danger of extinction and thus does not warrant listing as Endangered because:

(1) While *A. palmata*'s distribution in the Caribbean increases its risk of exposure to threats as described above, its habitat includes back reef environments and turbulent water on the fore reef, reef crest, shallow spur and groove zone. It is most commonly found in depths of one to 12 m but is also found in depths up to 30 m. This moderates vulnerability to extinction currently because the species is not limited to one habitat type but occurs in numerous types of reef environments that will experience highly variable thermal regimes and ocean chemistry on local and regional scales at any given point in time, as described in more detail in the Coral Habitat and Threats Evaluation sections;

(2) *Acropora palmata*'s absolute abundance is at least hundreds of thousands of colonies based on estimates from two locations in its range. Absolute abundance is higher than estimates from these locations since *A. palmata* occurs in many other locations throughout its range. This absolute abundance allows for variation in the responses of individuals to threats to play a role in moderating vulnerability to extinction for the species to some degree, as described in more detail in the Corals and Coral Reefs section;

(3) Recent information indicates that proportions of Caribbean sites where *A. palmata* is present and dominant have stabilized;

(4) *Acropora palmata* has fast growth rates and high capacity to produce clones through asexual fragmentation, which can aid in local recovery from mortality events; and

(5) *Acropora palmata* shows evidence of resistance to bleaching from warmer temperatures in some portions of its range under some circumstances (*e.g.* Little Cayman).

The combination of these characteristics indicates that the species does not exhibit the characteristics of one that is currently in danger of extinction, as described previously in the Risk Analyses section and thus does not warrant listing as endangered at this time. Therefore, we withdraw our proposal to list *A. palmata* as endangered.

Progress has been made with *A. palmata*-specific conservation and restoration projects, albeit small-scale, and these projects are likely to increase in the future. Within some countries, *A. palmata*-specific conservation and restoration projects show promise for enhancing species recovery at very small spatial scales and facilitating the persistence of the species in some areas in the face of continuing threats. Range-wide, a multitude of conservation efforts are already broadly employed specifically for *A. palmata.* However, considering the global scale of the most important threats to the species, and the ineffectiveness of conservation efforts at addressing the root cause of global threats (*i.e.,* GHG emissions), we do not believe that any current conservation efforts or conservation efforts planned in the future will result in affecting the species' status to the point at which listing is not warranted.

Indo-Pacific Species Determinations

Absolute abundance is approximated at a coarse scale in the Demographic Information sections for most of the Indo-Pacific species, based on a comparison of corrected data from Richards *et al.* (2008) and the distribution and abundance results from Veron (2014). Mean global census sizes for four species in this final rule (*Acropora jacquelineae, A. lokani, A. speciosa,* and *A. tenella*) are provided in Richards *et al.* (2008). An error in the global census size formula (Richards *et al.* 2008, Supplementary Information file Methods_S1) resulted in 1,000-fold under-estimates of global census size in Richards *et al.* (2008) for these four species, as confirmed by NMFS with the author in 2013. Richards *et al.'*s (2008) corrected census results were compared with Veron's ecoregion distribution and semi-quantitative abundance results to derive coarse approximations of absolute abundance. For each species, the resulting absolute abundance is described as either ''at least millions of colonies,'' or ''at least tens of millions of colonies'' (NMFS, 2014). Although this comparison produces only very general approximations of abundance, large scale estimates are sufficient for considering whether population size provides buffering capacity within the context of our listing determinations.

Genus Millepora

Genus Introduction

The SRR and SIR provided no genus-level introduction information for *Millepora.* However, they did provide the following information on reproduction in the genus. *Millepora* species are hydrozoans, thus their life history cycle includes a medusae stage, a free-swimming, bell-shaped form (''jellyfish'') that produces gametes. Reproduction is seasonal. The adult coral colonies produce tiny medusae, which release gametes within a few days after being released from the colony. Medusae are in separate sexes, and the milleporid medusae of some species live for only a few hours. The gametes of some milleporids can become mature in 20 to 30 days, more rapidly than for many scleractinians. Hydrozoan corals of the genus *Millepora* are the only reef-building corals with medusae as part of their life history. Branching and columnar forms of *Millepora* are subject to fragmentation and may use this mechanism to reproduce asexually; unlike scleractinian corals, the survival of *Millepora* fragments may not be size-dependent.

There is only one genus in the Family Milleporidae, the genus *Millepora.* About 16 species of *Millepora* are currently considered valid. While all coral species in this final rule are ''cnidarians'' (Phylum Cnidaria), *Millepora* are ''hydrozoans'' (Class Hydrozoa, which includes jellyfish), whereas all other species in this rule are ''scleractinians'' (Class Anthozoa, Order Scleractinia). Like other reef-building corals, *Millepora* species contain zooxanthellae, produce calcium carbonate skeletons, may grow fast, and are thus major contributors to the physical structure of coral reefs. Unlike other reef-building corals, the surfaces of *Millepora* colonies are covered with tiny polyps that look like hairs, containing stinging cells to capture prey. Most species can sting humans with the same stinging cells, hence the common name ''fire corals.'' Colonies of *Millepora* species are encrusting, branching, foliose (leafy), or combinations of these forms. The biology and ecology of *Millepora* are reviewed in Lewis (2006).

Genus Susceptibility to Threats

The SRR and SIR provided the following information on the threat susceptibilities of the genus *Millepora.* The genus *Millepora* has been called a bleaching ''loser.'' *Millepora* species are ranked as the most susceptible to bleaching in response to high seawater temperatures of any of the 40 genera or other categories of hermatypic corals in the Great Barrier Reef. The genus has been reported to be highly susceptible to bleaching in the western Indian Ocean and appears to have experienced local extirpations in the tropical eastern Pacific. Low bleaching occurred in *Millepora* in Moorea during the 1991 event, but elevated temperatures can also kill *Millepora* even in the absence of bleaching. At elevated temperatures, *Millepora dichotoma* showed decreased zooxanthellae density, changes in chlorophyll concentrations, and decreased calcification. *Millepora* species are among the first to bleach and die in response to high temperature events, but they also seem to have a high capacity for quickly recovering by recruiting new colonies.

Millepora have been observed with a greater than 20 percent prevalence of skeleton-eroding-band disease in the Red Sea. There are reports of black-band disease on *Millepora* on the Great Barrier Reef and white plague in Florida. Few other reports exist for the Pacific, and Caribbean congeners have been observed with a small number of diseases.

Millepora species are known to be preyed on by the crown-of-thorns seastar *Acanthaster planci,* although they are less preferred prey than acroporids and perhaps most scleractinians. *Millepora* species are also preyed on by the polychaete *Hermodice carunculata,* the nudibranch mollusk *Phyllidia,* and filefish of the genera *Alutera* and *Cantherhines.*

Although *Millepora* species tend to favor relatively clear water with low rates of sedimentation, they were reported to be among the last 17 out of 42 genera to drop out along a gradient of increasing rate of sedimentation. *Millepora* also showed increased relative abundance and colony size on sediment impacted reefs in Kenya. Though little is known about effects of nutrients on Pacific *Millepora,* Caribbean congeners were found to decrease in percent cover on eutrophic reefs in Barbados.

The genus *Millepora* has been involved in international trade from Indonesia, Solomon Islands, and Fiji with reported exports between 200 and 3000 pieces per year in the years 2000–2008. Reported exports from Vietnam, Malaysia, and Tonga were less than 1000 pieces per year in the same time period.

Public comments did not provide any information on the genus *Millepora*. We gathered supplemental information on the susceptibilities of *Millepora* species to some threats, including the following. High bleaching and mortality in *Millepora* species has been reported in response to warming events. All *Millepora* colonies on reef flats of two islands in the Thousand Islands of Indonesia died in the 1983 El Nino mass bleaching (Brown and Suharsono, 1990). In contrast, *Millepora* colonies showed no evidence of bleaching in Moorea, French Polynesia in the 1991 bleaching event other than occasional mild paling (Gleason, 1993). In Palau in 2000, some mortality was seen among *Millepora* colonies (Bruno *et al.,* 2001). Almost all *Millepora* colonies in study sites outside of marine protected areas in Kenya were killed by mass bleaching in 1998, but in protected sites there was actually an increase in *Millepora* colonies (McClanahan *et al.,* 2001). *Millepora* colonies had a bleaching index of 23.06 for eight countries in the western Indian Ocean in 1998–2005, which was 12th highest of the 45 genera recorded, and 56 percent of the highest value (McClanahan *et al.,* 2007a). *Millepora* had the highest bleaching level of any genus in Australia, and a moderately high level in Kenya in 1998 (Pandolfi *et al.,* 2011). *Millepora* colonies in Okinawa, Japan, experienced sharp drops in populations following the 1998 and 2010 mass bleaching episodes (Hongo and Yamano, 2013). At Mauritius in a bleaching event in 2004, *Millepora* had a bleaching index of 35, the second highest of the 32 genera recorded (McClanahan *et al.,* 2005a). *Millepora* colonies had the highest level of bleaching among the corals of the Socotra islands of Yemen, just outside the Red Sea, in 1998 (DeVantier *et al.,* 2005).

While *Millepora* species are among the most susceptible of all reef-building corals to warming-induced bleaching, they also often recover more quickly than scleractinians, opportunistically over-growing bleached colonies. Such relatively rapid recovery by *Millepora* species from bleaching events has been observed in both the Indo-Pacific and Caribbean, and is facilitated by short colony life and ready regeneration of fragments (Lewis, 2006). At a forereef site in the Marquesas Islands, French Polynesia, *Millepora platyphyllia* overgrew dead scleractinian colonies to form a large monospecific stand (Andréfouët *et al.,* 2014). At a back-reef site on Ofu Island, American Samoa, following a bleaching event in 2002 that killed almost all *Millepora dichotoma,* colonies appeared and became fairly common within a few years (Doug Fenner, personal comm.). Following both the 1982–83 and 1997–98 warming events, *Millepora intricata* was extirpated from shallow water in the eastern Pacific, but showed recovery within several years, likely because of recolonization from deep water (Smith *et al.,* in press). In contrast, a long-term study showed that three *Millepora* species were ''long-term losers'' (*i.e.,* populations decreased to zero, and remained there) following mass bleaching events in Japan in 1998 and 2010, while two other species of *Millepora* were ''neither winners nor losers'' (*i.e.,* changes in their populations were not significant) (van Woesik *et al.,* 2011).

Millepora colonies in the Great Barrier Reef had low susceptibility to Skeletal Eroding Band (the most prevalent disease on the GBR), with a prevalence of 0.4 percent out of 4,068 colonies surveyed (Page and Willis, 2007).

Several recent studies compare vulnerabilities across genera or species for a large number of reef-building coral species, and the results of these studies are summarized below with regard to *Millepora.* Foden *et al.* (2013) developed a framework for evaluating the vulnerability of corals (and birds and amphibians) to extinction due to climate change. They categorized all of the six species of *Millepora,* which they reported on as having a low vulnerability to climate change. A field study that tracked the responses of 46 reef-building coral species in southern Japan from 1997 to 2010 through two bleaching events in 1998 and 2001 rated three *Millepora* species as neither winners nor losers, and two *Millepora* species as long term losers. Three of the *Millepora* species were branching and all three branching species were ''long term losers,'' one species is encrusting and one produces plates, and those two species were neither long term winners or losers (van Woesik *et al.,* 2011). There is no information available on the effects of any other threat for *Millepora* species.

Genus Conclusion

Based on the information from the SRR, SIR, public comments, and supplemental information we can make the following inferences about the susceptibilities of an unstudied *Millepora* species to ocean warming, disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, or collection and trade. The large majority of studies report that *Millepora* species are highly susceptible to thermal stress and bleaching, but vulnerability may be moderated by the capacity for rapid recovery in some species. An unstudied species of *Millepora* such as *M. tuberosa* can be predicted in a bleaching event to not be a ''winner'' in the long term, but it cannot be predicted whether they will be a long term loser, or neither a winner or loser. Thus, an unstudied species of *Millepora* is likely to be highly susceptible to ocean warming. Based on the above information, an unstudied species of *Millepora* is likely to have some susceptibility to disease, sedimentation, nutrients, and predation.

The SRR rated ocean acidification as ''medium-high'' importance, the third most important threat to corals overall, because of the likely effects of decreasing ocean pH on coral calcification and reproduction. Thus, an unstudied *Millepora* species is likely to have some susceptibility to ocean acidification. The SRR rated the trophic effects of fishing as ''medium'' importance, the fourth most important threat to corals overall. This threat was not addressed at the genus or species level in the SRR or SIR, because it is an ecosystem-level process. That is, removal of herbivorous fish from coral reef systems by fishing alters trophic interactions by reducing herbivory on algae, thereby providing a competitive advantage for space to algae over coral. Thus, the SRR did not discuss this threat in terms of coral taxa, as its effects are difficult to distinguish between coral genera and species. Therefore, an unstudied *Millepora* species is likely to have some susceptibility to the trophic effects of fishing. The SRR rated sea-level rise as ''low-medium'' importance to corals overall. This threat was not addressed at the genus or species level in the SRR or SIR. Increasing sea levels may increase land-based sources of pollution due to inundation, resulting in changes to coral community structure, most likely to sediment-tolerant assemblages and slower growing species. Because *Millepora* are not generally sediment-tolerant and are faster growing species, an unstudied *Millepora* species is likely to have some susceptibility to sea-level rise. The SRR rated ornamental trade (referred to in the proposed rule as Collection and Trade) as ''low'' importance to corals overall, and this threat is addressed at both the genus and species levels in the SRR. Because *Millepora* species are widely collected and traded, an unstudied *Millepora* species is likely to have some susceptibility to collection and trade.

In conclusion, an unstudied *Millepora* species is likely to be highly susceptible to ocean warming (*i.e.,* thermal stress, leading to warming-induced bleaching), and to have some susceptibility to disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade.

Millepora foveolata

Introduction

The SRR and SIR provided the following information on *M. foveoloata*'s morphology and taxonomy. Colonies of *Millepora foveolata* form thin encrusting laminae that adhere closely to the underlying substrata. *Millepora foveolata* is sometimes confused with the similarly encrusting *Millepora exaesa.*

The public comments did not provide any new or supplemental information on *M. foveoloata*'s morphology and taxonomy. However, we gathered supplemental information on *M. foveoloata* that indicates a very high level of species identification uncertainty, because its distinctive features are very small and difficult to learn. In addition, no pictures of live colonies have been published of this species. Corals of the World (Veron, 2000) does not include non-scleractinians such *Millepora* species, making it very difficult to obtain reliable reference material. Many coral experts also ignore *Millepora* species, but even those that are interested in them have little opportunity to hone identification skills because the species is quite rare and not often encountered on surveys. Thus, even though *M. foveolata* is considered a valid species, and there are no known taxonomic uncertainty issues, the species is so difficult to identify in the field that there is very little reliable information available for this species (Fenner, 2014b). Thus, a high proportion of the information on *M. foveolata*'s distribution and abundance information in the SRR or SIR is likely based on inaccurate field identifications, thus we do not consider this information to be sufficiently reliable, and are unable to provide a reliable species description for *M. foveolata* in this final rule.

Listing Determination

In the proposed rule, *M. foveolata* was proposed for listing as endangered because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); uncommon generalized range wide abundance (E); narrow overall distribution (based on narrow geographic distribution and shallow depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

Based on the lack of information on *M. foveolata*'s distribution, abundance, and threat vulnerabilities due to this species' identification uncertainty, we believe there is not sufficient evidence to support a listing determination of threatened or endangered. Therefore, we find that listing is not warranted at this time.

Millepora tuberosa

Introduction

The SRR and SIR provided the following information on *M. tuberosa*'s morphology and taxonomy. *Millepora tuberosa*'s colony morphology consists of thin (about 1 mm at encrusting peripheral margins) to moderately thick (3 cm or more in the central regions of larger colonies) encrusting laminae that closely adhere to the underlying substrata. They are always encrusting and so do not make vertical plates or branches, although they can be nodular or lumpy, especially when they encrust rubble. *Millepora tuberosa* is often found as small colonies (5 to 30 cm diameter) but can be greater than one meter in diameter. The SIR reports that several authors have commented that people could inadvertently misidentify *M. tuberosa* colonies as crustose coralline algae, and the SIR reports it can look similar to *Psammocora nierstrazi* if they have similar color. There is some taxonomic uncertainty, as *M. tuberosa* has been synonymized with *Millepora exaesa* in one review. The problem may be that the skeletons are quite similar, but the living colonies appear quite different, mainly in color; *M. tuberosa* is a wine color, unlike other *Millepora* species.

The public comments and information we gathered did not provide any new or supplemental information on morphology or taxonomy. We gathered supplemental information, which confirmed that *M. tuberosa* has moderate taxonomic uncertainty, but is easily identified. *Millepora tuberosa* is distinctive and not difficult to identify by experts, thus the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *M. tuberosa's* distribution, habitat, and depth range. *Millepora tuberosa* is known from Mauritius, Taiwan, Mariana Islands, Caroline Islands, American Samoa, and New Caledonia. The species occurs in a broad range of habitats on the reef slope, reef crest, and back-reef, including but not limited to lower reef crests, upper reef slopes, and lagoons, from 1 to at least 12 m depth.

Public comments and information we gathered provided new or supplemental information on *M. tuberosa*'s distribution. One public comment stated *M. tuberosa* has been reported from a variety of sources suggesting that its range extends from that shown in the proposed rule westward to Madagascar, indicating a broader distribution than shown in the proposed rule. We gathered supplemental information, including results from surveys carried out from 2005 to 2014 in New Caledonia, American Samoa, the Northern Mariana Islands, Nauru, Tonga, and the Chagos Islands, that confirmed the occurrence of *M. tuberosa* in the first three areas but did not find it in the latter three areas (D. Fenner, personal comm.). Many experts, including Veron, do not record the presence of *Millepora* species, thus the small number of reliable observations for this species likely indicates under-reporting rather than a reflection of its actual distribution or overall abundance. However, surveys by *Millepora* experts have not found the species at all coral reef sites surveyed within the areas encompassed by its known locations. Thus we conclude that the available information suggests a patchy range bounded by east Africa, Taiwan, Mariana Islands, Caroline Islands, American Samoa, and New Caledonia, and that the species' range makes up approximately one third to one half of the coral reef areas within the Indo-Pacific.

Demographic Information

The SRR and SIR provided the following information on *M. tuberosa*'s abundance. The SRR stated that the species is most often reported as occasional, but in Guam it is predominant in an area of lagoonal reef south of Agat Boat Harbor. The SIR cited several sources of information not available in the SRR, and concluded that the species' abundance should be considered common.

The public comments did not provide any new or supplemental information on *M. tuberosa*'s abundance. We gathered supplemental information, including abundance results from surveys conducted in New Caledonia, American Samoa, and the Northern Mariana Islands between 2005 and 2013. In New Caledonia, 87 sites were surveyed from 2006 to 2009, and only a single colony of *M tuberosa* was found. At 67 sites surveyed in American Samoa from 2005 to 2010, *M. tuberosa* was found at 18 sites (of the sites, 31 were on Tutuila, and the species was found at 13 of them). At 22 sites surveyed in the Northern Mariana Islands in 2013, *M. tuberosa* was found at three sites (D. Fenner, personal comm.). At sites where *M. tuberosa* has been actively surveyed (*i.e.,* by coral abundance monitoring programs that includes *Millepora* experts), the available information shows wide variability in the species' abundance, from dominant or common (Guam) to uncommon (Tutuila, Northern Mariana Islands) to rare (New Caledonia). Based on the available information, we conclude that *M. tuberosa*'s overall abundance is common or uncommon overall, but locally rare.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *M. tuberosa,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 59 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 22 percent (Carpenter *et al.,* 2008). This estimated decline is approximately 50 percent higher than most other Indo-Pacific species included in the Carpenter paper, apparently because of the combined restricted geographic and depth ranges. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *M. tuberosa* probably occurs in many areas affected by these broad changes, and that it has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species-specific information.

Other Biological Information

The public comments and information we gathered did not provide additional biological information on *M. tuberosa.*

Susceptibility to Threats

The SRR and SIR provided species-specific information on the susceptibility of *M. tuberosa* to sedimentation, predation, and secondary effects of heavy fishing pressure. The relatively high abundance of this species on Guam suggests it is resistant to those threats. Genus-level information is provided for the effects on *Millepora* of ocean warming, disease, predation, land-based sources of pollution (*i.e.,* sedimentation, nutrients, toxins, and salinity), and collection and trade. The SRR and SIR did not provide any other species-specific information on the effects of these threats on *M. tuberosa.* The threat susceptibility and exposure information from the SRR and SIR was interpreted in the proposed rule for *M. tuberosa*'s vulnerabilities to threats as follows: High vulnerability to ocean warming, moderate vulnerabilities to disease, acidification, trophic effects of fishing, nutrients, and low vulnerabilities to predation, sedimentation, sea-level rise, and collection and trade.

Public comments did not provide any new or supplemental information on *M. tuberosa*'s threat susceptibilities. We gathered the following species-specific and genus-level supplemental information on this species' threat susceptibilities. *Millepora tuberosa* has been rated as moderately or highly susceptible to bleaching but not coral disease, but these ratings are not based on species-specific data (Carpenter *et al.,* 2008). Some colonies in American Samoa and Guam have been observed to have a discolored yellow area around part of the perimeter, which appeared to be a non-lethal disease (not all colonies had it, and no mortality was seen. No other disease was seen (Fenner, 2014a). There is no other species-specific information for the exposure or susceptibility of *M. tuberosa* to any threat. Based on information provided in the genus description above, *M. tuberosa* is likely to be highly susceptible to ocean warming, and has some susceptibilities to disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on regulatory mechanisms or conservation efforts for *M. tuberosa*. Criticisms of our approach received during public comment led us to the following analysis to attempt to analyze regulatory mechanisms on a species basis.

Veron's updated report on the listed coral species and their occurrence in various ecoregions (Veron, 2014) did not include *M. tuberosa*. To determine what countries the species occurs in we used the SRR, IUCN Red List of Threatened Species, and other sources where the species has been confirmed (Fenner, 2011) and conclude that the species occurs in a minimum of six countries' EEZs. Those six countries are the Federated States of Micronesia, France (New Caledonia), Mauritius, Palau, Taiwan, and the United States (CNMI, Guam, American Samoa). As noted in the Spatial Information paragraph above, it is likely the species occurs in a number of other countries, but we cannot determine which ones at this time, thus this management analysis is limited to the six countries where the species has been confirmed.

The regulatory mechanisms available to *M. tuberosa,* described first as a percentage of the above countries that utilize them to any degree, and second as the percentage of those countries whose regulatory mechanisms are limited in scope, are as follows: General coral protection (33 percent with none limited in scope), coral collection (67 percent with 17 limited in scope), pollution control (33 percent with 17 percent limited in scope), fishing regulations on reefs (100 percent with 17 percent limited in scope), managing areas for protection and conservation (100 percent with none limited in scope). The most common regulatory mechanisms in place for *M. tuberosa* are reef fishing regulations and area management for protection and conservation. Coral collection laws are also somewhat utilized. General coral protection and pollution control laws are much less common regulatory mechanisms for the management of *M. tuberosa*.

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that the high bleaching rate, based on genus-level information, is the primary threat of extinction for *M. tuberosa,* which was compounded by the disjunct geographic range. The SRR also stated that factors that potentially reduce the extinction risk are that *M. tuberosa* might be more common than previously observed, and that like other *Millepora* species, it likely has a high capacity for recovering from bleaching.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *M. tuberosa,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution, based on the available information, includes patchy areas from the western Indian Ocean across the western and central Pacific, as far east as American Samoa. Its geographic distribution moderates vulnerability to extinction because some areas within its range are projected to have less than average warming and acidification over the foreseeable future, including the western Indian Ocean, the central Pacific, and other areas, so portions of the population in these areas will be less exposed to severe conditions. Its depth range is from zero to at least 12 meters. On one hand, its depth range may moderate vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. On the other hand, its depth range may exacerbate vulnerability to extinction over the foreseeable future if the species occurs predominantly in the shallower portion of its depth range, since those areas will have higher irradiance and thus be more severely affected by warming-induced bleaching. Its habitat includes lower reef crests, upper reef slopes, and lagoons, which moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. While the species is locally rare, its overall abundance is common or uncommon. Thus, its overall abundance, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule using the determination tool formula approach, *M. tuberosa* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); common generalized range wide abundance (E); narrow overall distribution (based on narrow geographic distribution and shallow depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *M. tuberosa* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *M. tuberosa*'s spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to be likely to become endangered throughout its range within the foreseeable future, and thus it is not warranted for listing at this time, because:

(1) *Millepora tuberosa*'s distribution stretches across the Indian Ocean and most of the Pacific Ocean and is spread over a very large area. While some areas within its range are projected to be affected by warming and acidification, other areas are projected to have less than average warming and acidification, including the western Indian Ocean, the central Pacific, and other areas. This distribution and the heterogeneous habitats it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future; and

(2) *Millepora tuberosa*'s abundance is described as common or uncommon overall which, in terms of relative abundance of corals and in combination with the size of its range, indicates this species likely numbers in the tens or hundreds of millions of colonies, at least. This provides buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses significant buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that *M. tuberosa*'s extinction risk may increase in the future if global threats continue and worsen in severity, likely resulting in the continued decline of this species into the future. As the species experiences reduced abundance or range constriction of a certain magnitude, its ability to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *M. tuberosa* is not warranted for listing at this time under any of the listing factors.

Genus Seriatopora

Genus Introduction

The family Pocilloporidae includes three genera: *Pocillopora, Seriatopora,* and *Stylophora. Seriatopora* contains six species, all occurring in the Indo-Pacific (Veron, 2000). *Seriatopora* species have branching colonies. The SRR and SIR provided no genus-level introductory information on *Seriatopora.*

Genus Susceptibility to Threats

The SRR and SIR provided the following information on the threat susceptibilities of the genus *Seriatopora.* Species in the genus *Seriatopora* are highly susceptible to bleaching across regions, including Micronesia the GBR, and the western Indian Ocean. The genus *Seriatopora* is known to be susceptible to predation by snails and the crown-of-thorns seastar, *Acanthaster planci.* The genus *Seriatopora* has been heavily traded, primarily from Fiji and Indonesia (and occasionally the Philippines and Taiwan). Many records are at the genus level; trade was heavy in the mid-1980s (exceeding 134,000 pieces in 1987). *Seriatopora hystrix* is the most heavily exploited species, although *Seriatopora caliendrum* is also exported.

The public comments did not provide any new or supplemental information on the threat susceptibilities of the genus *Seriatopora.* We gathered supplemental information, which provided the following. There are several reports of high bleaching and mortality in *Seriatopora* species in response to warming events. In response to the 1998 warming event, *Seriatopora* colonies in Palau had high levels of bleaching with high mortality (Bruno *et al.,* 2001). In response to the same warming event, over half of *Seriatopora* colonies in study sites within Kenyan marine protected areas were killed by mass bleaching (McClanahan *et al.,* 2001). A large study of the bleaching responses of over 100 coral species on the GBR to the 1998 bleaching event included one *Seriatopora* species, *Seriatopora hystrix.* For this species, approximately 40 percent of the observed colonies were bleached, resulting in *S. hystrix* being more affected than most of the Pocilloporidae and Acroporidae species in the study, and one of the 20 most affected species in the entire study (Done *et al.,* 2003b).

In response to a 2008 bleaching event in Papua New Guinea, two Pocilloporidae species (including *S. hystrix*) and 14 Acroporidae species were monitored, and each species' relative susceptibility to bleaching was evaluated in relationship to the other species in the study. Nine of the 16 species, including *S. hystrix,* had moderate susceptibility to bleaching, while five species were rated as severe or high susceptibilities, and two as low. Of the 139 *S. hystrix* colonies monitored in the study, 126 bleached (Bonin, 2012). In response to a 2004 warming event in Mauritius, the genus *Seriatopora* was the most bleached of the 32 genera recorded (McClanahan *et al.,* 2005b). In eight countries in the western Indian Ocean in 1998–2005, the *Seriatopora* genus had a bleaching index of 32, the fourth highest of the 45 genera recorded, and 75 percent of the highest value (McClanahan *et al.,* 2007a).

McClanahan *et al.* (2007a) calculated a relative extinction risk score based on bleaching for genera of corals in the western Indian Ocean. The index of extinction risk was proportional to the degree of bleaching and inversely proportional to the abundance and number of reefs on which a taxon was found. The index of extinction risk for *Seriatopora* was the eighth highest out of 47 genera, with a score of 0.46 based on a scale of zero to one, with one being the score of the highest extinction risk.

With regard to disease, two reports from the GBR provide contrasting information regarding the susceptibilities of *Seriatopora* species to various coral diseases. One study found that Black Band Disease was nearly absent on colonies of *Seriatopora* species (Page and Willis, 2006). In contrast, colonies of *Seriatopora* species had high susceptibility to Skeletal Eroding Band, with a prevalence of 5.8 percent. Skeletal Eroding Band is the most prevalent disease on the GBR (Page and Willis, 2007). *Seriatopora* in Indonesia was reported to have no diseases (Haapkyla *et al.,* 2007). There is no information available on the effects of any other threat for *Seriatopora* species.

Genus Conclusion

Based on the information from the SRR, SIR, public comments, and supplemental information, we can make the following inferences about the susceptibilities of an unstudied *Seriatopora* species to ocean warming, disease, ocean acidification, sedimentation, nutrients, trophic effects of fishing, sea-level rise, predation, and collection and trade. The SRR rated ocean warming and disease as ''high'' importance to corals. These were rated as the three most important threats to reef-building corals overall. All studies on thermal stress in *Seriatopora* report high levels of bleaching in response to warming events. Thus, we conclude that *Seriatopora* likely has high susceptibility to ocean warming. Studies reported that one disease did not infect *Seriatopora,* but another did at high prevalence, and no diseases infected it in Indonesia. Thus, we conclude that *Seriatopora* has some susceptibility to disease. Although there is no other genus-level or species-specific information on the susceptibilities of *Seriatopora* species to ocean acidification, the SRR rated it as ''medium-high'' importance to corals. Thus, we conclude that an unstudied *Seriatopora* species has some susceptibility to ocean acidification.

The SRR rated the trophic effects of fishing as ''medium'' importance, the fourth most important threat to corals overall. This threat was not addressed at the genus or species level in the SRR or SIR, because it is an ecosystem-level process. That is, removal of herbivorous fish from coral reef systems by fishing alters trophic interactions by reducing herbivory on algae, thereby providing a competitive advantage for space to algae over coral. Thus, the SRR did not discuss this threat in terms of coral taxa, as its effects are difficult to distinguish between coral genera and species. Therefore, we conclude that an unstudied *Seriatopora* species has some susceptibility to the trophic effects of fishing.

Although there is no genus-level or species-specific information on the susceptibilities of *Seriatopora* species to sedimentation or nutrients, the SRR rated both threats as ''low-medium'' importance to corals. Thus, we conclude that an unstudied *Seriatopora* species has some susceptibility to these threats. Sea-level rise was also rated as ''low-medium'' importance to corals. Increasing sea levels may increase land-based sources of pollution due to inundation, resulting in changes to coral community structure, thus an unstudied *Seriatopora* species is likely to have some susceptibility to sea-level rise. The SRR rated predation and ornamental trade (referred to in the proposed rule as Collection and Trade) as ''low'' importance to corals overall. *Seriatopora* is preyed on by both snails and crown-of-thorns starfish. Thus we conclude that *Seriatopora* has some susceptibility to predation. *Seriatopora* is heavily traded, thus we conclude that *Seriatopora* has some susceptibility to collection and trade.

In conclusion, an unstudied *Seriatopora* species is likely to be highly susceptible to ocean warming, and to have some susceptibility to disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade.

Seriatopora aculeata

Introduction

The SRR and SIR provided the following information on *S. aculeata*'s morphology and taxonomy. Morphology was described as thick, short, tapered branches, usually in fused clumps. The taxonomy was described as somewhat uncertain, because genetic studies have not corresponded well with morphology for *S. aculeata* and other species of *Seriatopora*. Similar species, *Seriatopora stellata* and *S. hystrix,* can have similar branching structures in shallow, exposed reef flats.

The public comments and information we gathered did not provide any new or supplemental information on morphology, and confirmed that there is a moderate level of taxonomic uncertainty for *S. aculeata,* and that there is a moderate level of species identification uncertainty for this species. Veron (Veron, 2014) states that *S. aculeata* is sometimes confused with *S. stellata,* but Veron (Veron, 2000; Veron, 2014) continues to consider it a valid species, and we conclude it can be identified by experts, and that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *S. aculeata*'s distribution, habitat, and depth range. *Seriatopora aculeata* is distributed from Australia, Fiji, Indonesia, Japan, Papua New Guinea, and Madagascar to the Marshall Islands. The SRR and SIR described *S. aculeata*'s habitat as shallow reef environments, and its depth range as three to 40 meters. The SIR reported it in Guam and the Northern Marianas.

The public comments and information we gathered provided supplemental information on the distribution and habitat of *S. aculeata.* One public comment stated that in Guam, the few specimens of *S. aculeata* observed since 2004 were found in areas with high rates of sedimentation. Thus, based on all the available information, *S. aculeata*'s habitat can be summarized as follows: The species occurs in a broad range of habitats on the reef slope and back-reef, including but not limited to upper reef slopes, mid-slope terraces, lower reef slopes, reef flats, and lagoons. Supplemental information provided the following. Veron (2014) provides an updated, much more detailed range map for this species than the maps used in the SRR. Veron reports that *S. aculeata* is confirmed in 19 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional seven.

Demographic Information

The SRR and SIR provided the following information on *S. aculeata*'s abundance. *Seriatopora aculeata* has been reported as uncommon.

The public comments did not provide any new or supplemental information on *S. aculeata*'s abundance, but the supplemental information provided the following. Veron (2014) reports that *S. aculeata* occupied 10.3 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.70 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''common,'' and overall abundance was described as ''uncommon.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *S. aculeata,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 37 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 14 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *S. aculeata* occurs in many areas affected by these broad changes, and that it has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but quantification is not possible based on the limited species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *S. aculeata*'s life history. Little is known of *S. aculeata*'s life history. The much more common species, *S. hystrix,* is a simultaneous hermaphrodite that reproduces sexually via brooded larvae. The public comments and information we gathered provided no additional biological information.

Susceptibility to Threats

To describe *S. aculeata*'s threats, the SRR and SIR provided genus-level information for the effects on *Seriatopora* of o ocean warming, disease, acidification, sedimentation, nutrients, predation, and collection and trade. The SRR and SIR did not provide any species-specific information on the effects of these threats on *S. aculeata,* except for a single export record from Indonesia for four pieces of the species in 2008. We interpreted the threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *S. aculeata*'s vulnerabilities as follows. High vulnerability to ocean warming; moderate vulnerability to disease, ocean acidification, trophic effects of reef fishing, nutrients, and predation; and low vulnerability to sedimentation, sea level rise, and collection and trade.

Public comments provided some supplemental information on *S. aculeata*'s threat susceptibilities. One comment stated that the depth range for *S. aculeata* on the reef slopes of Guam are coincident with those of the crown-of-thorns starfish, both of which are below 5 to 7 meters depth, exposing *S. aculeata* to predation. *Seriatopora aculeata* has been rated as not moderately or highly susceptible to bleaching and disease, but this rating is not based on species-specific data (Carpenter *et al.* 2008). There is no supplemental species-specific information for the susceptibility of *S. aculeata* to any threat. Based on information provided in the *Seriatopora* genus description above, *S. aculeata* is likely to be highly susceptible to ocean warming, and is likely to have some susceptibility to disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade. The available information does not support more precise ratings of the susceptibilities of *S. aculeata* to the threats.

Regulatory Mechanisms.

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *S. aculeata*. Criticisms of our approach received during public comment led us to the following analysis to attempt to analyze regulatory mechanisms on a species basis. Records confirm that *S. aculeata* occurs in 19 Indo-Pacific ecoregions that encompass 10 countries' EEZs. The 10 countries are Federated States of Micronesia, France (French Pacific Island Territories), Indonesia, Japan, Palau, Papua New Guinea, Philippines, Solomon Islands, Timor-Leste, and the United States (CNMI, Guam, PRIAs). The regulatory mechanisms available to *S. aculeata,* described first as a percentage of the above countries that utilize them to any degree, and second as the percentage of those countries whose regulatory mechanisms are limited in scope, are as follows: General coral protection (40 percent with none limited in scope), coral collection (70 percent with 20 percent limited in scope), pollution control (30 percent with 20 percent limited in scope), fishing regulations on reefs (100 percent with none limited in scope), and managing areas for protection and conservation (100 percent with none limited in scope). The most common regulatory mechanisms in place for *S. aculeata* are reef fishing regulations and area management for protection and conservation. Coral collection laws are also heavily utilized for the species. General coral protection and pollution control laws are less common regulatory mechanisms for the management of *S. aculeata*.

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that the primary factor that increases the potential extinction risk is its high bleaching susceptibility. The genus *Seriatopora* is heavily traded, but not often identified to species. Heavy use in the aquarium trade implies the potential for local extirpation for this usually uncommon species.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *S. aculeata,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution is limited to parts of the Coral Triangle and the western equatorial Pacific Ocean. Despite the large number of islands and environments that are included in the species' range, this range exacerbates vulnerability to extinction over the foreseeable future because it is mostly limited to an area projected to have the most rapid and severe impacts from climate change and localized human impacts for coral reefs over the 21st century. Its depth range of 40 meters moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. The species occurs in a broad range of habitats on the reef slope and back-reef, including but not limited to upper reef slopes, mid-slope terraces, lower reef slopes, reef flats, and lagoons. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. There is not enough information about its abundance to determine if it moderates or exacerbates extinction. It is common and has at least millions of colonies, but the great majority of the population is within an area expected to be severely impacted by threats over the foreseeable future. While depth distribution and habitat variability moderate vulnerability to extinction, the combination of its geographic distribution and high susceptibility to ocean warming are likely to be more influential to the status of this species over the foreseeable future, because of the projected severity of ocean warming throughout the species' range in the foreseeable future, and its high susceptibility to this threat.

Listing Determination

In the proposed rule, using the determination tool formula approach, *S. aculeata* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); uncommon generalized range wide abundance (E); moderate overall distribution (based on moderate geographic distribution and moderate depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we maintain the listing determination for *S. aculeata* as threatened. Based on the best available information provided above on *S. aculeata*'s spatial structure, demography, threat susceptibilities, and management indicate that it is likely to become endangered throughout its range within the foreseeable future, and thus warrants listing as threatened at this time, because:

(1) *Seriatopora aculeata* is highly susceptible to ocean warming (ESA Factor E), and susceptible to disease (C) ocean acidification (E), trophic effects of fishing (A), nutrients (A, E), and collection and trade (B). In addition, existing regulatory mechanisms to address global threats that contribute to extinction risk for this species are inadequate (D); and

(2) *Seriatopora aculeata*'s distribution is constrained to the Coral Triangle and western equatorial Pacific, which is projected to have the most rapid and severe impacts from climate change and localized human impacts for coral reefs over the 21st century, as described in the Threats Evaluation. Multiple ocean warming events have already occurred within the western equatorial Pacific that suggest future ocean warming events may be more severe than average in this part of the world. A range constrained to this particular geographic area that is likely to experience severe and increasing threats indicates that a high proportion of the population of this species is likely to be exposed to those threats over the foreseeable future.

The combination of these characteristics and projections of future threats indicates that the species is likely to be in danger of extinction within the foreseeable future throughout its range and warrants listing as threatened at this time due to factors A, C, D, and E.

The available information above on *S. aculeata*'s spatial structure, demography, threat susceptibilities, and management also indicate that the species is not currently in danger of extinction and thus does not warrant listing as Endangered because:

(1) While half of *S. aculeata*s' range is within the Coral Triangle which increases its extinction risk as described above, its habitat includes various shallow reef environments down to 40 meters. This moderates vulnerability to extinction currently because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, at local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time, as described in more detail in the Coral Habitat sub-section and Threats Evaluation section. There is no evidence to suggest that the species is so spatially fragmented that depensatory processes, environmental stochasticity, or the potential for catastrophic events currently pose a high risk to the survival of the species;

(2) *Seriatopora aculeata* occurs down to at least 40 m so its depth range will provide some refugia from threats because deeper areas of its range will usually have lower irradiance than surface water, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs; and

(3) *Seriatopora aculeata's* absolute abundance is at least millions of colonies, which allows for variation in the responses of individuals to threats to play a role in moderating vulnerability to extinction for the species to some degree, as described in more detail in the Corals and Coral Reefs section. There is no evidence of depensatory processes such as reproductive failure from low density of reproductive individuals and genetic processes such as inbreeding affecting this species. Thus, its absolute abundance indicates it is currently able to avoid high mortality from environmental stochasticity, and mortality of a high proportion of its population from catastrophic events.

The combination of these characteristics indicates that the species does not exhibit the characteristics of one that is currently in danger of extinction, as described previously in the Risk Analyses section, and thus does not warrant listing as endangered at this time.

Range-wide, a multitude of conservation efforts are already broadly employed that are likely benefiting *S. aculeata.* However, considering the global scale of the most important threats to the species, and the ineffectiveness of conservation efforts at addressing the root cause of global threats (*i.e.,* GHG emissions), we do not believe that any current conservation efforts or conservation efforts planned in the future will result in affecting the species status to the point at which listing is not warranted.

Genus Acropora, Indo-Pacific

Genus Introduction

The SRR and SIR provided an introduction to Indo-Pacific *Acropora,* covering geological history, taxonomy, life history, and threat susceptibilities of the genus as a whole. *Acropora* colonies are usually branching, bushy, or plate-like, rarely encrusting or submassive. *Acropora* is by far the largest genus of corals with over 150 species, and dominates many reefs, making *Acropora* the most important single genus of corals in the world. Almost all species of *Acropora* are in the Indo-Pacific.

Genus Susceptibility to Threats

The SRR and SIR provided the following information on genus-level threat susceptibilities for Indo-Pacific *Acropora. Acropora* are widely reported to be more sensitive to bleaching in response to high temperatures than other coral genera. Some studies report branching species of *Acropora* to bleach more than table species, but other studies do not find this. Bleaching mortality in *Acropora* can be very severe. Larval connectivity and survival of partially-dead colonies are probably important in population recovery. Bleaching of *Acropora* has been followed by disease outbreaks and by reduced fecundity for a year or two. Fertilization and larval stages of *Acropora* are particularly sensitive to high temperatures.

Ocean acidification decreases the rate of calcification in *Acropora.* For one species of *Acropora* in the Caribbean, decreases in growth rates on reefs over decades has been attributed to acidification. Acidification negatively affects a variety of stages of reproduction in *Acropora.*

Acropora are vulnerable to most of the diseases that infect coral, and are more commonly affected by acute and lethal diseases (''white diseases'' or tissue loss) than other corals. Such lethal diseases have been the major cause of the loss of most *Acropora* in the Caribbean. The reduction of coral populations by disease leads to negative synergisms, as it reduces *Acropora* reproductive output and can lead to recruitment failure, making population recovery very difficult.

Acropora are preferred prey for most predators that prey on coral, including the crown-of-thorns starfish, a variety of snails including *Drupella,* butterflyfish, and fireworms. Individual territorial butterflyfish can take 400–700 bites per hour, and butterflyfish densities can be 50–70 per 1000m^2, demonstrating possible intense predation on *Acropora. Acropora* have low carbon and protein content in their tissues so a low nutrient value, yet are still preferred prey. This suggests that instead of investing in chemical defenses against predation, *Acropora* invests its energy in rapid growth. However, when coral populations are greatly reduced, the predatory pressure is increased on colonies, and can exert a positive-feedback effect (Allee Effect or depensation) that makes populations unstable and can lead to collapse or lack of recovery.

In general, *Acropora* species are relatively more susceptible to the effects of sedimentation than many other reef-building corals. Though certain growth forms (*e.g.,* cylindrical branches) may be more effective at passive sediment rejection than others, *Acropora* are generally not adept at actively removing sediment. *Acropora* have also shown particular sensitivity to shading, an effect of turbid waters resulting from sedimentation. In addition, adult colonies of *Acropora* have reportedly shown impacts from sedimentation especially during reproduction.

Acropora species are also relatively more susceptible to the effects of nutrients, especially with regard to reproduction and recruitment. Elevated nutrients have been shown to reduce fertilization success, survival, and settlement of *Acropora* larvae. Further, iron-rich ''red'' soils typical of tropical islands, as well as other chemicals in run-off, interfere with synchronization of spawning among colonies, egg-sperm recognition and interactions, fertilization, and embryo development.

Acropora species are heavily collected and widely traded internationally. Trade quotas and reports are typically listed only at the genus level, making any species-specific inferences with regard to this threat very difficult.

The public comments did not provide any supplemental information on genus-level threat susceptibilities for Indo-Pacific *Acropora.* However, we gathered supplemental information, which provides the following genus-level information on threat susceptibilities of Indo-Pacific *Acropora* for ocean warming, disease, ocean acidification, and predation. With regard to susceptibility to ocean warming, Fisk and Done (1985) report bleaching patterns on a site on the Great Barrier Reef in 1982 to 1983. Most species of *Acropora* in shallow water had significant mortality, but *Acropora hyacinthus* did not. Mortality varied by species and site. Brown and Suharsono (1990) reported that the 1983 El Niño caused a mass bleaching event in the Thousand Islands, Indonesia. The mass bleaching event killed all *Acropora* (22 species) in the transects on the reef flats of two islands (Brown and Suharsono, 1990). Gleason (1993) reported that *Acropora* was the second most affected genus by bleaching (*Montastraea* was the most affected) in Moorea, French Polynesia in 1991, and that it had the greatest mortality. McClanahan *et al.* (2001) report that almost all *Acropora* in study sites in Kenya were killed by mass bleaching in 1998. Kayanne *et al.* (2002) reported that in 1998 in the Ryukyu Islands of Japan, branching *Acropora* was susceptible to bleaching and mortality was high. The branching species in this study were primarily *A. formosa* (= *A. muricata*) and also *A. pulchra* and *A. palifera* (= *Isopora palifera*). Hughes *et al.* (2003) reported that 11 *Acropora* species ranged from 0 to 100 percent affected by bleaching in Raiatea, French Polynesia, in 2002. Done *et al.* (2003b) reported that 46 *Acropora* species ranged from 0 to 44 percent affected by bleaching on the Great Barrier Reef in 2003.

Based on a bleaching index scaled from 0 to 100 (with 0 as no bleaching and 100 as complete bleaching), McClanahan *et al.* (2004) reported that during mass bleaching in 1998, *Acropora* had a higher index in Kenya (80) than in Australia (40); temperatures were higher in Kenya. *Acropora* in Mauritius had an index of 39, the fifth highest of the 32 genera recorded, following a 2004 bleaching event (McClanahan *et al.,* 2005a). *Acropora* had an index of 28.9 for eight countries in the western Indian Ocean in 1998–2005, which was fifth highest of the 45 genera recorded (McClanahan *et al.,* 2007a). The abundance of *Acropora* after 1998 in the western Indian Ocean decreased strongly in proportion to the number of degree heating weeks in 1998 (McClanahan *et al.,* 2007b). Based on a bleaching index scaled from 0 to 250 (with 0 as no bleaching and 250 as complete bleaching), Pandolfi *et al.* (2011) report that *Acropora* bleached heavily in Kenya and moderately in Australia in 1998, with scores of 225 and 120, respectively. *Acropora* had a moderate percentage of bleaching on Howland and Baker islands in the U.S. Pacific in early 2010, with 28.7 percent bleached on Baker and 47.7 percent on Howland. *Acropora* was the fifth most-bleached genus out of 14 genera, and was 60 percent as bleached as the most bleached genus (Vargas-Angel *et al.,* 2011).

During a mass-bleaching event in Western Australia in 2010–2011, *Acropora* had the highest mortality with 100 percent mortality of colonies larger than 10 cm diameter in size, and *Montipora* the second highest mortality, while massive and encrusting corals, such as *Porites* and faviids, had much higher survival rates. Colonies less than 10 cm diameter were not killed (Depczynski *et al.,* 2012). *Acropora* in the turbid waters off Okinawa, Japan, experienced sharp drops in populations following the 1998 and 2010 mass bleaching episodes (Hongo and Yamano, 2013). Sutthacheep *et al.* (2013) report that all colonies of one species of *Acropora* were completely bleached at Laem Set at Samui Island in the western Gulf of Thailand in 1998 and 80 percent of the colonies of the other reef-building coral species were as well. In 2010, 80 percent colonies of one species were completely bleached and all colonies of the other species were partly bleached. After the 1998 bleaching event, 72 percent of colonies had complete mortality, and after the 2010 event, all bleached colonies had complete mortality.

Bleaching does not always result in mortality, thus it is important to consider bleaching-induced mortality and bleaching rates from a single event, as well as the recovery of a population over time to a bleaching event. In Kenya in 1998, mortality in *Acropora* was sixth highest of the 18 genera, and 55 percent of the genus with the most mortality (McClanahan, 2004). Three species of *Acropora* were long-term winners following mass bleaching events in Japan (decreasing from 3.4 percent cover to 0 percent then increasing to 3.5 percent; decreasing from 0.2 percent to 0 percent and then increasing to 3.2 percent; decreasing from 1.2 percent cover to 0 percent and then increasing to 0.7 percent), and one species was neither a winner or a loser (van Woesik *et al.,* 2011). Bridge *et al.* (2013a) report that *Acropora* mortality after bleaching was higher than for all corals as a whole. Total coral mortality at 0 to 2 m depth was 70 percent, while it was 90 percent for *Acropora,* and at 3 to 4 m depth it was 20 percent for all corals but 60 percent for *Acropora* (Bridge *et al.,* 2013a).

Species or genera that readily bleach but recover quickly are relatively resilient to warming-induced bleaching. For example, the genus *Acropora* received a +1 resilience score based on trait and process scores assigned to the genus (van Woesik *et al.,* 2012). Traits and processes were chosen which were thought to confer resilience to climate change. Resilience scores of 16 Indo-Pacific genera that were evaluated varied between +7 and −5. Scores below 0 were correlated with a high extinction probability (van Woesik *et al.,* 2012). McClanahan *et al.* (2007a) calculated a relative extinction risk score based on bleaching for genera of corals in the western Indian Ocean. The index of extinction risk was proportional to the degree of bleaching and inversely proportional to the abundance and number of reefs on which a taxon was found. The index of extinction risk for *Acropora* was the ninth lowest out of 47 genera, with a score of 0.11 based on a scale of 0 to 1, with 1 being the score of the highest extinction risk (McClanahan *et al.,* 2007a).

Diseases have been reported to be more common in *Acropora* than in other corals in some areas of the Indo-Pacific, such as the Northwest Hawaiian Islands (Aeby, 2006) and American Samoa (Fenner *et al.,* 2008). However, in the Philippines, *Porites* was the dominant host with almost all disease observed in that genus, and only rarely observed on *Acropora* (Raymundo *et al.,* 2005). In New Caledonia, *Turbinaria* had the highest disease prevalence of any genus with 2.5% infected, while *Acropora* was tied with *Montipora* for the least disease among the 12 most common genera affected, with less than 0.1% infected (Tribollet *et al.,* 2011). On the Great Barrier Reef, Pocilloporidae and Acroporidae have the highest prevalence of families, and diseases have been recorded on at least 23 species of *Acropora* (Willis *et al.,* 2004). Black band disease on the Great Barrier Reef is concentrated in staghorn *Acropora* species with 76 diseased colonies counted in one study, and *Acropora* species with other colony morphologies (tables, bushy, corymbose, digitate, bottlebrush) had far fewer diseased colonies (Page and Willis, 2006). In American Samoa, French Frigate Shoals (Hawaii) and Johnston Atoll, two species of table *Acropora* (*A. hyacinthus* and *A. cytherea*) had larger numbers of colonies (13 each) with growth anomalies in transects than any of 10 other taxa, and much higher than one other table coral (*A.* clathrata, with one; Work *et al.,* 2008). In Indonesia, bushy *Acropora* had the highest prevalence (8%) of disease of any taxon (out of 35 taxa), while corymbose *Acropora* was the eighth highest taxon and second highest *Acropora* group with 0.5 percent disease, and all other *Acropora* groups (tabulate, bottlebrush, digitate, and staghorn) had 0 percent disease (Haapkyla *et al.,* 2007).

Ocean acidification can have a variety of effects on Indo-Pacific *Acropora* species. While increased CO_2 does not appear to affect the survival of unidentified *Acropora* larvae, postsettlement skeletal growth of the polyps of unidentified *Acropora* species (Suwa *et al.,* 2010) and *A. digitifera* (Inoue *et al.,* 2011) are impaired. In addition, increased CO_2 impairs the rate of zooxanthellae acquisition in the polyps of *A. digitifera* (Inoue *et al.,* 2011) and *A. millepora* (Kaniewska *et al.,* 2012). In Caribbean *Acropora* species, fertilization and settlement are impaired by increased CO_2 (Albright *et al.,* 2010). Elevated CO_2 also induces bleaching in *Acropora,* even more so than temperature increases (Anthony *et al.,* 2008). Carbon dioxide enrichment to 600 to 790 ppm enhanced maximum photosynthetic rates in *A. formosa* (Crawley *et al.,* 2010), but elevated CO_2 levels had no effect on photosynthesis or respiration in *A. eurystoma* (Schneider and Erez, 2006). A study of the effects of near-term ocean acidification and elevated seawater temperature on the physiology of *A. aspera* suggested that gene expression of key metabolic proteins is impacted by the synergistic effects of near term ocean acidification (*i.e.,* the conditions expected to result from 50–90 ppm CO_2 above current atmospheric levels) and ocean warming (Ogawa *et al.,* 2013a). Physical factors may moderate impacts of acidification, as shown by a study of *A. hyacinthus,* which found that natural daily oscillations in CO_2 may reduce the locally negative effects of increasing ocean acidification (Comeau *et al.,* 2014). Moderate increases in CO_2 may enhance *Acropora* growth and calcification rates in some species, however, at higher CO_2 levels, growth and calcification rates drop to zero. More consistently across species, elevated CO_2 tends to decrease *Acropora* growth and calcification rates (Anthony *et al.,* 2008; Chauvin *et al.,* 2011; Purkis *et al.,* 2011; Schneider and Erez, 2006; Suggett *et al.,* 2013). *Acropora* species appear to be more susceptible to acidification than most other genera, as demonstrated by the lack of *Acropora* species in coral communities existing in naturally low pH waters (Fabricius *et al.,* 2011).

With regard to predation, De'ath and Moran (1998) reported that *Acropora* was the most preferred prey of crown-of-thorns starfish out of the 10 most common genera on 15 reefs in the Great Barrier Reef (preferred 14:1 over *Porites,* the least preferred genus). Pratchett (2001) reported that in a choice experiment, crown-of-thorns starfish always ate *Acropora* colonies before eating colonies of other genera. This was true of all four of the *Acropora* species tested. When a crown-of-thorns starfish has finished eating preferred species, it moves to eating less preferred species, and thus in an outbreak, almost all species may be eaten (Pratchett *et al.,* 2001). The snail *Drupella rugosa* preferred to eat *Acropora pruinosa* over *Montipora informis,* one agaricid and four faviid corals in laboratory tests in Hong Kong (Morton *et al.,* 2002).

The public comments did not provide any supplemental information on genus-level threat susceptibilities for Indo-Pacific *Acropora.* We gathered the supplemental information above, which provides genus-level information on threat susceptibilities of Indo-Pacific *Acropora* for ocean warming, disease, ocean acidification, and predation. We did not gather any supplemental information on the other threats (*i.e.,* sedimentation, nutrients, trophic effects of fishing, sea-level rise, or collection and trade).

Genus Conclusion

Based on the information from the SRR, SIR, public comments, and supplemental information, we make the following inferences regarding the susceptibilities of an unstudied *Acropora* species to ocean warming, disease, ocean acidification, predation, sedimentation, nutrients, trophic effects of fishing, sea-level rise, and collection and trade. Nearly all the studies cited on thermal stress in *Acropora* report high levels of bleaching in response to warming events. Thus, it is possible to predict that an unstudied *Acropora* species is likely to be highly susceptible to warming-induced bleaching, as long as some considerations are kept in mind: (1) Despite high overall susceptibility within the genus to warming-induced bleaching, there can be high variability between species and habitats (Done *et al.,* 2003b); (2) colonies that bleach do not necessarily die (in general, *Acropora* species have higher post-bleaching mortality than corals as a whole, but there is high variability in response throughout the genus); (3) recovery from bleaching provides the mechanism for acclimatization; and (4) while most *Acropora* species readily bleach in response to warming events, most also have the capacity to reestablish local populations relatively quickly through their rapid growth and asexual reproduction capacity.

The studies cited above suggest that diseases are generally more common in *Acropora* than other coral genera, although there are numerous documented exceptions, depending on location. These studies also demonstrate high variability in disease susceptibility across *Acropora* species, depending on growth form, with wide divergence of disease susceptibilities among colony morphological groups under the same conditions. Thus, it is possible to predict that an unstudied *Acropora* species is likely to have some susceptibility to disease.

The studies cited above on ocean acidification in *Acropora* report impacts on skeletal growth rates. Thus, it is possible to predict that an unstudied *Acropora* species is likely to have some susceptibility to ocean acidification in terms of impacts on skeletal growth. The studies cited above on predation in *Acropora* report that predators such as crown-of-thorns starfish and *Drupella* snails prefer to eat *Acropora* over other genera. Thus, it is possible to predict that an unstudied *Acropora* species is likely to have some susceptibility to predation. Most studies summarized in the SRR on the effects of land-based sources of pollution suggest that an unstudied *Acropora* species is likely to have some susceptibility to sedimentation and nutrient enrichment.

The SRR rated the trophic effects of fishing as ‘‘medium’’ importance, and it was the fourth most important threat to corals overall. This threat was not addressed at the genus or species level in the SRR or SIR, because it is an ecosystem-level process. That is, removal of herbivorous fish from coral reef systems by fishing alters trophic interactions by reducing herbivory on algae, thereby providing a competitive advantage for space to algae over coral. Thus, the SRR did not discuss this threat in terms of coral taxa, as its effects are difficult to distinguish between coral genera and species. Accordingly, an unstudied *Acropora* species is likely to have some susceptibility to the trophic effects of fishing.

The SRR rated sea-level rise as ‘‘low-medium’’ importance to corals overall. This threat was not addressed at the genus or species level in the SRR or SIR. Increasing sea levels may provide new coral habitats by submergence of hard substrates; however sea-level rise is also likely to increase land-based sources of pollution due to inundation, resulting in changes to coral community structure, most likely to sediment-tolerant assemblages and slower-growing species. Because *Acropora* are not generally sediment-tolerant and are faster growing species, an unstudied *Acropora* species is likely to have some susceptibility to sea-level rise.

The SRR rated ornamental trade (referred to in the proposed rule as Collection and Trade) as ‘‘low’’ importance to corals overall, and this threat was addressed at both the genus and species levels in the SRR. Because *Acropora* species are some of the most popular coral species to collect and trade, an unstudied *Acropora* species is likely to have some susceptibility to collection and trade.

In conclusion, an unstudied *Acropora* species is likely to be highly susceptible to ocean warming and to have some susceptibility to disease, acidification, sedimentation, nutrients, trophic effects of fishing, sea-level rise, predation, and collection and trade.

Acropora aculeus

Introduction

The SRR and SIR provided the following information on *A. aculeus'* morphology and taxonomy. Morphology was described as small bushy colonies with flat tops, and taxonomy was described as having no taxonomic issues but being similar in appearance to *A. latistella.*

The public comments and information we gathered provided information on the morphology or taxonomy of *A. aculeus.* One public comment stated that specimens collected in the Mariana Islands and identified by coral expert Richard H. Randall as *A. aculeus* appear to be different than colonies described as *A. aculeus* in references used in the SRR. Also, one public comment stated that specimens collected in American Samoa and identified by the American Samoa Department of Marine and Water Resources as *A. jacquelineae* appear to be *A. aculeus,* thereby illustrating the species identification uncertainties associated with this species. In addition, we gathered supplemental information, including Veron (2014), which states that this species is distinctive. Thus, while the public comments and supplemental information provided some information on the taxonomy of *A. aculeus,* we conclude it can be identified by experts, and that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *A. aculeus'* distribution, habitat, and depth range: *Acropora aculeus* is distributed from East Africa to the Pitcairn Islands in the eastern Pacific. The SRR and SIR reported the species as having the 15th largest range of 114 *Acropora* species in a large study. Its predominant habitat is shallow lagoons, and it is also found in other habitats protected from direct wave action on back-reefs and reef slopes, and its depth range is low tide to at least 20 m.

The public comments did not provide any new or supplemental information on *A. aculeus'* distribution. We gathered supplemental information, including Veron (2014), which reports that this species is confirmed in 68 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional 16. Wallace (1999b) reports its occurrence in 24 of her 29 Indo-Pacific areas, many of which are significantly larger than Veron's ecoregions. Richards (2009) calculated the geographic range of *A. aculeus* at over 100 million km^2. The public comments and information we gathered provided nothing additional on *A. aculeus'* habitat and depth range.

Demographic Information

The SRR and SIR provided the following information on *A. aculeus'* abundance. *Acropora aculeus* has been reported as generally common and locally abundant, especially in the central Indo-Pacific, and that it is particularly abundant in shallow lagoons and common in most habitats where it is protected from direct wave action.

The public comments did not provide any new or supplemental information on *A. aculeus'* abundance. We gathered supplemental information, including

Richards (2009) and Richards *et al.* (2013b), which concluded that this species is globally widespread, locally widespread, and locally common. Based on these results, the authors concluded that *A. aculeus* is among the most abundant *Acropora* species, and also among those *Acropora* species that are most likely to persist in the future. They placed 12 species in this category out of 85 species of *Acropora.* Veron (2014) reports that *A. aculeus* occupied 32.1 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.55 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''common.'' Overall abundance was described as ''usually common in the central Indo-Pacific, uncommon elsewhere.'' Veron did not infer abundance trend results from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least tens of millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *A. aculeus,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 37 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 15 percent. However, as summarized above in the Inter-basin Comparisons sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context. Thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred and are occurring from a combination of global and local threats. Given that *A. aculeus* occurs in many areas affected by these broad changes, and that it is likely has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but quantification is not possible based on the limited species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *A. aculeus'* life history. *Acropora aculeus* is a hermaphroditic spawner that is a participant in mass broadcast spawning in some localities. The public comments and information we gathered provided no additional biological information.

Susceptibility to Threats

To describe *A. aculeus'* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Acropora* of ocean warming, acidification, disease, predation, sedimentation, nutrients, and collection and trade. The SRR and SIR did not provide any other species-specific information on the effects of these threats on *A. aculeus.* We interpreted the threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *A. aculeus'* vulnerabilities as follows: High vulnerability to ocean warming, moderate vulnerabilities to disease, acidification, trophic effects of fishing, nutrient over-enrichment, and predation, and low vulnerabilities to sedimentation, sea-level rise, and collection and trade.

Public comments provided some supplemental information on *A. aculeus'* threat susceptibilities. One comment stated that *A. aculeus* is more susceptible to predation than indicated in the proposed rule because of the overlap in the depth ranges of this species with crown of thorns starfish. In addition, we gathered the following species-specific and genus-level supplemental information on this species' threat susceptibilities. *Acropora aculeus* has been rated as moderately or highly susceptible to bleaching, but this rating is not based on species-specific data (Carpenter *et al.,* 2008). Done *et al.* (2003b) report 20 percent of *A. aculeus* colonies were affected by bleaching on the GBR in 2002, and the species ranked 31st in proportion of coral colonies on the GBR that were bleached and killed out of 52 studied *Acropora* species. That is, 30 of the 52 species bleached more than *A. aculeus,* and 21 bleached less. Bonin (2012) reported that *A. aculeus* had a ''high'' susceptibility to bleaching in Kimbe Bay, Papua New Guinea on a scale of ''severe,'' ''high,'' ''moderate,'' and ''lowest.'' *Acropora aculeus* was fourth highest out of 16 species, with 50 percent of colonies either severely bleached or dead. The most severely affected species had 74 percent of colonies either severely bleached or dead (Bonin, 2012).

Acropora aculeus has been rated as moderately or highly susceptible to disease, but this rating is not based on species-specific data (Carpenter *et al.,* 2008). Page and Willis (2007) reported that Skeletal Eroding Band has been found in *A. aculeus.* Skeletal Eroding Band is the most prevalent disease on the Great Barrier Reef. They also reported that corymbose *Acropora* had moderate susceptibility to Skeletal Eroding Band in the Great Barrier Reef, with a prevalence of 2.4 percent (Page and Willis, 2007). No other species-specific information is available for the susceptibility of *A. aculeus* to any other threat.

Based on information from other *Acropora* species provided in the genus description above, *A. aculeus* may be susceptible to the effects of ocean acidification on skeletal growth. Genus-level information also suggests that *A. aculeus* is susceptible to trophic effects of fishing, sedimentation, nutrients, predation, sea-level rise, and collection and trade. Thus, based on the available species-specific and genus information summarized above, *A. aculeus* is likely highly susceptible to ocean warming, and also likely has some susceptibilities to disease, acidification, trophic effects of fishing, sedimentation, nutrients, predation, sea-level rise, and collection and trade. The available information does not support more precise ratings of the susceptibilities of *A. aculeus* to the threats.

Regulatory Mechanisms

In the proposed rule we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *A. aculeus.* Public comments were critical of that approach, and we therefore attempt to analyze regulatory mechanisms and conservation efforts on a species basis, where possible, in this final rule. Records confirm that *A. aculeus* occurs in 68 Indo-Pacific ecoregions that encompass 39 countries' EEZs. The 39 countries are Australia, Bangladesh, Brunei, China, Comoros Islands, Federated States of Micronesia, Fiji, France (French Pacific Island Territories), India (including Andaman and Nicobar Islands), Indonesia, Japan, Kenya, Kiribati, Madagascar, Malaysia, Maldives, Marshall Islands, Mauritius, Mozambique, Myanmar, New Zealand (Tokelau), Niue, Palau, Papua New Guinea, Philippines, Samoa, Seychelles, Solomon Islands, South Africa, Sri Lanka, Taiwan, Tanzania, Thailand, Tonga, Tuvalu, United Kingdom (British Indian Ocean Territory and Pitcairn Islands), United States (CNMI, Guam, American Samoa, PRIAs), Vanuatu, and

Vietnam. The regulatory mechanisms relevant to *A. aculeus,* described first as the percentage of the above countries that utilize them to any degree, and second as the percentages of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (28 percent with 8 percent limited in scope), coral collection (56 percent with 31 percent limited in scope), pollution control (38 percent with 10 percent limited in scope), fishing regulations on reefs (95 percent with 26 percent limited in scope), and managing areas for protection and conservation (97 percent with 8 percent limited in scope). The most common regulatory mechanisms in place for *A. aculeus* are reef fishing regulations and area management for protection and conservation. Coral collection laws are also somewhat common for the species, but 31 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection and pollution control laws are much less common regulatory mechanisms for the management of *A. aculeus.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that the high bleaching rate of the *Acropora* genus is the primary known threat of extinction for *A. aculeus.* It listed factors that reduce *A. aculeus'* threat of extinction including its geographic range, depth range, abundance, and variable habitats.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *A. aculeus,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution includes most of the coral reef ecoregions in the Indian Ocean and western and central Pacific Ocean. Its geographic distribution moderates vulnerability to extinction because some areas within its range are projected to have less than average warming and acidification over the foreseeable future, including the western Indian Ocean, the central Pacific, and other areas, so portions of the population in these areas will be less exposed to severe conditions. Its depth range is from low tide to at least 20 meters. This moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Its predominant habitat is shallow lagoons, and it is found in other habitats protected from direct wave action on back-reefs and reef slopes. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Its absolute abundance of at least tens of millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule using the determination tool formula approach, *A. aculeus* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); common generalized range wide abundance (E); wide overall distribution (based on wide geographic distribution and moderate depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *A. aculeus* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *A. aculeus'* spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to be likely to become endangered throughout its range within the foreseeable future, and thus it is not warranted for listing at this time, because:

(1) *Acropora aculeus'* distribution across the Indian Ocean and most of the Pacific Ocean is spread over a very large area. While some areas within its range are projected to be affected by warming and acidification, other areas are projected to have less than average warming and acidification, including the western Indian Ocean, the central Pacific, and other areas. This distribution and the heterogeneous habitats it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future);

(2) *Acropora aculeus'* total absolute abundance is at least tens of millions of colonies, providing buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response; and

(3) It is a broadcast spawner and fast grower, enhancing recovery potential from mortality events as described in the Corals and Coral Reefs section above.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future if global threats continue and worsen in severity and the species' exposure to the threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *A. aculeus* is not warranted for listing at this time under any of the listing factors.

Acropora acuminata

Introduction

The SRR and SIR provided the following information on *A. acuminata's* morphology and taxonomy. Morphology was described as typically forming a tabular base of fused horizontal branches that turn upward and taper to points, and the taxonomy was described as having no taxonomic issues, but colonies turn black when dried.

The public comments and information we gathered provided information on the morphology or taxonomy of *A. acuminata.* One public comment letter stated that specimens of *A. acuminata* in the Mariana Islands may be a different species or a distinct sub-species, based on colony morphology. We gathered supplemental information, including Veron (2014), which states that this species is distinctive. While the public comments and supplemental information provided some information on the morphology and taxonomy of *A. acuminata,* it is sufficiently distinctive to be identified by experts, thus we conclude that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *A. acuminata's* distribution, habitat, and depth range. *Acropora acuminata's* distribution is from the Red Sea to the Pitcairn Islands in the eastern Pacific, covering 110 million km^2, the 5th largest range of 114 *Acropora* species in a large study. In general, its habitat is upper reef slopes and mid-slope terraces and shelves in turbid or clear water at 15–20 m of depth. In Guam, its habitat is deeper reef flat areas and channel slopes.

The public comments and information we gathered provided information on the distribution and habitat of *A. acuminata.* One public comment letter stated that *A. acuminata* in the Mariana Islands appears to be restricted to reef flats and upper reef slopes in protected to semi-protected areas. Thus, based on all the available information, *A. acuminata's* habitat can be summarized as follows: Its predominant habitat is upper reef slopes and mid-slope terraces and shelves in turbid or clear water, and it also occurs in back-reef habitats including reef flats and channels. Its depth range is approximately two to 20 m depth. We gathered supplemental information, including Veron (2014), which reports that *A. acuminata* is confirmed in 60 of his 133 Indo-Pacific ecoregions and is strongly predicted to be found in an additional 12. Wallace (1999b) reports its occurrence in 23 of her 29 Indo-Pacific areas, many of which are significantly larger than Veron's ecoregions.

Demographic Information

The SRR and SIR provided the following information on *A. acuminata's* abundance. *Acropora acuminata* has been reported to occasionally live in extensive clumps with dimensions of several meters, and it can be very common in the center of its range (*e.g.,* Indonesia), but it can be uncommon in the outer parts of its range. The public comments and information we gathered provided information on the abundance of *A. acuminata.* A public comment letter stated that *A. acuminata* in the Mariana Islands is uncommon to rare. We gathered supplemental information, including Richards (2009) and Richards *et al.* (2013b), which conclude from their data that this species is globally widespread, locally restricted, and locally rare, and thus in the second rarest category of *Acropora* with the predicted consequence of persistence. They placed 39 species in this category out of 85 species of *Acropora.* Veron (2014) reports that *A. acuminata* occupied 4.7 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.21 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''uncommon.'' Overall abundance was described as ''sometimes common.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least tens of millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *A. acuminata,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 35 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 14 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context. Thus, quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *A. acuminata* occurs in many areas affected by these broad changes, and that it has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *A. acuminata's* life history. Like most of its congeners, *A. acuminata* is a broadcast spawner. However, some degree of reproductive isolation probably occurs in some locations because the species does not spawn synchronously with the majority of its congeners. The public comments and information we gathered provided no additional biological information.

Susceptibility to Threats

To describe *A. acuminata's* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Acropora* of ocean warming, disease, acidification, sedimentation, nutrients, predation, and collection and trade. The SRR and SIR also stated that *Acropora acuminata* is the only *Acropora* known to not be preferred as prey by the crown-of-thorns starfish, thus susceptibility to predation appears to be low. The SRR and SIR did not provide any other species-specific information on the effects of these threats on *A. acuminata.* The threat susceptibility and exposure information from the SRR and SIR was interpreted in the proposed rule for *A. acuminata'*s vulnerabilities to threats: High vulnerability to ocean warming; moderate vulnerability to disease, acidification, trophic effects of reef fishing, and nutrient over-enrichment; and low vulnerability to sedimentation, sea-level rise, predation, and collection and trade.

Public comments did not provide any information on *A. acuminata's* threat susceptibilities. We gathered the following species-specific and genus-level supplemental information on this species' threat susceptibilities. *Acropora acuminata* has been rated as moderately or highly susceptible to bleaching and coral disease, but these ratings are not based on species-specific data (Carpenter *et al.,* 2008). Based on information from other *Acropora* species provided in the genus description above, *A. acuminata* likely has high susceptibility ocean warming, and also has some susceptibilities to coral disease, acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade. Thus, based on the available species-specific and genus information summarized above, *A. acuminata* is likely highly susceptible to ocean warming, likely has some susceptibilities to disease, acidification, sedimentation, nutrients, trophic effects of fishing, sea-level rise, and collection and trade, and also has low susceptibility to predation.

Regulatory Mechanisms

In the proposed rule we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *A. acuminata.* Public comments were critical of that approach, and we therefore attempt to analyze regulatory mechanisms and conservation efforts on a species basis, where possible, in this final rule. Records confirm that *A. acuminata* occurs in 60 Indo-Pacific ecoregions that encompass 42 countries' EEZs. The 42 countries are Australia, Brunei, China, Comoros Islands, Djibouti, Egypt, Eritrea, Federated States of Micronesia, Fiji, France (French Pacific Island Territories), Indonesia, Israel, Japan, Jordan, Kiribati, Madagascar, Malaysia, Maldives, Marshall Islands, Mauritius, Myanmar, Nauru, New Zealand (Tokelau), Niue, Palau, Papua New Guinea, Philippines, Samoa, Saudi Arabia, Seychelles, Solomon Islands, Sri Lanka, Sudan, Taiwan, Thailand, Tonga, Tuvalu, United Kingdom (British Indian Ocean Territory, Pitcairn Islands), United States (CNMI, Guam, American Samoa, PRIAs), Vanuatu, Vietnam, and Yemen. The regulatory mechanisms available to *A. acuminata,* described first as a percentage of the above countries that utilize them to any degree, and second as the percentages of those countries whose regulatory mechanisms may be limited in scope, are general coral protection (29 percent with 7 percent limited in scope), coral collection (60 percent with 29 percent limited in scope), pollution control (45 percent with 7 percent limited in scope), fishing regulations on reefs (90 percent with 21 percent limited in scope), and managing areas for protection and conservation (93 percent with 10 percent limited in scope). The most common regulatory mechanisms in place for *A. acuminata* are reef fishing regulations and area management for protection and conservation. Coral collection and pollution control laws are also somewhat utilized for the species, but 29 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection laws are much less prominent regulatory mechanisms for the management of *A. acuminata.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that the high bleaching rate of the *Acropora* genus is the primary known threat of extinction for *A. acuminata.* It listed factors that reduce the threat of extinction including the very wide geographic range, the broad depth range, the fact that it is often common and sometimes abundant, and the somewhat broad range of suitable habitats for *A. acuminata.*

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *A. acuminata,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution includes most of the coral reef ecoregions in the Indian Ocean and western and central Pacific Ocean. Its geographic distribution moderates vulnerability to extinction because some areas within its range are projected to have less than average warming and acidification over the foreseeable future, including the western Indian Ocean, the central Pacific, and other areas, so portions of the population in these areas will be less exposed to severe conditions. Its depth range is from 15 to at least 20 meters. This moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Its habitat includes multiple habitat types on both the reef slope and back reef. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. In addition, turbidity can mitigate against the effects of high irradiance by blocking it from the water column in turbid environments. Its absolute abundance of at least tens of millions of colonies, combined with spatial variability in ocean warming and ocean acidification across the species' range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule, using the determination tool formula, *A. acuminata* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); uncommon generalized range wide abundance (E); wide overall distribution (based on wide geographic distribution and moderate depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *A. acuminata* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *A. acuminata's* spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to become endangered throughout its range within the foreseeable future, and thus it is not warranted for listing at this time, because:

(1) *Acropora acuminata*'s distribution across the Indian Ocean and most of the Pacific Ocean is spread over a very large area. While some areas within its range are projected to be affected by warming and acidification, other areas are projected to have less than average warming and acidification, including the western Indian Ocean, the central Pacific, and other areas. This distribution and the heterogeneous habitats it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species' range. As explained in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species' range within the foreseeable future;

(2) *Acropora acuminata*'s total absolute abundance is at least tens of millions of colonies, providing buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all the individuals that are exposed will not have the same response; and

(3) It is a broadcast spawner and fast grower, enhancing recovery potential from mortality events as described in the Corals and Coral Reefs section above.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future if global threats continue and increase in severity and the species exposure to threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *A. acuminata* is not warranted for listing at this time under any of the listing factors.

Acropora aspera

Introduction

The SRR and SIR provided the following information on *A. aspera*'s morphology and taxonomy. The morphology was described as arborescent or bushy clumps which may have largely vertical branches, and the taxonomy was described as having no taxonomic issues.

The public comments did not provide supplemental information on morphology. We gathered supplemental information, including van Oppen *et al.* (2001), which found that *A. aspera* is the only genetically distinct member of the *A. aspera* group of *Acropora* species, a group of morphologically similar species that hybridize at least occasionally. Other supplemental information we gathered was Veron (2014), which states that *A. aspera* is distinctive, thus we conclude it is sufficiently distinctive to be identified by experts, and that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *A. aspera*'s distribution, habitat, and depth range. *Acropora aspera* is distributed from the Red Sea to the Samoan Islands. The species has a relatively broad range, the 46th largest range of 114 *Acropora* species in a large study. It occurs in a broad range of habitats and its depth range as low tide to at least 10 m.

The public comments did not provide supplemental information on *A. aspera*'s distribution. We gathered supplemental information, including Veron (2014), which reports that this species is confirmed in 68 of his 133 Indo-Pacific ecoregions, and is strongly predicted to be found in an additional 17. Wallace (1999b) reports its occurrence in 21 of her 29 Indo-Pacific areas, many of which are significantly larger than Veron's ecoregions, and Richards (2009) calculated the geographic range of *A. aspera* at 70 million km^2. Wallace (1999b) describes its habitat as ''intertidal/shallow subtidal,'' and in much of its range the species is confined to reef flats. Thus, based on all the available information, *A. aspera's* habitat can be summarized as follows: The species occurs in a broad range of habitats on the reef slope and back-reef, including but not limited to lower reef crests, upper reef slopes, reef flats, and lagoons. Its depth range is approximately low tide to 20 m depth.

Demographic Information

The SRR and SIR provided the following information on *A. aspera*'s abundance. *Acropora aspera* has been reported as sometimes locally common and it can occasionally live in extensive clumps with dimensions of several meters.

The public comments and information we gathered provided information on the abundance of *A. aspera.* One public comment letter stated that *A. aspera* is relatively limited in abundance in Guam compared to co-occurring arborescent species such as *Acropora pulchra* and *Acropora muricata.* We gathered supplemental information, including Veron (2014), which reports that *A. aspera* occupied 7.5 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.76 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''common.'' Overall abundance was described as ''sometimes common.'' Veron did not infer trends in abundance from these data. *Acropora asper*a is a reef flat species, and reef flats have a larger global area than reef slopes (Vecsei, 2004). This information is relevant because most coral abundance surveys are carried out only on reef slopes, and thus may significantly underestimate the abundance of species such as *A. aspera* that are more common on reef-flats than reef slopes. In American Samoa, *A. aspera* forms clumps on reef flats many meters across, as much as about 100 m some places (D. Fenner, personal comm.). Richards (2009) and Richards *et al.* (2013b) conclude from their data that this species is globally widespread, locally restricted, and locally common, and thus in one of the categories of highest abundance with the predicted consequence of persistence. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least tens of millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *A. aspera,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 37 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 15 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences of species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *A. aspera* occurs in many areas affected by these broad changes, and that it has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *A. aspera*'s life history. *Acropora aspera* is a hermaphroditic spawner. While it is a participant in mass broadcast spawning in some localities, asynchronous gamete development on the Great Barrier Reef and New Caledonia may provide a degree of reproductive isolation, although *A. aspera* has been shown to hybridize with other acroporids. Gamete development in *A. aspera* may be aborted in years with storm impacts. Asexual reproduction can account for the majority of *A. aspera* population structure in certain areas and can lead to local dominance.

The public comments provided no supplemental biological information. We gathered the following information. In a study of biological traits of coral species, Darling *et al.* (2012) found that all of over 30 *Acropora* species studied were classified as ''competitive'' species which were considered to be less tolerant of environmental stress and disturbance than those species that were classified as ''stress-tolerant,'' ''generalist,'' or ''weedy'', because of documented shifts in coral communities from ''competitive'' to the other categories. *Acropora aspera* was one of the *Acropora* species studied, and was classified as ''competitive'' as were all other *Acropora* species.

Susceptibility to Threats

To describe *A. aspera*'s threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Acropora* of ocean warming, disease, acidification, sedimentation, nutrients, predation, and collection and trade. The SRR and SIR did not provide any species-specific information on the effects of these threats on *A. aspera.* The threat exposure and susceptibility information from the SRR and SIR was interpreted in the proposed rule for *A. aspera's* vulnerabilities to threats as follows: High vulnerability to ocean warming, moderate vulnerabilities to disease, acidification, trophic effects of fishing, nutrients, and predation, and low vulnerabilities to sedimentation, sea-level rise, and collection and trade.

Public comments did not provide supplemental information on *A. aspera*'s threat susceptibilities. We gathered the following species-specific and genus-level supplemental information on this species' threat susceptibilities. *Acropora aspera* was rated as moderately or highly susceptible to bleaching and disease, but this rating is not based on species-specific data (Carpenter *et al.,* 2008). Done *et al.* (2003b) reported that 33 percent of *A. aspera*'s colonies on the GBR were affected by bleaching in 2002, and the species ranked 9th in proportion of coral colonies that were bleached out of 52 studied *Acropora* species. That is, eight of the 52 species bleached more than *A. aspera,* and 43 bleached less.

Acropora aspera experiences sub-acute black-band disease (UNEP, 2010), as well as ciliate infections (Antonius and Lipscomb, 2000). Page and Willis (2007) reported that Skeletal Eroding Band has been found in *A. aspera.* They also reported that bushy *Acropora* had high susceptibility to Skeletal Eroding Band on the GBR, with a prevalence of 3.1 percent. Skeletal Eroding Band is the most prevalent disease on the GBR. A study of the effects of near-term ocean acidification and elevated seawater temperature on the physiology of *A. aspera* suggested that gene expression of key metabolic proteins is impacted by the synergistic effects of near term ocean acidification (*i.e.,* the conditions expected to result from 50 to 90 ppm CO_2 above current atmospheric levels) and ocean warming (Ogawa *et al.,* 2013b). *Acropora aspera* is a preferred prey of crown-of-thorns seastar (Sonoda and Paul, 1993). With regard to sedimentation, *A. aspera* was found to be relatively tolerant of silty, turbid water in the South China Sea (Latypov and Dautova, 2005). No other species-specific information is available for the susceptibility of *A. aspera* to any other threat.

Based on the available genus-level and species-specific information, *A. aspera* is likely highly susceptible to ocean warming, and it also likely has some susceptibilities to disease, acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade. The available information does not support more precise ratings of the susceptibilities of *A. aspera* to the threats.

Regulatory Mechanisms

In the proposed rule we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *A. aspera.* Public comments were critical of that approach, and we therefore attempt to analyze regulatory mechanisms and conservation efforts on a species basis, where possible, in this final rule. Records confirm that *Acropora aspera* occurs in 68 Indo-Pacific ecoregions that encompass 44 countries' EEZs. The 44 countries are Australia (including Cocos-Keeling Islands), Bahrain, Brunei, Cambodia, China, Federated States of Micronesia, Fiji, France (French Pacific Island Territories), India (including Andaman and Nicobar Islands), Indonesia, Iran, Japan, Kiribati, Kuwait, Madagascar, Malaysia, Maldives, Marshall Islands, Mauritius, Myanmar, New Zealand (Tokelau), Niue, Oman, Palau, Papua New Guinea, Philippines, Qatar, Samoa, Saudi Arabia, Seychelles, Singapore, Solomon Islands, Sri Lanka, Taiwan, Thailand, Timor-Leste, Tonga, Tuvalu, United Arab Emirates, United Kingdom (British Indian Ocean Territory), United

States (CNMI, Guam, American Samoa, PRIAs), Vanuatu, Vietnam, and Yemen. The regulatory mechanisms available to *A. aspera,* described first as a percentage of the above countries that utilize them to any degree, and second as the percentage of those countries whose regulatory mechanisms are limited in scope, are as follows: General coral protection (32 percent with 9 percent limited in scope), coral collection (52 percent with 25 percent limited in scope), pollution control (43 percent with 7 percent limited in scope), fishing regulations on reefs (91 percent with 23 percent limited in scope), and managing areas for protection and conservation (89 percent with 9 percent limited in scope). The most common regulatory mechanisms in place for *A. aspera* are reef fishing regulations and area management for protection and conservation. Coral collection and pollution control laws are also somewhat utilized for the species, but 25 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection laws are much less common regulatory mechanisms for the management of *A. aspera.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that the high bleaching rate of the *Acropora* genus is the primary known threat of extinction for *A. aspera.* It listed factors that reduce the threat of extinction including the wide geographic range, the fact that it is often common and sometimes abundant, and the somewhat broad range of suitable habitats for *A. aspera.*

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *A. aspera,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution includes most of the coral reef ecoregions in the Indian Ocean and western and central Pacific Ocean. Its geographic distribution moderates vulnerability to extinction because some areas within its range are projected to have less than average warming and acidification over the foreseeable future, including the western Indian Ocean, the central Pacific, and other areas, so portions of the population in these areas will be less exposed to severe conditions. Its depth range is from low tide to at least 10 meters. Assuming that the species' depth distribution is limited to 10 meters, this exacerbates vulnerability to extinction over the foreseeable future because shallow areas are more likely to be affected by warming-induced bleaching and disease than deeper areas. Its habitat includes lower reef crests, upper reef slopes, reef flats, and lagoons. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Its absolute abundance of at least tens of millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule using the determination tool formula approach, *A. aspera* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); common generalized range wide abundance (E); narrow overall distribution (based on moderate geographic distribution and shallow depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *A. aspera* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *A. aspera'* spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to be likely to become endangered throughout its range within the foreseeable future, and thus it is not warranted for listing at this time, because:

(1) *Acropora aspera*'s distribution is spread over a very large area. While some areas within its range are projected to be affected by warming and acidification, other areas are projected to have less than average warming and acidification, including the western Indian Ocean, the central Pacific, and other areas. This distribution and the heterogeneous habitats it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future;

(2) *Acropora aspera*'s absolute abundance is at least tens of millions of colonies, providing buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response; and

(3) It is a broadcast spawner and fast grower, enhancing recovery potential from mortality events as described in the Corals and Coral Reefs section above.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future if global threats continue and worsen in severity and the species' exposure to the threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *A. aculeus* is not warranted for listing at this time under any of the listing factors.

Acropora dendrum

Introduction

The SRR and SIR provided the following information on *A. dendrum*'s morphology and taxonomy. The morphology was described as plates 0.5 to1 m diameter, with widely spaced vertical branchlets, and taxonomy was described as having no taxonomic issues. However, *A. dendrum* is ''poorly characterized and may indeed be a 'phantom' species, being made up from specimens that cannot be allocated to other species.'' However, the BRT treats it as a nominal species. They stated that it is most similar to *Heteropora appressa* and *A. microclados*.

The public comments did not provide supplemental information on morphology or taxonomy. We gathered supplemental information, which confirmed that while there is some taxonomic uncertainty for *A. dendrum,* it is recognized as valid by experts (Veron, 2000; Veron, 2014; Wallace, 1999b). Veron (2014) states that *A. dendrum* is distinctive, thus we conclude it is sufficiently distinctive to be identified by experts, and that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *A. dendrum*'s distribution, habitat, and depth range. *Acropora dendrum* is distributed from the north-central Indian Ocean to Fiji, and from Japan to the Great Barrier Reef. The species' predominant habitat is upper reef slopes and mid-slope terraces, and its depth range is 5 to 20 m. Upper reef slopes and mid-slope terraces extend seaward from the reef crest toward the open ocean, forming one of the most common and widespread coral reef habitats. They vary in gradient from gentle to steep, and include a great deal of physical complexity, including ridges, furrows, walls, caves, and other structures, collectively providing highly diverse coral habitats.

The public comments did not provide supplemental information on *A. dendrum*'s distribution. We gathered supplemental information, including Veron (2014), which reports that this species is confirmed in 32 of his 133 Indo-Pacific ecoregions, and is strongly predicted to be found in an additional 20. Wallace (1999b) reports its occurrence in nine of her 29 Indo-Pacific areas, many of which are significantly larger than Veron's ecoregions, and Richards (2009) reported the species as having the 48th smallest range of 114 *Acropora* species in a large study and calculated the geographic range at over 20 million km^2. *Acropora dendrum* occurs on exposed reef fronts where *Acropora* diversity is high (Veron and Wallace, 1984). The public comments and information we gathered provided nothing additional on *A. dendrum*'s habitat and depth range.

Demographic Information

The SRR and SIR provided the following information on *A. dendrum*'s abundance. *Acropora dendrum* has been reported as uncommon or rare.

The public comments did not provide supplemental information on *A. dendrum*'s abundance. We gathered supplemental information, which indicates that there are no locations recorded where *A. dendrum* is common or even more abundant than a rare species (Wallace, 1999b). Veron (2014) provides a much more detailed range map for this species than the maps used in the SRR, and reports that *A. dendrum* occupied 2.0 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.11 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''uncommon.'' Overall abundance was described as ''rare.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least tens of millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *A. dendrum,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 35 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 14 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences of species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *A. dendrum* occurs in many areas affected by these broad changes, and that it has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *A. dendrum*'s life history. Like most of its congeners, *A. dendrum* is a hermaphroditic spawner (Mezaki *et al.,* 2007; Wallace, 1985) with lecithotrophic (yolk-sac) larvae (Baird *et al.,* 2009). The public comments and information we gathered provided no supplemental biological information.

Susceptibility to Threats

To describe *A. dendrum*'s threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Acropora* of ocean warming, disease, acidification, sedimentation, nutrients, predation, and collection and trade. The SRR and SIR did not provide any other species-specific information on the effects of these threats on *A. dendrum.* We interpreted the threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *A. dendrum*'s vulnerabilities as follows: High vulnerability to ocean warming, moderate vulnerabilities to disease, acidification, trophic effects of fishing, nutrients, and predation, and low vulnerabilities to sedimentation, sea-level rise, and collection and trade.

Public comments did not provide supplemental information on *A. dendrum*'s threat susceptibilities. We gathered the following species-specific and genus-level supplemental information on this species' threat susceptibilities. *Acropora dendrum* has been rated as moderately or highly susceptible to bleaching and disease, but these ratings are not based on species-specific data (Carpenter *et al.,* 2008). Based on information from other *Acropora* species provided in the genus description above, *A. dendrum* is likely to be highly susceptible to ocean warming, and also has some susceptibilities to disease, acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade. The available information does not support more precise ratings of the susceptibilities of *A. dendrum* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *A. dendrum.* Public comments were critical of that approach, and we therefore attempt to analyze regulatory mechanisms and conservation efforts on a species basis, where possible, in this final rule. *Acropora dendrum* has confirmed records of occurrence in 32 Indo-Pacific ecoregions that encompass 14 countries' EEZs. The 14 countries are Australia, Brunei, China, France (French Pacific Island Territories), Indonesia, Japan, Malaysia, Myanmar, Papua New Guinea, Philippines, Solomon Islands, Thailand, Vanuatu, and Vietnam. The regulatory mechanisms available to *A. dendrum,* described first as a percentage of the above countries that utilize them to any degree, and second as the percentage of those countries whose regulatory mechanisms are limited in scope, are as follows: General coral protection (36 percent with seven percent limited in scope), coral collection (57 percent with 29 percent limited in scope), pollution control (43 percent with 21 percent limited in scope), fishing regulations on reefs (100 percent with 21 percent limited in scope), and managing areas for protection and conservation (93 percent with none limited in scope). The most common regulatory mechanisms in place for *A. dendrum* are reef fishing regulations and area management for protection and conservation. Coral collection and pollution control laws are also somewhat utilized for the species, but 29 percent of those laws are limited in scope and may not provide substantial protection. General coral protection laws are much less common regulatory mechanisms for the management of *A. dendrum.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that the high bleaching rate of the *Acropora* genus is the primary known threat of extinction for *A. dendrum.* It listed factors that reduce the threat of extinction, including the fairly wide geographic range, the depth range, and the somewhat broad range of suitable habitats.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *A. dendrum,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic range extends from western Malaysia to Vanuatu, and southern Japan to the GBR. On one hand, this moderates vulnerability to extinction because the high latitude areas in the northern and southern portions of its range are projected to have less than average warming over the foreseeable future, thus populations in these areas will be less exposed to severe warming conditions. On the other hand, the species' geographic distribution exacerbates vulnerability to extinction because much of it lies within the western equatorial Pacific, an area projected to have the highest seawater temperatures in the foreseeable future. Its depth range is from 5 to 20 meters. This moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Its habitat includes upper reef slopes and mid-slope terraces. This moderates vulnerability to extinction over the foreseeable future because upper reef slopes and mid-slope terraces are physically diverse and widespread, thus the species occurs in reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Its absolute abundance of at least tens of millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule using the determination tool formula approach, *A. dendrum* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); rare generalized range wide abundance (E); moderate overall distribution (based on moderate geographic distribution and moderate depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *A. dendrum* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *A. dendrum*'s spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to be likely to become endangered throughout its range within the foreseeable future, and thus it is not warranted for listing at this time, because:

(1) *Acropora dendrum*'s distribution is spread over a very large area. While some areas within its range are projected to be affected by warming and acidification, other areas are projected to have less than average warming and acidification, including the central Pacific and other areas. This distribution and the heterogeneous habitats it occupies reduce exposure to

any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future;

(2) *Acropora dendrum*'s absolute abundance is at least tens of millions of colonies, providing buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response; and

(3) As with other *Acropora* species, it is a broadcast spawner and fast grower, enhancing recovery potential from mortality events.

Notwithstanding projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future if global threats continue and worsen in severity and the species' exposure to the threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *A. dendrum* is not warranted for listing at this time under any of the listing factors.

Acropora donei

Introduction

The SRR and SIR provided the following information on *A. donei*'s morphology and taxonomy. Morphology was described as table-like, up to 2 m diameter, with branchlets that are horizontal near the edge but upturned in the middle, and taxonomy was described as having no taxonomic issues, but being similar in appearance to *A. yongei*.

The public comments did not provide any new or supplemental information on morphology or taxonomy. We gathered supplemental information, which indicated that there is some taxonomic uncertainty with this species, but that it is recognized as valid by experts (Fukami *et al.,* 2004; Veron, 2000). Veron (2014) states that *A. donei* is distinctive, thus we conclude it is sufficiently distinctive to be identified by experts, and that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *A. donei*'s distribution, habitat, and depth range. *Acropora donei* is distributed from the northern Indian Ocean to the central Indo-Pacific, and from Australia to Japan. They reported that it had the 44th largest range of 114 *Acropora* species examined. The species' habitat is upper reef slopes and mid-slope terraces. It may be restricted habitats where *Acropora* diversity is high, but this includes a large proportion of the Indo-Pacific's reef slopes. Its depth range is 5 to 20 m.

The public comments did not provide any new or supplemental information on *A. donei*'s distribution. We gathered supplemental information, including Veron (2014), which provides an updated, much more detailed range map for this species than the maps used in the SRR. Veron reports that *A. donei* is confirmed in 50 of his 133 Indo-Pacific ecoregions, and is strongly predicted to be found in an additional 17. Wallace (1999b) reports its occurrence in 20 of her 29 Indo-Pacific areas, many of which are significantly larger than Veron's ecoregions. *Acropora donei* has a relatively broad range overall, estimated at 75 million km^2 (Richards, 2009). The public comments and information we gathered provided nothing additional on *A. donei*'s habitat and depth range.

Demographic Information

The SRR and SIR provided the following information on *A. donei*'s abundance. *Acropora donei* has been reported to be uncommon. Richards (2009) concluded that *A. donei* is globally widespread, locally restricted, and locally rare, and thus in the second rarest category of *Acropora* with the predicted consequence of local extinction. The public comments and information we gathered provided information on *A. donei*'s abundance. One public comment stated that a recently published paper (Kayanne *et al.,* 2012) reported that *A. donei* was among the second most abundant group of corals on Okinotorishima, Japan, and was classified as ''common'' (paper was provided with the comment). We gathered supplemental information, which reports that *A. donei* is a common species on Indonesian reefs and reefs of the South China Sea and Japan (Wallace and Wolstenholme, 1998). Veron (2014) reports that *A. donei* occupied 4.7 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.16 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''uncommon,'' and overall abundance was also described as ''uncommon.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least tens of millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *A. donei,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 37 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 15 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *A. donei* occurs in many areas affected by these broad changes, and that it has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *A. donei*'s life history. *Acropora donei* is a hermaphroditic spawner with lecithotrophic (yolk-sac) larvae. The public comments and information we gathered provided no additional biological information.

Susceptibility to Threats

To describe *A. donei*'s threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Acropora* of ocean warming, disease, acidification, sedimentation, nutrients, predation, and collection and trade. The SRR and SIR did not provide any other species-specific information on the effects of these threats on *A. donei.* We interpreted the threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *A. donei*'s vulnerabilities as follows: High vulnerability to ocean warming, moderate vulnerabilities to disease, ocean acidification, trophic effects of fishing, nutrients, and predation, and low vulnerabilities to sedimentation, sea-level rise, and collection and trade.

Public comments did not provide any new or supplemental information on *A. donei*'s threat susceptibilities. We gathered the following species-specific and genus-level supplemental information on this species' threat susceptibilities. *Acropora donei* has been rated as moderately or highly susceptible to bleaching and disease, but these ratings are not based on species-specific data (Carpenter *et al.,* 2008). Based on information from other *Acropora* species provided in the genus description above, *A. donei* is likely highly susceptible to ocean warming, and likely has some susceptibilities to disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade. The available information does not support more precise ratings of the susceptibilities of *A. donei* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *A. donei.* Criticisms of our approach received during public comment led us to the following analysis to attempt to analyze regulatory mechanisms on a species basis. Records confirm that *A. donei* occurs in 68 Indo-Pacific ecoregions that encompass 34 countries' EEZs. The 34 countries are Australia, Brunei, China, Comoros Islands, Djibouti, Eritrea, Federated States of Micronesia, Fiji, France (French Pacific Island Territories), Indonesia, Japan, Kiribati, Madagascar, Malaysia, Maldives, Marshall Islands, Myanmar, New Zealand (Tokelau), Niue, Palau, Papua New Guinea, Philippines, Samoa, Saudi Arabia, Solomon Islands, Sri Lanka, Taiwan, Thailand, Tonga, Tuvalu, United States (American Samoa, PRIAs), Vanuatu, Vietnam, and Yemen. The regulatory mechanisms relevant to *A. donei,* described first as the percentage of the above countries that utilize them to any degree, and second as the percentages of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (32 percent with 6 percent limited in scope), coral collection (59 percent with 29 percent limited in scope), pollution control (44 percent with 9 percent limited in scope), fishing regulations on reefs (97 percent with 15 percent limited in scope), and managing areas for protection and conservation (94 percent with 3 percent limited in scope). The most common regulatory mechanisms in place for *A. donei* are reef fishing regulations and area management for protection and conservation. Coral collection and pollution control laws are also somewhat utilized for the species, but 29 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection laws are much less common regulatory mechanisms for the management of *A. donei.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that the high bleaching rate of the *Acropora genus* is the primary known threat of extinction for *A. donei.* It listed factors that reduce the threat of extinction including the moderate geographic and depth ranges.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *A. donei,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution includes most of the coral reef ecoregions in the Indian Ocean and western and central Pacific Ocean. Its geographic distribution moderates vulnerability to extinction because some areas within its range are projected to have less than average warming and acidification over the foreseeable future, including the western Indian Ocean, the central Pacific, and other areas, so portions of the population in these areas will be less exposed to severe conditions. Its depth range is from five to at least 20 meters. This moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Its habitat includes upper reef slopes and mid-slope terraces. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Its absolute abundance of at least tens of millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule using the determination tool formula, *A. donei* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); uncommon generalized range wide abundance (E); moderate overall distribution (based on moderate geographic distribution and moderate depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *A. donei* from threatened to not warranted. We made this decision based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *A. donei*'s spatial structure, demography, threat susceptibilities, and management none of the five ESA factors, alone or in combination, are causing this species to be endangered throughout its range within the foreseeable future, and thus it is not warranted for listing at this time, because:

(1) *Acropora donei*'s distribution across the Indian Ocean and most of the Pacific Ocean is spread over a very large area. While some areas within its range are projected to be affected by warming and acidification, other areas are projected to have less than average warming and acidification, including the western Indian Ocean, the central Pacific, and other areas. This distribution and the heterogeneous habitats it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future);

(2) *Acropora donei*'s total absolute abundance is at least tens of millions of colonies, providing buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response; and

(3) It is a broadcast spawner and fast grower, enhancing recovery potential from mortality events as described in the Corals and Coral Reefs section above.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future if global threats continue and worsen in severity and the species' exposure to the threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *A. donei* is not warranted for listing at this time under any of the listing factors.

Acropora globiceps

Introduction

The SRR and SIR provided the following information on *A. globiceps'* morphology and taxonomy. Morphology was described as digitate and usually small, and taxonomy was described as having no taxonomic issues, but radial corallites were reported similar to *Acropora secale* and *Acropora retusa*. It appears similar to *Acropora gemmifera,* but in strong wave action is similar to *Acropora monticulosa*.

The public comments did not provide any new or supplemental information on morphology and taxonomy. We gathered supplemental information, including Wallace (1999b), which states that *A. globiceps'* branch thickness and colony shape is similar to that of *Acropora humilis,* and its branch shape and radial corallite morphology is similar to that of *Acropora samoensis*. It appears that this species has often been mistaken for *A. humilis* (Fenner, 2014b). Veron (2014) states that *A. globiceps* is distinctive, thus we conclude it can be identified by experts, and that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *A. globiceps'* distribution, habitat, and depth range. *Acropora globiceps* is distributed from the oceanic west Pacific to the central Pacific as far east as the Pitcairn Islands. The species has the 27th smallest range of 114 *Acropora* species in a large study. The species occurs on upper reef slopes, reef flats, and adjacent habitats in depths ranging from 0 to 8 m.

The public comments did not provide any new or supplemental information on *A. globiceps'* distribution. We gathered supplemental information, including Veron (2014), which reports that *A. globiceps* is confirmed in 22 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional 16. Wallace (1999b) reports its occurrence in seven of her 29 Indo-Pacific areas, many of which are significantly larger than Veron's ecoregions. Wallace's (1999b) map shows it from a smaller area than Veron (Veron, 2000; Veron, 2014). Based on the Wallace (1999b) range, *A. globiceps* has a relatively small range, estimated at 5 million km^2 (Richards, 2009). The public comments and information we gathered provided nothing additional on *A. globiceps'* habitat and depth range.

Demographic Information

The SRR and SIR provided the following information on *A. globiceps'* abundance. *Acropora globiceps* has been reported as common (Veron, 2000). The public comments did not provide any new or supplemental information on *A. globiceps'* abundance. We gathered supplemental information, including Veron (2014), which reports that *A. globiceps* occupied 3.2 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.95 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''uncommon.'' Overall abundance was described as ''sometimes common.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least tens of millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *A. globiceps,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 35 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 14 percent (Carpenter et al., 2008). However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *A. globiceps* occurs in many areas affected by these broad changes, and that it has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible due to the limited species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *A. globiceps'* life history. *Acropora globiceps* is a hermaphroditic spawner with lecithotrophic (yolk-sac) larvae. The public comments and information we gathered did not provide additional biological information.

Susceptibility to Threats

To describe *A. globiceps'* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Acropora* of ocean warming, acidification, disease, predation, sedimentation, and nutrients. The SRR and SIR did not provide any other species-specific information on the effects of these threats on *A. globiceps*. The exposure and susceptibility threat information from the SRR and SIR was interpreted in the proposed rule for *A. globiceps'* vulnerabilities to threats as follows: High vulnerability to ocean warming, moderate vulnerabilities to disease, ocean acidification, trophic effects of fishing, nutrients, and predation, and low vulnerabilities to sedimentation, sea-level rise, and collection and trade.

Public comments did not provide any new or supplemental information on *A. globiceps'* threat susceptibilities. We gathered the following species-specific and genus-level supplemental information on this species' threat susceptibilities. *Acropora globiceps* has been rated as moderately or highly susceptible to bleaching and disease, but these ratings are not based on species-specific data (Carpenter *et al.,* 2008). Based on information from other *Acropora* species provided in the genus description above, *A. globiceps* is likely highly susceptible to ocean warming, and also likely has some susceptibilities to disease, acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade. The available information does not support more precise ratings of the susceptibilities of *A. globiceps* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *A. globiceps*. Criticisms of our approach received during public comment led us to the following analysis to attempt to analyze regulatory mechanisms on a species basis. Records confirm that *A. globiceps* occurs in 22 Indo-Pacific ecoregions that encompass 19 countries' EEZs. The 19 countries are Australia, Federated States of Micronesia, Fiji, France (French Pacific Island Territories), Indonesia, Japan, New Zealand (Cook Islands, Tokelau), Niue, Palau, Papua New Guinea, Philippines, Samoa, Solomon Islands, Timor-Leste, Tonga, Tuvalu, United Kingdom (Pitcairn Islands), United States (CNMI, Guam, American Samoa), and Vietnam. The regulatory mechanisms relevant to *A. globiceps,* described first as the percentage of the above countries that utilize them to any degree and second, as the percentages of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (32 percent with none limited in scope), coral collection (74 percent with 37 percent limited in scope), pollution control (42 percent with 16 percent limited in scope), fishing regulations on reefs (100 percent with 11 percent limited in scope), and managing areas for protection and conservation (100 percent with 5 percent limited in scope). The most common regulatory mechanisms in place for *A. globiceps* are reef fishing regulations, area management for protection and conservation, and coral collection laws. However, 37 percent of coral collection laws are limited in scope and may not provide substantial protection. Pollution control laws are also somewhat utilized for the species. General coral protection laws are much less common regulatory mechanisms for the management of *A. globiceps*.

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that the high bleaching rate of the *Acropora* genus is the primary known threat of extinction for *A. globiceps,* but the narrow depth range also increases the risk of extinction. It listed factors that reduce the threat of extinction including common abundance and persistence in intertidal habitats.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *A. globiceps,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution includes the Coral Triangle, but also includes many coral reef ecoregions in the western and central Pacific Ocean, as far east as the Pitcairn Islands. Some areas within its range are projected to have less than average warming and acidification over the foreseeable future, including the central Pacific, so portions of the population in these areas will be less exposed to severe conditions. On the other hand, the Coral Triangle area is projected to have the most rapid and severe impacts from climate change and localized human impacts for coral reefs over the 21st century. As such, its geographic distribution has the ability to both moderate and exacerbate vulnerability to extinction. Its depth range of zero to 8 meters exacerbates vulnerability to extinction over the foreseeable future because a large proportion of the population is restricted to shallow areas. Shallow reef areas can be physically diverse, but are often subjected to frequent changes in environmental conditions, extremes, high irradiance, and simultaneous effects from multiple stressors, both local and global in nature. Its habitat includes upper reef slopes, reef flats, and adjacent habitats. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Its absolute abundance of at least tens of millions of colonies combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule using the determination tool formula approach, *A. globiceps* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); common generalized range wide abundance (E); narrow overall distribution (based on moderate geographic distribution and narrow depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we maintain the listing determination for *A. globiceps*. Based on the best available information provided above on *A. globicep*'s spatial structure, demography, threat susceptibilities, and management indicate that it is likely to become endangered throughout its range within the foreseeable future, and thus warrants listing as threatened at this time, because:

(1) *Acropora globiceps* is highly susceptible to ocean warming (ESA Factor E), and susceptible to disease (C), ocean acidification (E), trophic effects of fishing (A, E), nutrients (A, E), and predation (C). These threats are expected to continue and increase into the future. In addition, existing regulatory mechanisms to address global threats that contribute to extinction risk for this species are inadequate (D); and

(2) *Acropora globiceps* occurs primarily in depths of zero to eight meters which can be considered a shallow depth range compared to the overall depth of occurrence for reef building corals in general. Shallow reef areas are often subjected to highly variable environmental conditions, extremes, high irradiance, and simultaneous effects from multiple stressors, both local and global in nature. A limited depth range reduces the absolute area in which the species may occur throughout its geographic range and indicates that a large proportion of the population is likely to be exposed to threats that are worse in shallow habitats, such as simultaneously elevated irradiance and seawater temperatures, as well as localized impacts.

The combination of these characteristics and future projections of threats indicates that the species is likely to be in danger of extinction within the foreseeable future throughout its range and warrants listing as threatened at this time due to factors A, C, D, and E.

The available information above on *A. globiceps'* spatial structure, demography, threat susceptibilities, and management also indicate that the species is not currently in danger of extinction and thus does not warrant listing as Endangered because:

(1) While *A. globiceps'* distribution includes the Coral Triangle area, it also includes many ecoregions throughout the central Pacific from Japan down to New Caledonia and as far east as the Pitcairn Islands. This distribution includes some areas within its range that are projected to have less than average warming and acidification over the foreseeable future, including the central Pacific, so portions of the population in these areas will be less exposed to severe conditions.

(2) *Acropora globiceps'* absolute abundance is at least tens of millions of colonies which allows for variation in the responses of individuals to threats to play a role in moderating vulnerability to extinction for the species to some degree, as described in more detail in the Corals and Coral Reefs section. There is no evidence of depensatory processes such as reproductive failure from low density of reproductive individuals and genetic processes such as inbreeding affecting this species. Thus, its absolute abundance indicates it is currently able to avoid high mortality from environmental stochasticity, and mortality of a high proportion of its population from catastrophic events.

The combination of these characteristics indicates that the species does not exhibit the characteristics of one that is currently in danger of extinction, as described previously in the Risk Analyses section, and thus does not warrant listing as endangered at this time.

Range-wide, a multitude of conservation efforts are already broadly employed that are likely benefiting *A. globiceps*. However, considering the global scale of the most important threats to the species, and the ineffectiveness of conservation efforts at addressing the root cause of global threats (*i.e.,* GHG emissions), we do not believe that any current conservation efforts or conservation efforts planned in the future will result in affecting the species status to the point at which listing is not warranted.

Acropora horrida

Introduction

The SRR and SIR provided the following information on *A. horrida*'s morphology and taxonomy. Morphology was described as usually open branched, becoming bushy on upper reef slopes and in shallow lagoons. No taxonomic issues were raised, but *A. horrida* was stated to be similar to *Acropora tortuosa,* and *Acropora vaughani.*

The public comments did not provide any new or supplemental information on morphology or taxonomy. We gathered supplemental information, including Veron (2014), which states that *A. horrida* is distinctive, thus we conclude it can be identified by experts, and that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *A. horrida*'s distribution, habitat, and depth range. *Acropora horrida* is distributed from the Red Sea to French Polynesia. The species has a very broad range overall, having the 14th largest range of 114 *Acropora* species examined. It is found in numerous reef slope and back-reef habitats with turbid water, including but not limited to, upper reef slopes, mid-slope terraces, lagoons, and adjacent habitats. The SRR described its depth range as 5 to 20 m.

The public comments did not provide any new or supplemental information on *A. horrida*'s distribution. We gathered supplemental information, including Veron (2014), which reports that this species is confirmed in 61 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional 22. Wallace (1999b) reports its occurrence in 24 of her 29 Indo-Pacific areas, many of which are significantly larger than Veron's ecoregions. Richards (2009) calculated the geographic range of *A. horrida* at over 100 million km^2. Wallace (1999b) reports the depths from which *A. horrida* specimens were collected ranged from 17 to 39 m.

Demographic Information

The SRR and SIR provided the following information on *A. horrida*'s abundance. *Acropora horrida* has been reported as usually uncommon. This is a species that is globally widespread, locally restricted, and locally rare, and thus in the second rarest category of *Acropora* with the predicted consequence of local extinction. The public comments did not provide any new or supplemental information on *A. horrida*'s abundance. We gathered supplemental information, including Veron (2014), which reports that *A. horrida* occupied 8.9 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.70 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''common.'' Overall abundance was described as ''uncommon.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least tens of millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *A. horrida,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 36 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 15 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *A. horrida* occurs in many areas affected by these broad changes, and that it has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *A. horrida*'s life history. *Acropora horrida* is a hermaphroditic spawner with lecithotrophic (yolk-sac) larvae. Mean egg size for *A. horrida* has been recorded as 0.64 mm and mean polyp fecundity has been recorded as 9.0 eggs per polyp. This species did synchronize its spawning with other *Acropora* species on the central GBR during the major multispecies spawning events in early summer 1981–1983.

Public comments provided no additional biological information. We gathered the following supplemental information on the life history of *A. horrida*. Darling *et al.* (2012) found that all of over 30 *Acropora* species studied were classified as ''competitive'' species which were considered to be less tolerant of environmental stress and disturbance than those species that were classified as ''stress-tolerant,'' ''generalist,'' or ''weedy,'' because of documented shifts in coral communities from ''competitive'' to the other categories. *Acropora horrida* was one of the *Acropora* species studied.

Susceptibility to Threats

To describe *A. horrida'* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Acropora* of ocean warming, acidification, disease, predation, sedimentation, nutrients, and collection and trade. The SRR and SIR also provided the following species-specific information on *A. horrida*'s threats. With regard to ocean warming, *A. horrida* is thought to have been locally extirpated in the Arabian Gulf after the 1996 and 1998 bleaching events, but the species is considered less susceptible to bleaching than other *Acropora* spp. The SRR and SIR did not provide any species-specific information on the effects of these threats on *A. horrida*. We interpreted the threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *A. horrida*'s vulnerabilities as follows: High vulnerability to ocean warming, moderate vulnerabilities to disease, acidification, trophic effects of fishing, nutrients, and predation, and low vulnerabilities to sedimentation, sea-level rise, and collection and trade.

Public comments did not provide any new or supplemental information on *A. lokani*'s threat susceptibilities. We gathered the following species-specific and genus-level supplemental information on this species' threat susceptibilities. *Acropora horrida* has been rated as moderately or highly susceptible to bleaching and disease, but these ratings are not based on species-specific data (Carpenter *et al.,* 2008). Done *et al.* (2003b) reported that 20 percent of *A. horrida* colonies on the Great Barrier Reef were affected by bleaching in 2002, and the species ranked 29th in proportion of coral colonies that were bleached and killed out of 52 studied *Acropora* species. That is, 28 of the 52 species bleached more than *A. horrida,* and 23 bleached less.

No other species-specific information is available for the susceptibility of *A. horrida* to any other threat. Based on information from other *Acropora* species provided in the genus description above, *A. horrida* may be susceptible to the effects of disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade. Thus, based on the available species-specific and genus information summarized above, *A. horrida* is likely highly susceptible to ocean warming, and also likely has some susceptibilities to disease, ocean acidification, trophic effects of fishing, predation, sedimentation, nutrients, sea-level rise, and collection and trade. The available information does not support more precise ratings of the susceptibilities of *A. horrida* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *A. horrida.* Criticisms of our approach received during public comment led us to the following analysis to attempt to analyze regulatory mechanisms on a species basis. Records confirm that *A. horrida* occurs in 61 Indo-Pacific ecoregions that encompass 45 countries' EEZs. The 45 countries are Australia, Bahrain, China, Djibouti, Egypt, Eritrea, Federated States of Micronesia, Fiji, France (French Pacific Island Territories), Indonesia, Iran, Israel, Japan, Jordan, Kenya, Kiribati, Kuwait, Madagascar, Malaysia, Maldives, Marshall Islands, Mauritius, Mozambique, Myanmar, New Zealand (Tokelau), Niue, Palau, Papua New Guinea, Philippines, Qatar, Samoa, Saudi Arabia, Seychelles, Solomon Islands, Sudan, Taiwan, Tanzania, Thailand, Tonga, Tuvalu, United Arab Emirates, United Kingdom (British Indian Ocean Territory), United States (American Samoa, PRIAs), Vietnam, and Yemen. The regulatory mechanisms relevant to *A. horrida,* described first as the percentage of the above countries that utilize them to any degree and second, as the percentages of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (24 percent with 2 percent limited in scope), coral collection (58 percent with 24 percent limited in scope), pollution control (44 percent with 7 percent limited in scope), fishing regulations on reefs (87 percent with 24 percent limited in scope), and managing areas for protection and conservation (87 percent with 11 percent limited in scope). The most common regulatory mechanisms in place for *A. horrida* are reef fishing regulations and area management for protection and conservation. Coral collection and pollution control laws are also somewhat utilized for the species, but 24 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection laws are much less common regulatory mechanisms for the management of *A. horrida.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that the high bleaching rate of the *Acropora* genus is the primary known threat of extinction for *A. horrida.* It listed factors that reduce the threat of extinction including the very wide geographic range, with large local distributions, and tolerance for turbid water.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *A. horrida,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution includes most of the coral reef ecoregions in the Indian Ocean and western and central Pacific Ocean. Its geographic distribution moderates vulnerability to extinction because some areas within its range are projected to have less than average warming and acidification over the foreseeable future, including the western Indian Ocean, the central Pacific, and other areas, so portions of the population in these areas will be less exposed to severe conditions. Its depth range is from five to 39 meters. This moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Its habitat includes numerous reef slope and back-reef habitats with turbid water, including but not limited to, upper reef slopes, mid-slope terraces, lagoons, and adjacent habitats. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. In addition, turbidity can mitigate the effects of high irradiance by blocking it from the water column. Its absolute abundance of at least tens of millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule using the determination tool formula approach, *A. horrida* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); uncommon generalized range wide abundance (E); wide overall distribution (based on wide geographic distribution and moderate depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *A. horrida* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *A. horrida's* spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to be likely to become endangered throughout its range within the foreseeable future, and thus it is not warranted for listing at this time, because:

(1) *Acropora horrida'*s distribution from the Red Sea across the Indian Ocean and most of the Pacific Ocean is spread over a very large area. While some areas within its range are projected to be affected by warming and acidification, other areas are projected to have less than average warming and acidification, including the western Indian Ocean, the central Pacific, and other areas. This distribution and the heterogeneous habitats it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future;

(2) *Acropora horrida'*s total absolute abundance is at least tens of millions of colonies, providing buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response; and

(3) It is a broadcast spawner and fast grower, enhancing recovery potential from mortality events as described in the Corals and Coral Reefs section above.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future if global threats continue and increase in severity and the species exposure to threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *A. horrida* is not warranted for listing at this time under any of the listing factors.

Acropora jacquelineae

Introduction

The SRR and SIR provided the following information on *A. jacquelineae's* morphology and taxonomy. The morphology was described as flat plates up to 1 m in diameter. Viewed from above, plates are covered with a mass of fine delicately-curved axial corallites giving an almost moss-like appearance. Evidence from genetics indicates it is not a hybrid, and so the SRR considered it a valid species.

The public comments and information we gathered provided supplemental information on the morphology or taxonomy of *A. jacquelineae.* One public comment stated that specimens collected in American Samoa and identified by the American Samoa Department of Marine and Water Resources as *A. jacquelineae* appear to be *A. aculeus,* thereby illustrating the species identification uncertainties associated with this species. We gathered supplemental information, including Veron (2014), which states that *A. jacquelineae* is distinctive when compared with other species but not on its own. We conclude the species can be identified by experts (Fenner, 2014b). Thus, we conclude that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *A. jacquelineae's* distribution, habitat, and depth range. *Acropora jacquelineae* is distributed within the Coral Triangle including Papua New Guinea, and is reported from American Samoa. The species has a limited range overall, the 22nd smallest range of 114 *Acropora* species. It is found in numerous subtidal reef slope and back-reef habitats, including but not limited to, lower reef slopes, walls and ledges, mid-slopes, and upper reef slopes protected from wave action, and its depth range is 10 to 35 m.

The public comments did not provide any new or supplemental information on *A. jacquelineae's* distribution, habitat, or depth range. We gathered supplemental information on its distribution, including Veron (2014), which reports that *A. jacquelineae* is confirmed in 12 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional five. Wallace (1999b) reports its occurrence in seven of her 29 Indo-Pacific areas, many of which are larger than Veron's ecoregions. Richards (2009) calculated the geographic range of this species at 2 million km^2, which was 1.8 percent of the size of the largest range for any species.

Demographic Information

The SRR and SIR provided the following information on *A. jacquelineae's* abundance. *Acropora jacquelineae* has been reported as uncommon.

The public comments did not provide any new or supplemental information on *A. jacquelineae's* abundance. We gathered supplemental information, including Richards (2009) and Richards *et al.* (2013b), which conclude from their data that *A. jacquelineae* is globally restricted, locally restricted, and locally rare, and thus in the rarest category of *Acropora* with the predicted consequence of global extinction. They placed 15 species in this category out of 85 species of *Acropora.* Bonin (2012) reported that *A. jacquelineae* was the 19th most abundant species of *Acropora* in Kimbe Bay, Papua New Guinea, with about 18 percent of the abundance of the most abundant species of *Acropora.* Veron (2014) reports that *A. jacquelineae* occupied 1.6 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.44 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''uncommon.'' Overall abundance was also described as ''uncommon.'' Veron did not infer trends in abundance from these data.

Richards *et al.* (2008) reported that *A. jacquelineae* had the 14th lowest population of the 15 rare *Acropora* species they studied. Richards *et al.* (2008) gave the total world population of this species as 31,599 +/-17,358 colonies, and the effective population size (*i.e.,* a mathematical estimate of the size of the breeding population) as 3,476 colonies. The calculation of the total world population of this species was flawed, since the area of 1 km^2 was given as 1,000 m^2 (Richards *et al.,* 2008: Appendix 1), when it is actually 1,000,000 m^2. Thus, the correct population estimate is 1,000 times greater than stated, or a total population size of 31,599,000 colonies, and an effective population size of 3,476,000 colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *A. jacquelineae,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 37 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 14 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *A. jacquelineae* occurs in many areas affected by these broad changes, and has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *A. jacquelineae's* life history. *Acropora jacquelineae* is a hermaphroditic spawner with lecithotrophic (yolk-sac) larvae. The public comments and information we gathered did not provide anything additional to the above-described biological information.

Susceptibility to Threats

To describe *A. jacquelineae's* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Acropora* of ocean warming, acidification, disease, predation, sedimentation, nutrients, and collection and trade. The SRR and SIR did not provide any species-specific information on the effects of these threats on *A. jacquelineae.* We interpreted the threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *A. jacquelineae's* vulnerabilities as follows: High vulnerability to ocean warming, moderate vulnerability to disease, ocean acidification, trophic effects of fishing, nutrients, and predation, and low vulnerability to sedimentation, sea-level rise, and collection and trade.

Public comments did not provide any new or supplemental information on *A. jacquelineae's* threat susceptibilities. We gathered the following species-specific and genus-level supplemental information on this species' threat susceptibilities. *Acropora jacquelineae* has been rated as moderately or highly susceptible to bleaching and disease, but this rating is not based on species-specific data (Carpenter *et al.,* 2008). There is no species-specific information for the exposure or susceptibility of *A. jacquelineae* to any threat. Thus, based on the available genus information summarized above, *A. jacquelineae* is likely highly susceptible to ocean warming, and also likely has some susceptibility to disease, ocean acidification, sedimentation, nutrients, trophic effects of fishing, sea-level rise, predation, and collection and trade. The available information does not support more precise ratings of the susceptibilities of *A. jacquelineae* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *A. jacquelineae.* Criticisms of our approach received during public comment led us to the following analysis to attempt to analyze regulatory mechanisms on a species basis. Records confirm that *A. jacquelineae* occurs in 12 Indo-Pacific ecoregions that encompass five countries' EEZs. The five countries are Federated States of Micronesia, Indonesia, Papua New Guinea, Solomon Islands, and Timor-Leste. The regulatory mechanisms relevant to *A. jacquelineae,* described first as the percentage of the above countries that utilize them to any degree and second, as the percentages of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (20 percent with none limited in scope), coral collection (40 percent with none limited in scope), pollution control (20 percent with 20 percent limited in scope), fishing regulations on reefs (100 percent with none limited in scope), and managing areas for protection and conservation (100 percent with none limited in scope). The most common regulatory mechanisms in place for *A. jacquelineae* are reef fishing regulations and area management for protection and conservation. General coral protection, coral collection, and pollution control laws are much less common regulatory mechanisms for the management of *A. jacquelineae.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that the high bleaching rate of the *Acropora* genus is the primary known threat of extinction for *A. jacquelineae.* It listed factors that contribute to the threat of extinction including limited range, small local distribution and small local abundance, as well as the possibility of genetic introgression.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *A. jacquelineae,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution is limited almost exclusively to the Coral Triangle in the western equatorial Pacific Ocean. Despite the large number of islands and environments that are included in the species range, this range exacerbates vulnerability to extinction over the foreseeable future because it is limited to the area projected to have the most rapid and severe impacts from climate change and localized human impacts for coral reefs over the 21st century. Its depth range of ten to 35 meters moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Its habitat includes lower reef slopes, walls and ledges, mid-slopes, and upper reef slopes protected from wave action. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Its effective population size estimate of approximately 3.5 million colonies, combined with the location of its range, exacerbates vulnerability to extinction because increasingly severe conditions within the limited species range are likely to affect a high proportion of its effective population at any given point in time.

Listing Determination

In the proposed rule using the determination tool formula approach, *A. jacquelineae* was proposed for listing as endangered because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); rare generalized range wide abundance (E); narrow overall distribution (based on narrow geographic distribution and moderate depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *A. jacquelineae* from endangered to threatened. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including adequate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information provided above on *A. jacquelineae's* spatial structure, demography, threat susceptibilities, and management indicate that it is likely to become endangered throughout its range within the foreseeable future, and thus warrants listing as threatened at this time, because:

(1) *Acropora jacquelineae* is highly susceptible to ocean warming (ESA Factor E), and susceptible to disease (C), ocean acidification (E), trophic effects of

fishing (A), predation (C), and nutrient enrichment (A, E). These threats are expected to continue and increase into the future. In addition existing regulatory mechanisms to address global threats that contribute to extinction risk for this species are inadequate (D).

(2) *Acropora jacquelineae'*s distribution is constrained mostly to the Coral Triangle and western equatorial Pacific, which is projected to have the most rapid and severe impacts from climate change and localized human impacts for coral reefs over the 21st century, as described in the Threats Evaluation. Multiple ocean warming events have already occurred within the western equatorial Pacific that suggest future ocean warming events may be more severe than average in this part of the world. A range constrained to this particular geographic area that is likely to experience severe and increasing threats indicates that a high proportion of the population of this species is likely to be exposed to those threats over the foreseeable future; and

(3) *Acropora jacquelineae'*s absolute abundance is estimated to be 31 million colonies, however its estimated effective population size is much lower at approximately 3.5 million genetically distinct individuals. Considering the limited range of this species in an area where severe and increasing impacts are predicted, this level of abundance leaves the species vulnerable to becoming of such low abundance within the foreseeable future that it may be at risk from depensatory processes, environmental stochasticity, or catastrophic events, as explained in more detail in the Corals and Coral Reefs and Risk Analyses sections.

The combination of these characteristics and projections of future threats indicates that the species is likely to be in danger of extinction within the foreseeable future throughout its range and warrants listing as threatened at this time due to factors A, C, D, and E.

The available information above on *A. jacquelineae'*s spatial structure, demography, threat susceptibilities, and management also indicate that the species the species is not currently in danger of extinction and thus does not warrant listing as Endangered because:

(1) While *A. jacquelineae'*s distribution is constrained mostly to the Coral Triangle which increases it extinction risk as described above, its habitat includes sub-tidal walls, ledges on walls, and shallow reef slopes protected from wave action. This moderates vulnerability to extinction currently because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time, as described in more detail in the Coral Habitat sub-section and Threats Evaluation section. There is no evidence to suggest the species is so spatially fragmented that depensatory processes, environmental stochasticity, or the potential for catastrophic events currently pose a high risk to the survival of the species;

(2) *Acropora jacquelineae'*s absolute abundance is tens of millions of colonies and effective population size is still millions of colonies which allows for variation in the responses of individuals to threats to play a role in moderating vulnerability to extinction for the species to some degree, as described in more detail in the Corals and Coral Reefs section. There is no evidence of depensatory processes such as reproductive failure from low density of reproductive individuals and genetic processes such as inbreeding affecting this species. Thus, its absolute abundance indicates it is currently able to avoid high mortality from environmental stochasticity, and mortality of a high proportion of its population from catastrophic events; and

(3) It is a broadcast spawner and fast grower, enhancing recovery potential from mortality events, as described in the Corals and Coral Reefs section above.

The combination of these characteristics indicates that the species does not exhibit the characteristics of one that is currently in danger of extinction, as described previously in the Risk Analyses section, and thus does not warrant listing as endangered at this time.

Range-wide, a multitude of conservation efforts are already broadly employed that are likely benefiting *A. jacquelineae.* However, considering the global scale of the most important threats to the species, and the ineffectiveness of conservation efforts at addressing the root cause of global threats (*i.e.,* GHG emissions), we do not believe that any current conservation efforts or conservation efforts planned in the future will result in affecting the species status to the point at which listing is not warranted.

Acropora listeri

Introduction

The SRR and SIR provided the following information on *A. listeri'*s morphology and taxonomy. Morphology was described as irregular clumps or plates with thick branches of highly irregular length and shape, and the taxonomy was described as having no taxonomic issues but this species was reported to be similar to *Acropora polystoma* and *Acropora lutkeni,* and is not easily identified in the field.

The public comments did not provide any new or supplemental information on morphology or taxonomy. We gathered supplemental information, including Veron (2014), which states that *A. listeri* is distinctive, thus we conclude the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *A. listeri'*s distribution, habitat, and depth range. *Acropora listeri* is distributed from the Red Sea through the Indian Ocean to the southeast Pacific. The species has a very broad range overall, the 13th largest range of 114 *Acropora* species. Its predominant habitat is lower reef crests and upper reef slopes in strong wave action, and adjacent or similar habitats. Its depth range is from near the surface to 15 m deep.

The public comments did not provide any new or supplemental information on *A. listeri'*s distribution, habitat, or depth range. We gathered supplemental information, including Veron (2014), which reports that this species is confirmed in 54 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional 14. Wallace (1999b) reports its occurrence in 21 of her 29 Indo-Pacific areas (Wallace, 1999b), many of which are larger than Veron's ecoregions. Richards (2009) calculated the geographic range of *A. listeri* at 105 million km^2.

Demographic Information

The SRR and SIR provided the following information on *A. listeri's* abundance. *Acropora listeri* has been reported as uncommon. This species is globally widespread, locally restricted, and locally rare, and thus in the second rarest category of *Acropora* with the predicted consequence of local extinction.

The public comments did not provide any new or supplemental information on *A. listeri'*s abundance. We gathered supplemental information, including Veron (2014), which reports that *A. listeri* occupied 5.5 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.35 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''uncommon.'' and overall abundance was also described as ''uncommon.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least tens of millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *A. listeri,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 35 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 14 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *A. listeri* occurs in many areas affected by these broad changes, and has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *A. listeri's* life history. *Acropora listeri* is a hermaphroditic spawner with lecithotrophic (yolk-sac) larvae. The public comments and information we gathered did not provide anything additional to the above-described biological information.

Susceptibility to Threats

To describe *A. listeri's* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Acropora* of ocean warming, acidification, disease, predation, sedimentation, nutrients, and collection and trade. The SRR and SIR did not provide any species-specific information on the effects of these threats on *A. listeri.* We interpreted the threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *A. listeri's* vulnerabilities as follows: High vulnerability to ocean warming, moderate vulnerability to disease, ocean acidification, trophic effects of fishing, nutrients, and predation, and low vulnerability to sedimentation, sea-level rise, and collection and trade.

Public comments did not provide any new or supplemental information on *A. listeri's* threat susceptibilities. We gathered the following species-specific and genus-level supplemental information on this species' threat susceptibilities. *Acropora listeri* has been rated as moderately or highly susceptible to bleaching and disease, but this rating is not based on species-specific data (Carpenter *et al.,* 2008). Done *et al.* (2003b) report 20 percent of *A. listeri* colonies were affected by bleaching on the Great Barrier Reef in 2002, which was 47 percent as much as the most affected species (Brown and Cossins, 2011).

With regard to disease, *A. listeri* has been rated as moderately or highly susceptible to bleaching and disease, but this rating is not based on species-specific data (Carpenter *et al.,* 2008). Skeletal Eroding Band is the most prevalent disease on the GBR, and it has been found in *A. listeri. Acropora* species with similar morphology to *A. listeri* had moderate susceptibility to this disease on the GBR, with a prevalence of 2.4 percent (Page and Willis, 2007). No other species-specific information is available for the susceptibility of *A. listeri* to any other threat. Based on information from other *Acropora* species provided in the genus description above, *A. listeri* may be susceptible to the effects of ocean acidification, sedimentation, and nutrients, and predation. Thus, based on the available species-specific and genus information summarized above, *A. listeri* likely is highly susceptible to ocean warming, and also likely has some susceptibility to disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade. The available information does not support more precise ratings of the susceptibilities of *A. listeri* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *A. listeri.* Criticisms of our approach received during public comment led us to the following analysis to attempt to analyze regulatory mechanisms on a species basis. Records confirm that *A. listeri* occurs in 54 Indo-Pacific ecoregions that encompass 40 countries' EEZs. The 40 countries are Australia, Brunei, China, Djibouti, Egypt, Eritrea, Federated States of Micronesia, Fiji, France (French Pacific Island Territories), India (Andaman and Nicobar Islands), Indonesia, Israel, Japan, Jordan, Kiribati, Malaysia, Marshall Islands, Mauritius, Myanmar, New Zealand (Tokelau), Niue, Palau, Papua New Guinea, Philippines, Samoa, Saudi Arabia, Seychelles, Solomon Islands, Sri Lanka, Sudan, Taiwan, Tanzania, Timor-Leste, Tonga, Tuvalu, United Kingdom (British Indian Ocean Territory, Pitcairn Islands), United States (CNMI, Guam, American Samoa, PRIAs), Vanuatu, Vietnam, and Yemen. The regulatory mechanisms relevant to *A. listeri,* described first as the percentage of the above countries that utilize them to any degree and second, as the percentages of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (30 percent with 8 percent limited in scope), coral collection (63 percent with 30 percent limited in scope), pollution control (45 percent with 8 percent limited in scope), fishing regulations on reefs (90 percent with 23 percent limited in scope), and managing areas for protection and conservation (95 percent with 10 percent limited in scope). The most common regulatory mechanisms in place for *A. listeri* are reef fishing regulations and area management for protection and conservation. Coral collection and pollution control laws are also somewhat common for the species, but 30 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection laws are much less prominent regulatory mechanisms for the management of *A. listeri.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that the high bleaching rate of the *Acropora* genus is the primary known threat of extinction for *A. listeri.* Its limited local distribution was also listed as a contributing factor to its threat of extinction. The SRR also listed factors that reduce the threat of extinction including its broad geographic range and tolerance for high-energy environments.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *A. listeri,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution stretches from the Red Sea and east coast of Africa, across the Indian Ocean and over to the southeast Pacific Ocean. Its geographic distribution moderates vulnerability to extinction because some areas within its range are projected to have less than average warming and acidification over the foreseeable future, including the western Indian Ocean, the central Pacific, and other areas, so portions of the population in these areas will be less exposed to severe conditions. Its depth range is from near the surface to 15 meters. On one hand, its depth range may moderate vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. On the other hand, its depth range may exacerbate vulnerability to extinction over the foreseeable future if the species occurs predominantly in the shallower portion of its depth range, since those areas will have higher irradiance and thus be more severely affected by warming-induced bleaching. Its habitat includes lower reef crests, upper reef slopes, and other habitats exposed to strong wave action, and its depth range is from near the surface to 15 m deep. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. In addition, reef zones with strong wave action experience high levels of mixing which can dilute adverse environmental conditions. Its absolute abundance of at least tens of millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule using the determination tool formula approach, *A. listeri* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); uncommon generalized range wide abundance (E); moderate overall distribution (based on wide geographic distribution and shallow depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *A. aculeus* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information provided on *A. listeri's* spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to be likely to become endangered throughout its range within the foreseeable future, and thus is not warranted for listing at this time, because:

(1) *Acropora listeri'*s distribution from the Red Sea across the Indian Ocean and most of the Pacific Ocean is spread over a very large area. While some areas within its range are projected to be affected by warming and acidification, other areas are projected to have less than average warming and acidification, including the western Indian Ocean, the central Pacific, and other areas. This distribution and the heterogeneous habitats it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future;

(2) *Acropora listeri'*s absolute abundance is at least tens of millions of colonies, providing buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response; and

(3) It is a broadcast spawner and fast grower, enhancing recovery potential from mortality events, as described in the Corals and Coral Reefs section above.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future if global threats continue and increase in severity and the species exposure to threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *A. listeri* is not warranted for listing at this time under any of the listing factors.

Acropora lokani

Introduction

The SRR and SIR provided the following information on *A. lokani'*s morphology and taxonomy. Morphology was described as small bushy colonies of forked branches, and taxonomy was described as having no taxonomic issues but being similar in appearance to some other *Acropora* species.

The public comments did not provide supplemental information on morphology or taxonomy. We gathered supplemental information, including Veron (2014), which states that *A. lokani* is distinctive, thus we conclude it can be identified by experts, and that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *A. lokani'*s distribution, habitat, and depth range. *Acropora lokani* occurs from central Indonesia to Fiji. The species has the 33rd smallest range of 114 *Acropora* species in a large study. However, as described below, this was an error, as *A. lokani* actually had the 30th smallest range in the study. *A. lokani* occurs in reef slope and back-reef habitats, including at least upper reef-slopes, mid-slopes, and lagoon patch reefs, and its depth range as 8 to 25 m.

The public comments and information we gathered provided information on the distribution of *A. lokani.* One public comment letter indicated that the range map for *A. lokani* mistakenly included American Samoa. We gathered supplemental information, including Veron (2014), which provides an much more detailed range map for this species than the maps used in the SRR. Veron reports that this species is confirmed in 14 of his 133 Indo-Pacific ecoregions is strongly predicted to be found in an additional six, and confirms that the species is not known to occur in American Samoa. Wallace (1999) reports its occurrence in four of her 29 Indo-Pacific areas, many of which are significantly larger than Veron's ecoregions. Richards (2009) calculated the geographic range of this species at over 5 million km^2, which was the 30th smallest among the 114 *Acropora* species for which ranges were calculated, and 3.6 percent of the size of the largest range for any species. Richards *et al.* (Richards *et al.,* 2013a) calculate the range of this species as 8.5 million km^2. The public comments and information we gathered provided nothing additional on *A. lokani'*s habitat and depth range.

Demographic Information

The SRR and SIR provided the following information on *A. lokani'*s abundance. *Acropora lokani* has been reported as uncommon, but sometimes common.

The public comments did not provide supplemental information on *A. lokani'*s abundance. We gathered supplemental information, including Richards *et al.* (2013b), which concludes that this species is globally restricted, locally restricted, and locally rare, and thus in the rarest category of *Acropora* with the predicted consequence of global extinction. They placed 15 species in this category out of 85 species of *Acropora* (Richards *et al.,* 2013b). Veron (2014) reports that *A. lokani* occupied 2.75 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.44 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''uncommon.'' Overall abundance was described as ''sometimes common.'' Veron did not infer trends in abundance from these data.

Richards *et al.* (2008) reported that *A. lokani* had the eleventh lowest population of the 15 rare *Acropora* species they studied. Richards *et al.* (2008) gave the total world population of this species as about 18,960 +/-9480 colonies, and the effective population size (*i.e.,* a mathematical estimate of the size of the breeding population) as about 2,086 colonies. The calculation of the total world population of this species was flawed, since the area of 1 km^2 was given as 1,000 m^2 (Richards *et al.,* 2008: Appendix 1), when it is actually 1,000,000 m^2. Thus, the correct population estimate is 1,000 times greater than stated, or a total population size of 18,960,000 colonies, and an effective population size of 2,086,000 colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *A. lokani,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 36 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 14 percent. However, as summarized above in the Inter-basin Comparisons sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context. Thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *A. lokani* occurs in many areas affected by these broad changes, and that it has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *A. lokani'*s life history. *Acropora lokani* is assumed to be a hermaphroditic spawner with lecithotrophic (yolk-sac) larvae. The public comments and information we gathered did not provide anything additional to the above-described biological information.

Susceptibility to Threats

To describe *A. lokani'*s threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Acropora* of ocean warming, acidification, disease, predation, sedimentation, nutrients, and collection and trade. The SRR and SIR did not provide any species-specific information on the effects of these threats on *A. lokani.* We interpreted the threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *A. lokani'*s vulnerabilities as follows: High vulnerability to ocean warming, moderate vulnerabilities to disease, acidification, trophic effects of fishing, nutrients, and predation, and low vulnerabilities to sedimentation, sea-level rise, and collection and trade.

Public comments did not provide any new or supplemental information on *A. lokani'*s threat susceptibilities. We gathered the following species-specific and genus-level supplemental information on this species' threat susceptibilities. *Acropora lokani* has been rated as moderately or highly susceptible to thermal bleaching and disease, but these ratings are not based on species-specific data (Carpenter *et al.,* 2008). Based on information from other *Acropora* species provided in the genus description above, *A. lokani* is likely highly susceptible to ocean warming, and likely has some susceptibility to disease, acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade. The available information does not support more precise ratings of the susceptibilities of *A. lokani* to the threats.

Regulatory Mechanisms

In the proposed rule we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *A. lokani.* Criticisms of our approach received during public comment led us to the following analysis to attempt to analyze regulatory mechanisms on a species basis. Records confirm that *A. lokani* occurs in 14 Indo-Pacific ecoregions that encompass nine countries' EEZs. The nine countries are Federated States of Micronesia, Fiji, France (French Pacific Island Territories), Indonesia, Palau, Papua New Guinea, Philippines, Solomon Islands, and Timor-Leste. The regulatory mechanisms relevant to *A. lokani,* described first as a percentage of the above countries that utilize them to any degree, and second as the percentage of those countries whose regulatory mechanisms are limited in scope, are as follows: General coral protection (33 percent with none limited in scope), coral collection (67 percent with 22 percent limited in scope), pollution control (33 percent with 22 percent limited in scope), fishing regulations on reefs (100 percent with none limited in scope), and managing areas for protection and conservation (100 percent with none limited in scope). The most common regulatory mechanisms in place for *A. lokani* are coral collection laws, reef fishing regulations, and area management for protection and conservation. General coral protection and pollution control laws are much less common regulatory mechanisms for the management of *A. lokani.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that the high bleaching rate of the *Acropora* genus is the primary known threat of extinction for *A. lokani,* with the potential for extinction increased by the smallest effective population size of species with actual data, limited geographic and restricted latitudinal range, and also the small global distribution, small local distributions, and small local abundances.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *A. lokani,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution is limited to parts of the Coral Triangle and the western equatorial Pacific Ocean. Despite the large number of islands and environments that are included in the species' range, this range exacerbates vulnerability to extinction over the foreseeable future because it is mostly limited to an area projected to have the most rapid and severe impacts from climate change and localized human impacts for coral reefs over the 21st century. Its depth range of eight to 25 meters moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Its habitat includes at least upper reef-slopes, mid-slopes, and lagoon patch reefs. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Its effective population size of two million colonies, combined with the location of its range, exacerbates vulnerability to extinction because increasingly severe conditions within the limited species range are likely to affect a high proportion of its effective population at any given point in time.

Listing Determination

In the proposed rule using the determination tool formula approach, *A. lokani* was proposed for listing as endangered because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); rare generalized range wide abundance (E); overall narrow distribution (based on narrow geographic distribution and moderate depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *A. lokani* from endangered to threatened. No supplemental information or public comments changed our assessment of the type and severity of threats affecting *A. lokani.* Rather, we made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information provided above on *A. lokani*'s spatial structure, demography, threat susceptibilities, and management indicate that it is likely to become endangered throughout its range within the foreseeable future, and thus warrants listing as threatened at this time, because:

(1) *Acropora lokani* is highly susceptible to ocean warming (ESA Factor E), and susceptible to disease (C) ocean acidification (E), trophic effects of fishing (A), nutrients (A, E), and predation (C). These threats are expected to continue and increase into the future. In addition, existing regulatory mechanisms to address global threats that contribute to extinction risk for this species are inadequate (D).

(2) *Acropora lokani*'s distribution is mostly constrained to the Coral Triangle and western equatorial Pacific, which is projected to have the most rapid and severe impacts from climate change and localized human impacts for coral reefs over the 21st century, as described in the Threats Evaluation. Multiple ocean warming events have already occurred within *the western equatorial Pacific* that suggest future ocean warming events may be more severe than average in this part of the world. A range constrained to this particular geographic area that is likely to experience severe and increasing threats indicates that a high proportion of the population of this species is likely to be exposed to those threats over the foreseeable future; and

(3) *Acropora lokani*'s absolute abundance is estimated to be 19 million colonies, however its estimated effective population size is much lower at around two million genetically distinct colonies. Considering the limited range of this species in an area where severe and increasing impacts are predicted,

this level of abundance leaves the species vulnerable to becoming of such low abundance within the foreseeable future that it may be at risk from depensatory processes, environmental stochasticity, or catastrophic events, as explained in more detail in the Corals and Coral Reefs and Risk Analyses sections.

The combination of these characteristics and projections of future threats indicates that the species is likely to be in danger of extinction within the foreseeable future throughout its range and warrants listing as threatened at this time due to factors A, C, D, and E.

The available information above on *A. lokani's* spatial structure, demography, threat susceptibilities, and management also indicate that the species is not currently in danger of extinction and thus does not warrant listing as Endangered because:

(1) While *A. lokani's* distribution is constrained mostly to the Coral Triangle which increases it extinction risk as described above, its habitat includes sheltered lagoon patch reefs and other shallow reef environments. This moderates vulnerability to extinction currently because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time, as described in more detail in the Coral Habitat and Threats Evaluation sections. There is no evidence to suggest that the species is so spatially fragmented that depensatory processes, environmental stochasticity, or the potential for catastrophic events currently pose a high risk to the survival of the species; and

(2) *Acropora lokani's* absolute abundance is tens of millions of colonies, and effective population size is still millions of colonies which allows for variation in the responses of individuals to threats to play a role in moderating vulnerability to extinction for the species to some degree, as described in more detail in the Corals and Coral Reefs section. There is no evidence of depensatory processes such as reproductive failure from low density of reproductive individuals and genetic processes such as inbreeding affecting this species. Thus, its absolute abundance indicates it is currently able to avoid high mortality from environmental stochasticity, and mortality of a high proportion of its population from catastrophic events.

The combination of these characteristics indicates that the species does not exhibit the characteristics of one that is currently in danger of extinction, as described previously in the Risk Analyses section, and thus does not warrant listing as endangered at this time.

Range-wide, a multitude of conservation efforts are already broadly employed that are likely benefiting *A. lokani.* However, considering the global scale of the most important threats to the species, and the ineffectiveness of conservation efforts at addressing the root cause of global threats (*i.e.,* GHG emissions), we do not believe that any current conservation efforts or conservation efforts planned in the future will result in affecting the species status to the point at which listing is not warranted.

Acropora microclados

Introduction

The SRR and SIR provided the following information on *A. microclados'* morphology and taxonomy. Morphology was described as plates up to 1 m diameter, with short, uniform, evenly spaced, tapered branchlets up to 10 mm thick at the base, and taxonomy was described as having no taxonomic issues but that it is most similar to *A. massawensis, A. lamarcki,* and *A. macrostoma.*

The public comments did not provide any new or supplemental information on morphology or taxonomy. We gathered supplemental information, including Veron (2014), which states that *A. microclados* is distinctive, thus we conclude it can be identified by experts, and that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *A. microclados'* distribution, habitat, and depth range. *Acropora microclados* is distributed from the Red Sea, to the central Pacific. The species has a broad range overall with the 20th largest range of 114 *Acropora* species. Its habitat is predominantly lower reef crests, upper reef slopes, and mid-slope terraces, and its depth range is from five to 20 m.

The public comments provided the following supplemental information on *A. microclados'* distribution. One public comment stated that the species has not been confirmed in the Commonwealth of the Northern Mariana Islands by expert Richard H. Randall, in contradiction to the SRR. We gathered supplemental information, including Veron (2014), which reports that this species is confirmed in 56 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional 18. Wallace (1999b) reports its occurrence in 21 of her 29 Indo-Pacific areas, many of which are larger than Veron's ecoregions. Richards (2009) calculated the geographic range of *A. microclados* at 100 million km^2. The public comments and information we gathered provided nothing additional on *A. microclados'* habitat and depth range.

Demographic Information

The SRR and SIR provided the following information on *A. microclados'* abundance. *Acropora microclados* has been reported as uncommon. This species is globally widespread, locally restricted, and locally rare, and thus in the second rarest category of *Acropora* with the predicted consequence of local extinction. The public comments did not provide any new or supplemental information on *A. microclados'* abundance. We gathered supplemental information, including Veron (2014), which reports that *A. microclados* occupied 15.2 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.51 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''common.'' Overall abundance was also described as ''usually uncommon.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least tens of millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *A. microclados,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 33 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 14 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years

(Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *A. microclados* occurs in many areas affected by these broad changes, and that it has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *A. microclados'* life history. *Acropora microclados* is a hermaphroditic spawner with lecithotrophic (yolk-sac) larvae. The public comments and information we gathered did not provide anything additional to the above-described biological information.

Susceptibility to Threats

To describe *A. microclados'* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Acropora* of ocean warming, acidification, disease, predation, sedimentation, nutrients, and collection and trade. The SRR and SIR did not provide any species-specific information on the effects of these threats on *A. microclados.* We interpreted the threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *A. microclados'* vulnerabilities as follows: High vulnerability to ocean warming, moderate vulnerabilities to disease, ocean acidification, trophic effects of fishing, nutrients, and predation, and low vulnerabilities to sedimentation, sea-level rise, and collection and trade.

Public comments provided some supplemental information on *A. microclados'* threat susceptibilities. One comment stated that *A. microclados* is more susceptible to predation than indicated in the proposed rule because of the overlap in the depth ranges of this species with crown of thorns starfish. We gathered the following species-specific and genus-level supplemental information on this species' threat susceptibilities. *Acropora microclados* has been rated as moderately or highly susceptible to bleaching and disease, but this rating is not based on species-specific data (Carpenter *et al.,* 2008). Supplemental species-specific information is available on the susceptibility of *A. microclados* to ocean warming. In a study of ocean warming of *Acropora* species on the GBR, *A. microclados* had low bleaching susceptibility: of 48 *Acropora* species, only three species had no bleaching, including *A. microclados* (Done *et al.,* 2003b). In a study of ocean warming of *Acropora* species in Kimbe Bay, Papua New Guinea, *A. microclados* had moderate bleaching susceptibility: of 16 *Acropora* species, *A. microclados* had the sixth highest level of bleaching, with seven percent mortality compared to 40 percent for the highest species, and was rated ''moderate'' on a scale of severe, high, moderate, and least (Bonin, 2012). No other species-specific information is available for the susceptibility of *A. microclados* to any other threat. Based on information from other *Acropora* species provided in the genus description above, *A. microclados* may be susceptible to ocean warming, disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade. Thus, based on the available species-specific and genus information summarized above, *A. microclados* likely has some susceptibility to ocean warming, disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade. The available information does not support more precise ratings of the susceptibilities of *A. microclados* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *A. microclados.* Criticisms of our approach received during public comment led us to the following analysis to attempt to analyze regulatory mechanisms on a species basis. Records confirm that *A. microclados* occurs in 56 Indo-Pacific ecoregions that encompass 37 countries' EEZs. The 37 countries are Australia, China, Comoros Islands, Djibouti, Egypt, Eritrea, Federated States of Micronesia, Fiji, France (French Pacific Island Territories), Indonesia, Israel, Japan, Jordan, Malaysia, Maldives, Marshall Islands, Mauritius, Myanmar, New Zealand (Cook Islands, Tokelau), Niue, Palau, Papua New Guinea, Philippines, Samoa, Saudi Arabia, Seychelles, Solomon Islands, Sudan, Taiwan, Thailand, Tonga, Tuvalu, United Kingdom (British Indian Ocean Territory, Pitcairn Islands), United States (CNMI, Guam, American Samoa, PRIAs), Vanuatu, Vietnam, and Yemen. The regulatory mechanisms relevant to *A. microclados,* described first as the percentage of the above countries that utilize them to any degree and second, as the percentages of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (27 percent with 5 percent limited in scope), coral collection (62 percent with 30 percent limited in scope), pollution control (46 percent with 8 percent limited in scope), fishing regulations on reefs (89 percent with 16 percent limited in scope), and managing areas for protection and conservation (95 percent with 11 percent limited in scope). The most common regulatory mechanisms in place for *A. microclados* are reef fishing regulations and area management for protection and conservation. Coral collection and pollution control laws are also somewhat common for the species, but 30 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection laws are much less prominent regulatory mechanisms for the management of *A. microclados.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that the high bleaching rate of the *Acropora genus* is the primary known threat of extinction for *A. microclados.* The threat of extinction may be increased to by its limited local distribution and uncommon local abundance. The SRR also listed factors that reduce the threat of extinction including the species' geographic and depth ranges.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *A. microclados,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution includes most of the coral reef ecoregions in the Indian Ocean and western and central Pacific Ocean. Its geographic distribution moderates vulnerability to extinction because some areas within its range are projected to have less than average warming and acidification over the foreseeable future, including the western Indian Ocean, the central Pacific, and other areas, so portions of the population in these areas will be less exposed to severe conditions. Its depth range is from five to 20 meters. This moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Its habitat is predominantly lower reef crests, upper reef slopes, and mid-slope terraces. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Its absolute abundance of at least tens of millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time. In addition, two species-specific studies indicate that, unlike many other *Acropora* species, *A. microclados* is not highly susceptible to warming-induced bleaching, one of the primary threats identified for corals.

Listing Determination

In the proposed rule using the determination tool formula approach, *A. microclados* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); uncommon generalized range wide abundance (E); wide overall distribution (based on wide geographic distribution and moderate depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *A. microclados* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *A. microclados'* spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to be likely to become endangered throughout its range within the foreseeable future, and thus it is not warranted for listing at this time, because:

(1) While the species has some susceptibility to bleaching, unlike most other *Acropora* species, it does not appear to be highly susceptible to this threat, as shown by two newly available species-specific studies;

(2) *Acropora microclados'* distribution from the Red Sea across the Indian Ocean and most of the Pacific Ocean includes is spread over a very large area. While some areas within its range are projected to be affected by warming and acidification, other areas are projected to have less than average warming and acidification, including the western Indian Ocean, the central Pacific, and other areas. This distribution and the heterogeneous habitats it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future;

(3) *Acropora microclados'* absolute abundance is at least tens of millions of colonies, providing buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response; and

(4) It is a broadcast spawner and fast grower, enhancing recovery potential from mortality events, as described in the Corals and Coral Reefs section above.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future if global threats continue and increase in severity and the species exposure to threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *A. microclados* is not warranted for listing at this time under any of the listing factors.

Acropora palmerae

Introduction

The SRR and SIR provided the following information on *A. palmerae's* morphology and taxonomy. Morphology was described as encrusting with or without short, irregularly shaped branches. Colonies seldom exceed 1 m across. There is doubt as to whether *A. palmerae* is a separate species or a strong-water form of *A. robusta;* however, in the absence of genetic information, the BRT considered it a valid species. *A. palmerae* is like the encrusting base of *A. robusta,* but it has smaller branches, if any.

The public comments did not provide any new or supplemental information on morphology or taxonomy. We gathered supplemental information, including Wallace (1999b) and Veron (Veron, 2000), who both considered it a valid species. In addition, Veron (2014) states that *A. palmerae* is distinctive, thus we conclude it can be identified by experts, and that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *A. palmerae's* distribution, habitat, and depth range. *Acropora palmerae* is distributed from the northern Indian Ocean to the central Indo-Pacific and central Pacific. The species has a moderate range overall, with the 52nd largest range of 114 *Acropora* species. The SRR and SIR reported that it occurs in most reef slope and back-reef habitats, including upper reef slopes, lower reef crests, and reef flats, with a depth range of five to 20 m. The public comments and information we gathered provided the following information on *A. palmerae's* distribution. One public comment stated that the depth distribution appears to be restricted to depths of less than 12 m, based on observations in Guam and reports from elsewhere. We gathered supplemental information, including observations that the depth range of *A. palmerae* in American Samoa is low tide to about 5 m deep, and on Tinian Island in the Marianas it is from about 2 to 5 m (D. Fenner, pers. communication). Thus, based on all the available information, *A. palmerae's* habitat includes upper reef slopes, mid-slope terraces, lower reef crests, and reef flats. Based on all the information from across its range, we consider its depth range to be from two to 20 m depth. Veron (2014) reports that *A. palmerae* is confirmed in 42 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional 17. Wallace (1999b) reports its occurrence in seven of her 29 Indo-Pacific areas, many of which are larger than Veron's ecoregions. Richards (2009) calculated the geographic range at over 60 million km^2.

Demographic Information

The SRR and SIR provided the following information on *A. palmerae's* abundance. *Acropora palmerae* has been reported as uncommon.

The public comments did not provide any new or supplemental information on *A. palmerae's* abundance. We gathered supplemental information, including Veron (2014), which reports that *A. palmerae* occupied 2.7 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.81 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''uncommon,'' and overall abundance was also described as ''uncommon.'' Veron did not infer trends in abundance from these data. *Acropora palmerae* can be abundant within a very narrow depth range in shallow water (as it is on the west coast of Tinian in the Marianas), which may be missed in some surveys (D. Fenner, personal comm.). As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least tens of millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *A. palmerae,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 39 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 15 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *A. palmerae* occurs in many areas affected by these broad changes, and that it has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *A. palmerae's* life history. Like most other *Acropora* species, *A. palmerae* is a hermaphroditic spawner with lecithotrophic (yolk-sac) larvae. Unlike most other *Acropora* species, colonies of *A. palmerae* can be entirely encrusting with no branches (or colonies may have short, irregularly-shaped branches). The public comments and information we gathered did not provide anything additional to the above-described biological information.

Susceptibility to Threats

To describe *A. palmerae's* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Acropora* of ocean warming, acidification, disease, predation, sedimentation, nutrients, and collection and trade. The SRR and SIR did not provide any species-specific information on the effects of these threats on *A. palmerae.* We interpreted the threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *A. palmerae's* vulnerabilities as follows: High vulnerability to ocean warming, moderate vulnerabilities to disease, ocean acidification, trophic effects of fishing, nutrients, and predation, and low vulnerabilities to sedimentation, sea-level rise, and collection and trade.

Public comments did not provide any new or supplemental information on *A. palmerae's* threat susceptibilities. We gathered the following species-specific and genus-level supplemental information on this species' threat susceptibilities. *Acropora palmerae* has been rated as moderately or highly susceptible to thermal bleaching and coral disease, but these ratings are not based on species-specific data (Carpenter *et al.,* 2008). No other species-specific information is available for the susceptibility of *A. palmerae* to any other threat. Based on information from other *Acropora* species provided in the genus description above, *A. palmerae* is likely highly susceptible to ocean warming, and also has some susceptibilities to disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade. The available information does not support more precise ratings of the susceptibilities of *A. palmerae* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *A. palmerae.* Criticisms of our approach received during public comment led us to the following analysis to attempt to analyze regulatory mechanisms on a species basis. Records confirm that *A. palmerae* occurs in 42 Indo-Pacific ecoregions that encompass 28 countries' EEZs. The 28 countries are Australia, China, Federated States of Micronesia, Fiji, France (French Pacific Island Territories), India (including Andaman and Nicobar Islands), Indonesia, Japan, Marshall Islands, Mauritius, Myanmar, New Zealand (Cook Islands, Tokelau), Niue, Palau, Papua New Guinea, Philippines, Samoa, Seychelles, Solomon Islands, Sri Lanka, Taiwan, Thailand, Timor-Leste, Tonga, Tuvalu, United States (CNMI, Guam, American Samoa, PRIAs), Vanuatu, and Vietnam. The regulatory mechanisms relevant to *A. palmerae,* described first as the percentage of the above countries that utilize them, to any degree and second, as the percentages of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (36 percent with 11 percent limited in scope), coral collection (57 percent with 29 percent limited in scope), pollution control (39 percent with 11 percent limited in scope), fishing regulations on reefs (96 percent with 11 percent limited in scope), and managing areas for protection and conservation (96 percent with 4 percent limited in scope). The most common regulatory mechanisms in place for *A. palmerae* are reef fishing regulations and area management for protection and conservation. Coral collection and pollution control laws are also somewhat common for the species, but 29 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection laws are much less prominent regulatory mechanisms for the management of *A. palmerae.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that the high bleaching rate of the *Acropora genus* is the primary known threat of extinction for *A. palmerae.* It listed factors that reduce the threat of extinction including its very broad geographic range, the fact that it is often common and sometimes abundant, and the broad range of suitable habitat types for *A. palmerae.*

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *A. palmerae,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution includes most of the coral reef ecoregions in the Indian Ocean and western and central Pacific Ocean. Its geographic distribution moderates vulnerability to extinction because some areas within its range are projected to have less than average warming and acidification over the foreseeable future, including the western Indian Ocean, the central Pacific, and other areas, so portions of the population in these areas will be less exposed to severe conditions. Its depth range is from the surface to as much as 20 meters. This moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Its habitat includes upper reef slopes, mid-slope terraces, lower reef crests, and reef flats in depth ranging from two to 20 m depth. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Reef zones subject to high wave action also experience high levels of mixing which can dilute adverse environmental conditions. Its absolute abundance of at least tens of millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule using the determination tool formula approach, *A. palmerae* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); uncommon generalized range wide abundance (E); moderately wide distribution (based on moderate geographic distribution and moderate depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *A. palmerae* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *A. palmerae's* spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to be likely to become endangered throughout its range within the foreseeable future, and thus is not warranted for listing at this time, because:

(1) *Acropora palmerae's* distribution across the Indian Ocean and most of the Pacific Ocean is spread over a very large area. While some areas within its range are projected to be affected by warming and acidification, other areas are projected to have less than average warming and acidification, including the western Indian Ocean, the central Pacific, and other areas. This distribution and the wide variety of habitat types it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future;

(2) *Acropora palmerae's* absolute abundance is at least tens of millions of colonies, providing buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response; and

(3) It is a broadcast spawner and fast grower, enhancing recovery potential from mortality events, as described in the Corals and Coral Reefs section above.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future if global threats continue and increase in severity and the species exposure to threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *A. palmerae* is not warranted for listing at this time under any of the listing factors.

Acropora paniculata

Introduction

The SRR and SIR provided the following information on *A. paniculata's* morphology and taxonomy. Morphology was described as large plates or tables that are 25 mm thick and frequently greater than 1 m across, and taxonomy was described as having no taxonomic issues, but it is quite similar to *A. cytherea* and similar to *A. jacquelineae.*

The public comments and information we gathered provided information on morphology and taxonomy of *A. paniculata.* One public comment stated that in Hawaii, colony morphology of *A. paniculata* resembles that of *A. cytherea,* but that *A. paniculata* occurs at greater depths than *A. cytherea,* which opens the possibility of them being the same species that changes growth forms at different depths. We gathered supplemental information, including Veron (2014), which states that *A. paniculata* is distinctive, thus we conclude it can be identified by experts, and that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *A. paniculata's* distribution, habitat, and depth range. *Acropora paniculata* is distributed from the Red Sea and Indian Ocean to the west and central Pacific, including within the Mariana Islands. The species has a moderately broad range, the 40th largest range of 114 *Acropora* species. Its habitat includes numerous reef slope and back-reef habitats, including at least upper reef slopes, mid-slope terraces, lower reef slopes, and sheltered lagoons, and its depth range is 10 to 35 m.

The public comments and the supplemental information provided the following information on *A. paniculata's* distribution. One public comment stated that occurrence of *A. paniculata* within the Mariana Islands has not been confirmed by expert Richard H. Randall, in contradiction to the SRR. We gathered supplemental information, including Veron (2014), which reports that *A. paniculata* is confirmed in 51 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional 15. Wallace (1999b) reports its occurrence in 19 of her 29 Indo-Pacific areas, many of which are larger than Veron's ecoregions. Richards (2009) calculated the geographic range at 80 million km^2. The public comments and information we gathered provided nothing additional on *A. paniculata's* habitat and depth range.

Demographic Information

The SRR and SIR provided the following information on *A. paniculata's* abundance. *Acropora paniculata* has been reported as uncommon to rare (Veron, 2000). Richards (2009) concluded that this species is globally widespread, locally restricted, and locally rare, and thus in the second rarest category of *Acropora* with the predicted consequence of local extinction.

The public comments and information we gathered provided the following information on *A. paniculata's* abundance. One public comment stated that Fenner's 2005 book Corals of Hawaii notes that in the Hawaiian Islands, *A. paniculata* is ''not common,'' which the commenter argued demonstrates that the species is not rare, at least in Hawaii. We gathered supplemental information, including observations made in 2014 that *A. paniculata* is one of the most common corals in the Chagos Islands in the Indian Ocean, where it has recovered rapidly from the 1998 mass bleaching event (D. Fenner, personal comm.). Veron (2014) reports that *A. paniculata* occupied 14.3 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.43 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''common,'' and overall abundance was described as ''uncommon.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least tens of millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *A. paniculata,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 35 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 14 percent in the study. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *A. paniculata* occurs in many areas affected by these broad changes, and that it has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *A. paniculata's* life history. Like most other *Acropora* species, *A. paniculata* is a hermaphroditic spawner with lecithotrophic (yolk-sac) larvae. The public comments and information we gathered did not provide anything additional to the above-described biological information.

Susceptibility to Threats

To describe *A. paniculata's* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Acropora* of ocean warming, acidification, disease, predation, sedimentation, nutrients, and collection and trade. The SRR and SIR did not provide any species-specific information on the effects of these threats on *A. paniculata.* We interpreted the threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *A. paniculata's* vulnerabilities as follows: High vulnerability to ocean warming, moderate vulnerabilities to disease, ocean acidification, trophic effects of fishing, nutrients, and predation, and low vulnerabilities to sedimentation, sea-level rise, and collection and trade.

Public comments did not provide any new or supplemental information on *A. paniculata's* threat susceptibilities. We gathered the following species-specific and genus-level supplemental information on this species' threat susceptibilities. *Acropora paniculata* has been rated as moderately or highly susceptible to bleaching and disease, but these ratings are not based on species-specific data (Carpenter *et al.,* 2008). No other species-specific information is available for the susceptibility of *A. paniculata* to any other threat. Based on information from other *Acropora* species provided in the genus description above, *A. paniculata* likely is highly susceptible to ocean warming, and also has some susceptibility to disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade. The available information does not support more precise ratings of the susceptibilities of *A. paniculata* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *A. paniculata.* Criticisms of our approach received during public comment led us to the following analysis to attempt to analyze regulatory mechanisms on a species basis. Records confirm that *A. paniculata* occurs in 51 Indo-Pacific ecoregions that encompass 37 countries' EEZs. The 37 countries are Australia (including Cocos-Keeling Islands), China, Comoros Islands, Egypt, Federated States of Micronesia, Fiji, France (French Pacific Island Territories), India (Andaman and Nicobar Islands), Indonesia, Israel, Japan, Jordan, Kiribati, Madagascar, Malaysia, Maldives, Marshall Islands, Mauritius, Myanmar, Nauru, New Zealand (Tokelau), Niue, Palau, Papua New Guinea, Philippines, Samoa, Saudi Arabia, Solomon Islands, Sudan, Taiwan, Thailand, Tonga, Tuvalu, United Kingdom (British Indian Ocean Territory), United States (Hawaii, American Samoa, PRIAs), Vanuatu, and Vietnam. The regulatory mechanisms relevant to *A. paniculata,* described first as the percentage of the above countries that utilize them to any degree and second, as the percentages of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (24 percent with 3 percent limited in scope), coral collection (59 percent with 30 percent limited in scope), pollution control (43 percent with 8 percent limited in scope), fishing regulations on reefs (89 percent with 22 percent limited in scope), and managing areas for protection and conservation (95 percent with 11 percent limited in scope). The most common regulatory mechanisms in place for *A. paniculata* are reef fishing regulations and area management for protection and conservation. Coral collection and pollution control laws are also somewhat common for the species, but 30 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection laws are much less prominent regulatory mechanisms for the management of *A. paniculata.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that the high bleaching rate of the *Acropora genus* is the primary known threat of extinction for *A. paniculata.* It listed factors that reduce the threat of extinction including the moderately wide geographic range, presence in deeper habitats, and being common in New Guinea though rare elsewhere.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *A. paniculata,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution includes most of the coral reef ecoregions in the Indian Ocean and western and central Pacific Ocean. Its geographic distribution moderates vulnerability to extinction because some areas within its range are projected to have less than average warming and acidification over the foreseeable future, including the western Indian Ocean, the central Pacific, and other areas, so portions of the population in these areas will be less exposed to severe conditions. Its depth range is from 10 to 35 meters. This moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Its habitat includes at least upper reef slopes, mid-slope terraces, lower reef slopes, and sheltered lagoons. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Its absolute abundance of at least tens of millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule using the determination tool formula approach, *A. paniculata* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); uncommon generalized range wide abundance (E); wide overall distribution (based on wide geographic distribution and moderate depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *A. paniculata* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *A.*

paniculata's spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to be likely to become endangered throughout its range within the foreseeable future, and thus is not warranted for listing at this time, because:

(1) *Acropora paniculata*'s distribution from the Red Sea across the Indian Ocean and most of the Pacific Ocean is spread over a very large area. While some areas within its range are projected to be affected by warming and acidification, other areas are projected to have less than average warming and acidification, including the western Indian Ocean, the central Pacific, and other areas. This distribution and the heterogeneous habitats it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future;

(2) *Acropora paniculata*'s absolute abundance is at least tens of millions of colonies, providing buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response; and

(3) It is a broadcast spawner and fast grower, enhancing recovery potential from mortality events as described in the Corals and Coral Reefs section above.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future if global threats continue and increase in severity and the species exposure to threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *A. paniculata* is not warranted for listing at this time under any of the listing factors.

Acropora pharaonis

Introduction

The SRR and SIR provided the following information on *A. pharaonis'* morphology and taxonomy. Morphology was described as large horizontal tables or irregular clusters of horizontal or upright interlinked contorted branches, and taxonomy was described as having no taxonomic issues but being similar in appearance to *Acropora clathrata* and *Acropora plumosa.*

The public comments did not provide supplemental information on morphology or taxonomy. We gathered supplemental information, including that *A. pharaonis* is recognized as valid by experts (Veron, 2000; Veron, 2014; Wallace, 1999a). Veron (2014) also states that records of this species in the Pacific by other authors are likely to be another, probably undescribed species. However, we conclude the species can be identified by experts, thus the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *A. pharaonis'* distribution, habitat, and depth range. *Acropora pharaonis* has a disjoint distribution, being present in the Red Sea and western/northern Indian Ocean, and areas in the Pacific Ocean. It notes that IUCN stated that there are doubts about the Pacific records. The species has the 14th smallest range of 114 *Acropora* species. Its habitat includes reef slope and back-reef habitats, including at least upper reef slopes, mid-slope terraces, and lagoons, and its depth range is 5 to 25 meters.

The public comments did not provide supplemental information on *A. pharaonis'* distribution. We gathered supplemental information, including Veron (2014), which reports that *A. pharaonis* is confirmed in 11 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional eight. All 19 of these ecoregions are in the Indian Ocean. Wallace (1999b) reports its occurrence in six of her 29 Indo-Pacific areas, many of which are larger than Veron's ecoregions, stating that, ''This unusual species appears to be restricted to the Red Sea.'' Richards (2009) estimated its range at 1.4 million km^2. The public comments and information we gathered provided nothing additional on *A. pharaonis'* habitat and depth range.

Demographic Information

The SRR and SIR provided the following information on *A. pharaonis'* abundance. *Acropora pharaonis* has been reported as common. The public comments did not provide supplemental information on *A. pharaonis'* abundance. We gathered supplemental information, including Veron (2014), which reports that *A. pharaonis* occupied 3.6 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.80 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''uncommon.'' Overall abundance was described as ''common in the Red Sea, uncommon elsewhere.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *A. pharaonis,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 30 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 14 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *A. pharaonis* occurs in areas affected by these broad changes, and has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *A. pharaonis'* life history. *Acropora pharaonis* is a hermaphroditic spawner with lecithotrophic (yolk-sac) larvae. The public comments and information we gathered did not provide anything additional to the above-described biological information.

Susceptibility to Threats

To describe *A. pharaonis'* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Acropora* of ocean warming, acidification, disease, predation, sedimentation, nutrients, and collection and trade. The SRR also reported that *A. pharaonis* was locally extirpated in the SE Arabian Gulf after the combined impacts of the 1996 and 1998 bleaching events, and that the species is susceptible to several diseases that affect reproduction including reduced fecundity. We interpreted the threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *A. pharaonis'* vulnerabilities as follows: High vulnerability to ocean warming and disease, moderate vulnerabilities to ocean acidification, trophic effects of fishing, nutrients, and predation, and low vulnerabilities to sedimentation, sea-level rise, and collection and trade.

Public comments did not provide supplemental information on *A. pharaonis'* threat susceptibilities. We gathered the following species-specific and genus-level supplemental information on this species' threat susceptibilities. *Acropora pharaonis* has been rated as moderately or highly susceptible to bleaching and disease, but these ratings are not based on species-specific data (Carpenter *et al.,* 2008). No other species-specific information is available for the susceptibility of *A. pharaonis* to any other threat. Based on information from other *Acropora* species provided in the genus description above, *A. pharaonis* likely has high susceptibility ocean warming, and also likely has some susceptibility to disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, and collection and trade. Based on the available information, high susceptibility to disease (as stated in the proposed rule for this species) is not supported. The available information does not support more precise ratings of the susceptibilities of *A. pharaonis* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *A. pharaonis.* Criticisms of our approach received during public comment led us to the following analysis to attempt to analyze regulatory mechanisms on a species basis. Records confirm that *A. pharaonis* occurs in 11 Indo-Pacific ecoregions that encompass 21 countries' EEZs. The 21 countries are Bahrain, Djibouti, Egypt, Eritrea, France (French Pacific Island Territories), India, Iran, Israel, Jordan, Kuwait, Madagascar, Maldives, Mauritius, Qatar, Saudi Arabia, Seychelles, Somalia, Sri Lanka, Sudan, United Arab Emirates, and Yemen. The regulatory mechanisms relevant to *A. pharaonis,* described first as the percentage of the above countries that utilize them to any degree and second, as the percentages of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (29 percent with 10 percent limited in scope), coral collection (43 percent with five percent limited in scope), pollution control (52 percent with five percent limited in scope), fishing regulations on reefs (76 percent with 24 percent limited in scope), and managing areas for protection and conservation (71 percent with 14 percent limited in scope). The most common regulatory mechanisms in place for *A. pharaonis* are reef fishing regulations and area management for protection and conservation. Coral collection and pollution control laws are also somewhat common for the species. General coral protection laws are much less prominent regulatory mechanisms for the management of *A. pharaonis.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that the high bleaching rate of the *Acropora genus* is the primary known threat of extinction for *A. pharaonis.* This is exacerbated by its restricted range and the need for protected habitats. The SRR also listed factors that reduce the threat of extinction including its moderate depth range (5 m to 25 m) and its common abundance levels in the Red Sea.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *A. pharaonis,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution includes the Red Sea and Arabian Gulf, but relatively few islands. This exacerbates vulnerability to extinction over the foreseeable future because it is restricted a portion of the Indian Ocean with a limited amount of island and offshore habitat, and includes areas projected to have the most rapid and severe impacts from climate change and localized human impacts for coral reefs over the 21st century (*i.e.,* the Red Sea and the Arabian Gulf). Its depth range of five to 25 meters moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Its habitat includes reef slope and back-reef habitats, including at least upper reef slopes, mid-slope terraces, and lagoons. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. There is not enough information about its abundance to determine if it moderates or exacerbates extinction: It is common in the Red Sea, uncommon elsewhere, and has at least millions of colonies, but the Red Sea and Arabian Gulf portions of the population are expected to be severely impacted by threats over the foreseeable future. While depth distribution and habitat variability moderate vulnerability to extinction, the combination of its geographic distribution and high susceptibility to ocean warming are likely to be more influential to the status of this species over the foreseeable future, because of the projected severity of ocean warming in much of the species' range in the foreseeable future, and its high susceptibility to this threat.

Listing Determination

In the proposed rule using the determination tool formula approach, *A. pharaonis* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E) and disease (C); moderate vulnerability to acidification (E); common generalized range wide abundance (E); narrow overall distribution (based on narrow geographic distribution and moderate depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we confirmed the species' proposed listing determination as threatened. Based on the best available information provided above on *A. pharaonis'* spatial structure, demography, threat susceptibilities, and management indicate that it is likely to become endangered throughout its range within the foreseeable future, and thus still warrants listing as threatened at this time, because:

(1) *Acropora pharaonis* is highly susceptible to ocean warming (ESA Factor E), and susceptible to disease (C), ocean acidification (E), trophic effects of fishing (A), predation (C), and nutrients (A, E). These threats are expected to continue and increase into the future. In addition, existing regulatory mechanisms to address global threats that contribute to extinction risk for this species are inadequate (D).

(2) *Acropora pharaonis'* distribution is constrained entirely to the Red Sea, Arabian Gulf, and western and central Indian Ocean where projections of ocean warming and local threats (*e.g.,* land-based sources of pollution) are both frequent and severe over the foreseeable future compared to other areas of the Indo-Pacific. A range constrained to a particular geographic area that is likely to experience severe and worsening threats indicates that a high proportion of the population of this species is likely to be exposed to those threats over the foreseeable future; and

(3) *Acropora pharaonis* suffered documented local extirpation in the southeast Arabian Gulf after the combined impacts of the 1996 and 1998 bleaching events, providing evidence that this species has already been severely impacted by ocean warming in some parts of its range.

The combination of these characteristics and future projections of threats indicates that the species is likely to be in danger of extinction within the foreseeable future throughout its range and warrants listing as threatened at this time due to factors A, C, D, and E.

The available information above on *A. pharaonis'* spatial structure, demography, threat susceptibilities, and management also indicate that the species the species is not currently in danger of extinction and thus does not warrant listing as Endangered because:

(1) While *A. pharaonis'* distribution in only the Indian Ocean and the Middle East, which increases it extinction risk as described above, its habitat includes sheltered lagoon patch reefs and other shallow reef environments. This moderates vulnerability to extinction currently because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time, as described in more detail in the Coral Habitat and Threats Evaluation sections. There is no evidence that the species is so spatially fragmented or geographically constrained that depensatory processes, environmental stochasticity, or the potential for catastrophic events currently pose a high risk to the survival of the species; and

(2) *Acropora pharaonis* absolute abundance is at least millions of colonies, which allows for variation in the responses of individuals to threats to play a role in moderating vulnerability to extinction for the species to some degree, as described in more detail in the Corals and Coral Reefs section. There is no evidence of depensatory processes such as reproductive failure from low density of reproductive individuals and genetic processes such as inbreeding affecting this species. Thus, its absolute abundance indicates it is currently able to avoid high mortality from environmental stochasticity, and mortality of a high proportion of its population from catastrophic events.

The combination of these characteristics indicates that the species does not exhibit the characteristics of one that is currently in danger of extinction, as described previously in the Risk Analyses section, and thus does not warrant listing as endangered at this time.

Range-wide, a multitude of conservation efforts are already broadly employed that are likely benefiting *A. pharaonis.* However, considering the global scale of the most important threats to the species, and the ineffectiveness of conservation efforts at addressing the root cause of global threats (*i.e.,* GHG emissions), we do not believe that any current conservation efforts or conservation efforts planned in the future will result in affecting the species status to the point at which listing is not warranted.

Acropora polystoma

Introduction

The SRR and SIR provided the following information on *A. polystoma'*s morphology and taxonomy. Morphology was described as irregular clumps or plates with tapered branches of similar length and shape, and being similar to *A. massawensis* and *A. polystoma.* The taxonomy was described as not having much uncertainty, except in the Mariana Islands where specimens previously identified as *A. polystoma* may be a different species.

The public comments and information we gathered provided information on morphology or taxonomy of *A. polystoma.* One public comment stated that specimens of *A. polystoma* in Guam may represent a different species. We gathered supplemental information, including Veron (2014), which states that *A. polystoma* is distinctive, thus we conclude it can be identified by experts, and that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *A. polystoma'*s distribution, habitat, and depth range. *Acropora polystoma* is distributed from the Red Sea to the Indian Ocean to the central Pacific. The species has the 28th largest range of 114 *Acropora* species. Its habitat includes areas exposed to strong wave action, including upper reef slopes, lower reef crests, reef flats, and other habitats, and its depth range is three to 10 meters.

The public comments did not provide any new or supplemental information on *A. polystoma'*s distribution. We gathered supplemental information, including Veron (2014), which reports that this species is confirmed in 48 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional 19. Wallace (1999b) reports its occurrence in 19 of her 29 Indo-Pacific areas, many of which are significantly larger than Veron's ecoregions. Richards (2009) calculated the geographic range of *A. polystoma* at 85 million km^2. The public comments and information we gathered provided nothing additional on *A. polystoma's* habitat and depth range.

Demographic Information

The SRR and SIR provided the following information on *A. polystoma's* abundance. *Acropora polystoma* has been reported as uncommon.

The public comments did not provide any new or supplemental information on *A. polystoma's* abundance. We gathered supplemental information, including Veron (2014), which reports that *A. polystoma* occupied 6.7 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.74 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''common.'' Overall abundance was described as ''uncommon.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least tens of millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *A. polystoma,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 35 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 14 percent. However, as summarized above in in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *A. polystoma* occurs in many areas affected by these broad changes, and that it has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *A. polystoma's* life history. *Acropora polystoma* is a hermaphroditic spawner with lecithotrophic (yolk-sac) larvae. The public comments and information we gathered did not provide anything additional to the above-described biological information.

Susceptibility to Threats

To describe *A. polystoma's* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Acropora* of ocean warming, acidification, disease, predation, sedimentation, nutrients, and collection and trade. The SRR and SIR did not provide any species-specific information on the effects of these threats on *A. polystoma.* We interpreted the threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *A. polystoma's* vulnerabilities as follows: High vulnerability to ocean warming and disease, moderate vulnerabilities to ocean acidification, trophic effects of fishing, nutrients, and predation, and low vulnerabilities to sedimentation, sea-level rise, and collection and trade.

Public comments did not provide any new or supplemental information on *A. polystoma's* threat susceptibilities. We gathered the following species-specific and genus-level supplemental information on this species' threat susceptibilities. *A. polystoma* has been rated as moderately or highly susceptible to bleaching and warming-induced disease, but these ratings are not based on species-specific data (Carpenter *et al.,* 2008). No other species-specific information is available for the susceptibility of *A. polystoma* to any other threat. Based on information from other *Acropora* species provided in the genus description above, *A. polystoma* likely has high susceptibility ocean warming, and also likely has some susceptibilities to disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, and collection and trade. Based on the available information, high susceptibility to disease, as stated in the proposed rule for this species, is not supported. The available information does not support more precise ratings of the susceptibilities of *A. polystoma* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *A. polystoma.* Criticisms of our approach received during public comment led us to the following analysis to attempt to analyze regulatory mechanisms on a species basis. Records confirm that *A. polystoma* occurs in 48 Indo-Pacific ecoregions that encompass 41 countries' EEZs. The 41 countries are Australia, Brunei, China, Djibouti, Egypt, Eritrea, Federated States of Micronesia, Fiji, France (French Pacific Island Territories), India (Andaman and Nicobar Islands), Indonesia, Israel, Japan, Jordan, Kenya, Madagascar, Malaysia, Maldives, Marshall Islands, Mauritius, Myanmar, New Zealand (Tokelau), Niue, Palau, Papua New Guinea, Philippines, Samoa, Saudi Arabia, Solomon Islands, Sudan, Taiwan, Tanzania, Thailand, Timor-Leste, Tonga, Tuvalu, United Kingdom (British Indian Ocean Territory), United States (CNMI, Guam, American Samoa, PRIAs), Vanuatu, Vietnam, and Yemen. The regulatory mechanisms relevant to *A. polystoma,* described first as the percentage of the above countries that utilize them to any degree and second, the percentages of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (24 percent with two percent limited in scope), coral collection (63 percent with 32 percent limited in scope), pollution control (39 percent with seven percent limited in scope), fishing regulations on reefs (90 percent with 20 percent limited in scope), and managing areas for protection and conservation (95 percent with 10 percent limited in scope). The most common regulatory mechanisms in place for *A. polystoma* are reef fishing regulations and area management for protection and conservation. Coral collection and pollution control laws are also somewhat common for the species, but 32 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection laws are much less prominent regulatory mechanisms for the management of *A. polystoma.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that the high bleaching rate of the *Acropora* genus is the primary known threat of extinction for *A. polystoma,* which is exacerbated by the relatively restricted depth range and the uncommon abundance. It listed factors that reduce the threat of extinction including the wide geographic range, and the intertidal habitat which may indicate potentially increased tolerance.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *A. polystoma,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution includes most of the coral reef ecoregions in the Indian Ocean and western and central Pacific Ocean. Its geographic distribution moderates vulnerability to extinction because some areas within its range are projected to have less than average warming and acidification over the foreseeable future, including the western Indian Ocean, the central Pacific, and other areas, so portions of the population in these areas will be less exposed to severe conditions. Its depth distribution down to 10 meters may exacerbate the species exposure to some threats that are more severe in shallower water. Shallow reef environments can experience frequent changes in environmental conditions, extremes, high irradiance, and multiple stressors simultaneously. However, its habitat includes areas exposed to strong wave action, including upper reef slopes, lower reef crests, reef flats, and other high energy habitats. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. In addition, areas of high currents and/or wave action experience high levels of mixing which can dilute adverse environmental conditions. Its absolute abundance of at least tens of millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule using the determination tool formula approach, *A. polystoma* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); uncommon generalized range wide abundance (E); moderate overall distribution (based on wide geographic distribution and shallow depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *A. polystoma* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *A. polystoma's* spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to be likely to become endangered throughout its range within the foreseeable future, and thus is not warranted for listing at this time, because:

(1) *Acropora polystoma'*s distribution across the Red Sea, Indian Ocean and most of the Pacific Ocean is spread over a very large area. While some areas within its range are projected to be affected by warming and acidification, other areas are projected to have less than average warming and acidification, including the western Indian Ocean, the central Pacific, and other areas. This distribution and the heterogeneous habitats it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future;

(2) *Acropora polystoma'*s absolute abundance is at least tens of millions of colonies, providing buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response; and

(3) *A. polystoma* is a broadcast spawner and fast grower, enhancing recovery potential from mortality events as described in the Corals and Coral Reefs section above.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future as global threats continue and increase in severity and the species exposure to threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *A. polystoma* is not warranted for listing at this time under any of the listing factors.

Acropora retusa

Introduction

The SRR and SIR provided the following information on *A. retusa'*s morphology and taxonomy. The morphology was described as flat plates with short thick digitate branchlets and taxonomy was described as having no taxonomic issues, but it is similar to *Acropora branchi, Acropora gemmifera,* and *Acropora monticulosa.*

The public comments did not provide any new or supplemental information on morphology or taxonomy of *A.*

retusa. We gathered supplemental information, which indicated that while there is some taxonomic uncertainty for this species, it is recognized as valid by experts (Veron, 2000; Wallace, 1999a). Veron (2014) states that *A. retusa* is readily confused with other *Acropora,* but we conclude it can be identified by experts, and that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *A. retusa's* distribution, habitat, and depth range. *Acropora retusa* is distributed from the Red Sea and the Indian Ocean to the central Pacific. The species has the 52nd largest range of 114 *Acropora* species. Its habitat includes shallow reef slope and back-reef areas, such as upper reef slopes, reef flats, shallow lagoons, and its depth range is one to five meters.

The public comments did not provide any new or supplemental information on *A. retusa's* distribution. We gathered supplemental information, including Veron (2014), which reports that this species is confirmed in 23 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional 21. Wallace (1999b) reports its occurrence in five of her 29 Indo-Pacific areas, many of which are larger than Veron's ecoregions. Richards (2009) estimated its range at 68 million km^2. The public comments and information we gathered provided nothing additional on *A. retusa's* habitat and depth range.

Demographic Information

The SRR and SIR provided the following information on *A. retusa's* abundance. *Acropora retusa* has been reported as common in South Africa and uncommon elsewhere. The public comments did not provide any new or supplemental information on *A. retusa's* abundance. We gathered supplemental information, including Veron (2014), which reports that *A. retusa* occupied 0.5 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.21 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''rare.'' Overall abundance was described as ''common in South Africa, rare elsewhere.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *A. retusa,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 49 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 18 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *A. retusa* occurs in many areas affected by these broad changes, and that it has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible due to the limited amount of species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *A. retusa's* life history. *Acropora retusa* is a hermaphroditic spawner with lecithotrophic (yolk-sac) larvae. The public comments and information we gathered did not provide anything additional to the above-described biological information.

Susceptibility to Threats

To describe *A. retusa'* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Acropora* of ocean warming, acidification, disease, predation, sedimentation, nutrients, and collection and trade. The SRR and SIR did not provide any other species-specific information on the effects of these threats on *A. retusa.* We interpreted the threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *A. retusa's* vulnerabilities as follows: High vulnerability to ocean warming, moderate vulnerabilities to disease, ocean acidification, trophic effects of fishing, nutrients, and predation, and low vulnerabilities to sedimentation, sea-level rise, and collection and trade.

Public comments did not provide any new or supplemental information on *A. retusa's* threat susceptibilities. We gathered the following species-specific and genus-level supplemental information on this species' threat susceptibilities. *Acropora retusa* has been rated as moderately or highly susceptible to bleaching and disease, but these ratings are not based on species-specific data (Carpenter *et al.,* 2008). No other species-specific information is available for the susceptibility of *A. retusa* to any other threat. Based on information from other *Acropora* species provided in the genus description above, *A. retusa* is likely highly susceptible to ocean warming, and also likely has some susceptibilities to disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade. The available information does not support more precise ratings of the susceptibilities of *A. retusa* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *A. retusa.* Criticisms of our approach received during public comment led us to the following analysis to attempt to analyze regulatory mechanisms on a species basis. Records confirm that *A. retusa* occurs in 23 Indo-Pacific ecoregions that encompass 26 countries' EEZs. The 26 countries are Brunei, Federated States of Micronesia, Fiji, France (French Pacific Island Territories), India, Indonesia, Japan, Kenya, Madagascar, Malaysia, Mauritius, Mozambique, New Zealand (Cook Islands, Tokelau), Niue, Palau, Papua New Guinea, Samoa, Seychelles, Solomon Islands, South Africa, Sri Lanka, Tanzania, Tonga, Tuvalu, United States (CNMI, Guam, American Samoa), and Vietnam. The regulatory mechanisms relevant to *A. retusa,* described first as the percentage of the above countries that utilize them to any degree and second, as the percentages of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (19 percent with eight percent limited in scope), coral collection (58 percent with 35 percent limited in scope), pollution control (38 percent with 12 percent limited in scope), fishing regulations on reefs (96 percent with 23 percent limited in scope), and managing areas for protection and conservation (100 percent with none limited in scope). The most common regulatory mechanisms in place for *A. retusa* are reef fishing regulations and area management for protection and conservation. Coral collection and pollution control laws are also somewhat common for the species, but 35 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection laws are much less prominent regulatory mechanisms for the management of *A. retusa.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that the high bleaching rate of the *Acropora genus* is the primary known threat of extinction for *A. retusa.* The species' rarity adds to its risk of extinction. The SRR also listed factors that reduce the threat of extinction including its geographic range and its occurrence in tidal pools (suggesting high physiological stress tolerance).

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *A. retusa,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution includes many coral reef ecoregions in the Indian Ocean and western and central Pacific Ocean. Its geographic distribution moderates vulnerability to extinction because some areas within its range are projected to have less than average warming and acidification over the foreseeable future, including the western Indian Ocean, the central Pacific, and other areas, so portions of the population in these areas will be less exposed to severe conditions. Its depth range of zero to five meters exacerbates vulnerability to extinction over the foreseeable future. Shallow reef areas are often subjected to highly variable environmental conditions, extremes, high irradiance, and simultaneous effects from multiple stressors, both local and global in nature. A species restricted to such shallow depths is likely to have a high proportion of individuals exposed to higher levels of irradiance and other threats that are more severe in shallow habitats. Its habitat includes shallow reef slope and back-reef areas, such as upper reef slopes, reef flats, and shallow lagoons. While this generally moderates vulnerability to extinction for most species that can occupy a diverse set of habitat types, in this case, habitat heterogeneity likely does not provide much moderation of exposure to threats because of the shallow depth restriction for this species. Its absolute abundance of at least millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time. However, its qualitative abundance is described as rare, which combined with its restricted depth distribution indicates it is likely that a high proportion of individuals will be affected by threats that are typically more severe in shallow habitats at any given point in time.

Listing Determination

In the proposed rule using the listing determination tool approach, *A. retusa* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); uncommon generalized range wide abundance (E); moderate overall distribution (based on wide geographic distribution and shallow depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we maintain the species' proposed listing determination as threatened. Based on the best available information provided above on *A. retusa's* spatial structure, demography, threat susceptibilities, and management indicate that it is likely to become endangered throughout its range within the foreseeable future, and thus warrants listing as threatened at this time, because:

(1) *Acropora retusa* is highly susceptible to ocean warming (ESA Factor E), and susceptible to disease (C), ocean acidification (E), trophic effects of fishing (A), predation (C), and nutrients (A, E). These threats are expected to continue and increase into the future. In addition, existing regulatory mechanisms addressing global threats that contribute to extinction risk for this species inadequate (D);

(2) *Acropora retusa* is restricted to shallow habitat (zero to five meters), where many global and local threats may be more severe, especially near populated areas. Shallow reef areas are often subjected to highly variable environmental conditions, extremes, high irradiance, and simultaneous effects from multiple stressors, both local and global in nature. A limited depth range also reduces the absolute area in which the species may occur throughout its geographic range, and indicates that a large proportion of the population is likely to be exposed to threats that are worse in shallow habitats, such as simultaneously elevated irradiance and seawater temperatures, as well as localized impacts; and

(3) *Acropora retusa's* abundance is considered rare overall. This level of abundance, combined with its restricted depth distribution where impacts are more severe, leaves the species vulnerable to becoming of such low abundance within the foreseeable future that it may be at risk from depensatory processes, environmental stochasticity, or catastrophic events, as explained in more detail in the Corals and Coral Reefs and Risk Analyses sections.

The combination of these characteristics and future projections of threats indicates that the species is likely to be in danger of extinction within the foreseeable future throughout its range and warrants listing as threatened at this time due to factors A, C, D, and E.

The available information above on *A. retusa's* spatial structure, demography, threat susceptibilities, and management also indicate that the species is not currently in danger of extinction and thus does not warrant listing as Endangered because:

(1) *Acropora retusa's* distribution from South Africa to the Pitcairn Islands is spread over a very large area. While some areas within its range are projected to be affected by warming and acidification, other areas are projected to have less than average warming and acidification, including the western Indian Ocean, the central Pacific, and

other areas. This distribution reduces exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future;

(2) While *Acropora retusa* is limited to shallow depths, which increases its extinction risk as described above, its geographic range encompasses heterogeneous habitat, the benefits of which are explained in detail in the Coral Habitat sub-section above, across almost half of the coral reef area in the Indo-Pacific, and there is no evidence to suggest that it is so spatially fragmented that depensatory processes, environmental stochasticity, or the potential for catastrophic events currently pose a high risk to the survival of the species; and

(3) While *Acropora retusa*'s qualitative abundance is characterized as rare, its absolute abundance is at least millions of colonies. Additionally, *A. retusa* is considered common in a portion of its range (South Africa), indicating it is not of such low abundance that depensatory processes, environmental stochasticity, or the potential for catastrophic events currently pose a high risk to the survival of the species.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species does not exhibit the characteristics of one that is currently in danger of extinction, as described previously in the Risk Analyses section, and thus does not warrant listing as endangered at this time.

Range-wide, a multitude of conservation efforts are already broadly employed that are likely benefiting *A. retusa.* However, considering the global scale of the most important threats to the species, and the ineffectiveness of conservation efforts at addressing the root cause of global threats (*i.e.,* GHG emissions), we do not believe that any current conservation efforts or conservation efforts planned in the future will result in affecting the species status to the point at which listing is not warranted.

Acropora rudis

Introduction

The SRR and SIR provided the following information on *A. rudis'* morphology and taxonomy. Morphology was described as arborescent with large, tapered, prostate branches, reaching a maximum size of 50 cm and taxonomy was described as having no taxonomic issues but being similar in appearance to *A. hemprichii* and *A. variolosa.*

The public comments and information we gathered provided information on morphology or taxonomy. One public comment stated that specimens collected in American Samoa and identified by the American Samoa Department of Marine and Water Resources as *A. rudis* appear to be *A. aculeus,* thereby illustrating the species identification uncertainties associated with this species. We gathered supplemental information, including Veron (2014), which states that *A. rudis* is readily confused with *Acropora schmitti* in shallow habitats, but is very distinctive otherwise, thus we conclude it can be identified by experts, and that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *A. rudis'* distribution, habitat, and depth range. *Acropora rudis'* distribution has long been thought by Veron and others to be restricted to the northeastern Indian Ocean, with recent reports by Fenner suggesting it may also occur in New Caledonia and the Samoas. The species has the 24th smallest range of 114 *Acropora* species. Its predominant habitat is lower reef crests and upper reef slopes in three to 15 m of depth.

The public comments did not provide supplemental information on *A. rudis'* distribution. We gathered supplemental information, including Veron (2014), which provides much more detailed range map for this species than the maps used in the SRR. Veron reports that this species is confirmed in seven of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional two. Veron (2014) does not show it in New Caledonia and the Samoas, apparently because he does not believe there is enough information available to strongly predict its occurrence there. Wallace (1999b) reports its occurrence in four of her 29 Indo-Pacific areas, many of which are larger than Veron's ecoregions. Richards (2009) calculated the geographic range of *A. rudis* at two million km^2, which was the 24th smallest range of the 114 *Acropora* species examined. The public comments and information we gathered provided nothing additional on *A. rudis'* habitat and depth range.

Demographic Information

The SRR and SIR provided the following information on *A. rudis'* abundance. *Acropora rudis* has been reported as uncommon, however, it has been noted to comprise as much as half of the *Acropora* in some areas.

The public comments did not provide supplemental information on *A. rudis'* abundance. We gathered supplemental information, including Veron (2014), which reports that *A. rudis* occupied 0.1 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.25 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''rare.'' Overall abundance was described as ''uncommon.'' Veron did not infer trends in abundance from these data. Other information indicates that *A. rudis* can be locally common, as it has been reported to comprise as much as half of the *Acropora* in the area south of the Hikkaduwa Nature Reserve in Sri Lanka (Rajasuriya, 2002). As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *A. rudis,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 59 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 22 percent. This estimated decline is approximately 50 percent higher than most other Indo-Pacific *Acropora* species included in the paper, apparently because of the combined restricted geographic and depth ranges (Carpenter *et al.,* 2008). However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *A. rudis* occurs in many areas affected by these broad changes, and that it has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *A. rudis'* life history. There is no information available on the reproductive biology of *A. rudis,* but all other *Acropora* studied to date are hermaphroditic broadcast spawners. The public comments and information we gathered did not provide anything additional to the above-described biological information.

Susceptibility to Threats

To describe *A. rudis'* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Acropora* of ocean warming, acidification, disease, predation, sedimentation, and nutrients. The SRR and SIR did not provide any species-specific information on the effects of these threats on *A. rudis.* We interpreted the threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *A. rudis'* vulnerabilities as follows: High vulnerability to ocean warming, moderate vulnerabilities to disease, ocean acidification, trophic effects of fishing, nutrients, and predation, and low vulnerabilities to sedimentation, sea-level rise, and collection and trade.

Public comments did not provide supplemental information on *A. rudis'* threat susceptibilities. We gathered the following species-specific and genus-level supplemental information on this species' threat susceptibilities. *Acropora rudis* has been rated as moderately or highly susceptible to bleaching and disease, but these ratings are not based on species-specific data (Carpenter *et al.,* 2008). No other species-specific information is available for the susceptibility of *A. rudis* to any other threat. Based on information from other *Acropora* species provided in the genus description above, *A. rudis* is likely highly susceptible to ocean warming, and also likely has some susceptibilities to disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade. The available information does not support more precise ratings of the susceptibilities of *A. rudis* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *A. rudis.* Criticisms of our approach received during public comment led us to the following analysis to attempt to analyze regulatory mechanisms on a species basis. Records confirm that *A. rudis* occurs in seven Indo-Pacific ecoregions that encompass eight countries' EEZs. The eight countries are Bangladesh, India (Andaman and Nicobar Islands), Indonesia, Malaysia, Maldives, Myanmar, Sri Lanka, and Thailand. The regulatory mechanisms relevant to *A. rudis,* described first as the percentage of the above countries that utilize them to any degree and second, as the percentages of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (25 percent with 13 percent limited in scope), coral collection (38 percent with 13 percent limited in scope), pollution control (50 percent with 13 percent limited in scope), fishing regulations on reefs (100 percent with 25 percent limited in scope), and managing areas for protection and conservation (88 percent with 13 percent limited in scope). The most common regulatory mechanisms in place for *A. rudis* are reef fishing regulations and area management for protection and conservation. Coral collection and pollution control laws are also somewhat common for the species. General coral protection laws are much less common regulatory mechanisms for the management of *A. rudis.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that factors that increase the potential extinction risk of *A. rudis* include the relatively high susceptibility of the genus *Acropora* to common threats, and a particularly narrow and somewhat disjointed biogeographic range with limited latitudinal extent. They stated that there are no factors that notably reduce the threat of extinction.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *A. rudis,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution includes the Maldives and parts of the northeastern Indian Ocean. This range exacerbates vulnerability to extinction over the foreseeable future because it is restricted to an area projected to experience severe climate change and localized impacts within the foreseeable future. Its depth range is three to 15 meters. On one hand, its depth range may moderate vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. On the other hand, its depth range may exacerbate vulnerability to extinction over the foreseeable future if the species occurs predominantly in the shallower portion of its depth range, since those areas will have higher irradiance and thus will be more severely affected by warming-induced bleaching. Its habitat includes lower reef crests and upper reef slopes. This moderates vulnerability to extinction over the foreseeable future because upper reef slopes are physically diverse and widespread reef areas, thus the species occurs in reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. It is rare, but has at least millions of colonies. On one hand, its depth range may moderate vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. On the other hand, its depth range may exacerbate vulnerability to extinction over the foreseeable future if the species occurs predominantly in the shallower portion of its depth range, since those areas will have higher irradiance and thus will be more severely affected by warming-induced bleaching. Its absolute abundance of at least millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time. However, its qualitative abundance is described as rare, which combined with its restricted depth distribution indicates it is likely that a high proportion of individuals will be affected by threats that are typically more severe in shallow habitats at any given point in time.

Listing Determination

In the proposed rule using the determination tool formula approach, *A. rudis* was proposed for listing as endangered because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); uncommon generalized range wide abundance (E); narrow overall distribution (based on narrow geographic distribution and shallow depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *A. rudis* from endangered to threatened. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information provided above on *A. rudis'*s spatial structure, demography, threat susceptibilities, and management indicate that it is likely to become endangered throughout its range within the foreseeable future, and thus warrants listing as threatened at this time, because:

(1) *Acropora rudis* is highly susceptible to ocean warming (ESA Factor E), and susceptible to disease (C), ocean acidification (E), trophic effects of fishing (A), predation (C), and nutrients (A, E). These threats are expected to continue and increase into the future. In addition, existing regulatory mechanisms to address global threats that contribute to extinction risk for this species are inadequate (D);

(2) *Acropora rudis'* geographic distribution is restricted to the Maldives and northeastern Indian Ocean. While coral reefs in this area are projected to experience climate change effects later than the average predictions of severe conditions, it is nevertheless projected to experience severe impacts from combined climate change and localized human impacts for coral reefs within the foreseeable future. In addition, its range is constrained to a particular geographic area such that a high proportion of the population of this species is likely to be exposed to threats that occur throughout this range over the foreseeable future; and

(3) While *A. rudis'* abundance can be locally common, overall it is considered uncommon or rare, which means it does not possess as much buffering capacity in the form of variability in response between individuals or absolute abundance that would be afforded to a more abundant or common species. Considering the limited range of this species, this level of abundance leaves the species vulnerable to becoming of such low abundance within the foreseeable future that it may be at risk from depensatory processes, environmental stochasticity, or catastrophic events, as explained in more detail in the Corals and Coral Reefs and Risk Analyses sections.

The combination of these characteristics and future projections of threats indicates that the species is likely to be in danger of extinction within the foreseeable future throughout its range and warrants listing as threatened at this time due to factors A, C, D, and E.

The available information above on *A. rudis'* spatial structure, demography, threat susceptibilities, and management also indicate that the species is not currently in danger of extinction and thus does not warrant listing as Endangered because:

(1) While *A. rudis'* distribution is restricted to the Maldives and northeastern Indian Ocean, its habitat is upper reef slopes of fringing reefs. This moderates vulnerability to extinction currently because the species occurs in common and variable habitats that are predicted, on local and regional scales, to experience highly variable thermal regimes and ocean chemistry at any given point in time, as described in more detail in the Coral Habitat and Threats Evaluation sections. There is no evidence to suggest it is so spatially fragmented that depensatory processes, environmental stochasticity, or the potential for catastrophic events currently pose a high risk to the survival of the species; and

(2) *Acropora rudis'* abundance is locally common in portions of its range, it has at least millions of colonies, and there is no evidence of depensatory processes such as reproductive failure from low density of reproductive individuals and genetic processes such as inbreeding affecting this species. Thus, its abundance indicates it is currently able to avoid high mortality from environmental stochasticity, and mortality of a high proportion of its population from catastrophic events;

The combination of these characteristics indicates that the species does not exhibit the characteristics of one that is currently in danger of extinction, as described previously in the Risk Analyses section, and thus does not warrant listing as endangered at this time.

Range-wide, a multitude of conservation efforts are already broadly employed that are likely benefiting *A. rudis.* However, considering the global scale of the most important threats to the species, and the ineffectiveness of conservation efforts at addressing the root cause of global threats (*i.e.,* GHG emissions), we do not believe that any current conservation efforts or conservation efforts planned in the future will result in affecting the species status to the point at which listing is not warranted.

Acropora speciosa

Introduction

The SRR and SIR provided the following information on *A. speciosa*'s morphology and taxonomy. Morphology was described as thick cushions or bottlebrush branches and taxonomy was described as having no taxonomic issues but being similar in appearance to *A. echinata* and *A. granulosa.*

The public comments did not provide supplemental information on morphology or taxonomy. We gathered supplemental information, including by Wallace (1999b), indicating species identification uncertainty for *A. speciosa.* However, Veron (2014) states that *A. speciosa* is distinctive so we conclude it can be identified by experts and that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *A. speciosa*'s distribution, habitat, and depth range. *Acropora speciosa* is distributed from Indonesia to French Polynesia. The species has the 51st smallest range of 114 *Acropora* species. It occurs on lower reef slopes and walls, especially those characterized by clear water and high *Acropora* diversity on steep slopes. Its depth range is 12 to 40 meters, and it has been found in mesophotic habitats.

The public comments did not provide supplemental information on *A. speciosa's* distribution. We gathered supplemental information, including Veron (2014), which reports that *A. speciosa* is confirmed in 26 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional 12. Wallace (1999b) reports its occurrence in 10 of her 29 Indo-Pacific areas, many of which are larger than Veron's ecoregions. Richards (2009) estimated its range at 20 million km^2. The species was tentatively identified in mesophotic assemblages in American Samoa: ''Shallow, plate-like reefs (more than 50 m) were comprised mostly of *Acropora* spp., possibly *A. clathrata, A. speciosa,* and *A. crateriformis*'' (Bare *et al.,* 2010). The public comments and information we gathered provided nothing additional on *A. speciosa's* habitat and depth range.

Demographic Information

The SRR and SIR provided the following information on *A. speciosa's* abundance. *Acropora speciosa* has been reported as uncommon.

The public comments did not provide supplemental information on *A. speciosa's* abundance. We gathered supplemental information, including Richards *et al.* (2013b), which concludes that this species is globally widespread, locally restricted, and locally rare, and thus in the second rarest category of *Acropora* with the predicted consequence of local extinction. Veron (2014) reports that *A. speciosa* occupied 8.3 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.60 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''common.'' Overall abundance was described as ''usually uncommon.'' Veron did not infer trends in abundance from these data.

Richards *et al.* (2008) reported that *A. speciosa* had the ninth smallest population of the 15 rare *Acropora* species they studied. Richards *et al.* (2008: Appendix 1) gave the total world population of this species as 10,942 ± 5,471 colonies, and the effective population size (*i.e.,* a mathematical estimate of the size of the breeding population) as 1,204 colonies. The calculation of the total world population of this species was flawed, since the area of 1 km^2 was given as 1,000 m^2, when it is actually 1,000,000 m^2. Thus, the correct population estimate is 1,000 times greater than stated, or a total population size of 10,942,000 colonies, and an effective population size of 1,204,000 colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *A. speciosa,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 35 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 14 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *A. speciosa* occurs in many areas affected by these broad changes, and likely has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *A. speciosa's* life history. Based on information from other *Acropora* species, *A. speciosa* is most likely a hermaphroditic spawner with lecithotrophic (yolk-sac) larvae. The public comments and information we gathered did not provide anything additional to the above-described biological information.

Susceptibility to Threats

To describe *A. speciosa's* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Acropora* of ocean warming, acidification, disease, predation, sedimentation, and nutrients. The SRR and SIR did not provide any species-specific information on the effects of these threats on *A. speciosa.* We interpreted the threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *A. speciosa's* vulnerabilities as follows: High vulnerability to ocean warming, moderate vulnerabilities to disease, ocean acidification, trophic effects of fishing, nutrients, and predation, and low vulnerabilities to sedimentation, sea-level rise, and collection and trade.

Public comments did not provide supplemental information on *A. speciosa's* threat susceptibilities. We gathered the following species-specific and genus-level supplemental information on this species' threat susceptibilities. *Acropora speciosa* has been rated as moderately or highly susceptible to bleaching and coral disease, but these ratings are not based on species-specific data (Carpenter *et al.,* 2008). No other species-specific information is available for the susceptibility of *A. speciosa* to any other threat. Based on information from other *Acropora* species provided in the genus description above, *A. speciosa* likely is highly susceptible to ocean warming, and also likely has some susceptibility to disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade. The available information does not support more precise ratings of the susceptibilities of *A. speciosa* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *A. speciosa.* Criticisms of our approach received during public comment led us to the following analysis to attempt to analyze regulatory mechanisms on a species basis. Records confirm that *A. speciosa* occurs in 26 Indo-Pacific ecoregions that encompass 18 countries' EEZs. The 18 countries are Australia, Brunei, China, Federated States of Micronesia, Fiji, France (French Pacific Island Territories), Indonesia, Malaysia, Maldives, Marshall Islands, Palau, Papua New Guinea, Philippines, Solomon Islands, Taiwan, Timor-Leste, United States (PRIAs), and Vietnam. The regulatory mechanisms relevant to *A. speciosa,* described first as the percentage of the above countries that utilize them to any degree and second, as the percentages of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (39 percent with none limited in scope), coral collection (67 percent with 28 percent limited in scope), pollution control (50 percent with 17 percent limited in scope), fishing regulations on reefs (94 percent with 17 percent limited in scope), and managing areas for protection and conservation (100 percent with six percent limited in scope). The most common regulatory mechanisms in place for *A. speciosa* are reef fishing regulations and area management for protection and conservation. Coral collection and pollution control laws are also common for the species, but 28 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection laws are less common regulatory mechanisms for the management of *A. speciosa.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that factors that increase the potential extinction risk for *A. speciosa* include the relatively high susceptibility of the genus *Acropora* to common threats. It listed factors that reduce the threat of extinction for this species including high local abundance and broad depth range.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *A. speciosa,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution includes most of the ecoregions in the Coral Triangle, the western Pacific, and the GBR, as well as parts of the Indian Ocean and central Pacific. Its geographic distribution moderates vulnerability to extinction because some areas within its range are projected to have less than average warming and acidification over the foreseeable future, including the central Pacific, so portions of the population in these areas will be less exposed to severe conditions. Its depth range of 12 to 40 moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters. However, while acidification is generally predicted to accelerate more quickly in waters that are deeper and cooler than those in which the species occurs, the lower portion of its depth range may be affected by acidification over the foreseeable future. Its habitat is lower reef slopes and walls, especially those characterized by clear water and high *Acropora* diversity on steep slopes. This specialized habitat may exacerbate vulnerability to extinction over the foreseeable future because the species is somewhat limited in its habitat, reducing the buffering capacity of habitat heterogeneity. While the geographic distribution, depth distribution, and habitat of *A. speciosa* all may moderate extinction risk over the foreseeable future, its effective population size of 1.2 million colonies substantially exacerbate extinction risk over the foreseeable future, because increasingly severe conditions are likely to affect a high proportion of its effective population at any given point in time.

Listing Determination

In the proposed rule, using the determination tool formula approach, *A. speciosa* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); uncommon generalized range wide abundance (E); moderate overall distribution (based on moderate geographic distribution and moderate depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we maintain the species' proposed listing determination as threatened. Based on the best available information provided above on *A. speciosa's* spatial structure, demography, threat susceptibilities, and management indicate that it is likely to become endangered throughout its range within the foreseeable future, and thus warrants listing as threatened at this time, because:

(1) *Acropora speciosa* is highly susceptible to ocean warming (ESA Factor E), and susceptible to disease (C), ocean acidification (E), trophic effects of fishing (A), predation (C), and nutrient enrichment (A, E). These threats are expected to continue and increase into the future. In addition, existing regulatory mechanisms to address global threats that contribute to extinction risk for this species are inadequate (D);

(2) Although *A. speciosa's* habitat includes mesophotic depths which may provide some buffering capacity against threats that are more severe in shallower reef environments such as warming, its habitat is quite specialized, which may limit buffering capacity if threats are more pronounced within the type of habitat where the species occurs within; and

(3) *Acropora speciosa's* effective population size of 1.2 million genetically distinct colonies could increase vulnerability to extinction if a high proportion of the effective population occurs within the parts of its range most affected by threats, potentially causing the species to decline to such low abundance within the foreseeable future that it may be at risk from depensatory processes, environmental stochasticity, or catastrophic events.

The combination of these characteristics and projections of future threats indicates that the species is likely to be in danger of extinction within the foreseeable future throughout its range and warrants listing as threatened at this time due to factors A, C, D, and E.

The available information above on *A. speciosa's* spatial structure, demography, threat susceptibilities, and management also indicate that the species is not currently in danger of extinction and thus does not warrant listing as Endangered because:

(1) *Acropora speciosa* lives at depths of at least 40 m, providing some buffering capacity against threat-induced mortality events that may be more severe in shallow habitats; and

(2) *Acropora speciosa's* total population size is estimated at 10.9 million colonies, approximately ten times the size of its effective population, providing a buffer against the species declining to such low abundance that depensatory processes, environmental stochasticity, or the potential for catastrophic events currently pose a high risk to the survival of the species.

The combination of these characteristics indicates that the species does not exhibit the characteristics of one that is currently in danger of extinction, as described previously in the Risk Analyses section, and thus does not warrant listing as endangered at this time.

Range-wide, a multitude of conservation efforts are already broadly employed that are likely benefiting *A. speciosa.* However, considering the global scale of the most important threats to the species, and the ineffectiveness of conservation efforts at addressing the root cause of global threats (*i.e.,* GHG emissions), we do not believe that any current conservation efforts or conservation efforts planned in the future will result in affecting the species status to the point at which listing is not warranted.

Acropora striata

Introduction

The SRR and SIR provided the following information on *A. striata'*s morphology and taxonomy. Morphology was described as dense thickets with short cylindrical branches, and taxonomy was described as having no taxonomic issues but being similar in appearance to *A. tumida, A. sekesiensis,* and *A. parahemprichii.*

The public comments and information we gathered provided supplemental information on morphology or taxonomy. One public comment stated that specimens reported as *A. striata* in Guam differ in colony form and in other characteristics from the species described as *A. striata* in Veron (2000). We gathered supplemental information, including Wallace (1999b), which provide contradictory information to Veron (2000) regarding the morphology of this species. Veron (2014) states that *A. striata* is easily confused with other *Acropora* with a bushy growth form. Although there is uncertainty, we conclude that *A. striata* can be identified by experts, and that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *A. striata'*s distribution, habitat, and depth range. *Acropora striata* is distributed from Indonesia to French Polynesia, and possibly to Japan. The species has the 54th largest range of 114 *Acropora* species. Its predominant habitat is upper reef slopes, and it occurs in other shallow habitats such as mid-slopes and lagoons, and its depth range is at 10 to 25 m.

The public comments did not provide any new or supplemental information on *A. striata'*s distribution. We gathered supplemental information, including Veron (2014), which reports that *A. striata* is confirmed in 36 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional 17. Wallace (1999b) reports its occurrence in 16 of her 29 Indo-Pacific areas, many of which are larger than Veron's ecoregions. Richards (2009) estimated its range at 50 million km^2. The public comments and information we gathered provided nothing additional on *A. striata'*s habitat and depth range.

Demographic Information

The SRR and SIR provided the following information on *A. striata'*s abundance. *Acropora striata* has rare overall abundance but may be locally dominant in some areas in Japan.

The public comments did not provide any new or supplemental information on *A. striata'*s abundance. We gathered supplemental information, including Richards *et al.* (2013b), which concludes that this species is globally widespread, locally widespread, and locally rare. Veron (2014) reports that *A. striata* occupied 3.2 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.38 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''uncommon.'' Overall abundance was described as ''may be locally dominant in Japan, uncommon elsewhere.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least tens of millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *A. striata,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 36 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 14 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *A. striata* occurs in many areas affected by these broad changes, and that it has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years but a precise quantification is not possible due to the limited amount of species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *A. striata'*s life history. *Acropora striata* is a hermaphroditic spawner, with larval development and settlement taking five to 10 days, and larvae remaining competent for 31 days. The public comments and information we gathered did not provide anything additional to the above-described biological information.

Susceptibility to Threats

To describe *A. striata'*s threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Acropora* of ocean warming, acidification, disease, predation, sedimentation, nutrients, and collection and trade. The SRR and SIR did not provide any species-specific information on the effects of these threats on *A. striata.* We interpreted the threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *A. striata'*s vulnerabilities as follows: High vulnerability to ocean warming, moderate vulnerabilities to disease, ocean acidification, trophic effects of fishing, nutrients, and predation, and low vulnerabilities to sedimentation, sea-level rise, and collection and trade.

Public comments did not provide any new or supplemental information on *A. striata'*s threat susceptibilities. We gathered the following species-specific and genus-level supplemental information on this species' threat susceptibilities. *Acropora striata* has been rated as moderately or highly susceptible to bleaching and disease, but these ratings are not based on species-specific data (Carpenter *et al.,* 2008). There is no species-specific information for the susceptibility of *A. striata* to any threat. Based on information from other *Acropora* species provided in the genus description above, *A. striata* is likely highly susceptible to ocean warming, and also likely has some susceptibility to disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade. The available information does not support more precise ratings of the susceptibilities of *A. striata* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *A. striata.* Criticisms of our approach received during public comment led us to the following analysis to attempt to analyze regulatory mechanisms on a species basis. Records confirm that *A. striata* occurs in 36 Indo-Pacific ecoregions that encompass 38 countries' EEZs. The 38 countries are Australia, China, Comoros Islands, Egypt, Federated States of Micronesia, Fiji, France (French Pacific Island Territories), Indonesia, Israel, Japan, Jordan, Kenya, Kiribati, Madagascar, Malaysia, Maldives, Marshall Islands, Mauritius, Myanmar, Nauru, New Zealand (Cook Islands, Tokelau), Niue, Palau, Papua New Guinea, Philippines, Samoa, Saudi Arabia, Seychelles, Solomon Islands, Sudan, Taiwan, Tanzania, Thailand, Timor-Leste, Tonga, Tuvalu, United States (CNMI, Guam, American Samoa, PRIAs), and Vietnam. The regulatory mechanisms relevant to *A. striata,* described first as the percentage of the above countries that utilize them to any degree and second, as the percentages of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (26 percent with 3 percent limited in scope), coral collection (58 percent with 26 percent limited in scope), pollution control (45 percent with eight percent limited in scope), fishing regulations on reefs (89 percent with 21 percent limited in scope), and managing areas for protection and conservation (95 percent with eight percent limited in scope). The most common regulatory mechanisms in place for *A. striata* are reef fishing regulations and area management for protection and conservation. Coral collection and pollution control laws are also somewhat common for the species, but 26 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection laws are much less prominent regulatory mechanisms for the management of *A. striata.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that factors that increase the potential extinction risk for *A. striata* include its locally rare abundance. Factors that reduce the potential extinction risk *A. striata* include its relatively broad global distribution. Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *A. striata,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution includes most of the coral reef ecoregions in the Indian Ocean and western and central Pacific Ocean. Its geographic distribution moderates vulnerability to extinction because some areas within its range are projected to have less than average warming and acidification over the foreseeable future, including the western Indian Ocean, the central Pacific, and other areas, so portions of the population in these areas will be less exposed to severe conditions. Its depth range is from ten to 25 meters. This moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower temperatures than surface waters due to local and micro-habitat variability in environmental conditions, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Its habitat includes upper reef slopes, mid-slopes and lagoons. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Its absolute abundance of at least tens of millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule using the determination tool formula approach, *A. striata* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); uncommon generalized range wide abundance (E); moderate overall distribution (based on moderate geographic distribution and moderate depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *A. striata* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *A. striata's* spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to be likely to become endangered throughout its range within the foreseeable future, and thus it is not warranted for listing at this time, because:

(1) *Acropora striata*'s distribution across most of the Pacific Ocean is spread over a very large area. While some areas within its range are projected to be affected by warming and acidification, other areas are projected to have less than average warming and acidification, including the western Indian Ocean, the central Pacific, and other areas. This distribution and the heterogeneous habitats it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to

occur uniformly throughout the species range within the foreseeable future);

(2) *Acropora striata's* total absolute abundance is at least tens of millions of colonies, providing buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response; and

(3) It is a broadcast spawner and fast grower, enhancing recovery potential from mortality events as described in the Corals and Coral Reefs section above.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future if global threats continue and increase in severity and the species exposure to threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *A. striata* is not warranted for listing at this time under any of the listing factors.

Acropora tenella

Introduction

The SRR and SIR provided the following information on *A. tenella's* morphology and taxonomy. Morphology was described as horizontal, platy colonies with flattened branches, and taxonomy was described as having no taxonomic issues but being similar in appearance to *Acropora pichoni.*

The public comments did not provide supplemental information on morphology or taxonomy. We gathered supplemental information, including Veron (2014), which states that *A. tenella* is readily confused with other flattened, finely branched *Acropora.* However, the species is recognized as valid and distinct by experts (Veron, 2000; Wallace, 1999a), so we conclude it can be identified by experts and that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *A. tenella's* distribution, habitat, and depth range. *Acropora tenella* is distributed from Japan to Indonesia to New Guinea and the Marshall Islands. The species has the 43rd smallest range of 114 *Acropora* species. Its habitat is lower reef slopes and shelves between 40 and 70 meters, and it apparently is specialized for calm, deep conditions.

The public comments did not provide supplemental information on *A. tenella's* distribution. We gathered supplemental information, including Veron (2014), which reports that *A. tenella* is confirmed in 18 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional six. Wallace (1999b) reports its occurrence in six of her 29 Indo-Pacific areas, many of which are larger than Veron's ecoregions. Richards (2009) estimated its range at 15 million km^2, which was the 43rd smallest range of 114 *Acropora* species examined. *Acropora tenella* was one of three species that dominated mesophotic reef habitat in Okinawa between 35 and 47 m depth (Sinniger *et al.,* 2013).

Demographic Information

The SRR and SIR provided the following information on *A. tenella's* abundance. *Acropora tenella* has been reported as locally common in some locations.

The public comments did not provide supplemental information on *A. tenella's* abundance. We gathered supplemental information, including Richards (2013b), which concludes that this species is globally widespread, locally restricted, and locally rare, and thus in the second rarest category of *Acropora* with the predicted consequence of local extinction. Veron (2014) reports that *A. tenella* occupied 0.4 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.25 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''rare,'' and its overall abundance was also described as ''rare.'' Veron did not infer trends in abundance from these data.

Richards *et al.* (2008) reported that *A. tenella* had the seventh lowest population of the 15 rare *Acropora* species they studied. Richards *et al.* (2008) gave the total world population of this species as about 5207 +/-1606 colonies, and the effective population size (*i.e.,* a mathematical estimate of the size of the breeding population) as about 573 colonies (Richards *et al.,* 2008). The calculation of the total world population of this species was flawed, since the area of 1 km^2 was given as 1,000 m^2 (Richards *et al.,* 2008: Appendix 1), when it is actually 1,000,000 m^2. Thus, the correct population estimate is 1,000 times greater than stated, or a total population size of 5,207,000 colonies, and an effective population size of 573,000 colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *A. tenella,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 39 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 15 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *A. tenella* occurs in many areas affected by these broad changes, and that it has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *A. tenella's* life history. Based on information from other *Acropora* species, *A. tenella* is most likely a hermaphroditic spawner with lecithotrophic (yolk-sac) larvae. The public comments and information we gathered did not provide anything additional to the above-described biological information.

Susceptibility to Threats

To describe *A. tenella's* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Acropora* of ocean warming, acidification, disease, predation, sedimentation, nutrients, and collection and trade. The SRR and SIR did not provide any species-specific information on the effects of these threats on *A. tenella.* We interpreted the threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *A. tenella's* vulnerabilities as follows: High vulnerability to ocean warming, moderate vulnerabilities to disease, ocean acidification, trophic effects of fishing, nutrients, and predation, and low vulnerabilities to sedimentation, sea-level rise, and collection and trade.

Public comments did not provide supplemental information on *A. tenella's* threat susceptibilities. We gathered the following species-specific and genus-level supplemental information on this species' threat susceptibilities. *Acropora tenella* has been rated as moderately or highly susceptible to bleaching and disease, but these ratings are not based on species-specific data (Carpenter *et al.,* 2008). No other species-specific information is available for the susceptibility of *A. tenella* to any other threat. Based on information from other *Acropora* species provided in the genus description above, *A. tenella* is likely highly susceptible to ocean warming, and also likely has some susceptibilities to disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade. The available information does not support more precise ratings of the susceptibilities of *A. tenella* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *A. tenella.* Criticisms of our approach received during public comment led us to the following analysis to attempt to analyze regulatory mechanisms on a species basis. Records confirm that *A. tenella* occurs in 18 Indo-Pacific ecoregions that encompass 12 countries' EEZs. The 12 countries are Brunei, China, Federated States of Micronesia, Indonesia, Japan, Marshall Islands, Palau, Papua New Guinea, Philippines, Taiwan, United States (PRIAs), and Vietnam. The regulatory mechanisms relevant to *A. tenella,* described first as the percentage of the above countries that utilize them to any degree and second, as the percentages of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (25 percent with none limited in scope), coral collection (58 percent with 33 percent limited in scope), pollution control (33 percent with 17 percent limited in scope), fishing regulations on reefs (92 percent with 17 percent limited in scope), and managing areas for protection and conservation (100 percent with eight percent limited in scope). The most common regulatory mechanisms in place for *A. tenella* are reef fishing regulations and area management for protection and conservation. Coral collection laws are also somewhat common for the species, but 33 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection and pollution control laws are much less prominent regulatory mechanisms for the management of *A. tenella.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that one factor that reduces the potential extinction risk for this species is its deep depth range, which reduces exposure to surface-based threats. Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *A. tenella,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution is limited to the Coral Triangle and parts of the western equatorial Pacific Ocean. Despite the large number of islands and environments that are included in the species' range, this range exacerbates vulnerability to extinction over the foreseeable future because it is mostly limited to an area projected to have the most rapid and severe impacts from climate change and localized human impacts for coral reefs over the 21st century. Its mesophotic depth range of 40 to 70 meters moderates vulnerability to extinction over the foreseeable future because of lower irradiance, sharply reducing warming-induced bleaching. In addition, other threats usually occur at lower levels at such depths, such as sedimentation resulting from land-based sources of pollution. However, unlike the other *Acropora* species in this final rule, *A. tenella's* mesophotic habitat may often have substantially cooler temperatures than the shallower photic zone, and thus more likely to be affected by increasing acidification over the foreseeable future. Its habitat consists of lower reef slopes and shelves spanning 40 to 70 meters of depth, a much different habitat than the surface and shallow reef habitats occupied by the other *Acropora* species in this final rule. Its habitat may moderate vulnerability to extinction over the foreseeable future because of variable conditions at any given point in time. However, its habitat may exacerbate extinction risk over the foreseeable future because increasing acidification is expected to vary less spatially at these depths on coral reefs than in shallower areas on coral reefs. Its effective population size of approximately half a million colonies, combined with the location of its range, exacerbates vulnerability to extinction because increasingly severe conditions within the limited species range are likely to affect a high proportion of its effective population at any given point in time.

Listing Determination

In the proposed rule, using the determination tool formula approach, *A. tenella* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); uncommon generalized range wide abundance (E); wide overall distribution (based on moderate geographic distribution and wide depth distribution, E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we maintain the species' proposed listing determination as threatened. Based on the best available information provided above on *A. tenella's* spatial structure, demography, threat susceptibilities, and management indicate that it is likely to become endangered throughout its range within the foreseeable future, and thus warrants listing as threatened at this time, because:

(1) *Acropora tenella* is highly susceptible to ocean warming (ESA Factor E), and susceptible to disease (C), ocean acidification (E), trophic effects of fishing (A), predation (C), and nutrient enrichment (A, E). These threats are expected to continue and increase into the future. Although its mesophotic depth distribution may provide some buffering capacity against threats that are more severe in shallower reef environments, it may not provide buffering capacity against other threats for which depth is a less influential factor, like acidification and disease. In addition, existing regulatory mechanisms to address global threats that contribute to extinction risk for this species are inadequate (D);

(2) *Acropora tenella's* distribution is constrained mostly within the Coral Triangle and western equatorial Pacific, which is projected to have the most rapid and severe impacts from climate change and localized human impacts for coral reefs over the 21st century, as described in the Threats Evaluation. Multiple ocean warming events have already occurred within the western equatorial Pacific that suggest future ocean warming events may be more severe than average in this part of the world. Although the mesophotic range of the species reduces the impacts of warming, disease, and localized human impacts, the species occurs at mesophotic depths where the effects of acidification are expected to be greater over the foreseeable future than in shallower areas; and

(3) *Acropora tenella's* effective population size of 0.5 million colonies could increase vulnerability to extinction if a high proportion of the effective population occurs within the parts of its range most affected by threats, potentially causing the species to decline to such low abundance within the foreseeable future that it may be at risk from depensatory processes, environmental stochasticity, or catastrophic events.

The combination of these characteristics and projections of future threats indicates that the species is likely to be in danger of extinction within the foreseeable future throughout its range and warrants listing as threatened at this time due to factors A, C, D, and E.

The available information above on *A. tenella's* spatial structure, demography, threat susceptibilities, and management also indicate that the species is not currently in danger of extinction and thus does not warrant listing as Endangered because:

(1) While *Acropora tenella's* range is constrained to mesophotic habitat in the Coral Triangle and western Pacific, its habitat heterogeneity moderates vulnerability to extinction currently because of variable conditions at any given point in time. There is no evidence to suggest that the species is not so spatially fragmented or geographically constrained that depensatory processes, environmental stochasticity, or the potential for catastrophic events currently pose a high risk to the survival of the species; and

(2) *Acropora tenella's* mesophotic depth distribution provides some buffering capacity against threats that are more severe in shallower environments such as nutrient enrichment, sedimentation, and ocean warming;

(3) *Acropora tenella's* total population size is estimated at five million colonies, approximately ten times the size of its effective population, providing a buffer against the species declining to such low abundance that depensatory processes, environmental stochasticity, or the potential for catastrophic events currently pose a high risk to the survival of the species.

The combination of these characteristics indicates that the species does not exhibit the characteristics of one that is currently in danger of extinction, as described previously in the Risk Analyses section, and thus does not warrant listing as endangered at this time. Range-wide, a multitude of conservation efforts are already broadly employed that are likely benefiting *A. tenella.* However, considering the global scale of the most important threats to the species, and the ineffectiveness of conservation efforts at addressing the root cause of global threats (*i.e.,* GHG emissions), we do not believe that any current conservation efforts or conservation efforts planned in the future will result in affecting the species status to the point at which listing is not warranted.

Acropora vaughani

Introduction

The SRR and SIR provided the following information on *A. vaughani's* morphology and taxonomy. Morphology was described as open-branched, bushy, arborescent colonies, and the taxonomy was described as having no taxonomic issues but being similar to *A. horrida, A. tortuosa, A. rufus* and *A. austera.*

The public comments did not provide supplemental information on morphology or taxonomy. We gathered supplemental information, including Veron (2014), which indicates that *A. vaughani* is distinctive, thus we conclude it can be identified by experts, and that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *A. vaughani's* distribution, habitat, and depth range. *Acropora vaughani* is distributed from the Red Sea to Fiji. The species has the 34th largest range of 114 *Acropora* species. It is found in numerous reef slope and back-reef habitats with turbid water, including but not limited to, upper reef slopes, mid-slope terraces, lagoons, and adjacent habitats, and the depth range is from low tide to 20 or 30 meters.

The public comments did not provide supplemental information on *A. vaughani's* distribution. We gathered supplemental information, including Veron (2014), who reports that *A. vaughani* is confirmed in 59 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional 13. Wallace (1999b) reports its occurrence in 24 of her 29 Indo-Pacific areas, many of which are larger than Veron's ecoregions. Richards (2009) calculated the geographic range of *A. vaughani* at over 80 million km^2. The public comments and information we gathered provided nothing additional on *A. vaughani's* habitat and depth range.

Demographic Information

The SRR and SIR provided the following information on *A. vaughani's* abundance. *Acropora vaughani* is reported to be uncommon. The public comments did not provide supplemental information on *A. vaughani's* abundance. We gathered supplemental information, including Richards *et al.* (2013b), which conclude from their data that this species is globally widespread, locally restricted, and locally rare, and thus in the second rarest category of *Acropora* with the predicted consequence of local extinction. Veron (2014) reports that *A. vaughani* occupied 7.5 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.69 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''common.'' Overall abundance was described as ''uncommon.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least tens of millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *A. vaughani,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 35 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 14 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *A. vaughani* occurs in many areas affected by these broad changes, and that it has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *A. vaughani'*s life history. *Acropora vaughani* is a hermaphroditic spawner with lecithotrophic (yolk-sac) larvae. It is one of several *Acropora* that achieve reproductive isolation by spawning earlier in the evening than other species. The public comments and information we gathered did not provide anything additional to the above-described biological information.

Susceptibility to Threats

To describe *A. vaughani'*s threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Acropora* of ocean warming, acidification, disease, predation, sedimentation, nutrients, and collection and trade. The SRR and SIR also provided species-specific information reporting that *Acropora* species including *A. vaughani* suffered greater than 90 percent mortality during the 1996 and 1998 bleaching events in the southeastern Arabian Gulf, but that portions of some *A. vaughani* survived, contributing to potentially accelerated recovery. The SRR and SIR did not provide any other species-specific information on the effects of these threats on *A. vaughani.* We interpreted the threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *A. vaughani'*s vulnerabilities as follows: High vulnerability to ocean warming, moderate vulnerabilities to disease, ocean acidification, trophic effects of fishing, nutrients, and predation, and low vulnerabilities to sedimentation, sea-level rise, and collection and trade.

Public comments provided some supplemental information on *A. vaughani'*s threat susceptibilities. One comment stated that *A. vaughani* is more susceptible to predation than indicated in the proposed rule because of the overlap in the depth ranges of this species with crown of thorns starfish. We gathered the following species-specific and genus-level supplemental information on this species' threat susceptibilities. *Acropora vaughani* has been rated as moderately or highly susceptible to bleaching, but this rating is not based on species-specific data (Carpenter *et al.,* 2008). All *Acropora* species in the southeastern Arabian Gulf, including *A. vaughani,* suffered nearly complete mortality during the 1996 bleaching event (Riegl, 1999), but some *A. vaughani* colonies survived the 1998 mass bleaching event (Riegl and Piller, 2001). No other species-specific information is available for the susceptibility of *A. vaughani* to any other threat. For the other threats, based on information from other *Acropora* species provided in the genus description above, *A. vaughani* may be susceptible to the effects of coral disease, ocean acidification, predation, sedimentation, nutrient enrichment, trophic effects of fishing, sea-level rise, and collection and trade. Thus, based on the available species-specific and genus information summarized above, *A. vaughani* is likely highly susceptible to ocean warming, and also likely has some susceptibilities to disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade. The available information does not support more precise ratings of the susceptibilities of *A. vaughani* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *A. vaughani.* Criticisms of our approach received during public comment led us to the following analysis to attempt to analyze regulatory mechanisms on a species basis. Records confirm that *A. vaughani* occurs in 59 Indo-Pacific ecoregions that encompass 43 countries' EEZs. The 43 countries are Australia, Cambodia, China, Comoros Islands, Djibouti, Egypt, Eritrea, Federated States of Micronesia, Fiji, France (French Pacific Island Territories), India (Andaman and Nicobar Islands), Indonesia, Israel, Japan, Jordan, Kenya, Kiribati, Malaysia, Maldives, Marshall Islands, Mauritius, Myanmar, New Zealand (Tokelau), Niue, Palau, Papua New Guinea, Philippines, Samoa, Saudi Arabia, Seychelles, Solomon Islands, Sri Lanka, Sudan, Taiwan, Tanzania, Thailand, Timor-Leste, Tonga, Tuvalu, United Kingdom (British Indian Ocean Territory), United States (CNMI, Guam, American Samoa, PRIAs), Vietnam, and Yemen. The regulatory mechanisms relevant to *A. vaughani,* described first as the percentage of the above countries that utilize them to any degree and second, as the percentages of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (28 percent with five percent limited in scope), coral collection (58 percent with 26 percent limited in scope), pollution control (44 percent with seven percent limited in scope), fishing regulations on reefs (91 percent with 19 percent limited in scope), and managing areas for protection and conservation (95 percent with nine percent limited in scope). The most common regulatory mechanisms in place for *A. vaughani* are reef fishing regulations and area management for protection and conservation. Coral collection and pollution control laws are also somewhat common for the species, but 26 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection laws are much less prominent regulatory mechanisms for the management of *A. vaughani.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that factors that reduce the potential extinction risk for this species include the broad global distribution, the wide range of habitats occupied by *A. vaughani,* its use in restoration and replantation, and its known recovery after bleaching events via tissue remnants from within the reef framework.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *A. vaughani,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution includes about half of the coral reef ecoregions in the Indian Ocean and western and central Pacific Ocean. Its geographic distribution moderates vulnerability to extinction because some areas within its range are projected to have less than average warming and acidification over the foreseeable future, including the western Indian Ocean, the central Pacific, and other areas, so portions of the population in these areas will be less exposed to severe conditions. Its depth range is from low tide to 20 or 30 meters. This moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Its habitat includes turbid upper reef slopes, mid-slope terraces, lagoons, and adjacent habitats, and the depth range is from low tide to 20 or 30 meters. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Its absolute abundance of at least tens of millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule, using the determination tool formula approach, *A. vaughani* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); uncommon generalized range wide abundance (E); wide overall distribution (based on wide geographic distribution and moderate depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *A. vaughani* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *A. vaughani*'s spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to be likely to become endangered throughout its range within the foreseeable future, and thus it is not warranted for listing at this time, because:

(1) *Acropora vaughani*'s distribution is spread over a very large area. While some areas within its range are projected to be affected by warming and acidification, other areas are projected to have less than average warming and acidification, including the western Indian Ocean, the central Pacific, and other areas. This distribution and the heterogeneous habitats it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future;

(2) *Acropora vaughani's* total abundance is at least tens of millions of colonies, providing buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response; and

(3) It is a broadcast spawner and fast grower, enhancing recovery potential from mortality events as described in the Corals and Coral Reefs section above.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future if global threats continue and worsen in severity and the species' exposure to the threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *A. vaughani* is not warranted for listing at this time under any of the listing factors.

Acropora verweyi

Introduction

The SRR and SIR provided the following information on *A. verweyi*'s morphology and taxonomy. Morphology was described as clumps with noticeably rounded or bulb-like corallites, and taxonomy was described as having no taxonomic issues.

The public comments did not provide any new or supplemental information on morphology or taxonomy. We gathered supplemental information, including Veron (2014) which states that *A. verweyi* is distinctive, thus we conclude it can be identified by experts and that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *A. verweyi's* distribution, habitat, and depth range. *Acropora verweyi* is distributed from the western Indian Ocean to the central Pacific. The species has the 16th largest range of 114 *Acropora* species. Its habitat is predominantly lower reef crests, upper reef slopes and other high energy habitats and its depth range is to at least 15 m.

The public comments did not provide any new or supplemental information on *A. verweyi's* distribution. We gathered supplemental information, including Veron (2014), which reports that *A. verweyi* is confirmed in 63 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional 17. Wallace (1999b) reports it from 17 of her 29 Indo-Pacific areas, many of which are larger than Veron's ecoregions. Richards (2009) calculated the geographic range of *A. verweyi* at over 100 million km^2. *Acropora verweyi* occurs in many different habitats, including fringing reefs with turbid water (Veron, 2000), and shallow reef top and reef edge habitats (Wallace, 1999b). *Acropora verweyi* occurs on upper reef slopes, especially those exposed to wave action or currents (Veron, 2014). Carpenter *et al.* (2008) give the depth range for *A. verweyi* as 2 to 15 meters.

Demographic Information

The SRR and SIR provided the following information on *A. verweyi's* abundance. *Acropora verweyi* is generally common, but can be locally abundant, especially in the western Indian Ocean. The public comments did not provide any new or supplemental information on *A. verweyi's* abundance. We gathered supplemental information, including Richards *et al.* (2013b), which concludes that the species is globally widespread, locally widespread, and locally rare. Veron (2014) reports that *A. verweyi* occupied 4.7 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.59 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''uncommon.'' Overall abundance was described as ''occasionally common in the western Indian Ocean.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least tens of millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *A. verweyi,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 37 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 15 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *A. verweyi* occurs in many areas affected by these broad changes, and that it has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible.

Other Biological Information

The SRR and SIR provided the following information on *A. verweyi's* life history. *Acropora verweyi* is a hermaphroditic spawner that is a participant in mass broadcast spawning in some localities. The public comments and information we gathered did not provide anything additional to the above-described biological information based on the limited species-specific information.

Susceptibility to Threats

To describe *A. verweyi's* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Acropora* of ocean warming, acidification, disease, predation, sedimentation, nutrients, and collection and trade. The SRR and SIR did not provide any other species-specific information on the effects of these threats on *A. verweyi.* We interpreted the threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *A. verweyi's* vulnerabilities as follows: High vulnerability to ocean warming, moderate vulnerabilities to disease, ocean acidification, trophic effects of fishing, nutrients, and predation, and low vulnerabilities to sedimentation, sea-level rise, and collection and trade.

Public comments did not provide any new or supplemental information on *A. verweyi's* threat susceptibilities. We gathered the following species-specific and genus-level supplemental information on this species' threat susceptibilities. *Acropora verweyi* has been rated as moderately or highly susceptible to bleaching and disease, but these ratings are not based on species-specific data (Carpenter *et al.,* 2008). *Acropora verweyi* tolerates high temperatures in back-reef pools on Ofu, American Samoa where corals are more tolerant than elsewhere due to repeated brief exposure to high temperatures (Craig *et al.,* 2001), although *A. verweyi* is not abundant and acroporids still bleach some in these pools (Fenner and Heron, 2008). *Acropora verweyi* was relatively resistant to bleaching in Moorea during the 1991 warming event (Gleason, 1993). Reduced carbonate concentrations decrease calcification rates in *A. verweyi* (Marubini *et al.,* 2003). While the overall magnitude of calcification was similar to the other coral species tested, *A. verweyi* showed reductions in mineral density that other species did not, potentially making it more susceptible to bioerosion or breaking from wave action (Marubini *et al.,* 2003). No other species-specific information is available for the susceptibility of *A. verweyi* to any other threat. For the other threats, based on information from other *Acropora* species provided in the genus description above, *A. verweyi* may be susceptible to the effects of disease, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade. Thus, based on the available species-specific and genus information summarized above, *A. verweyi* is likely to have some susceptibility to ocean warming, disease, acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade. The available information does not support more precise ratings of the susceptibilities of *A. verweyi* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *A. verweyi.* Criticisms of our approach received during public comment led us to the following analysis to attempt to analyze regulatory mechanisms on a species basis. Records confirm that *A. verweyi* occurs in 63 Indo-Pacific ecoregions that encompass 41 countries' EEZs. The 41 countries are Australia, Cambodia, China, Comoros Islands, Egypt, Federated States of Micronesia, Fiji, France (French Pacific Island Territories), Indonesia, Israel, Japan, Jordan, Kenya, Kiribati, Madagascar, Malaysia, Maldives, Marshall Islands, Mauritius, Myanmar, Nauru, New Zealand (Cook Islands, Tokelau), Niue, Palau, Papua New Guinea, Philippines, Samoa, Saudi Arabia, Seychelles, Solomon Islands, Sri Lanka, Sudan, Taiwan, Tanzania, Thailand, Tonga, Tuvalu, United Kingdom (Pitcairn Islands), United States (CNMI, Guam, American Samoa, PRIAs), Vanuatu, and Vietnam. The regulatory mechanisms relevant to *A. verweyi,* described first as the percentage of the above countries that utilize them to any degree and second, as the percentages of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (27 percent with seven percent limited in scope), coral collection (56 percent with 29 percent limited in scope), pollution control (44 percent with seven percent limited in scope), fishing regulations on reefs (90 percent with 22 percent limited in scope), and managing areas for protection and conservation (95 percent with 10 percent limited in scope). The most common regulatory mechanisms in place for *A. verweyi* are reef fishing regulations and area management for protection and conservation. Coral collection and pollution control laws are also somewhat common for the species, but 29 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection laws are much less prominent regulatory mechanisms for the management of *A. verweyi.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that the factors that increase the potential extinction risk for *A. verweyi* include the relatively high susceptibility of the genus *Acropora* to common threats. It listed factors that reduce the potential extinction risk for *A. verweyi* including its very wide latitudinal and longitudinal geographic range, observations of occasional resistance to thermal stress in shallow backreef pools, and its relatively common abundance.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *A. verweyi,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution includes most of the coral reef ecoregions in the Indian Ocean and western and central Pacific Ocean. Its geographic distribution moderates vulnerability to extinction because some areas within its range are projected to have less than average warming and acidification over the foreseeable future, including the western Indian Ocean, the central Pacific, and other areas, so portions of the population in these areas will be less exposed to severe conditions. Its depth range is from low tide to at least 15 meters. On one hand, its depth range may moderate vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. On the other hand, its depth range may exacerbate vulnerability to extinction over the foreseeable future if the species occurs predominantly in the shallower portion of its depth range, since those areas will have higher irradiance and thus be more severely affected by warming-induced bleaching. Its habitat includes lower reef crests, upper reef slopes and other high energy habitats. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. In addition, areas with good circulation experience high levels of mixing which can dilute adverse environmental conditions. Its absolute abundance of at least tens to hundreds of millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule using the determination tool formula approach, *A. verweyi* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); common generalized range wide abundance (E); moderate overall distribution (based on wide geographic distribution and shallow depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *A. verweyi* from threatened to not warranted. No supplemental information or public comments changed our assessment of the type and severity of threats affecting *A. verweyi.* Rather, we made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *A. verweyi's* spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to be likely to become endangered throughout its range within the foreseeable future, and thus it is not warranted for listing at this time, because:

(1) *Acropora verweyi*'s distribution across the Indian Ocean and most of the Pacific Ocean is spread over a very large area. While some areas within its range are projected to be affected by warming and acidification, other areas are projected to have less than average warming and acidification, including the western Indian Ocean, the central

Pacific, and other areas. This distribution and the heterogeneous habitats it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future;

(2) *Acropora verweyi's* absolute abundance is at least tens of millions of colonies, providing buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response; and

(3) It is a broadcast spawner and fast grower, enhancing recovery potential from mortality events as described in the Corals and Coral Reefs section above.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future if global threats continue and increase in severity and the species exposure to threats increases throughout its range. Despite its current distribution, *A. verweyi* is characterized as uncommon overall, thus its abundance may not provide much buffering capacity in terms of overall numbers. In addition, *A. verweyi* showed reductions in mineral density in response to reduced carbonate concentrations, potentially making it more susceptible to bioerosion or breaking from wave action as ocean acidification increases. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of its range to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *A. verweyi* is not warranted for listing at this time under any of the listing factors.

Genus Anacropora

Genus Introduction

The family Acroporidae includes five genera, *Acropora, Montipora, Astreopora, Isopora,* and *Anacropora. Anacropora* contains seven species, all occurring in the Indo-Pacific. Like most *Acropora* species, colonies of *Anacropora* species are branching. Unlike *Acropora,* there is no corallite on the tip of the branches of *Anacropora* colonies, a diagnostic characteristic of *Acropora* (Veron, 2000). *Anacropora* is morphologically like branching *Montipora* without an encrusting base (Veron and Wallace, 1985). The SRR and SIR provided the following genus-level introductory information on *Anacropora.* Morphologic taxonomy has been unable to resolve whether *Anacropora* are recently derived from *Montipora* or from *Acropora,* but genetic evidence supports the former view.

Genus Susceptibility to Threats

The SRR and SIR provided the following information on the threat susceptibilities of the genus *Anacropora.* The bleaching susceptibility in the genus *Anacropora* is not well known. In the 1998 bleaching event in Palau, *Anacropora* colonies (not identified to species) were moderately affected relative to other coral genera, with total mortality of some *Anacropora* colonies in some limited areas, while those in other areas were unaffected. This was a major bleaching event, with 48 percent bleaching overall (all coral species combined), and bleaching and mortality of different genera and species ranging from zero to nearly 100 percent (Bruno *et al.,* 2001). With regard to predation, *A. puertogalerae* have been reported to be only preyed on by wrasses in proportion to its availability (Cole *et al.,* 2010). With regard to sedimentation and nutrients, some *Anacropora* species appear resistant to both these threats while others appear susceptible (Mohammed and Mohammed, 2005). Collection and trade in the genus *Anacropora* has been reported to be negligible, with only 14 pieces reported in export over the last decade (CITES, 2010).

The public comments did not provide any new or supplemental information on the threat susceptibilities of the genus *Anacropora.* We gathered supplemental information that provided the following. One study reported that disease was not found on *Anacropora* at a site in Indonesia, while the taxon with the highest prevalence out of 25 taxa had 8 percent prevalence of disease (Haapkyla *et al.,* 2007).

Genus Conclusion

Based on the information from the SRR, SIR, public comments, and information we gathered, we can make the following inferences about the susceptibilities of an unstudied *Anacropora* species to ocean warming, disease, acidification, sedimentation, nutrients, trophic effects of fishing, sea-level rise, predation, and collection and trade. The SRR rated ocean warming and disease as ''high'' importance, and ocean acidification as ''medium-high'' importance, to corals. These were rated as the three most important threats to reef-building corals overall. The one available study on the effects of ocean warming on *Anacropora* reported variable thermal-induced bleaching within the genus (Bruno *et al.,* 2001). While there is no other genus-level or species-specific information on the susceptibilities of *Anacropora* species to ocean warming, the SRR rated it as ''high'' importance to corals. Thus, we conclude that an unstudied *Anacropora* species has some susceptibility to ocean warming. Similarly for ocean acidification, while there is no genus-level or species-specific information on the susceptibilities of *Anacropora* species to ocean acidification, the SRR rated it as ''medium-high'' importance to corals. Thus, we conclude that an unstudied *Anacropora* species has some susceptibility to ocean acidification. The one available study on the effects of disease on *Anacropora* reported no disease on *Anacropora* colonies (Haapkyla *et al.,* 2007). However, this single study is inadequate to imply susceptibility level for all *Anacropora* species, thus we conclude that *Anacropora* has some susceptibility to disease.

The SRR rated the trophic effects of fishing as ''medium'' importance, the fourth most important threat to corals overall. This threat was not addressed at the genus or species level in the SRR or SIR, because it is an ecosystem-level process. That is, removal of herbivorous fish from coral reef systems by fishing alters trophic interactions by reducing herbivory on algae, thereby providing a competitive advantage for space to algae over coral. Thus, the SRR did not discuss this threat in terms of coral taxa, as its effects are difficult to distinguish between coral genera and species. Therefore, an unstudied *Anacropora* species is likely to have some susceptibility to the trophic effects of fishing.

The SRR rated sedimentation, nutrients, and sea-level rise as ''low-medium'' importance to corals overall. The one available study on the effects of sedimentation and nutrients (Mohammed and Mohammed, 2005) on *Anacropora* species suggest either intermediate or variable susceptibilities. Thus we conclude that an unstudied *Anacropora* species has some susceptibility to sedimentation and nutrients. Sea-level rise was not addressed at the genus or species level in the SRR or SIR. Increasing sea levels may increase land-based sources of pollution due to inundation, resulting in changes to coral community structure, thus an unstudied *Anacropora* species is likely to have some susceptibility to sea-level rise. The SRR rated predation and ornamental trade (referred to in the proposed rule as Collection and Trade) as ''low'' importance to corals overall. The one available study on the effects of predation (Cole *et al.,* 2010) on *Anacropora* species suggest either intermediate or variable susceptibility, thus we conclude that an unstudied *Anacropora* species has some susceptibility to predation. Because the available information suggests that *Anacropora* species are lightly collected and traded, an unstudied *Anacropora* species is likely to have low susceptibility to collection and trade.

In conclusion, an unstudied *Anacropora* species is likely to have some susceptibility to ocean warming, disease, ocean acidification, sedimentation, nutrients, trophic effects of fishing, sea-level rise, predation, and low susceptibility to collection and trade.

Anacropora puertogalerae

Introduction

The SRR and SIR provided the following information on *A. puertogalerae's* morphology and taxonomy. Morphology was described as compact branches, typically less than 13 mm in diameter and tapering, with thin spines under corallites, and taxonomy was described as having no taxonomic issues but being similar in appearance to *A. spinosa* and *A. forbesi.*

The public comments and information we gathered did not provide any new or supplemental information on morphology, and confirmed that there are no known taxonomic problems for *A. puertogalerae,* but that there is a moderate level of species identification uncertainty for this species. However, the species can be identified by experts (Fenner, 2014b), thus we conclude that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *A. puertogalerae's* distribution, habitat, and depth range. *Anacropora puertogalerae's* distribution is the Coral Triangle and western equatorial Pacific, plus southern Japan to the GBR. *Its* habitat includes both coral reef and non-reefal environments, including upper reef slopes, mid-slopes, and lagoons on reefs, and various substrates in non-reefal areas. Its depth range as five to at least 20 meters depth.

The public comments did not provide any new or supplemental information on *A. puertogalerae's* distribution. We gathered supplemental information, including Veron (2014), which reports that *A. puertogalerae* is confirmed in 26 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional seven.

Demographic Information

The SRR and SIR provided the following information on *A. puertogalerae's* abundance. *Anacropora puertogalerae* is reported to be uncommon but can form large thickets in the Philippines.

The public comments did not provide any new or supplemental information on *A. puertogalerae's* abundance. We gathered supplemental information, including Veron (2014), which states that it is sometimes a dominant species where it occurs. Veron (2014) reports that *A. puertogalerae* occupied 4.6 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 2.02 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''uncommon.'' Overall abundance was also described as ''uncommon.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least tens of millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *A. puertogalerae,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 38 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 15 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *A. puertogalerae* occurs in many areas affected by these broad changes, and that it has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *A. puertogalerae's* life history. *Anacropora puertogalerae* has been reported to be a simultaneous hermaphrodite and a broadcast spawner. Clonal structure suggests the species also reproduces by fragmentation. Larvae contain zooxanthellae that can supplement maternal provisioning with energy sources provided by their photosynthesis. The public comments and information we gathered provided no additional biological information.

Susceptibility to Threats

To describe *A. puertogalerae's* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Acropora* of ocean warming, acidification, disease, predation, sedimentation, nutrients, and collection and trade. The SRR and SIR provided the following species-specific information on *A. puertogalerae's* threats. In a two month study in Kimbe Bay, PNG, it was observed that *A. puertogalerae* was only preyed on by wrasses in proportion to its availability (Cole *et al.,* 2010). The SRR and SIR did not provide any other species-specific information on the effects of these threats on *A. puertogalerae.* We interpreted the threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *A. puertogalerae's* vulnerabilities as follows: High vulnerability to ocean warming, moderate vulnerability to disease, ocean acidification, trophic effects of fishing, nutrients and predation, and low vulnerability to sedimentation, sea level rise, predation, and collection and trade.

Public comments did not provide any new or supplemental information on *A. puertogalerae's* threat susceptibilities. We gathered the following species-specific and genus-level supplemental information on this species' threat susceptibilities. *Anacropora puertogalerae* has been rated as moderately or highly susceptible to bleaching and disease, but these ratings are not based on species-specific data (Carpenter *et al.,* 2008). Based on the genus and species-specific information described above, *A. puertogalerae* likely has some susceptibility to ocean warming, disease, acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, and predation, and low susceptibility to collection and trade. The available information does not support more precise ratings of the susceptibilities of *A. puertogalerae* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *A. puertogalerae.* Criticisms of our approach received during public comment led us to the following analysis to attempt to analyze regulatory mechanisms on a species basis. Records confirm that *A. puertogalerae* occurs in 26 Indo-Pacific ecoregions that encompass 16 countries' EEZs. The 16 countries are Australia, Brunei, China, Fiji, France (French Pacific Island Territories), Indonesia, Japan, Malaysia, Palau, Papua New Guinea, Philippines, Solomon Islands, Taiwan, Timor-Leste, Vanuatu, and Vietnam. The regulatory mechanisms relevant to *A. puertogalerae,* described first as the percentage of the above countries that utilize them, to any degree and second, as the percentages of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (38 percent with 6 percent limited in scope), coral collection (69 percent with 38 percent limited in scope), pollution control (44 percent with 19 percent limited in scope), fishing regulations on reefs (100 percent with 19 percent limited in scope), and managing areas for protection and conservation (100 percent with none limited in scope). The most common regulatory mechanisms in place for *A. puertogalerae* are reef fishing regulations and area management for protection and conservation. Coral collection and pollution control laws are also somewhat common for the species, but 38 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection laws are much less common regulatory mechanisms for the management of *A. puertogalerae.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that ''factors that increase the potential extinction risk for *A. puertogalerae* are that the high susceptibility to threats common to members of the genus *Acropora* (bleaching, disease, and predation) are generally considered appropriate to species in the confamilial genus *Anacropora* as well.'' It noted that a factor that reduces potential extinction risk is that *A. puertogalerae* has a somewhat broad range.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *A. puertogalerae,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution includes many of the coral reef ecoregions in the western and central Pacific Ocean; the Coral Triangle and western equatorial Pacific, plus southern Japan to the GBR. On one hand, this moderates vulnerability to extinction because the high latitude areas in the northern and southern portions of its range are projected to have less than average warming over the foreseeable future, thus populations in these areas will be less exposed to severe warming conditions. On the other hand, the species' geographic distribution exacerbates vulnerability to extinction because much of it lies within the western equatorial Pacific, an area projected to have the highest seawater temperatures in the foreseeable future. Its depth range is from five to at least 20 meters. This moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Its habitat includes both coral reef and non-reefal environments, including upper reef slopes, mid-slopes, and lagoons on reefs, and various substrates in non-reefal areas. This is particularly important for moderating vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef and non-reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Its absolute abundance of at least tens of millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule using the determination tool formula approach, *A. puertogalerae* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); uncommon generalized range wide abundance (E); moderate overall distribution (based on moderate geographic distribution and moderate depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *A. puertogalerae* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *A. puertogalerae's* spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to be likely to become endangered throughout its range within the foreseeable future, and thus is not warranted for listing at this time, because:

(1) *Anacropora puertogalerae's* distribution is spread over a very large area. While some areas within its range are projected to be affected by warming and acidification, other areas are projected to have less than average warming, including high latitude areas in both the northern and southern portions of the species' range. This distribution and the heterogeneous habitats it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future;

(2) *Anacropora puertogalerae* occurs in very diverse habitats, including both coral reef and non-reefal habitats so the species will experience a variety of environmental conditions at any given time; and

(3) *Anacropora puertogalerae's* absolute abundance is at least tens of millions of colonies, providing buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future if global threats continue and increase in severity and the species exposure to threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future. Therefore, *A. puertogalerae* is not warranted for listing at this time under any of the listing factors.

Anacropora spinosa

Introduction

The SRR and SIR provided the following information on *A. spinosa's* morphology and taxonomy. Morphology was described as compact branches, less than 10 mm in diameter and tapering. They have elongate, crowded, irregular spines that are not strongly tapered, and taxonomy was described as having no taxonomic issues but being similar in appearance to *Anacropora puertogalerae.*

The public comments and information we gathered did not provide information on morphology, and confirmed that there are no known taxonomic problems for *A. spinosa* and that there is a moderate level of species identification uncertainty for this species. Veron (2014) states that *A. spinosa* is easily confused with *Anacropora puertogalerae.* However, the species can be identified by experts (Fenner, 2014b), thus we conclude that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *A. spinosa's* distribution, habitat, and depth range. *Anacropora spinosa's* distribution is the Coral Triangle and southern Japan. *Its* habitat includes both coral reef and non-reefal environments, including upper reef slopes, mid-slopes, and lagoons on reefs, and various substrates in non-reefal areas. Its depth range is five to 15 meters deep.

The public comments provided the following information that a photograph of *A. spinosa* that appeared in Veron (2000) was erroneously attributed to Guam but was actually taken in Palau. We gathered supplemental information, including Veron (2014), which reports that *A. spinosa* is confirmed in 13 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional six.

Demographic Information

The SRR and SIR provided the following information on *A. spinosa's* abundance. Its abundance is reported to be uncommon, but it may occur in extensive tracts in certain areas.

The public comments did not provide any new or supplemental information on *A. spinosa's* abundance. We gathered supplemental information, including Veron (2014), which reports that *A. spinosa* occupied 1.5 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.84 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''uncommon,'' and overall abundance was described as ''usually uncommon.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *A. spinosa,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 58 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 22 percent in the study. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *A. spinosa* occurs in many areas affected by these broad changes, and that it has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *A. spinosa's* life history: *Anacropora spinosa* has been reported to be a simultaneous hermaphrodite that broadcast spawns mature gametes. Planula larvae contain zooxanthellae that can supplement maternal provisioning with energy sources provided by their photosynthesis. The public comments and information we gathered did not provide anything additional to the above-described biological information.

Susceptibility to Threats

To describe *A. spinosa's* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Anacropora* of ocean warming, acidification, disease, predation, sedimentation, nutrients, and collection and trade. The SRR and SIR provided the following species-specific information on *A. spinosa's* threats. The only known export of *A. spinosa* was a single specimen from Indonesia in 2005. We interpreted the threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *A. spinosa's* vulnerabilities as follows: High vulnerability to ocean warming; moderate vulnerability to disease, ocean acidification, trophic effects of reef fishing, nutrients, and predation, and low vulnerability to sedimentation, sea level rise, and collection and trade.

Public comments did not provide any new or supplemental information on *A. spinosa's* threat susceptibilities, but we gathered species-specific and genus-level supplemental information on this species' threat exposures. *Anacropora spinosa* has been rated as moderately or highly susceptible to bleaching and disease, but these ratings are not based on species-specific data (Carpenter *et al.,* 2008). No other species-specific information is available for the susceptibility of *A. spinosa* to any other threat.

Based on information provided in the genus description above, *A. spinosa* likely has some susceptibilities to ocean warming, disease, acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and low susceptibility to collection and trade. The available information does not support more precise ratings of the susceptibilities of *A. spinosa* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *A. spinosa.* Criticisms of our approach received during public comment led us to the following analysis to attempt to analyze regulatory mechanisms on a species basis. Records confirm that *A. spinosa* occurs in 13 Indo-Pacific ecoregions that encompass six countries' EEZs. The six countries are Indonesia, Japan, Palau, Papua New Guinea, Philippines, and the Solomon Islands. The regulatory mechanisms relevant to *A. spinosa,* described first as the percentage of the above countries that utilize them to any degree and second, as the percentages of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (17 percent with none limited in scope), coral collection (67 percent with 33 percent limited in scope), pollution control (17 percent with 17 percent limited in scope), fishing regulations on reefs (100 percent with none limited in scope), and managing areas for protection and conservation (100 percent with none limited in scope). The most common regulatory mechanisms in place for *A. spinosa* are reef fishing regulations and area management for protection and conservation. Coral collection laws are also somewhat common for the species, but 33 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection and pollution control laws are much less common regulatory mechanisms for the management of *A. spinosa.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated factors that increase the potential extinction risk for *A. spinosa* are that the high susceptibility to threats common to members of the genus *Acropora* (bleaching, disease, and predation) are generally considered appropriate to species in the confamilial genus *Anacropora* as well.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *A. spinosa,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution is limited to the Coral Triangle and southern Japan. Despite the large number of islands and environments that are included in the species' range, this range exacerbates vulnerability to extinction over the foreseeable future because it is mostly limited to an area projected to have the most rapid and severe impacts from climate change and localized human impacts for coral reefs over the 21st century. Its depth range is five to 15 meters On one hand, its depth range may moderate vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. On the other hand, its depth range may exacerbate vulnerability to extinction over the foreseeable future if the species occurs predominantly in the shallower portion of its depth range, since those areas will have higher irradiance and thus be more severely affected by warming-induced bleaching. Its habitat includes upper reef slopes, mid-slopes, and lagoons on reefs, and various substrates in non-reefal areas. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef and non-reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. There is not enough information about its abundance to determine if it moderates or exacerbates extinction: It is uncommon and has at least millions of colonies, but the great majority of the population is within an area expected to be severely impacted by threats over the foreseeable future.

Listing Determination

In the proposed rule using the determination tool formula approach, *A. spinosa* was proposed for listing as endangered because of: High vulnerability to ocean warming (ESA

Factor E); moderate vulnerability to disease (C) and acidification (E); uncommon generalized range wide abundance (E); narrow overall distribution (based on narrow geographic distribution and shallow depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *A. spinosa* from endangered to threatened. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information provided above on *A. spinosa's* spatial structure, demography, threat susceptibilities, and management indicate that it is likely to become endangered throughout its range within the foreseeable future, and thus warrants listing as threatened at this time, because:

(1) *Anacropora spinosa* is likely to be susceptible to ocean warming (ESA Factor E), disease (C), ocean acidification (E), trophic effects of fishing (A), nutrients (A, E), and predation (C). In addition, existing regulatory mechanisms to address global threats that contribute to extinction risk for this species are inadequate (D); and

(2) *Anacropora spinosa's* distribution is constrained almost entirely within the Coral Triangle, which is projected to have the most rapid and severe impacts from climate change and localized human impacts for coral reefs over the 21st century, as described in the Threats Evaluation. Multiple ocean warming events have already occurred within the western equatorial Pacific that suggest future ocean warming events may be more severe than average in this part of the world. A range constrained to this particular geographic area that is likely to experience severe and increasing threats indicates that a high proportion of the population of this species is likely to be exposed to those threats over the foreseeable future.

The combination of these characteristics and projections of future threats indicates that the species is likely to be in danger of extinction within the foreseeable future throughout its range and warrants listing as threatened at this time due to factors A, C, D, and E.

The available information above on *A. spinosa's* spatial structure, demography, threat susceptibilities, and management also indicate that the species is not currently in danger of extinction and thus does not warrant listing as Endangered because:

(1) While *A. spinosa's* distribution is constrained almost entirely to the Coral Triangle which increases it extinction risk as described above, its habitat includes shallow reef environments, generally in clear or slightly turbid water and on soft substrates of lower reef slopes, and it has also been found in non-reef environments. This moderates vulnerability to extinction currently because the species is not limited to one habitat type but occurs in numerous types of reef and non-reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time, as described in more detail in the Coral Habitat and Threats Evaluation sections. There is no evidence to suggest that the species is so spatially fragmented that depensatory processes, environmental stochasticity, or the potential for catastrophic events currently pose a high risk to the survival of the species; and

(2) *Anacropora spinosa's* absolute abundance is at least millions of colonies which allows for variation in the responses of individuals to threats to play a role in moderating vulnerability to extinction for the species to some degree, as described in more detail in the Corals and Coral Reefs section. There is no evidence of depensatory processes such as reproductive failure from low density of reproductive individuals and genetic processes such as inbreeding affecting this species. Thus, its absolute abundance indicates it is currently able to avoid high mortality from environmental stochasticity, and mortality of a high proportion of its population from catastrophic events.

The combination of these characteristics indicates that the species does not exhibit the characteristics of one that is currently in danger of extinction, as described previously in the Risk Analyses section, and thus does not warrant listing as endangered at this time.

Range-wide, a multitude of conservation efforts are already broadly employed that are likely benefiting *A. spinosa.* However, considering the global scale of the most important threats to the species, and the ineffectiveness of conservation efforts at addressing the root cause of global threats (*i.e.,* GHG emissions), we do not believe that any current conservation efforts or conservation efforts planned in the future will result in affecting the species status to the point at which listing is not warranted.

Genus Astreopora

Genus Introduction

The family Acroporidae includes five genera, *Acropora, Montipora, Astreopora, Isopora,* and *Anacropora. Astreopora* contains 15 species, all occurring in the Indo-Pacific (Veron, 2000; Wallace *et al.,* 2011). Unlike *Acropora* and *Anacropora* species, *Astreopora* colonies are massive, laminar, or encrusting. The SRR and SIR provided no genus-level introductory information on *Astreopora.*

Genus Susceptibility to Threats

The SRR and SIR provided the following information on the threat susceptibilities of the genus *Astreopora. Astreopora* species can be susceptible to bleaching, although overall *Astreopora* species are less susceptible to bleaching than other genera within the family Acroporidae, and often survive when they do bleach. Congeners have contracted a fungal disease in Kenya, and *Astreopora myriophthalma* was infected with black-band disease at a polluted site in Jordan. Trade in the genus *Astreopora* has been reported to be light and sporadic.

The public comments did not provide any new or supplemental information on the threat susceptibilities of the genus *Astreopora,* but the supplemental information provided the following. In Palau in 1998, *Astreopora* species had moderate levels of bleaching and moderate mortality (Bruno *et al.,* 2001). In Kenya in 1998, three quarters of *Astreopora* species within marine protected areas were affected by mass bleaching. Although many *Astreopora* colonies bleached, none died. Of the 18 genera included in the study, five genera including *Astreopora* had some bleaching but no mortality, and the bleaching index for *Astreopora* was the fifth lowest of the 18 genera (McClanahan *et al.,* 2004; McClanahan *et al.,* 2001). In Thailand in 1998 and 2010, all colonies of *Astreopora myriophthalma* completely bleached, but in both events, all colonies completely recovered (Sutthacheep *et al.,* 2013). In Mauritius in 2004, the *Astreopora* genus had the 23rd highest bleaching rate of the 32 genera recorded, and 12 percent of the highest value (McClanahan *et al.,* 2005a). In eight countries in the western Indian Ocean in 1998–2005, the *Astreopora* genus had the 21st highest bleaching rate of the 45 genera recorded, and 39 percent of the highest value (McClanahan *et al.,* 2007a).

On the GBR, *Astreopora* species had a very low level of Black Band Disease occurrence, just two percent the level of this disease found in *Acropora* species at the same sites (Page and Willis, 2006). Likewise, another study from the GBR reported that *Astreopora* species had low susceptibility to Skeletal Eroding Band, with a prevalence of 0.1 percent. Skeletal Eroding Band is the most prevalent coral disease on the GBR (Page and Willis, 2007). In New Caledonia, *Astreopora* was reported to have a disease prevalence of 0.5 percent, which was the fifth highest prevalence of 12 genera reported (Tribollet *et al.,* 2011). In Indonesia, *Astreopora* had a disease prevalence of 1.5 percent, which was the 2nd highest reported among 35 taxa (Haapkyla *et al.,* 2007).

In a study of sediment rejection in 22 coral species (including one *Astreopora* species), *A. myriophthalma* cleared 98 percent of the sediment within 48 hours, the seventh most efficient of the 22 species at clearing sediment (Stafford-Smith, 1993). *Astreopora* species trade has been reported to be light and sporadic (CITES, 2010). There is no information available on the effects of any other threat for *Astreopora* species.

Genus Conclusion

Based on the information from the SRR, SIR, public comments, and supplemental information, we can make the following inferences about the susceptibilities of an unstudied *Astreopora* species to ocean warming, disease, acidification, sedimentation, nutrients, trophic effects of fishing, sea-level rise, predation, and collection and trade. The SRR rated ocean warming and disease as ''high'' importance, and ocean acidification as ''medium-high'' importance, to corals. These were rated as the three most important threats to reef-building corals overall. The studies cited above on thermal stress in *Astreopora* report moderate levels of bleaching in response to warming events, but low mortality levels. The studies cited above report variable levels of disease in *Astreopora*. Thus, we conclude that *Astreopora* has some susceptibility to ocean warming and disease. Although there is no genus-level or species-specific information on the susceptibilities of *Astreopora* species to ocean acidification, the SRR rated it as ''medium-high'' importance to corals. Thus, we conclude that an unstudied *Astreopora* species has some susceptibility to ocean acidification.

The SRR rated the trophic effects of fishing as ''medium'' importance, the fourth most important threat to corals overall. This threat was not addressed at the genus or species level in the SRR or SIR, because it is an ecosystem-level process. That is, removal of herbivorous fish from coral reef systems by fishing alters trophic interactions by reducing herbivory on algae, thereby providing a competitive advantage for space to algae over coral. Thus, the SRR did not discuss this threat in terms of coral taxa, as its effects are difficult to distinguish between coral genera and species. Therefore, an unstudied *Astreopora* species is likely to have some susceptibility to the trophic effects of fishing.

The SRR rated sedimentation, nutrients, and sea-level rise as ''low-medium'' importance to corals overall. The study cited above reports high sediment rejection efficiency in *A. myriophthalma.* This one study is inadequate to rate the susceptibility as low, thus we conclude that *Astreopora* has some susceptibility to sedimentation. Although there is no genus-level or species-specific information on the susceptibilities of *Astreopora* species to nutrients, the SRR rated it as ''low-medium'' importance to corals. Thus, we conclude that an unstudied *Astreopora* species has some susceptibility to nutrients. Sea-level rise was not addressed at the genus or species level in the SRR or SIR. Increasing sea levels may increase land-based sources of pollution due to inundation, resulting in changes to coral community structure, thus an unstudied *Astreopora* species is likely to have some susceptibility to sea-level rise. Although there is no genus-level or species-specific information on the susceptibilities of *Astreopora* species to predation, there is no information suggesting they are not susceptible to these threats. Thus, we conclude that an unstudied *Astreopora* species has some susceptibility to predation. The SRR rated ornamental trade (referred to in the proposed rule as Collection and Trade) as ''low'' importance to corals overall. Although there is no other genus-level or species-specific information on the susceptibilities of *Astreopora* species to collection and trade, there is no information suggesting they are not susceptible to these threats. Thus we conclude that an unstudied *Astreopora* species is likely to have some susceptibility to collection and trade.

In conclusion, an unstudied *Astreopora* species is likely to have some susceptibility to ocean warming, disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade.

Astreopora cucullata

Introduction

The SRR and SIR provided the following information on *A. cucullata'*s morphology and taxonomy. Morphology was described as thick or encrusting platy colonies, with inclined corallites, and taxonomy was described as having no taxonomic issues but being similar to *Astreopora scabra.*

The public comments and information we gathered did not provide information on morphology, and confirmed that there are no known taxonomic problems for *A. cucullata,* but that there is a high level of species identification uncertainty for this species. Veron (Veron, 2014) states that *A. cucullata* is not readily distinguished from other *Astreopora* but Veron (Lamberts, 1980; Lamberts, 1982; Veron, 2000) considers it a valid species, thus we conclude it is sufficiently distinctive to be identified by experts, and that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *A. cucullata'*s distribution, habitat, and depth range. *Astreopora cucullata'*s distribution is a broad distribution, from the Red Sea and central Indo-Pacific to the central Pacific. The SRR and SIR described *A. cucullata'*s habitat as protected reef environments, and the depth range as five to 15 m. The public comments provided the following information. One comment stated that *A. cucculata* was recorded from Apra Harbor, Guam, but no sample or photo was provided for confirmation. We gathered supplemental information, including Veron (2014), which reports that *A. cucullata* is confirmed in 31 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional 15. *Astreopora cucullata* occurs in most reef environments except reef flats (Lamberts, 1980; Lamberts, 1982; Veron, 2000). It has been reported as ''found only in deep waters at reef edges'' (Lamberts, 1980), and is likely to have a depth range of approximately 3 m to at least 20 m. Fenner (personal comm.) reports it is on outer reef slopes in American Samoa. Thus, based on all the available information, *A. cucullata'*s habitat includes most coral reef habitats, including at least upper reef slopes, mid-slope terraces, lower reef slopes, lower reef crests, and lagoons in depths ranging from two to 20 m depth.

Demographic Information

The SRR and SIR provided the following information on *A. cucullata's* abundance. *Astreopora cucullata* is reported as rare. The SIR reported it is common in parts of its range such as in American Samoa (Fenner *et al.,* 2008) and Guam (Lamberts, 1982). *Astreopora cucullata* was found in 10 of 51 sites (Donnelly *et al.,* 2003) and four of 39 sites (Turak and DeVantier, 2003) in Indonesian national park surveys.

The public comments did not provide any new or supplemental information on *A. cucullata's* abundance. We gathered supplemental information, including Veron (2014), which reports that *A. cucullata* occupied 6.8 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.25 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''uncommon,'' and overall abundance was described as ''rare.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least tens of millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *A. cucullata,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 34 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 13 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *A. cucullata* occurs in many areas affected by these broad changes, and has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *A. cucullata's* life history. Reproductive characteristics of *A. cucullata* have not been determined. However, other species in the *Astreopora* genus (*Astreopora gracilis, Astreopora myriophthalma,* and *Astreopora listeri*) are hermaphroditic broadcast spawners. The public comments and information we gathered provided no additional biological information.

Susceptibility to Threats

To describe *A. cucullata's* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Astreopora* of ocean warming, acidification, disease, predation, sedimentation, nutrients, and collection and trade. The SRR and SIR provided the following species-specific information on *A. cucullata's* threats. A single *A. cucullata* export was reported from Saudi Arabia in 1999. The SRR and SIR did not provide any other species-specific information on the effects of these threats on *A. cucullata.* We interpreted the threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *A.* cucullata's vulnerabilities as follows: High vulnerability to ocean warming, moderate vulnerability to disease, ocean acidification, trophic effects of reef fishing, and nutrients, and low vulnerability to sedimentation, sea level rise, predation, and collection and trade.

Public comments did not provide any new or supplemental information on *A. cucullata's* threats, but we gathered species-specific and genus-level supplemental information on this species' threat exposures, susceptibilities, and vulnerabilities. *Astreopora cucullata* has been rated as moderately or highly susceptible to bleaching and disease, but these ratings are not based on species-specific data (Carpenter *et al.,* 2008). No other species-specific information is available for the susceptibility of *A. cucullata* to any other threat. Based on the available genus-level and species information summarized above, *A. cucullata* likely has some susceptibilities to ocean warming, disease, acidification, trophic effects of fishing, sedimentation, nutrients, predation, sea-level rise, and collection and trade. The available information does not support more precise ratings of susceptibilities of *A. cucullata* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *A. cucullata.* Criticisms of our approach received during public comment led us to the following analysis to attempt to analyze regulatory mechanisms on a species basis. Records confirm that *A. cucullata* occurs in 31 Indo-Pacific ecoregions that encompass 30 countries' EEZs. The 30 countries are Australia, Brunei, China, Djibouti, Egypt, Federated States of Micronesia, Fiji, France (French Pacific Island Territories), Indonesia, Israel, Jordan, Malaysia, Marshall Islands, Myanmar, New Zealand (Tokelau), Niue, Palau, Papua New Guinea, Philippines, Samoa, Saudi Arabia, Solomon Islands, Sudan, Thailand, Timor-Leste, Tonga, Tuvalu, United States (American Samoa, Guam), Vietnam, and Yemen. The regulatory mechanisms relevant to *A. cucullata,* described first as the percentage of the above countries that utilize them to any degree and second, as the percentages of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (23 percent with 0 percent limited in scope), coral collection (67 percent with 30 percent limited in scope), pollution control (50 percent with 10 percent limited in scope), fishing regulations on reefs (87 percent with 17 percent limited in scope), and managing areas for protection and conservation (97 percent with 10 percent limited in scope). The most common regulatory mechanisms in place for *A. cucullata* are reef fishing regulations and area management for protection and conservation. Coral collection and pollution control laws are also somewhat common for the species, but 30 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection laws are much less common regulatory mechanisms for the management of *A. cucullata.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that factors that increase the potential extinction risk for *A. cucullata* are its rarity and that it belongs to a family that is highly susceptible to stress. It listed factors that reduce the potential extinction risk including a widespread distribution and the fact that it appears to be less vulnerable to bleaching than other species in its family.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *A. cucullata,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution includes the Red Sea, parts of the western Indian Ocean, and most of the ecoregions throughout the western and central Pacific Ocean. Its geographic distribution moderates vulnerability to extinction because some areas within its range are projected to have less than average warming and acidification over the foreseeable future, including the western Indian Ocean, the central Pacific, and other areas, so portions of the population in these areas will be less exposed to severe conditions. Its depth range is from two to 20 meters. This moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Its habitat includes at least upper reef slopes, mid-slope terraces, lower reef slopes, lower reef crests, and lagoons. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Its absolute abundance of at least tens of millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule using the determination tool formula approach, *A. cucullata* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); common generalized range wide abundance (E); moderate overall distribution (based on wide geographic distribution and shallow depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *A. cucullata* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *A. cucullata's* spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to be likely to become endangered throughout its range within the foreseeable future, and thus is not warranted for listing at this time, because:

(1) *Astreopora cucullata*'s distribution in the Red Sea, central Indo-Pacific, and the central Pacific Ocean is spread over a very large area. While some areas within its range are projected to be affected by warming and acidification, other areas are projected to have less than average warming and acidification, including the central Pacific, and other areas. This distribution and the heterogeneous habitats it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future; and

(2) While *A. cucullata*'s qualitative abundance is characterized as rare, its absolute abundance at least tens of millions of colonies, providing buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future if global threats continue and increase in severity and the species exposure to threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *A. cucullata* is not warranted for listing at this time under any of the listing factors.

Genus Isopora

Genus Introduction

The family Acroporidae includes five genera, *Acropora, Montipora, Astreopora, Isopora,* and *Anacropora. Isopora* was formerly considered a sub-genus of *Acropora,* but was recently elevated to genus level (Wallace *et al.,* 2007). The genus contains seven species, all occurring in the Indo-Pacific. *Isopora* have branching or encrusting colonies. The SRR and SIR provided no genus-level introductory information on *Isopora.*

Genus Susceptibility to Threats

The SRR and SIR provided the following information on the threat susceptibilities of the genus *Isopora. Isopora cuneata* has intermediate bleaching susceptibility relative to other acroporids but showed severe losses in a 2006 mass bleaching event in the Marshall Islands, with only shaded bases of colonies surviving. *Isopora cuneata* was a common species in the

Acropora palifera zone of the Chagos, but *I. cuneata* was nearly completely eliminated in 1998 and has not yet regenerated. Competition with algae significantly reduces growth rates of *I. cuneata.* At high latitude Lord Howe Island, *I. cuneata* was found to host five types of C zooxanthellae, with an ability to host specialized types in turbid environments. The species is also capable of photo-adapting to low light environments by increasing zooxanthellae density altering photosynthetic mechanisms (dark reaction enzymes or electron transport rates).

The public comments did not provide any new or supplemental information on the threat susceptibilities of the genus *Isopora.* We gathered supplemental information that provided the following material. A large study of the bleaching responses of over 100 coral species on the GBR to the 2002 bleaching event included three *Isopora* species (Done *et al.,* 2003b). At that time, *Isopora* species were still considered *Acropora* species, and they are listed in the report as *Acropora palifera, A. cuneata,* and *A. brueggemanni,* but these three species are now referred to as *Isopora palifera, I. cuneata,* and *I. brueggemanni.* For *I. palifera,* approximately 42 percent of the observed colonies were bleached, resulting in *I. palifera* being more affected than 43 of the 45 *Acropora* species in the study, and one of the 20 most affected species in the study. For *I. cuneata* and *I. brueggemanni,* approximately 20 percent of the observed colonies for both species were bleached, an intermediate bleaching level compared to the 45 *Acropora* species in the study (Done *et al.,* 2003b). In response to a 2008 bleaching event in Papua New Guinea, two Pocilloporidae and 14 Acroporidae species (including *I. brueggemanni*) were monitored: five of the 16 species had severe or high ‘‘relative susceptibility’’ to bleaching, (including *I. brueggemanni,* which was rated as high). All 29 *I. brueggemanni* colonies were bleached severely, but none were killed (Bonin, 2012).

In a study of coral disease on the GBR, approximately one percent of colonies of observed *Isopora* were affected by Skeletal Eroding Band, the most prevalent coral disease on the GBR (Page and Willis, 2007). *Isopora* had a disease prevalence of 1% in Indonesia, which was tied for 5th highest among 35 taxa (Haapkyla *et al.,* 2007). *Isopora crateriformis* and *I. palifera* were affected differently by white diseases in American Samoa: an outbreak resulted in low prevalence in *I. crateriformis,* but high prevalence in *I. palifera* (D. Fenner, personal comm.). There is no information available on the effects of any other threat for *Isopora* species.

Genus Conclusion

Based on the information from the SRR, SIR, public comments, and supplemental information, we can make the following inferences about the susceptibilities of an unstudied *Isopora* species to ocean warming, disease, acidification, sedimentation, nutrients, trophic effects of fishing, sea-level rise, predation, and collection and trade. The SRR rated ocean warming and disease as ‘‘high’’ importance, and ocean acidification as ‘‘medium-high’’ importance, to corals. These were rated as the three most important threats to reef-building corals overall. The studies described above report moderate to high levels of bleaching in *Isopora* species in response to warming events. With regard to disease, the information above indicates variable levels (from low to high) of disease in *Isopora* species. Thus, we conclude that *Isopora* is likely to be highly susceptible to ocean warming and to have some susceptibility to disease. Although there is no genus-level or species-specific information on the susceptibilities of *Isopora* species to ocean acidification, the SRR rated it as ‘‘medium-high’’ importance to corals. Thus, we conclude that an unstudied *Isopora* species has some susceptibility to ocean acidification.

The SRR rated the trophic effects of fishing as ‘‘medium’’ importance, the fourth most important threat to corals overall. This threat was not addressed at the genus or species level in the SRR or SIR, because it is an ecosystem-level process. That is, removal of herbivorous fish from coral reef systems by fishing alters trophic interactions by reducing herbivory on algae, thereby providing a competitive advantage for space to algae over coral. Thus, the SRR did not discuss this threat in terms of coral taxa, as its effects are difficult to distinguish between coral genera and species. Therefore, an unstudied *Isopora* species is likely to have some susceptibility to the trophic effects of fishing.

The SRR rated sedimentation, nutrients, and sea-level rise as ‘‘low-medium’’ importance to corals overall. Although there is no genus-level or species-specific information on the susceptibilities of *Isopora* species to sedimentation or nutrients, the SRR rated them as ‘‘low-medium’’ importance to corals. Thus, we conclude that an unstudied *Isopora* species has some susceptibility to sedimentation and nutrients.

Sea-level rise was not addressed at the genus or species level in the SRR or SIR. Increasing sea levels may increase land-based sources of pollution due to inundation, resulting in changes to coral community structure, thus an unstudied *Isopora* species is likely to have some susceptibility to sea-level rise. The SRR rated predation and ornamental trade (referred to in the proposed rule as Collection and Trade) as ‘‘low’’ importance to corals overall. Although there is no genus-level or species-specific information on the susceptibilities of *Isopora* species to collection and trade, there is no information suggesting they are not susceptible to these threats. Thus, we conclude that an unstudied *Isopora* species has some susceptibility to collection and trade.

In conclusion, an unstudied *Isopora* species is likely to be highly susceptible to ocean warming, and to have some susceptibility to disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade.

Isopora crateriformis

Introduction

The SRR and SIR provided the following information on *I. crateriformis’* morphology and taxonomy. Morphology was described as solid encrusting plates sometimes over one meter diameter, and taxonomy was described as having no taxonomic issues.

The public comments and information we gathered did not provide any new or supplemental information on morphology, but found that there is a moderate level of taxonomic uncertainty for *I. crateriformis,* and that there is a moderate level of species identification uncertainty for this species. Veron (2014) states that *I. crateriformis* is easily confused with *I. cuneata,* but Veron (2000; 2014), Wallace (1999b) and Wallace *et al.* (2012) continue to consider it a valid species, and it can be identified by experts (Fenner, 2014b). Thus, the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *I. crateriformis’* distribution, habitat, and depth range. *Isopora crateriformis’* distribution is from Sumatra (Indonesia) to American Samoa, and there are reports from the western and central Indian Ocean that need confirmation.

The SRR reported that this species is found most commonly in shallow, high-wave energy environments, from low tide to at least 12 meters deep, and has been reported from mesophotic depths (<50 m depth). The SIR reported that *I. crateriformis* is one of the most common species on upper reef slopes of southwest Tutuila, American Samoa. Rangewide, its predominant habitat is reef flats and lower reef crests, and it also occurs in adjacent habitats such us upper reef slopes.

Public comments did not provide any new or supplemental information on the distribution and habitat of *I. crateriformis. Isopora crateriformis* is reported from American Samoa (Kenyon *et al.,* 2010). Veron (2014) reports that *I. crateriformis* is confirmed in 13 of his 133 Indo-Pacific ecoregions, and is strongly predicted to be found in an additional 17. Wallace (1999b) reports its occurrence in three of her 29 Indo-Pacific areas, many of which are larger than Veron's ecoregions. Richards *et al.* (2009) calculated the geographic range of this species at about 11 million km^2, the 35th smallest range of the 114 species of *Acropora* and *Isopora* that she calculated. Worldwide, reef flats have a larger area than reef slopes (Vecsei, 2004). Most coral abundance surveys are carried out only on reef slopes, and thus may significantly underestimate the abundance of species such as *I. crateriformis* that are more common on reef flats than reef slopes.

Demographic Information

The SRR and SIR reported *I. crateriformis'* abundance as sometimes common and occasionally locally abundant. *Isopora crateriformis* has been reported as common in Indonesia (Veron, 2000) and as one of the most prevalent corals in American Samoa (Birkeland *et al.,* 1987).

Public comments did not provide information on the abundance of *I. crateriformis.* We gathered supplemental information, which includes the following. Richards *et al.* (2013b) conclude from their data that this species is globally widespread, locally restricted, and locally rare, and thus in the second rarest category with the predicted consequence of local extinction. Veron (2014) reports that *I. crateriformis* occupied 0.3 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.4 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''rare.'' Overall abundance was described as ''occasionally common on reef flats.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *I. crateriformis,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 38 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 14 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences of species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *I. crateriformis* occurs in many areas affected by these broad changes, and likely has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *I. crateriformis'* life history. *Isopora crateriformis* is not prone to asexual reproduction via fragmentation, based on its semi-encrusting morphology. Supplemental information we gathered added that, while *I. crateriformis* often has a lower plate edge on colonies on slopes, colonies are very hard and thus unlikely to fragment often (D. Fenner, personal comm.). Public comments did not provide anything additional to the above-described biological information.

Susceptibility to Threats

To describe *I. crateriformis'* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Isopora* of ocean warming, acidification, disease, sedimentation, nutrients, predation, and collection and trade. The SRR and SIR did not provide any other species-specific information on the effects of these threats on *I. crateriformis.* We interpreted threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *I. crateriformis'* vulnerabilities as follows: High vulnerability to ocean warming, moderate vulnerability to disease, ocean acidification, trophic effects of reef fishing, and nutrients, and low vulnerability to sedimentation, sea level rise, predation, and collection and trade.

Public comments did not provide any new or supplemental information on *I. crateriformis'* threat susceptibilities. We gathered the following species-specific and genus-level supplemental information on this species' threat susceptibilities. *Isopora crateriformis* is not rated as moderately or highly susceptible to bleaching or disease, but this rating is not based on species-specific data (Carpenter *et al.,* 2008). Based on information for the genus *Isopora,* an unstudied species such as *I. crateriformis* can be predicted to have high susceptibility to ocean warming. Fenner (personal comm.) reports seeing a ''white disease'' or ''tissue loss'' on *I. crateriformis* that appeared similar to white syndrome during a brief disease outbreak in American Samoa, but prevalence was low. Since only one observation of disease on *I. crateriformis* is reported, it is likely that *I. crateriformis* has some susceptibility to disease. Based on species-specific and genus-level information described above, *I. crateriformis* likely is highly susceptible to ocean warming and likely has some susceptibility to disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade. The available information does not support more precise ratings of the susceptibilities of *I. crateriformis* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *I. crateriformis.* We received criticism of that approach in public comments and in response we present a species-specific analysis of regulatory mechanisms in this final rule. Records confirm that *I. crateriformis* occurs in 13 Indo-Pacific ecoregions that encompass 17 countries' EEZs. The 17 countries are Australia, Brunei, Fiji, France (French Pacific Island Territories), Indonesia, Kiribati, Malaysia, New Zealand (Tokelau), Niue, Papua New Guinea, Philippines, Samoa, Solomon Islands, Timor-Leste, Tonga, Tuvalu, and the United States (American Samoa). The regulatory mechanisms relevant to *I. crateriformis,* described first as the percentage of the above countries that utilize them to any degree and second, as the percentage of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (41 percent with none limited in scope), coral collection (82 percent with 35 percent limited in scope), pollution control (53 percent with 12 percent limited in scope), fishing regulations on reefs (100 percent with 24 percent limited in scope), and managing areas for protection and conservation (100 percent with none limited in scope). The most common regulatory mechanisms in place for *I. crateriformis* are reef fishing regulations and area management for protection and conservation. Coral collection and pollution control laws are also common for the species, but 35 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection laws are the least common regulatory mechanisms for the management of *I. crateriformis.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that factors that increase the risk of extinction were the high susceptibility to threats inferred to be common to members of the family Acroporidae. It listed factors that reduce the risk of extinction including its prevalence in areas of heavy wave action as water motion can reduce bleaching vulnerability.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of I. *crateriformis,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat subsection, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic range extends from Sumatra (Indonesia) to American Samoa, and the Philippines to the GBR. On one hand, this moderates vulnerability to extinction because the central Pacific portion of its range is projected to have less than average warming over the foreseeable future, thus population in these areas will be less exposed to severe warming conditions. On the other hand, the species' geographic distribution exacerbates vulnerability to extinction because much of it lies within the western equatorial Pacific, an area projected to have the highest seawater temperatures in the foreseeable future. Its depth range is from zero to 12 meters. On one hand, its depth range may moderate vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. On the other hand, its depth range may exacerbate vulnerability to extinction over the foreseeable future if the species occurs predominantly in the shallower portion of its depth range, since those areas will have higher irradiance and thus be more severely affected by warming-induced bleaching. Its habitat includes at least reef flats, lower reef crests, and upper reef slopes. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Shallow areas may experience more frequent changing environmental conditions, extremes, high irradiance, and multiple simultaneous stressors, however, high energy environments experience high levels of mixing which can dilute adverse environmental conditions. Its absolute abundance of at least millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time. However, its qualitative abundance is described as rare, which combined with its restricted depth distribution indicates it is likely that a high proportion of individuals will be affected by threats that are typically more severe in shallow habitats at any given point in time.

Listing Determination

In the proposed rule using the determination tool formula, *I. crateriformis* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); common generalized range wide abundance (E); moderate overall distribution (based on moderate geographic distribution and moderate depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we confirmed our listing determination for I. *crateriformis* as threatened. Based on the best available information provided above on *I. crateriformis'* spatial structure, demography, threat susceptibilities, and management, it is likely to become endangered throughout its range within the foreseeable future, and thus warrants listing as threatened at this time, because:

(1) *Isopora crateriformis* is highly susceptible to ocean warming (ESA Factor E), and susceptible to disease (C), acidification (E), trophic effects of fishing (A), and nutrients (A, E), and predation (C). In addition, existing regulatory mechanisms to address global threats that contribute to extinction risk for this species are inadequate (D);

(2) The majority of *Isopora crateriformis'* distribution is within the Coral Triangle and western equatorial Pacific, which is projected to have the most rapid and severe impacts from climate change and localized human impacts for coral reefs over the 21st century, as described in the Threats Evaluation. Multiple ocean warming events have already occurred within the western equatorial Pacific that suggest future ocean warming events may be more severe than average in this part of the world. A range constrained to this particular geographic area that is likely to experience severe and increasing threats indicates that a high proportion of the population of this species is likely to be exposed to those threats over the foreseeable future; and

(3) *Isopora crateriformis'* qualitative abundance is rare overall. Considering that much of the range of this species

includes areas where severe and increasing impacts are predicted, this level of abundance combined with its restricted depth distribution, leaves the species vulnerable to becoming of such low abundance within the foreseeable future that it may be at risk from depensatory processes, environmental stochasticity, or catastrophic events, as explained in more detail in the Corals and Coral Reefs and Risk Analyses sections.

The combination of these biological and environmental characteristics and future projections of threats indicates that the species is likely to be in danger of extinction within the foreseeable future throughout its range and warrants listing as threatened at this time due to factors A, C, D, and E.

The available information above on *I. crateriformis'* spatial structure, demography, threat susceptibilities, and management also indicate that the species is not currently in danger of extinction and thus does not warrant listing as Endangered because:

(1) While *I. crateriformis'* distribution is mostly in the Coral Triangle and western equatorial Pacific, which increases it extinction risk as described above, its habitat includes at least reef flats, lower reef crests, and upper reef slopes. This moderates vulnerability to extinction currently because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time, as described in more detail in the Coral Habitat and Threats Evaluation sections.

(2) While *I. crateriformis'* depth range is primarily restricted to shallow habitats from zero to 12 meters, it has been reported from 50 meters in American Samoa. This moderates vulnerability to extinction over the foreseeable future because there may be depth refugia for *I. crateriformis* in some parts of its range from threats that are typically more severe in shallow habitats.

(3) Even though this species is considered rare, the absolute abundance of *I. crateriformis* is at least millions of colonies. In addition, it is ''occasionally common on reef flats,'' a habitat type that has larger area than reef slopes. There is no evidence of depensatory processes such as reproductive failure from low density of reproductive individuals and genetic processes such as inbreeding affecting this species. Thus, its absolute abundance indicates it is currently able to avoid high mortality from environmental stochasticity, and mortality of a high proportion of its population from catastrophic events.

The combination of these biological and environmental characteristics indicates that the species does not exhibit the characteristics of one that is currently in danger of extinction, as described previously in the Risk Analyses section, and thus does not warrant listing as endangered at this time.

Range-wide, a multitude of conservation efforts are already broadly employed that are likely benefiting *I. crateriformis.* However, considering the global scale of the most important threats to the species, and the ineffectiveness of conservation efforts at addressing the root cause of global threats (*i.e.,* GHG emissions), we do not believe that any current conservation efforts or conservation efforts planned in the future will result in affecting the species status to the point at which listing is not warranted.

Isopora cuneata

Introduction

The SRR and SIR provided the following information on *I. cuneata's* morphology and taxonomy. Morphology was described as sometimes flattened solid encrusting plates like *Isopora crateriformis,* but usually also forms ''Mohawk'' ridges parallel to the main wave motion or short flattened blades. Taxonomy was described as having no taxonomic issues.

Public comments and information we gathered provided the following information on the morphology or taxonomy of *I. cuneata. Isopora cuneata* has moderate taxonomic uncertainty, and moderate species identification uncertainty (Fenner, 2014b). Veron (2014) states that *I. cuneata* is easily confused with *I. palifera* which it closely resembles, but Veron (2000; 2014), Wallace (1999a) and Wallace *et al.* (2012) continue to consider it a valid species, and it can be identified by experts (Fenner, 2014b). Thus, we conclude that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *I. cuneata's* distribution, habitat, and depth range. *Isopora cuneata's* distribution is from the east coast of Africa to the central Pacific. One expert source does not recognize records from east Africa (Riegl, 1995), and the SRR questions whether they should be checked. The SRR reported that *I. cuneata's* habitat is shallow, high wave-energy environments. Its predominant habitat is high energy environments such as lower reef crests and reef flats, but it is also found in upper reef slopes, lagoons, and adjacent habitats. Its depth range is low tide to 15 meters deep.

Public comments provided the following information. One public comment stated that *I. cuneata* is widely distributed in Indonesian waters. We gathered supplemental information, including Veron (2014) which reports that *I. cuneata* is confirmed in 43 of his 133 Indo-Pacific ecoregions, and is strongly predicted to be found in an additional nine. Wallace (1999b) reports it from 11 of her 29 Indo-Pacific areas, many of which are larger than Veron's ecoregions. Richards *et al.* (2009) calculated the geographic range of *I. cuneata* at 27 million km^2, which was the 45th smallest among the 114 *Acropora* species for which ranges were calculated.

Demographic Information

The SRR and SIR reported *I. cuneata's* abundance as generally common, occasionally locally abundant, and by far the most predominant of acroporids on some areas of the Great Barrier Reef.

Public comments provided the following information. One public comment stated that *I. cuneata* is very abundant in all Indonesian waters. We gathered supplemental information which included the following. Worldwide, reef flats have a larger area than reef slopes (Vecsei, 2004). Most coral abundance surveys are carried out only on reef slopes, and thus may significantly underestimate the abundance of species such as *I. cuneata* that are more common on reef flats and crests than reef slopes. Richards *et al.* (2013b) consider this to be a species that is globally widespread, locally restricted, and locally rare, and thus in the second rarest category with the predicted consequence of local extinction. Veron (2014) reports that *I. cuneata* occupied 5.1 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.76 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''uncommon.'' Overall abundance was described as ''uncommon.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least tens of millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *I. cuneata,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 37 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 15 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences of species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *I. cuneata* occurs in many areas affected by these broad changes, and likely has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible due to the limited species-specific information.

Other Biological Information

The SRR and SIR provided the following information on I. *cuneata'*s life history. *Isopora cuneata* is a simultaneous hermaphroditic brooder. Larvae lack zooxanthellae, and in some areas the species can undergo several seasonal cycles of larval production. Its brooding life history allows *Isopora* species to locally dominate recruitment at Lord Howe Island, Australia; colonies of this genus also dominate the adult population there, suggesting brooding may drive community structure in remote areas. *Isopora cuneata* is not prone to asexual reproduction via fragmentation, based on its semi-encrusting morphology. The species shows moderate gene flow but little potential for large-scale dispersal. Public comments and information we gathered did not provide anything additional to the above-described biological information.

Susceptibility to Threats

To describe *I. cuneata's* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Isopora* of ocean warming, acidification, disease, sedimentation, nutrients, predation, and collection and trade. The SRR and SIR also provided the following species-specific information on *I. cuneata's* threats. *Isopora cuneata* showed intermediate bleaching susceptibility relative to other acroporids on the Great Barrier Reef in 2002, but showed severe losses in a 2006 mass bleaching event in the Marshall Islands, with only shaded bases of colonies surviving. *Isopora cuneata* was a common species in the *Acropora palifera* zone of the Chagos, but *I. cuneata* was nearly completely eliminated in 1998 and has not yet regenerated. Competition with algae significantly reduces growth rates of *I. cuneata.* At high latitude Lord Howe Island, *I. cuneata* was found to host five types of C zooxanthellae, with an ability to host specialized types in turbid environments. The species is also capable of photo-adapting to low light environments by increasing zooxanthellae density altering photosynthetic mechanisms (dark reaction enzymes or electron transport rates). The SRR and SIR did not provide any other species-specific information on the effects of these threats on *I. cuneata.* We interpreted threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *I. cuneata* as follows: High vulnerability to ocean warming, moderate vulnerability to disease, acidification, trophic effects of fishing, and nutrients, and low vulnerability to sedimentation, sea-level rise, predation, and collection and trade.

Public comments did not provide any new or supplemental information on *I. cuneata'*s threats susceptibilities. We gathered the following species-specific and genus-level supplemental information on this species' threat susceptibilities. *Isopora cuneata* has been rated as moderately or highly susceptible to bleaching, but this rating is not based on species-specific data (Carpenter *et al.,* 2008). Done *et al.* (2003b) reported that 20 percent of *I. cuneata* colonies on the GBR were affected by bleaching in 2002, and the species ranked 21st in proportion of coral colonies that were bleached or partially killed out of 52 studied *Acropora* and *Isopora* species. That is, 20 of the 52 species bleached more than *I. cuneata* and 31 bleached less.

Isopora cuneata has been rated as moderately or highly susceptible to disease, but this rating is not based on species-specific data (Carpenter *et al.,* 2008). Willis *et al.* (2004) report Black Band Disease on *I. cuneata* on No Name Reef in the Great Barrier Reef. No other species-specific information is available for the susceptibility of *I. cuneata* to any other threat. Based on genus-level and species information, *I. cuneata* is predicted to likely be highly susceptible to ocean warming and to have some susceptibility to disease, acidification, trophic effects of fishing, nutrients, sedimentation, sea-level rise, predation, and collection and trade.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *I. cuneata.* We received criticism of that approach in public comments and in response we present a species-specific analysis of regulatory mechanisms in this final rule. Records confirm that *I. cuneata* occurs in 43 Indo-Pacific ecoregions that encompass 23 countries' EEZs. The 23 countries are Australia, China, Federated States of Micronesia, Fiji, France (French Pacific Island Territories), Indonesia, Japan, Madagascar, Mauritius, New Zealand (Tokelau), Niue, Palau, Papua New Guinea, Philippines, Samoa, Solomon Islands, Taiwan, Timor-Leste, Tonga, Tuvalu, United States (American Samoa, PRIAs), Vanuatu, and Vietnam. The regulatory mechanisms relevant to *I. cuneata,* described first as the percentage of the above countries that utilize them to any degree and second, as the percentage of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (35 percent with four percent limited in scope), coral collection (65 percent with 30 percent limited in scope), pollution control (39 percent with 13 percent limited in scope), fishing regulations on reefs (100 percent with 13 percent limited in scope), and managing areas for protection and conservation (100 percent with none limited in scope). The most common regulatory mechanisms in place for *I. cuneata* are reef fishing regulations and area management for protection and conservation. Coral collection laws are also somewhat common for the species, but 30 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection and pollution control laws are much less common regulatory mechanisms for the management of *I. cuneata.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that factors that increase potential extinction risk for *I. cuneata* are high susceptibility to threats inferred to be common to members of the family Acroporidae. A factor that reduces potential extinction risk is its prevalence in areas of heavy wave action, as water motion may reduce bleaching vulnerability.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *I. cuneata,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution includes most of the coral reef ecoregions in the Indian Ocean and western and central Pacific Ocean. Its geographic distribution moderates vulnerability to extinction because some areas within its range are projected to have less than average warming and acidification over the foreseeable future, including the western Indian Ocean, the central Pacific, and other areas, so portions of the population in these areas will be less exposed to severe conditions. Its depth range is from low tide to at least 15 meters. On one hand, its depth range may moderate vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. On the other hand, its depth range may exacerbate vulnerability to extinction over the foreseeable future if the species occurs predominantly in the shallower portion of its depth range, since those areas will have higher irradiance and thus be more severely affected by warming-induced bleaching. Its habitat includes at least lower reef crests, reef flats, upper reef slopes, and lagoons. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. In addition, high energy environments experience high levels of mixing which can dilute adverse environmental conditions. Its absolute abundance of at least tens of millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule using the determination tool formula approach, *I. cuneata* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); common generalized range wide abundance (E); moderate overall distribution (based on wide geographic distribution and shallow depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *I. cuneata* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *I. cuneata's* spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to be likely to become endangered throughout its range within the foreseeable future, and thus it is not warranted for listing at this time, because:

(1) *Isopora cuneata'*s distribution across the Indian Ocean and most of the Pacific Ocean is spread over a very large area. While some areas within its range are projected to be affected by warming and acidification, other areas are projected to have less than average warming and acidification, including the western Indian Ocean, the central Pacific, and other areas. This distribution and the heterogeneous habitat it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future);

(2) *Isopora cuneata'* absolute abundance is at least tens of millions of colonies, providing buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response; and

(3) It is a broadcast spawner and fast grower, enhancing recovery potential from mortality events as described in the Corals and Coral Reefs section above.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future if global threats continue and worsen in severity and the species' exposure to the threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *I. cuneata* is not warranted for listing at this time under any of the listing factors.

Genus Montipora

Genus Introduction

The SRR and SIR provided an introduction to Indo-Pacific *Montipora,* covering geological history, taxonomy, life history, and threat susceptibilities of the genus as a whole. *Montipora* colonies are usually laminar, encrusting, massive, or branching, and usually have small protrusions between corallites, called papillae, tuberculae, or verrucae. The genus *Montipora* is the second largest genus of reef corals, with 75 species currently recognized, all in the Indo-Pacific.

Genus Susceptibility to Threats

The SRR and SIR provided the following information on genus-level threat susceptibilities for *Montipora. Montipora* has a high susceptibility to bleaching, just below *Acropora* and *Millepora.* One species of *Montipora* has been tested for susceptibility to acidification, and was predicted to have 10 to 15 percent reductions in growth to pH by 2100. *Montipora* species have moderate susceptibility to diseases. *Montipora* has been characterized as a ''sediment-intolerant'' genus, but individual species range from tolerant to intolerant. Elevated nutrients have not been found to affect *Montipora* fecundity or fertilization. Crown-of-thorns seastar prey preferentially on *Montipora* and crown-of-thorns seastar outbreaks can cause substantial mortality. The genus *Montipora* is heavily used in the international aquarium trade.

The public comments did not provide any supplemental information on genus-level threat susceptibilities for Indo-Pacific *Montipora.* We gathered supplemental information, which provides the following genus-level information on threat susceptibilities of Indo-Pacific *Montipora* for ocean warming (thermal stress), coral disease, ocean acidification, and predation. With regard to thermal stress, almost all *Montipora* on the reef flats of two islands in the Thousand Islands of Indonesia died in the 1983 El Nino mass bleaching. A branching species, *Montipora digitata,* subsequently recovered on one island but not the other (Brown and Suharsono, 1990). In Moorea in 1998, *Montipora* was the third most affected genus by bleaching after *Montastraea* and *Acropora,* and second in mortality, with slightly less mortality than *Acropora* (Gleason, 1993). In Palau in 2000, many but not all *Montipora* species had heavy bleaching. In that event, 48 percent of all coral colonies of all species were bleached, with bleaching of different genera and species ranging from none to very high, and mortality from none to near 100 percent (Bruno *et al.,* 2001). In Kenya in 1998, unprotected and protected sites were compared, and it was found that all *Montipora* species in unprotected sites died during the mass bleaching event while only half of the *Montipora* species in marine protected areas died (McClanahan *et al.,* 2001). In 1998 in Kenya, Tanzania, Mozambique, and Madagascar, 100 percent of *M. tuberculosa* colonies were affected by bleaching at the peak of bleaching, and 13 percent of the colonies died by the end of the bleaching event (Obura, 2001). In Raiatea, French Polynesia, in 2002, 53 percent of *Montipora tuberculosa* colonies and 18 percent *Montipora caliculata* colonies were bleached respectively, the third and fifth most bleached species of the 11 coral species included in the study (Hughes *et al.,* 2003).

On the GBR in 2002, 18 species of *Montipora* ranged from zero to 77 percent affected by bleaching (Done *et al.,* 2003b). During mass bleaching in 1998, *Montipora* had a higher bleaching index in Kenya (64) than in Australia (38), but seawater temperatures were higher in Kenya (McClanahan *et al.,* 2004). At Mauritius in a bleaching event in 2004, *Montipora* had a bleaching index of 27, the 8th highest of the 32 genera recorded, which was 41 percent of the index of the genus with the highest index (McClanahan *et al.,* 2005a). In the western Indian Ocean in 1998–2005, *Montipora* had a bleaching index of 7.9 for eight countries, which was 34th highest of the 45 genera recorded, and 19 percent of the highest value (McClanahan *et al.,* 2007a). On Howland and Baker islands in the U.S. Pacific in early 2010, *Montipora* had a low percentage of bleaching with zero percent bleached on Baker and 4.8 percent on Howland. *Montipora* was the 13th most bleached genus out of 14 genera reported, with 4 percent as much bleaching as the most bleached genus (Vargas-Angel *et al.,* 2011). In a mass bleaching event in Western Australia, *Acropora* had the highest mortality, with *Montipora* having the second highest mortality (87 percent), while massive and encrusting corals (such as *Porites* and faviids) had much higher survival rates. Colonies less than 10 cm in size were not killed (Depczynski *et al.,* 2012).

In Okinawa, Japan, *Montipora* species experienced moderate drops in populations following the 1998 and 2010 mass bleaching episodes (Hongo and Yamano, 2013). At Laem Set at Samui Island in the western Gulf of Thailand in 1998, half of all colonies of *M. tuberculosa* were partly bleached, and in 2010 all colonies were bleached. It was the 10th most bleached species out of 24 species in 1998, and was tied with seven other species out of 24 for most bleached in 2010. After the 1998 bleaching event, 75 percent of *M. tuberculosa* colonies had partial mortality, and after the 2010 event all colonies were dead. In 1998 it was tied for third place in mortality, and in 2010 it was in a three-way tie for most mortality (Sutthacheep *et al.,* 2013). In Kenya in 1998, 47 percent of *Montipora* colonies bleached, and of those, 73 percent died. Mortality was the fifth highest of any coral genus. The abundance of *Montipora* after 1998 in the western Indian Ocean decreased strongly in proportion to the number of degree heating weeks in 1998 (McClanahan *et al.,* 2007b). In Japan, one species of *Montipora* was a long-term winner following mass bleaching events (increasing from 0.2 percent to 2 percent cover), one species was a short term loser but a long term winner (decreasing from 1.8 percent to zero percent, and then increasing to 3.3 percent later), and one species was a long-term loser (decreasing from 1.6 percent to zero percent cover and staying there) (van Woesik *et al.,* 2011).

With regard to disease, a very low level of Black Band Disease was found on *Montipora* on the Great Barrier Reef, just 3 percent of the level on staghorn *Acropora* (Page and Willis, 2006). *Montipora* had a low susceptibility to Skeletal Eroding Band in the GBR, with a prevalence of 0.4 percent. Skeletal Eroding Band is the most prevalent disease on the GBR (Page and Willis, 2007). *Montipora* was had the second lowest rate of disease in American Samoa of the five genera with the most disease in American Samoa, with 0.08 percent prevalence. The highest rate of disease was *Acropora* with 0.39 percent prevalence. About 14 percent of sites in American Samoa have growth anomalies recorded on *Montipora,* compared to 71 percent for white syndrome on *Acropora,* so disease is relatively low on *Montipora* in American Samoa (Fenner and Heron, 2008). *Montipora* had the fourth highest prevalence of disease of coral genera in American Samoa at 0.06 percent, with the highest being *Acropora* at 0.85 percent (Aeby *et al.,* 2008). In Guam, *Montipora* had the fourth highest prevalence out of 12 genera, with 2 percent of colonies having disease compared to 6.7% for the highest genus (Myers and Raymundo, 2009). In New Caledonia, *Montipora* was tied for lowest disease prevalence among 12 genera, with less than 0.1 percent prevalence (Tribollet *et al.,* 2011). In Indonesia, *Montipora* had the eighth highest prevalence of disease out of 35 taxa, with 0.5 percent prevalence compared to 8 percent for the highest taxon (Haapkyla *et al.,* 2007).

With regards to predation, *Montipora* was the third most preferred prey of crown-of-thorns starfish out of the 10 most common genera on 15 reefs in the Great Barrier Reef, with a preference estimate 81 percent as high as the highest genus (*Acropora)* (De'ath and Moran, 1998). With regards to sedimentation, *M. aequituberculata* was the poorest species of 22 at clearing sediment off itself (Stafford-Smith, 1993).

Genus Conclusion

Based on the information from the SRR, SIR, public comments, and supplemental information, we can make the following inferences about the susceptibilities of an unstudied *Montipora* species to ocean warming, disease, acidification, sedimentation, nutrients, trophic effects of fishing, sea-level rise, predation, and collection and trade. The SRR rated ocean warming and disease as ''high'' importance, and ocean acidification as ''medium-high'' importance, to corals. These were rated as the three most important threats to reef-building corals overall. Most studies report that the genus *Montipora* shows high rates of bleaching from ocean warming, almost as much as *Acropora* and *Millepora.* However, there was a range of bleaching responses reported for the genus *Montipora,* and a study of individual species showed a wide range of bleaching responses between species, with some not bleaching at all. While there is variability in the available information on the susceptibility of *Montipora* species to ocean warming, most of the information suggests high susceptibility. Thus, we conclude that an unstudied species of *Montipora* likely is highly susceptible to ocean warming. *Montipora* has been reported to have low to moderate rates of disease, thus we conclude that *Montipora* is likely to have some susceptibility to disease. One species of *Montipora* showed a reduction in growth at the acidification level anticipated for the end of the century, but gamete production was not affected. Thus we conclude that *Montipora* is likely to have some susceptibility to ocean acidification.

The SRR rated the trophic effects of fishing as ''medium'' importance, the fourth most important threat to corals overall. This threat was not addressed at the genus or species level in the SRR or SIR, because it is an ecosystem-level process. That is, removal of herbivorous fish from coral reef systems by fishing alters trophic interactions by reducing herbivory on algae, thereby providing a competitive advantage for space to algae over coral. Thus, the SRR did not discuss this threat in terms of coral taxa, as its effects are difficult to distinguish between coral genera and species. Therefore, an unstudied *Montipora* species is likely to have some susceptibility to the trophic effects of fishing.

The SRR rated sedimentation, nutrients, and sea-level rise as ''low-medium'' importance to corals overall. *Montipora* has been called a ''sediment-intolerant'' genus but there are variations in tolerance between species. We conclude that *Montipora* has some susceptibility to sedimentation. Elevated nutrients have had no effect on fecundity or fertilization success in *Montipora,* but competition with algae reduced settlement and survival of *Montipora* larvae. We conclude that *Montipora* has some susceptibility to nutrients. Sea-level rise was not addressed at the genus or species level in the SRR or SIR. Increasing sea levels may increase land-based sources of pollution due to inundation, resulting in changes to coral community structure, thus an unstudied *Montipora* species is likely to have some susceptibility to sea-level rise. The little available information on predation of *Montipora* suggest that predators prefer to eat *Montipora* over most other genera. Thus, it is possible to predict that an unstudied *Montipora* species is likely to have some susceptibility to predation. The SRR rated ornamental trade (referred to in the proposed rule as Collection and Trade) as ''low'' importance to corals overall, and this threat was addressed at both the genus and species levels in the SRR. Because *Montipora* species are some of the more popular coral species to be collected and traded, an unstudied *Montipora* species is likely to have some susceptibility to collection and trade.

In conclusion, an unstudied *Montipora* species is likely to have high susceptibility to ocean warming, and some susceptibility to disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade.

Montipora angulata

Introduction

The SRR and SIR provided the following information on *M. angulata's* morphology and taxonomy. Morphology was described as extensive encrusting bases with short branches that form compact clumps and are pale brown in color. Genetic evidence places *M. angulata* in a clade with some other *Montipora* species, depending on which gene is used. The SRR treated *M. angulata* as a valid species.

The public comments and information we gathered did not provide information on morphology, and confirmed that the species has low uncertainty in morphological taxonomy. Clustering with other species in an initial genetics study gives moderate uncertainty. There is a moderate level of species identification uncertainty for this species, but Veron (2014) states that *M. angulata* is distinctive and Veron (2000; 2014), considers the species valid, and that it is sufficiently distinctive to be identified by experts (Fenner, 2014b). Thus, we conclude that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *M. angulata's* distribution, habitat and depth. *Montipora angulata's* distribution is from the northern and eastern Indian Ocean to the central Indo-Pacific to the central Pacific. Its habitat includes upper reef slopes, mid-slopes, lower reef crests, and reef flats, and its depth distribution is one to 20 m.

The public comments did not provide any new or supplemental information on *M. angulata's* distribution. We gathered supplemental information, including Veron (2014), which reports that this species is confirmed in 34 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional 26.

Demographic Information

The SRR and SIR provided the following information on *M. angulata's* abundance. *Montipora angulata's* abundance is mostly rare.

The public comments did not provide any new or supplemental information on *M. angulata's* abundance. We gathered supplemental information, which provided the following information. Worldwide, reef flats have a larger area than reef slopes (Vecsei, 2004), and most coral abundance surveys are carried out only on reef slopes, and thus may significantly underestimate the abundance of species such as *M. angulata* that occur primarily on reef flats. Veron (2014) reports that *M. angulata* occupied 0.34 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.3 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''rare,'' and overall abundance was also described as ''rare.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least millions of colonies.

Carpenter *et al.* (Carpenter *et al.,* 2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *M. angulata,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 39 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 16 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *M. angulata* occurs in many areas affected by these broad changes, and likely has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible due to the limited species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *M. angulata's* life history. The sexuality and reproductive modes have been determined for 35 other species of *Montipora,* all of which are hermaphroditic broadcast spawners. Also, the larvae of all other *Montipora* species studied contain zooxanthellae that can supplement maternal provisioning with energy sources provided by their photosynthesis. Thus, these characteristics likely occur in *M. angulata* as well. The public comments and information we gathered provided no additional biological information.

Susceptibility to Threats

To describe *M. angulata's* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Montipora* of ocean warming, acidification, disease, predation, sedimentation, nutrients, and collection and trade. The SRR and SIR also provided the following species-specific information on *M. angulata's* threats. *Montipora angulata* contains Clade C zooxanthella; this clade varies in its thermal tolerance, but is generally less resistant to bleaching than Clade D. The SRR and SIR did not provide any other species-specific information on the effects of these threats on *M. angulata.* We interpreted the threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *M. angulata's* vulnerabilities as follows: High vulnerability to ocean warming; moderate vulnerability to disease, ocean acidification, trophic effects of reef fishing, nutrients, and predation, and low vulnerability to sedimentation, sea level rise, and collection and trade.

Public comments did not provide any new or supplemental information on *M. angulata's* threat susceptibilities. We gathered the following species-specific and genus-level supplemental information on this species' threat susceptibilities. *Montipora angulata* has been rated as moderately or highly susceptible to bleaching, but this rating is not based on species-specific data (Carpenter *et al.,* 2008). In one study, colonies of *M. angulata* contained Clade C zooxanthellae (Good *et al.,* 2005). However, other *Montipora* species are known to contain Clade D zooxanthellae, depending on colony location or depth (LaJeunesse *et al.,* 2004b; Stat *et al.,* 2009). Thus, it is possible that broader sampling of *M. angulata* colonies would show that this species also hosts Clade D zooxanthellae in some habitats. There are no studies of the effects of any other threats on *M. angulata.* Based on species-specific and genus-level information described above, *M. angulata* is likely to be highly susceptible to ocean warming and likely to have some susceptibility to disease, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade. The available information does not support more precise ratings of the susceptibilities of *M. angulata* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *M. angulata.* Criticisms of our approach received during public comment led us to the following analysis to attempt to analyze regulatory mechanisms on a species basis. Records confirm that *M. angulata* occurs in 34 Indo-Pacific ecoregions that encompass 17 countries' EEZs. The 17 countries are Australia (including Cocos-Keeling Islands), Brunei, Cambodia, China, India (Andaman and Nicobar Islands), Indonesia, Japan, Malaysia, Myanmar, Papua New Guinea, Philippines, Solomon Islands, Sri Lanka, Taiwan, Thailand, Timor-Leste, and Vietnam. The regulatory mechanisms relevant to *M. angulata,* described first as the percentage of the above countries that utilize them to any degree and second, as the percentages of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (29 percent with 6 percent limited in scope), coral collection (41 percent with 18 percent limited in scope), pollution control (35 percent with 12 percent limited in scope), fishing regulations on reefs (100 percent with 18 percent limited in scope), and managing areas for protection and conservation (94 percent with none limited in scope). The most common regulatory mechanisms in place for *M. angulata* are reef fishing regulations and area management for protection and conservation. General coral protection, pollution control, and coral collection laws are much less common regulatory mechanisms for the management of *M. angulata.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that factors that increase the potential extinction risk for this species include its rare abundance combined with presumed generic vulnerability to a range of threats including disease, bleaching, and predation as well as potentially increasing threats from collection and trade. It listed factors that reduce potential extinction risk including its relatively wide geographic distribution.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *M. angulata,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution includes many coral reef ecoregions in the central Indo-Pacific oceans. Its geographic distribution moderates vulnerability to extinction because some areas within its range are projected to have less than average warming and acidification over the foreseeable future, including the central Pacific, and other areas, so portions of the population in these areas will be less exposed to severe conditions. Its depth range is from one to 20 meters. This moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower temperatures than surface waters due to local and micro-habitat variability in environmental conditions, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Its habitat includes upper reef slopes, mid-slopes, lower reef crests, and reef flats. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Although its qualitative abundance is described as rare, its absolute abundance is at least millions of colonies, which combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule using the determination tool formula approach, *M. angulata* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); uncommon generalized range wide abundance (E); wide overall distribution (based on wide geographic distribution and moderate depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *M. angulata* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including a more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *M. angulata'*s spatial structure, demography, threat susceptibilities, none of the five ESA listing factors, alone or in combination, are causing this species to be likely to become endangered throughout its range within the foreseeable future, and thus it is not warranted for listing at this time, because:

(1) *Montipora angulata'*s distribution across the central Indo-Pacific is spread over a large area. While some areas within its range are projected to be affected by warming and acidification, other areas are projected to have less than average warming and acidification, including the western Indian Ocean, the central Pacific, and other areas. This distribution and the heterogeneous habitats it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future) and

(2) While *M. angulata'*s qualitative abundance is characterized as rare, the species consists of at least millions of colonies that are broadly distributed, providing buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future if global threats continue and worsen in severity and the species' exposure to the threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *M. angulata* is not warranted for listing at this time under any of the listing factors.

Montipora australiensis

Introduction

The SRR and SIR provided the following information on *M. australiensis'* morphology and taxonomy. Morphology was described as thick plates and irregular columns that are pale brown, and the taxonomy was described as having no taxonomic issues.

The public comments and information we gathered did not provide any new or supplemental information on morphology, and confirmed that there are no known taxonomic problems for *M. australiensis.* There is a moderate level of species identification uncertainty for this species, and Veron (2014) states that *M. australiensis* is easily confused with several other *Montipora,* but Veron (2000; 2014) also considers the species valid, and we consider it is sufficiently distinctive to be identified by experts (Fenner, 2014b). Thus, we conclude that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *M. australiensis'* distribution, habitat, and depth range. *Montipora australiensis'* distribution is broad longitudinally, including eastern Africa, the central

Indo-Pacific, and the entire central Pacific, its habitat is shallow reef environments with high wave action, and its depth range is given as 2 to 30 meters, which the SRR noted seems at odds with the shallow reef environment habitat description.

The public comments did not provide any new or supplemental information on *M. australiensis'* distribution. We gathered supplemental information, including Veron (2014), which reports that this species is confirmed in 17 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional 16. Veron 2014 also provides a more recent geographic range description and map for this species which includes areas in the western Indian Ocean, and most ecoregions between southern Japan and the GBR, and between western Australia and Vanuatu. We did not gather or receive any information on habitat or depth, thus we interpret the available information as follows: Its predominant habitat is upper reef slopes, lower reef crests, and reef flats, and it likely also occurs on mid-slopes and possibly other habitats at depths of two to 30 m.

Demographic Information

The SRR and SIR provided the following information on *M. australiensis'* abundance. *Montipora australiensis* has been reported as rare.

The public comments did not provide any new or supplemental information on *M. australiensis'* abundance. We gathered supplemental information, including Veron (Veron, 2014), which reports that *M. australiensis* occupied 0.40 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.50 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''rare.'' Overall abundance was described as ''usually rare.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *M. australiensis,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 37 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 14. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context. Thus, quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *M. australiensis* occurs in many areas affected by these broad changes, and likely has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible due to the limited species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *M. australiensis'* life history. Sexuality and reproductive modes have been determined for 35 other species of *Montipora,* all of which are hermaphroditic broadcast spawners. Although specific observations have not been published for this species, the larvae of all other *Montipora* species studied contain zooxanthellae that can supplement maternal provisioning with energy sources provided by their photosynthesis. It is likely these characteristics occur in this species as well. The public comments and information we gathered provided no additional biological information.

Susceptibility to Threats

To describe *M. australiensis'* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Montipora* of ocean warming, acidification, disease, predation, sedimentation, nutrients, and collection and trade. The SRR and SIR did not provide any species-specific information on the effects of these threats on *M. australiensis.* We interpreted the threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *M. australiensis'* vulnerabilities as follows: High vulnerability to ocean warming, moderate vulnerability to disease, acidification, trophic effects of reef fishing, nutrients, and predation, and low vulnerability to sedimentation, sea level rise, and collection and trade.

Public comments did not provide any new or supplemental information on *M. australiensis'* threats susceptibilities. We gathered the following species-specific and genus-level information on this species' threat susceptibilities. *Montipora australiensis* has been rated as moderately or highly susceptible to bleaching, but this rating is not based on species-specific data (Carpenter *et al.,* 2008). There are no species-specific studies of the effects of any threats on *M. australiensis.* Based on the genus-level information described above, *M. australiensis* likely is highly susceptible to ocean warming, and likely has some susceptibility to disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, predation, and collection and trade. The available information does not support more precise ratings of the susceptibilities of *M. australiensis* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *M. australiensis.* Criticisms of our approach received during public comment led us to the following analysis to attempt to analyze regulatory mechanisms on a species basis. Records confirm that *M. australiensis* occurs in 17 Indo-Pacific ecoregions that encompass 13 countries' EEZs. The 13 countries are Australia, Cambodia, France (French Pacific Island Territories), Indonesia, Japan, Madagascar, Mauritius, Papua New Guinea, Philippines, Seychelles, Solomon Islands, Thailand, and Vietnam. The regulatory mechanisms relevant to *M. australiensis,* first described as the percentage of the above countries that utilize them to any degree and second, as the percentages of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (31 percent with 8 percent limited in scope), coral collection (46 percent with 8 percent limited in scope), pollution control (38 percent with 23 percent limited in scope), fishing regulations on reefs (100 percent with 8 percent limited in scope), and managing areas for protection and conservation (100 percent with none limited in scope). The most common regulatory mechanisms in place for *M. australiensis* are reef fishing regulations and area management for protection and conservation. Coral collection and pollution control laws are also somewhat common for the species, but 23 percent of pollution control laws are limited in scope and may not provide substantial protection. General coral protection laws are much less common regulatory mechanisms for the management of *M. australiensis.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated the factors that increase the potential extinction risk for *M. australiensis* include its rare abundance combined with presumed generic vulnerability to a range of threats including disease, bleaching, and predation. It listed factors that reduce potential extinction risk including its relatively wide geographic distribution.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *M. australiensis,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution is mostly limited to parts of the Coral Triangle and the western Indian Ocean. Despite the large number of islands and environments that are included in the species' range, this range exacerbates vulnerability to extinction over the foreseeable future because it is mostly limited to an area projected to have the most rapid and severe impacts from climate change and localized human impacts for coral reefs over the 21st century. Its depth range of two to at least 30 meters moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Its habitat includes upper reef slopes, lower reef crests, reef flats, and mid-slopes. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Additionally, habitats in high wave action have increased water mixing that can reduce irradiance and dilute other adverse environmental conditions. Its absolute abundance of at least millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time. However, its qualitative abundance is described as rare, which combined with its restricted depth distribution indicates it is likely that a high proportion of individuals will be affected by threats that are typically more severe in shallow habitats at any given point in time.

Listing Determination

In the proposed rule using the determination tool formula, *M. australiensis* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); uncommon generalized range wide abundance (E); wide overall distribution (based on wide geographic distribution and moderate depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we confirmed the listing determination for M. *australiensis* as threatened. Based on the best available information provided above on *A. lokani's* spatial structure, demography, threat susceptibilities, and management indicate that it is likely to become endangered throughout its range within the foreseeable future, and thus warrants listing as threatened at this time, because:

(1) *Montipora australiensis* is highly susceptible to ocean warming (ESA Factor E), and susceptible to disease (C), ocean acidification (E), trophic effects of fishing (A), and predation (C), and nutrients (A, E). These threats are expected to continue and worsen into the future. In addition, existing regulatory mechanisms for global threats that contribute to extinction risk for the species are inadequate (D);

(2) The majority of *Montipora australiensis'* distribution is within the Coral Triangle which is projected to have the most rapid and severe impacts from climate change and localized human impacts for coral reefs over the 21st century, as described in the Threats Evaluation. Multiple ocean warming events have already occurred within the western equatorial Pacific that suggest future ocean warming events may be more severe than average in this part of the world. A range constrained to this particular geographic area that is likely to experience severe and increasing threats indicates that a high proportion of the population of this species is likely to be exposed to those threats over the foreseeable future; and

(3) *Montipora australiensis'* qualitative abundance is rare. Considering the limited range of this species in an area where severe and increasing impacts are predicted, this level of abundance leaves the species vulnerable to becoming of such low abundance within the foreseeable future that it may be at risk from depensatory processes, environmental stochasticity, or catastrophic events, as explained in more detail in the Corals and Coral Reefs and Risk Analyses sections.

The combination of these characteristics and future projections of threats indicates that the species is likely to be in danger of extinction within the foreseeable future throughout its range and warrants listing as threatened at this time due to factors A, C, D, and E.

The available information above on *M. australiensis'* spatial structure, demography, threat susceptibilities, and management also indicate that the species the species is not currently in danger of extinction and thus does not warrant listing as Endangered because:

(1) While *M. australiensis'* range is mostly constrained to the Coral Triangle which increases it extinction risk as described above, other areas within its range are projected to have less than average warming and acidification, such as the western Indian Ocean. Additionally, its habitat includes upper reef slopes, lower reef crests, and reef flats, and it likely also occurs on mid-slopes. This moderates vulnerability to extinction currently because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time, as described in more detail in the Coral

Habitat and Threats Evaluation sections; and

(2) While *M. australiensis'* qualitative abundance is characterized as rare, its absolute abundance is at least millions of colonies. There is no evidence that this species is of such low abundance that depensatory processes, environmental stochasticity, or the potential for catastrophic events currently pose a high risk to the survival of the species.

The combination of these characteristics indicates that the species does not exhibit the characteristics of one that is currently in danger of extinction, as described previously in the Risk Analyses section, and thus does not warrant listing as endangered at this time.

Range-wide, a multitude of conservation efforts are already broadly employed that are likely benefiting *M. australiensis.* However, considering the global scale of the most important threats to the species, and the ineffectiveness of conservation efforts at addressing the root cause of global threats (*i.e.,* GHG emissions), we do not believe that any current conservation efforts or conservation efforts planned in the future will result in affecting the species status to the point at which listing is not warranted.

Montipora calcarea

Introduction

The SRR and SIR provided the following information on *M. calcarea'*s morphology and taxonomy. The morphology was described as irregular thick plates with columnar upgrowths and are pale brown or blue in color, and taxonomy was described as having no taxonomic issues.

The public comments and information we gathered did not provide information on morphology, and confirmed that there are no known taxonomic problems for *M. calcarea.* There is a moderate level of species identification uncertainty for this species, and Veron (2014) states that *M. calcarea* is easily confused with several other *Montipora,* but Veron (2000; 2014), considers the species valid, and we consider it is sufficiently distinctive to be identified by experts (Fenner, 2014b). Thus, we conclude the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *M. calcarea'*s distribution, habitat, and depth range. *Montipora calcarea'*s range is fairly wide but somewhat discontinuous, it is known from the Red Sea and east Africa, parts of the Coral Triangle, northwestern Australia, and the central Pacific. Its habitat includes at least upper reef slopes, mid-slopes, lower reef crests, and reef flats, and its depth range as 0 to 20 m.

The public comments did not provide any new or supplemental information on *M. calcarea'*s distribution. We gathered supplemental information, including Veron (2014), which reports that this species is confirmed in 25 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional 24. The public comments and information we gathered provided nothing additional on *M. calcarea'*s habitat and depth range.

Demographic Information

The SRR and SIR provided the following information on *M. calcarea'*s abundance. The abundance of *M. calcarea* has been reported as rare, but may be locally abundant in some areas.

The public comments did not provide any new or supplemental information on *M. calcarea'*s abundance, but the supplemental information provided the following. Surveys in Indonesia recorded the species at eight of 51 sites (Donnelly *et al.,* 2003), and nine of 39 sites (Turak and DeVantier, 2003). Veron (2014) reports that *M. calcarea* occupied 5.8 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.35 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''rare.'' Overall abundance was described as ''usually rare.'' As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least tens of millions of colonies.

Carpenter *et al.* (Carpenter *et al.,* 2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *M. calcarea,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 34 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 13 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *M. calcarea* occurs in many areas affected by these broad changes, and likely has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *M. calcarea'*s life history. The reproductive characteristics of *M. calcarea* have not been determined. However, sexuality and reproductive modes have been determined for 35 other species of *Montipora,* all of which are hermaphroditic broadcast spawners. Although specific observations have not been published for this species, the larvae of all other *Montipora* species studied contain zooxanthellae that can supplement maternal provisioning with energy sources provided by their photosynthesis. It is likely these characteristics occur in this species as well. The public comments and information we gathered provided no additional biological information.

Susceptibility to Threats

To describe *M. calcarea'*s threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Montipora* of ocean warming, acidification, disease, sedimentation, nutrients, predation, and collection and trade. The SRR and SIR also provided the following species-specific information on *M. calcarea'*s threats. *Montipora calcarea* was not susceptible to algal or sediment impacts in anthropogenically impacted waters in Egypt, but one of the studies appears to be a study of the effects of low tide. The SRR and SIR did not provide any other species-specific information on the effects of these threats on *M. calcarea.* We interpreted the threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *M. calcarea'*s vulnerabilities as follows: High vulnerability to ocean warming; moderate vulnerability to disease, ocean acidification, trophic effects of reef fishing, nutrients and predation, and low vulnerability to sedimentation, sea level rise, and collection and trade.

Public comments did not provide any new or supplemental information on *M. calcarea's* threats, but we gathered the following species-specific and genus-level information on this species' threat susceptibilities. *Montipora calcarea* has been rated as moderately or highly susceptible to bleaching but not disease, but this rating is not based on species-specific data (Carpenter *et al.,* 2008). There are no species-specific studies of the effects of any threats on *M. calcarea.* Based on the genus-level and species information described above, *M. calcarea* likely is highly susceptible to ocean warming, and also likely has some susceptibility to disease, ocean acidification, trophic effects of fishing, sedimentation nutrients, sea-level rise, predation, and collection and trade. The available information does not support more precise ratings of the susceptibilities of *M. calcarea* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *M. calcarea.* Criticisms of our approach received during public comment led us to the following analysis to attempt to analyze regulatory mechanisms on a species basis. Records confirm that *M. calcarea* occurs in 25 Indo-Pacific ecoregions that encompass 28 countries' EEZs. The 28 countries are Australia, Brunei, Djibouti, Eritrea, Federated States of Micronesia, Fiji, France (French Pacific Island Territories), Indonesia, Madagascar, Malaysia, Mauritius, Myanmar, New Zealand (Tokelau), Niue, Palau, Papua New Guinea, Philippines, Samoa, Saudi Arabia, Seychelles, Solomon Islands, Thailand, Timor-Leste, Tonga, Tuvalu, United States (American Samoa), Vietnam, and Yemen. The regulatory mechanisms relevant to *M. calcarea,* described first as the percentage of the above countries that utilize them to any degree and second, as the percentages of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (29 percent with 4 percent limited in scope), coral collection (61 percent with 25 percent limited in scope), pollution control (43 percent with 11 percent limited in scope), fishing regulations on reefs (100 percent with 14 percent limited in scope), and managing areas for protection and conservation (93 percent with none limited in scope). The most common regulatory mechanisms in place for the species are reef fishing regulations and area management for protection and conservation. Coral collection and pollution control laws are also somewhat common for *M. calcarea,* but 25 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection laws are much less common regulatory mechanisms for the management of *M. calcarea.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that factors that increase the potential extinction risk for *M. calcarea* include its rare abundance combined with presumed generic vulnerability to a range of threats including disease, bleaching, and predation. It listed factors that reduce potential extinction risk including its relatively wide geographic distribution.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *M. calcarea,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution includes the Red Sea and many of the coral reef ecoregions in the Indian Ocean and western and central Pacific Ocean. Its geographic distribution moderates vulnerability to extinction because some areas within its range are projected to have less than average warming and acidification over the foreseeable future, including the western Indian Ocean, the central Pacific, and other areas, so portions of the population in these areas will be less exposed to severe conditions. Its depth range is from zero to 20 meters. This moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Its habitat includes at least upper reef slopes, mid-slopes, lower reef crests, and reef flats. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Although its qualitative abundance is described as rare, its absolute abundance is at least tens of millions of colonies, which combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule using the determination tool formula approach, *M. calcarea* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); uncommon generalized range wide abundance (E); wide overall distribution (based on wide geographic distribution and moderate depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *M. calcarea* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *M. calcarea's* spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to be likely to become endangered throughout its range within the foreseeable future, and thus is not warranted for listing at this time, because:

(1) *Montipora calcarea's* distribution across the Red Sea, Indian Ocean and the central Pacific Ocean is spread over a very large area. While some areas within its range are projected to be affected by warming and acidification, other areas are projected to have less than average warming and acidification, including the western Indian Ocean, the central Pacific, and other areas. This distribution and the heterogeneous habitats it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future; and

(2) While *M. calcarea's* qualitative abundance is characterized as rare, the species consists of at least tens of millions of colonies that are broadly distributed, providing buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future if global threats continue and increase in severity and the species exposure to threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *M. calcarea* is not warranted for listing at this time under any of the listing factors.

Montipora caliculata

Introduction

The SRR and SIR provided the following information on *M. caliculata's* morphology and taxonomy. Morphology was described as brown or blue and massive, and corallites are a mixture of immersed and foveolate (in a funnel shape). The taxonomy was described as having no taxonomic issues.

The public comments and information we gathered did not provide any new or supplemental information on morphology, and confirmed that there is little taxonomic uncertainty for *M. caliculata.* There is a moderate level of species identification uncertainty for this species, and Veron (2014) states that *M. caliculata* is easily confused with several other *Montipora,* but Veron (2000; 2014) also considers the species valid, and we consider it is sufficiently distinctive to be identified by experts (Fenner, 2014b). Thus, the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *M. caliculata's* distribution, habitat, and depth range. *Montipora caliculata* is found in the central Indo-Pacific and the Pacific as far east as the Pitcairn Islands. Its habitat includes at least upper reef slopes, mid-slopes, lower reef crests, and reef flats, and its depth range extends as deep as 20 m.

The public comments did not provide any new or supplemental information on *M. caliculata's* distribution. We gathered supplemental information, including Veron (2014), which reports that this species is confirmed in 53 of his 133 Indo-Pacific ecoregions, and strongly predicted to occur in an additional 29. The public comments and information we gathered provided nothing additional on *M. caliculata's* habitat and depth range.

Demographic Information

The SRR and SIR provided the following information on *M. caliculata's* abundance. *Montipora caliculata* has been reported as uncommon.

The public comments did not provide any new or supplemental information on *M. caliculata's* abundance. We gathered supplemental information, including surveys in Indonesia and Vietnam that recorded the species at ten of 51 sites (Donnelly *et al.,* 2003), and five of seven sites (Latypov, 2011), respectively. Veron (2014) reports that *M. caliculata* occupied 12.1 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.55 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''common.'' Overall abundance was described as ''uncommon.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least tens of millions of colonies.

Carpenter *et al.* (Carpenter *et al.,* 2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *M. caliculata,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 36 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 14 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *M. caliculata* occurs in many areas affected by these broad changes, and likely has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *M. caliculata's* life history. The sexuality and reproductive modes have been determined for 35 other species of *Montipora,* all of which are hermaphroditic broadcast spawners. Although specific observations have not been published for this species, the larvae of all other *Montipora* species studied contain zooxanthellae that can supplement maternal provisioning with energy sources provided by their photosynthesis. It is likely these characteristics occur in this species as well. The public comments and information we gathered provided no additional biological information.

Susceptibility to Threats

To describe *M. caliculata's* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Montipora* of ocean warming, acidification, disease, predation, sedimentation, nutrients, and collection and trade. The SRR and SIR also provided the following species-specific information on *M. caliculata's* threats. *Montipora caliculata* is known to contain mycosporine-like amino acids, which can play a role in reducing bleaching exposure. However, *M. caliculata* was the 7th most susceptible to bleaching of the 18 *Montipora* listed on the Great Barrier Reef, but showed only moderate bleaching (~ 20%, or less than half as susceptible as congener *Montipora tuberculosa*) in French Polynesia during the 2002 bleaching event. The SRR and SIR did not provide any other species-specific information on the effects of these threats on *M. caliculata.* We interpreted the threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *M. caliculata's* vulnerabilities as follows: High vulnerability to ocean warming; moderate vulnerability to disease, ocean acidification, trophic effects of reef fishing, nutrients and predation, and low vulnerability to sedimentation, sea level rise, and collection and trade.

Public comments did not provide any new or supplemental information on *M. caliculata's* threats, but we gathered the following species-specific and genus-level supplemental information on this species' threat susceptibilities. *Montipora caliculata* has been rated as moderately or highly susceptible to bleaching, but this rating is not based on species-specific data (Carpenter *et al.,* 2008). Done *et al.* (2003b) report 50 percent of colonies of *M. caliculata* were affected by bleaching on the GBR in 2002. This was more than 11 out of 17 *Montipora* species and 67 percent as much as the species that bleached the most. No other species-specific information is available for the susceptibility of *M. caliculata* to any other threat. Based on genus-level and species information described above, *M. caliculata* may be highly susceptible to ocean warming, and likely has some susceptibilities to disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, predation, and collection and trade. The available information does not support more precise ratings of the susceptibilities of *M. caliculata* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *M caliculata.* Criticisms of our approach received during public comment led us to the following analysis to attempt to analyze regulatory mechanisms on a species basis. Records confirm that *M caliculata* occurs in 53 Indo-Pacific ecoregions that encompass 36 countries' EEZs. The 36 countries are Australia, Brunei, Cambodia, China, Djibouti, Eritrea, Federated States of Micronesia, Fiji, France (French Pacific Island Territories), India (Andaman and Nicobar Islands), Indonesia, Japan, Kiribati, Madagascar, Malaysia, Marshall Islands, Myanmar, Nauru, New Zealand (Cook Islands, Tokelau), Niue, Palau, Papua New Guinea, Philippines, Samoa, Saudi Arabia, Solomon Islands, Taiwan, Thailand, Timor-Leste, Tonga, Tuvalu, United Kingdom (Pitcairn Islands), United States (CNMI, Guam, American Samoa, PRIAs), Vanuatu, Vietnam, and Yemen. The regulatory mechanisms relevant to *M. caliculata,* described first as the percentage of the above countries that utilize them to any degree and second, as the percentages of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (28 percent with three percent limited in scope), coral collection (58 percent with 31 percent limited in scope), pollution control (36 percent with eight percent limited in scope), fishing regulations on reefs (97 percent with 19 percent limited in scope), and managing areas for protection and conservation (92 percent with six percent limited in scope). The most common regulatory mechanisms in place for *M. caliculata* are reef fishing regulations and area management for protection and conservation. Coral collection laws are also somewhat common for the species, but 31 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection and pollution control laws are much less common regulatory mechanisms for the management of *M. caliculata.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that factors that increase the potential extinction risk for *M. caliculata* include its presumed generic vulnerability to a range of threats including disease, bleaching, and predation. It listed factors that reduce potential extinction risk including its relatively wide geographic distribution.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *M. caliculata,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution includes most of the coral reef ecoregions in the Indian Ocean and western and central Pacific Ocean. Its geographic distribution moderates vulnerability to extinction because some areas within its range are projected to have less than average warming and acidification over the foreseeable future, including the western Indian Ocean, the central Pacific, and other areas, so portions of the population in these areas will be less exposed to severe conditions. Its depth range is down to at least 20 meters. This moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Its habitat includes at least upper reef slopes, mid-slopes, lower reef crests, and reef flats. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Its absolute abundance of at least tens of millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule using the determination tool formula approach, *M. caliculata* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); uncommon generalized range wide abundance (E); wide overall distribution (based on wide geographic distribution and moderate depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *M. caliculata* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *M. caliculata's* spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to be likely to become endangered throughout its range within the foreseeable future, and thus is not warranted for listing at this time, because:

(1) *Montipora caliculata'*s distribution from the Red Sea across the Indian Ocean and most of the Pacific Ocean is spread over a very large area. While some areas within its range are projected to be affected by warming and acidification, other areas are projected to have less than average warming and acidification, including the western Indian Ocean, the central Pacific, and other areas. This distribution throughout the entire region and the heterogeneous habitats it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future; and

(2) *Montipora caliculata'*s absolute abundance is at least tens of millions of colonies, providing buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future if global threats continue and increase in severity and the species exposure to threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *M. caliculata* is not warranted for listing at this time under any of the listing factors.

Montipora dilatata/flabellata/turgescens

Introduction

As discussed above in the response to comments, public comments did not provide any new or supplemental information, nor did we find any new or supplemental information, contradicting the key study used by the SRR to lump these nominal species (see SRR for further explanation) into one species as a listable entity under the ESA. The SRR and SIR provided the following information on *M. dilatata/flabellate/turgescens'* morphology and taxonomy. *Montipora dilatata* morphology was described as colonies that are encrusting to submassive, with irregular branch-like upgrowths, and are pale to dark brown in color. *Montipora flabellata* morphology was described as colonies that are encrusting, with irregular lobes, and usually blue in color, but sometimes brown or purple. *Montipora turgescens* morphology was described as colonies that are massive, flat, hemispherical or columnar and are brown, cream, or purple in color.

The public comments and information we gathered did not provide any new or supplemental information on morphology, and confirmed that *M. dilatata/flabellata/turgescens* has little taxonomic uncertainty, but a moderate level of species identification uncertainty. One public comment stated that *M. dilatata* and *M. flabellata* were described by Studer, 1901, instead of Dana, 1846 as stated in the SRR. Veron (2014) states that *M. dilatata* and *M. flabellata* are apparently distinctive, and *M. turgescens* is distinctive and Veron (2000; 2014) considers these species valid, so we consider these morphological variations of this single species sufficiently distinctive to be identified by experts (Fenner, 2014b). Thus, we consider the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *M. dilatata/flabellata/turgescens'* distribution, habitat, and depth range. The distribution of this species is the sum of the distributions of the three nominal species. *Montipora dilatata* and *M. flabellata* are in Hawaii and *M. turgescens* ranges from the Red Sea and east Africa to French Polynesia, thus the whole entity ranges from the Red Sea and east Africa to Hawaii and French Polynesia. This species' habitat includes at least upper reef slopes, mid-slopes, lower reef slopes, lower reef crests, reef flats, and lagoons, and extends to 30 m deep.

The public comments provided the following supplemental information. One public comment stated that *M.* turgescens that was reported by Fenner (2005) to be restricted within Hawaii and the Northwestern Hawaiian Islands. We gathered supplemental information which provided the following. *Montipora dilatata* was previously only known from Hawaii, but has recently been reported to occur in the northern and southern Line Islands of Kiribati and the Cook Islands (Veron, 2014). Within Hawaii, *M.* dilatata has only been observed at Kaneohe Bay on Oahu and at Laysan Island in the northwestern Hawaiian Islands. However, the Laysan location has not been confirmed recently and may need further investigation. *Montipora flabellata* was also previously known only from Hawaii (Veron, 2000), but has recently been reported to occur in the northern Line Islands of Kiribati (Veron, 2014). In contrast, *M. turgescens* is broadly distributed throughout the Indo-Pacific from South Africa and Socotra Island to Hawaii and French Polynesia, and from Japan to the mid-latitudes in Australia (Veron, 2014). Veron (Veron, 2014)) confirms *M. dilatata* in four of his 133 Indo-Pacific ecoregions (northwestern and main Hawaiian Islands and the northern and southern Line Islands), *M. flabellata* from three of the same four ecoregions (all but the southern Line Islands), and *M. turgescens* in 71 (including both Hawaii ecoregions but neither Line Islands ecoregions). Thus, *M. dilatata/flabellata/turgescens* is confirmed in 73 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional 30 (Veron, 2014).

Montipora dilatata is reported from subtidal environments (Veron, 2000). In the only location within the main Hawaiian Islands where *M.* dilatata is known, Kaneohe Bay on Oahu, it is limited to shallow water protected from wave action. *Montipora flabellata* is reported from shallow reef environments, and *M. turgescens* is reported from most reef environments (Veron, 2000). *Montipora dilatata* and *M. flabellata* are both reported from 1 to 10 m depth, whereas *M. turgescens* has been reported to 30 m depth (Carpenter *et al.,* 2008). Thus we consider the depth range for this species to be from one to at least 30 meters.

Demographic Information

The SRR and SIR provided the following information on *M. dilatata/flabellata/turgescens'* abundance. *Montipora dilatata* is rare, *M. flabellata* is the 5th most common coral in Hawaii, and *M. turgescens* is described as common.

Public comments provided the following. One comment provided quantitative transect data from Hawaii that included coral cover measures of *M. flabellata.* At Kahului Harbor channel entrance, *M. flabellata* was the most abundant coral. At several other sites, *M. flabellata* was not recorded or was recorded at low levels. Supplemental information provided the following. Veron (2014) reports that *M. dilatata* and *M. turgescens* occupied 0.03 and 16.66 percent respectively of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 3.0 and 1.40 respectively on a 1 to 5 rating scale at those sites in which it was found. The ''mean abundance when present'' rating of 3.0 for *M. dilatata* was the highest of all species in Veron (2014), indicating that it was highly abundant at the few sites where it was observed. Based on this semi-quantitative system, *M. dilatata* and *M. turgescens'* abundances were characterized as ''rare'' and ''common'' respectively, and overall abundances were also described as ''rare'' and ''common'' respectively. *Montipora flabellata* was not encountered in their surveys because they did not survey in Hawaii (Veron, 2014). Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least tens of millions of colonies.

Montipora dilatata and *M. turgescens* are rare in the main Hawaiian Islands, thus they are not recorded in the Hawaii Coral Reef Assessment and Monitoring Program (CRAMP) data-sets. In contrast, CRAMP results indicate that *M. flabellata* has an overall statewide mean cover of 2.2 percent, making it the fifth most abundant coral in the main Hawaiian Islands (CRAMP, 2008a). Jokiel and Brown (2004) reported *M. flabellata* as the sixth most abundant coral in the main Hawaiian Islands, with 0.7 percent cover. A model predicted that *M. flabellata* was sixth in coral cover of all corals in the Main Hawaiian Islands, with about 0.3 percent cover (Franklin *et al.,* 2013). Kenyon and Brainard (2006) reported that *M. flabellata* and *M. turgescens* along with *M. capitata* dominate many backreef locations on the northern three atolls in the Northwestern Hawaiian Islands. Hunter (2011) reported that the number of *M. dilatata* colonies in Kaneohe Bay, Oahu has increased with increasing search effort, and in 2010 a total of 43 confirmed *M. dilatata* colonies were located. This is the only location in the main Hawaiian Islands where *M. dilatata* is known to occur.

There is no overall abundance trend information for *M. dilatata, M. flabellata,* or *M. turgescens,* but *M. flabellata* has been monitored on some time-series transects in Hawaii. Dollar and Grigg (2004) monitored coral cover over 12 and 20 year periods at three sites in Hawaii, each with multiple transects: a semi-enclosed embayment on Maui and two open coastal sites on Kauai and the Big Island. At the Maui site, overall live coral cover declined by approximately 33 percent from 1990 to 2002. *Montipora flabellata* cover increased from 6.9 to 7.1 percent of total live coral cover, and was the fifth most abundant coral. At the Kauai site, overall live coral cover increased by approximately 30 percent from 1983 to 2002. *Montipora flabellata* increased from 7.4 to 14.3 percent of total live coral cover and was the fourth most abundant coral. At the Big Island site, overall live coral cover increased by approximately 50 percent from 1983 to 2002, but *M. flabellata* was not present during the study (Dollar and Grigg, 2004).

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *M. turgescens,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 20 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 9 percent. Estimates for *M. dilatata* and *M. flabellata* were not available. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years. These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *M. turgescens* occurs in many areas affected by these broad changes, and likely has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited information.

Other Biological Information

The SRR and SIR provided the following information on *M. dilatata/flabellata/turgescens'* life history. *Montipora dilatata/flabellata/turgescens* is a hermaphroditic broadcast spawner. The public comments and information we gathered provided no additional biological information.

Susceptibility to Threats

To describe *M. dilatata/flabellata/turgescens'* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Montipora* of ocean warming, disease, ocean acidification, sedimentation, nutrients, predation, and collection and trade. The SRR and SIR also provided the following species-specific information on *M. dilatata/flabellata/turgescens'* threats. *Montipora dilatata* and *M. flabellata* are highly susceptible to bleaching, with substantial local declines of *M. dilatata* in Kāne‘ohe Bay, Hawai‘i, from bleaching mortality. The SRR and SIR did not provide any other species-specific information on the effects of these threats on *M. dilatata/flabellata/turgescens.* We interpreted the susceptibility and exposure information from the SRR and SIR in the proposed rule for *M. dilatata/flabellata/turgescens'* vulnerabilities as follows: High vulnerability to ocean warming, moderate vulnerability to disease, ocean acidification, trophic effects of reef fishing, nutrients, and predation, and low vulnerability to sedimentation, sea level rise, and collection and trade.

Public comments did not provide any new or supplemental information on *M. dilatata/flabellata/turgescens'* threats, but we gathered the following species-specific and genus-level supplemental information on this species' threat susceptibilities. *Montipora dilatata, M. flabellata,* and *M. turgescens* have each been rated as moderately or highly susceptible to bleaching but not to disease, however, these ratings are not based on species-specific data (Carpenter *et al.* 2008). With regard to thermal stress, in the Northwest Hawaiian Islands, *M. turgescens* bleached much less severely than *Montipora capitata* in 2002 (G. Aeby personal comm.). Kenyon and Brainard (2006) report that in 2004, *M. capitata* and *M. turgescens* had high levels of bleaching in the northern three atolls, with up to 100 percent bleaching in some areas. *Montipora flabellata,* though, had very low levels of bleaching (1.2 to 4.7 percent). Jokiel and Brown (2004) reported that *M. dilatata* and *M. flabellata* had low resistance to bleaching in 1996 in Hawaii. *Montipora dilatata* was the most sensitive species to bleaching in Kaneohe Bay in 1996. It was the first to bleach and few survived the event (Jokiel and Brown, 2004). The majority of the species-specific and genus-level information above suggests that *M. dilatata/flabellata/turgescens* likely is highly susceptible to warming-induced bleaching.

With regard to disease, *M. turgescens* is specifically described with mortality from a rapid tissue-loss (‘‘white’’) syndrome in the Northwestern Hawaiian Islands, and this condition affected more than 21 percent of *Montipora* colonies in a 2003 survey (Aeby, 2006). In the main Hawaiian Islands, an outbreak of filamentous bacterial diseases began in 2012 on Kauai, and continued in 2013, heavily affecting the *Montipora* species on these reefs, including *Montipora capitata, M. flabellata,* and *M. patula* (Work, 2013). *This* species appears to be highly susceptible to these diseases when environmental conditions are degraded, especially the larger colonies (Thierry Work, personal comm.).

Based on genus-level and species information described above, *M. dilatata/flabellata/turgescens* likely is highly susceptible to ocean warming, and likely has some susceptibilities to disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, predation, and collection and trade.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *M. dilatata/flabellata/turgescens.* Criticisms of our approach received during public comment led us to the following analysis to attempt to analyze regulatory mechanisms on a species basis. Records confirm that *M dilatata/flabellata/turgescens* occurs in 73 Indo-Pacific ecoregions that encompass 30 countries' EEZs. The 30 countries are Australia (including Norfolk Island), Brunei, Cambodia, China, Federated States of Micronesia, Fiji, France (French Pacific Island Territories), India (including Andaman and Nicobar Islands), Indonesia, Japan, Kiribati, Madagascar, Malaysia, Mauritius, Myanmar, New Zealand (Cook Islands), Palau, Papua New Guinea, Philippines, Seychelles, Solomon Islands, South Africa, Sri Lanka, Taiwan, Thailand, Timor-Leste, United States (Hawaii, PRIAs), Vanuatu, Vietnam, and Yemen. The regulatory mechanisms relevant to *M. dilatata/flabellata/turgescens,* described first as the percentage of the above countries that utilize them to any degree and second, as the percentages of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (33 percent with 10 percent limited in scope), coral collection (53 percent with 23 percent limited in scope), pollution control (43 percent with 10 percent limited in scope), fishing regulations on reefs (97 percent with 20 percent limited in scope), and managing areas for protection and conservation (97 percent with none limited in scope). The most common regulatory mechanisms in place for to *M. dilatata/flabellata/turgescens* are reef fishing regulations and area management for protection and conservation. Coral collection and pollution control laws are also somewhat common for the species, but 23 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection laws are less common regulatory mechanisms for the management of *M. dilatata/flabellata/turgescens.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that factors that increase the potential extinction risk for *M. dilatata/flabellata/turgescens* include its presumed generic vulnerability to a range of threats including ocean warming, disease, predation, as well as documented declines in Hawai‘i of the *M. dilatata* component. Factors that reduce potential extinction risk are the common occurrence and relatively wide geographic distribution of the *M. turgescens* component.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *M. dilatata/flabellata/turgescens,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution includes nearly all of the coral reef ecoregions in the Indian Ocean and western and central Pacific Ocean. Its geographic distribution moderates vulnerability to extinction because some areas within its range are projected to have less than average warming and acidification over the foreseeable future, including the western Indian Ocean, the central Pacific, and other areas, so portions of the population in these areas will be less exposed to severe conditions. Its depth range is from low tide to at least 30 meters. This moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Its habitat includes at least upper reef slopes, mid-slopes, lower reef slopes, lower reef crests, reef flats, and lagoons. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Its absolute abundance of tens to hundreds of millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule using the determination tool formula approach, *M. dilatata/flabellata/turgescens* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); common generalized range wide abundance (E); wide overall distribution (based on wide geographic distribution and moderate depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *M. dilatata/flabellata/turgescens* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *M. dilatata/flabellata/turgescens'* spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to be likely to become endangered throughout its range within the foreseeable future, and thus is not warranted for listing at this time, because:

(1) *Montipora dilatata/flabellata/turgescens'* distribution across the Indian Ocean and most of the Pacific Ocean is spread over a very large area. While some areas within its range are projected to be affected by warming and acidification, other areas are projected to have less than average warming and acidification, including the western Indian Ocean, the central Pacific, and other areas. This distribution and the heterogeneous habitats it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future; and

(2) *Montipora dilatata/flabellata/turgescens'* absolute abundance is at least tens of millions of colonies, providing buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future if global threats continue and increase in severity and the species exposure to threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *M. dilatata/flabellata/turgescens* is not warranted for listing at this time under any of the listing factors.

Montipora lobulata

Introduction

The SRR and SIR provided the following information on *M. lobulata'*s morphology and taxonomy. Colonies of *Montipora lobulata* are mottled brown or white and submassive. Colony surfaces consist of irregular mounds. There are no taxonomic issues for *M. lobulata.*

The public comments did not provide any new or supplemental information on *M. lobulata's* morphology and taxonomy. We gathered supplemental information on this species, which indicates a very high level of species identification uncertainty for this species. *Montipora lobulata* is too difficult to identify on reefs, even for experts, for the data collected on it to be reliable. Veron (2014) states that *M. lobulata* has a poorly known distribution and his distribution map is not suitable for analysis. Although Veron (2000; 2014), considers the species valid, we conclude it not sufficiently distinctive to be reliably identified (Fenner, 2014b). Thus, we do not consider the *M. lobulata* distribution and abundance information in the SRR or SIR to be sufficiently reliable and are unable to provide a reliable species description for *M. lobulata* in this final rule.

Listing Determination

In the proposed rule using the determination tool formula approach, *M. lobulata* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); uncommon generalized range wide abundance (E); narrow overall distribution (based on narrow geographic distribution and shallow depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

Based on the lack of information on *M. lobulata'*s distribution, abundance, and threat susceptibilities due to this species' identification uncertainty, we believe there is not sufficient evidence to support a listing determination of threatened or endangered. Therefore, we find that listing is not warranted at this time under any factor.

Montipora patula/verrilli

Introduction

The SRR and SIR provided the following information on *M. patula/verrilli'*s morphology and taxonomy. Morphology was described as encrusting or tiered plates that are tan in color, most often with purple polyps.

Due to taxonomic issues from recent genetic and micro-morphological analyses, the BRT chose to evaluate extinction risk of *Montipora patula/verrilli* as a species since they are indistinguishable genetically and micro-morphologically.

The public comments provided the following information on morphology and taxonomy. One public comment stated that there are subtle but consistent differences between the two nominal species, and despite genetic analysis showing strong similarity between the two species, it cannot be conclusive until more of the genome is analyzed. A second public comment stated that since the combining of morphological species into a single entity was only done for two groups of species in Hawaii and for none of the other species around the world, for consistency these species should be considered separately. The commenter stated that these groupings are based on a single scientific publication that suggests, but does not state conclusively, that these species contain the same identical genomes and that combining them makes it so that differences between them in abundance and physiological characteristics cannot be separated. The group as a whole, suggested the commenter, might have one status while species within the group could have another. As discussed above in the response to comments, public comments did not provide any new or supplemental information contradicting the SRR to lump these nominal species (see SRR for further explanation) into one species as a listable entity under the ESA.

Supplemental information we gathered confirms the known taxonomic problems for *M. patula/verrilli,* and reports that there is a moderate level of species identification uncertainty for this species. *Montipora patula* and *M. verrilli* are similar (Veron, 2000; Veron, 2014; Wallace, 1999b), and may be indistinguishable (Fenner, 2005). However, the species *M. patula/verrilli* is distinctive and not difficult to identify by experts (Fenner, 2014b). Veron (2014) states that *M. patula* is very similar to *M. verrilli* and Veron (2000; 2014) considers the species valid. As already stated, we consider *M. patula/verrilli* is sufficiently distinctive to be identified by experts (Fenner, 2014b). Thus, we conclude that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *M. patula/verrilli's* distribution, habitat, and depth range. *Montipora patula/verrilli* has a very restricted range, centered on the Main and Northwestern Hawaiian Islands. *Montipora verrilli* has been reported from some other locations. *Montipora patula* has been reported to occupy shallow reef environments and reef flats, and is common in wave-swept environments but less tolerant of sediment-impacted areas. *Montipora patula/verrilli's* habitat includes at least upper reef slopes, mid-slopes, lower reef slopes, lower reef crests, and reef flats. The depth range is described as shallow reef flats down to 10 meters depth, with a report of 40 meters.

The public comments provided the following information. One public comment stated that a species that is highly consistent with Veron's description of *M. verrilli* has been reported from the Marianas. We gathered supplemental information, which stated that *M. patula* was considered endemic to the Hawaiian Islands and Johnston Atoll (Veron, 2000), but is now known to occur throughout the Hawaiian Islands, and also in the Line Islands, Marquesas, and Austral Islands (Veron, 2014). Veron (2014) reports *M. patula* as absent from Johnston Atoll, but this is an error as it is well known to occur there (Maragos and Jokiel, 1986); (Coles *et al.,* 2001); (Brainard *et al.,* 2005; Veron, 2000; Williams and Miller, 2012); (Lobel and K., 2008). Veron (2014) does not report on *M. verrilli.* Like *M. patula, M. verrilli* is reported from the Hawaiian Islands and Johnston Atoll (Veron, 2000), but is also reported from the Mariana Islands and Palau (Randall, 1995; Randall, 2003; Randall and Myers, 1983). Veron (2014) reports that *M. patula* is confirmed in five of his 133 Indo-Pacific ecoregions and strongly predicted in an additional two ecoregions.

Montipora patula is commonly observed deeper than 10 m throughout the Hawaiian Islands (Samuel Kahng, personal comm.), but its deepest depth range is not reported. The public comments and information we gathered provided nothing supplemental on *M. patula/verrilli's* habitat and depth range.

Demographic Information

The SRR and SIR provided the following information on *M. patula/verrilli's* abundance. *Montipora patula* and *M. verrilli* have been reported as sometimes common. *Montipora patula* is the most abundant of the three Hawaiian endemic (nominal) *Montipora* with overall statewide mean cover of 3.3 percent, making it the fourth most abundant coral in Hawai'i. *Montipora verrilli* is less abundant in Hawai'i. Dollar and Grigg (2004) show substantial declines of *M. patula* on a subset of their transects over 12 years, but other transects within sites show high variability between surveys or similar cover between the beginning and end of the study.

The public comments provided the following information on this species' demography. One public comment stated that data from 79 monitoring sites in Hawaii from 1999 to 2012 suggest that *M. patula* and *M. verrilli* are experiencing different trajectories in growth and abundance. A second public comment stated that the SRR's characterization of *M. patula's* populations as declining disregards public records of numerous long-term monitoring programs that have demonstrated its considerable abundance along the Hawaiian coast and its resistance to extreme conditions. A third public comment provided quantitative coral cover data from a variety of transects taken in Hawaii. *Montipora patula* often had the third, fourth, or fifth highest coral cover of any species. We gathered supplemental information, including Veron (2014), which while he did not conduct abundance surveys in Hawaii, describes the overall abundance of *M. patula* as ''uncommon.'' *Montipora patula* is one of the most common reef-building corals in Hawaii. Jokiel *et al.* (2004) reported that *M. patula* has an overall statewide mean cover of 2.7 percent and the Hawaii Coral Reef Assessment and Monitoring Program (CRAMP) indicates that *M. patula* has an overall statewide mean cover of 3.3 percent (CRAMP, 2008b). Those mean cover percentages make *M. patula* the fourth most abundant coral in the main Hawaiian Islands. Fenner (2005) considered *M. patula* as one of the five most common corals in Hawaii. Grigg (1984) found that *M. patula* was the fifth most common coral in the main Hawaiian Islands. A species distribution model predicted that *M. patula* has the second highest coral cover of all reef-building coral species in the main Hawaiian Islands (Franklin *et al.,* 2013). *Montipora verrilli* has been reported to dominate deep, still water along with another *Montipora* species at Johnston Island (Jokiel and Tyler III, 1992) and *M. patula* is reported to be one of the two most common corals at Johnston Island (NOAA, 2006). In one study, *M. patula* was found at every one of the 11 stations at Johnston Island that were surveyed (Coles *et al.,* 2001). These three studies may refer to the same species.

The species has been monitored on some time-series transects in Hawaii.

Dollar and Grigg (2004) monitored coral cover over 12 and 20 year periods at three sites in Hawaii, each with multiple transects: a semi-enclosed embayment on Maui and two open coastal sites on Kauai and the Big Island. At the Maui site, overall live coral cover declined by approximately 33 percent from 1990 to 2002; *M. patula* cover declined from 13.8 to 8.2 percent of total live coral cover, and was the fourth most abundant coral at this site. At the Kauai site, overall live coral cover increased by approximately 30 percent from 1983 to 2002; *M. patula* increased from 24.9 to 36.0 percent of total live coral cover, and was the second most abundant coral at this site. At the Big Island site, overall live coral cover increased by approximately 50 percent from 1983 to 2002; *M. patula* increased from 0.7 to 3.3 percent of total live coral cover, and was the fourth most abundant coral at this site (Dollar and Grigg, 2004). Friedlander and Brown (2005) monitored coral cover for 12 years at 20 transects in Hanalei Bay, Kauai. Overall live coral cover increased by approximately 30 percent from 1993 to 2004, *M. patula* increased from approximately 50 to 60 percent of total live coral cover, and was the most abundant coral (Friedlander and Brown, 2005). In its public comment letter on the proposed rule, the National Park Service summarized data collected from 1999 to 2012 at 79 sites at different depths from the main Hawaiian Islands (exact locations not identified) showing that *M. patula* increased in live coral cover by approximately 2.3 percent over the 14 year period at all sites combined. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least millions of colonies.

Other Biological Information

The SRR and SIR provided the following information on *M. patula/verrilli's* life history. *Montipora patula* and *M. verrilli* are both documented as hermaphroditic broadcast spawners. Release of packaged egg and sperm bundles has been observed in the months of July through September at Coconut Island, Oahu, during two moon phases: new to first quarter, and full to third quarter. Although specific larval descriptions have not been published for this species, the larvae of all other *Montipora* species studied contain zooxanthellae that can supplement maternal provisioning with energy sources provided by their photosynthesis. The public comments and information we gathered provided no supplemental biological information.

Susceptibility to Threats

To describe *M. patula/verrilli's* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Montipora* of ocean warming, acidification, disease, sedimentation, nutrients, predation, and collection and trade. The SRR and SIR also provided the following species-specific information on *M. patula/verrilli's* threats. *Montipora patula* is among the most bleaching-susceptible corals in the Northwestern Hawaiian Islands and may be moderately susceptible in the main Hawaiian Islands. What ultimately became known as the stress-tolerant zooxanthellae clade D was first documented in shallow-water *M. patula* in Hawai'i, though it also hosts clade C in deeper waters. Both nominal *M. patula* and *M. verrilli* are specifically noted with acute disease conditions (involving tissue loss/partial mortality) with high frequency of occurrence (over 20 percent of surveyed sites where the taxa was observed showed disease signs) and high prevalence (over seven percent in some sites) in the Northwestern Hawaiian Islands (Aeby, 2006). This author points out that the high prevalence sites had suffered severe bleaching in the previous year. *Montipora patula* may be less sediment tolerant than other *Montipora* species (Jokiel *et al.,* 2007), and it did disappear from survey stations in Pelekane Bay, Hawaiʻi between 1977 and 1996 as the bay became more impacted by sediment. The SRR and SIR did not provide any other species-specific information on the effects of these threats on *M. patula/verrilli.* We interpreted the threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *M. patula/verrilli's* vulnerabilities as follows: High vulnerability to ocean warming, moderate vulnerabilities to disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, and predation, and low vulnerability to sea-level rise, and collection and trade.

Public comments provided some supplemental information on *M. patula/verrilli's* threat susceptibilities. One public comment stated that in nearshore areas exposed to extremes of low salinity and temperature such as the eastern shore of the island of Hawaii where there are many streams and groundwater discharges, *M. patula* is one of the most common corals, sometimes nearly covering the entire reef surface. *Montipora patula* is one of the most common corals in harbors around the state of Hawaii, where it tolerates elevated sediment loading and resuspension.

We gathered the following species-specific and genus-level information on this species' threat susceptibilities. *Montipora patula* has been rated as moderately or highly susceptible to bleaching and coral disease, but *M. verrilli* has not been rated as moderately or highly susceptible to bleaching and coral disease, however, these ratings are not based on species-specific data (Carpenter *et al.,* 2008). Kenyon and Brainard (2006) report that *M. patula* was the most frequently bleached coral in Maro, Laysan, and Lisianski in the Northwestern Hawaiian Islands in 2004. At Pearl and Hermes reef, more than half of the *M. patula* colonies bleached, although more than half of the colonies of several other coral species also bleached. In a bleaching event in 1996, *M. patula* was found to have a moderate sensitivity to bleaching (Jokiel and Brown, 2004). At Kailua, Oahu, *M. patula* was observed to partly bleach every year for four years in April or May and October or September (Hoegh-Guldberg, 1995). *Montipora patula* colonies host multiple zooxanthellae clades, depending on location and depth. In Hawaii, colonies from different sites and depths had two different clades (LaJeunesse *et al.,* 2004a), and at Johnston Atoll, colonies from different sites and depths had four different clades, including the two found in the Hawaii colonies (Stat *et al.,* 2009).

In the main Hawaiian Islands, an outbreak of filamentous bacterial diseases began in 2012 on Kauai, and continued in 2013, heavily affecting the *Montipora* species on these reefs, including *M. capitata, M. flabellata,* and *M. patula* (Work, 2013). These *Montipora* species appear to be highly susceptible to these diseases when environmental conditions are degraded, especially the larger colonies (Thierry Work, personal comm.). It is unknown if these *Montipora* species are highly susceptible to these diseases when environmental conditions are not as degraded as they are on Kauai. With regards to sedimentation, the SRR referred to a study that concluded *M. patula* was more sensitive to sediment than other corals and another study that concluded *M. verrilli* was relatively resistant to sedimentation. No other species-specific information is available for the susceptibility of *M. patula/verrilli* to any other threat.

Based on genus-level and species-specific information described above, *M. patula/verrilli* likely is highly susceptible to ocean warming, likely has some susceptibility to disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade. The available information does not support more precise ratings of the susceptibilities of *M. patula/verrilli* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *M. patula/verrilli.* Criticisms of our approach received during public comment led us to the following analysis to attempt to analyze regulatory mechanisms on a species basis. Records confirm that *M. patula/verrilli* occurs in eight Indo-Pacific ecoregions that encompass four countries' EEZs. The four countries are France (French Pacific Island Territories), Kiribati, Palau, and the United States (Guam, CNMI, Hawaii, PRIAs). The regulatory mechanisms relevant to *M. patula/verrilli,* described first as the percentage of the above countries that utilize them to any degree and second, as the percentages of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (75 percent with none limited in scope), coral collection (100 percent with 25 percent limited in scope), pollution control (75 percent with 25 percent limited in scope), fishing regulations on reefs (100 percent with 25 percent limited in scope), and managing areas for protection and conservation (100 percent with none limited in scope). All five regulatory mechanisms are very common for managing *M. patula/verrilli,* with only coral collection, pollution control, and reef fishing laws somewhat limited in scope.

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that factors that increase the potential extinction risk for *M. patula/verrilli* include its combined very narrow geographic distribution, restriction to shallow habitats, and its generic high susceptibility to a range of threats (bleaching, predation) and documented species-specific impacts from disease. No species characteristics were noted in the SRR that reduced expectations of extinction risk.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *M. patula/verrilli,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution includes coral reef ecoregions spanning an arc across the Pacific Ocean from the Mariana to Hawaiian to Austral Islands. Its geographic distribution moderates vulnerability to extinction because some areas within its range are projected to have less than average warming and acidification over the foreseeable future, including the central Pacific, so portions of the population in these areas will be less exposed to severe conditions. Its depth range is from low tide to more than 10 meters, possibly as deep as 40 meters. This moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Its habitat includes at least upper reef slopes, mid-slopes, lower reef slopes, lower reef crests, and reef flats. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Its common and stable or increasing abundance in parts of its range, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule, using the determination tool formula approach, *M. patula/verrilli* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); common generalized range wide abundance (E); narrow overall distribution (based on narrow geographic distribution and moderate depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *M. patula/verrilli* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *M. patula/verrilli's* spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to be likely to become endangered throughout its range within the foreseeable future, and thus it is not warranted for listing at this time, because:

(1) *Montipora patula/verrilli's* distribution range is widespread, although disjointed and not continuous, from Palau to Hawaii to French Polynesia. While some areas within its range are projected to be affected by warming and acidification, other areas are projected to have less than average warming and acidification, including the central Pacific. This distribution and the heterogeneous habitats it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future;

(2) *Montipora patula/verrilli* is one of the most abundant species in Hawaii, a major part of its range, and time-series studies of various sites around Hawaii since the 1980s seem to show stability in overall abundance trends in *M. patula.* The species' abundance

provides buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response;

(3) The depth range for *M. patula/verrilli* likely extends to 40 m depth, suggesting the possibility of depth refuges from ocean warming and other threats, and indicating a higher absolute area of potential occupancy within the species range;

(4) Many of the areas where *M. patula/verrilli* is found in the Pacific are remote and mostly uninhabited, reducing the likelihood of exposure to local sources of impacts that result from human activities; and

(5) All five major categories of protective regulatory mechanisms addressing local sources of threats are implemented by 75 to 100 percent of the countries within *M. patula/verrilli'*s range, with only three categories somewhat limited in scope.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future if global threats continue and worsen in severity and the species' exposure to the threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *M. patula/verrilli* is not warranted for listing at this time under any of the listing factors.

Genus Alveopora

Genus Introduction

The family Poritidae consists of six genera: *Porites, Goniopora, Alveopora, Stylaraea, Poritipora,* and *Calathistes. Alveopora* consists of 14 species, all occurring in the Indo-Pacific (Veron, 2000). Colonies are usually massive, branching, plating, or a combination. The SRR and SIR provided no genus-level introductory information on *Alveopora.*

Genus Susceptibility to Threats

The SRR and SIR provided the following information on the threat susceptibilities of the genus *Alveopora.* The genus *Alveopora* is listed as having the highest bleaching response from the 17 included genera in the Indian Ocean. *Alveopora* had high bleaching in Guam in 1994 and South Africa in 2000, but had little bleaching or mortality in Palau in the 2001 event. Low-to-moderate bleaching of *Alveopora allingi* was observed in East Africa during the 1997–1998 event. A few disease reports for the genus *Alveopora* can be found in the Global Disease Database.

The public comments did not provide supplemental information on the threat susceptibilities of the genus *Alveopora.* We gathered supplemental information that provided the following. In Palau in 2000, *Alveopora* species had ''relatively little bleaching and mortality.'' Forty eight percent of all colonies of all species were bleached, and bleaching of different genera and species ranged from none to very high, but no quantitative results were reported for any *Alveopora* species (Bruno *et al.,* 2001). In Kenya in a bleaching event in 1998, all *Alveopora* colonies in the study sites were killed by mass bleaching (McClanahan *et al.,* 2001). In Mauritius in a bleaching event in 2004, *Alveopora* colonies had a bleaching index of 62, the second highest of the 32 genera recorded (McClanahan *et al.,* 2005a). In the western Indian Ocean, relative extinction risk scores for coral genera were calculated based on observed genus-level bleaching between 1998 and 2005. The index of extinction risk was proportional to the degree of bleaching, and inversely proportional to the abundance and number of reefs on which a taxon was found on. The index of extinction risk for *Alveopora* was the ninth highest out of 47 genera, with a score of 0.41 based on a scale of 0 to 1 with 1 being the score of the highest scoring genus (McClanahan *et al.,* 2007a). In Indonesia, colonies of *Goniopora* and *Alveopora* had a combined disease prevalence of about 0.3 percent, which was considered low (Haapkyla *et al.,* 2007).

Genus Conclusion

Based on the information from the SRR, SIR, public comments, and supplemental information, we can make the following inferences about the susceptibilities of an unstudied *Alveopora* species to ocean warming, disease, acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade. The SRR rated ocean warming and disease as ''high'' importance, and ocean acidification as ''medium-high'' importance, to corals. These were rated as the three most important threats to reef-building corals overall. The studies reporting bleaching in the genus *Alveopora* reported a wide range of results, from high levels of bleaching to low levels of bleaching. There are a few reports of disease in *Alveopora* in the Global Disease database, and *Goniopora* and *Alveopora* had low combined disease prevalence in Indonesia. Thus, we conclude that *Alveopora* is likely to have some susceptibility to ocean warming and disease. Although there is no other genus-level or species-specific information on the susceptibilities of *Alveopora* species to ocean acidification, the SRR rated it as ''medium-high'' importance to corals. Thus, we conclude that an unstudied *Alveopora* species is likely to have some susceptibility to ocean acidification.

The SRR rated the trophic effects of fishing as ''medium'' importance, the fourth most important threat to corals overall. This threat was not addressed at the genus or species level in the SRR or SIR, because it is an ecosystem-level process. That is, removal of herbivorous fish from coral reef systems by fishing alters trophic interactions by reducing herbivory on algae, thereby providing a competitive advantage for space to algae over coral. Thus, the SRR did not discuss this threat in terms of coral taxa, as its effects are difficult to distinguish between coral genera and species. Therefore, an unstudied *Alveopora* species is likely to have some susceptibility to the trophic effects of fishing.

The SRR rated sedimentation, nutrients, and sea-level rise as ''low-medium'' importance to corals overall. Although there is no other genus-level or species-specific information on the susceptibilities of *Alveopora* species to sedimentation and nutrients, the SRR rated them as ''low-medium'' importance to corals. Thus we conclude that an unstudied *Alveopora* species is likely to have some susceptibility to sedimentation and nutrients. Sea-level rise was not addressed at the genus or species level in the SRR or SIR. Increasing sea levels may increase land-based sources of pollution due to inundation, resulting in changes to coral community structure, thus an unstudied *Alveopora* species is likely to have some susceptibility to sea-level rise. The SRR rated predation and ornamental trade (referred to in the proposed rule as Collection and Trade) as ''low'' importance to corals overall. Although there is no other genus-level or species-specific information on the susceptibilities of *Alveopora* species to collection and trade, there is no information suggesting they are not susceptible to these threats. Thus we conclude that an unstudied *Alveopora* species is likely to have some susceptibility to collection and trade.

In conclusion, an unstudied *Alveopora* species is likely to have some susceptibility to ocean warming, disease, acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade.

Alveopora allingi

Introduction

The SRR and SIR provided the following information on *A. allingi'*s morphology and taxonomy. Its morphology was described as colonies being encrusting or having short irregular lobes with rounded surfaces or being columnar. Its taxonomy was described as having no taxonomic issues, but being similar to *Alveopora catalai* and

Alveopora marionensis.

Public comments and information we gathered did not provide supplemental information on morphology, and confirmed that there are no known taxonomic problems for *A. allingi,* and a low level of species identification uncertainty. Veron (2014) states that *A. allingi* is distinctive and Veron (2000; 2014) considers the species valid, thus we consider it can be identified by experts and conclude that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *A. allingi'*s distribution, habitat, and depth range. *Alveopora allingi* has a very broad distribution from the Red Sea and Indian Ocean to most of the Pacific Ocean. The SRR reported that *A. allingi'*s habitat is protected reef environments and its depth range is five to 10 m deep. Protected reef environments includes a large diversity of habitats, including lagoons, back-reef pools, leeward reefs, and others.

Public comments provided supplemental information on the distribution and habitat of *A. allingi.* A public comment pointed out that in the Marianas, this species is restricted to depths greater than 60 meters. The four type specimens of *A. allingi* were dredged from Pago Pago harbor, all from a depth of 100 feet or more (Hoffmeister, 1925). We also gathered supplemental information, including Veron (2014), which reports that *A. allingi* is confirmed in 53 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional 27. Thus, based on all the available information, *A. allingi'*s habitat includes lagoons, upper reef slopes, mid-slope terraces, lower reef slopes, and mesophotic areas in depths ranging from five to greater than 60 m.

Demographic Information

The SRR and SIR reported *A. allingi'*s abundance as usually uncommon.

Public comments did not provide supplemental information on the abundance of *A. allingi.* We gathered supplemental information, including Veron (2014), which reports that *A. allingi* occupied 1.2 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.27 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''uncommon,'' and overall abundance was described as ''usually uncommon.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least tens of millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *A. allingi,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 35 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 14 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *A. allingi* occurs in many areas affected by these broad changes, and likely has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *A. allingi'*s life history. On high latitude reefs (28 to 29 degrees South) in the Houtman Abrolhos Islands, western Australia, two colonies of *A. allingi* were sampled before the main mass spawning nights in late March 1987. There was no indication of developed gametes, suggesting that this species does not participate in the mass spawning. Public comments and information we gathered did not provide anything additional to the above-described biological information.

Susceptibility to Threats

To describe *A. allingi'*s threat susceptibilities, The SRR and SIR provided genus-level information for the effects on *Alveopora* of ocean warming, acidification, disease, sedimentation, nutrients, predation, and collection and trade. The SRR and SIR also provided the following species-specific information on *A. allingi'*s threats. Low-to-moderate bleaching of *Alveopora allingi* was observed in East Africa during the 1997–1998 event. The SRR and SIR did not provide any other species-specific information on the effects of these threats on *A. allingi.* We interpreted threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *A. allingi'*s vulnerabilities as follows: High vulnerability to ocean warming, moderate vulnerability to disease, ocean acidification, trophic effects of reef fishing, and nutrients, and low vulnerability to sedimentation, sea level rise, predation, and collection and trade.

Public comments did not provide supplemental information on *A. allingi's* threat susceptibilities. We gathered the following species-specific and genus-level supplemental information on this species' threat susceptibilities. *Alveopora allingi* has been rated as moderately or highly susceptible to bleaching but not to disease, but this rating is not based on species-specific data (2008). Based on the genus-level and species information described above, *A. allingi* is likely to have some susceptibility to warming-induced bleaching, disease, acidification, trophic effects of fishing, sedimentation, nutrients, seal-level rise, predation, and collection and trade. The available information does not support more precise ratings of the susceptibility of *A. allingi* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *A. allingi.* Criticisms of our approach received during public comment led us to attempt the following analysis of regulatory mechanisms on a species basis. Records confirm that *A. allingi* occurs in 53 Indo-Pacific ecoregions that encompass 40 countries' EEZs. The 40 countries are Australia, Cambodia, China, Djibouti, Egypt, Eritrea, Federated States of Micronesia, Fiji, France (French Pacific Island Territories), Indonesia, Israel, Japan, Jordan, Madagascar, Malaysia, Maldives, Marshall Islands, Mauritius, Mozambique, Myanmar, New Zealand (Tokelau), Niue, Palau, Papua New Guinea, Philippines, Samoa, Saudi Arabia, Seychelles, South Africa, Sri Lanka, Sudan, Taiwan, Tanzania, Timor-Leste, Tonga, Tuvalu, United Kingdom (British Indian Ocean Territory), United States (CNMI, Guam, American Samoa, PRIAs), Vietnam, and Yemen. The regulatory mechanisms relevant to *A. allingi,* described first as the percentage of the above countries that utilize them to any degree and second, as the percentage of those countries whose regulatory mechanisms may be limited in scope are as follows: General coral protection (28 percent with five percent limited in scope), coral collection (60 percent with 25 percent limited in scope), pollution control (45 percent with eight percent limited in scope), fishing regulations on reefs (88 percent with 20 percent limited in scope), and managing areas for protection and conservation (95 percent with 10 percent limited in scope). The most common regulatory mechanisms in place for *A. allingi* are reef fishing regulations and area management for protection and conservation. Coral collection and pollution control laws are also somewhat common for the species, but 25 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection laws are much less common regulatory mechanisms for the management of *A. allingi.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR states that the high bleaching rate is the primary known threat of extinction for *A. allingi.* It listed factors that reduce potential extinction risk including that *A. allingi* occupies a variety of habitat types and is broadly distributed both latitudinally and longitudinally in the Indo-Pacific.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *A. allingi,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution includes many of the coral reef ecoregions in the Indian Ocean and western and central Pacific Ocean. Its geographic distribution moderates vulnerability to extinction because some areas within its range are projected to have less than average warming and acidification over the foreseeable future, including the western Indian Ocean and the central Pacific, so portions of the population in these areas will be less exposed to severe conditions. Its depth range is from five to 60 meters. Its depth range moderates vulnerability to extinction over the foreseeable future because of lower irradiance in the deeper portion of its range, sharply reducing warming-induced bleaching. In addition, other threats usually occur at lower levels at mesophotic depths, such as sedimentation resulting from land-based sources of pollution. However, *A. allingi* colonies in mesophotic habitat may be affected by increasing acidification over the foreseeable future, but the species also occurs in shallow depths less affected by acidification. Its habitat includes lagoons, upper reef slopes, mid-slope terraces, lower reef slopes, and mesophotic areas, moderating vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Its absolute abundance of at least tens of millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule, using the determination tool formula approach, *A. allingi* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); uncommon generalized range wide abundance (E); moderate overall distribution (based on wide geographic distribution and shallow depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *A. allingi* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *A. allingi's* spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to be likely to become endangered throughout its range within the foreseeable future, and thus it is not warranted for listing at this time, because:

(1) *Alveopora allingi's* distribution across the Red Sea, Indian Ocean and most of the Pacific Ocean is spread over a vast area. While some areas within its range are projected to be affected by

warming and acidification, other areas are projected to have less than average warming and acidification, including the western Indian Ocean and the central Pacific. This distribution and the heterogeneous habitats it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future;

(2) *Alveopora allingi's* depth range down to 60 m and below includes depths that provide a refuge from ocean warming, and increase the absolute area of potential occupancy throughout the range of the species; and

(3) *Alveopora allingi's* total population size is at least tens of millions of colonies, providing buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future if global threats continue and worsen in severity and the species' exposure to the threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *A. allingi* is not warranted for listing at this time under any of the listing factors.

Alveopora fenestrata

Introduction

The SRR and SIR provided the following information on *A. fenestrata's* morphology and taxonomy. Morphology was described as generally hemispherical with the surface divided into lobes, and the taxonomy was described as having no taxonomic issues, but it is similar to *Alveopora marionensis* and *Alveopora verrilliana.*

Public comments and information we gathered did not provide any new or supplemental information on morphology and confirmed that there are no known taxonomic problems for *A. fenestrata,* but that there is a moderate to high level of species identification uncertainty for this species. Veron (2014) states that *A. fenestrata* is easily confused with other *Alveopora* with similar growth form, but Veron (2000; 2014) considers the species valid, and we consider it can be identified by experts, thus we conclude that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *A. fenestrata's* distribution, habitat, and depth range. *Alveopora fenestrata* has a relatively broad distribution from the Red Sea and Indian Ocean to the central Pacific. Its habitat includes most coral reef environments, such as upper reef slopes, mid-slopes, lower reef slopes, lower reef crests, reef flats, and lagoons, and its depth range is from three to 30 m.

Public comments provided the following information. *Alveopora fenestrata* occurs in Guam, but is not confirmed in the Northern Marianas. We gathered supplemental information, including Veron (2014) which reports that *A. fenestrata* is confirmed in 39 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional 19.

Demographic Information

The SRR and SIR reported that *A. fenestrata's* abundance is uncommon.

Public comments provided the following information. *Alveopora fenestrata* is rare on Guam. We gathered supplemental information including Veron (2014) which reports that *A. fenestrata* occupied 1.98 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.29 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''uncommon,'' and overall abundance was also described as ''uncommon.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least tens of millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *A. fenestrata,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 36 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 14 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *A. fenestrata* occurs in many areas affected by these broad changes, and likely has some susceptibility to both local and global threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species-specific information.

Other Biological Information

The SRR and SIR did not provide supplemental species-specific biological information for *A. fenestrata.* Public comments provided no new or supplemental biological information.

Susceptibility to Threats

To describe *A. fenestrata's* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Alveopora* of ocean warming, acidification, disease, sedimentation, nutrients, predation, and collection and trade. The SRR and SIR did not provide any other species-specific information on the effects of these threats on *A. fenestrata.* We interpreted threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *A. fenestrata's* vulnerabilities as follows: High vulnerability to ocean warming, moderate vulnerability to disease, ocean acidification, trophic effects of fishing, and nutrients, and low vulnerability to sedimentation, sea level rise, predation, and collection and trade.

Public comments did not provide supplemental information on *A. fenestrata's* threat susceptibilities. We gathered the following species-specific and genus-level supplemental information on this species' susceptibilities. *Alveopora fenestrata* has been rated as moderately or highly susceptible to bleaching but not to disease, but this rating is not based on species-specific data (Carpenter *et al.,* 2008). Darling *et al.* (2012) performed a biological trait-based analysis to categorize the relative tolerance of coral species to environmental stress and *A. fenestrata* was classified as a ''stress-tolerant'' species. There is no other species-specific information for the susceptibility of *A. fenestrata* to any threat. Based on the genus-level and species information described above, *A. fenestrata* is likely to have some susceptibility to warming-induced bleaching disease, acidification, trophic effects of fishing, sedimentation, nutrients, seal-level rise, predation, and collection and trade. The available information does not support more precise ratings of the susceptibility of *A. fenestrata* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *A. fenestrata.* Criticisms of our approach received during public comment led us to attempt the following analysis of regulatory mechanisms on a species basis. Records confirm that *A. fenestrata* occurs in 39 Indo-Pacific ecoregions that encompass 27 countries' EEZs. The 27 countries are Australia, Brunei, China, Egypt, Federated States of Micronesia, France (French Pacific Island Territories), Indonesia, Israel, Jordan, Kenya, Madagascar, Malaysia, Marshall Islands, Mauritius, Papua New Guinea, Philippines, Saudi Arabia, Seychelles, Solomon Islands, Sri Lanka, Sudan, Taiwan, Tanzania, Timor-Leste, United States (CNMI, Guam, PRIAs), Vanuatu, and Vietnam. The regulatory mechanisms relevant to *A. fenestrata,* first described as the percentage of the above countries that utilize them to any degree, and second as the percentage of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (33 percent with 11 percent limited in scope), coral collection (56 percent with 22 percent limited in scope), pollution control (48 percent with 11 percent limited in scope), fishing regulations on reefs (85 percent with 22 percent limited in scope), and managing areas for protection and conservation (100 percent with 11 percent limited in scope). The most common regulatory mechanisms in place for *A. fenestrata* are reef fishing regulations and area management for protection and conservation. Coral collection and pollution control laws are also somewhat common for the species, but 40 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection laws are much less prominent regulatory mechanisms for the management of *A. fenestrata.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that a high bleaching rate is the primary known threat of extinction for *A. fenestrata.* It listed factors that reduce potential extinction risk including occupying a range of depths and being broadly distributed both latitudinally and longitudinally in the Indo-Pacific.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *A. fenestrata,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution includes many of the coral reef ecoregions in the Indian Ocean and western and central Pacific Ocean. Its geographic distribution moderates vulnerability to extinction because some areas within its range are projected to have less than average warming and acidification over the foreseeable future, including the western Indian Ocean, so portions of the population in these areas will be less exposed to severe conditions. Its depth range is from three to 30 meters. This moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Its habitat includes upper reef slopes, mid-slopes, lower reef slopes, lower reef crests, reef flats, and lagoons, moderating vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Its absolute abundance of at least tens of millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule, using the determination tool formula approach, *A. fenestrata* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); uncommon generalized range wide abundance (E); wide overall distribution (based on wide geographic distribution and moderate depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *A. fenestrata* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *A. fenestrata'* spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to be likely to become endangered throughout its range within the foreseeable future, and thus it is not warranted for listing at this time, because:

(1) *Alveopora fenestrata'*s distribution across approximately three quarters of the Indo-Pacific region is spread over a vast area. While some areas within its range are projected to be affected by warming and acidification, other areas are projected to have less than average warming and acidification, including the western Indian Ocean and the central Pacific. This distribution and the heterogeneous habitats it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future;

(2) *Alveopora fenestrata'*s depth range down to 30 m and below includes depths that provide a refuge from ocean warming, and increase the absolute area of potential occupancy throughout the range of the species; and

(3) *Alveopora fenestrata'*s total population size is at least tens of millions of colonies, providing buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future if global threats continue and worsen in severity and the species' exposure to the threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *A. fenestrata* is not warranted for listing at this time under any of the listing factors.

Alveopora verrilliana

Introduction

The SRR and SIR provided the following information on *A. verrilliana'*s morphology and taxonomy. Morphology was described as short irregularly dividing knob-like branches and the taxonomy was described as having no taxonomic issues. *Alveopora verrilliana* is similar to *Alveopora fenestrata.*

Public comments and information we gathered did not provide any new or supplemental information on morphology, and confirmed that there are no known taxonomic problems for *A. verrilliana,* but that there is a high level of species identification uncertainty for this species. Veron (2014) states that *A. verrilliana* is easily confused with other *Alveopora* with a similar growth form and it is impossible to confirm many citations of this species. However, Veron (2000; 2014) considers the species valid, and we consider it can be identified by experts, thus we conclude that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *A. verrilliana'*s distribution, habitat, and depth range. *Alveopora verrilliana's* distribution is from the Red Sea to the central Indo-Pacific to most of the Pacific. Its habitat includes most coral reef environments, such as upper reef slopes, mid-slopes, lower reef slopes, lower reef crests, reef flats, and lagoons, and its depth range is three to at least 40 meters depth, and possibly down to 80 meters (it is not certain that the identity of the coral at 80 meters has been verified).

Public comments provided the following supplemental information on *A. verrilliana'*s distribution, habitat and depth range. One public comment stated that *A. verrilliana* has been found in the Marianas on shallow fringing reef platforms at a depth between 1.5 and 2 meters deep, and a terrace at 17 meters deep. We gathered supplemental information, including Veron (2014), which reports that *A. verrilliana* is confirmed in 28 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional 30. One of the 30 strongly predicted ecoregions is the Main Hawaiian Islands (Veron, 2014), and may be based on reports that Hawaii is a similar type ecoregion. However, there are no reliable reports of the species being found in the Main Hawaiian Islands, in spite of many divers in the water observing coral species (Douglas Fenner, personal com.). Veron (2014)'s map indicates that the report(s) of this species from the Red Sea have also not been verified.

Demographic Information

The SRR and SIR reported *A. verrilliana'*s abundance as ''uncommon.'' Public comments provided the following supplemental information on *A. verrilliana'*s abundance. One public comment stated that *A. verrilliana* is uncommon in the Marianas with only 10 to12 colonies recorded so far. We gathered the following supplemental information on the abundance of *A. verrilliana.* Veron (2014) reports that *A. verrilliana* occupied 0.27 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.13 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''rare,'' and overall abundance was described as ''uncommon.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *A. verrilliana,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 34 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 14 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years

(Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *A. verrilliana* occurs in many areas affected by these broad changes, and likely has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *A. verrilliana's* life history. *Alveopora verrilliana* is a hermaphroditic broadcast spawner. On temperate latitude reefs (28 to 29 degrees S) in the Houtman Abrolhos Islands, western Australia, seven of 12 colonies sampled had ripe gametes, and spawning was inferred during the time of mass spawning for this region. Public comments and information we gathered did not provide anything additional to the above-described biological information.

Susceptibility to Threats

To describe *A. verrilliana's* threat susceptibilities, The SRR and SIR provided genus-level information for the effects on *Alveopora* of ocean warming, acidification, disease, sedimentation, nutrients, predation, and collection and trade. The SRR and SIR did not provide any other species-specific information on the effects of these threats on *A. verrilliana.* We interpreted threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *A. verrilliana's* vulnerabilities as follows: High vulnerability to ocean warming, moderate vulnerability to disease, ocean acidification, trophic effects of reef fishing, and nutrients, and low vulnerability to sedimentation, sea level rise, predation, and collection and trade.

Public comments did not provide any new or supplemental information on *A. verrilliana's* threats. We gathered the following species-specific and genus-level supplemental information on this species' threat susceptibilities. *Alveopora verrilliana* has been rated as moderately or highly susceptible to bleaching but not to disease, but this rating is not based on species-specific data (2008). There is no species-specific information for the exposure or susceptibility of *A. verrilliana* to any threat. Based on the genus-level and species information described above, *A. verrilliana* likely has some susceptibility to ocean warming, disease, acidification, trophic effects of fishing, sedimentation, nutrients, seal-level rise, predation, and collection and trade. The available information does not support more precise ratings of the susceptibility of *A. verrilliana* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *A. verrilliana.* Criticisms of our approach received during public comment led us to attempt the following analysis of regulatory mechanisms on a species basis. Records confirm that *A. verrilliana* occurs in 28 Indo-Pacific ecoregions that encompass 23 countries' EEZs. The 23 countries are Australia, Brunei, Cambodia, China, Federated States of Micronesia, France (French Pacific Island Territories), Indonesia, Japan, Malaysia, New Zealand (Tokelau), Niue, Palau, Papua New Guinea, Philippines, Samoa, Solomon Islands, Taiwan, Thailand, Tonga, Tuvalu, United States (CNMI, Guam, American Samoa), Vanuatu, and Vietnam. The regulatory mechanisms relevant to *A. verrilliana,* described first as the percentage of the above countries that utilize them to any degree, and second as the percentages of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (30 percent with 4 percent limited in scope), coral collection (61 percent with 35 percent limited in scope), pollution control (39 percent with 13 percent limited in scope), fishing regulations on reefs (100 percent with 17 percent limited in scope), and managing areas for protection and conservation (100 percent with none limited in scope). The most common regulatory mechanisms in place for *A. verrilliana* are reef fishing regulations and area management for protection and conservation. Coral collection laws are also somewhat common for the species, but 35 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection and pollution control laws are much less common regulatory mechanisms for the management of *A. verrilliana.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR states that the high bleaching rate is the primary known threat of extinction for *A. verrilliana.* It listed factors that reduce potential extinction risk including that *A. verrilliana* occupies a variety of habitat types and is broadly distributed both latitudinally and longitudinally in the Indo-Pacific.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *A. verrilliana,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution includes many of the coral reef ecoregions in the western and central Pacific Ocean. Its geographic distribution moderates vulnerability to extinction because some areas within its range are projected to have less than average warming and acidification over the foreseeable future, including the central Pacific, so portions of the population in these areas will be less exposed to severe conditions. Its depth range is from three to 40 meters, which moderates vulnerability to extinction over the foreseeable future because of lower irradiance in the deeper portion of its range, sharply reducing warming-induced bleaching. In addition, other threats usually occur at lower levels at mesophotic depths, such as sedimentation resulting from land-based sources of pollution. However, *A. verrilliana* colonies in mesophotic habitat may be affected by increasing acidification over the foreseeable future, but the species also occurs in shallow depths less affected by acidification. Its habitat includes most coral reef environments, such as upper reef slopes, mid-slopes, lower reef slopes, lower reef crests, reef flats, and lagoons. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Its total abundance is unknown, and it is uncommon or rare. Its absolute abundance of at least millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule, using the determination tool formula approach, *A. verrilliana* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); uncommon generalized range wide abundance (E); wide overall distribution (based on wide geographic distribution and wide depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *A. verrilliana* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *A. verrilliana's* spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to be likely to become endangered throughout its range within the foreseeable future, and thus it is not warranted for listing at this time, because:

(1) *Alveopora verrilliana's* distribution across more than half of the Indo-Pacific region is spread over a vast area. While some areas within its range are projected to be affected by warming and acidification, other areas are projected to have less than average warming and acidification, including the central Pacific. This distribution and the heterogeneous habitats it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future;

(2) *Alveopora verrilliana's* depth distribution down to 40 meters includes depths that provide a refuge from ocean warming, and increase the absolute area of potential occupancy throughout the range of the species; and

(3) *Alveopora verrilliana's* total population size is at least millions of colonies, providing buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future if global threats continue and worsen in severity and the species' exposure to the threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *A. verrilliana* is not warranted for listing at this time under any of the listing factors.

Genus Porites

Genus Introduction

Porites colonies are flat (laminar or encrusting), massive, or branching. Massive colonies are spherical or hemispherical when small, and helmet or dome-shaped when large, and may be over five meters across (Veron, 2000). *Porites* is the third largest genus of reef building scleractinia, and Veron (2000) recognizes 52 species. This description of the *Porites* genus focuses on the Indo-Pacific, where most of the species occur. The larvae of all *Porites* species studied contain zooxanthellae that can supplement maternal provisioning with energy sources provided by their photosynthesis. The SRR and SIR provided no genus-level introductory information on *Porites.*

Genus Susceptibility to Threats

The SRR and SIR provided the following information on the threat susceptibilities of the genus *Porites.* On the GBR and in the western Indian Ocean, massive *Porites* generally have moderate susceptibility to bleaching, while branching *Porites* generally have higher susceptibility to bleaching, comparable to *Pocillopora* and *Acropora.* For example, *Porites horizontalata* was a bleaching ''loser'' in Okinawa, disappearing after the 1998 event. Recent work comparing *P. lobata* from extreme lagoonal environments with individuals from more benign forereef habitats in American Samoa indicates that thermal history of these corals plays a large part in their reaction to thermal stress.

The SRR reported that a study that looked at 328 colonies of massive *Porites* from 69 reefs of the GBR found a decline in calcification of 14.2 percent since 1990, predominantly because extension declined by 13.3 percent. This is similar to the estimates of a global decline in aragonite saturation state of 16 percent since the beginning of global industrialization. The study agreed with earlier, more limited work on *Porites* on the GBR and in laboratory and mesocosm experiments that showed declines in calcification with reduced aragonite saturation state in *P. cylindrical, P. compressa,* and *P. lutea* adults, and *P. astreoides* juveniles. Acidification has not been found to interfere with settlement of larvae in *P. astreoides* in the Caribbean.

The SRR reported several studies showing subacute (lesions resulting in slow progressive tissue loss) tissue loss, black band disease, and endolithic hypermycosis in *Porites.* The SIR reported that the genus *Porites* had the highest prevalence of disease throughout Guam; however, it may have also been a function of the fact that *Porites* corals are also the most common. Likewise, in a study from Hawaii, with 12 diseases recorded among three coral genera, *Porites* was shown to have the highest prevalence of disease. *Porites* was also shown to have severe damage as a result of high disease prevalence of black-band disease in Southeastern India.

The SRR reported that *Porites* is susceptible to crown-of-thorns seastar (*Acanthaster planci*) and corallivorous snail predation, including predation of *Coralliphilia violacea* on both massive and branching forms. Massive *Porites* are susceptible, but not a preferred prey, of the predatory asteroid *Culcita novaeguineae,* and the butterflyfish *Chaetodon unimaculatus. Porites* is intermediate for its sediment tolerance in the western Indian Ocean. In contrast, *Porites* is often found in relatively turbid waters in Asia and the eastern Pacific and were considered sediment tolerant. About 25,000–50,000 pieces of *Porites* spp. per year are traded.

The public comments did not provide any new or supplemental information on the threat susceptibilities of the genus *Porites.* We gathered supplemental information that provided the following. Thermal stress was studied by Gleason (1993), who reported that *Porites* was little affected by bleaching in Moorea, French Polynesia. Bruno *et al.* (2001) reported that in Palau in 2000, four different species of *Porites* ranged from low-moderate levels of bleaching to very high-moderate, and ranged from low-moderate mortality to high mortality. Done *et al.* (2003b) reported bleaching levels in seven species of *Porites* and one morphological group (massive) of *Porites.* Individual species ranged from eight to 33 percent affected by bleaching. The two least affected species (*P. cylindrica* and *P. annae*) were branching and the most affected was massive (*P. vaughani*), though it had a low mortality. Generally, massive *Porites* were affected more than average. The species with the greatest mortality was a species with columns and plates (*P. rus*) though another species (*P. lichen*) with columns and plates had a mortality rate nearly as low as the lowest mortality species, and another species with columns (*P. heronensis*) had high bleaching (Done *et al.,* 2003b).

Pandolfi *et al.* (2011) reported that massive species of *Porites* bleached about average for genera in Kenya and Australia in 1998. A study that monitored the impacts of the 1998 and 2010 bleaching events on coral in Japan (van Woesik *et al.,* 2011) reported that one species of branching *Porites* was neither a winner or a loser (increasing from 1.4 percent cover to four percent and then decreasing to 0.9 percent), and six species of branching *Porites* were long-term losers (decreasing to 0 percent cover and staying there). Vargas-Angel *et al.* (2011) reported that *Porites* had a fairly low percentage of bleaching on Howland and Baker islands in the U.S. Pacific, with 16.1 percent on Baker and 24.6 percent on Howland. *Porites* was the ninth most-bleached genus out of 14 genera, and had 32 percent as much bleaching as the most bleached genus (Vargas-Angel *et al.,* 2011). *Porites* in Okinawa, Japan, experienced no decrease in populations following the 1998 and 2010 mass bleaching episodes. Okinawa has turbid waters from runoff increased by human activities (Hongo and Yamano, 2013).

In areas of Papua New Guinea, where volcanic carbon dioxide bubbling produced pH equal to that predicted for 2100, massive *Porites* dominated the community, indicating they are more resistant to low pH than other corals (Fabricius *et al.,* 2011). Massive *Porites* growth rates in bays in Palau, with pH approaching that predicted for 2100 and aragonite saturation equal to that predicted for 2100, was similar to colonies in water with current mean pH and aragonite saturation (Shamberger *et al.,* in press).

Raymundo *et al.* (2005) reported that *Porites* had the highest levels of disease in the Philippines, where only rarely did other genera show disease. Individual species of *Porites* differed greatly in the prevalence of disease, with zero prevalence in about half of the species, and a wide range of prevalence in the others. Further, there was no consistent difference between massive and branching species: branching species displayed the entire range of prevalence; massive *Porites* having relatively high prevalence, though not as high as three branching species; and one massive *Porites* (*P. evermanni*) having zero prevalence (Raymundo *et al.,* 2005). *Porites* had the lowest prevalence of disease (0.025 percent) of the only five genera with diseases recorded in American Samoa. *Porites* tissue loss was found at 15 percent of sites compared to 71 percent of sites for *Acropora* white syndrome, the most common disease(Fenner and Heron, 2008). In another study in American Samoa, *Porites* had the third highest level of prevalence of any genus, with a prevalence of 0.11 percent (Aeby *et al.,* 2008). Growth anomalies are occasional on massive *Porites* in backreef pools on Ofu, American Samoa but less common on reef slopes in American Samoa. Growth anomalies are abundant on one color morph of *Porites cylindrica* in one small area of one back reef pool in Tutuila, American Samoa, but not on another color morph. A white disease that is rare on Tutuila, killed all *Porites rus* colonies (about 50) in front of Vaoto Lodge, Ofu, American Samoa. What appears to possibly be the same disease is killing all yellow massive *Porites* in the Hurricane House back reef pool on Ofu, American Samoa (Fenner, 2013b). In Guam, *Porites* had by far the highest prevalence, with 6.7 percent of colonies having disease (Myers and Raymundo, 2009). *Porites* was tied for the second highest disease prevalence of 12 genera in New Caledonia, with 0.7 percent of colonies showing disease (Tribollet *et al.,* 2011). *Porites* massive was tied for third highest disease prevalence of 35 taxa in Indonesia, with 1.5 percent prevalence. *Porites* branching had the 14th highest disease prevalence of 35 taxa in Indonesia, with 0.25 percent of colonies showing disease. Other *Porites* had no disease in Indonesia (Haapkyla *et al.,* 2007).

Predation was studied by De'ath and Moran (1998), who reported that *Porites* was the least preferred prey of crown-of-thorns starfish out of the 10 most common genera on 15 reefs in the GBR. *Porites* species are relatively less susceptible to the effects of land-based sources of pollution than many other reef-building corals. *Porites* species are heavily collected and widely traded internationally. There is no information on the effects of fishing, sea-level rise, or any other threat to *Porites* species.

Genus Conclusions

Based on the information from the SRR, SIR, public comments, and supplemental information, we can make the following inferences about the susceptibilities of an unstudied *Porites* species to ocean warming, disease, acidification, sedimentation, nutrients, trophic effects of fishing, sea-level rise, predation, and collection and trade. The SRR rated ocean warming and disease as ''high'' importance, and ocean acidification as ''medium-high'' importance, to corals. These were rated as the three most important threats to reef-building corals overall. Most studies reported moderate to high levels of bleaching in *Porites,* but one study reported low levels and some individual species had low levels. In three studies, branching species showed higher levels of bleaching than massive species, and one study showed the reverse. Generally, *Porites* as a whole has moderate to high susceptibility to ocean warming. However, different species of *Porites* have a wide range of susceptibilities to ocean warming, thus we conclude that an unstudied *Porites* species has some susceptibility to ocean warming. Most studies found high levels of disease in *Porites,* but one study found low levels. We conclude that an unstudied *Porites* species has some susceptibility to disease. Several studies reported that calcification declined with decreasing pH in short term experiments, but massive *Porites* are common and have normal growth rates in natural areas of low pH. We conclude that *Porites* has some susceptibility to ocean acidification.

The SRR rated the trophic effects of fishing as ''medium'' importance, the fourth most important threat to corals overall. This threat was not addressed at the genus or species level in the SRR or SIR, because it is an ecosystem-level process. That is, removal of herbivorous fish from coral reef systems by fishing alters trophic interactions by reducing herbivory on algae, thereby providing a competitive advantage for space to algae over coral. Thus, the SRR did not discuss this threat in terms of coral taxa, as its effects are difficult to distinguish between coral genera and species. Therefore, an unstudied *Porites* species is likely to have some susceptibility to the trophic effects of fishing.

The SRR rated sedimentation, nutrients, and sea-level rise as ''low-medium'' importance to corals overall. Porites is reported to have intermediate to high sediment tolerance. Thus we conclude that an unstudied Porites has some susceptibility to sedimentation. Although there is no genus-level or species-specific information on the susceptibilities of *Porites* species to nutrients, the SRR rated it as ''low-medium'' importance to corals.. Thus, we conclude that an unstudied *Porites* species has some susceptibility to nutrients. Sea-level rise was not addressed at the genus or species level in the SRR or SIR. Increasing sea levels may increase land-based sources of pollution due to inundation, resulting in changes to coral community structure, thus an unstudied *Porites* species is likely to have some susceptibility to sea-level rise. The SRR rated predation and ornamental trade (referred to in the proposed rule as Collection and Trade) as ''low'' importance to corals overall. The only study of predation reporting on *Porites* indicated it was a not a preferred prey item of crown-of-thorns starfish. Thus, we conclude that *Porites* has a low susceptibility to predation. *Porites* species are heavily collected and widely traded internationally. Thus we conclude that *Porites* has some susceptibility to collection and trade.

In conclusion, an unstudied *Porites* species is likely to have some susceptibility to ocean warming, disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, and collection and trade, and low susceptibility to predation.

Porites horizontalata

Introduction

The SRR and SIR provided the following information on *P. horizontalata's* morphology and taxonomy. Morphology was described as composites of encrusting plates and contorted fused branches. With respect to taxonomy, *Porites* is known to be morphologically plastic and multiple sympatric species frequently exhibit intergradation of skeletal characteristics. The results of a study of genetics of other *Porites* species found that genetics did not correspond well with *Porites* species based on morphology. The laminar parts of colonies of *P. horizontalata* resemble *Porites vaughani,* the branching parts may have corallites arranged in a star-like pattern like *Porites rus,* and the corallite features are most similar to *Porites eridani.*

Public comments and information we gathered did not provide any new or supplemental information on morphology, and confirmed that there are no known taxonomic problems for *P. horizontalata,* and that there is a moderate level of species identification uncertainty for this species. Veron (2000; 2014) states that *P. horizontalata* is easily confused with *P. rus,* but the species can be identified by experts (Fenner, 2014b), thus we conclude that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *P. horizontalata's* distribution, habitat, and depth range. *Porites horizontalata's* distribution is from the central Indian Ocean to the central Indo-Pacific and central Pacific. The SRR reported that *P. horizontalata's* habitat is shallow reef environments, and the depth range is from five to 20 m, though it is also known to range into deep water. *Porites horizontalata* is uncommon in Guam and found in deeper quiet waters.

Public comments did not provide any new or supplemental information on *P. horizontalata's* distribution. We gathered supplemental information including Veron (2014), which reports that *P. horizontalata* is confirmed in 28 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional 13. Supplemental information on the depth range of *P. horizontalata* in American Samoa indicates it is from about 10 m to at least 30 m deep, and it has been observed at 20 to 30 m of depth in New Caledonia, where it appears much as it does in American Samoa in similar locations (D. Fenner, personal comm.). Thus, based on all the available information, *P. horizontalata's* habitat includes at least upper reef slopes, mid-slope terraces, lower reef crests, and lagoons in depth ranging from five to 30 m depth.

Demographic Information

The SRR and SIR provided the following information on *P. horizontalata's* abundance. *Porites horizontalata* has been reported as sometimes common. Public comments did not provide any new or supplemental information on *P. horizontalata's* abundance. We gathered supplemental information including Veron (2014) and Richards *et al.* (2008). Veron (2014) reports that *P. horizontalata* occupied 4.2 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.62 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''uncommon,'' and overall abundance was described as ''sometimes common in isolated habitats.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least tens of millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *P. horizontalata,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 37 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 15 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *P. horizontalata* occurs in many areas affected by these broad changes, and that it likely has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *P. horizontalata's* life history. *Porites horizontalata* is a gonochoric broadcast spawner. Although specific observations have not been published for this species, the larvae of all other *Porites* species studied contain zooxanthellae that can supplement maternal provisioning with energy sources provided by their photosynthesis. The public comments did not provide new or supplemental information, and we did not find new or supplemental information on the above-described biological information.

Susceptibility to Threats

To describe *P. horizontalata's* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Porites* of ocean warming, acidification, disease, predation, sedimentation, nutrients, and collection and trade. The SRR and SIR also provided the following species-specific information on *P. horizontalata's* threats. *Porites horizontalata* was a bleaching ''loser'' in Okinawa, disappearing after the 1998 event. The SRR and SIR did not provide any other species-specific information on the effects of these threats on *P. horizontalata.* We interpreted threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *P. horizontalata's* vulnerabilities as follows: High vulnerability to ocean warming; moderate vulnerability to disease, ocean acidification, trophic effects of reef fishing, and nutrients, and low vulnerability to sedimentation, sea level rise, predation, and collection and trade.

Several public comments provided supplemental information on *P. horizontalata's* threat susceptibilities. One public comment stated that the Loya (2001) study of the effects of bleaching in Okinawa, which reported *P. horizontalata* as a loser, did not actually directly observe bleaching but rather looked at before and after abundances and deduced that species had or had not suffered from bleaching. It also stated that the sampling effort was small and the changes in low abundances may not even have been statistically significant. The comment suggests reducing the ocean warming component for this species in the determination tool to moderate to low (2.5) or to low (3). Another public comment stated that a published study (Goreau *et al.,* 1972) as well as observations on Guam suggest that *Porites* species in the subgenus *Synaraea* are among the least-preferred prey of the crown-of-thorns starfish. The comment stated that other studies (Colgan, 1987; Pratchett, 2007) suggest that *Porites* species in general are among the least preferred prey of crown-of-thorns. The comment further stated that workers on Guam have never seen crown-of-thorns predation on *P. horizontalata* and suspect that this species is among the least preferred prey of crown-of-thorns. The comment suggests changing the predation susceptibility to low (3) or moderate to low (2.5) in the determination tool. A third comment suggested *P. horizontalata* be considered a ''*Synaraea''* species instead of a branching *Porites* species. The common *Synaraea* species *Porites rus* has bleaching levels that are lower than both *Porites* branching and *Porites* massive corals. *Porites horizontalata* is within the *Synaraea* sub-genus and has not been observed to bleach in Guam to date.

We gathered the following supplemental species-specific information on susceptibility to threats for *P. horizontalata.* This species has been rated as moderately or highly susceptible to bleaching and disease, but this rating is not based on species-specific data (Carpenter *et al.,* 2008). *Porites horizontalata* was found to be a long term loser in Japan following bleaching events (decreasing from 1.2 percent cover to zero and staying there) (van Woesik *et al.,* 2011). *Porites horizontalata* had the ninth highest disease prevalence of 21 species of *Porites* in the Philippines. *Porites horizontalata* had a prevalence of 4, which was 20 percent of the prevalence of the species with the highest prevalence (Raymundo *et al.,* 2005). There is no species-specific information for the susceptibility of *P. horizontalata* to any other threat. Based on information provided in the *Porites* genus description and the species-specific information above, *P. horizontalata* likely has some susceptibility to ocean warming, disease, acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, and collection and trade, and low susceptibility to predation. The available information does not support more precise ratings of the susceptibilities of *P. horizontalata* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on regulatory mechanisms or conservation efforts for *P. horizontalata.* Criticisms of our approach received during public comment led us to the following analysis to attempt to analyze regulatory mechanisms on a species basis. Records confirm that *P. horizontalata* occurs in 28 Indo-Pacific ecoregions that encompass 25 countries' EEZs. The 25 countries are Brunei, China, Federated States of Micronesia, Fiji, France (French Pacific Island Territories), Indonesia, Japan, Malaysia, Marshall Islands, Myanmar, New Zealand (Tokelau), Niue, Palau, Papua New Guinea, Philippines, Samoa, Solomon Islands, Taiwan, Thailand, Timor-Leste, Tonga, Tuvalu, United States (CNMI, Guam, American Samoa, PRIAs), Vanuatu, and Vietnam. The regulatory mechanisms relevant to *P. horizontalata,* described first as the percentage of the above countries that utilize them to any degree and second, as the percentages of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (28 percent with 4 percent limited in scope), coral collection (64 percent with 40 percent limited in scope), pollution control (36 percent with 12 percent limited in scope), fishing regulations on reefs (96 percent with 16 percent limited in scope), and managing areas for protection and conservation (96 percent with 4 percent limited in scope). The most common regulatory mechanisms in place for *P. horizontalata* are reef fishing regulations and area management for protection and conservation. Coral collection laws are also somewhat utilized for the species, but 40 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection and pollution control laws are less prominent regulatory mechanisms for the management of *P. horizontalata.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that factors that increase the potential extinction risk for *P. horizontalata* include the fairly low tolerance to thermal stress and susceptibility to acidification based on genus-level information. It listed factors that reduce potential extinction risk including the species' broad distribution and the low predation susceptibility of the genus.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *P. horizontalata,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution includes many of the coral reef ecoregions in the central Indo-Pacific, and western and central Pacific Ocean. Its geographic distribution moderates vulnerability to extinction because some areas within its range are projected to have less than average warming and acidification over the foreseeable future including the central Pacific, and other areas, so portions of the population in these areas will be less exposed to severe conditions. Its depth range is from five to 30 meters, and has been found deeper. This moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Its habitat includes at least upper reef slopes, mid-slope terraces, lower reef crests, and lagoons. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Its absolute abundance of at least tens of millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule using the determination tool formula approach, *P. horizontalata* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); common generalized range wide abundance (E); wide overall distribution (based on wide geographic distribution and moderate depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *P. horizontalata* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *P. horizontalata's* spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to be likely to become endangered throughout its range within the foreseeable future, and thus is not warranted for listing at this time, because:

(1) *Porites horizontalata's* distribution across the central Indo-Pacific and central Pacific Ocean is spread over a vast area. While some areas within its range are projected to be affected by warming and acidification, other areas are projected to have less than average warming and acidification, including the western Indian Ocean, the central Pacific, and other areas. This distribution and the heterogeneous habitats it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future; and

(2) *Porites horizontalata's* absolute abundance is at least tens of millions of colonies, which provides buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future as global threats continue and increase in severity and the species exposure to threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *P. horizontalata* is not warranted for listing at this time under any of the listing factors.

Porites napopora

Introduction

The SRR and SIR provided the following information on *P. napopora's* morphology and taxonomy. Morphology was described as broad basal plates with irregular clumps of tapered irregularly fused branches. *Porites* is known to be morphologically plastic and multiple sympatric species frequently exhibit intergradation of skeletal characteristics. The results of a study of the genetics did not correspond well with the *Porites* species based on morphology. *Porites napopora* is similar to *P. nigrescens* and *P. negrosensis.*

Public comments and information we gathered did not provide any new or supplemental information on morphology, but did confirm that there is moderate taxonomic uncertainty for *P. napopora* and a moderate level of species identification uncertainty. Veron (Veron, 2014) states that *P. napopora* is distinctive, and *P. napopora* can be identified by experts (Fenner, 2014b), thus we conclude that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *P. napopora's* distribution, habitat, and depth range. The SRR and SIR described *P. napopora's* distribution as the Coral Triangle plus Micronesia and the Marianas Islands. Its habitat includes at least upper reef slopes, mid-slopes, lower reef crests, reef flats, and lagoons, and the depth range as three to 15 meters.

Public comments did not provide any new or supplemental information on *P. napopora's* distribution. We gathered supplemental information including Veron (Veron, 2014) which provides an updated, much more detailed range map for this species than the maps used in the SRR. Veron reports that this species is confirmed in 13 of his 133 Indo-Pacific ecoregions, and is strongly predicted to be found in an additional 13.

Demographic Information

The SRR and SIR provided the following information on *P. napopora's* abundance. *Porites napopora* has been reported as sometimes common.

Public comments did not provide any new or supplemental information on *P. napopora's* abundance. We gathered supplemental information including Veron (Veron, 2014), which reports that *P. napopora* occupied 2.6 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.79 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''uncommon,'' and overall abundance was described as ''sometimes common in isolated habitats.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *P. napopora,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 33 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 15 percent in the study. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *P. napopora* occurs in many areas affected by these broad changes, and likely has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species specific information.

Other Biological Information

The SRR and SIR provided the following information on *P. napopora's* life history. Although specific observations have not been published for this species, the larvae of all other *Porites* species studied contain zooxanthellae that can supplement maternal provisioning with energy sources provided by their photosynthesis. The public comments did not provide new or supplemental information, and we did not find new or supplemental information on the above-described biological information.

Susceptibility to Threats

To describe *P. napopora's* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Acropora* of ocean warming, acidification, disease, predation, sedimentation, nutrients, and collection and trade. The SRR and SIR did not provide any other species-specific information on the effects of these threats on *P. napopora.* We interpreted threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *P. napopora's* vulnerabilities as follows: High vulnerability to ocean warming; moderate vulnerability to disease, ocean acidification, trophic effects of fishing, and nutrients, and low vulnerability to sedimentation, sea level rise, predation, and collection and trade.

Public comments did not provide any new or supplemental information on *P. napopora's* threat susceptibilities. We gathered the following species-specific and genus-level supplemental information on this species' threat susceptibilities. *Porites napopora* has been rated as moderately or highly susceptible to disease but not to bleaching, but this rating is not based on species-specific data (2008). With regard to disease, *P. napopora* had the 13th highest disease prevalence of 21 species of *Porites* in the Philippines. *Porites napopora* had a prevalence of 0.2, which was one percent of the prevalence of the species with the highest prevalence (Raymundo *et al.,* 2005). There is no species-specific information for the susceptibility of *P. napopora* to any other threat. Based on information provided in the *Porites* genus description above, *P. napopora* is predicted to have some susceptibility to ocean warming, disease, acidification, and likely has some susceptibility to trophic effects of fishing, sedimentation, nutrients, sea-level rise, and collection and trade. Genus-level information indicates this species has low susceptibility to predation.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *P. napopora.* Criticisms of our approach received during public comment led us to the following analysis to attempt to analyze regulatory mechanisms on a species basis. Records confirm that *P. napopora* occurs in 13 Indo-Pacific ecoregions that encompass 10 countries' EEZs. The 10 countries are Brunei, China, Federated States of Micronesia, Indonesia, Japan, Malaysia, Philippines, Taiwan, Timor-Leste, and Vietnam. The regulatory mechanisms relevant to *P. napopora,* described first as the percentage of the above countries that utilize them to any degree, and second as the percentages of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (30 percent with none limited in scope), coral collection (60 percent with 30 percent limited in scope), pollution control (30 percent with 10 percent limited in scope), fishing regulations on reefs (100 percent with 30 percent limited in scope), and managing areas for protection and conservation (100 percent with none limited in scope). The most common regulatory mechanisms in place for *P. napopora* are reef fishing regulations and area management for protection and conservation. Coral collection laws are also somewhat utilized for the species, but 30 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection and pollution control laws are less prominent regulatory mechanisms for the management of *P. napopora.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that factors that increase the potential extinction risk for *P. napopora* include the species' distribution that is restricted to the western Pacific and the fairly low tolerance to thermal stress and susceptibility to acidification based on genus-level information. It listed factors that reduce potential extinction risk including its high tolerance of sediment stress and turbid water, and low predation susceptibility of the genus.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *P. napopora,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution is limited to parts of the Coral Triangle and the western equatorial Pacific Ocean. Despite the large number of islands and environments that are included in the species' range, this range exacerbates vulnerability to extinction over the foreseeable future because it is mostly limited to an area projected to have the most rapid and severe impacts from climate change and localized human impacts for coral reefs over the 21st century. Its depth range is down to 15 meters. On one hand, its depth range may moderate vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. On the other hand, its depth range may exacerbate vulnerability to extinction over the foreseeable future if the species occurs predominantly in the shallower portion of its depth range, since those areas will have higher irradiance and thus be more severely affected by warming-induced bleaching. Its habitat includes at least upper reef slopes, mid-slopes, lower reef crests, reef flats, and lagoons. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. There is not enough information about its abundance to determine if it moderates or exacerbates extinction: It is uncommon overall but common in parts of its range, and has at least millions of colonies, but the great majority of the population is within an area expected to be severely impacted by threats over the foreseeable future.

Listing Determination

In the proposed rule using the determination tool formula approach, *P. napopora* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); common generalized range wide abundance (E); narrow overall distribution (based on moderate geographic distribution and shallow depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we did not change the listing determination for *P. napopora.* Based on the best available information provided above on *P. napopora's* spatial structure, demography, threat susceptibilities, and management indicate that it is likely to become endangered throughout its range within the foreseeable future, and thus warrants listing as threatened at this time, because:

(1) *Porites napopora* is susceptible to warming induced bleaching (ESA Factor E), disease (C), trophic effects of fishing (A), and nutrients (A, E). These threats are expected to continue and worsen into the future. In addition, existing regulatory mechanisms to address global threats that contribute to extinction risk for this species are inadequate (D); and

(2) *Porites napopora's* distribution is constrained mostly to the Coral Triangle and western equatorial Pacific, which is projected to have the most rapid and severe impacts from climate change and localized human impacts for coral reefs over the 21st century, as described in the Threats Evaluation. Multiple ocean warming events have already occurred within the western equatorial Pacific that suggest future ocean warming events may be more severe than average in this part of the world. In addition, the species has a depth distribution of three to 15 m. Such a geographic and depth distribution is likely to experience severe and increasing threats, indicating that a high proportion of the population of this species is likely to be exposed to those threats over the foreseeable future.

The combination of these characteristics and future projections of threats indicates that the species is likely to be in danger of extinction within the foreseeable future throughout its range and warrants listing as threatened at this time due to factors A, C, D, and E.

The available information above on *P. napopora's* spatial structure, demography, threat susceptibilities, and management also indicate that the species is not currently in danger of extinction and thus does not warrant listing as Endangered because:

(1) While *P. napopora's* distribution is restricted mostly to the Coral Triangle, which increases it extinction risk as described above, its habitat includes shallow reef environments, which describes a variety of reef zones and habitat types in the coral reef ecosystem. This moderates vulnerability to extinction currently because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time, as described in more detail in the Coral Habitat and Threats Evaluation sections. There is no evidence to suggest that the species is so spatially fragmented that depensatory processes, environmental stochasticity, or the potential for catastrophic events currently pose a high risk to the survival of the species; and

(2) *Porites napopora's* its absolute abundance is likely at least millions of colonies and is described as ''sometimes common in isolated habitats'' providing areas of localized abundance which allows for variation in the responses of individuals to threats to play a role in moderating vulnerability to extinction for the species to some degree, as described in more detail in the Corals and Coral Reefs section. There is no evidence of depensatory processes such as reproductive failure from low density of reproductive individuals and genetic

processes such as inbreeding affecting this species. Thus, its absolute abundance indicates it is currently able to avoid high mortality from environmental stochasticity, and mortality of a high proportion of its population from catastrophic events.

The combination of these characteristics indicates that the species does not exhibit the characteristics of one that is currently in danger of extinction, as described previously in the Risk Analyses section, and thus does not warrant listing as endangered at this time.

Range-wide, a multitude of conservation efforts are already broadly employed that are likely benefiting *P. napopora.* However, considering the global scale of the most important threats to the species, and the ineffectiveness of conservation efforts at addressing the root cause of global threats (*i.e.,* GHG emissions), we do not believe that any current conservation efforts or conservation efforts planned in the future will result in affecting the species status to the point at which listing is not warranted.

Porites nigrescens

Introduction

The SRR and SIR provided the following information on *P. nigrescens'* morphology and taxonomy. The morphology was described as branching, sometimes with an encrusting base, and concave calices give the surface a pitted appearance. *Porites* is known to be morphologically plastic and multiple sympatric species frequently exhibit intergradation of skeletal characteristics. The results of a genetics study did not correspond well with the *Porites* species based on morphology. *Porites nigrescens* is similar in appearance to *Porites cylindrica.*

The public comments and information we gathered did not provide any new or supplemental information on morphology, and confirmed that there is moderate taxonomic uncertainty for *P. nigrescens* and that there is a moderate level of species identification uncertainty for this species. Veron (2014) states that *P. nigrescens* is easily distinguished from other branching *Porites,* thus we conclude it can be identified by experts, and that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *P. nigrescens'* distribution, habitat, and depth range. The SRR and SIR described *P. nigrescens'* distribution as occurring from the Red Sea and east Africa to the central Pacific. Its habitat includes coral reef environments protected from wave action, including at least upper reef slopes, mid-slopes, lower reef slopes, and lagoons, and its depth range as 0 to 20 meters.

The public comments provided information that *P. nigrescens* is widely distributed in all Indonesian waters. We gathered supplemental information, including Veron (2014), which reports that this species is confirmed in 56 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional 18.

Demographic Information

The SRR and SIR provided the following information on *P. nigrescens'* abundance. *Porites nigrescens* has been reported as sometimes common. Where found, it can be a part of a locally abundant branching poritid assemblage.

The public comments and information we gathered provided supplemental information on *P. nigrescens'* abundance. One public comment stated that *P. nigrescens* is very abundant in all Indonesian waters. We gathered supplemental information, including Veron (2014), which reports that *P. nigrescens* occupied 29.05 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 2.01 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''very common.'' Overall abundance was described as ''sometimes common.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least tens of millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *P. nigrescens,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 35 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 14 percent in the study. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *P. nigrescens* occurs in many areas affected by these broad changes, and that it is likely has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species specific information.

Other Biological Information

The public comments and information we gathered did not provide any new or supplemental biological information on *P. nigrescens.*

Susceptibility to Threats

To describe *P. nigrescens'* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Porites* of ocean warming, acidification, disease, predation, sedimentation, nutrients, and collection and trade. The SRR and SIR did not provide any other species-specific information on the effects of these threats on *P. nigrescens.* We interpreted the threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *P. nigrescens'* vulnerabilities as follows: High vulnerability to ocean warming, moderate vulnerability to disease, ocean acidification, trophic effects of fishing, and nutrients, and low vulnerability to sedimentation, sea-level rise, predation, and collection and trade.

Public comments did not provide any new or supplemental information on *P. nigrescens'* threat susceptibilities. We gathered the following species-specific and genus-level supplemental information on this species' threat susceptibilities. *Porites nigrescens* has not been rated as moderately or highly susceptible to bleaching, but this rating is not based on species-specific data (2008). *Porites nigrescens* appears to have high susceptibility to thermal stress and warming-induced bleaching. *Porites nigrescens* had high bleaching rates in East Africa in 1998 (Obura, 2001) and Palau in 2000 (Bruno *et al.,* 2001). In East Africa, 99 percent of *P. nigrescens* colonies were affected by bleaching at the peak of bleaching in

1998 in Kenya, Tanzania, Mozambique, and Madagascar. This was the third-most affected species out of 14 species, and was affected 99 percent as much as the most affected species. At the end of bleaching, 87 percent of colonies were dead, which was the fifth-highest mortality species, and 94 percent of the mortality level of the highest mortality species (Obura, 2001). In Palau in 2000, *P. nigrescens* had very high to moderate bleaching, and very high mortality. Of all *P. nigrescens* colonies at the study site, 48 percent bleached, and bleaching of different genera and species ranged from none to very high, with mortality from zero to near 100 percent (Bruno *et al.,* 2001). Loya *et al.* (Loya *et al.,* 2001) reported that *P. nigrescens* was a ''loser'' in a 1998 bleaching event in Japan where it went down to zero abundance and cover (Loya *et al.,* 2001).

Porites nigrescens has been rated as moderately or highly susceptible to disease, but these ratings are not based on species-specific data (Carpenter *et al.,* 2008). Raymundo *et al.* (2005) reported *P. nigrescens* had the seventh-highest disease prevalence of 21 species of *Porites* in the Philippines. *Porites nigrescens* had a moderate level of disease prevalence relevant to the other coral species in the study. No other species-specific information is available for the susceptibility of *P. nigrescens* to any other threat.

Based on species-specific and genus-level information above, *P. nigrescens* is likely highly susceptible to ocean warming and also likely has some susceptibilities to disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade. The available information does not support more precise ratings of the susceptibilities of *P. nigrescens* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *P. nigrescens.* Public comments were critical of that approach, and we therefore attempt to analyze regulatory mechanisms and conservation efforts on a species basis, where possible, in this final rule. Records confirm that *P. nigrescens* occurs in 56 Indo-Pacific ecoregions that encompass 43 countries' EEZs. The 43 countries are Australia, Brunei, Cambodia, China, Djibouti, Eritrea, Federated States of Micronesia, Fiji, France (French Pacific Island Territories), India (Andaman and Nicobar Islands), Indonesia, Japan, Kenya, Kiribati, Madagascar, Malaysia, Marshall Islands, Mauritius, Mozambique, Myanmar, New Zealand (Tokelau), Niue, Palau, Papua New Guinea, Philippines, Samoa, Saudi Arabia, Seychelles, Solomon Islands, Somalia, South Africa, Sri Lanka, Taiwan, Tanzania, Thailand, Timor-Leste, Tonga, Tuvalu, United Kingdom (British Indian Ocean Territory), United States (American Samoa, PRIAs), Vanuatu, Vietnam, and Yemen. The regulatory mechanisms available to *P. nigrescens,* described first as a percentage of the above countries that utilize them to any degree and second, as the percentages of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (28 percent with 7 percent limited in scope), coral collection (56 percent with 28 percent limited in scope), pollution control (35 percent with 7 percent limited in scope), fishing regulations on reefs (95 percent with 23 percent limited in scope), and managing areas for protection and conservation (93 percent with 5 percent limited in scope). The most common regulatory mechanisms in place for *P. nigrescens* are reef fishing regulations and area management for protection and conservation. Coral collection laws are somewhat utilized but some are limited in scope and may not provide substantial protection for *P. nigrescens.* General coral protection and pollution control laws are much less prominent regulatory mechanisms for the management of *P. nigrescens.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that factors that increase the potential extinction risk for *P. nigrescens* include the fairly low tolerance to thermal stress and susceptibility to acidification impacts in the genus. It listed factors that reduce potential extinction risk including the species' broad distribution, the high tolerance of sediment stress and turbid water, and low disease and predation susceptibility of the genus.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *P. nigrescens,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution includes most of the coral reef ecoregions in the Indian Ocean and western and central Pacific Ocean. Its geographic distribution moderates vulnerability to extinction because some areas within its range are projected to have less than average warming and acidification over the foreseeable future, including the western Indian Ocean, the central Pacific, and other areas, so portions of the population in these areas will be less exposed to severe conditions. Its depth range is down to at least 20 meters. This moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Its habitat includes at least upper reef slopes, mid-slopes, lower reef slopes, and lagoons protected from wave action. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Its abundance of at least tens of millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule using the determination tool formula approach, *P. nigrescens* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA

Factor E); moderate vulnerability to disease (C) and acidification (E); common generalized range wide abundance (E); wide overall distribution (based on wide geographic distribution and moderate depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *P. nigrescens* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *P. nigrescens'* spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to be likely to become endangered throughout its range within the foreseeable future, and thus is not warranted for listing at this time, because:

(1) *Porites nigrescens'* distribution from the Red Sea and east Africa across most of the Pacific Ocean is spread over a very large area. While some areas within its range are projected to be affected by warming and acidification, other areas are projected to have less than average warming and acidification, including the western Indian Ocean, the central Pacific, and other areas. This distribution and the heterogeneous habitats it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future; and

(2) *Porites nigrescens'* absolute abundance is at least tens of millions of colonies, providing buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future if global threats continue and increase in severity and the species exposure to threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *P. nigrescens* is not warranted for listing at this time under any of the listing factors.

Genus Pachyseris

Genus Introduction

The family Agaricidae includes six genera, *Agaricia* (Caribbean only), *Leptoseris, Pavona, Pachyseris, Gardineroseris,* and *Coeloseris. Pachyseris* contains four species, all in the Indo-Pacific. *Pachyseris* species are foliose, and one species can produce short columns or branches. The SRR and SIR provided no genus-level introductory information on *Pachyseris.*

Genus Susceptibility to Threats

The SRR and SIR provided the following information on the threat susceptibilities of the genus *Pachyseris.* A series of studies reported that *Pachyseris* experiences variable but high levels of bleaching, though in some places it may be bleaching tolerant. *Pachyseris'* high bleaching rate and relative rarity may give it a relatively high extirpation risk in the western Indian Ocean. Trade in this genus is relatively high.

The public comments did not provide any new or supplemental information on the threat susceptibilities of the genus *Pachyseris.* We gathered supplemental information that provided the following details. *Pachyseris* had a bleaching index of 8.3 for eight countries in the western Indian Ocean in 1998–2005, which was 33rd highest of the 45 genera recorded, and 20 percent of the highest value. As a genus, its moderate bleaching rate combined with relative rarity may give it a relatively high extirpation risk in the western Indian Ocean (McClanahan *et al.,* 2007a). Done *et al.* (2003b) reported that overall bleaching rates for two species of *Pachyseris* were 15 percent and 38 percent on the GBR in 2002, which were the seventh and third highest levels of bleaching out of 16 species of Agariciids. There is no information available on the effects of any other threat for *Pachyseris.*

Genus Conclusion

Based on the information from the SRR, SIR, public comments, and supplemental information, we can make the following inferences about the susceptibilities of an unstudied *Pachyseris* species to ocean warming, disease, acidification, sedimentation, nutrients, trophic effects of fishing, sea-level rise, predation, and collection and trade. The SRR rated ocean warming and disease as ''high'' importance, and ocean acidification as ''medium-high'' importance, to corals. These were rated as the three most important threats to reef-building corals overall. *Pachyseris* has a variable level of susceptibility to bleaching, with most reports of bleaching being moderate to high. Thus, we conclude that an unstudied *Pachyseris* species is likely to have high susceptibility to ocean warming. Although there is no other genus-level or species-specific information on the susceptibilities of *Pachyseris* species to disease and ocean acidification, the SRR rated them as ''high'' and ''medium-high'' importance to corals, respectively. Thus, we conclude that an unstudied *Pachyseris* species is likely to have some susceptibility to disease and ocean acidification.

The SRR rated the trophic effects of fishing as ''medium'' importance, the fourth most important threat to corals overall. This threat was not addressed at the genus or species level in the SRR or SIR, because it is an ecosystem-level process. That is, removal of herbivorous fish from coral reef systems by fishing alters trophic interactions by reducing herbivory on algae, thereby providing a competitive advantage for space to algae over coral. Thus, the SRR did not discuss this threat in terms of coral taxa, as its effects are difficult to distinguish between coral genera and species. Therefore, an unstudied *Pachyseris* species is likely to have some susceptibility to the trophic effects of fishing.

The SRR rated sedimentation, nutrients, and sea-level rise as ''low-medium'' importance to corals overall. Although there is no genus-level or species-specific information on the susceptibilities of *Pachyseris* species to sedimentation and nutrients, the SRR rated them as ''low-medium'' importance to corals.. Thus, we conclude that an unstudied *Pachyseris* species is likely to have some susceptibility to sedimentation and nutrients. Sea-level rise was not addressed at the genus or species level in the SRR or SIR. Increasing sea levels may increase land-based sources of pollution due to inundation, resulting in changes to coral community structure, thus an unstudied *Pachyseris* species is likely to have some susceptibility to sea-level rise. Although there is no genus-level or species-specific information on the susceptibilities of *Pachyseris* species to predation, there is no information suggesting they are not susceptible to this threat. Thus, we conclude that an unstudied *Pachyseris* species has some susceptibility to predation. The SRR rated predation and ornamental trade (referred to in the proposed rule as Collection and Trade) as ''low'' importance to corals overall. Because the available general information suggests that collection and trade of *Pachyseris* species is relatively high, we conclude an unstudied *Pachyseris* species is likely to have some susceptibility to collection and trade.

In conclusion, an unstudied *Pachyseris* species is likely to have high susceptibility to ocean warming, and some susceptibility to disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, predation, sea-level rise, and collection and trade.

Pachyseris rugosa

Introduction

In The SRR and SIR provided the following information on *P. rugosa's* morphology and taxonomy. Morphology was described as colonies that are upright, irregular, fused, bifacial plates, and taxonomy was described as having no taxonomic issues, but being similar to *Pachyseris gemmae* and *Pachyseris involuta.*

Public comments and information we gathered did not provide any new or supplemental information on morphology, and confirmed that there are no known taxonomic problems for *P. rugosa,* and a low level of species identification uncertainty. Veron (2014) states that *P. rugosa* is very distinctive and Veron (2000; 2014) considers the species valid, and we consider it can be identified by experts, thus we conclude that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *P. rugosa's* distribution, habitat, and depth range. The SRR and SIR described *P. rugosa's* distribution as from the Red Sea and east Africa to the central Pacific. Regarding habitat, the SRR and SIR stated that *P. rugosa* may develop into large mound-shaped colonies in shallow water but smaller colonies occur in a wide range of habitats including those exposed to strong wave action. It is associated with fine-grained sediments on the Great Barrier Reef, and could be an indicator of quiet water or a moderate energy environment. Thus, its habitat includes at least upper reef slopes, mid-slopes, and lagoons. Its depth range is from five to 20 meters, and it may be excluded from shallow environments by excess light.

Public comments did not provide any new or supplemental information on *P. rugosa's* distribution. We gathered supplemental information, including Veron (2014), which reports that this species is confirmed in 57 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional 17.

Demographic Information

The SRR and SIR reported *P. rugosa's* abundance as common.

Public comments did not provide any new or supplemental information on *P. rugosa's* abundance. We gathered supplemental information, including Veron (2014), which reports that *P. rugosa* occupied 23.5 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.45 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''common,'' and overall abundance was also described as ''common.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least tens of millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *P. rugosa,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 36 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 14 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *P. rugosa* occurs in many areas affected by these broad changes, and likely has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *P. rugosa's* life history. *Pachyseris rugosa* is a gonochoric broadcast spawner. This species contains clade C zooxanthellae, with a predominance of clade C3h in areas of greater temperature or turbidity. Public comments and information we gathered added no new or supplemental information to the above-described biological information.

Susceptibility to Threats

To describe *P. rugosa's* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Pachyseris* of ocean warming, acidification, disease, sedimentation, nutrients, predation, and collection and trade. The SRR and SIR also provided the following species-specific information on *P. rugosa's* threats. *Pachyseris rugosa* is vulnerable to a ciliate disease skeletal eroding band. Although overall disease presence was low during a survey in Indonesia, the black-band progressed across *P. rugosa* at an average rate of 0.63cm/d. Mass mortality of this species on the GBR has been attributed to crown of thorns starfish, although predation was not observed directly. *Pachyseris rugosa* has suffered high partial mortality as a result of dredging, but its branching structure should make it an efficient sediment-rejecter. The species disappeared in Jakarta Bay between 1920 and 2005, which was attributed to decreased water quality from coastal development. *Pachyseris rugosa* experiences substantial export, averaging 1195 specimens annually from 1991 to 2008, decreasing in 1997–2003, but returning to 2085 per year in

2004–2008. The SRR and SIR did not provide any other species-specific information on the effects of these threats on *P. rugosa.* We interpreted threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *P. rugosa'*s vulnerabilities as follows: High vulnerability to ocean warming, moderate vulnerability to disease, ocean acidification, and trophic effects of fishing, and low vulnerability to sedimentation, sea level rise, predation, and collection and trade.

Public comments did not provide any new or supplemental information on *P. rugosa'*s susceptibility to threats. We gathered the following supplemental species-specific and genus-level information on this species' threat susceptibilities. *Pachyseris rugosa* has been rated as moderately or highly susceptible to bleaching but not disease, but this rating is not based on species-specific data (Carpenter *et al.,* 2008). With regard to thermal stress, 15 percent of *P. rugosa* colonies were affected by bleaching on the GBR in 2002. The median bleaching level among Agariciidae colonies was 10 percent, and the maximum was 58 percent. The only other *Pachyseris* reported, *P. speciosa,* bleached at a rate of 38 percent (Done *et al.,* 2003b). All colonies of *P. rugosa* were partly bleached at Laem Set at Samui Island in the western Gulf of Thailand in 1998, and all were completely bleached in 2010. However, after both bleaching events, all colonies recovered and were healthy (Sutthacheep *et al.,* 2013). In Palau in 2000, *P. rugosa* had variable but generally high bleaching levels and high mortality: 48 percent of all colonies of all species were bleached, and bleaching of different genera and species ranged from none to very high, and mortality from zero to near 100 percent (Bruno *et al.,* 2001). Based on species specific and genus information presented above, *P. rugosa* is predicted to have a moderate to high level of susceptibility to bleaching. With regard to disease, Page and Willis (2007) reported that skeletal eroding band has been found in *P. rugosa* on the GBR, where it is the most prevalent disease on corals. However, the prevalence on *P. rugosa* was too low to record in transects. Darling *et al.* (2012) performed a biological trait-based analysis to categorize the relative tolerance of coral species to environmental stress. *Pachyseris rugosa* was classified as a ''generalist'' species, defined as species that can do well in habitats where competition is limited by low levels of stress. There are no other reports of the effects of any other threats on *P. rugosa.* Based on genus-level and species-specific information describe above, *P. rugosa* is likely to have high susceptibility to ocean warming and some susceptibility to disease, ocean acidification, trophic effects of fishing, nutrients, sedimentation, sea level rise, predation, and collection and trade. The available information does not support more precise ratings of the susceptibility of *P. rugosa* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanism or conservation efforts for *P. rugosa.* Criticisms of our approach received during public comment led us to attempt the following analysis of regulatory mechanisms on a species basis. Records confirm that *P. rugosa* occurs in 57 Indo-Pacific ecoregions that encompass 36 countries' EEZs. The 36 countries are Australia, Brunei, China, Egypt, Federated States of Micronesia, Fiji, France (French Pacific Island Territories), India (including Andaman and Nicobar Islands), Indonesia, Israel, Japan, Jordan, Madagascar, Malaysia, Maldives, Mauritius, Myanmar, New Zealand (Tokelau), Niue, Palau, Papua New Guinea, Philippines, Samoa, Saudi Arabia, Solomon Islands, Sri Lanka, Sudan, Taiwan, Thailand, Timor-Leste, Tonga, Tuvalu, United Kingdom (British Indian Ocean Territory), United States (American Samoa, PRIAs), Vanuatu, and Vietnam. The regulatory mechanisms relevant to *P. rugosa,* described first as the percentage of the above countries that utilize them to any degree, and second as the percentage of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (28 percent with 6 percent limited in scope), coral collection (61 percent with 31 percent limited in scope), pollution control (44 percent with 8 percent limited in scope), fishing regulations on reefs (92 percent with 19 percent limited in scope), managing areas for protection and conservation (97 percent with 8 percent limited in scope). The most common regulatory mechanisms in place for *P. rugosa* are reef fishing regulations and area management for protection and conservation. Coral collection and pollution control laws are also somewhat common for the species, but 31 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection laws are much less common regulatory mechanisms for the management of *P. rugosa.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that factors that increase the potential extinction risk for *P. rugosa* are that it has had high (but variable) observed bleaching in response to warming events, has been observed to be susceptible to multiple types of disease, and has been inferred to be susceptible to poor water quality. Substantial collection from the aquarium trade could lead to local extirpation in some areas. It listed factors that reduce potential extinction risk including that *P. rugosa* has a widespread distribution from the central Pacific to Africa, and it can have a high local abundance.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *P. rugosa,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution includes most of the coral reef ecoregions in the Indian Ocean and western and central Pacific Ocean, and some in the Red Sea. Its geographic distribution moderates vulnerability to extinction because some areas within its range are projected to have less than average warming and acidification over the foreseeable future, including the western Indian Ocean, the central Pacific, and other areas, so portions of the population in these areas will be less exposed to severe conditions. Its depth range is from five to at least 20 meters. This moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Its habitat includes at least upper reef slopes, mid-slopes, and lagoons. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Its abundance of at least tens of millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore, there will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule using the determination tool formula approach, *P. rugosa* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); common generalized range wide abundance (E); wide overall distribution (based on wide geographic distribution and moderate depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *P. rugosa* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *P. rugosa'*s spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to likely become endangered throughout its range within the foreseeable future, and thus it is not warranted for listing at this time, because:

(1) *Pachyseris rugosa'*s distribution from the Red Sea across the Indian Ocean and most of the Pacific Ocean includes tens of thousands of islands and reefs spread over a vast area. While some areas within its range are projected to be affected by warming and acidification, other areas are projected to have less than average warming and acidification, including the western Indian Ocean, the central Pacific, and other areas. This distribution and the heterogeneous habitats it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future; and

(2) *Pachyseris rugosa* is described as common throughout its vast geographic range and its total population size is at least tens of millions of colonies, providing buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future if global threats continue and increase in severity and the species exposure to threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *P. rugosa* is not warranted for listing at this time under any of the listing factors.

Genus Pavona

Genus Introduction

The family Agaricidae includes six genera, *Agaricia* (Caribbean only), *Leptoseris, Pavona, Pachyseris, Gardineroseris,* and *Coeloseris.* Veron (Veron, 2000) recognizes 14 species in the genus *Pavona.* Colonies of *Pavona* species have plates, branches, or are massive. The SRR and SIR provided no genus-level introductory information on *Pavona.*

Genus Susceptibility to Threats

The SRR and SIR provided the following information on the threat susceptibilities of the genus *Pavona.* One study reports *Pavona* had mixed bleaching susceptibility on the GBR. Other studies reported that both massive and encrusting *Pavona* have been highly susceptible to bleaching in the eastern Pacific. Calcification in one *Pavona* species slowed in reduced aragonite saturation state. Two massive *Pavona* in the eastern Pacific showed little calcification reduction over 30 years in response to acidification. The presence of several species of *Pavona* in low aragonite saturation states in the Eastern Pacific suggests some tolerance to acidification. There are a medium number of acute white diseases found in *Pavona* by surveys in the Pacific. Members of the genus *Pavona* are susceptible to predation by crown-of-thorns seastar (*Acanthaster planci*), but susceptibility is variable among species in the eastern Pacific. The genus *Pavona* is generally regarded as moderately tolerant to sediment stress. More than 1,000 pieces of *Pavona* are traded per year.

The public comments did not provide any new or supplemental information on the threat susceptibilities of the genus *Pavona.* We gathered supplemental information that provided the following. With regard to thermal stress, Brown and Suharsono (1990) reported that less than half of the *Pavona* on the reef flats of two islands in the Thousand Islands of Indonesia died in the 1983 El Nino mass bleaching. In the mass bleaching event in 1998 in the Ryukyu Islands of Japan, *Pavona* was highly susceptible to bleaching, and mortality was 100 percent, higher than any other of the six genera included in the study (Kayanne *et al.,* 2002). In contrast, during the same 1998 bleaching event in Kenya, mortality of *Pavona* colonies was zero, and *Pavona* was one of five genera out of the 18 genera in the study that had no mortality (McClanahan *et al.,* 2004). *Pavona's* bleaching index was the second lowest of the 18 genera (McClanahan *et al.,* 2004). In a bleaching event on Palau in 2000, three species of *Pavona* had high levels of bleaching and high mortality. Forty-eight percent of all colonies of all species were bleached, and both bleaching and mortality of different genera and species ranged from zero to near 100 percent (Bruno *et al.,* 2001). In a bleaching event on the GBR in 2002, between seven percent and 57 percent of six species of *Pavona* were affected (Done *et al.,* 2003b). In a bleaching event on Mauritius in 2004, *Pavona* had the fourth lowest bleaching of the 32 genera recorded (McClanahan *et al.,* 2005a). In a bleaching event on Howland and Baker Islands in 2010, between 32 and 37 percent of *Pavona* colonies bleached (Vargas-Angel *et al.,* 2011). During the same 2010 bleaching event in Thailand, between 47 and 67 percent of *Pavona* colonies bleached (Sutthacheep *et al.,* 2013).

In a broad study of 45 genera in the western Indian Ocean in 1998 to 2005, *Pavona* ranked 31st in bleaching susceptibility (McClanahan *et al.,* 2007a). *Pavona* had a low prevalence of disease in Guam, with 0.5% of colonies with disease, tied for sixth highest prevalence out of 12 genera, with the highest genus having 6.7 percent (Myers and Raymundo, 2009). There is no other supplemental information on the susceptibilities or vulnerabilities of *Pavona* to other threats.

Genus Conclusion

Based on the information from the SRR, SIR, public comments, and supplemental information, we can make the following inferences about the susceptibilities of an unstudied *Pavona* species to ocean warming, disease, ocean acidification, sedimentation, nutrients, trophic effects of fishing, sea-level rise, predation, and collection and trade. The SRR rated ocean warming and disease as ''high'' importance, and ocean acidification as ''medium-high'' importance, to corals. These were rated as the three most important threats to reef-building corals overall. There was a wide range of reported susceptibility of *Pavona* colonies to ocean warming and acidification. One study reported a moderate disease prevalence in *Pavona* and another reported a low prevalence. Thus, we conclude that an unstudied *Pavona* species is likely to have some susceptibility to ocean warming, disease, and acidification.

The SRR rated the trophic effects of fishing as ''medium'' importance, the fourth most important threat to corals overall. This threat was not addressed at the genus or species level in the SRR or SIR, because it is an ecosystem-level process. That is, removal of herbivorous fish from coral reef systems by fishing alters trophic interactions by reducing herbivory on algae, thereby providing a competitive advantage for space to algae over coral. Thus, the SRR did not discuss this threat in terms of coral taxa, as its effects are difficult to distinguish between coral genera and species. Therefore, an unstudied *Pavona* species is likely to be susceptible to the trophic effects of fishing.

The SRR rated sedimentation, nutrients, and sea-level rise as ''low-medium'' importance to corals overall. The SRR reported that one study showed *Pavona decussata* had an intermediate level of susceptibility to sedimentation. Thus, we conclude that an unstudied *Pavona* species is likely to have some susceptibility to sedimentation. Although there is no genus-level or species-specific information on the susceptibilities of *Pavona* species to nutrients, the SRR rated it as ''low-medium'' importance to corals.. Thus, we conclude that an unstudied *Pavona* species is likely to have some susceptibility to nutrients. Sea-level rise was not addressed at the genus or species level in the SRR or SIR. Increasing sea levels may increase land-based sources of pollution due to inundation, resulting in changes to coral community structure, thus an unstudied *Pavona* species is likely to have some susceptibility to sea-level rise. The SRR reported that *Pavona* was susceptible to starfish predation (but the level varied by species) and that the genus is traded in a moderate amount. Thus, we conclude that an unstudied *Pavona* species has some susceptibility to predation and to collection and trade.

In conclusion, an unstudied *Pavona* species is likely to have some susceptibility to ocean warming, disease, acidification, trophic effects of fishing, nutrients, sedimentation, nutrients, sea-level rise, predation, and collection and trade.

Pavona diffluens

Introduction

The SRR and SIR provided the following information on *P. diffluens'* morphology and taxonomy. Morphology was described as submassive, and the taxonomy was described as having no taxonomic issues, but it is similar to *Pavona gigantea* and *Pavona explanulata.*

The public comments and information we gathered did not provide any new or supplemental information on morphology. There is high taxonomic uncertainty about colonies that appear similar to *P. diffluens* in the Pacific, but low taxonomic uncertainty about *P. diffluens* in the Red Sea and Indian Ocean. Both colonies in the Red Sea/Indian Ocean, and in the Pacific, are easily distinguished from other *Pavona.* Veron (2014) states that, ''We believe that Pacific *P. diffluens* is likely to be a similar but different species from western Indian Ocean *P. diffluens.''* We treat *P. diffluens* as the colonies in the Red Sea and Indian Ocean only, as this is the best currently available scientific information. Veron (2000; 2014) considers the species valid, and we consider it is sufficiently distinctive to be identified by experts, thus we conclude that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *P. diffluens'* distribution, habitat, and depth range. *Pavona diffluens* occurs from the Red Sea to the Arabian Gulf, and records show this species from the Marianas Islands and American Samoa, but the records from the Marianas Islands were unlikely. Its habitat includes at least upper reef slopes, mid-slopes, lower reef crests, reef flats, and lagoons, in depths ranging from five to at least 20 m.

The public comments and information we gathered provided supplemental information on the distribution of *P. diffluens.* One public comment stated that the occurrence of *P. diffluens* in the Marianas indicates that this species has a broader range than has been recognized by the authors. We gathered supplemental information, including additional reports of *P. diffluens* from American Samoa (Fenner, 2014b; Kenyon *et al.,* 2010), but the taxonomic question for them remains. Veron (2014) reports that this species is confirmed in five of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional three, all of which are in the western Indian Ocean. The public comments and information we gathered provided nothing new or supplemental on *P. diffluens'* habitat and depth range.

Demographic Information

The SRR and SIR provided the following information on *P. diffluens'* abundance. *Pavona diffluens* has been reported as uncommon.

The public comments did not provide any new or supplemental information on *P. diffluens'* abundance, but we gathered supplemental information that provided the following: Veron (Fenner, 2014b; Veron, 2014) reported that *P. diffluens* occupied 0.47% of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.43 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance is characterized as ''rare,'' and overall abundance is described as ''uncommon.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *P. diffluens,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 36 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 20 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context. Thus, these changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *P. diffluens* occurs in many areas affected by these broad changes, and likely has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *P. diffluens'* life history. The reproductive characteristics of *P. diffluens* have not been determined, but six other species in the genus are known to be gonochoric broadcast spawners. The public comments did not provide new or supplemental information, and we did not find new or supplemental information on the above-described biological information.

Susceptibility to Threats

To describe *P. diffluens'* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Pavona* of ocean warming, disease, acidification, sedimentation, predation, and collection and trade. The SRR and SIR did not provide any other species-specific information on the effects of these threats on *P. diffluens.* We interpreted the threat susceptibility and exposure information from the SRR and SIR in the proposed rule as follows: High vulnerability to ocean warming, moderate vulnerabilities to disease, ocean acidification, and trophic effects of fishing, low vulnerabilities to sedimentation, sea-level rise, predation, and collection and trade, and unknown vulnerability to nutrients.

Public comments did not provide any new or supplemental information on *P. diffluens'* threat susceptibilities. We gathered the following species-specific and genus-level supplemental information on this species' threat susceptibilities. *P. diffluens* has not been rated as moderately or highly susceptible to bleaching or disease, but this rating is not based on species-specific data (Carpenter *et al.,* 2008). There is no species-specific information for the exposure or susceptibility of *P. diffluens* to any threat. Based on genus-level and species information described above, *P. diffluens* likely has some susceptibilities to ocean warming, disease, acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade. The available information does not support more precise ratings of the susceptibilities of *P. diffluens* to the threats.

Regulatory Mechanisms

In the proposed rule we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *P. diffluens.* Criticisms of our approach received during public comment led us to the following analysis to attempt to analyze regulatory mechanisms on a species basis. Records confirm that *Pavona diffluens* occurs in five Indo-Pacific ecoregions that encompass 14 countries' EEZs. The 14 countries are Djibouti, Egypt, Eritrea, France (French Pacific Island Territories), Iran, Israel, Jordan, Madagascar, Oman, Pakistan, Saudi Arabia, Sudan, United Arab Emirates, and Yemen. The regulatory mechanisms relevant to *P. diffluens,* described first as the percentage of the above countries that utilize them to any degree, and second, as the percentages of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (21 percent with 7 percent limited in scope), coral collection (43 percent with 7 percent limited in scope), pollution control (64 percent with 7 percent limited in scope), fishing regulations on reefs (71 percent with 21 percent limited in scope), and managing areas for protection and conservation (79 percent with 21 percent limited in scope). The most common regulatory mechanisms in place for *P. diffluens* are reef fishing regulations and area management for protection and conservation. Pollution control laws are also common for the species. Coral collection and general coral protection laws are less common regulatory mechanisms for the management of *P. diffluens.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that *P. diffluens'* fairly moderate-to-low tolerance to thermal stress and the species' narrow distribution range increase the potential extinction risk. It listed factors that reduce potential extinction risk for *P. diffluens* including its moderate tolerance of sediment stress and its low susceptibility of the genus to disease and predation.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *P. diffluens,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution is limited only to parts of the western Indian Ocean along coastal East Africa, the Red Sea, and the Gulf of Oman. This range exacerbates vulnerability to extinction over the foreseeable future because of its size and localized human impacts for coral reefs over the 21st century. In addition, parts of the Red Sea are projected to experience severe impacts from climate change more rapidly than other parts of the Indo-Pacific region. Its depth range of five to 25 meters moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Its habitat includes at least upper reef slopes, mid-slopes, lower reef crests, reef flats, and lagoons. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Its abundance of at least millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time. However, its qualitative abundance is described as rare, which can exacerbate its vulnerability given its restricted range.

Listing Determination

In the proposed rule using the determination tool formula approach, *P. diffluens* was proposed for listing as threatened because of: Moderate vulnerability to ocean warming (ESA Factor E), disease (C) and acidification (E); uncommon generalized range wide abundance (E); narrow overall distribution (based on narrow geographic distribution and moderate depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, the listing determination for *P. diffluens* remained threatened. Based on the best available information provided above on *P. diffluens'* spatial structure, demography, threat susceptibilities, and management, it is likely to become endangered throughout its range within the foreseeable future, and thus warrants listing as threatened at this time, because:

(1) *Pavona diffluens* is susceptible to ocean warming (E), disease (C), ocean acidification (E), trophic effects of fishing (A), nutrients (A, E), and predation (C). In addition, the species has inadequate regulatory mechanisms for global threats (D);

(2) *Pavona diffluens'* distribution is mostly constrained to a small part of the Indian Ocean where projections of local threats (*e.g.,* land-based sources of pollution) and general effects of climate change are both frequent and severe over the foreseeable future. The Red Sea in particular is projected to experience frequent warming events sooner than most other parts of the Indo-Pacific region. A range constrained to a particular geographic area this size, predicted to experience increasing threat impacts, indicates that a high proportion of the population of this species is likely to be exposed to threats that occur throughout this range over the foreseeable future; and

(3) *Pavona diffluens'* qualitative abundance is rare, which means it does not possess as much buffering capacity in the form of variability in response between individuals or absolute abundance that would be afforded to a more abundant or common species. Combined with the limited range of this species, this level of abundance leaves the species vulnerable to becoming of such low abundance within the foreseeable future that it may be at risk from depensatory processes, environmental stochasticity, or catastrophic events, as explained in more detail in the Corals and Coral Reefs and Risk Analyses sections.

The combination of these characteristics and projections of future threats indicates that the species is likely to be in danger of extinction within the foreseeable future throughout its range and warrants listing as threatened at this time due to factors A, C, D, and E.

The available information above on *P. diffluens'* spatial structure, demography, threat susceptibilities, and management also indicate that the species is not currently in danger of extinction and thus does not warrant listing as Endangered because:

(1) While *P. diffluens'* distribution is constrained only to parts the western Indian Ocean along coastal East Africa, the Red Sea, and the Gulf of Oman, the species' range still includes heterogeneous habitat across its range, including at least upper reef slopes, mid-slopes, lower reef crests, reef flats, and lagoons. Thus, the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time, as described in more detail in the Coral Habitat and Threats Evaluation sections. There is no evidence to suggest that the species is so spatially fragmented or geographically constrained that depensatory processes, environmental stochasticity, or the potential for catastrophic events currently pose a high risk to the survival of the species; and

(2) While *P. diffluens'* qualitative abundance is rare, its absolute abundance is at least millions of colonies, which allows for some variation in the responses of individuals to threats. There is no evidence of depensatory processes such as reproductive failure from low density of reproductive individuals and genetic processes such as inbreeding affecting this species. Thus, its abundance indicates it is currently able to avoid high mortality from environmental stochasticity, and mortality of a high proportion of its population from catastrophic events.

The combination of these characteristics indicates that the species does not exhibit the characteristics of one that is currently in danger of extinction, as described previously in the Risk Analyses section, and thus does not warrant listing as endangered at this time.

Range-wide, a multitude of conservation efforts are already broadly employed that are likely benefiting *P. diffluens.* However, considering the global scale of the most important threats to the species, and the ineffectiveness of conservation efforts at addressing the root cause of global threats (*i.e.,* GHG emissions), we do not believe that any current conservation efforts or conservation efforts planned in the future will result in affecting the species status to the point at which listing is not warranted.

Genus Pectinia

Genus Introduction

The family Pectiniidae includes five genera, *Pectinia, Echinomorpha, Echinophyllia, Oxypora* and *Mycedium.* Veron (2000) recognizes nine species of *Pectinia.* Colonies are laminar to branching, and may have high walls separating wide valleys. The SRR and SIR provided no genus-level introductory information on *Pectinia.*

Genus Susceptibility to Threats

The SRR and SIR provided the following information on the threat susceptibilities of the genus *Pectinia.* A case study from the Waikiki Aquarium reported tolerance of *Pectinia alcicornis* to low pH. With regards to disease, the SRR referred to a study that reported crustacean parasites in *Pectinia lactuca* in American Samoa. However, taxonomists have not recorded any *Pectinia* species there so far (D. Fenner, personal comm.). Another study referred to in the SRR reported *Pectinia* was not infected by ciliate skeletal eroding band on the GBR. The SRR referred to two studies that reported that *Pectinia* is tolerant of sediment, one study that indicated it was tolerant of high nutrients, and one study that reported it decreased along a gradient of reduced water quality. The SRR reported that Pectinidae species are highly susceptible to crown-of-thorns seastar. The SRR reported that the genus *Pectinia* is heavily exported—several thousand specimens are exported annually.

The public comments did not provide any new or supplemental information on the threat susceptibilities of the genus *Pectinia.* We gathered supplemental information that provided the following. With regard to thermal stress, during a bleaching event on the GBR in 2002, between five and 11 percent of three species of *Pectinia* were affected (Done *et al.,* 2003a). In Palau in 2000, *Pectinia lactuca* and *Pectinia peonia* both had high levels of bleaching and high mortality. Forty-eight percent of all colonies of all species were bleached, and both bleaching and mortality of different genera and species ranged from zero to near 100 percent (Bruno *et al.,* 2001). Ruiz-Moreno *et al.* (2012) reported that the family Pectinidae had the highest disease prevalence of any family of corals in the Pacific, and third highest of all coral families they studied in the Caribbean and Indo-Pacific. However, the family Pectinidae has five genera, and the study did not report on the genus *Pectinia.* There is no other supplemental information on the susceptibilities of *Pectina* to threats.

Genus Conclusion

Based on the information from the SRR, SIR, public comments, and supplemental information, we can make the following inferences about the susceptibilities of an unstudied *Pectinia* species to ocean warming, disease, ocean acidification, sedimentation, nutrients, trophic effects of fishing, sea-level rise, predation, and collection and trade. The SRR rated ocean warming and disease as ''high'' importance, and ocean acidification as ''medium-high'' importance, to corals. These were rated as the three most important threats to reef-building corals overall. *Pectinia* shows a variable level of warming-induced bleaching, thus we conclude that an unstudied *Pectinia* is likely to have some susceptibility to ocean warming. Although there is no other genus-level or species-specific information on the susceptibility of *Pectinia* species to disease, the SRR rated it as ''high'' importance to corals, thus we conclude that an unstudied *Pectinia* is likely to have some susceptibility to disease. One study reported one species of *Pectinia* had some resistant to acidification, thus with only one study, we conclude that an unstudied *Pectinia* is likely to have some susceptibility to ocean acidification.

The SRR rated the trophic effects of fishing as ''medium'' importance, the fourth most important threat to corals overall. This threat was not addressed at the genus or species level in the SRR or SIR, because it is an ecosystem-level process. That is, removal of herbivorous fish from coral reef systems by fishing alters trophic interactions by reducing herbivory on algae, thereby providing a competitive advantage for space to algae over coral. Thus, the SRR did not discuss this threat in terms of coral taxa, as its effects are difficult to distinguish between coral genera and species. Therefore, an unstudied *Pectinia* species is likely to have some susceptibility to the trophic effects of fishing.

The SRR rated sedimentation, nutrients, and sea-level rise as ''low-medium'' importance to corals overall. Studies of the effects of sediment and nutrients on *Pectinia* were inconsistent, thus we conclude that an unstudied *Pectinia* species is likely to have some susceptibility to sediment and nutrients. Sea-level rise was not addressed at the genus or species level in the SRR or SIR. Increasing sea levels may increase land-based sources of pollution due to inundation, resulting in changes to coral community structure, thus an unstudied *Pectinia* species is likely to have some susceptibility to sea-level rise. The SRR reported that Pectinidae species are highly susceptible to crown-of-thorns seastar, thus we conclude that an unstudied *Pectinia* species is likely to have some susceptibility to collection and trade. The SRR rated ornamental trade (referred to in the proposed rule as Collection and Trade) as ''low'' importance to corals overall. The SRR reported that *Pectinia* is heavily traded, thus we conclude that an unstudied *Pectinia* species is likely to have some susceptibility to collection and trade.

In conclusion, an unstudied *Pectinia* species is likely to have some susceptibility to ocean warming, disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade.

Pectinia alcicornis

Introduction

The SRR and SIR provided the following information on *P. alcicornis'* morphology and taxonomy. Morphology was described as irregular clusters with thin, flat, grooved plates and tall, upward-projecting spires that can dominate its structure. The taxonomy was described as having no taxonomic issues but being similar in appearance to *Pectinia paeonia.*

Public comments and information we gathered did not provide any new or supplemental information on morphology, and confirmed that there are no known taxonomic problems for *P. alcicornis,* but a moderate level of species identification uncertainty exists. Veron (2014) states that *P. alcicornis* is sometimes confused with other *Pectinia* species and Veron (2000; 2014) considers the species valid, thus we conclude it can be identified by experts, and that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *P. alcicornis'* distribution, habitat, and depth range. The SRR and SIR described *P. alcicornis'* distribution as broadly distributed from the northern Indian Ocean to Fiji. It inhabits turbid water and other low-light environments in most coral reef habitats, including at least upper reef slopes, mid-slopes, lagoons, and caves, at depths of five to 25 m.

Public comments did not provide any new or supplemental information on *P. alcicornis'* distribution. We gathered supplemental information including, Veron (2014), which reports that this species is confirmed in 39 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional 16.

Demographic Information

The SRR and SIR reported *P. alcicornis'* abundance as usually uncommon.

Public comments did not provide any new or supplemental information on *P. alcicornis'* abundance. We gathered supplemental information including Veron (2014), which reports that *P. alcicornis* occupied 16.6 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.6 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''common,'' and overall abundance was described as ''usually uncommon.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least tens of millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *P. alcicornis,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 38 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 15 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context. Thus, quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *P. alcicornis* occurs in many areas affected by these broad changes, and likely has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species-specific information.

Other Biological Information

The SRR and SIR reported that *P. alcicornis* is a hermaphroditic broadcast spawner. The public comments and information we gathered provided no new or supplemental biological information.

Susceptibility to Threats

To describe *P. alcicornis'* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Pectinia* of ocean warming, acidification, disease, predation, sedimentation, nutrients, and collection and trade. The SRR and SIR also provided the following species-specific information on *P. alcicornis'* threats. *Pectinia alcicornis* showed very little mortality on the GBR in the 2001–2002 mass bleaching event. *Pectinia alcicornis* harbors Clade C zooxanthellae in Okinawa and the South China Sea, but contained Clade D zooxanthellae in Palau after the 2001 mass bleaching event. It is one of many species that has been raised in the Waikiki Aquarium, which is characterized by high-nutrient, low-pH waters. Although it is generally a sediment-tolerant genus, *P. alcicornis* decreased along a deteriorating water quality gradient on the Great Barrier Reef. *Pectinia alcicornis* exports were reported at the species level only for 2000–2003, with a total of 133 specimens reported. The SRR and SIR did not provide any other species-specific information on the effects of these threats on *P. alcicornis.* We interpreted threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *P. alcicornis'* vulnerabilities as follows: High vulnerability to ocean warming, moderate vulnerability to disease, ocean acidification, trophic effects of fishing, and predation, and low vulnerability to sedimentation, nutrients, sea level rise, and collection and trade.

Public comments did not provide any new or supplemental information on *P. alcicornis'* threats susceptibilities. We gathered supplemental species-specific and genus-level information on this species' threat susceptibilities. *Pectinia alcicornis* has been rated as moderately or highly susceptible to bleaching but not to disease, however this rating is not based on species-specific data (Carpenter *et al.* 2008). With regard to thermal stress, eight percent of *P. alcicornis* was affected by bleaching on the GBR in 2002. The other two *Pectinia* species included in the study were affected by bleaching at rates of three percent and 12 percent, and the range for all members of family Pectiniidae was zero to 17 percent (Done *et al.,* 2003a). There is no other supplemental information on the effects of threats on this species. Based on genus-level and species-specific information described above, *P. alcicornis* likely has some susceptibility to ocean warming, disease, acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade. The available information does not support more precise ratings of this species' threat susceptibilities.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *P. alcicornis.* Public comments were critical of that approach and we therefore attempt to analyze regulatory mechanisms on a species basis in this final rule. Records confirm that *Pectinia alcicornis* occurs in 39 Indo-Pacific ecoregions that encompass 21 countries' EEZs. The 21 countries are Australia, Brunei, China, Federated States of Micronesia, Fiji, France (French Pacific Island Territories), India (Andaman and Nicobar Islands), Indonesia, Japan, Malaysia, Myanmar, Palau, Papua New Guinea, Philippines, Solomon Islands, Sri Lanka, Taiwan, Thailand, Timor-Leste, Vanuatu, and Vietnam. The regulatory mechanisms relevant to *P. alcicornis,* described first as the percentage of the above countries that utilize them to any degree, and second as the percentage of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (33 percent with 10 percent limited in scope), coral collection (52 percent with 29 percent limited in scope), pollution control (38 percent with 14 percent limited in scope), fishing regulations on reefs (100 percent with 14 percent limited in scope), and managing areas for protection and conservation (95 percent with none limited in scope). The most common regulatory mechanisms in place for *P. alcicornis* are reef fishing regulations and area management for protection and conservation. Coral collection laws are also somewhat utilized for the species, but 29 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection and pollution control laws are less common regulatory mechanisms for the management of *P. alcicornis.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that high bleaching rate is the primary threat of extinction for *Pectinia,* although *P. alcicornis* may be relatively resistant in some areas. Factors that increase potential extinction risk for *P. alcicornis* include susceptibility to bleaching, predation, and harvesting. It listed factors that reduce potential extinction risk including that *P. alcicornis* occupies a variety of habitat types and is broadly distributed both latitudinally and longitudinally in the Indo-Pacific.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *P. alcicornis,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution is from the northern Indian Ocean to Fiji. Its geographic distribution moderates vulnerability to extinction because some areas within its range are projected to have less than average warming and acidification over the foreseeable future, including the central Pacific, and other areas, so portions of the population in these areas will be less exposed to severe conditions. Its depth range is five to 25 m. This moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Its inhabits turbid water and other low-light environments in most coral reef habitats, including at least upper reef slopes, mid-slopes, lagoons, and caves. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Turbidity in particular can moderate exposure to high irradiance by blocking light and resulting heat from the water column. Its absolute abundance of at least tens of millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule using the determination tool formula approach, *P. alcicornis* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); uncommon generalized range wide abundance (E); wide overall distribution (based on wide geographic distribution and moderate depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *P. alcicornis* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *P. alcicornis'* spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to likely become endangered throughout its range within the foreseeable future, and thus it is not warranted for listing at this time, because:

(1) *Pectinia alcicornis'* distribution from the northern Indian Ocean through the western Pacific Ocean to Fiji includes tens of thousands of islands and reefs spread over a vast area. While some areas within its range are projected to be affected by warming and acidification, other areas are projected to have less than average warming and acidification, including the central Pacific and other areas. This distribution and the heterogeneous habitats it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future;

(2) *Pectinia alcicornis'* total population size is at least tens of millions of colonies, providing buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response; and

(3) *Pectinia alcicornis* extends down to 25 meters depth, providing some buffering capacity against threat-induced mortality events that may be more severe in shallow habitats;

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future if global threats continue and worsen in severity and the species' exposure to the threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *P. alcicornis* is not warranted for listing at this time under any of the listing factors.

Genus Acanthastrea

Genus Introduction

The family Mussidae has 13 genera, eight of which are restricted to the Indo-Pacific, including *Acanthastrea.* The genus *Acanthastrea* contains 12 known species. Most *Acanthastrea* are encrusting, but one is massive. The SRR and SIR provided no genus-level introductory information on *Acanthastrea.*

Genus Susceptibility to Threats

The SRR and SIR provided the following information on the threat susceptibilities of the genus *Acanthastrea.* The genus *Acanthastrea* has been reported to be highly susceptibility to bleaching in Australia and in the western Indian Ocean. The genus sustained moderate bleaching in Palau in 1994 and several *Acanthastrea* species were relatively unaffected during the 2002 event on the GBR (Done *et al.,* 2003b). Although no exports of *Acanthastrea* were reported from 2000–2009, 1,000 *Acanthastrea* pieces were exported from Indonesia in 2010.

The public comments did not provide any new or supplemental information on the threat susceptibilities of the genus *Acanthastrea.* We gathered supplemental information which provided the following details. All *Acanthastrea* in protected areas in Kenya were killed by mass bleaching in 1998 (McClanahan *et al.,* 2001). Out of four *Acanthastrea* species on the GBR, three species were not affected by the 2002 GBR bleaching event, while 22 percent of one species was affected (Done *et al.,* 2003b). At Mauritius in a bleaching event in 2004, *Acanthastrea* had a bleaching index of nine, the 22nd highest of the 32 genera recorded, which was 14 percent of the index of the genus with the highest index (McClanahan *et al.,* 2005a). In the western Indian Ocean in 1998–2005, *Acanthastrea* had a bleaching index of 14.4 for eight countries, which was 24th highest of the 45 genera recorded, and 35 percent of the highest value (McClanahan *et al.,* 2007a).

With regard to land-based sources of pollution, Stafford-Smith (1993) reported that 14 of 20 *Acanthastrea echinata* samples cleared over 98 percent of sediment within 48 hours, the 12th best score. This score was 70 percent of the highest scoring species. There is no other supplemental information on the effects of threats on the genus *Acanthastrea.*

Genus Conclusion

Based on the information from the SRR, SIR, public comments, and supplemental information, we can make the following inferences about the susceptibilities of an unstudied *Acanthastrea* species to ocean warming, disease, ocean acidification, sedimentation, nutrients, trophic effects of fishing, sea-level rise, predation, and collection and trade. The SRR rated ocean warming and disease as ''high'' importance, and ocean acidification as ''medium-high'' importance, to corals. These were rated as the three most important threats to reef-building corals overall. The above information on *Acanthastrea* shows a wide range of susceptibility to ocean warming, thus we conclude that an unstudied *Acanthastrea* species is likely to have some susceptibility to ocean warming. Although there is no genus-level or species-specific information on the susceptibilities of *Acanthastrea* species to disease and ocean acidification, the SRR rated it as ''medium-high'' importance to corals. Thus, we conclude that an unstudied *Acanthastrea* species is likely to have some susceptibility to disease and ocean acidification.

The SRR rated the trophic effects of fishing as ''medium'' importance, the fourth most important threat to corals overall. This threat was not addressed at the genus or species level in the SRR or SIR, because it is an ecosystem-level process. That is, removal of herbivorous fish from coral reef systems by fishing alters trophic interactions by reducing herbivory on algae, thereby providing a competitive advantage for space to algae over coral. Thus, the SRR did not discuss this threat in terms of coral taxa, as its effects are difficult to distinguish between coral genera and species. Therefore, an unstudied *Acanthastrea* species is likely to have some susceptibility to the trophic effects of fishing.

The SRR rated sedimentation, nutrients, and sea-level rise as ''low-medium'' importance to corals overall. One study found an *Acanthastrea* species to have moderate sediment-clearing ability. Thus we conclude that an unstudied *Acanthastrea* species is likely to have some susceptibility to sedimentation. Although there is no genus-level or species-specific information on the susceptibilities of *Acanthastrea* species to nutrients, the SRR rated it as ''low-medium'' importance to corals. Thus, we conclude that an unstudied *Acanthastrea* species has some susceptibility to nutrients. Sea-level rise was not addressed at the genus or species level in the SRR or SIR. Increasing sea levels may increase land-based sources of pollution due to inundation, resulting in changes to coral community structure, thus an unstudied *Acanthastrea* species is likely to have some susceptibility to sea-level rise. The SRR rated predation and ornamental trade (referred to in the proposed rule as Collection and Trade) as ''low'' importance to corals overall. Although there is no genus-level or species-specific information on the susceptibilities of *Acanthastrea* species to predation, there is no information suggesting they are not susceptible to this threat. Thus, we conclude that an unstudied *Acanthastrea* species has some susceptibility to predation. Because the available information suggests that *Acanthastrea* species are lightly collected and traded, an unstudied *Acanthastrea* species is likely to have low susceptibility to collection and trade.

In conclusion, an unstudied *Acanthastrea* species is likely to have some susceptibility to ocean warming, disease, acidification, sedimentation, nutrients, trophic effects of fishing, sea-level rise, and predation, and is likely to have low susceptibility to collection and trade.

Acanthastrea brevis

Introduction

The SRR and SIR provided the following information on *A. brevis'* morphology and taxonomy. Morphology was described as mostly submassive, attached and colonial, and the taxonomy was described as having no taxonomic issues but being similar in appearance to *Acanthastrea echinata.*

Public comments and information we gathered did not provide any new or supplemental information on morphology, and confirmed that there are no known taxonomic problems for *A. brevis,* but a moderate to high level of species identification uncertainty. Veron (2014) states that it is ''readily confused with *Acanthastrea echinata,''* but Veron (2000; 2014) considers the species valid, thus we conclude it can be identified by experts and that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *A. brevis'* distribution, habitat, and depth range. *Acanthastrea brevis* is distributed from the Red Sea and western Indian Ocean to American Samoa in the central Pacific. Its habitat includes all coral reef habitats, in a depth range of one to 20 m.

Public comments provided the following information on distribution for *A. brevis.* One public comment stated that *A. brevis* likely occurs in the Marianas and will be included in an upcoming book. We gathered supplemental information, including Veron (2014), which reports that this species is confirmed in 29 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional 17. *Acanthastrea brevis* is found in the Northern Marianas and American Samoa as well (D. Fenner, personal comm.) and the Marianas are one of the predicted areas for *A. brevis* in the Veron (2014) information. Public comments and information we gathered did not provide any more information on the habitat and depth range of this species.

Demographic Information

The SRR and SIR reported *A. brevis'* abundance as uncommon but conspicuous.

Public comments did not provide any new or supplemental information on *A. brevis'* abundance. We gathered supplemental information, including Veron (2014), which reports that *A. brevis* occupied 6.5 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.49 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''uncommon,'' and overall abundance was also described as ''uncommon.''

Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least tens of millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *A. brevis,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 36 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 14 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context. Thus, quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *A. brevis* occurs in many areas affected by these broad changes, and likely has some susceptibility to both local and global threats, we conclude it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *A. brevis'* life history. Although specific larval descriptions have not been published for this species, the larvae of three other *Acanthastrea* species studied do not contain zooxanthellae that can supplement maternal provisioning with energy sources provided by their photosynthesis. The public comments did not provide new or supplemental information, and we did not find new or supplemental information on the above-described biological information.

Susceptibility to Threats

To describe *A. brevis'* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Acanthastrea* of ocean warming, acidification, disease, sedimentation, nutrients, predation, and collection and trade. The SRR and SIR did not provide any other species-specific information on the effects of these threats on *A. brevis.* We interpreted threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *A. brevis'* vulnerabilities as follows: High vulnerability to ocean warming, moderate vulnerability to disease, ocean acidification, and trophic effects of fishing, and low vulnerability to sedimentation, sea level rise, and collection and trade, and unknown vulnerability to nutrients.

Public comments did not provide any new or supplemental information on *A. brevis'* threats susceptibilities. We gathered supplemental species-specific and genus-level information on this species' threat susceptibilities. *Acanthastrea brevis* was not rated as moderately or highly susceptible to bleaching or coral disease by Carpenter *et al.* (2008), but they did not use species-specific data for their ratings. Based on genus-level and species information described above, *A. brevis* likely has some susceptibility to ocean warming, disease, ocean acidification, trophic effects of fishing, nutrients, sedimentation, sea-level rise, and predation, and low susceptibility to collection and trade.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *A. brevis.* Criticisms of our approach received during public comment led us to attempt the following analysis of regulatory mechanisms on a species basis. Records confirm that *Acanthastrea brevis* occurs in 29 Indo-Pacific ecoregions that encompass 31 countries' EEZs. The 31 countries are Australia, Djibouti, Egypt, Eritrea, Federated States of Micronesia, Fiji, France (French Pacific Island Territories), Indonesia, Israel, Jordan, Kiribati, Madagascar, Malaysia, Mauritius, New Zealand (Tokelau), Niue, Palau, Papua New Guinea, Philippines, Samoa, Saudi Arabia, Seychelles, Solomon Islands, Sri Lanka, Sudan, Tonga, Tuvalu, United Kingdom (British Indian Ocean Territory), United States (American Samoa), Vietnam, and Yemen. The regulatory mechanisms relevant to *A. brevis,* described first as the percentage of the above countries that utilize them to any degree, and second as the percentage of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (29 percent with 6 percent limited in scope), coral collection (65 percent with 26 percent limited in scope), pollution control (55 percent with 10 percent limited in scope), fishing regulations on reefs (90 percent with 19 percent limited in scope), and managing areas for protection and conservation (97 percent with 10 percent limited in scope). The most common regulatory mechanisms in place for *A. brevis* are reef fishing regulations and area management for protection and conservation. Coral collection and pollution control laws are somewhat common for the species, but 26 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection laws are much less common regulatory mechanisms for the management of *A. brevis.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that high susceptibility to bleaching is the primary factor that increases potential extinction risk for *A. brevis.* It listed factors that reduce potential extinction risk for *A. brevis* including the fact that it occupies a variety of habitat types and is broadly distributed, both latitudinally and longitudinally, in the Indo-Pacific.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *A. brevis,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution is from the Red Sea and western Indian Ocean to American Samoa in the central Pacific. Its geographic distribution moderates vulnerability to extinction because some areas within its range are projected to have less than average warming and acidification over the foreseeable future, including the western Indian Ocean, the central Pacific, and other areas, so portions of the population in these areas will be less exposed to severe conditions. Its depth range is from one to 20 meters. This moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Its habitat includes all coral reef habitats. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Its abundance of at least tens of millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule using the determination tool formula approach, *A. brevis* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); uncommon generalized range wide abundance (E); wide overall distribution (based on wide geographic distribution and moderate depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *A. brevis* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *A. brevis'* spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to likely become endangered throughout its range within the foreseeable future, and thus it is not warranted for listing at this time, because:

(1) *Acanthastrea brevis'* distribution from the western Indian Ocean to the central Pacific across is spread over a vast area, approximately half of the Indo-Pacific region. While some areas within its range are projected to be affected by warming and acidification, other areas are projected to have less than average warming and acidification, including the western Indian Ocean, the central Pacific, and other areas. This distribution and the heterogeneous habitats it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future; and

(2) *Acanthastrea brevis's* absolute abundance is at least tens of millions of colonies, providing buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future if global threats continue and worsen in severity and the species' exposure to the threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *A. brevis* is not warranted for listing at this time under any of the listing factors.

Acanthastrea hemprichii

Introduction

The SRR and SIR provided the following information on *A. hemprichii's* morphology and taxonomy. Morphology was described as encrusting to massive and frequently over one meter across, and the taxonomy was described as having no taxonomic issues but being similar in appearance to *Acanthastrea echinata, Acanthastrea bowerbanki,* and *Acanthastrea hillae.*

Public comments and information we gathered did not provide any new or supplemental information on morphology, and confirmed that there are no known taxonomic problems for *A. hemprichii* and a low to moderate level of species identification uncertainty. Veron (2014) states that *A. hemprichii* is usually distinctive and Veron (2000; 2014) considers the species valid, thus we conclude it can be identified by experts and that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *A. hemprichii's* distribution, habitat, and depth range. *Acanthastrea hemprichii's* distribution extends from the Red Sea and east Africa to the central Indo-Pacific and central Pacific, it occupies most reef habitats, and its depth range is from two to 20 m depth.

Public comments did not provide any new or supplemental information on *A. hemprichii's* distribution. We gathered supplemental information, including Veron (2014), which reports that this species is confirmed in 47 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional 23.

Demographic Information

The SRR and SIR reported *A. hemprichii's* abundance as uncommon.

Public comments did not provide any new or supplemental information on *A. hemprichii's* abundance. We gathered supplemental information, including Veron (2014), which reports that *A. hemprichii* occupied 11.4 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.47 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''common,'' and overall abundance was described as ''uncommon.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least tens of millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *Acanthastrea hemprichii,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 35 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 14 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context. Thus, quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *A. hemprichii* occurs in many areas affected by these broad changes, and likely has some susceptibility to local and global threats, we conclude it has likely declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species specific information.

Other Biological Information

The SRR and SIR provided the following information on *A. hemprichii's* life history. Although specific larval descriptions have not been published for this species, the larvae of three other *Acanthastrea* species studied do not contain zooxanthellae that can supplement maternal provisioning with energy sources provided by their photosynthesis. The public comments did not provide new or supplemental information, and we did not find new or supplemental information on the above-described biological information.

Susceptibility to Threats

To describe *A. hemprichii's* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Acanthastrea* of ocean warming, disease, acidification, sedimentation, nutrients, predation, and collection and trade. The SRR and SIR also provided the following species-specific information on *A. hemprichii's* threats. *Acanthastrea hemprichii* was relatively unaffected during the 2002 bleaching event on the Great Barrier Reef. The SRR and SIR did not provide any other species-specific information on the effects of these threats on *A. hemprichii.* We interpreted threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *A. hemprichii's* vulnerabilities as follows: High vulnerability to ocean warming, moderate vulnerability to disease, ocean acidification, trophic effects of fishing, and predation, low vulnerability to sedimentation, sea level rise, and collection and trade, and unknown susceptibility for nutrients.

Public comments did not provide any new or supplemental information on *A. hemprichii's* threats. We gathered supplemental species-specific and genus-level information on this species' threat susceptibilities. *Acanthastrea hemprichii* was not rated as moderately or highly susceptible to bleaching or disease by Carpenter *et al.* (2008), but they did not have species-specific data. Done *et al.* (2003b) reported no bleaching in *A. hemprichii* on the GBR in 2002. Eight of 14 species of Mussidae bleached with six to 26% of colonies bleached, and for species in other families, as much as 80% of colonies bleached. Based on genus-level and species-specific information described above, *A. hemprichii* likely has some susceptibility to ocean warming, disease, acidification, trophic effects of fishing, nutrients, sedimentation, sea level rise, predation, and collection and trade. The available information does not support more precise ratings of the susceptibility of *A. hemprichii* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *A. hemprichii.* Criticisms of our approach received during public comment led us to attempt the following analysis of regulatory mechanisms on a species basis. Records confirm that *Acanthastrea hemprichii* occurs in 47 Indo-Pacific ecoregions that encompass 30 countries' EEZs. The 30 countries are Australia, China, Djibouti, Egypt, Eritrea, Federated States of Micronesia, Fiji, France (French Pacific Island Territories), India (Andaman and Nicobar Islands), Indonesia, Israel, Japan, Jordan, Kenya, Madagascar, Malaysia, Marshall Islands, Myanmar, Papua New Guinea, Philippines, Saudi Arabia, Seychelles, Solomon Islands, Somalia, Sudan, Taiwan, Tanzania, Thailand, Vietnam, and Yemen. The regulatory mechanisms relevant to *A. hemprichii,* first described as the percentage of the above countries that utilize them to any degree, and second as the percentage of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (20 percent with three percent limited in scope), coral collection (47 percent with 20 percent limited in scope), pollution control (43 percent with 10 percent limited in scope), fishing regulations on reefs (87 percent with 17 percent limited in scope), and managing areas for protection and conservation (90 percent with 10 percent limited in scope). The most common regulatory mechanisms in place for *A. hemprichii* are reef fishing regulations and area management for protection and conservation. Coral collection and pollution control laws are somewhat common for the species, but 20 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection laws are much less common regulatory mechanisms for the management of *A. hemprichii.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that high susceptibility to bleaching is the primary factor that increases potential extinction risk for *A. hemprichii.* It listed factors that reduce potential extinction risk for *A. hemprichii* are includes the fact that it occupies a variety of habitat types and is broadly distributed, both latitudinally and longitudinally, in the Indo-Pacific.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *A. hemprichii,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution includes most of the coral reef ecoregions in the Red sea and western Indian Ocean and many in the central Indo-Pacific and western and central Pacific Ocean. Its geographic distribution moderates vulnerability to extinction because some areas within its range are projected to have less than average warming and acidification over the foreseeable future, including the western Indian Ocean, the central Pacific, and other areas, so portions of the population in these areas will be less exposed to severe conditions. Its depth range is from two to 20 meters. This moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Its habitat includes most reef habitats. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Its abundance of at least tens of millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule using the determination tool formula approach, *A. hemprichii* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); uncommon generalized range wide abundance (E); wide overall distribution (based on wide geographic distribution and moderate depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *A. hemprichii* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *A. hemprichii's* spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to be likely to become endangered throughout its range within the foreseeable future, and thus is not warranted for listing at this time, because:

(1) *Acanthastrea hemprichii'*s distribution includes the Red Sea and east coast of Africa, plus many of the coral reef ecoregions in the central Indo-Pacific and central Pacific Ocean includes and is spread over a vast area. While some areas within its range are projected to be affected by warming and acidification, other areas are projected to have less than average warming and acidification, including the western Indian Ocean, the central Pacific, and other areas. This distribution and the heterogeneous habitats it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future; and

(2) *Acanthastrea hemprichii'*s absolute abundance is at least tens of millions of colonies, providing buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future if global threats continue and increase in severity and the species exposure to threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *A. hemprichii* is not warranted for listing at this time under any of the listing factors.

Acanthastrea ishigakiensis

Introduction

The SRR and SIR provided the following information on *A. ishigakiensis'* morphology and taxonomy. Morphology was described as massive and usually hemispherical and often more than 0.5 meters across, and taxonomy was described as having no taxonomic issues but being similar in appearance to *Acanthastrea hillae* and *Symphyllia erythraea*.

Public comments and information we gathered did not provide any new or supplemental information on morphology, and confirmed that there are no known taxonomic problems for *A. ishigakiensis,* but that there is a moderate level of species identification uncertainty for this species. Veron (2014) states that *A. ishigakiensis* is readily confused with *A. hillae,* but Veron (2000; 2014) also considers the species valid, thus we conclude it can be identified by experts and that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *Acanthastrea ishigakiensis'* distribution, habitat, and depth range. *Acanthastrea ishigakiensis'* distribution extends from the Red Sea and east coast of Africa to the central Pacific, but excludes Australia. Its habitat includes upper reef slopes, lagoons and other areas protected from wave action, in depths from one to 15 m depth.

Public comments provided the following information on *A. ishigakiensis'* distribution. One public comment stated that R.H. Randall recalls seeing this species in Guam at 60 m deep. We gathered supplemental information, including Veron (2014), which reports that this species is confirmed in 25 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional 19.

Demographic Information

The SRR and SIR reported *A. ishigakiensis'* abundance as uncommon but conspicuous.

Public comments did not provide any new or supplemental information on *A. ishigakiensis'* abundance. We gathered supplemental information, including Veron (2014), which reports that *A. ishigakiensis* occupied 2.9 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.3 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''uncommon,'' and overall abundance was described as ''uncommon but conspicuous.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least tens of millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *A. ishigakiensis,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 34 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 14 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context. Thus, quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *A. ishigakiensis* occurs in many areas affected by these broad changes, and likely has some susceptibility to local and global threats, we conclude it has likely declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the lack of species specific information.

Other Biological Information

The SRR and SIR provided the following information on *A. ishigakiensis'* life history. Although specific larval descriptions have not been published for this species, the larvae of three other *Acanthastrea* species studied do not contain zooxanthellae that can supplement maternal provisioning with energy sources provided by their photosynthesis. The public comments did not provide new or supplemental information, and we did not find new or supplemental information on the above-described biological information.

Susceptibility to Threats

To describe *A. ishigakiensis'* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Acanthastrea* of ocean warming, disease, acidification, sedimentation, nutrients, predation, and collection and trade. The SRR and SIR did not provide any other species-specific information on the effects of these threats on *A. ishigakiensis.* We interpreted threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *A. ishigakiensis'* vulnerabilities as follows: High vulnerability to ocean warming, moderate vulnerability to disease, ocean acidification, trophic effects of fishing, and predation, low vulnerability to sedimentation, sea level rise, and collection and trade, and unknown susceptibility to nutrients.

Public comments did not provide any new or supplemental information on *A. ishigakinesis'* threats susceptibilities. We gathered supplemental species-specific and genus-level information on this species' threat susceptibilities. *Acanthastrea ishigakiensis* was not rated as moderately or highly susceptible to bleaching or disease by Carpenter *et al.* (2008), but they did not have species-specific data. No species-specific information is available for the susceptibility of *A. ishigakiensis* to any threat. Based on genus-level information described above, *A. ishigakiensis* likely has some susceptibility to ocean warming, disease, ocean acidification, trophic effects of fishing, nutrients, sedimentation, sea level rise, predation, and low susceptibility to collection and trade.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *A. ishigakiensis.* Criticisms of our approach received during public comment led us to attempt the following analysis of regulatory mechanisms on a species basis. Records confirm *A. ishigakiensis* occurs in 24 Indo-Pacific ecoregions that encompass 25 countries' EEZs. The 25 countries are Egypt, Federated States of Micronesia, Fiji, France (French Pacific Island Territories), Indonesia, Israel, Japan, Jordan, Kenya, Madagascar, Malaysia, Mauritius, Mozambique, Papua New Guinea, Philippines, Saudi Arabia, Seychelles, Solomon Islands, Sudan, Tanzania, United States (CNMI, Guam), Vanuatu, Vietnam, and Yemen. Regulatory mechanisms relevant to *A. ishigakiensis,* described first as the percentage of the above countries that utilize them to any degree, and second as the percentage of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (21 percent with eight percent limited in scope), coral collection (63 percent with 25 percent limited in scope), pollution control (50 percent with 13 percent limited in scope), fishing regulations on reefs (88 percent with 21 percent limited in scope), and managing areas for protection and conservation (100 percent with eight percent limited in scope). The most common regulatory mechanisms in place for *A. ishigakiensis* are reef fishing regulations and area management for protection and conservation. Coral collection and pollution control laws are somewhat common the species, but 25 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection laws are much less common regulatory mechanisms for the management of *A. ishigakiensis.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that high susceptibility to bleaching is the primary factor that increases potential extinction risk for *A. ishigakiensis.* It listed factors that reduce potential extinction risk including the fact that *A. ishigakiensis* is broadly distributed, both latitudinally and longitudinally, in the Indo-Pacific.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *A. ishigakiensis,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution includes most of the coral reef ecoregions in the Red Sea and western Indian Ocean and many in the western and central Pacific Ocean. Its geographic distribution moderates vulnerability to extinction because some areas within its range are projected to have less than average warming and acidification over the foreseeable future, including the western Indian Ocean, the central Pacific, and other areas, so portions of the population in these areas will be less exposed to severe conditions. Its depth range is from one to 15 meters, and there is one anecdotal record from Guam of this species observed at 60 meters depth. On one hand, its depth range may moderate vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. On the other hand, its depth range may exacerbate vulnerability to extinction over the foreseeable future if the species occurs predominantly in the shallower portion of its depth range, since those areas will have higher irradiance and thus be more severely affected by warming-induced bleaching. Its habitat includes upper reef slopes, lagoons, and other areas protected from wave action. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Its absolute abundance of at least tens of millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule using the determination tool formula approach, *A. ishigakiensis* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); uncommon generalized range wide abundance (E); moderate overall distribution (based on wide geographic distribution and shallow depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *A. ishigakiensis* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *A. ishigakiensis'* spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to be likely to become endangered throughout its range within the foreseeable future, and thus is not warranted for listing at this time, because:

(1) *Acanthastrea ishigakiensis'* distribution includes the Red Sea and most of the western Indian Ocean along with many of the coral reef ecoregions in the western and central Pacific. While some areas within its range are projected to be affected by warming and acidification, other areas are projected to have less than average warming and acidification, including the western Indian Ocean, the central Pacific, and other areas. This distribution and the heterogeneous habitats it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future; and

(2) *Acanthastrea ishigakiensis'* absolute abundance is at least tens of millions of colonies, providing buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future if global threats continue and increase in severity and the species exposure to threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *A. ishigakiensis* is not warranted for listing at this time under any of the listing factors.

Acanthastrea regularis

Introduction

The SRR and SIR provided the following information on *A. regularis'* morphology and taxonomy. Morphology was described as massive and with corallites united by fused compound walls, and taxonomy was described as having no taxonomic issues but being similar in appearance to *Montastraea* and *Favia* underwater.

Public comments and information we gathered did not provide any new or supplemental information on morphology, and confirmed that there are no known taxonomic problems for *A. regularis,* and a moderate level of species identification uncertainty for this species. Veron (2014) states that *A.*

regularis is readily confused with *Favia* species but Veron (2000; 2014) considers the species valid, thus we conclude it can be identified by experts and that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *A. regularis'* distribution, habitat, and depth range. *Acanthastrea regularis'* distribution is restricted, and includes the Coral Triangle and some islands in the west and central Pacific. Its habitat includes most reef habitats, including upper reef slopes, mid-slopes, lower reef crests, reef flats, and lagoons in depths from two to 20 m.

Public comments provided the following information on distribution of *A. regularis.* One public comment stated that *A. regularis* is likely in the Marianas. We gathered supplemental information, including Veron (2014), which reports that this species is confirmed in 17 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional 16.

Demographic Information

The SRR and SIR reported *A. regularis'* abundance as uncommon.

Public comments did not provide any new or supplemental information on *A. regularis'* abundance. We gathered supplemental information, including Veron (2014), which reports that *A. regularis* occupied 5.1 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.21 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''uncommon,'' and overall abundance was also described as ''uncommon.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *A. regularis,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 36 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 14 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context. Thus, quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *A. regularis* occurs in many areas affected by these broad changes, and likely has some susceptibility to local and global threats, we conclude it has likely declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *A. regularis'* life history. Although specific larval descriptions have not been published for this species, the larvae of three other *Acanthastrea* species studied do not contain zooxanthellae that can supplement maternal provisioning with energy sources provided by their photosynthesis.

The public comments did not provide new or supplemental information, and we did not find new or supplemental information on the above-described biological information.

Susceptibility to Threats

To describe *A. regularis'* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Acanthastrea* of ocean warming, acidification, disease, sedimentation, nutrients, predation, and collection and trade. The SRR and SIR did not provide any other species-specific information on the effects of these threats on *A. regularis.* We interpreted threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *A. regularis'* vulnerabilities as follows: High vulnerability to ocean warming, moderate vulnerability to disease, ocean acidification, and trophic effects of fishing, and predation, low vulnerability to sedimentation, sea level rise, and collection and trade, and unknown vulnerability to nutrients.

Public comments did not provide any new or supplemental information on *A. regularis'* threat susceptibilities. We gathered supplemental species-specific and genus-level information on this species' threat susceptibilities. *Acanthastrea regularis* was not rated as moderately or highly susceptible to bleaching or disease by Carpenter *et al.* (2008), but they did not have species-specific data. Based on genus-level information presented above, *A. regularis* likely has some susceptibility to ocean warming, disease, ocean acidification, trophic effects of fishing, nutrients, sedimentation, sea-level rise, and predation, and low susceptibility to collection and trade.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *A. regularis.* Criticisms of our approach received during public comment led us to attempt the following analysis of regulatory mechanisms on a species basis. Records confirm that *A. regularis* occurs in 17 Indo-Pacific ecoregions that encompass eight countries' EEZs. The eight countries are Australia, Federated States of Micronesia, Fiji, Indonesia, Malaysia, Papua New Guinea, Philippines, and Vietnam. The regulatory mechanisms relevant to *A. regularis,* described first as the percentage of the above countries that utilize them to any degree, and second as the percentage of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (25 percent with none limited in scope), coral collection (63 percent with 25 percent limited in scope), pollution control (63 percent with 25 percent limited in scope), fishing regulations on reefs (100 percent with 13 percent limited in scope), and managing areas for protection and conservation (100 percent with none limited in scope). The most common regulatory mechanisms in place for *A. regularis* are reef fishing regulations and area management for protection and conservation. Coral collection and pollution control laws are also somewhat common for the species, but 25 percent of those laws are limited in scope and may not provide substantial protection. General coral protection laws are much less common regulatory mechanisms for the management of *A. regularis.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that high susceptibility to bleaching is the primary factor that increases potential extinction risk for *A. regularis*. This species occupies a variety of habitat types and extends down to 20 meters depth which are factors listed in the SRR that reduce potential extinction risk.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *A. regularis,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. *Acanthastrea regularis* is not highly susceptible to any of the nine most important threats, although it has some susceptibility to each. Its geographic distribution is mostly constrained to parts of the Coral Triangle and western equatorial Pacific Ocean—areas which are projected to have the most rapid and severe impacts from climate change and localized human impacts for coral reefs over the 21st century. For a species that is highly susceptible to climate change related threats, this range would exacerbate vulnerability to extinction but *A. regularis* is not highly susceptible susceptibility. Vulnerability to extinction may be exacerbated by the severe nature of local threats predicted within its range, however, *A. regularis* is not highly susceptible to any local sources of impact either. Its depth range is from two to 20 meters. This moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Its habitat includes upper reef slopes, mid-slopes, lower reef crests, reef flats, and lagoons. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Its absolute abundance of at least millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule using the determination tool formula approach, *A. regularis* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); uncommon generalized range wide abundance (E); moderate overall distribution (based on moderate geographic distribution and moderate depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *A. regularis* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *A. regularis'* spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to be likely to become endangered throughout its range within the foreseeable future, and thus is not warranted for listing at this time, because:

(1) While *A. regularis'* distribution is mostly constrained to parts of the Coral Triangle and western equatorial Pacific Ocean, its distribution is spread over a large area across the Coral Triangle, the Marianas archipelago, Palau, Micronesia, and Fiji. While some areas within its range are projected to be affected by warming and acidification, *A. regularis* is not highly susceptible to ocean warming, acidification, or any of the nine most important threats. This distribution and the heterogeneous habitats it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future; and

(2) *Acanthastrea regularis'* absolute abundance is at least millions of colonies, providing buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future if global threats continue and increase in severity and the species exposure to threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *A. regularis* is not warranted for listing at this time under any of the listing factors.

Genus Barabattoia

Genus Introduction

The family Favidae includes 24 genera, more than any other family, including *Barabattoia. Barabattoia* contains two species, *B. laddi* and *B. amicorum*. Colonies are massive or encrusting. The SRR and SIR provided no genus-level introductory information on *Barabattoia*.

Genus Susceptibility to Threats

The SRR and SIR provided the following information on the threat susceptibilities of the genus *Barabattoia. Barabattoia amicorum* has low-to-moderate bleaching susceptibility with an unknown degree of resultant mortality (Bruno *et al.,* 2001).

The public comments did not provide any new or supplemental information on the threat susceptibilities of the genus *Barabattoia.* We gathered supplemental information that provided the following. With regard to thermal stress, *B. amicorum* experienced low to moderate bleaching in Palau in 2000, but mortality was not reported (Bruno *et al.,* 2001). Forty-eight percent of all colonies of all species were bleached, and bleaching of different genera and species ranged from none to very high, and mortality of different genera and species ranged from none to near 100 percent (Bruno *et al.,* 2001). There is no information on the susceptibilities of *Barabattoia* to any other threats.

Genus Conclusion

Based on the information from the SRR, SIR, public comments, and supplemental information, we can make the following inferences about the susceptibilities of an unstudied *Barabattoia* species to ocean warming, disease, acidification, sedimentation, nutrients, trophic effects of fishing, sea-level rise, predation, and collection and trade. The SRR rated ocean warming and disease as ''high'' importance, and ocean acidification as ''medium-high'' importance, to corals. These were rated as the three most important threats to reef-building corals overall. The one available study on the effects of ocean warming on *Barabattoia* found that *B. amicorum* in Palau experienced low to moderate bleaching (Bruno *et al.,* 2001). Even though there is only one study available, since there are only two species within the genus *Barabattoia,* it is reasonable to make inferences about the susceptibility of *B. laddi* to ocean warming. Although there is no other genus-level or species-specific information on the susceptibilities of *Barabattoia* species to ocean warming, disease, and acidification, the SRR rated them as ''high'' or ''medium-high'' importance to corals. Thus, we conclude that an unstudied *Barabattoia* species is likely to have some susceptibility to ocean warming, disease, and acidification.

The SRR rated the trophic effects of fishing as ''medium'' importance, the fourth most important threat to corals overall. This threat was not addressed at the genus or species level in the SRR or SIR, because it is an ecosystem-level process. That is, removal of herbivorous fish from coral reef systems by fishing alters trophic interactions by reducing herbivory on algae, thereby providing a competitive advantage for space to algae over coral. Thus, the SRR did not discuss this threat in terms of coral taxa, as its effects are difficult to distinguish between coral genera and species. Therefore, an unstudied *Barabattoia* species is likely to have some susceptibility to the trophic effects of fishing.

The SRR rated sedimentation, nutrients, and sea-level rise as ''low-medium'' importance to corals overall. Although there is no genus-level or species-specific information on the susceptibilities of *Barabattoia* species to sedimentation and nutrients, there is no information suggesting they are not susceptible to these threats. Thus we conclude that an unstudied *Barabattoia* species is likely to have some susceptibility to sedimentation and nutrients. Sea-level rise was not addressed at the genus or species level in the SRR or SIR. Increasing sea levels may increase land-based sources of pollution due to inundation, resulting in changes to coral community structure, thus an unstudied *Barabattoia* species is likely to have some susceptibility to sea-level rise. The SRR rated predation and ornamental trade (referred to in the proposed rule as Collection and Trade) as ''low'' importance to corals overall. Because there is no information on the effects of predation and ornamental trade on *Barabattoia,* we conclude that *Barabattoia* has some susceptibility to predation and ornamental trade.

In conclusion, an unstudied *Barabattoia* species is likely to have some susceptibility to ocean warming, disease, acidification, disease, sedimentation, nutrients, trophic effects of fishing, sea-level rise, predation, and collection and trade.

Barabattoia laddi

Introduction

The SRR and SIR provided the following information on *B. laddi's* morphology and taxonomy: the morphology was described as clusters of tubular corallites, and the taxonomy was described as having no taxonomic issues but being similar in appearance to *B. amicorum* and *Montastraea* sp.

The public comments and information we gathered did not provide any new or supplemental information on morphology, and confirmed that there are no known taxonomic problems for *B. laddi,* and that there is a low to moderate level of species identification uncertainty for this species, since it is so rare that surveyors get little experience with it. Veron (2014) states that *B. laddi* is distinctive and Veron (2000; 2014) considers the species valid, thus we conclude it is sufficiently distinctive to be identified by experts, and that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *B. laddi's* distribution, habitat, and depth range. *Barabattoia laddi's* range is somewhat restricted, centered on the Coral Triangle and extending to the central Pacific including perhaps French Polynesia. The SRR and SIR described *B. laddi's* habitat as recorded only from shallow lagoons, and the depth range as 0 to 10 m. The public comments provided the following details. One public comment stated that *B. laddi* tentatively occurs in Apra Harbor, Guam. We gathered supplemental information, including Veron (2014), which reports that this species is confirmed in 22 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional 15. Surveys in Indonesia record the species at multiple sites with depths greater than 10 m (Bigot and Amir, 2009; Donnelly *et al.,* 2003; Turak and DeVantier, 2003) and surveys in the Maldives record the species at multiple sites with depths up to 20 m (Bigot and Amir, 2009; Donnelly *et al.,* 2003; Turak and DeVantier, 2003). These surveys were done in different habitats, including reef slopes and lagoons. Thus, based on all the available information, *B. laddi's* habitat includes at least upper reef slopes, mid-slope terraces, and lagoons in depths ranging from zero to 20 m.

Demographic Information

The SRR and SIR reported *B. laddi's* abundance as rare. The public comments did not provide any new or supplemental information on *B. laddi's* abundance, but we gathered supplemental information, including Veron (2014), which reports that *B. laddi* occupied 5.2 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.33 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''uncommon,'' and overall abundance was described as ''rare.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least tens of millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *B. laddi,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 35 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 14 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context. Thus, quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *B. laddi* occurs in many areas affected by these broad changes, and likely has some susceptibility to local and global threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on the limited species specific information.

Other Biological Information

The SRR and SIR provided the following information on *B. laddi'*s life history. The reproductive characteristics of *B. laddi* have not been determined. There is only one other species in the genus, *B. amoricum,* which is a hermaphroditic broadcast spawner that participated in multispecies spawning events at Magnetic Island and Orpheus Island on the Great Barrier Reef. The larvae of *B. amoricum* do not contain zooxanthellae that might supplement maternal provisioning with energy from photosynthesis. The public comments and information we gathered provided no new or supplemental biological information.

Susceptibility to Threats

To describe *B. laddi'*s threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Barabattoia* of ocean warming, disease, acidification, sedimentation, nutrients, predation, and collection and trade. The SRR and SIR did not provide any other species-specific information on the effects of these threats on *B. laddi.* We interpreted the threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *B. laddi'*s vulnerabilities as follows: Moderate vulnerability to ocean warming, disease, acidification, trophic effects of fishing, and nutrients, low vulnerability to sedimentation, sea level rise, and collection and trade, and unknown vulnerability to predation.

Public comments did not provide any new or supplemental information on *B. laddi'*s threats. We gathered the following species-specific supplemental information on this species' threat susceptibilities. *Barabattoia laddi* has not been rated as moderately or highly susceptible to bleaching or disease, but this rating is not based on species-specific data (2008). No other species-specific information is available for the susceptibility of *B. laddi* to any other threat. Based on the available genus-level information described above, *B. laddi* likely has some susceptibility to ocean warming, disease, acidification, trophic effects of fishing, sedimentation, nutrients, predation, sea-level rise, and collection and trade. The available information does not support more precise ratings of the susceptibility of *B. laddi* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *B. laddi.* Criticisms of our approach received during public comment led us to attempt the following analysis of regulatory mechanisms on a species basis. Records confirm *B. laddi* occurs in 22 Indo-Pacific ecoregions that encompass 15 countries' EEZs. The 15 countries are Australia, Brunei, China, France (French Pacific Island Territories), Indonesia, Malaysia, Marshall Islands, Palau, Papua New Guinea, Philippines, Solomon Islands, Taiwan, United Kingdom (Pitcairn Islands), United States (PRIAs), and Vietnam. The regulatory mechanisms relevant to *B. laddi,* described first as the percentage of the above countries that utilize them to any degree and second, as the percentages of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (33 percent with none limited in scope), coral collection (67 percent with 33 percent limited in scope), pollution control (47 percent with 20 percent limited in scope), fishing regulations on reefs (93 percent with 27 percent limited in scope), and managing areas for protection and conservation (100 percent with 13 percent limited in scope). The most common regulatory mechanisms in place for *B. laddi* are reef fishing regulations and area management for protection and conservation. Coral collection and pollution control laws are also somewhat common for the species, but 33 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection laws are much less common regulatory mechanisms for the management of *B. laddi.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that factors that increase the potential extinction risk are the species' limited western Pacific distribution, its occurrence in shallow lagoons and its rare abundance.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *B. laddi,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. *Barabattoia laddi* has not been rated highly susceptible to ocean warming or disease, the two most important threats to corals in this final rule, nor is it highly susceptible to the other threats identified in this rule. Its geographic distribution includes coral reef ecoregions in the western and central Pacific Ocean from Malaysia to the Pitcairn Islands. Its geographic distribution in combination with its low to moderate susceptibility to threats, moderates vulnerability to extinction because it is spread across a large area.

While its range includes the Coral Triangle, it also includes some areas projected to have less than average warming and acidification over the foreseeable future, including the central Pacific so portions of the population in these areas will be less exposed to severe conditions, plus those that are exposed may not show negative responses because of low or moderate susceptibility. Its depth range is from zero to 20 meters. This would exacerbate vulnerability to extinction over the foreseeable future for a species with high susceptibility to the nine most important threats, but *B. laddi* is not highly susceptible. Its habitat includes at least upper reef slopes, mid-slope terraces, and lagoons. Its absolute abundance of at least tens of millions of colonies, combined with low to moderate susceptibility and spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule using the determination tool formula approach, *B. laddi* was proposed for listing as threatened because of: Moderate vulnerability to ocean warming (ESA Factor E), disease (C) and acidification (E); uncommon generalized range wide abundance (E); narrow overall distribution (based on moderate geographic distribution and shallow depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *B. laddi* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *B. laddi's* spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to be likely to become endangered throughout its range within the foreseeable future, and thus is not warranted for listing at this time, because:

(1) *Barabattoia laddi's* distribution includes many of the coral reef ecoregions in the western and central Pacific, from Malaysia as far east as the Pitcairn Islands, and is spread over a very large area. While some areas within its range are projected to be affected by warming and acidification, other areas are projected to have less than average warming and acidification, including the central Pacific, and other areas. This distribution and the heterogeneous habitats it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future;

(2) *Barabattoia laddi's* absolute abundance is at least tens of millions of colonies, providing buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response; and

(3) The best available information suggests that *Barabattoia laddi* is not highly susceptible to any of the nine threats identified in this rule, so even if a proportion of its population overlaps in time and space with a threat event, many colonies may not exhibit a negative response.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future if global threats continue and increase in severity and the species exposure to threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *B. laddi* is not warranted for listing at this time under any of the listing factors.

Genus Caulastrea

Genus Introduction

The family Favidae includes 24 genera, more than any other family, including *Caulastrea.* The genus *Caulastrea* contains five species, including *C. echinulata.* Colonies are branching, and branches may be short or close together. The SRR and SIR provided no genus-level introductory information on *Caulastrea.*

Genus Susceptibility to Threats

The SRR and SIR provided the following information on the threat susceptibilities of the genus *Caulastrea. Caulastrea furcata* was not observed to bleach in 1998 in Palau.

The public comments did not provide any new or supplemental information on the threat susceptibilities of the genus *Caulastrea.* We gathered supplemental information which provided the following details. In a study of warming-induced bleaching of over 100 coral species on the GBR in 2002, approximately 10 percent of *C. furcata* colonies were affected by bleaching, making it one of the least affected species in the study (Done *et al.,* 2003b). There is no information on the susceptibilities or vulnerabilities of *Caulastrea* to any other threats.

Genus Conclusion

Based on the information from the SRR, SIR, public comments, and supplemental information, we can make the following inferences about the susceptibilities of an unstudied *Caulastrea* species to ocean warming, disease, acidification, sedimentation, nutrients, trophic effects of fishing, sea-level rise, predation, and collection and trade. The SRR rated ocean warming and disease as ''high'' importance, and ocean acidification as ''medium-high'' importance, to corals. These were rated as the three most important threats to reef-building corals overall. *Caulastrea* has shown low levels or no thermal-induced bleaching in two studies, one reported in the SRR, and one reported above (Done *et al.,* 2003b). Thus, we conclude that an unstudied *Caulastrea* is likely to have low susceptibility to ocean warming. Although there is no other genus-level or species-specific information on the susceptibilities of *Caulastrea* species to disease and ocean acidification, the SRR rated them as ''high'' and ''medium-high'' importance to corals, respectively. Thus, we conclude that an unstudied *Caulastrea* species is likely to have some susceptibility to disease and ocean acidification.

The SRR rated the trophic effects of fishing as ''medium'' importance, the fourth most important threat to corals overall. This threat was not addressed at the genus or species level in the SRR or SIR, because it is an ecosystem-level process. That is, removal of herbivorous fish from coral reef systems by fishing alters trophic interactions by reducing herbivory on algae, thereby providing a competitive advantage for space to algae over coral. Thus, the SRR did not discuss this threat in terms of coral taxa, as its effects are difficult to distinguish between coral genera and species. Therefore, an unstudied *Caulastrea* species is likely to have some susceptibility to the trophic effects of fishing.

The SRR rated sedimentation and nutrients as ''low-medium'' importance to corals overall. Although there is no genus-level or species-specific information on the susceptibilities of *Caulastrea* species to sedimentation and nutrients, there is no information suggesting they are not susceptible to these threats. Thus, we conclude that an unstudied *Caulastrea* species is likely to have some susceptibility to sedimentation and nutrients. Sea-level rise was not addressed at the genus or species level in the SRR or SIR. Increasing sea levels may increase land-based sources of pollution due to inundation, resulting in changes to coral community structure, thus an unstudied *Caulastrea* species is likely to have some susceptibility to sea-level rise. The SRR rated predation and ornamental trade (referred to in the proposed rule as Collection and Trade) as ''low'' importance to corals overall. There is no information on the effects of predation and collection and trade on *Caulastrea,* thus we conclude that *Caulastrea* likely has some susceptibility to predation and collection and trade.

In conclusion, an unstudied *Caulastrea* species is likely to have low susceptibility to ocean warming, and some susceptibility to disease, ocean acidification, sedimentation, nutrients, trophic effects of fishing, sea-level rise, predation, and collection and trade.

Caulastrea echinulata

Introduction

The SRR and SIR provided the following information on *C. echinulata's* morphology and taxonomy. Morphology was described as elongated, closely compacted corallites on the ends of branches, and taxonomy was described as having no taxonomic issues but being similar in appearance to *Caulastrea furcata.*

The public comments and information we gathered did not provide any new or supplemental information on morphology, and indicated that there is moderate taxonomic uncertainty for *C. echinulata* and a moderate level of species identification uncertainty for this species. Veron (2014) states that *C. echinulata* is commonly confused with *C. furcata,* but the species can be identified by experts (Fenner, 2014b), thus we conclude that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *C. echinulata's* distribution, habitat, and depth range. The distribution includes the Coral Triangle and GBR and a few nearby areas. Its primary habitat is horizontal substrates protected from wave action and with turbid water, which can occur in a variety of reef habitats, including at least upper reef slopes, mid-slopes, and lagoons. Its depth range is one to 20 meters.

The public comments did not provide any new or supplemental information on *C. echinulata's* distribution. We gathered supplemental information, including Veron (2014), which reports that this species is confirmed in 15 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional 12.

Demographic Information

The SRR and SIR reported *C. echinulata's* abundance as uncommon. The public comments did not provide any new or supplemental information on *C. echinulata's* abundance. We gathered supplemental information, including Veron (2014), which reports that *C. echinulata* occupied 0.34 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.3 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''rare,'' and overall abundance was described as ''uncommon.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *C. echinulata,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 36 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 14 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context. Thus, quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *C. echinulata* occurs in many areas affected by these broad changes, and likely has some susceptibility to local and global threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible due to the limited species-specific information.

Other Biological Information

The public comments and information we gathered did not provide any other biological information on this species.

Susceptibility to Threats

The SRR and SIR provided the following species-specific information on *C. echinulata's* threats. Trade in *C. echinulata* is heavy. From 1999 to 2009, gross exports averaged 8,713 specimens annually, with the vast majority originating in Indonesia. Take quotas over that same period increased from 9,000 in 1999 to 10,670 in 2010. Some general (*i.e.,* family-level and coral-level) information was also provided for the effects of ocean warming, acidification, disease, predation, sedimentation, nutrients, and collection and trade. The SRR and SIR did not provide any other species-specific information on the effects of these threats on *C. echinulata.* We interpreted threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *C. echinulata's* vulnerabilities as follows: Moderate vulnerability to ocean warming, disease, acidification, trophic effects of fishing, and nutrients, low vulnerability to sea level rise and collection and trade, and unknown vulnerability to sedimentation and predation.

Public comments did not provide any new or supplemental information on *C. echinulata's* threat susceptibilities. We gathered the following species-specific and genus-level supplemental information on this species' threat susceptibilities. *Caulastrea echinulata* has not been rated as moderately or highly susceptible to bleaching or disease, but this rating is not based on species-specific data (Carpenter *et al.,* 2008). Based on genus information described above, *C. echinulata* is likely to have low susceptibility to ocean warming, and likely has some susceptibility to disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade. The available information does not support more precise ratings of the susceptibilities of *C. echinulata* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *C. echinulata.* Criticisms of our approach received during public comment led us to attempt the following analysis of regulatory mechanisms on a species basis. Records confirm *C. echinulata* occurs in 15 Indo-Pacific ecoregions that encompass 12 countries' EEZs. The 12 countries are Australia, Brunei, China, Fiji, Indonesia, Japan, Malaysia, Palau, Papua New Guinea, Philippines, Solomon Islands, and Taiwan. The regulatory mechanisms relevant to *C. echinulata,* described first as the percentage of the above countries that utilize them to any degree and second, as the percentages of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (25 percent with none limited in scope), coral collection (67 percent with 42 percent limited in scope), pollution control (42 percent with 8 percent limited in scope), fishing regulations on reefs (100 percent with 25 percent limited in scope), and managing areas for protection and conservation (100 percent with none limited in scope). The most common regulatory mechanisms in place for *C. echinulata* are reef fishing regulations and area management for protection and conservation. Coral collection and pollution control laws are also somewhat utilized for the species, but 42 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection laws are much less common regulatory mechanisms for the management of *C. echinulata.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that factors that increase the potential extinction risk for *C. echinulata* are its uncommon abundance and that it is heavily traded. It listed factors that reduce potential extinction risk including that the species distribution is broad latitudinally, and that its preferred habitat type (turbid conditions) may provide some refuge from global threats such as bleaching (to which it may have relatively low susceptibility).

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of C. *echinulata,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. *Caulastrea echinulata* has low susceptibility to ocean warming-induced bleaching, based on species-specific and genus-level information. Its geographic distribution is mostly constrained to parts of the Coral Triangle and western equatorial Pacific Ocean—areas which are projected to have the most rapid and severe impacts from climate change and localized human impacts for coral reefs over the 21st century. For a species that is highly susceptible to climate change related threats, this range would exacerbate vulnerability to extinction but *C. echinulata* has low susceptibility. Vulnerability to extinction may be exacerbated by the severe nature of local threats predicted within its range, however, *C. echinulata* is not highly susceptible to any local sources of impact either. Its depth range is from one to 20 meters. This moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Its habitat includes horizontal substrates protected from wave action and with turbid water, which can occur on at least upper reef slopes, mid-slopes, and lagoons. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. In addition, turbidity can mitigate against the effects of high irradiance by blocking it from the water column in turbid environments. Its absolute abundance of at least millions of colonies, combined with its low susceptibility to ocean warming, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time. Further, its absolute abundance of at least tens of millions of colonies also provides buffering capacity against collection pressures for the purposes of international trade.

Listing Determination

In the proposed rule using the determination tool formula, *C. echinulata* was proposed for listing as threatened because of: Moderate vulnerability to ocean warming (ESA Factor E), disease (C) and acidification (E); uncommon generalized range wide abundance (E); narrow overall distribution (based on narrow geographic distribution and moderate depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *C. echinulata* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *C. echinulata's* spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to be likely to become endangered throughout its range within the foreseeable future, and thus it is not warranted for listing at this time, because:

(1) *Caulastrea echinulata's* low sensitivity to bleaching and depth range down to 20 m, along with its preference for turbid water habitat, all combine to provide refuge from thermal stress and may decrease synergistic impacts from other threats;

(2) While *Caulastrea echinulata's* distribution is mostly constrained to parts of the Coral Triangle and western equatorial Pacific Ocean, its distribution is spread over a large area across the Coral Triangle, southern Japan and Fiji. While some areas within its range are projected to be affected by warming and acidification, other areas are projected to have less than average warming and acidification. This distribution and the heterogeneous habitats it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future; and

(3) *Caulastrea echinulata's* absolute abundance is at least tens of millions of colonies, providing buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. Its absolute abundance also provides buffering capacity against collection pressures for purposes of international trade. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future if global threats continue and worsen in severity and the species' exposure to the threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *C. echinulata* is not warranted for listing at this time under any of the listing factors.

Genus Euphyllia

Genus Introduction

The family Euphyllidae contains five genera, all in the Indo-Pacific, including *Euphyllia.* The genus *Euphyllia* contains eight species. The SRR and SIR provided no genus-level introductory information on *Euphyllia.*

Genus Susceptibility to Threats

The SRR and SIR provided the following information on the threat susceptibilities of the genus *Euphyllia. Euphyllia* species experienced high bleaching, but mortality is unknown, following the 1997/1998 mass bleaching event in Palau. In Indonesia, the family Euphyllidae had no prevalence of coral disease. When raised in acidified conditions, *Euphyllia paradivisa* showed little change in skeletal morphology, while *Galaxea* and *Stylophora* showed substantial skeletal change and *Pocillopora* died. The SRR reported that abundance of *Euphyllia* recruits was enhanced in areas where fish were excluded, indicating it may be more tolerant of the shaded conditions created by increased algal biomass in overfished areas. *Euphyllia divisa* was fairly sensitive to exposure to cyanide; concentrations at or below those used in cyanide fishing caused a progressive tissue detachment, microbial infection, and death. Large patches of *Euphyllia* species can form in turbid areas in Indonesia, suggesting a toleration of high sediment loads. *Euphyllia cristata* is heavily used in the aquarium trade with species-specific exports or quotas from Indonesia, Fiji, Malaysia, and Tonga. Actual reported annual exports from Indonesia alone averaged over 36,000 pieces from 2000 to 2008.

The public comments did not provide any new or supplemental information on the threat susceptibilities of the genus *Euphyllia,* except for a public comment on a study cited in the SRR on the effects of ocean acidification on *E. paradivisa,* which is discussed in the description of that species below. We gathered supplemental information which provided the following. The 1998 Palau bleaching event affected at least three *Euphyllia* species (*E. divisa, E. glabrescens,* and *E. paraancora*), and all three species reported high levels of bleaching (Bruno *et al.,* 2001). *Euphyllia* was the largest live trade genus from 1985 to 1997 (Green and Shirley, 1999) and in 1999 (Bruckner, 2001). There is no other supplemental information on the effects of threats on the genus *Euphyllia.*

Genus Conclusion

Based on the information from the SRR, SIR, public comments, and supplemental information, we can make the following inferences about the susceptibilities of an unstudied *Euphyllia* species to ocean warming, disease, ocean acidification, sedimentation, nutrients, trophic effects of fishing, sea-level rise, predation, and collection and trade. The SRR rated ocean warming and disease as ''high'' importance, and ocean acidification as ''medium-high'' importance, to corals. These were rated as the three most important threats to reef-building corals overall. The one available study reporting the effects of ocean warming on *Euphyllia* reported high levels of bleaching. We conclude that an unstudied *Euphyllia* species is likely to have high susceptibility to ocean warming. Family Euphyllidae was found to be disease-free in Indonesia. However, this single study provides inadequate information to conclude low susceptibility to disease, thus we conclude that an unstudied *Euphyllia* species is likely to have some susceptibility to disease. The one available study on a *Euphyllia* species in acidified water did not show effects on skeletal growth. This is the Tibbits (2009) study on *E. paradivisa* that a public comment stated is flawed. As described below in the *E. paradivisa* species description below, we reviewed the study and we concur that the methods were flawed, thus the study does not provide an adequate basis to conclude low susceptibility. Therefore, we conclude that an unstudied *Euphyllia* species is likely to have some susceptibility to ocean acidification.

The SRR rated the trophic effects of fishing as ''medium'' importance, the fourth most important threat to corals overall. This threat was not addressed at the genus or species level in the SRR or SIR, because it is an ecosystem-level process. That is, removal of herbivorous fish from coral reef systems by fishing alters trophic interactions by reducing herbivory on algae, thereby providing a competitive advantage for space to algae over coral. Thus, the SRR did not discuss this threat in terms of coral taxa, as its effects are difficult to distinguish between coral genera and species. Therefore, an unstudied *Euphyllia* species is likely to have some susceptibility to the trophic effects of fishing.

The SRR rated sedimentation and nutrients as ''low-medium'' importance to corals overall. One study reported *Euphyllia* tolerates turbid waters, suggesting tolerance of sedimentation, and one study suggested that *Euphyllia* may be tolerant of increased algae due to nutrients. However, these single studies provide inadequate information to conclude low susceptibilities, thus we conclude that an unstudied *Euphyllia* species is likely to have some susceptibility to sedimentation and nutrients. Sea-level rise was not addressed at the genus or species level in the SRR or SIR. Increasing sea levels may increase land-based sources of pollution due to inundation, resulting in changes to coral community structure, thus an unstudied *Euphyllia* species is likely to have some susceptibility to sea-level rise. Although there is no genus-level or species-specific information on the susceptibility of *Euphyllia* species to predation, there is no information suggesting they are not susceptible to these threats. Thus, we conclude that an unstudied *Euphyllia* species is likely to have some susceptibility to predation. Some *Euphyllia* species are heavily exploited in the ornamental trade, thus we conclude that an unstudied *Euphyllia* species is likely to have high susceptibility to collection and trade.

In conclusion, an unstudied *Euphyllia* species is likely to have high susceptibility to ocean warming and collection and trade, and some susceptibility to disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, and predation.

Euphyllia cristata

Introduction

The SRR and SIR provided the following information on *E. cristata's* morphology and taxonomy. Morphology was described as branching separate corallites without a shared wall but close together, and solitary polyps are common, and taxonomy was described as having no taxonomic issues.

Public comments and information we gathered did not provide any new or supplemental information on morphology, and confirmed that there are no known taxonomic problems for *E. cristata,* and a moderate level of species identification uncertainty. Veron (2014) states that *E. cristata* is sometimes confused with *Euphyllia glabrescens.* However, it can be identified by experts (Fenner, 2014b), thus we conclude that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *E. cristata's* distribution, habitat, and depth range. *Euphyllia cristata's* distribution is the central Indo-Pacific and the central Pacific. Its habitat includes most coral reef environments, and its depth range is one to 35 meters.

Public comments did not provide any new or supplemental information on *E. cristata's* distribution. We gathered supplemental information, including Veron (2014), which reports that this species is confirmed in 37 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional 12. Public comments and information we gathered did not provide any more information on *E. cristata's* habitat and depth range.

Demographic Information

The SRR and SIR reported *E. cristata's* abundance as uncommon.

Public comments did not provide any new or supplemental information on *E. cristata's* abundance. We gathered supplemental information, including Veron (2014), which reports that *E. cristata* occupied 12.1 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.33 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''common,'' and overall abundance was described as ''uncommon but conspicuous.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least tens of millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *E. cristata,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 36 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 14 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context. Thus, quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *E. cristata* occurs in many areas affected by these broad changes, and likely has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on limited species specific information.

Other Biological Information

The public comments and information we gathered did not provide any other biological information on this species.

Susceptibility to Threats

The SRR and SIR provided the following species-specific information on *E. cristata's* threats. *Euphyllia cristata* is heavily used in the aquarium trade with species-specific exports or quotas from Indonesia, Fiji, Malaysia, and Tonga. Actual reported annual exports from Indonesia alone averaged over 36,000 pieces from 2000 to 2008. Genus-level information is provided for the effects on *Euphyllia* of ocean warming, disease, ocean acidification, land-based sources of pollution (sedimentation, nutrients, toxins, and salinity), predation, and collection/trade. The SRR and SIR did not provide any other species-specific information on the effects of these threats on *E. cristata.* We interpreted threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *E. cristata's* vulnerabilities as follows: High vulnerability to ocean warming; moderate vulnerability to disease, ocean acidification, trophic effects of fishing, and nutrients, and low vulnerability to sedimentation, sea level rise, predation, and collection and trade.

Public comments did not provide any new or supplemental information on *E. cristata's* threat susceptibilities. We gathered supplemental species-specific and genus-level information on this species' threat susceptibilities. *Euphyllia cristata* was not rated as moderately or highly susceptible to bleaching or coral disease by Carpenter *et al.* (2008), but they did not have species-specific data. There are no studies of the effects of any threat on this species. Based on genus-level information presented above, *E. cristata* is likely to have high susceptibility to ocean warming and collection and trade, and some susceptibility to disease, ocean acidification, trophic effects of fishing, nutrients, sedimentation, sea-level rise, and predation.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *E. cristata.* Criticisms of our approach received during public comment led us to attempt the following analysis of regulatory mechanisms on a species basis. Records confirm *E. cristata* occurs in 37 Indo-Pacific ecoregions that encompass 21 countries' EEZs. The 21 countries are Australia, Brunei, China, Federated States of Micronesia, Fiji, France (French Pacific Island Territories), Indonesia, Japan, Malaysia, Maldives, Myanmar, Palau, Papua New Guinea, Philippines, Solomon Islands, Taiwan, Thailand, Timor-Leste, United States (CNMI, Guam), Vanuatu, and Vietnam. The regulatory mechanisms relevant to *E. cristata,* described first as the percentage of the above countries that utilize them to any degree, and second as the percentage of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (38 percent with five percent limited in scope), coral collection (62 percent with 29 percent limited in scope), pollution control (43 percent with 14 percent limited in scope), fishing regulations on reefs (100 percent with 14 percent limited in scope), and managing areas for protection and conservation (95 percent with none limited in scope). The most common regulatory mechanisms in place for *E. cristata* are reef fishing regulations and area management for protection and conservation. Coral collection and pollution control laws are also somewhat utilized for the species, but 29 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection laws are much less common regulatory mechanisms for the management of *E. cristata.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that factors that increase potential extinction risk for *E. cristata* include its heavy involvement in international trade combined with its rare existence but conspicuous colonies, suggesting it is vulnerable to overexploitation. *Euphyllia cristata* appears to be susceptible to bleaching. The SRR noted that its geographic distribution is moderate, although wider than its congeners under consideration in this review.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *E. cristata,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution includes many of the coral reef ecoregions from the northern Indian Ocean through the western and central Pacific Ocean. Its geographic distribution moderates vulnerability to extinction because some areas within its range are projected to have less than average warming and acidification over the foreseeable future, including the western Indian Ocean, the central Pacific, and other areas, so portions of the population in these areas will be less exposed to severe conditions. Its depth range is from one to 35 meters. This moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Its habitat includes most coral reef environments. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Its absolute abundance of at least tens of millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time. Further, its absolute abundance of at least tens of millions of colonies also provides buffering capacity against collection pressures for the purposes of international trade.

Listing Determination

In the proposed rule using the determination tool formula approach, *E. cristata* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); uncommon generalized range wide abundance (E); moderate overall distribution (based on moderate geographic distribution and moderate depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *E. cristata* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *E. cristata's* spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to be likely to become endangered throughout its range within the foreseeable future, and thus is not warranted for listing at this time, because:

(1) *Euphyllia cristata's* distribution in the northern Indian Ocean, central Indo-Pacific, and central Pacific is spread

over a vast area. While some areas within its range are projected to be affected by warming and acidification, other areas are projected to have less than average warming and acidification, including the central Pacific, and other areas. This distribution and the heterogeneous habitats it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future;

(2) *Euphyllia cristata's* absolute abundance is at least tens of millions of colonies, providing buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. Its absolute abundance also provides buffering capacity against collection pressures for purposes of international trade. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response; and

(3) *Euphyllia cristata* occurs from one to 35 meters of depth which provides vertical moderation of exposure to threats and increases the absolute area of potential occupancy within the species range, therefore buffering against extinction risk.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future if global threats continue and increase in severity and the species exposure to threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *E. cristata* is not warranted for listing at this time under any of the listing factors.

Euphyllia paraancora

Introduction

The SRR and SIR provided the following information on *E. paraancora's* morphology and taxonomy. Morphology was described as branching separate corallites without a shared wall, and tentacles have anchor-shaped ends. Taxonomy was described as having no taxonomic issues but tentacles are similar to *Euphyllia ancora,* and the skeleton is the same as *Euphyllia glabrescens, Euphyllia paraglabrescens,* and *Euphyllia paradivisa.*

Public comments and information we gathered did not provide any new or supplemental information on morphology, and confirmed that there are no known taxonomic problems for *E. paraancora,* but there is a low level of species identification uncertainty for this species. The species can be easily identified by experts, thus we conclude that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *E. paraancora's* distribution, habitat, and depth range. *Euphyllia paraancora* is found in the Coral Triangle, Taiwan, the Mariana Islands, New Caledonia and Vanuatu. The SIR reports that colonies found in Guam were in turbid environments. Its habitat includes reef environments protected from wave action, including at least upper reef slopes, mid-slopes, lower reef slopes, and lagoons, from three to 30 m deep.

One public comment confirmed the presence of *E. paraancora* in Guam. We gathered supplemental information, including Veron (2014), which reports that this species is confirmed in 19 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional 15. *Euphyllia paraancora* has been reported in water as deep as 70 m (Carpenter *et al.,* 2008; Rooney *et al.,* 2012). Based on all the available information, its habitat includes least upper reef slopes, mid-slopes, lower reef slopes, lagoons, and mesophotic areas, from three to 70 m deep.

Demographic Information

The SRR and SIR reported *E. paraancora's* abundance as uncommon. However, it has reportedly been found in large monospecific stands at six to 8 m depth in Taiwan.

Public comments did not provide any new or supplemental information on *E. paraancora's* abundance. We gathered supplemental information that provides the following. *Euphyllia paraancora* has been reported from large monospecific stands at 60 to 70 m depth in Saipan (Rooney *et al.,* 2012). Veron (2014) reports that *E. paraancora* occupied 1.9 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.46 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''uncommon,'' and overall abundance was also described as ''uncommon.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *E. paraancora,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 36 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 14 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context. Thus, quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *E. paraancora* occurs in many areas affected by these broad changes, and likely has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible based on limited species specific information.

Other Biological Information

The public comments and information we gathered did not provide any other biological information on this species.

Susceptibility to Threats

To describe *E. paraancora's* threat susceptibilities, the SRR and SIR provided the following species-specific information on *E. paraancora's* threats. *Euphyllia paraancora* and its congeners experienced high bleaching but mortality is unknown following the 1997/1998 mass bleaching event in Palau (Bruno *et al.,* 2001). *Euphyllia paraancora* in Taiwan contained both Clades C and D zooxanthellae, with Clade D primarily in stressful environments like shallow waters and reef edges. *Euphyllia paraancora* is specifically listed in the CITES databases with a 2008 annual export quota of ~ 5000 (up from 1000 in 2004) ''maricultured'' pieces from Indonesia although the meaning of ''maricultured'' is unclear. Genus-level information is provided for the effects on *Euphyllia* of ocean warming, ocean acidification, disease, land-based sources of pollution (sedimentation, nutrients, toxins, and salinity), predation, and collection/trade. The SRR and SIR did not provide any other species-specific information on the effects of these threats on *E. paraancora.* We interpreted threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *E. paraancora's* vulnerabilities as follows: High vulnerability to ocean warming; moderate vulnerability to disease, ocean acidification, trophic effects of fishing, and nutrients, and low vulnerability to sedimentation, sea level rise, and collection and trade.

Public comments did not provide any new or supplemental information on *E. paraancora's* threats susceptibilities. We gathered supplemental species-specific and genus-level information on this species' threat susceptibilities. *Euphyllia paraancora* was not rated as moderately or highly susceptible to bleaching or disease by Carpenter *et al.* (2008), but they did not have species-specific data. In Palau in 2000, *E. paraancora* had high levels of bleaching, but an unknown level of mortality. In that event, 48 percent of all coral colonies of all species were bleached, with bleaching of different genera and species ranging from none to very high, and mortality from none to near 100 percent (Bruno *et al.,* 2001). There are no other studies of the effects of any threat on this species. Combined with genus-level information presented above, *E. paraancora* is likely to have high susceptibility to ocean warming and collection and trade. Further based on genus level information, *E. paraancora* can be predicted to have some susceptibility to disease, ocean acidification, trophic effects of fishing, nutrients, sedimentation, sea-level rise, and predation.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *E. paraancora.* We received criticism of that approach in public comments and in response we present a species-specific analysis of regulatory mechanisms in this final rule. Records confirm that *Euphyllia paraancora* occurs in 19 Indo-Pacific ecoregions that encompass 16 countries' EEZs. The 16 countries Australia, Brunei, China, Federated States of Micronesia, France (French Pacific Island Territories), Indonesia, Japan, Malaysia, Palau, Papua New Guinea, Philippines, Solomon Islands, Taiwan, Timor-Leste, United States (CNMI, Guam), and Vietnam. The regulatory mechanisms relevant to *E. paraancora,* described first as the percentage of the above countries that utilize them to any degree, and second as the percentage of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (38 percent with none limited in scope), coral collection (63 percent with 25 percent limited in scope), pollution control (44 percent with 19 percent limited in scope), fishing regulations on reefs (100 percent with 19 percent limited in scope), and managing areas for protection and conservation (100 percent with none limited in scope). The most common regulatory mechanisms in place for *E. paraancora* are reef fishing regulations and area management for protection and conservation. Coral collection and pollution control laws are also somewhat utilized for the species, but 25 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection laws are much less common regulatory mechanisms for the management of *E. paraancora.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that factors that increase potential extinction risk for *E. paraancora* include its heavy involvement in international trade combined with its rare existence but conspicuous colonies, suggesting it is vulnerable to overexploitation. The species appears bleaching-susceptible. Its geographic distribution is also somewhat restricted, centered in the threat-prone Coral Triangle Region.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *E. paraancora,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution occurs in the Coral Triangle, the western equatorial Pacific Ocean, the Mariana Islands, and New Caledonia. Despite the large number of islands and environments that are included in the species' range, this range exacerbates vulnerability to extinction over the foreseeable future because it is mostly limited to an area projected to have the most rapid and severe impacts from climate change and localized human impacts for coral reefs over the 21st century. Its depth range goes down to 70 meters which stretches into the mesophotic zone. This moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Its habitat includes at least upper reef slopes, mid-slopes, lower reef slopes, lagoons, and mesophotic areas. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Its absolute abundance of at least millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time. Further, its absolute abundance of at least tens of millions of colonies also provides buffering capacity against collection pressures for the purposes of international trade.

Listing Determination

In the proposed rule using the determination tool formula approach, *E. paraancora* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); uncommon generalized range wide abundance (E); wide overall distribution (based on moderate geographic distribution and wide depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *E. paraancora* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *E. paraancora's* spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to be likely to become endangered throughout its range within the foreseeable future, and thus is not warranted for listing at this time, because:

(1) *Euphyllia paraancora's* depth distribution of three to 70 m is exceptionally broad and deep for most reef-building coral species. The ability to occupy a broad range of depths likely provides refugia from threats that may be more severe in shallow environments because irradiance is usually lower at depths at the deeper end of this species' range. It also increases the absolute area of potential occupancy throughout the species range. This distribution and the heterogeneous habitats it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future; and

(2) *Euphyllia paraancora's* absolute abundance is at least millions of colonies, providing buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. Its absolute abundance also provides buffering capacity against collection pressures for purposes of international trade. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response.

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future as global threats continue and increase in severity and the species exposure to threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *E. paraancora* is not warranted for listing at this time under any of the listing factors.

Euphyllia paradivisa

Introduction

The SRR and SIR provided the following information on *E. paradivisa's* morphology and taxonomy. Morphology was described as branching separate corallites without a shared wall and branching tentacles. The taxonomy was described as having no taxonomic issues but having tentacles similar to *Euphyllia divisa* and skeleton that is the same as *Euphyllia glabrescens, Euphyllia paraglabrescens,* and *Euphyllia paraancora.*

The public comments and information we gathered did not provide any new or supplemental information on morphology, and confirmed that there are no known taxonomic problems for *E. paradivisa,* and a low level of species identification uncertainty for this species. Veron (2014) states that *E. paradivisa* is very distinctive. The species can be easily identified by experts, thus we conclude that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *E. paradivisa's* distribution, habitat, and depth range. *Euphyllia paradivisa's* distribution is restricted to the Coral Triangle, and its habitat is shallow or mid-slope reef environments protected from wave action, from five to 20 meters depth.

The public comments did not provide any new or supplemental information on *E. paradivisa's* distribution. We gathered supplemental information, including Veron (2014) which reports that *E. paradivisa* is confirmed in eight of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional eight. Fenner (2013a) reported *E. paradivisa* (supported by photographs), from American Samoa at about 25 m deep protected from wave action. Veron (2014) reports it from American Samoa based on that record. Thus, based on all the available information, *E. paradivisa's* habitat includes environments protected from wave action on at least upper reef slopes, mid-slope terraces, and lagoons in depths ranging from two to 25 m depth.

Demographic Information

The SRR and SIR reported that *E. paradivisa's* abundance is uncommon.

The public comments did not provide any new or supplemental information on *E. paradivisa's* abundance. We gathered supplemental information, including Veron (2014) which reported that *E. paradivisa* occupied 0.2 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.5 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''rare,'' and overall abundance was described as ''uncommon.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species

Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least tens of millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *E. paradivisa,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 38 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 15 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context. Thus, quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *E. paradivisa* occurs in many areas affected by these broad changes, and likely has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible due to the limited species-specific information.

Other Biological Information

The public comments and information we gathered did not provide any other biological information on this species.

Susceptibility to Threats

To describe *E. paradivisa's* threat susceptibilities, the SRR and SIR provided genus-level information for the effects on *Euphyllia* of ocean warming, disease, acidification, sedimentation, predation, and collection and trade. The SRR and SIR also provided the following species-specific information on *E. paradivisa's* threats. When raised in acidified conditions, *E. paradivisa* showed little change in skeletal morphology, while *Galaxea* and *Stylophora* showed substantial skeletal change and *Pocillopora* died. *Euphyllia paradivisa* is specifically listed in the CITES databases with annual export quotas of up to 2380 ''maricultured'' pieces from Indonesia, although the meaning of ''maricultured'' is unclear. The SRR and SIR did not provide any other species-specific information on the effects of these threats on *E. paradivisa.* We interpreted the threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *E. paradivisa's* vulnerabilities to threats as follows: High vulnerability to ocean warming, moderate vulnerability to disease, ocean acidification, trophic effects of fishing, and nutrients, low vulnerability to sedimentation, sea level rise, and collection and trade, and unknown vulnerability to predation.

The public comments provided the following supplemental information on *E. paradivisa's* threat susceptibilities. A public comment stated that the SRR appeared to rely solely upon collection and trade to rate the extinction risk of this species, subsequently leading to the proposed Endangered listing. However, the SRR (and the Determination Tool in the proposed rule) both considered the susceptibilities and vulnerabilities of this species to multiple threats to help determine its extinction risk and proposed listing status. Likewise, as explained in the Determination Framework section above, this final rule considers the susceptibilities, exposures, and vulnerabilities of each species to the nine major threats to determine its extinction risk and listing status, including for *E. paradivisa.*

The public comment also stated that an unpublished study cited by the SRR on the effects of ocean acidification on *E. paradivisa* (Tibbits, 2009) is flawed. The study reported that the skeletal morphology of *E. paradivisa* specimens kept in acidified conditions over a three month period ''did not change noticeably.'' We reviewed the study, and we concur with the public comment, in that the methods used in the study to lower pH were flawed, thus the results should not be considered reliable information on the potential effects of ocean acidification on *E. paradivisa.*

We gathered the following species-specific supplemental information on this species' threat susceptibilities. *Euphyllia paradivisa* was not rated as moderately or highly susceptible to bleaching and disease, but these ratings are not based on species-specific data (Carpenter *et al.,* 2008). Based on the genus and species-specific information described above, *E. paradivisa* is likely to have high susceptibility to ocean warming and collection and trade, some susceptibility to disease, acidification, trophic effects of fishing, nutrients, and predation, and low susceptibility to sedimentation and sea-level rise. The available information does not support more precise ratings of the susceptibilities of *E. paradivisa* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanism or conservation efforts for *E. paradivisa.* Criticisms of our approach received during public comment led us to attempt the following analysis of regulatory mechanisms on a species basis. Records confirm that *Euphyllia paradivisa* occurs in eight Indo-Pacific ecoregions that encompass 15 countries' EEZs. The 15 countries are Brunei, Fiji, France (French Pacific Island Territories), Indonesia, Malaysia, New Zealand (Tokelau), Niue, Papua New Guinea, Philippines, Samoa, Timor-Leste, Tonga, Tuvalu, United States (American Samoa), and Vietnam. The regulatory mechanisms relevant to *E. paradivisa,* described first as the percentage of the above countries that utilize them to any degree and second, as the percentages of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (33 percent with none limited in scope), coral collection (80 percent with 40 percent limited in scope), pollution control (53 percent with 20 percent limited in scope), fishing regulations on reefs (100 percent with 20 percent limited in scope), managing areas for protection and conservation (100 percent with none limited in scope). The most common regulatory mechanisms in place for *E. paradivisa* are reef fishing regulations and area management for protection and conservation. Coral collection and pollution control laws are also common for the species, but 40 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection laws are much less common regulatory mechanisms for the management of *E. paradivisa.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated that factors that increase the potential extinction risk for *E. paradivisa* include its heavy involvement in international trade combined with its rare existence but conspicuous colonies, suggesting it is vulnerable to overexploitation. The species appears bleaching-susceptible. Its geographic distribution is also somewhat restricted, centered in the threat-prone Coral Triangle Region. No known factors were noted by the BRT to reduce the extinction risk of this species.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *E. paradivisa,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution is mostly limited to parts of the Coral Triangle. Despite the large number of islands and environments that are included in the species' range, this range exacerbates vulnerability to extinction over the foreseeable future because it is mostly limited to an area projected to have the most rapid and severe impacts from climate change and localized human impacts for coral reefs over the 21st century. Its depth range of two to 25 meters moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Its habitat includes environments protected from wave action on at least upper reef slopes, mid-slope terraces, and lagoons. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Its abundance of at least tens of millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time. However, its qualitative abundance is described as rare, which can exacerbate its vulnerability given its restricted range.

Listing Determination

In the proposed rule using the determination tool formula, *E. paradivisa* was proposed for listing as endangered because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); uncommon generalized range wide abundance (E); narrow overall distribution (based on narrow geographic distribution and moderate depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed our listing determination of *E. paradivisa* from endangered to threatened. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information provided above on *E. paradivisa'*s spatial structure, demography, threat susceptibilities, and management indicate that it is likely to become endangered throughout its range within the foreseeable future, and thus warrants listing as threatened at this time, because:

(1) *Euphyllia paradivisa* is susceptible to warming-induced bleaching (ESA Factor E), disease (C), ocean acidification (E), trophic effects of fishing (A), nutrients (A, E), predation (C), and collection and trade (B). These threats are expected to continue and worsen into the future. In addition, the species has inadequate existing regulatory mechanisms for global threats (D).

(2) *Euphyllia paradivisa'*s distribution is limited mostly to the Coral Triangle, which is projected to have the most rapid and severe impacts from climate change and localized human impacts for coral reefs over the 21st century, as described in the Threats Evaluation. Multiple ocean warming events have already occurred within the Coral Triangle that suggest future ocean warming events may be more severe than average in this part of the world. A range constrained to this particular geographic area that is likely to experience severe and increasing threats indicates that a high proportion of the population of this species is likely to be exposed to those threats over the foreseeable future; and

(3) *Euphyllia paradivisa'*s semi-quantitative abundance is rare. Considering the limited range of this species in an area where severe and increasing impacts are predicted, this level of abundance leaves the species vulnerable to becoming of such low abundance within the foreseeable future that it may be at risk from depensatory processes, environmental stochasticity, or catastrophic events, as explained in more detail in the Corals and Coral Reefs and Risk Analyses sections.

The combination of these characteristics and projections of future threats indicates that the species is likely to be in danger of extinction within the foreseeable future throughout its range and warrants listing as threatened at this time due to factors A, C, D, and E.

The available information above on *E. paradivisa'*s spatial structure, demography, threat susceptibilities, and management also indicate that the species is not currently in danger of extinction and thus does not warrant listing as Endangered because:

(1) While *E. paradivisa'* range is mostly within the Coral Triangle, which increases it extinction risk as described above, its habitat includes environments protected from wave action on at least upper reef slopes, mid-slope terraces, and lagoons. This moderates vulnerability to extinction currently because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time, as described in more detail in the Coral Habitat and Threats Evaluation sections. There is no evidence to suggest that the species is so spatially fragmented that depensatory processes, environmental stochasticity, or the potential for catastrophic events currently pose a high risk to the survival of the species; and

(2) While *Euphyllia paradivisa'*s qualitative abundance is rare, its absolute abundance is millions of colonies, which allows for some variation in the responses of individuals to threats. There is no evidence of depensatory processes such as reproductive failure from low density of reproductive individuals and genetic processes such as inbreeding affecting this species. Thus, its absolute abundance indicates it is currently able

to avoid high mortality from environmental stochasticity, and mortality of a high proportion of its population from catastrophic events. The combination of these characteristics indicates that the species does not exhibit the characteristics of one that is currently in danger of extinction, as described previously in the Risk Analyses section, and thus does not warrant listing as endangered at this time.

Range-wide, a multitude of conservation efforts are already broadly employed that are likely benefiting *E. paradivisa.* However, considering the global scale of the most important threats to the species, and the ineffectiveness of conservation efforts at addressing the root cause of global threats (*i.e.,* greenhouse gas emissions), we do not believe that any current conservation efforts or conservation efforts planned in the future will result in affecting the species status to the point at which listing is not warranted.

Genus Physogyra

Genus Introduction

The family Euphyllidae consists of five genera: *Euphyllia, Catalaphyllia, Nemenzophyllia, Plerogyra,* and *Physogyra.* The genus *Physogyra* is monospecific, meaning it only includes *P. lichtensteini* (Veron, 2000), so there is no need to provide genus-level information.

Physogyra lichtensteini

Introduction

The SRR and SIR provided the following information on *P. lichtensteini's* morphology and taxonomy. Morphology was described as massive or thick, platy and meandroid forms with short, widely separated valleys, and taxonomy was described as having no taxonomic issues, but being similar to *Plerogyra sinuosa.*

The public comments did not provide any new or supplemental information on morphology or taxonomy. We gathered supplemental information, including Veron (2014), which states that *P. lichtensteini* is one of the world's most distinctive species. In addition, Veron (2000; 2014) considers the species valid, thus we conclude it can be identified by experts and that the distribution and abundance information described below for this species is sufficiently reliable (Fenner, 2014b).

Spatial Information

The SRR and SIR provided the following information on *P. lichtensteini's* distribution, habitat, and depth range. *Physogyra lichtensteini* is distributed from the Red Sea and the Indian Ocean to the western and central Pacific Ocean. The SRR described *P. lichtensteini's* habitat as turbid reef environments, crevices and overhangs, especially in turbid water with tidal currents, and shallow but shaded waters such as caves on the GBR, with a depth range of one to 20 meters. The SIR added that the species is also known to occur in clear water.

The public comments did not provide any new or supplemental information on *P. lichtensteini's* distribution. We gathered supplemental information, including Veron (2014), which reports that *P. lichtensteini* is confirmed in 54 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional 18. In addition to shaded habitats, including turbid and clear water, *P. lichtensteini* also occurs in full sun (D. Fenner, personal comm.), thus the species occurs in variety of habitats. Thus, based on all the available information, *P. lichtensteini's* occurs in both turbid and clear upper reef slopes, mid-slopes, lower reef crests, reef flats, lagoons, and caves in depth ranging from one to 20 m depth.

Demographic Information

The SRR and SIR reported *P. lichtensteini's* abundance as common in turbid water and crevices and overhangs, especially in turbid water with tidal currents.

The public comments did not provide any new or supplemental information on *P. lichtensteini's* abundance. We gathered supplemental information, including Veron (2014), which reports that *P. lichtensteini* occupied 30.9 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.31 on a 1 to 5 rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''common,'' and overall abundance was described as ''common in protected habitats.'' Veron did not infer trends in abundance from these data. As described in the Indo-Pacific Species Determinations introduction above, based on results from Richards *et al.* (2008) and Veron (2014), the absolute abundance of this species is likely at least tens of millions of colonies.

Carpenter *et al.* (2008) extrapolated species abundance trend estimates from total live coral cover trends and habitat types. For *P. lichtensteini,* the overall decline in abundance (''Percent Population Reduction'') was estimated at 37 percent, and the decline in abundance before the 1998 bleaching event (''Back-cast Percent Population Reduction'') was estimated at 15 percent. However, as summarized above in the Inter-basin Comparison sub-section, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context. Thus, quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Birkeland, 2004; Fenner, 2012; Pandolfi *et al.,* 2003; Sale and Szmant, 2012). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *P. lichtensteini* occurs in many areas affected by these broad changes, and likely has some susceptibility to global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to 100 years, but a precise quantification is not possible due to the limited species-specific information.

Other Biological Information

The SRR and SIR provided the following information on *P. lichtensteini's* life history. *Physogyra lichtensteini* is a gonochoric broadcast spawner. Larvae do not contain zooxanthellae. The public comments provided no additional biological information. We gathered supplemental information, including the following: Darling *et al.* (2012) found that *P. lichtensteini* has a ''stress-tolerant'' life history strategy, defined as slow growth and large colonies which can survive through stress and disturbances.

Susceptibility to Threats

The SRR and SIR provided the following species-specific information on *P. lichtensteini's* threats. *Physogyra lichtensteini* has been identified as vulnerable to extinction due to its high bleaching rate, low diversity of its genus, and narrow habitat range. The species bleached at 31°C in Palau in 1998. *Physogyra lichtensteini* contains Clade C zooxanthellae in the South China Sea. *Physogyra lichtensteini* is preyed upon on by butterflyfish in Indonesia. Since *P. lichtensteini* prefers turbid waters the risk of sediment impacts are low. The genus *Physogyra* is heavily traded, primarily exported from Indonesia. Between 1999 and 2010, the trade quota for Indonesia has been approximately 10,000 specimens annually. The SRR and SIR also provided genus-level and coral-level information for the effects on *Physogyra* of thermal stress, acidification, disease, predation, sedimentation, nutrients, and collection and trade. The SRR and SIR did not provide any other species-specific information on the effects of these threats on *P. lichtensteini.* We interpreted the threat susceptibility and exposure information from the SRR and SIR in the proposed rule for *P. lichtensteini'*s vulnerabilities as follows: High vulnerability to ocean warming; moderate vulnerability to disease, ocean acidification, trophic effects of fishing, and nutrients, low vulnerability to sedimentation, sea level rise, and collection and trade, and unknown vulnerability to predation.

Public comments did not provide any new or supplemental information on *P. lichtensteini'*s threat susceptibilities. We gathered supplemental information, which provided the following species-specific and genus-level information on this species' threat susceptibilities. *Physogyra lichtensteini* was not rated as moderately or highly susceptible to bleaching and coral disease by Carpenter *et al.* (2008), but they did not have species-specific data. In the western Indian Ocean in 1998–2005, the genus *Physogyra* (which only includes *P. lichtensteini*) had a bleaching index of 16.7 for eight countries, which was 19th highest of the 45 genera recorded, and 45 percent of the highest value. In this study, *P. lichtensteini* was identified as vulnerable to extinction due to its high bleaching rate, low diversity of its genus, and narrow habitat range, and the genus *Physogyra* was rated as having the fifth highest extinction risk of the 45 genera in the study (McClanahan *et al.,* 2007a). In Palau in 2000, *P. lichtensteini* experienced very high levels of bleaching and mortality. In that event, 48 percent of all coral colonies of all species were bleached, with bleaching of different genera and species ranging from none to very high, and mortality from none to near 100 percent (Bruno *et al.,* 2001). There are no other studies of the effects of threats on this genus or species. Based on the species-specific information above, *P. lichtensteini* is likely highly susceptible to ocean warming. Based on the threat susceptibility information for other reef-building coral genera in this final rule, *P. lichtensteini* likely has some susceptibility to disease, ocean acidification, trophic effects of fishing, sedimentation, nutrients, sea-level rise, predation, and collection and trade. The available information does not support more precise ratings of the susceptibilities of *P. lichtensteini* to the threats.

Regulatory Mechanisms

In the proposed rule, we did not provide any species-specific information on the regulatory mechanisms or conservation efforts for *P. lichtensteini.* Criticisms of our approach received during public comment led us to attempt the following analysis of regulatory mechanisms on a species basis. Records confirm *P. lichtensteini* occurs in 54 Indo-Pacific ecoregions that encompass 35 countries' EEZs. The 35 countries are Australia, Brunei, China, Egypt, Federated States of Micronesia, Fiji, France (French Pacific Island Territories), India (including Andaman and Nicobar Islands), Indonesia, Israel, Japan, Jordan, Kenya, Madagascar, Malaysia, Maldives, Marshall Islands, Mauritius, Myanmar, Palau, Papua New Guinea, Philippines, Saudi Arabia, Seychelles, Solomon Islands, Sri Lanka, Sudan, Taiwan, Tanzania, Thailand, Timor-Leste, United Kingdom (British Indian Ocean Territory), United States (PRIAs), Vanuatu, and Vietnam. The regulatory mechanisms relevant to *P. lichtensteini,* described first as the percentage of the above countries that utilize them to any degree and second, as the percentages of those countries whose regulatory mechanisms may be limited in scope, are as follows: General coral protection (29 percent with 9 percent limited in scope), coral collection (57 percent with 29 percent limited in scope), pollution control (43 percent with 9 percent limited in scope), fishing regulations on reefs (89 percent with 20 percent limited in scope), managing areas for protection and conservation (97 percent with 11 percent limited in scope). The most common regulatory mechanisms in place for *P. lichtensteini* are reef fishing regulations and area management for protection and conservation. Coral collection and pollution control laws are also somewhat utilized for the species, but 29 percent of coral collection laws are limited in scope and may not provide substantial protection. General coral protection laws are less common regulatory mechanisms for the management of *P. lichtensteini.*

Vulnerability to Extinction

As explained above in the Risk Analyses section, a species' vulnerability to extinction results from the combination of its spatial and demographic characteristics, threat susceptibilities, and consideration of the baseline environment and future projections of threats. The SRR stated factors that increase the potential extinction risk for *P. lichtensteini* are its high bleaching rate and that it's heavily collected. It listed factors that reduce potential extinction risk including that *P. lichtensteini* has a wide latitudinal distribution, is common, and tolerates difficult (turbid) environments.

Subsequent to the proposed rule, we received and gathered supplemental species- or genus-specific information, described above, that expands our knowledge regarding the species abundance, distribution, and threat susceptibilities. We developed our assessment of the species' vulnerability to extinction using all the available information. As explained in the Risk Analyses section, our assessment in this final rule emphasizes the ability of the species' spatial and demographic traits to moderate or exacerbate its vulnerability to extinction, as opposed to the approach we used in the proposed rule, which emphasized the species' susceptibility to threats.

The following characteristics of *P. lichtensteini,* in conjunction with the information described in the Corals and Coral Reefs section, Coral Habitat sub-section, and Threats Evaluation section above, affect its vulnerability to extinction currently and over the foreseeable future. Its geographic distribution includes most of the coral reef ecoregions in the Indian Ocean and western and central Pacific Ocean. Its geographic distribution moderates vulnerability to extinction because some areas within its range are projected to have less than average warming and acidification over the foreseeable future, including the western Indian Ocean, the central Pacific, and other areas, so portions of the population in these areas will be less exposed to severe conditions. Its depth range is one to 20 meters. This moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower irradiance, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Its habitat includes both turbid and clear upper reef slopes, mid-slopes, lower reef crests, reef flats, lagoons, and caves. This moderates vulnerability to extinction over the foreseeable future because the species is not limited to one habitat type but occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Its abundance of at least tens of millions of colonies, combined with spatial variability in ocean warming and acidification across the species range, moderates vulnerability to extinction because the increasingly severe conditions expected in the foreseeable future will be non-uniform and therefore will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Listing Determination

In the proposed rule using the determination tool formula approach, *P. lichtensteini* was proposed for listing as threatened because of: High vulnerability to ocean warming (ESA Factor E); moderate vulnerability to disease (C) and acidification (E); common generalized range wide abundance (E); wide overall distribution (based on wide geographic distribution and moderate depth distribution (E); and inadequacy of existing regulatory mechanisms (D).

In this final rule, we changed the listing determination for *P. lichtensteini* from threatened to not warranted. We made this determination based on a more species-specific and holistic assessment of whether this species meets the definition of either a threatened or endangered coral largely in response to public comments, including more appropriate consideration of the buffering capacity of this species' spatial and demographic traits to lessen its vulnerability to threats. Thus, based on the best available information above on *P. lichtensteini's* spatial structure, demography, threat susceptibilities, and management, none of the five ESA listing factors, alone or in combination, are causing this species to be likely to become endangered throughout its range within the foreseeable future, and thus it is not warranted for listing at this time, because:

(1) *Physogyra lichtensteini's* distribution across the Red Sea, Indian Ocean and most of the Pacific is spread over a very large area. While some areas within its range are projected to be affected by warming and acidification, other areas are projected to have less than average warming and acidification, including the western Indian Ocean, the central Pacific, and other areas. This distribution and the heterogeneous habitats it occupies reduce exposure to any given threat event or adverse condition that does not occur uniformly throughout the species range. As explained above in the Threats Evaluation section, we have not identified any threat that is expected to occur uniformly throughout the species range within the foreseeable future);

(2) *Physogyra lichtensteini's* total absolute abundance is at least tens of millions of colonies providing buffering capacity in the form of absolute numbers of colonies and variation in susceptibility between individual colonies. As discussed in the Corals and Coral Reefs section above, the more colonies a species has, the lower the proportion of colonies that are likely to be exposed to a particular threat at a particular time, and all individuals that are exposed will not have the same response; and

Notwithstanding the projections through 2100 that indicate increased severity over time of the three high importance threats, the combination of these biological and environmental characteristics indicates that the species possesses sufficient buffering capacity to avoid being in danger of extinction within the foreseeable future throughout its range. It is possible that this species' extinction risk may increase in the future if global threats continue and increase in severity and the species exposure to threats increases throughout its range. Should the species experience reduced abundance or range constriction of a certain magnitude, the ability of these characteristics to moderate exposure to threats will diminish. However, the species is not likely to become of such low abundance or so spatially fragmented as to be in danger of extinction due to depensatory processes, the potential effects of environmental stochasticity, or the potential for mortality from catastrophic events within the foreseeable future throughout its range. Therefore, *P. lichtensteini* is not warranted for listing at this time under any of the listing factors.

Summary of Determinations

In this final rule, we are responsible for determining whether each of the proposed coral species meet the definition of either threatened or endangered under the ESA based on the best available information including that which supported the proposed rule, and public comments received and information we gathered since the proposed rule was published. Section 4(b)(1)(A) of the ESA requires us to make listing determinations based solely on the best scientific and commercial data available after conducting reviews of the statuses of the species and after taking into account efforts being made by any state or foreign nation to protect the species. We conclude that conservation efforts are not protecting any of the coral species determined to be warranted for listing in this final rule in a way that would reduce extinction risk such that a threatened determination would no longer be warranted. Finally, section 4(b)(1)(B) of the ESA requires us to give consideration to species which (1) have been designated as requiring protection from unrestricted commerce by any foreign nation, or (2) have been identified as in danger of extinction, or likely to become so within the foreseeable future, by any state agency or by any agency of a foreign nation. All stony corals are listed under Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora, which regulates international trade of species to ensure survival. *Dendrogyra cylindrus,* which we are listing as threatened, is also listed as threatened by the State of Florida and all stony corals are protected under the U.S. Virgin Islands Indigenous and Endangered Species Act of 1990. All of the corals in this final rule, including those we are listing under the ESA, are listed in the IUCN Red List of Threatened Species as vulnerable, endangered, or critically endangered. The final rule takes into consideration this information in its listing determinations.

In the proposed rule we determined that 12 species warranted listing as endangered: five in the Caribbean (*Dendrogyra cylindrus, Orbicella annularis, Orbicella faveolata, Orbicella franksi,* and *Mycetophyllia ferox*); and seven in the Indo-Pacific (*Millepora foveolata, Pocillopora elegans* (eastern Pacific), *Acropora jacquelineae, Acropora lokani, Acropora rudis, Anacropora spinosa,* and *Euphyllia paradivisa*). We also determined that 54 species warranted listing as threatened: two in the Caribbean (*Agaricia lamarcki* and *Dichocoenia stokesii);* and 52 in the Indo-Pacific (*Millepora tuberosa, Pocillopora danae, Pocillopora elegans (Indo-Pacific), Seriatopora aculeata, Acropora aculeus, Acropora acuminata, Acropora aspera, Acropora dendrum, Acropora donei, Acropora globiceps, Acropora horrida, Acropora listeri, Acropora microclados, Acropora palmerae, Acropora paniculata, Acropora pharaonis, Acropora polystoma, Acropora retusa, Acropora speciosa, Acropora striata, Acropora tenella, Acropora vaughani, Acropora verweyi, Anacropora puertogalerae, Astreopora cucullata, Isopora crateriformis, Isopora cuneata, Montipora angulata, Montipora australiensis, Montipora calcarea, Montipora caliculata, Montipora dilatata/flabellata/turgescens, Montipora lobulata, Montipora patula/verrilli, Alveopora allingi, Alveopora fenestrata, Alveopora verrilliana, Porites horizontalata, Porites napopora, Porites* *nigrescens, Acanthastrea brevis, Acanthastrea hemprichii, Acanthastrea ishigakiensis, Acanthastrea regularis, Pachyseris rugosa, Pectinia alcicornis, Barabattoia laddi, Pavona diffluens, Caulastrea echinulata, Euphyllia cristata, Euphyllia paraancora,* and *Physogyra lichtensteini).* Finally, we determined that two species in the Caribbean currently listed as threatened (*Acropora palmata* and *Acropora cervicornis*) warranted reclassification as endangered.

In this final rule we have determined that no species warrants listing as endangered. We have determined the following 20 species warrant listing as threatened: five in the Caribbean (*Dendrogyra cylindrus, Orbicella annularis, Orbicella faveolata, Orbicella franksi,* and *Mycetophyllia ferox*); and 15 in the Indo-Pacific (*Acropora globiceps, Acropora jacquelineae, Acropora lokani, Acropora pharaonis, Acropora retusa, Acropora rudis, Acropora speciosa, Acropora tenella, Anacropora spinosa, Euphyllia paradivisa, Isopora crateriformis, Montipora australiensis, Pavona diffluens, Porites napopora,* and *Seriatopora aculeata*). For the two species in the Caribbean currently listed as threatened *(Acropora cervicornis* and *Acropora palmata*), through this final rule we have conducted an updated status review and threats assessment, and determined they still warrant listing as threatened. We also determined that 43 proposed species do not warrant listing as endangered or threatened: two in the Caribbean (*Agaricia lamarcki, Dichocoenia stokesii*); and 41 in the Indo-Pacific (*Acanthastrea brevis, Acanthastrea hemprichii, Acanthastrea ishigakiensis, Acanthastrea regularis, Acropora aculeus, Acropora acuminata, Acropora aspera, Acropora dendrum, Acropora donei, Acropora horrida, Acropora listeri, Acropora microclados, Acropora palmerae, Acropora paniculata, Acropora polystoma, Acropora striata, Acropora vaughani, Acropora verweyi, Alveopora allingi, Alveopora fenestrata, Alveopora verrilliana, Anacropora puertogalerae, Astreopora cucullata, Barabattoia laddi, Caulastrea echinulata, Euphyllia cristata, Euphyllia paraancora, Isopora cuneata, Millepora foveolata, Millepora tuberosa, Montipora angulata, Montipora calcarea, Montipora caliculata, Montipora dilatata/flabellata/turgescens, Montipora lobulata, Montipora patula/verrilli, Pachyseris rugosa, Pectinia alcicornis, Physogyra lichtensteini, Porites horizontalata,* and *Porites nigrescens*). Three coral species were not determinable due to taxonomic uncertainty (*Pocillopora danae, Pocillopora elegans* (eastern Pacific), *Pocillopora elegans* (Indo-Pacific)).

As described previously in the Risk Analyses section, in this final rule we took a more holistic approach in response to public comments and reconsidered these coral species' demographic and distribution traits that buffer or moderate exposure to threats, and the resulting capacity to respond to changing conditions into the foreseeable future. This approach led to changes in listing status from the proposed rule for 58 of the 68 species while determinations for 10 species remained the same. While in some cases, a warranted species possesses one particularly compelling characteristic that increases its vulnerability to extinction (*e.g.,* a small effective population size, a depth restriction to shallow waters, or a highly constrained geographic range), no one factor in isolation led to a species being warranted for listing and the final determinations are all based on the suite of demographic, spatial, and susceptibility components that influence the species' vulnerability to extinction in the face of continuing threats over the foreseeable future.

Similarly, many of the not warranted species either lack one compelling characteristic that increases vulnerability to extinction or possess one or more compelling characteristics that reduce vulnerability to extinction (*e.g.,* a vast geographic distribution, low susceptibility to high importance threats, a depth range extending into deeper waters, or a large absolute abundance estimate), but no one factor in isolation led to a species being not warranted for listing and the final determinations are all based on the suite of demographic, spatial, and susceptibility components that influence the species' vulnerability to extinction, in the face of continuing threats over the foreseeable future.

Effects of Listing

Conservation measures provided for species listed as endangered or threatened under the ESA may include recovery plans (16 U.S.C. 1553(f)), critical habitat designations, Federal agency consultation requirements (16 U.S.C. 1536), and prohibitions on taking (16 U.S.C. 1538). Recognition of the species' plight through listing promotes conservation actions by Federal and state agencies, private groups, and individuals, as well as the international community. For listed species, a recovery program could be implemented, and critical habitat will be designated to the maximum extent prudent and determinable, for species that occur in U.S. jurisdiction. Protective regulations for threatened corals may be developed for the conservation of the species. Federal, state and private sector cooperation and participation will be necessary to effectively and efficiently conserve the listed coral species and the ecosystems upon which they depend.

Identifying Section 7 Consultation Requirements

Section 7(a)(2) of the ESA and NMFS/FWS regulations require Federal agencies to consult with us on any actions they authorize, fund, or carry out if those actions may affect the listed species or designated critical habitat. Based on currently available information, examples of Federal actions that may affect the 22 coral species listed as threatened include, but are not limited to: Energy projects, discharge of pollution from point sources, non-point source pollution, dredging, pile-driving, setting of water quality standards, vessel traffic, aquaculture facilities, military activities, and fisheries management practices.

Critical Habitat

Critical habitat is defined in section 3 of the ESA as: ''(i) the specific areas within the geographical area occupied by the species, at the time it is listed in accordance with the provisions of section 1533 of this title, on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and (ii) specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the provisions of 1533 of this title, upon a determination by the Secretary that such areas are essential for the conservation of the species'' (16 U.S.C. 1532(5)(A)). ''Conservation'' means the use of all methods and procedures needed to bring the species to the point at which listing under the ESA is no longer necessary (16 U.S.C. 1532(3)). Section 4(a)(3)(A) of the ESA requires that, to the maximum extent prudent and determinable, critical habitat be designated concurrently with the final listing of a species (16 U.S.C. 1533(a)(3)(A)(i)). Further, ESA implementing regulations at 50 CFR 424.12(h) specify that critical habitat shall not be designated within foreign countries or in other areas outside of U.S. jurisdiction.

The existing designated critical habitat for *Acropora palmata* and *A.*

cervicornis in the Caribbean (50 CFR 226.216) remains effective with this final rule. The designation of critical habitat is not determinable for any of the newly listed corals at this time due to the extremely complex biological and physical requirements of the species. Although we have gathered information through the status review and public comment processes on the habitats occupied by these species, we currently do not have enough information to determine which of features within those habitats are essential to the conservation of any of the listed corals and may require special management considerations or protection. We will continue to gather and review other ongoing studies on the habitat use and requirements of the newly listed corals to attempt to identify these features. Additionally, we need more time to gather the information needed to perform the required analyses of the impacts of the designation. Designations of critical habitat must be based on the best scientific data available and must take into consideration the economic, national security, and other relevant impacts of specifying any particular area as critical habitat. To the maximum extent prudent and determinable, we will publish proposed designations of critical habitat for the newly listed corals in a separate rule or rules. Once critical habitat is designated (only in U.S. jurisdictions), section 7 of the ESA requires Federal agencies to ensure that they do not fund, authorize, or carry out any actions that are likely to destroy or adversely modify that habitat. This requirement is in addition to the section 7 requirement that Federal agencies ensure that their actions are not likely to jeopardize the continued existence of listed species.

ESA Section 9 Take Prohibitions

ESA section 9(a) take prohibitions (16 U.S.C. 1538(a)(1)(B)) apply to all species listed as endangered. These section 9(a) prohibitions include prohibitions against importing, exporting, engaging in foreign or interstate commerce, or ‘‘taking’’ of the species. ‘‘Take’’ is defined under the ESA as ‘‘to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct.’’ These prohibitions apply to all persons subject to the jurisdiction of the United States, including in the United States, its territorial sea, or on the high seas. In the case of threatened species, section 9 prohibitions do not automatically apply. Section 4(d) of the ESA directs the Secretary to issue regulations she considers necessary and advisable for the conservation of the species, which may include applying some or all of the section 9 prohibitions to these species. Therefore, pursuant to ESA section 4(d), subsequent to this rulemaking we will evaluate whether there are protective regulations necessary and advisable for the conservation of any of the 20 species newly-listed as threatened in this final rule, including application of some or all of the take prohibitions. The existing 4(d) rule for *Acropora palmata* and *A. cervicornis* (50 CFR 223.208) will remain in effect for these threatened species.

Policies on Role of Peer Review

In December 2004, the Office of Management and Budget (OMB) issued a Final Information Quality Bulletin for Peer Review establishing minimum peer review standards, a transparent process for public disclosure of peer review planning, and opportunities for public participation. The OMB Bulletin, implemented under the Information Quality Act (Public Law 106–554) is intended to enhance the quality and credibility of the Federal government’s scientific information, and applies to influential or highly influential scientific information disseminated on or after June 16, 2005. To satisfy our requirements under the OMB Bulletin, the BRT obtained independent peer review of the draft Status Review Report, and NMFS obtained independent peer review of the draft Management Report. Independent specialists were selected from the academic and scientific community, Federal and state agencies, and/or the private sector for this review. All peer reviewer comments were addressed prior to dissemination of the final SRR and Management Report.

We determined that the peer review conducted pursuant to the OMB Bulletin also satisfied the requirements of the Services’ 1994 policy for peer review of scientific data included in listing decisions (59 FR 34270).

Solicitation of Information

We are soliciting information on features and areas that may support designations of critical habitat for the 20 newly listed coral species. Information provided should identify the physical and biological features essential to the conservation of the species and areas that contain these features for the coral species proposed to be listed. Areas outside the occupied geographical area should also be identified if such areas themselves are essential to the conservation of the species. Essential features may include, but are not limited to, features specific to individual species’ ranges, habitats and life history characteristics within the following general categories of habitat features: (1) Space for individual growth and for normal behavior; (2) food, water, air, light, minerals, or other nutritional or physiological requirements; (3) cover or shelter; (4) sites for reproduction and development of offspring; and (5) habitats that are protected from disturbance or are representative of the historical, geographical, and ecological distributions of the species (50 CFR 424.12(b)). ESA implementing regulations at 50 CFR 424.12(h) specify that critical habitat shall not be designated within foreign countries or in other areas outside of U.S. jurisdiction. Therefore, we request information only on potential areas of critical habitat within waters in U.S. jurisdiction.

For features and areas potentially qualifying as critical habitat, we also request information describing: (1) Activities or other threats to the essential features or activities that could be affected by designating them as critical habitat, and (2) the positive and negative economic, national security and other relevant impacts, including benefits to the recovery of the species, likely to result if these areas are designated as critical habitat.

Classification

National Environmental Policy Act

The 1982 amendments to the ESA, in section 4(b)(1)(A), restrict the information that may be considered when assessing species for listing. Based on this limitation of criteria for a listing decision and NOAA Administrative Order 216–6 (Environmental Review Procedures for Implementing the National Environmental Policy Act), we have concluded that ESA listing actions are not subject to requirements of the National Environmental Policy Act.

Executive Order 12866, Regulatory Flexibility Act, and Paperwork Reduction Act

As noted in the Conference Report on the 1982 amendments to the ESA, economic impacts cannot be considered when assessing the status of a species. Therefore, the economic analysis requirements of the Regulatory Flexibility Act are not applicable to listing actions.

In addition, this final rule is exempt from review under E.O. 12866.

This final determination does not contain a collection of information requirement for the purposes of the Paperwork Reduction Act.

Executive Order 13132, Federalism

In accordance with E.O. 13132, agencies are required to take into account any federalism impacts of regulations under development. This Executive Order includes specific consultation directives for situations where a regulation will preempt state law, or impose substantial direct compliance costs on state and local governments (unless required by statute). Neither of those circumstances is applicable to this final listing determination. In keeping with the intent of the Administration and Congress to provide continuing and meaningful dialogue on issues of mutual state and Federal interest, the proposed rule was provided to the relevant agencies in each state in which the subject species occurs, and these agencies were invited to comment. Their comments were addressed with other comments in the Summary of Comments Received section.

Executive Order 12898, Environmental Justice

Executive Order 12898 requires that Federal actions address environmental justice in the decision-making process. In particular, the environmental effects of the actions should not have a disproportionate effect on minority and low-income communities. This final rule is not expected to have a disproportionately high effect on minority populations or low-income populations.

List of Subjects in 50 CFR Part 223

Endangered and threatened species; Exports; Imports; Transportation.

Dated: August 26, 2014.

Eileen Sobeck,

Assistant Administrator for Fisheries, National Marine Fisheries Service.

For the reasons set out in the preamble, 50 CFR part 223 is amended as follows:

PART 223—THREATENED MARINE AND ANADROMOUS SPECIES

■ 1. The authority citation for part 223 continues to read as follows:

Authority: 16 U.S.C. 1531–1543; subpart B, § 223.201–202 also issued under 16 U.S.C. 1361 *et seq.;* 16 U.S.C. 5503(d) for § 223.206(d)(9).

■ 2. In § 223.102, in the table, amend paragraph (e) by removing the two existing entries under the ''Corals'' subheading and adding the following 22 entries to read as follows:

§ 223.102 Enumeration of threatened marine and anadromous species.

* * * * *

(e) * * *

Species[1]			Citation(s) for listing determination(s)	Critical habitat	ESA rules
Common name	Scientific name	Description of listed entity			
*	*	*	*	*	*
		Corals			
Coral, [no common name]	*Acropora globiceps*	Entire species	[Insert FR citation] 9/10/2014	NA	NA
Coral, [no common name]	*Acropora jacquelineae*	Entire species	[Insert FR citation] 9/10/2014	NA	NA
Coral, [no common name]	*Acropora lokani*	Entire species	[Insert FR citation] 9/10/2014	NA	NA
Coral, [no common name]	*Acropora pharaonis*	Entire species	[Insert FR citation] 9/10/2014	NA	NA
Coral, [no common name]	*Acropora retusa*	Entire species	[Insert FR citation] 9/10/2014	NA	NA
Coral, [no common name]	*Acropora rudis*	Entire species	[Insert FR citation] 9/10/2014	NA	NA
Coral, [no common name]	*Acropora speciosa*	Entire species.	[Insert FR citation] 9/10/2014	NA	NA
Coral, [no common name]	*Acropora tenella*	Entire species.	[Insert FR citation] 9/10/2014	NA	NA
Coral, [no common name]	*Anacropora spinosa*	Entire species	[Insert FR citation] 9/10/2014	NA	NA
Coral, [no common name]	*Euphyllia paradivisa*	Entire species	[Insert FR citation] 9/10/2014	NA	NA
Coral, [no common name]	*Isopora crateriformis*	Entire species.	[Insert FR citation] 9/10/2014	NA	NA
Coral, [no common name]	*Montipora australiensis*	Entire species.	[Insert FR citation] 9/10/2014	NA	NA
Coral, [no common name]	*Pavona diffluens*	Entire species	[Insert FR citation] 9/10/2014	NA	NA
Coral, [no common name]	*Porites napopora*	Entire species	[Insert FR citation] 9/10/2014	NA	NA
Coral, [no common name]	*Seriatopora aculeata*	Entire species	[Insert FR citation] 9/10/2014	NA	NA
Coral, boulder star	*Orbicella franksi*	Entire species	[Insert FR citation] 9/10/2014	NA	NA
Coral, elkhorn	*Acropora palmata*	Entire species	[Insert FR citation] 9/10/2014	226.216	223.208
Coral, lobed star	*Orbicella annularis*	Entire species	[Insert FR citation] 9/10/2014	NA	NA

Species[1]			Citation(s) for listing determination(s)	Critical habitat	ESA rules
Common name	Scientific name	Description of listed entity			
Coral, mountainous star	*Orbicella faveolata*	Entire species	[Insert FR citation & date of publication in the **Federal Register**	NA	NA
Coral, pillar	*Dendrogyra cylindrus*	Entire species	[Insert FR citation] 9/10/2014	NA	NA
Coral, rough cactus	*Mycetophyllia ferox*	Entire species	[Insert FR citation] 9/10/2014	NA	NA
Coral, staghorn	*Acropora cervicornis*	Entire species	[Insert FR citation] 9/10/2014	226.216	223.208
*	*	*	*	*	*

* * * * *

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