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Endangered and Threatened Wildlife and Plants; Endangered Species Act Listing Determination for Alewife and Blueback Herring; Notice

DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

[Docket No. 111024651–3630–02]

RIN 0648–XA739

Endangered and Threatened Wildlife and Plants; Endangered Species Act Listing Determination for Alewife and Blueback Herring

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

ACTION: Notice of a listing determination.

SUMMARY: We, NMFS, have completed a comprehensive review of the status of river herring (alewife and blueback herring) in response to a petition submitted by the Natural Resources Defense Council (NRDC) requesting that we list alewife (*Alosa pseudoharengus*) and blueback herring (*Alosa aestivalis*) as threatened under the Endangered Species Act (ESA) throughout all or a significant portion of their range or as specific distinct population segments (DPS) identified in the petition. The Atlantic States Marine Fisheries Commission (ASMFC) completed a comprehensive stock assessment for river herring in May 2012 which covers over 50 river specific stocks throughout the range of the species in the United States. The ASMFC stock assessment contained much of the information necessary to make an ESA listing determination for both species; however, any deficiencies were addressed through focused workshops and working group meetings and review of additional sources of information. Based on the best scientific and commercial information available, we have determined that listing alewife as threatened or endangered under the ESA is not warranted at this time. Additionally, based on the best scientific and commercial information available, we have determined that listing blueback herring as threatened or endangered under the ESA is not warranted at this time.

DATES: This finding is effective on August 12, 2013.

ADDRESSES: The listing determination, list of references used in the listing determination, and other related materials regarding this determination can be obtained via the Internet at: *http://www.nero.noaa.gov/prot_res/CandidateSpeciesProgram/RiverHerringSOC.htm* or by submitting a request to the Assistant Regional Administrator, Protected Resources Division, Northeast Region, NMFS, 55 Great Republic Drive, Gloucester, MA 01930.

FOR FURTHER INFORMATION CONTACT: Kim Damon-Randall, NMFS Northeast Regional Office, (978) 282–8485; or Marta Nammack, NMFS, Office of Protected Resources (301) 427–8469.

SUPPLEMENTARY INFORMATION:

Background

On August 5, 2011, we, the National Marine Fisheries Service (NMFS), received a petition from the Natural Resources Defense Council (NRDC), requesting that we list alewife (*Alosa pseudoharengus*) and blueback herring (*Alosa aestivalis*) under the ESA as threatened throughout all or a significant portion of their ranges. In the alternative, they requested that we designate DPSs of alewife and blueback herring as specified in the petition (Central New England, Long Island Sound, Chesapeake Bay, and Carolina for alewives, and Central New England, Long Island Sound, and Chesapeake Bay for blueback herring). The petition contained information on the two species, including the taxonomy, historical and current distribution, physical and biological characteristics of their habitat and ecosystem relationships, population status and trends, and factors contributing to the species' decline. The petition also included information regarding potential DPSs of alewife and blueback herring as described above. The following five factors identified in section 4(a)(1) of the ESA were addressed in the petition: (1) Present or threatened destruction, modification, or curtailment of habitat or range; (2) over-utilization for commercial, recreational, scientific, or educational purposes; (3) disease or predation; (4) inadequacy of existing regulatory mechanisms; and (5) other natural or man-made factors affecting the species' continued existence.

We reviewed the petition and determined that, based on the information in the petition and in our files at the time we received the petition, the petitioned action may be warranted. Therefore, we published a positive 90-day finding on November 2, 2011, and as a result, we were required to review the status of the species (e.g., anadromous alewife and blueback herring) to determine if listing under the ESA is warranted. We formed an internal status review team (SRT) comprised of nine NMFS staff members (Northeast Regional Office (NERO) Protected Resources Division and Northeast Fisheries Science Center staff) to compile the best commercial and scientific data available for alewife and blueback herring throughout their ranges.

In May 2012, the ASMFC completed a river herring stock assessment, which covers over 50 river-specific stocks throughout the ranges of the species in the United States (ASMFC, 2012; hereafter referred to in this determination as "the stock assessment"). In order to avoid duplicating this extensive effort, we worked cooperatively with ASMFC to use this information in the review of the status of these two species and identify information not in the stock assessment that was needed for our listing determination. We identified the missing required elements and held workshops/working group meetings focused on addressing information on stock structure, extinction risk analysis, and climate change.

Reports from each workshop/working group meeting were compiled and independently peer reviewed (the stock structure and extinction risk reports were peer reviewed by reviewers selected by the Center for Independent Experts, and the climate change report was peer reviewed by 4 experts identified during the workshops). These reports did not contain any listing advice or reach any ESA listing conclusions—such synthesis and analysis for river herring is solely within the agency's purview. We used this information to determine which extinction risk method and stock structure analysis would best inform the listing determination, as well as understand how climate change may impact river herring, and ultimately, we are using these reports along with the stock assessment and all other best available information in this listing determination.

Alewife and blueback herring are collectively referred to as "river herring." Due to difficulties in distinguishing between the species, they are often harvested together in commercial and recreational fisheries, and managed together by the ASMFC. Throughout this finding, where there are similarities, they will be collectively referred to as river herring, and where there are distinctions, they will be identified by species.

Range

River herring can be found along the Atlantic coast of North America, from the Southern Gulf of St. Lawrence, Canada to the southeastern United States (Mullen *et al.,* 1986; Schultz *et al.,* 2009). The coastal ranges of the two species overlap. Blueback herring range from Nova Scotia south to the St. John's River, Florida; and alewife range from Labrador and Newfoundland south to South Carolina, though their occurrence in the extreme southern range is less common (Collette and Klein-MacPhee, 2002; ASMFC, 2009a; Kocik *et al.,* 2009).

In Canada, river herring (i.e., gaspereau) are most abundant in the Miramichi, Margaree, LaHave, Tusket, Shubenacadie and Saint John Rivers (Gaspereau Management Plan, 2001). They are proportionally less abundant in smaller coastal rivers and streams (Gaspereau Management Plan, 2001). Generally, blueback herring in Canada occur in fewer rivers than alewives and are less abundant in rivers where both species coexist (DFO 2001).

Habitat and Migration

River herring are anadromous, meaning that they mature in the marine environment and then migrate up coastal rivers to estuarine and freshwater rivers, ponds, and lake habitats to spawn (Collette and Klein-MacPhee, 2002; ASMFC, 2009a; Kocik *et al.,* 2009). In general, adult river herring are most often found at depths less than 328 feet (ft) (100 meters (m)) in waters along the continental shelf (Neves, 1981; ASMFC, 2009a; Schultz *et al.,* 2009). They are highly migratory, pelagic, schooling species, with seasonal spawning migrations that are cued by water temperature (Collette and Klein-MacPhee, 2002; Schultz *et al.,* 2009). Depending upon temperature, blueback herring typically spawn from late March through mid-May. However, they spawn in the southern parts of their range as early as December or January, and as late as August in the northern portion of their range (ASMFC, 2009a). Alewives have been documented spawning as early as February in the southern portion of their range, and as late as August in the northern portion of the range (ASMFC, 2009a). The river herring migration in Canada extends from late April through early July, with the peak occurring in late May and early June. Blueback herring generally make their spawning runs about 2 weeks later than alewives do (DFO, 2001). River herring conform to a metapopulation paradigm (e.g., a group of spatially separated populations of the same species which interact at some level) with adults frequently returning to their natal rivers for spawning but with some limited straying occurring between rivers (Jones, 2006; ASMFC, 2009a).

Throughout their life cycle, river herring use many different habitats, including the ocean, estuaries, rivers, and freshwater lakes and ponds. The substrate preferred for spawning varies greatly and can include gravel, detritus, and submerged aquatic vegetation. Blueback herring prefer swifter moving waters than alewives do (ASMFC, 2009a). Nursery areas include freshwater and semi-brackish waters. Little is known about their habitat preference in the marine environment (Meadows, 2008; ASMFC, 2009a).

Landlocked Populations

Landlocked populations of alewives and blueback herring also exist. Landlocked alewife populations occur in many freshwater lakes and ponds from Canada to North Carolina as well as the Great Lakes (Rothschild, 1966; Boaze & Lackey, 1974). Many landlocked populations occur as a result of stocking to provide a forage base for game fish species (Palkovacs *et al.,* 2007).

Landlocked blueback herring occur mostly in the southeastern United States and the Hudson River drainage. The occurrence of landlocked blueback herring is primarily believed to be the result of accidental stockings in reservoirs (Prince and Barwick, 1981), unsanctioned stocking by recreational anglers to provide forage for game fish, and also through the construction of locks, dams and canal systems that have subsequently allowed for blueback herring occupation of several lakes and ponds along the Hudson River drainage up to, and including Lake Ontario (Limburg *et al.,* 2001).

Recent efforts to assess the evolutionary origins of landlocked alewives indicate that they rapidly diverged from their anadromous cousins between 300 and 5,000 years ago, and now represent a discrete life history variant of the species, *Alosa pseudoharengus* (Palkovacs *et al.,* 2007). Though given their relatively recent divergence from anadromous populations, one plausible explanation for the existence of landlocked populations may be the construction of dams by either native Americans or early colonial settlers that precluded the downstream migration of juvenile herring (Palkovacs *et al.,* 2007). Since their divergence, landlocked alewives have evolved to a point they now possess significantly different mouthparts than their anadromous cousins, including narrower gapes and smaller gill raker spacings to take advantage of year round availability of smaller prey in freshwater lakes and ponds (Palkovacs *et al.,* 2007). Furthermore, the landlocked alewife, compared to its anadromous cousin, matures earlier, has a smaller adult body size, and reduced fecundity (Palkovacs *et al.,* 2007). At this time, there is no substantive information that would suggest that landlocked populations can or would revert back to an anadromous life history if they had the opportunity to do so (Gephard, CT DEEP, Pers. comm. 2012; Jordaan, UMASS Amherst, Pers. comm. 2012).

The discrete life history and morphological differences between the two life history variants (anadromous and landlocked) provide substantial evidence that upon becoming landlocked, landlocked populations become largely independent and separate from anadromous populations and occupy largely separate ecological niches (Palkovacs and Post, 2008). There is the possibility that landlocked alewife and blueback herring may have the opportunity to mix with anadromous river herring during high discharge years and through dam removals which could provide passage over dams and access to historic spawning habitats restored for anadromous populations, where it did not previously exist. The implications of this are not known at this time.

In summary, genetics indicate that anadromous alewife populations are discrete from landlocked populations, and that this divergence can be estimated to have taken place from 300 to 5,000 years ago. Some landlocked populations of blueback herring do occur in the Mid-Atlantic and southeastern United States. Given the similarity in life histories between anadromous alewife and blueback herring, we assume that landlocked populations of blueback herring would exhibit a similar divergence from anadromous blueback herring, as has been documented with alewives.

A Memorandum of Understanding (MOU) between the U.S. Fish and Wildlife Service (USFWS) and NMFS (collectively, the Services) regarding jurisdictional responsibilities and listing procedures under the ESA was signed August 28, 1974. This MOU states that NMFS shall have jurisdiction over species ''which either (1) reside the major portion of their lifetimes in marine waters; or (2) are species which spend part of their lifetimes in estuarine waters, if the major portion of the remaining time (the time which is not spent in estuarine waters) is spent in marine waters.''

Given that landlocked populations of river herring remain in freshwater throughout their life history and are genetically divergent from the anadromous species, pursuant to the aforementioned MOU, we did not include the landlocked populations of alewife and blueback herring in our review of the status of the species and do not consider landlocked populations in this listing determination in response to the petition to list these anadromous species.

Listing Species Under the Endangered Species Act

We are responsible for determining whether alewife and blueback herring are threatened or endangered under the ESA (16 U.S.C. 1531 *et seq.*). Accordingly, based on the statutory, regulatory, and policy provisions described below, the steps we followed in making our listing determination for alewife and blueback herring were to: (1) Determine how alewife and blueback herring meet the definition of ''species''; (2) determine the status of the species and the factors affecting them; and (3) identify and assess efforts being made to protect the species and determine if these efforts are adequate to mitigate existing threats.

To be considered for listing under the ESA, a group of organisms must constitute a ''species.'' Section 3 of the ESA defines a ''species'' as ''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.'' 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.'' Thus, we interpret an ''endangered species'' to be one that is presently in danger of extinction. A ''threatened species,'' on the other hand, is not presently in danger of extinction, but is likely to become so in the foreseeable future (that is, at a later time). 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).

On February 7, 1996, the Services adopted a policy to clarify our interpretation of the phrase ''distinct population segment of any species of vertebrate fish or wildlife'' (61 FR 4722). The joint DPS policy describes two criteria that must be considered when identifying DPSs: (1) The discreteness of the population segment in relation to the remainder of the species (or subspecies) to which it belongs; and (2) the significance of the population segment to the remainder of the species (or subspecies) to which it belongs. As further stated in the joint policy, if a population segment is discrete and significant (i.e., it meets the DPS policy criteria), its evaluation for endangered or threatened status will be based on the ESA's definitions of those terms and a review of the five factors enumerated in section 4(a)(1) of the ESA.

As provided in section 4(a) of the ESA, the statute requires us to determine whether any species is endangered or threatened because of any of the following five factors: (1) The present or threatened destruction, modification, or curtailment of its habitat or range; (2) overutilization for commercial, recreational, scientific, or educational purposes; (3) disease or predation; (4) the inadequacy of existing regulatory mechanisms; or (5) other natural or manmade factors affecting its continued existence (section 4(a)(1)(A)(E)). Section 4(b)(1)(A) of the ESA further requires that listing determinations be based solely on the best scientific and commercial data available after taking into account efforts being made to protect the species.

Distribution and Abundance

United States

The stock assessment (described above) was prepared and compiled by the River Herring Stock Assessment Subcommittee, hereafter referred to as the 'subcommittee,' of the ASMFC Shad and River Herring Technical Committee. Data and reports used for this assessment were obtained from Federal and state resource agencies, power generating companies, and universities.

The subcommittee conducted its assessment on the coastal stocks of alewife and blueback herring by individual rivers as well as coast-wide depending on available data. The subcommittee concluded that river herring should ideally be assessed and managed by individual river system, but that the marine portion of their life history likely influences survival through mixing in the marine portion of their range. However, coast-wide assessments are complicated by the complex life history of these species as well, given that factors influencing population dynamics for the freshwater portion of their life history can not readily be separated from marine factors. In addition, it was noted that data quality and availability varies by river and is mostly dependent upon the monitoring efforts that each state dedicates to these species, which further complicated the assessment.

The subcommittee also noted that most state landings records listed alewife and blueback herring together as 'river herring' rather than identifying by species. These landings averaged 30.5 million pounds (lbs) (13,847 metric tons (mt)) per year from 1889 to 1938, and severe declines were noted coast-wide starting in the 1970s. Beginning in 2005, states began enacting moratoria on river herring fisheries, and as of January 2012, all directed harvest of river herring in state waters is prohibited unless states have submitted and obtained approved sustainable fisheries management plans (FMP) under ASMFC's Amendment 2 to the Shad and River Herring FMP.

The subcommittee summarized its findings for trends in commercial catch-per-unit-effort (CPUE); run counts; young-of-the-year (YOY) seine surveys; juvenile-adult fisheries independent seine, gillnet and electrofishing surveys; juvenile-adult trawl surveys; mean length; maximum age; mean length-at-age; repeat spawner frequency; total mortality (Z) estimates; and exploitation rates. Because the stock assessment contains the most recent and comprehensive description of this information and the subcommittee's conclusions, the following sections were taken from the stock assessment (ASMFC, 2012).

Commercial CPUE

Since the mid-1990s, CPUE indices for alewives showed declining trends in the Potomac River and James River (VA), no trend in the Rappahannock River (VA), and increasing trends in the York River (VA) and Chowan River (NC). CPUE indices available for blueback herring showed a declining trend in the Chowan River and no trend in the Santee River (SC). Combined species CPUE indices showed declining trends in Delaware Bay and the Nanticoke River, but CPUE has recently increased in the Hudson River (ASMFC, 2012).

Run Counts

Major declines in run sizes occurred in many rivers from 2001 to 2005. These declines were followed by increasing trends (2006 to 2010) in the Androscoggin River (ME), Damariscotta River (ME), Nemasket River (MA), Gilbert-Stuart River (RI), and Nonquit River (RI) for alewife and in the Sebasticook River (ME), Cocheco River (NH), Lamprey River (NH), and Winnicut River (NH) for both species combined. No trends in run sizes were evident following the recent major declines in the Union River (ME), Mattapoisett River (MA), and

Monument River (MA) for alewife and in the Exeter River (NH) for both species combined. Run sizes have declined or are still declining following recent and historical major declines in the Oyster River (NH) and Taylor River (NH) for both species, in the Parker River (MA) for alewife, and in the Monument River (MA) and Connecticut River for blueback herring (ASMFC, 2012).

Young-of-the-Year Seine Surveys

The young-of-the-year (YOY) seine surveys were quite variable and showed differing patterns of trends among rivers. Maine rivers showed similar trends in alewife and blueback herring YOY indices after 1991, with peaks occurring in 1995 and 2004. YOY indices from North Carolina and Connecticut showed declines from the 1980s to the present. New York's Hudson River showed peaks in YOY indices in 1999, 2001, 2005, and 2007. New Jersey and Maryland YOY indices showed peaks in 1994, 1996, and 2001. Virginia YOY surveys showed peaks in 1993, 1996, 2001, and 2003 (ASMFC, 2012).

Juvenile-Adult Fisheries-Independent Seine, Gillnet and Electrofishing Surveys

The juvenile-adult indices from fisheries-independent seine, gillnet and electrofishing surveys showed a variety of trends in the available datasets for the Rappahanock River (1991–2010), James River (2000–2010), St. John's River, FL (2001–2010), and Narragansett Bay (1988–2010). The gillnet indices from the Rappahannock River (alewife and blueback herring) showed a low and stable or decreasing trend after a major decline after 1995 and has remained low since 2000 (except for a rise in alewife CPUE during 2008). The gillnet and electrofishing indices in the James River (alewife and blueback herring) showed a stable or increasing trend. Blueback herring peak catch rates occurred in 2004, and alewife peak catch rates occurred in 2005. The blueback herring index from electrofishing in the St. John's River, FL, showed no trend after a major decline from 2001–2002. The seine indices in Narragansett Bay, RI (combined species) and coastal ponds (combined species) showed no trends over the time series. The CPUE for Narragansett Bay fluctuated without trend from 1988–1997, increased through 2000, declined and then remained stable from 2001–2004. The pond survey CPUE increased during 1993–1996, declined through 1998, increased in 1999, declined through 2002, peaked in 2003 and then declined and fluctuated without trend thereafter. The electrofishing indices showed opposing trends and then declining trends in the Rappahannock River (alewife and blueback herring) with catch rates of blueback herring peaking during 2001–2003, and catch rates of alewives lowest during the same time period (ASMFC, 2012).

Juvenile and Adult Trawl Surveys

Trends in trawl survey indices varied greatly with some surveys showing an increase in recent years, some showing a decrease, and some remaining stable. Trawl survey data were available from 1966–2010 (for a complete description of data see ASMFC (2012)). Trawl surveys in northern areas tended to show either an increasing or stable trend in alewife indices, whereas trawl surveys in southern areas tended to show stable or decreasing trends. Patterns in trends across surveys were less evident for blueback herring. The NMFS surveys showed a consistent increasing trend coast-wide and in the northern regions for alewife and the combined river herring species group (ASMFC, 2012).

Mean Length

Mean sizes for male and female alewife declined in 4 of 10 rivers, and mean sizes for female and male blueback herring declined in 5 of 8 rivers. Data were available from 1960–2010 (for a complete description of data see ASMFC (2012)). The common trait among most rivers in which significant declines in mean sizes were detected is that historical length data were available for years prior to 1990. Mean lengths started to decline in the mid to late 1980s; therefore, it is likely that declines in other rivers were not detected because of the shortness of their time series. Mean lengths for combined sexes in trawl surveys were quite variable through time for both alewives and blueback herring. Despite this variability, alewife mean length tended to be lowest in more recent surveys. This pattern was less apparent for blueback herring. Trend analysis of mean lengths indicated significant declines in mean lengths over time for alewives coast-wide and in the northern region in both seasons, and for blueback coast-wide and in the northern region in fall (ASMFC, 2012).

Maximum Age

Except for Maine and New Hampshire, maximum age of male and female alewife and blueback herring during 2005–2007 was 1 or 2 years lower than historical observations (ASMFC, 2012).

Mean Length-at-Age

Declines in mean length of at least one age were observed in most rivers examined. The lack of significance in some systems is likely due to the absence of data prior to 1990 when the decline in sizes began, similar to the pattern observed for mean length. Declines in mean lengths-at-age for most ages were observed in the north (NH) and the south (NC). There is little indication of a general pattern of size changes along the Atlantic coast (ASMFC, 2012).

Repeat Spawner Frequency

Examination of percentage of repeat spawners in available data revealed significant, declining trends in the Gilbert-Stuart River (RI—combined species), Nonquit River (RI—combined species), and the Nanticoke River (blueback herring). There were no trends in the remaining rivers for which data are available, although scant data suggest that current percentages of repeat spawners are lower than historical percentages in the Monument River (MA) and the Hudson River (NY) (ASMFC, 2012).

Total Mortality (Z) Estimates

With the exception of male blueback herring from the Nanticoke River, which showed a slight increase over time, there were no trends in the Z estimates produced using age data (ASMFC, 2012).

Exploitation Rates

Exploitation of river herring appears to be declining or remaining stable. In-river exploitation estimates have fluctuated, but are lower in recent years. A coast-wide index of relative exploitation showed a decline following a peak in the 1980s, and the index indicates that exploitation has remained fairly stable over the past decade. The majority of depletion-based stock reduction analysis (DB–SRA) model runs showed declining exploitation rates coast-wide. Exploitation rates estimated from the statistical catch-at-age model for blueback herring in the Chowan River also showed a slight declining trend from 1999 to 2007, at which time a moratorium was instituted. There appears to be a consensus among various assessment methodologies that exploitation has decreased in recent times. The decline in exploitation over the past decade is not surprising because river herring populations are at low levels and more restrictive regulations or moratoria have been enacted by states (ASMFC, 2012).

Summary of Stock Assessment Conclusions

Of the in-river stocks of alewife and blueback herring for which data were available and were considered in the stock assessment, 22 were depleted, 1 was increasing, and the status of 28 stocks could not be determined because the time-series of available data was too short. In most recent years, 2 in-river stocks were increasing, 4 were decreasing, and 9 were stable, with 38 rivers not having enough data to assess recent trends. The coast-wide meta-complex of river herring stocks in the United States is depleted to near historical lows. A depleted status indicates that there was evidence for declines in abundance due to a number of factors, but the relative importance of these factors in reducing river herring stocks could not be determined. Commercial landings of river herring peaked in the late 1960s, declined rapidly through the 1970s and 1980s and have remained at levels less than 3 percent of the peak over the past decade. Estimates of run sizes varied among rivers, but in general, declining trends in run size were evident in many rivers over the last decade. Fisheries-independent surveys did not show consistent trends and were quite variable both within and among surveys. Those surveys that showed declines tended to be from areas south of Long Island. A problem with the majority of fisheries-independent surveys was that the length of their time series did not overlap the period of peak commercial landings that occurred prior to 1970. There appears to be a consensus among various assessment methodologies that exploitation has decreased in recent times. The decline in exploitation over the past decade is not surprising because river herring populations are at low levels and more restrictive regulations or moratoria have been enacted by states (ASMFC, 2012).

Canada

The Department of Fisheries and Oceans (DFO) monitors and manages river herring runs in Canada. River herring runs in the Miramichi River in New Brunswick and the Maragree River in Cape Breton, Nova Scotia were monitored intensively from 1983 to 2000 (DFO, 2001). More recently (1997 to 2006) the Gaspereau River alewife run and harvest has been intensively monitored and managed partially in response to a 2002 fisheries management plan that had a goal of increasing spawning escapement to 400,000 adults (DFO, 2007). Elsewhere, river herring runs have been monitored less intensively, though harvest rates are monitored throughout Atlantic Canada through license sales, reporting requirements, and a logbook system that was enacted in 1992 (DFO, 2001).

At the time DFO conducted their last stock assessment in 2001, they identified river herring harvest levels as being low (relative to historical levels) and stable, to low and decreasing across most rivers where data were available (DFO, 2001). With respect to the commercial harvest of river herring, reported landings of river herring peaked in 1980 at slightly less than 25.5 million lbs (11,600 mt) and declined to less than 11 million lbs (5,000 mt) in 1996. Landings data reported through DFO indicate that river herring harvests have continued to decline through 2010.

Consideration as a Species Under the ESA

Distinct Population Segment Background

According to Section 3 of the ESA, the term ''species'' includes ''any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife that interbreeds when mature.'' Congress included the term ''distinct population segment'' in the 1978 amendments to the ESA. On February 7, 1996, the Services adopted a policy to clarify their interpretation of the phrase ''distinct population segment'' for the purpose of listing, delisting, and reclassifying species (61 FR 4721). The policy described two criteria a population segment must meet in order to be considered a DPS (61 FR 4721): (1) It must be discrete in relation to the remainder of the species to which it belongs; and (2) it must be significant to the species to which it belongs.

Determining if a population is discrete requires either one of the following conditions: (1) It is markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors. Quantitative measures of genetic or morphological discontinuity may provide evidence of this separation; or (2) it is delimited by international governmental boundaries within which differences in control of exploitation, management of habitat, conservation status, or regulatory mechanisms exist that are significant in light of section 4(a)(1)(D) of the ESA.

If a population is deemed discrete, then the population segment is evaluated in terms of significance. Factors to consider in determining whether a discrete population segment is significant to the species to which it belongs include, but are not limited to, the following: (1) Persistence of the discrete population segment in an ecological setting unusual or unique for the taxon; (2) evidence that loss of the discrete population segment would result in a significant gap in the range of the taxon; (3) evidence that the discrete population segment represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historic range; or (4) evidence that the discrete population segment differs markedly from other populations of the species in its genetic characteristics.

If a population segment is deemed discrete and significant, then it qualifies as a DPS.

Information Related to Discreteness

To obtain expert opinion about anadromous alewife and blueback herring stock structure, we convened a working group in Gloucester, MA, on June 20–21, 2012. This working group meeting brought together river herring experts from state and Federal fisheries management agencies and academic institutions. Participants presented information to inform the presence or absence of stock structure such as genetics, life history, and morphometrics. A public workshop was held to present the expert working group's findings on June 22, 2012, and during this workshop, additional information on stock structure was sought from the public. Subsequently, a summary report was developed (NMFS, 2012a), and a peer review of the document was completed by three independent reviewers. The summary report and peer review reports are available on the NMFS Web site (see the **ADDRESSES** section above).

Steve Gephard of the Connecticut Department of Energy and Environmental Protection (CT DEP) presented a preliminary U.S. coast-wide genetic analysis of alewife and blueback herring data (Palkovacs *et al.,* 2012, unpublished report). Palkovacs *et al.,* (2012, unpublished report) used 15 novel microsatellite markers on samples collected from Maine to Florida. For alewife, 778 samples were collected from spawning runs in 15 different rivers, and 1,201 blueback herring samples were collected from 20 rivers.

Bayesian analyses identified five genetically distinguishable stocks for alewife with similar results using both STRUCTURE and Bayesian Analysis of Population Structure (BAPS) software models. The alewife stock complexes identified were: (1) Northern New England; (2) Southern New England; (3)

Connecticut River; (4) Mid-Atlantic; and (5) North Carolina. For blueback herring, no optimum solution was reached using STRUCTURE, while BAPS suggested four genetically identifiable stock complexes. The stock complexes identified for blueback herring were: (1) Northern New England; (2) Southern New England; (3) Mid Atlantic; (4) and Southern. However, it should be noted that these Bayesian inferences of population structure provide a minimum number of genetically distinguishable groups. In the future, in order to better define potential stock complexes, further tests examining structure within designated stocks should be conducted using hierarchical clustering analysis and genetic tests.

The study also examined the effects of geography and found a strong effect of latitude on genetic divergence, suggesting a stepping stone model of population structure, and a strong pattern of isolation by distance, where gene flow is most likely among neighboring spawning populations. The preliminary results from the study found significant differentiation among spawning rivers for both alewife and blueback herring. Based on the results of their study, the authors' preliminary management recommendations suggest that river drainage is the appropriate level of management for both of the species. This inference was also supported by genetic tests which were conducted later. These tests suggest that there is substantial population structure at the drainage scale.

The authors noted a number of caveats for their study including: (1) Collection of specimens on their upstream spawning run may pool samples from what are truly distinct spawning populations within the major river drainages sampled, thereby, underestimating genetic structure within rivers (Hasselman, 2010); (2) a more detailed analysis of population structure within the major stocks identified (i.e., using hierarchical Bayesian clustering methods and genic test) would be useful for identifying any substructure within these major stocks; (3) neutral genetic markers used in this study represent the effects of gene flow and historical population isolation, but not the effects of adaptive processes, which are important to consider in the context of stock identification; (4) the analysis is preliminary, and there are a number of issues that need to be further investigated, including the effect of deviations in the Hardy-Weinberg Equilibrium model encountered in four alewife loci and the failure of STRUCTURE to perform well on the blueback herring dataset; and (5) hybridization may be occurring between alewife and blueback herring and may influence the results of the species-specific analyses.

Following the Stock Structure Workshop, additional analyses were run on the alewife dataset to examine the uniqueness of the (tentatively) designated Connecticut River alewife stock complex. Hybrids and misidentified samples were found and subsequently removed for this analysis, and the results were refined. By removing these samples from the Connecticut River alewife dataset, Palkovacs *et al.* (2012, unpublished report) found that, for alewife, the Connecticut and Hudson Rivers belong to the Southern New England stock. The analyses were further refined and Palkovacs *et al.* (2012, unpublished report) provided an updated map of the alewife genetic stock complexes, combining the tentative North Carolina stock with the Mid-Atlantic stock. This information and analysis is complete and is currently being prepared for publication. Thus, the refined genetic stock complexes for alewife in the coastal United States include Northern New England, Southern New England, and the Mid-Atlantic. For blueback herring, the identified genetic stocks include Northern New England, Southern New England, Mid-Atlantic and Southern (Palcovacs *et al.,* 2012, unpublished report).

Bentzen *et al.* (2012) implemented a two-part genetic analysis of river herring to evaluate the genetic diversity of alewives in Maine and Maritime Canada, and to assess the regional effects of stocking on alewives and blueback herring in Maine. The genetic analysis of alewives and blueback herring along mid-coast Maine revealed significant genetic differentiation among populations. Despite significant differentiation, the patterns of correlation did not closely correspond with geography or drainage affiliation. The genetic analysis of alewives from rivers in Maine and Atlantic Canada detected isolation by distance, suggesting that homing behavior indicative of alewives' metapopulation conformance does produce genetically distinguishable populations. Further testing also suggested that there may be interbreeding between alewives and blueback herring (e.g., hybrids), especially at sample sites with impassible dams.

The unusual genetic groupings of river herring in Maine are likely a result of Maine's complex stocking history, as alewife populations in Maine have been subject to considerable within and out of basin stocking for the purpose of enhancement, recolonization of extirpated populations, and stock introduction. Alewife stocking in Maine dates back at least to 1803 when alewives were reportedly moved from the Pemaquid and St. George Rivers to create a run of alewives in the Damariscotta River (Atkins and Goode, 1887). These efforts were largely responsive to considerable declines in alewife populations following the construction of dams, over exploitation and pollution. Although there has been considerable alewife stocking and relocation throughout Maine, there are very few records documenting these efforts. In contrast, considerably less stocking of alewives has occurred in Maritime Canada. These genetic analyses suggest that river herring from Canadian waters are genetically distinct from Maine river herring.

All of the expert opinions we received during the Stock Structure Workshop suggested evidence of regional stock structure exists for both alewife and blueback herring as shown by the recent genetics data (Palkovacs *et al.,* 2012, unpublished report; Bentzen *et al.,* unpublished data). However, the suggested boundaries of the regional stock complexes differed from expert to expert. Migration and mixing patterns of alewives and blueback herring in the ocean have not been determined, though regional stock mixing is suspected. Therefore, the experts suggested that the ocean phase of alewives and blueback herring should be considered a mixed stock until further tagging and genetic data become available. There is evidence to support regional differences in migration patterns, but not at a level of river-specific stocks.

In the mid-1980s, Rulifson *et al.* (1987) tagged and released approximately 19,000 river herring in the upper Bay of Fundy, Nova Scotia with an overall recapture rate of 0.39 percent. Alewife tag returns were from freshwater locations in Nova Scotia, and marine locations in Nova Scotia and Massachusetts. Blueback herring tag returns were from freshwater locations in Maryland and North Carolina and marine locations in Nova Scotia. Rulifson *et al.* (1987) suspected from recapture data that alewives and blueback herring tagged in the Bay of Fundy were of different origins, hypothesizing that alewives were likely regional fish from as far away as New England, while the blueback herring recaptures were likely not regional fish, but those of U.S. origin from the mid-Atlantic region. However, the low tag return numbers (n = 2) made it difficult to generalize about the natal rivers of blueback herring caught in the Bay of Fundy. The results of this tagging study show that river herring present in Canadian waters may originate from U.S. waters and vice versa.

Metapopulations of river herring are believed to exist, with adults frequently returning to their natal rivers for spawning and some straying occurring between rivers—straying rates have been estimated up to 20 percent (Jones, 2006; ASMFC, 2009a; Gahagan *et al.,* 2012). Given the available information on genetic differentiation coast-wide for alewife and blueback herring, it appears that stock complexes exist for both species.

River herring originating from Canadian rivers are delimited by international governmental boundaries. Differences in control of exploitation, management of habitat, conservation status, or regulatory mechanisms exist and, therefore, meet the discreteness criterion under the DPS policy; however, intermixing between both alewife and blueback herring from U.S. and Canadian coastal waters occurs, and the extent of this mixing is unknown.

Given the best available information, it is possible to determine that the various stocks of both alewife and blueback herring are discrete. The best available information suggests that the delineation of the stock complexes is as described above; however, future work will likely further refine these preliminary boundaries. Additionally, further information is needed on the oceanic migratory patterns of both species.

Information Related to Significance

If a population is deemed discrete, the population is evaluated in terms of significance. Significance can be determined using the four criteria noted above. Since the best available information indicates that the stock complexes identified for alewives and blueback herring are most likely discrete, the SRT reviewed the available information to determine if they are significant.

In evaluating the significance criterion, the SRT considered all of the above criteria. As indicated earlier, both alewives and blueback herring occupy a large range spanning almost the entire East Coast of the United States and into Canada. They appear to migrate freely throughout their oceanic range and return to freshwater habitats to spawn in streams, lakes and rivers. Therefore, they occupy many different ecological settings throughout their range.

As described earlier, the Palkovacs *et al.* (2012, unpublished report) study assessed the genetic composition of alewife and blueback herring stocks within U.S. rivers using 15 neutral loci and documented that there are at least three stock complexes of alewife in the United States and four stock complexes of blueback herring in the United States. Palkovac *et al.* (2012, unpublished report) showed a strong effect of latitude on genetic divergence, suggesting that although most populations are genetically differentiated, gene flow is greater among neighboring runs than among distant runs. The genetic data are consistent with the recent results of the ASMFC stock assessment (2012), which noted that even among rivers within the same state, there are differences in trends in abundance indices, size-at-age, age structure and other metrics, indicating there are localized factors affecting the population dynamics of both species.

Neutral genetic markers such as microsatellites have a longstanding history of utilization in stock designation for many anadromous fish species (Waples, 1998). However, these markers represent the effects of gene flow and historical population isolation and not the effects of adaptive processes. The effects of adaptive genetic and phenotypic diversity are also extremely important to consider in the context of stock designation, but are not captured by the use of neutral genetic markers. Therefore, the available genetic data are most appropriately used in support of the discreteness criterion, rather than to determine significance.

Determining whether a gap in the range of the taxon would be significant if a stock were extirpated is difficult to determine with anadromous fish such as river herring. River herring are suspected to migrate great distances between their natal rivers and overwintering areas, and therefore, estuarine and marine populations are comprised of mixed stocks. Consequently, the loss of a stock complex would mean the loss of riverine spawning subpopulations, while the marine and estuarine habitat would most likely still be occupied by migratory river herring from other stock complexes. As it has been shown that gene flow is greater among neighboring runs than among distant runs, we might expect that river herring would re-colonize neighboring systems over a relatively short time frame. Thus, the loss of one stock complex in itself may not be significant; the loss of contiguous stock complexes may be. The goal then for river herring stock complexes is to maintain connectivity between genetic groups to support proper metapopulation function (spatially separated populations of the same species that interact, recolonize vacant habitats, and occupy new habitats through dispersal mechanisms (Hanski and Gilpin, 1991)).

DPS Determination

Evidence for genetic differentiation exists for both alewife and blueback herring, allowing for preliminary identification of stock complexes; however, available data are lacking on the significance of each of these individual stock complexes. Therefore, we have determined that there is not enough evidence to suggest that the stock complexes identified through genetics should be treated under the DPS policy as separate DPSs. The stock complexes may be discrete, but under the DPS policy, they are not significant to the species as a whole. Furthermore, given the unknown level of intermixing between Canadian and U.S. river herring in coastal waters, the Canadian stock complex should also not be considered separately under the DPS policy.

Throughout the rest of this determination, the species will be referred to by species (alewife or blueback herring), as river herring where information overlaps, and by the identified stock complexes (Palkovacs *et al.,* 2012, unpublished report) for each species as necessary. While the individual stock complexes do not constitute separate DPSs, they are important components of the overall species and relevant to the evaluation of whether either species may be threatened or endangered in a significant portion of their overall range. Therefore, we have evaluated the threats to, and extinction risk of the overall species and each of the individual stock complexes as presented below. For this analysis, the identified stock complexes for alewife (Figure 1) in the coastal United States for the purposes of this finding will include Northern New England, Southern New England, the Mid-Atlantic, and Canada; and stock complexes for blueback herring (Figure 2) will include Northern New England, Southern New England, Mid-Atlantic, Southern Atlantic, and Canada. While the SRT concluded that there was not sufficient information at this time to determine with any certainty whether alewife or blueback herring stock complexes constitute separate DPSs, they recognized that future information on behavior, ecology and genetic population structure may reveal significant differences, showing fish to be uniquely adapted to each stock complex. We agree with this conclusion. Thus, we are not identifying DPSs for either species.

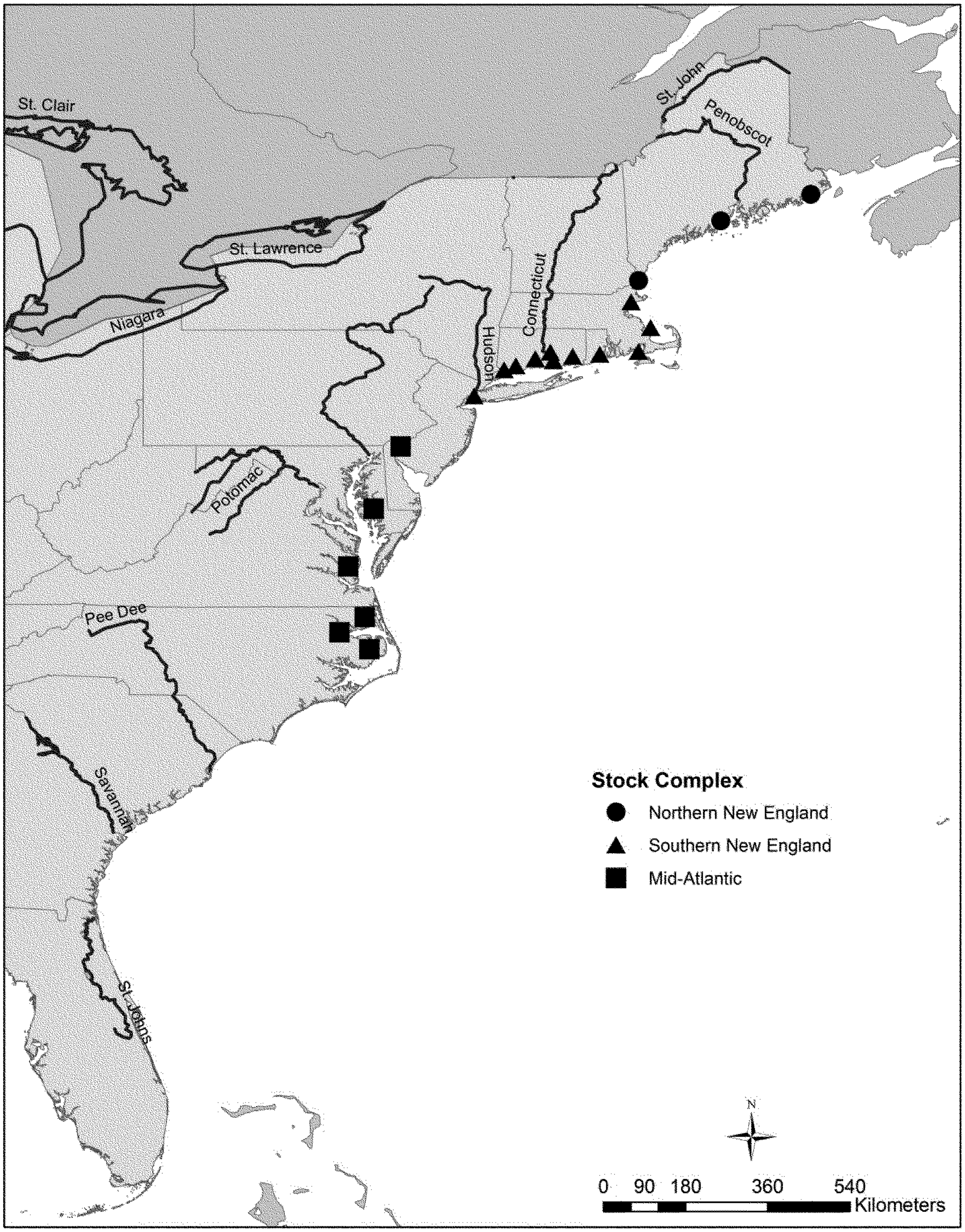

Figure 1. Alewife stock structure identified in Palkovacs et al., 2012, unpublished report.

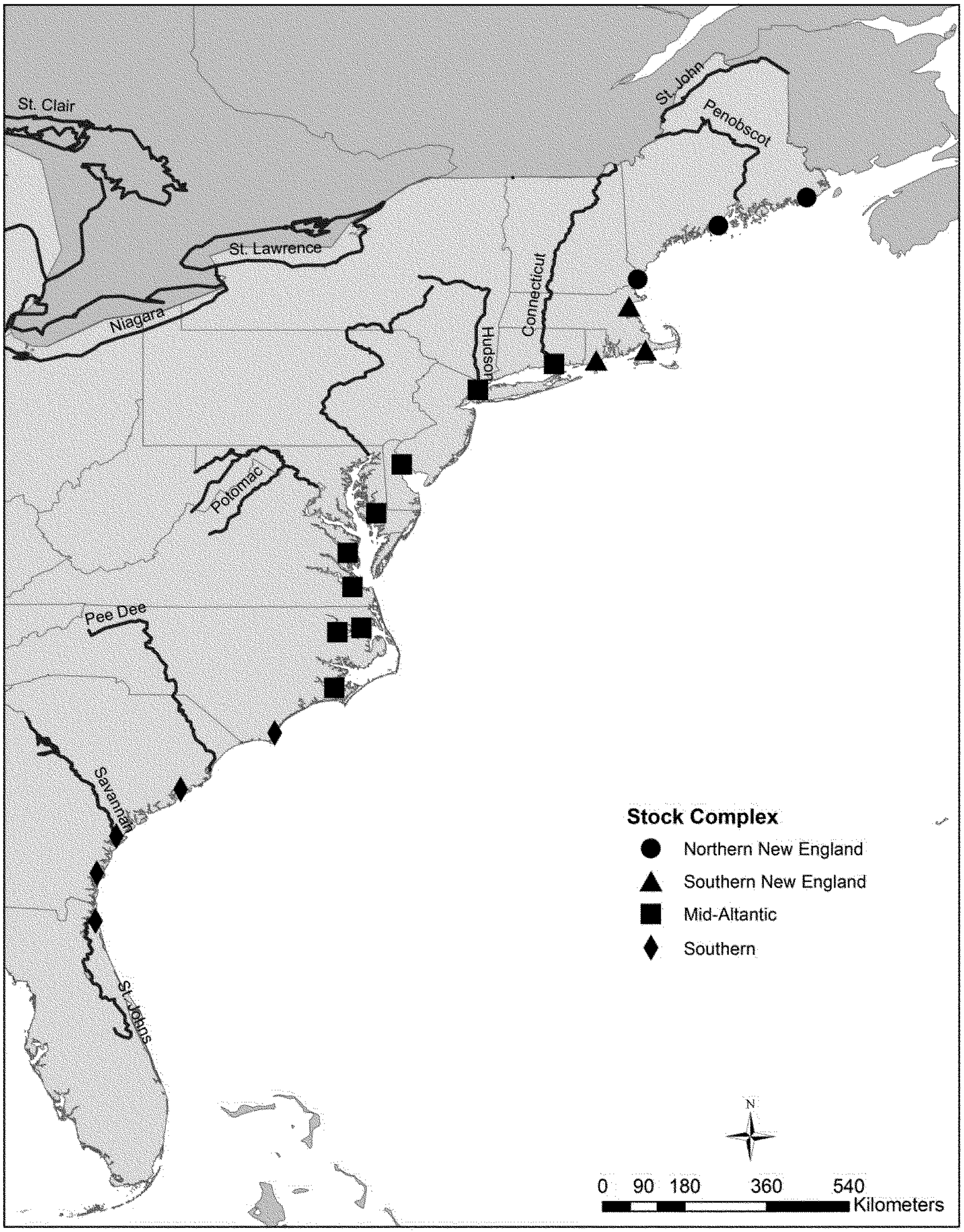

Figure 2. Blueback herring stock structure identified in Palkovacs et al., 2012, unpublished report.

Foreseeable Future and Significant Portion of Its Range

The ESA defines an ''endangered species'' as ''any species which is in danger of extinction throughout all or a significant portion of its range,'' while a ''threatened species'' is defined as ''any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.'' NMFS and the U.S. Fish and Wildlife Servce (USFWS) recently published a draft policy to clarify the interpretation of the phrase ''significant portion of the range'' in the ESA definitions of ''threatened'' and ''endangered'' (76 FR 76987; December 9, 2011). The draft policy provides that: (1) If a species is found to be endangered or threatened in only a significant portion of its range, the entire species is listed as endangered or threatened, respectively, and the ESA's protections apply across the species' entire range; (2) a portion of the range of a species is ''significant'' if its contribution to the viability of the species is so important that, without that portion, the species would be in danger of extinction; (3) the range of a species is considered to be the general geographical area within which that species can be found at the time USFWS or NMFS makes any particular status determination; and (4) if the species is not endangered or threatened throughout all of its range, but it is endangered or threatened within a significant portion of its range, and the population in that significant portion is a valid DPS, we will list the DPS rather than the entire taxonomic species or subspecies.

The Services are currently reviewing public comment received on the draft policy. While the Services' intent is to establish a legally binding interpretation of the term ''significant portion of the range,'' the draft policy does not have legal effect until such time as it may be adopted as final policy. Here, we apply the principles of this draft policy as non-binding guidance in evaluating whether to list alewife or blueback herring under the ESA. If the policy changes in a material way, we will revisit the determination and assess whether the final policy would result in a different outcome.

While we have determined that DPSs cannot be defined for either of these species based on the available information, the stock complexes do represent important groupings within the range of both species. Thus, in our analysis of extinction risk and threats assessment below, we have evaluated whether either species is at risk rangewide and within any of the individual stock complexes so that we can evaluate whether either species is threatened or endangered in a significant portion of its range.

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 river herring. The timeframe established for the foreseeable future takes into account the time necessary to provide for the conservation and recovery of each species 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 described below, the SRT determined that dams and other impediments to migration have already created a clear and present threat to river herring that will continue into the future. The SRT also evaluated the threat from climate change from 2060 to 2100 and climate variability in the near term (as described in detail below).

Highly productive species with short generation times are more resilient than less productive, long lived species, as they are quickly able to take advantage of available habitats for reproduction (Mace *et al.,* 2002). Species with shorter generation times, such as river herring (4 to 6 years), experience greater population variability than species with long generation times, because they maintain the capacity to replenish themselves more quickly following a period of low survival (Mace *et al.,* 2002). Given the high population variability among clupeids, projecting out further than three generations could lead to considerable uncertainty in the probability that the model will provide an accurate representation of the population trajectory for each species. Thus, a 12 to 18 year timeframe (e.g., 2024–2030), or a three-generation time period, for each species was determined by the Team to be appropriate for use as the foreseeable future for both alewife and blueback herring. We agree with the Team that a three-generation time period (12–18 years) is a reasonable foreseeable future for both alewife and blueback herring.

Connectivity, population resilience and diversity are important when determining what constitutes a significant portion of the species' range (Waples *et al.,* 2007). Maintaining connectivity between genetic groups supports proper metapopulation function, in this case, anadromy. Ensuring that river herring populations are well represented across diverse habitats helps to maintain and enhance genetic variability and population resilience (McElhany *et al.,* 2000). Additionally, ensuring wide geographic distribution across diverse climate and geographic regions helps to minimize risk from catastrophes (e.g., droughts, floods, hurricanes, etc.; McElhany *et al.,* 2000). Furthermore, preventing isolation of genetic groups protects against population divergence (Allendorf and Luikart, 2007).

Threats Evaluation

As described above, Section 4(a)(1) of the ESA and NMFS implementing regulations (50 CFR 424) states that we must determine whether a species is endangered or threatened because of any one or a combination of the following factors: (A) Current or threatened habitat destruction or 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; and (E) other natural or man-made factors affecting the species' continued existence. This section briefly summarizes the findings regarding these factors.

A. The Present or Threatened Destruction, Modification, or Curtailment of Its Habitat or Range

Past, present, and reasonably foreseeable future factors that have the potential to affect river herring habitat include, but are not limited to, dams and hydropower facilities, dredging, water quality (including land use change, water withdrawals, discharge and contaminants), climate change and climate variability. As noted above, river herring occupy a variety of different habitats including freshwater, estuarine and marine environments throughout their lives, and thus, they are subjected to habitat impacts occurring in all of these different habitats.

Dams and Other Barriers

Dams and other barriers to upstream and downstream passage (e.g., culverts) can block or impede access to habitats necessary for spawning and rearing; can cause direct and indirect mortality from injuries incurred while passing over dams, through downstream passage facilities, or through hydropower turbines; and can degrade habitat features necessary to support essential river herring life history functions. Man-made barriers that block or impede access to rivers throughout the entire historical range of river herring have resulted in significant losses of historical spawning habitat for river herring. Dams and other man-made barriers have contributed to the historical and current declines in abundance of both blueback and alewife populations. While estimates of habitat loss over the entire range of river herring are not available, estimates from studies in Maine show that less than 5 percent of lake spawning habitat and 20 percent of river habitat remains accessible for river herring (Hall *et al.,* 2010). As described in more detail below, dams are also known to impact river herring through various mechanisms, such as habitat alteration, fish passage delays, and entrainment and impingement (Ruggles 1980; NRC 2004). River herring can undergo indirect mortality from injuries such as scale loss, lacerations, bruising, eye or fin damage, or internal hemorrhaging when passing through turbines, over spillways, and through bypasses (Amaral *et al.,* 2012).

The following summary of the effects of dams and other barriers on river herring is taken from Amendment 2 to the Interstate Fishery Management Plan for Shad and River Herring (hereafter, referred to as ''Amendment 2'' and cited as ''ASMFC, 2009''). Because it includes a detailed description of barriers to upstream and downstream passage, it is the best source of comprehensive information on this topic. Please refer to Amendment 2 for more information.

Dams and spillways impeding rivers along the East Coast of the United States have resulted in a considerable loss of historical spawning habitat for shad and river herring. Permanent man-made structures pose an ongoing barrier to fish passage unless fishways are installed or structures are removed. Low-head dams can also pose a problem, as fish are unable to pass over them except when tides or river discharges are exceptionally high (Loesch and Atran, 1994). Historically, major dams were often constructed at the site of natural formations conducive to waterpower, such as natural falls. Diversion of water away from rapids at the base of falls can reduce fish habitat, and in some cases cause rivers to run dry at the base for much of the summer (MEOEA, 2005; ASMFC, 2009).

Prior to the early 1990s, it was thought that migrating shad and river herring suffered significant mortality going through turbines during downstream passage (Mathur and Heisey, 1992). Juvenile shad emigrating from rivers have been found to accumulate in larger numbers near the forebay of hydroelectric facilities, where they become entrained in intake flow areas (Martin *et al.,* 1994). Relatively high mortality rates were reported (62 percent to 82 percent) at a hydroelectric dam for juvenile American shad and blueback herring, depending on the power generation levels tested (Taylor and Kynard, 1984). In contrast, Mathur and Heisey (1992) reported a mortality rate of 0 percent to 3 percent for juvenile American shad (2 to 6 in fork length (55 to 140 mm)), and 4 percent for juvenile blueback herring (3 to 4 in fork length (77 to 105 mm)) through Kaplan turbines. Mortality rate increased to 11 percent in passage through a low-head Francis turbine (Mathur and Heisey, 1992). Other studies reported less than 5 percent mortality when large Kaplan and fixed-blade, mixed-flow turbines were used at a facility along the Susquehanna River (RMC, 1990; RMC, 1994). At the same site, using small Kaplan and Francis runners, the mortality rate was as high as 22 percent (NA, 2001). At another site, mortality rate was about 15 percent where higher revolution, Francis-type runners were used (RMC, 1992; ASMFC, 2009).

Additional studies reported that changes in pressure had a more pronounced effect on juveniles with thinner and weaker tissues as they moved through turbines (Taylor and Kynard, 1984). Furthermore, some fish may die later from stress, or become weakened and more susceptible to predation, and as such, losses may not be immediately apparent to researchers (Gloss, 1982) (ASMFC, 2009).

Changes to the river system, resulting in delayed migration among other things, were also identified in Amendment 2 as impacting river herring. Amendment 2 notes that when juvenile alosines delay out-migration, they may concentrate behind dams and become more susceptible to actively feeding predators. They may also be more vulnerable to anglers that target alosines as a source of bait. Delayed out-migration can also make juvenile alosines more susceptible to marine predators that they may have avoided if they had followed their natural migration patterns (McCord, 2005a). In open rivers, juvenile alosines gradually move seaward in groups that are likely spaced according to the spatial separation of spawning and nursery grounds (Limburg, 1996; J. McCord, South Carolina Department of Natural Resources, personal observation). Releasing water from dams and impoundments (or reservoirs) may lead to flow alterations, altered sediment transport, disruption of nutrient availability, changes in downstream water quality (including both reduced and increased temperatures), streambank erosion, concentration of sediment and pollutants, changes in species composition, solubilization of iron and manganese and their absorbed or chelated ions, and hydrogen sulfide in hypolimnetic (water at low level outlets) releases (Yeager, 1995; Erkan, 2002; ASMFC, 2009).

Many dams spill water over the top of the structure where water temperatures are the warmest, essentially creating a series of warm water ponds in place of the natural stream channel (Erkan, 2002). Conversely, water released from deep reservoirs may be poorly oxygenated, at below-normal seasonal water temperature, or both, thereby causing loss of suitable spawning or nursery habitat in otherwise habitable areas (ASMFC, 2009).

Reducing minimum flows can reduce the amount of water available and cause increased water temperature or reduced dissolved oxygen levels (ASMFC, 1985; ASMFC, 1999; USFWS *et al.,* 2001). Such conditions have occurred along the Susquehanna River at the Conowingo Dam, Maryland, from late spring through early fall, and have historically caused large fish kills below the dam (Krauthamer and Richkus, 1987; ASMFC, 2009).

Disruption of seasonal flow rates in rivers can impact upstream and downstream migration patterns for adult and juvenile alosines (ASMFC, 1985; Limburg, 1996; ASMFC, 1999; USFWS *et al.,* 2001). Changes to natural flows can also disrupt natural productivity and availability of zooplankton that larval and early juvenile alosines feed on (Crecco and Savoy, 1987; Limburg, 1996; ASMFC, 2009).

Although most dams that impact diadromous fish are located along the lengths of rivers, fish can also be affected by hydroelectric projects at the mouths of rivers, such as the large tidal hydroelectric project at the Annapolis River in the Bay of Fundy, Canada. This particular basin and other surrounding waters are used as foraging areas during summer months by American shad from all runs along the East Coast of the United States (Dadswell *et al.,* 1983). Because the facilities are tidal hydroelectric projects, fish may move in and out of the impacted areas with each tidal cycle. While turbine mortality is relatively low with each passage, the repeated passage in and out of these facilities may cumulatively result in substantial overall mortalities (Scarratt and Dadswell, 1983; ASMFC, 2009).

Additional man-made structures that may obstruct upstream passage include: tidal and amenity barrages (barriers constructed to alter tidal flow for aesthetic purposes or to harness energy); tidal flaps (used to control tidal flow); mill, gauging, amenity, navigation, diversion, and water intake weirs; fish counting structures; and earthen berms (Durkas, 1992; Solomon and Beach, 2004). The impact of these structures is site-specific and will vary with a number of conditions including head drop, form of the structure, hydrodynamic conditions upstream and downstream, condition of the structure, and presence of edge effects (Solomon and Beach, 2004). Road culverts are also a significant source of blockage. Culverts are popular, low-cost alternatives to bridges when roads must cross small streams and creeks. Although the amount of habitat affected by an individual culvert may be small, the cumulative impact of multiple culverts within a watershed can be substantial (Collier and Odom, 1989; ASMFC, 2009).

Roads and culverts can also impose significant changes in water quality.

Winter runoff in some states may include high concentrations of road salt, while stormwater flows in the summer may cause thermal stress and bring high concentrations of other pollutants (MEOEA, 2005; ASMFC, 2009).

Sampled sites in North Carolina revealed river herring upstream and downstream of bridge crossings, but no herring were found in upstream sections of streams with culverts. Additional study is underway to determine if river herring are absent from these areas because of the culverts (NCDENR, 2000). Even structures only 8 to 12 in (20 to 30 cm) above the water can block shad and river herring migration (ASMFC, 1999; ASMFC, 2009).

Rivers can also be blocked by non-anthropogenic barriers, such as beaver dams, waterfalls, log piles, and vegetative debris. These blockages may hinder migration, but they can also benefit by providing adhesion sites for eggs, protective cover, and feeding sites (Klauda *et al.,* 1991b). Successful passage at these natural barriers often depends on individual stream flow characteristics during the fish migration season (ASMFC, 2009).

Dredging

Wetlands provide migratory corridors and spawning habitat for river herring. The combination of incremental losses of wetland habitat, changes in hydrology, and nutrient and chemical inputs over time, can be extremely harmful, resulting in diseases and declines in the abundance and quality. Wetland loss is a cumulative impact that results from activities related to dredging/dredge spoil placement, port development, marinas, solid waste disposal, ocean disposal, and marine mining. In the late 1970s and early 1980s, the United States was losing wetlands at an estimated rate of 300,000 acres (1,214 sq km) per year. The Clean Water Act and state wetland protection programs helped decrease wetland losses to 117,000 acres (473 sq km) per year, between 1985 and 1995. Estimates of wetlands loss vary according to the different agencies. The U.S. Department of Agriculture (USDA) attributes 57 percent of wetland loss to development, 20 percent to agriculture, 13 percent to the creation of deepwater habitat, and 10 percent to forest land, rangeland, and other uses. Of the wetlands lost between 1985 and 1995, the USFWS estimates that 79 percent of wetlands were lost to upland agriculture. Urban development and other types of land use activities were responsible for 6 percent and 15 percent of wetland loss, respectively.

Amendment 2 identifies channelization and dredging as a threat to river herring habitat. The following section, taken from Amendment 2, describes these threats.

Channelization can cause significant environmental impacts (Simpson *et al.,* 1982; Brookes, 1988), including bank erosion, elevated water velocity, reduced habitat diversity, increased drainage, and poor water quality (Hubbard, 1993). Dredging and disposal of spoils along the shoreline can also create spoil banks, which block access to sloughs, pools, adjacent vegetated areas, and backwater swamps (Frankensteen, 1976). Dredging may also release contaminants, resulting in bioaccumulation, direct toxicity to aquatic organisms, or reduced dissolved oxygen levels (Morton, 1977). Furthermore, careless land use practices may lead to erosion, which can lead to high concentrations of suspended solids (turbidity) and substrate (siltation) in the water following normal and intense rainfall events. This can displace larvae and juveniles to less desirable areas downstream and cause osmotic stress (Klauda *et al.,* 1991b; ASMFC, 2009).

Spoil banks are often unsuitable habitat for fishes. Suitable habitat is often lost when dredge disposal material is placed on natural sand bars and/or point bars. The spoil is too unstable to provide good habitat for the food chain. Draining and filling, or both, of wetlands adjacent to rivers and creeks in which alosines spawn has eliminated spawning areas in North Carolina (NCDENR, 2000; ASMFC, 2009).

Secondary impacts from channel formation include loss of vegetation and debris, which can reduce habitat for invertebrates and result in reduced quantity and diversity of prey for juveniles (Frankensteen, 1976). Additionally, stream channelization often leads to altered substrate in the riverbed and increased sedimentation (Hubbard, 1993), which in turn can reduce the diversity, density, and species richness of aquatic insects (Chutter, 1969; Gammon, 1970; Taylor, 1977). Suspended sediments can reduce feeding success in larval or juvenile fishes that rely on visual cues for plankton feeding (Kortschal *et al.,* 1991). Sediment re-suspension from dredging can also deplete dissolved oxygen, and increase bioavailability of any contaminants that may be bound to the sediments (Clark and Wilber, 2000; ASMFC, 2009).

Migrating adult river herring avoid channelized areas with increased water velocities. Several channelized creeks in the Neuse River basin in North Carolina have reduced river herring distribution and spawning areas (Hawkins, 1979). Frankensteen (1976) found that the channelization of Grindle Creek, North Carolina removed in-creek vegetation and woody debris, which had served as substrate for fertilized eggs (ASMFC, 2009).

Channelization can also reduce the amount of pool and riffle habitat (Hubbard, 1993), which is an important food-producing area for larvae (Keller, 1978; Wesche, 1985; ASMFC, 2009).

Dredging can negatively affect alosine populations by producing suspended sediments (Reine *et al.,* 1998), and migrating alosines are known to avoid waters of high sediment load (ASMFC, 1985; Reine *et al.,* 1998). Fish may also avoid areas that are being dredged because of suspended sediment in the water column. Filter-feeding fishes, such as alosines, can be negatively impacted by suspended sediments on gill tissues (Cronin *et al.,* 1970). Suspended sediments can clog gills that provide oxygen, resulting in lethal and sub-lethal effects to fish (Sherk *et al.,* 1974 and 1975; ASMFC, 2009).

Nursery areas along the shorelines of the rivers in North Carolina have been affected by dredging and filling, as well as by erection of bulkheads; however, the degree of impact has not been measured. In some areas, juvenile alosines were unable to enter channelized sections of a stream due to high water velocities caused by dredging (ASMFC, 2000 and 2009).

Water Quality

Nutrient enrichment has become a major cumulative problem for many coastal waters. Nutrient loading results from the individual activities of coastal development, marinas and recreational boating, sewage treatment and disposal, industrial wastewater and solid waste disposal, ocean disposal, agriculture, and aquaculture. Excess nutrients from land based activities accumulate in the soil, pollute the atmosphere, pollute ground water, or move into streams and coastal waters. Nutrient inputs are known to have a direct effect on water quality. For example, nutrient enrichment can stimulate growth of phytoplankton that consumes oxygen when they decay, which can lead to low dissolved oxygen that may result in fish kills (Correll, 1987; Tuttle *et al.,* 1987; Klauda *et al.,* 1991b); this condition is known as eutrophication.

In addition to the direct cumulative effects incurred by development activities, inshore and coastal habitats are also threatened by persistent increases in certain chemical discharges. The combination of incremental losses of wetland habitat, changes in hydrology, and nutrient and chemical inputs produced over time can be extremely harmful to marine and estuarine biota, including river herring, resulting in diseases and declines in the abundance and quality of the affected resources.

Amendment 2 identified land use changes including agriculture, logging/forestry, urbanization and non-point source pollution as threats to river herring habitat. The following section, taken from Amendment 2, describes these threats.

The effects of land use and land cover on water quality, stream morphology, and flow regimes are numerous, and may be the most important factors determining quantity and quality of aquatic habitats (Boger, 2002). Studies have shown that land use influences dissolved oxygen (Limburg and Schmidt, 1990), sediments and turbidity (Comeleo *et al.,* 1996; Basnyat *et al.,* 1999), water temperature (Hartman *et al.,* 1996; Mitchell, 1999), pH (Osborne and Wiley, 1988; Schofield, 1992), nutrients (Peterjohn and Correll, 1984; Osborne and Wiley, 1988; Basnyat *et al.,* 1999), and flow regime (Johnston *et al.,* 1990; Webster *et al.,* 1992; ASMFC, 2009).

Siltation, caused by erosion due to land use practices, can kill submerged aquatic vegetation (SAV). SAV can be adversely affected by suspended sediment concentrations of less than 15 ppm (15 mg/L) (Funderburk *et al.,* 1991) and by deposition of excessive sediments (Valdes-Murtha and Price, 1998). SAV is important because it improves water quality (Carter *et al.,* 1991). SAV consumes nutrients in the water and as the plants die and decay, they slowly release the nutrients back into the water column. Additionally, through primary production and respiration, SAV affects the dissolved oxygen and carbon dioxide concentrations, alkalinity, and pH of the waterbody. SAV beds also bind sediments to the bottom resulting in increased water clarity, and they provide refuge habitat for migratory fish and planktonic prey items (Maldeis, 1978; Monk, 1988; Killgore *et al.,* 1989; ASMFC, 2009).

Decreased water quality from sedimentation became a problem with the advent of land-clearing agriculture in the late 18th century (McBride, 2006). Agricultural practices can lead to sedimentation in streams, riparian vegetation loss, influx of nutrients (e.g., inorganic fertilizers and animal wastes), and flow modification (Fajen and Layzer, 1993). Agriculture, silviculture, and other land use practices can lead to sedimentation, which reduces the ability of semi-buoyant eggs and adhesive eggs to adhere to substrates (Mansueti, 1962; ASMFC, 2009).

From the 1950s to the present, increased nutrient loading has made hypoxic conditions more prevalent (Officer *et al.,* 1984; Mackiernan, 1987; Jordan *et al.,* 1992; Kemp *et al.,* 1992; Cooper and Brush, 1993; Secor and Gunderson, 1998). Hypoxia is most likely caused by eutrophication, due mostly to non-point source pollution (e.g., industrial fertilizers used in agriculture) and point source pollution (e.g., urban sewage).

Logging activities can modify hydrologic balances and in-stream flow patterns, create obstructions, modify temperature regimes, and add nutrients, sediments, and toxic substances into river systems. Loss of riparian vegetation can result in fewer refuge areas for fish from fallen trees, fewer insects for fish to feed on, and reduced shade along the river, which can lead to increased water temperatures and reduced dissolved oxygen (EDF, 2003). Threats from deforestation of swamp forests include: siltation from increased erosion and runoff; decreased dissolved oxygen (Lockaby *et al.,* 1997); and disturbance of food-web relationships in adjacent and downstream waterways (Batzer *et al.,* 2005; ASMFC, 2009).

Urbanization can cause elevated concentrations of nutrients, organics, or sediment metals in streams (Wilber and Hunter, 1977; Kelly and Hite, 1984; Lenat and Crawford, 1994). More research is needed on how urbanization affects diadromous fish populations; however, Limburg and Schmidt (1990) found that when the percent of urbanized land increased to about 10 percent of the watershed, the number of alewife eggs and larvae decreased significantly in tributaries of the Hudson River, New York (ASMFC, 2009).

Water Withdrawal/Outfall

Water withdrawal facilities and toxic and thermal discharges have also been identified as impacting river herring, and the following section is summarized from Amendment 2.

Large volume water withdrawals (e.g., drinking water, pumped-storage hydroelectric projects, irrigation, and snow-making) can alter local current characteristics (e.g., reverse river flow), which can result in delayed movement past a facility or entrainment in water intakes (Layzer and O'Leary, 1978). Planktonic eggs and larvae entrained at water withdrawal projects experience high mortality rates due to pressure changes, shear and mechanical stresses, and heat shock (Carlson and McCann, 1969; Marcy, 1973; Morgan *et al.,* 1976). While juvenile mortality rates are generally low at well-screened facilities, large numbers of juveniles can be entrained (Hauck and Edson, 1976; Robbins and Mathur, 1976; ASMFC, 2009).

Fish impinged against water filtration screens can die from asphyxiation, exhaustion, removal from the water for prolonged periods of time, removal of protective mucous, and descaling (DBC, 1980). Studies conducted along the Connecticut River found that larvae and early juveniles of alewife, blueback herring, and American shad suffered 100-percent mortality when temperatures in the cooling system of a power plant were elevated above 82 °F (28°C); 80 percent of the total mortality was caused by mechanical damage, 20 percent by heat shock (Marcy, 1976). Ninety-five percent of the fish near the intake were not captured by the screen, and Marcy (1976) concluded that it did not seem possible to screen fish larvae effectively (ASMFC, 2009).

The physical characteristics of streams (e.g., stream width, depth, and current velocity; substrate; and temperature) can be altered by water withdrawals (Zale *et al.,* 1993). River herring can experience thermal stress, direct mortality, or indirect mortality when water is not released during times of low river flows and water temperatures are higher than normal. Water flow disruption can also result in less freshwater input to estuaries (Rulifson, 1994), which are important nursery areas for river herring and other anadromous species (ASMFC, 2009).

Industrial discharges may contain toxic chemicals, such as heavy metals and various organic chemicals (e.g., insecticides, solvents, herbicides) that are harmful to aquatic life (ASMFC, 1999). Many contaminants can have harmful effects on fish, including reproductive impairment (Safe, 1990; Mac and Edsall, 1991; Longwell *et al.,* 1992). Chemicals and heavy metals can move through the food chain, producing sub-lethal effects such as behavioral and reproductive abnormalities (Matthews *et al.,* 1980). In fish, exposure to polychlorinated biphenyls (PCBs) can cause fin erosion, epidermal lesions, blood anemia, altered immune response, and egg mortality (Post, 1987; Kennish *et al.,* 1992). Steam power plants that use chlorine to prevent bacterial, fungal, and algal growth present a hazard to all aquatic life in the receiving stream, even at low concentrations (Miller *et al.,* 1982; ASMFC, 2009).

Pulp mill effluent and other oxygen-consuming wastes discharged into rivers and streams can reduce dissolved oxygen concentrations below what is required for river herring survival. Low dissolved oxygen resulting from industrial pollution and sewage discharge can also delay or prevent upstream and downstream migrations. Everett (1983) found that during times of low water flow when pulp mill effluent comprised a large percentage of the flow, river herring avoided the effluent. Pollution may be diluted in the fall when water flows increase, but fish that reach the polluted waters downriver before the water has flushed the area will typically succumb to suffocation (Miller *et al.,* 1982; ASMFC, 2009).

Effluent may also pose a greater threat during times of drought. Such conditions were suspected of interfering with the herring migration along the Chowan River, North Carolina, in 1981. In the years before 1981, the effluent from the pulp mill had passed prior to the river herring run, but drought conditions caused the effluent to remain in the system longer that year. Toxic effects were indicated, and researchers suggested that growth and reproduction might have been disrupted as a result of eutrophication and other factors (Winslow *et al.,* 1983; ASMFC, 2009).

Klauda *et al.* (1991a) provides an extensive review of temperature thresholds for alewife and bluback herring. In summary, the spawning migration for alewives most often occurs when water temperatures range from 50–64 °F (10–18 °C), and for bluebacks when temperatures range from 57–77 °F (14–25 °C). Alewife egg deposition most often occurs when temperatures range between 50–72 °F (10 and 22 °C), and for bluebacks when temperatures range between 70–77 °F (21 and 25 °C). Alewife egg and larval development is optimal when temperatures range from 63—70 °F (17–21 °C), and for bluebacks when temperatures range from 68–75 °F (20–24 °C) (temperature ranges were also presented and discussed at the Climate Workshop (NMFS, 2012b)). Thermal effluent from power plants outside these temperature ranges when river herring are present can disrupt schooling behavior, cause disorientation, and may result in death. Sewage can directly and indirectly affect anadromous fish. Major phytoplankton and algal blooms that reduced light penetration (Dixon, 1996) and ultimately reduced SAV abundance (Orth *et al.,* 1991) in tidal freshwater areas of the Chesapeake Bay in the 1960s and early 1970s may have been caused by ineffective sewage treatment (ASMFC, 2009).

Water withdrawal for irrigation can cause dewatering or reduced streamflow of freshwater streams, which can decrease the quantity of both spawning and nursery habitat for anadromous fish. Reduced streamflow can reduce water quality by concentrating pollutants and/or increasing water temperature (ASMFC, 1985). O'Connell and Angermeier (1999) found that in some Virginia streams, there was an inverse relationship between the proportion of a stream's watershed that was agriculturally developed and the overall tendency of the stream to support river herring runs. In North Carolina, cropland alteration along several creeks and rivers significantly reduced river herring distribution and spawning areas in the Neuse River basin (Hawkins, 1979; ASMFC, 2009).

Atmospheric deposition occurs when pollutants (e.g. nitrates, sulfates, ammonium, and mercury) are transferred from the air to the earth's surface. Pollutants can get from the air into the water through rain and snow, falling particles, and absorption of the gas form of the pollutants into the water. Atmospheric pollutants can result in increased eutrophication (Paerl *et al.,* 1999) and acidification of surface waters (Haines, 1981). Atmospheric nitrogen deposition in coastal estuaries can lead to accelerated algal production (or eutrophication) and water quality declines (e.g., hypoxia, toxicity, and fish kills) (Paerl *et al.,* 1999). Nitrate and sulfate deposition is acidic and can reduce stream pH (measure of the hydronium ion concentration) and elevate toxic forms of aluminum (Haines, 1981). When pH declines, the normal ionic salt balance of the fish is compromised and fish lose body salts to the surrounding water (Southerland *et al.,* 1997). Sensitive fish species can experience acute mortality, reduced growth, skeletal deformities, and reproductive failure (Haines, 1981).

Climate Change and Climate Variability

Possible climate change impacts to river herring were noted in the stock assessment (ASMFC, 2012) based on regional patterns in trends (e.g., trawl surveys in southern regions showed declining trends more frequently compared to those in northern regions). However, additional information was needed on this topic to inform our listing decision, and as noted above, we held a workshop to obtain expert opinion on the potential impacts of climate change on river herring (NMFS, 2012b).

As discussed at the workshop, both natural climate variability and anthropogenic-forced climate change will affect river herring (NMFS, 2012b). Natural climate variability includes the Atlantic Multidecadal Oscillation, the North Atlantic Oscillation, and the El Niño Southern Oscillation. During the workshop, it was noted that impacts from global climate change induced by human activities are likely to become more apparent in future years (Intergovernmental Panel on Climate Change (IPCC), 2007). Results presented from the North American Regional Climate Change Assessment Program (NARCCAP—a group that uses fields from the global climate models to provide boundary conditions for regional atmospheric models covering most of North America and extending over the adjacent oceans) suggest that temperature will warm throughout the years over the northeast, mid-Atlantic and Southeast United States (comparing 1968–1999 to 2038–2069; NMFS, 2012b). Additionally, it was noted that there is an expected but less certain increase in precipitation over the northeast United States during fall and winter during the same years (NMFS, 2012b). In conjunction with increased evaporation from warmer temperatures, the Northeast and mid-Atlantic may experience decrease in runoff and decreased stream flow in late winter and early spring (NMFS, 2012b). Additionally, enhanced ocean stratification could be caused by greater warming at the ocean surface than at depth (NMFS, 2012b).

Many observed changes in river herring biology related to environmental conditions were noted at the workshop, but few detailed analyses were available to distinguish climate change from climate variability. One analysis by Massachusetts Division of Marine Fisheries showed precipitation effects on spawning run recruitment at Monument River, MA (1980–2012; NMFS, 2012b). Jordaan and Kritzer (unpublished data) showed normalized run counts of alewife and blueback herring have a stronger correlation with fisheries and predators than various climate variables at broad scales (NMFS, 2012b). Once fine-scale (flow related to fishways and dams) data were used, results indicate that summer and fall conditions were more important. Nye *et al.* (2012) investigated climate-related mechanisms in the marine habitat of the United States that may impact river herring. Their preliminary results indicate the following: (1) A shift in northern ocean distribution for both blueback herring and alewife depending on the season; (2) decrease in ocean habitat within the preferred temperature for alewife and blueback herring in the spring; and (3) effects of climate change on river herring populations may depend on the current condition (e.g., abundance and health) of the population, assumptions, and temperature tolerances (e.g., blueback herring have a higher temperature tolerance than alewife).

Although preliminary, Nye *et al.* (2012) indicate that climate change will impact river herring. The results (also supported by Nye *et al.,* 2009) indicate that both blueback herring and alewife have and will continue to shift their distribution to more northerly waters in the spring, and blueback herring has also shifted its distribution to more northerly waters in the fall (1975–2010) (Nye *et al.,* 2012). Additionally, Nye *et al.* (2012) found a decrease in habitat (bottom waters) within the preferred temperature for alewife and blueback herring in the spring under future climate predictions (2020–2060 and 2060–2100). They concluded that an expected decrease in optimal marine habitat and natal spawning habitat will negatively affect river herring populations at the southern extent of their range. Additionally, Nye *et al.* (2012) infer that this will have negative population level effects and cause population declines in southern rivers, resulting in an observed shift in distribution which has already been observed. Nye *et al.* (2012) also found that the effects of climate change on river herring populations may depend on the current condition (e.g., abundance and health) of the population, assumptions, and temperature tolerances. Using the model, projections of alewife distribution and abundance can be predicted for each year, but for ease of interpretation, 2 years of low and high relative abundance were chosen to illustrate the effects of population abundance and temperature on alewife distribution. The low and high abundance years were objectively chosen as the years closest to −1 and +1 standard deviation from overall mean abundance. Two years closest to the −1 and +1 standard deviation from mean population abundance were selected to reflect the combined effect of warming with low and high abundance of blueback herring. The difference in species response (as noted below) may reflect the different temperature tolerances (9–11 °C for blueback herring and 4–11 °C for alewife) as indicated by the southern limit of their ranges. Blueback herring may be able to tolerate higher temperature as their range extends as far south as Florida, but the southern extent of the alewife's range is limited to North Carolina. For both species, the Nye *et al.* (2012) analysis indicates that, if robust populations of these species are maintained, declines due to the effects of climate change will be reduced. Their specific results include the following:

- Alewife: At low population size, coast-wide abundance is projected to decrease with less suitable habitat and patchy areas of high density in the Gulf of Maine and Georges Bank in 2060–2100. At high population size, abundance is projected to increase slightly from 2020–2060 (+4.64 percent) but is projected to decrease (−39.14 percent) and become more patchy in 2060–2100.
- Blueback herring: Abundance is projected to increase at both high and low population size throughout the Northeast United States, especially in the mid-Atlantic and Georges Bank. However, at low abundance the increase is minimal and remains at a level below the 40-year mean. The percentage change due to climate change (factoring only temperature) is +29.93 percent for the time period 2020–2060 and +55.81 percent from 2060–2100.

We hoped to obtain information during the workshop on potential impacts of climate change by region, including information on species, life stage, indicators, potential impacts, and available data/relevant references (NMFS, 2012b). Although we did obtain information on each of these categories, substantial data gaps in the species information were apparent (NMFS, 2012b). For example, although no specific information on impacts of ocean acidification on river herring was presented, possible effects on larval development, chemical signaling (olfaction), and de-calcification of prey were noted (NMFS, 2012b). Additional research is needed to identify the limiting factor(s) for river herring populations. As Nye *et al.* (2012) noted, the links between climate and river herring biology during freshwater stages are unclear and will require additional time to research and thoroughly analyze. This conclusion is supported by the results of the workshop, which noted numerous potential climate effects on the freshwater stages, but little synthesis has been accomplished to date. The preliminary analysis of Nye *et al.* (2012) indicates that water temperatures in the rivers will be warmer, and there will be a decrease in the river flow in the northeast and Mid-Atlantic in late winter/early spring.

Although current information indicates climate change is and will continue to impact river herring (e.g., Nye *et al.,* 2012), climate variability rather than climate change is expected to have more of an impact on river herring from 2024–2030. Several studies have shown that the climate change signal is readily apparent by the end of the 21st century (Hare *et al.,* 2010; Hare *et al.,* 2012). At intermediate time periods (e.g., 2024–2030), the signal of natural climate variability is likely similar to the signal of climate change. Thus, a large component of the climate effect on river herring in 2024–2030 will be composed of natural climate variability, which could be either warming or cooling.

Summary and Evaluation of Factor A

Dams and hydropower facilities, water quality and water withdrawals from urbanization and agricultural runoff, dredging and other wetland alterations are likely the causes of historical and recent declines in abundance of alewife and blueback herring populations. Climate variability rather than climate change is expected to have more of an impact on river herring from 2024–2030 (NMFS' foreseeable future for river herring). Nye *et al.,* (2012) conducted a preliminary analysis investigating climate-related mechanisms in the marine habitat of the United States that may impact river herring, and found that changes in the amount of preferred habitat and a potential northward shift in distribution as a result of climate change may affect river herring in the future (e.g., 2020–2100). Thus, the level of threat posed by these potential stressors is evaluated further in the qualitative threats assessment as described below.

B. Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Directed Commercial Harvest

This following section on river herring fisheries in the United States is from the stock assessment (ASMFC, 2012).

Fisheries for anadromous species have existed in the United States for a very long time. They not only provided sustenance for early settlers but a source of income as the fisheries were commercialized. It is difficult to fully describe the characteristics of these early fisheries because of the lack of quantifiable data.

The earliest commercial river herring data were generally reported in state and town reports or local newspapers. In 1871, the U.S. Fish Commission was founded (later became known as the U.S. Fish and Fisheries Commission in 1881). This organization collected fisheries statistics to characterize the biological and economic aspects of commercial fisheries. Data describing historical river herring fisheries were available from two of this organization's publications—the Bulletin of the U.S. Fish Commission (renamed Fishery Bulletin in 1971; Collins and Smith, 1890; Smith, 1891) and the U.S. Fish Commission Annual Report (USFC, 1888–1940). In the stock assessment, the river herring data were transcribed and when available, dollar values were converted to 2010 dollar values using conversion factors based on the annual average consumer price index (CPI) values, which were obtained from the U.S. Bureau of Labor Statistics. Note that CPI values are not available for years prior to 1913 so conversion factors could not be calculated for years earlier than 1913 (ASMFC, 2012).

There are several caveats to using the historical fisheries data. There is an apparent bias in the area sampled. In most cases, there was no systematic sampling of all fisheries; instead, sampling appeared to be opportunistic, concentrating on the mid-Atlantic States. It is also difficult to assess the accuracy and precision of these data. In some instances, the pounds were reported at a fine level of detail (e.g., at the state/county/gear level), but details regarding the specific source of the data were often not described. The level of detail provided in the reports varied among states and years. Additionally, not all states and fisheries were canvassed in all years, so absence of landings data does not necessarily indicate the fishery was not active as it is possible that the data just were not collected. For these reasons, these historical river herring landings should not be considered even minimum values because of the variation in detail and coverage over the time series. No attempt was made to estimate missing river herring data since no benchmark or data characteristics could be found, and the stock assessment subcommittee also did not attempt to estimate missing data in a time series at a particular location because of the bias associated with these estimates (ASMFC, 2012).

During 1880 to 1938, reported commercial landings of river herring along the Atlantic Coast averaged approximately 30.5 million lbs (13,835 mt) per year. The majority of river herring landed by commercial fisheries in these early years are attributed to the mid-Atlantic region (NY–VA). The dominance of the mid-Atlantic region is, in part, due to the apparent bias in the spatial coverage of the canvass (see above). From 1920 to 1938, the average annual weight of reported commercial river herring landings was about 22.8 million lbs (10,351 mt). The value of the commercial river herring landings during this same time period was approximately 2.87 million dollars (2010 USD) (ASMFC, 2012).

Domestic commercial landings of river herring were presented in the stock assessment by state and by gear from 1887 to 2010 where available. Landings of alewife and blueback herring were collectively classified as ''river herring'' by most states. Only a few states had species-specific information recorded for a limited range of years. Commercial landings records were available for each state since 1887 except for Florida and the Potomac River Fisheries Commission (PRFC), which began recording landings in 1929 and 1960, respectively. It is important to note that historical landings presented in the stock assessment do not include all landings for all states over the entire time period and are likely underestimated, particularly for the first third of the time series, since not all river landings were reported (ASMFC, 2012).

Total domestic coast-wide landings averaged 18.5 million lb (8,399 mt) from 1887 to 1928 (*See table 2.2* in ASMFC (2012)). During this early time period, landings were predominately from Maryland, North Carolina, Virginia, and Massachusetts (overall harvest is likely underestimated because landings were not recorded consistently during this time). Virginia made up approximately half of the commercial landings from 1929 until the 1970s, and the majority of Virginia's landings came from the Chesapeake Bay, Potomac River, York River, and offshore harvest. Coast-wide landings started increasing sharply in the early 1940s and peaked at over 68.7 million lb (31,160 mt) in 1958 (*See Table 2.2,* ASMFC, 2012). In the 1950s and 1960s, a large proportion of the harvest came from Massachusetts purse seine fisheries that operated offshore on Georges Bank targeting Atlantic herring (G. Nelson, Massachusetts Division of Marine Fisheries, Pers. comm., 2012). Landings from North Carolina were also at their highest during this time and originated primarily from the Chowan River pound net fishery. Severe declines in landings began coast-wide in the early 1970s and domestic landings are now a fraction of what they were at their peak, having remained at persistently low levels since the mid-1990s. Moratoria were enacted in Massachusetts (commercial and recreational in 2005), Rhode Island (commercial and recreational in 2006), Connecticut (commercial and recreational in 2002), Virginia (for waters flowing into North Carolina in 2007), and North Carolina (commercial and recreational in 2007). As of January 1, 2012, river herring fisheries in states or jurisdictions without an approved sustainable fisheries management plan, as required under ASMFC Amendment 2 to the Shad and River Herring FMP, were closed. As a result, prohibitions on harvest (commercial or recreational) were extended to the following states: New Jersey, Delaware, Pennsylvania, Maryland, DC, Virginia (for all waters), Georgia and Florida (ASMFC, 2012).

Pound nets were identified as the dominant gear type used to harvest river herring from 1887 through 2010. Seines were more prevalent prior to the 1960s, but by the 1980s, they were rarely used. Purse seines were used only for herring landed in Massachusetts, but made up a large proportion of the landings in the 1950s and 1960s. Historically, gill nets made up a small percentage of the overall harvest. However, even though the actual pounds landed continued to decline, the proportion of gill nets that contributed to the overall harvest has increased in recent years (ASMFC, 2012).

Foreign fleet landings of river herring (reported as alewife and blueback shad) are available through the Northwest Atlantic Fisheries Organization (NAFO). Offshore exploitation of river herring and shad (generally <7.5 in (190 mm) in length) by foreign fleets began in the late 1960s and landings peaked at about 80 million lbs (36,320 mt) in 1969 (ASMFC, 2012).

Total U.S. and foreign fleet harvest of river herring from the waters off the coast of the United States (NAFO areas 5 and 6) peaked at about 140 million lb (63,560 mt) in 1969, after which landings declined dramatically. After 1977 and the formation of the Fishery Conservation Zone, foreign allocation of river herring (to both foreign vessels and joint venture vessels) between 1977 and 1980 was 1.1 million lb (499 mt). The foreign allocation was reduced to 220,000 lb (100 mt) in 1981 because of the condition of the river herring resource. In 1985, a bycatch cap of no more than 0.25 percent of total catch was enacted for the foreign fishery. The cap was exceeded once in 1987, and this shut down the foreign mackerel fishery. In 1991, area restrictions were passed to exclude foreign vessels from within 20 miles (32.2 km) of shore for two reasons: 1) In response to the increased occurrence of river herring bycatch closer to shore and 2) to promote increased fishing opportunities for the domestic mackerel fleet (ASMFC, 2012).

In-river Exploitation

The stock assessment subcommittee calculated in-river exploitation rates of the spawning runs for five rivers (Damariscotta River (ME—alewife), Union River (ME—alewife), Monument River (MA—both species combined), Mattapoisett River (MA—alewife), and Nemasket River (MA—alewife)) by dividing in-river harvest by total run size (escapement plus harvest) for a given year. Exploitation rates were highest (range: 0.53 to 0.98) in the Damariscotta River and Union River prior to 1985, while exploitation was lowest (range: 0.26 to 0.68) in the Monument River. Exploitation declined in all rivers through 1991 to 1992. Exploitation rates of both species in the Monument River and of alewives in the Mattapoisett River and Nemasket River were variable (average = 0.16) and, except for the Nemasket River, declined generally through 2005 until the Massachusetts moratorium was imposed. Exploitation rates of alewives in the Damariscotta River were low (<0.05) during 1993 to 2000, but they increased steadily through 2004 and remained greater than 0.34 through 2008. Exploitation in the Damariscotta dropped to 0.15 in 2009 to 2010. Exploitation rates of alewives in the Union River declined through 2005 but have remained above 0.50 since 2007 (ASMFC, 2012).

According to the stock assessment, exploitation of river herring appears to be declining or remaining stable. In-river exploitation was highest in Maine rivers (Damariscotta and Union) and has fluctuated, but it is currently lower than levels seen in the 1980s. Also, in-river exploitation in Massachusetts rivers (Monument and Mattapoisett) was declining at the time a moratorium was imposed in 2005. The coast-wide index of relative exploitation also declined following a peak in the late 1980s and has remained fairly stable over the past decade. Exploitation rates declined in the DB–SRA model runs except when the input biomass-to-*K* ratio in 2010 was 0.01. Exploitation rates estimated from the statistical catch-at-age model for blueback herring in the Chowan River (see the NC state report in the stock assessment) also showed a slight declining trend from 1999 to 2007, at which time a moratorium was instituted. There appears to be a consensus among various assessment methodologies that exploitation has decreased in recent times. The stock assessment indicates that the decline in exploitation over the past decade is not surprising because river herring populations are at low levels and more restrictive regulations or moratoria have been enacted by states (ASMFC, 2012).

Past high exploitation may also be a reason for the high amount of variation and inconsistent patterns observed in fisheries-independent indices of abundance. Fishing effort has been shown to increase variation in fish abundance through truncation of the age structure, and recruitment becomes primarily governed by environmental variation (Hsieh *et al.,* 2006; Anderson *et al.,* 2008). When fish species are at very low abundances, as is believed for river herring, it is possible that the only population regulatory processes operating are stochastic fluctuations in the environment (Shepherd and Cushing, 1990) (ASMFC, 2012).

Canadian Harvest

Fisheries in Canada for river herring are regulated through limited seasons, gears, and licenses. Licenses may cover different gear types; however, few new licenses have been issued since 1993 (DFO, 2001). River-specific management plans include closures and restrictions. River herring used locally for bait in other fisheries are not accounted for in river-specific management plans (DFO, 2001). DFO estimated river herring landings at just under 25.5 million lb (11,577 mt) in 1980, 23.1 million lb (10,487 mt) in 1988, and 11 million lb (4,994 mt) in 1996 (DFO, 2001). The largest river herring fisheries in Canadian waters occur in the Bay of Fundy, southern Gulf of Maine, New Brunswick, and in the Saint John and Miramichi Rivers where annual harvest estimates often exceed 2.2 million lb (1,000 mt) (DFO, 2001). Recreational fisheries in Canada for river herring are limited by regulations including area, gear and season closures with limits on the number of fish that can be harvested per day; however, information on recreational catch is limited. Licenses and reporting are not required by Canadian regulations for recreational fisheries, and harvest is not well documented.

Incidental Catch

The following section on river herring incidental catch in the United States is from the stock assessment (ASMFC, 2012).

Three recent studies estimated river herring discards and incidental catch (Cieri *et al.,* 2008; Wigley *et al.,* 2009; Lessard and Bryan, 2011). The discard and incidental catch estimates from these studies cannot be directly compared as they used different ratio estimators based on data from the Northeast Fishery Observer Program (NEFOP), as well as different raising factors to obtain total estimates. Cieri *et al.* (2008) estimated the kept (i.e., landed) portion of river herring incidental catch in the Atlantic herring fishery. Cieri *et al.* (2008) estimated an average annual landed river herring catch of approximately 71,290 lb (32.4 mt) in the Atlantic herring fishery for 2005–2007, and the corresponding coefficient of variation (CV) was 0.56. Cournane *et al.* (2010) extended this analysis with additional years of data. Further work is needed to elucidate how the landed catch of river herring in the directed Atlantic herring fishery compares to total incidental catch across all fisheries. Since this analysis only quantified kept river herring in the Atlantic herring fishery, it underestimates the total catch (kept plus discarded) of river herring across all fishing fleets. Wigley *et al.* (2009) quantified river herring discards across fishing fleets that had sufficient observer coverage from July 2007–August 2008. Wigley *et al.* (2009) estimated that approximately 105,820 lb (48 mt) were discarded during the 12 months (July 2007 to August 2008), and the estimated precision was low (149 percent CV). This analysis estimated only river herring discards (in contrast to total incidental catch), and noted that midwater trawl fleets generally retained river herring while otter trawls typically discarded river herring.

Lessard and Bryan (2011) estimated an average incidental catch of river herring and American shad of 3.3 million lb (1,498 mt)/yr from 2000–2008. The methodology used in this study differed from the Standardized Bycatch Reporting Methodology (SBRM) (the method used by NOAA's Northeast Fisheries Science Center (NEFSC) to quantify bycatch in stock assessments) (Wigley *et al.,* 2007; Wigley *et al.,* 2012). Data from NEFOP were analyzed at the haul level; however, the sampling unit for the NEFOP database is at the trip level. Within each gear and region, all data, including those from high volume fisheries, appeared to be aggregated across years from 2000 through 2008. However, substantial changes in NEFOP sampling methodology for high volume fisheries were implemented in 2005, limiting the interpretability of estimates from these fleets in prior years. Total number of tows from the fishing vessel trip report (VTR) database was used as the raising factor to estimate total incidental catch. The use of effort without standardization makes the implicit assumption that effort is constant across all tows within a gear type, potentially resulting in a biased effort metric. In contrast, the total kept weight of all species is used as the raising factor in SBRM. When quantifying incidental catch across multiple fleets, total kept weight of all species is an appropriate surrogate for effective fishing power because it is likely that all trips will not exhibit the same attributes. Lessard and Bryan (2011) also did not provide precision estimates, which are imperative for estimation of incidental catch.

The total incidental catch of river herring was estimated as part of the work for Amendment 14 to the Atlantic Mackerel, Squid and Butterfish (MSB) Fishery Management Plan, that includes measures to address incidental catch of river herring and shads. From 2005–2010, the total annual incidental catch of alewife ranged from 41,887 lb (19.0 mt) to 1.04 million lb (472 mt) in New England and 19,620 lb (8.9 mt) to 564,818 lb (256.4 mt) in the Mid-Atlantic. The dominant gear varied across years between paired midwater trawls and bottom trawls. Corresponding estimates of precision (COV) exhibited substantial interannual variation and ranged from 0.28 to 3.12 across gears and regions. Total annual blueback herring incidental catch from 2005 to 2010 ranged from 30,643 lb (13.9 mt) to 389,111 lb (176.6 mt) in New England and 2,645 lb (1.2 mt) to 843,479 lb (382.9 mt) in the Mid-Atlantic. Across years, paired and single midwater trawls exhibited the greatest blueback herring catches, with the exception of 2010 in the mid-Atlantic where bottom trawl was the most dominant gear. Corresponding estimates of precision ranged from 0.27 to 3.65. The temporal distribution of incidental catches was summarized by quarter and fishing region for the most recent 6-year period (2005 to 2010). River herring catches occurred primarily in midwater trawls (76 percent, of which 56 percent were from paired midwater trawls and the rest from single midwater trawls), followed by small mesh bottom trawls (24 percent). Catches of river herring in gillnets were negligible. Across gear types, catches of river herring were greater in New England (56 percent) than in the Mid-Atlantic (44 percent). The percentages of midwater trawl catches of river herring were similar between New England (37 percent) and the Mid-Atlantic (38 percent). However, catches in New England small mesh bottom trawls were three times higher (18 percent) than those from the Mid-Atlantic (6 percent). Overall, the highest quarterly catches of river herring occurred in midwater trawls during Quarter 1 in the Mid-Atlantic (35 percent), followed by catches in New England during Quarter 4 (16 percent) and Quarter 3 (11 percent). Quarterly catches in small mesh bottom trawls were highest in New England during Quarter 1 (7 percent) and totaled 3 to 4 percent during each of the other three quarters.

Recreational Harvest

The Marine Recreational Fishery Statistics Survey (MRFSS) provided estimates of numbers of fish harvested and released by recreational fisheries along the Atlantic coast. The stock assessment subcommittee extracted state harvest and release estimates for alewives and blueback herring from the MRFSS catch and effort estimates files available on the web (*http://www.sefsc.noaa.gov/about/mrfss.htm*). Historically, there were few reports of river herring taken by recreational anglers for food. Most often, river herring were taken for bait. MRFSS estimates of the numbers of river herring harvested and released by anglers are very imprecise and show little trend. Thus, the stock assessment concluded that these data are not useful for management purposes. MRFSS concentrates their sampling strata in coastal water areas and does not capture any data on recreational fisheries that occur in inland waters. Few states conduct creel surveys or other consistent survey instruments (diary or log books) in their inland waters to collect data on recreational catch of river herring. Some data are reported in the state chapters in the stock assessment; but the stock assessment committee concluded that data are too sparse to conduct any systematic comparison of trends (ASMFC, 2012).

Scientific Monitoring and Educational Harvest

Maine, New Hampshire, Massachusetts and Rhode Island estimate run sizes using electronic counters or visual methods. Various counting methods are used at the Holyoke Dam fish lift and fishways on the Connecticut River. Young of year (YOY) surveys are conducted through fixed seine surveys capturing YOY alewife and blueback herring generally during the summer and fall in Maine, Rhode Island, Connecticut, New York, New Jersey, Maryland, District of Columbia, Virginia and North Carolina. Rhode Island conducts surveys for juvenile and adult river herring at large fixed seine stations. Virginia samples river herring using a multi-panel gill net survey and electroshocking surveys. Florida conducts electroshocking surveys to sample river herring. Maine, New Hampshire, Massachusetts, Rhode Island, Maryland, and North Carolina collect age data from commercial and fisheries independent sampling programs, and length-at-age data. All of these scientific monitoring efforts are believed to have minimal impacts on river herring populations.

Summary and Evaluation of Factor B

Historical commercial and recreational fisheries for river herring likely contributed to the decline in abundance of both alewife and blueback herring populations. Current directed commercial and recreational alewife and blueback herring fisheries, as well as commercial fishery incidental catch may continue to pose a threat to these species. Since the 1970s, regulations have been enacted in the United States on the directed harvest of river herring in an attempt to halt or reverse their decline with the most recent regulations being imposed in January 2012. Additionally, there are regulations in Canada on river herring harvest. Historical landings data and current fishery effort is the best available information to describe the impact that the commercial fishery may be having on river herring.

Moratoria are in place on directed catch of these species throughout most of the United States; however, they are taken as incidental catch in several fisheries. The extent to which incidental catch is affecting river herring has not been quantified and is not fully understood. Thus, the level of threat posed by directed and indirect catch is evaluated further in the qualitative threats assessment as described below. Scientific collections or collections for educational purposes do not appear to be significantly affecting the status of river herring, as they result in low mortality.

C. Disease and Predation

Disease

Little information exists on diseases that may affect river herring; however, there are reports of a variety of parasites that have been found in both alewife and blueback herring. The most comprehensive report is that of Landry *et al.* (1992) in which 13 species of parasites were identified in blueback herring and 12 species in alewives from the Miramichi River, New Brunswick, Canada. The parasites found included one monogenetic trematode, four digenetic trematodes, one cestode, three nematodes, one acanthocephalan, one annelid, one copepod and one mollusk. The same species were found in both alewife and blueback herring with the exception of the acanthocephalan, which was absent from alewives.

In other studies, Sherburne (1977) reported piscine erythrocytic necrosis (PEN) in the blood of 56 percent of prespawning and 10 percent of postspawning alewives in Maine coastal streams. PEN was not found in juvenile alewives from the same locations. Coccidian parasites were found in the livers of alewives and other finfish off the coast of Nova Scotia (Morrison and Marryatt, 1990). Marcogliese and Compagna (1999) reported that most fish species, including alewife, in the St. Lawrence River become infected with trematode metacercariae during the first years of life. Examination of Great Lakes fishes in Canadian waters showed larval *Diplostomum* (trematode) commonly in the eyes of alewife in Lake Superior (Dechtiar and Lawrie, 1988) and Lake Ontario (Dechtiar and Christie, 1988), though intensity of infections was low (<9/host). Heavy infections of *Saprolegnia,* a fresh and brackish water fungus, were found in 25 percent of Lake Superior alewife examined, and light infections were found in 33 percent of Lake Ontario alewife (Dechtiar and Lawrie, 1988). Larval acanthocephala were also found in the guts of alewife from both lakes. *Saprolegnia* typically is a secondary infection, invading open sores and wounds, and eggs in poor environmental conditions, but under the right conditions it can become a primary pathogen. *Saprolegnia* infections usually are lethal to the host.

More recently, alewives were found positive for Cryptosporidium for the first time on record by Ziegler *et al.* (2007). Mycobacteria, which can result in ulcers, emaciation, and sometimes death, have been found in many Chesapeake Bay fish, including blueback herring (Stine *et al.,* 2010).

Predation

Information on predation of river herring was compiled and published in Volume I of the River Herring Benchmark Assessment (2012) by ASMFC. The following section on predation was compiled by Dr. Katie Drew from this assessment.

Alewife and blueback herring are an important forage fish for marine and anadromous predators, such as striped bass, spiny dogfish, bluefish, Atlantic cod, and pollock (Bowman *et al.,* 2000; Smith and Link, 2010). Historically, river herring and striped bass landings have tracked each other quite well, with highs in the 1960s, followed by declines through the 1970s and 1980s. Although populations of Atlantic cod and pollock are currently low, the populations of striped bass and spiny dogfish have increased in recent years (since the early 1980s for striped bass and since 2005 for spiny dogfish), while the landings and run counts of river herring remain at historical lows. This has led to speculation that increased predation may be contributing to the decline of river herring and American shad (Hartman, 2003; Crecco *et al.,* 2007; Heimbuch, 2008). Quantifying the impacts of predation on alewife and blueback herring is difficult. The diet of striped bass has been studied extensively, and the prevalence of alosines varies greatly depending on location, season, and predator size (Walter *et al.,* 2003). Studies from the northeast U.S. continental shelf show low rates of consumption by striped bass (alewife and blueback herring each make up less than 5 percent of striped bass diet by weight) (Smith and Link, 2010), while studies that sampled striped bass in rivers and estuaries during the spring spawning runs found much higher rates of consumption (greater than 60 percent of striped bass diet by weight in some months and size classes) (Walter and Austin, 2003; Rudershausen *et al.,* 2005). Translating these snapshots of diet composition into estimates of total removals requires additional data on both annual per capita consumption rates and estimates of annual abundance for predator species.

The diets of other predators, including other fish (e.g., bluefish, spiny dogfish), along with marine mammals (e.g., seals) and birds (e.g., double-crested cormorant), have not been quantified nearly as extensively, making it more difficult to assess the importance of river herring in the freshwater and marine food webs. As a result, some models predict a significant negative effect from predation (Hartman, 2003; Heimbuch, 2008), while other studies did not find an effect (Tuomikoski *et al.,* 2008; Dalton *et al.,* 2009).

In addition to predators native to the Atlantic coast, river herring are vulnerable to invasive species such as the blue catfish (*Ictalurus furcatus*) and the flathead catfish (*Pylodictis olivaris*). These catfish are large, opportunistic predators native to the Mississippi River drainage that were introduced into rivers on the Atlantic coast. They have been observed to consume a wide range of species, including alosines, and ecological modeling on flathead catfish suggests they may have a large impact on their prey species (Pine, 2003; Schloesser *et al.,* 2011). In August 2011, ASMFC approved a resolution calling for efforts to reduce the population size and ecological impacts of invasive species and named blue and flathead catfish specifically, as species of concern, due to their increasing abundance and potential impacts on native anadromous species. Non-native species are a particular concern because of the lack of native predators, parasites, and competitors to keep their populations in check.

Predation and multispecies models, such as the MS–VPA (NEFSC, 2006), have tremendous data needs, and more research needs to be conducted before they can be applied to river herring. However, given the potential magnitude of predatory interactions, it is an area of research worth pursuing (ASMFC, 2012).

Two papers have become available since the ASMFC (2012) stock assessment that discuss striped bass predation on river herring in Massachusetts and Connecticut estuaries and rivers, showing temporal and spatial patterns in predation (Davis *et al.,* 2012; Ferry and Mather, 2012). Davis *et al.* (2012) estimated that approximately 400,000 blueback herring are consumed annually by striped bass in the Connecticut River spring migration. In this study, striped bass were found in the rivers during the spring spawning migrations of blueback herring and had generally left the system by mid-June (Davis *et al.,* 2012). Many blueback herring in the Connecticut River are thought to be consumed prior to ascending the river on their spawning migration, and are, therefore, being removed from the system before spawning. Alternatively, Ferry and Mather (2012) discuss the results of a similar study conducted in Massachusetts watersheds with drastically different findings for striped bass predation. Striped bass were collected and stomach contents analyzed during three seasons from May through October (Ferry and Mather, 2012). The stomach contents of striped bass from the survey were examined and less than 5 percent of the clupeid category (from 12 categories identified to summarize prey) consisted of anadromous alosines (Ferry and Mather, 2012). Overall, the Ferry and Mather (2012) study observed few anadromous alosines in the striped bass stomach contents during the study period. These two recent studies echo similar contradictory findings from previous studies showing a wide variation in predation by striped bass with spatial and temporal effects; however, they exhibit no consistent trends along the coast.

Summary and Evaluation for Factor C

While data are limited, the best available information indicates that river herring are not likely affected to a large degree by diseases caused by viruses, bacteria, protozoans, metazoans, or microalgae. Much of the information on diseases in alewife or blueback herring comes from studies on landlocked species; therefore, even if studies indicated that landlocked alewife and blueback herring were highly susceptible to diseases and suffered high mortality rates, it is not known whether anadromous river herring would be affected in the same way. While it may be possible that disease threats to river herring could increase in prevalence or magnitude under various climate change scenarios, there are currently no data available to support this supposition. We have included disease as a threat in the qualitative threats assessment described in detail below.

Alewife and blueback herring are considered to be an important forage fish for many marine and anadromous predators, and therefore, may be affected by predation, especially if some populations of predators (e.g., striped bass, spiny dogfish) continue to increase. There may also be effects from predation by invasive species such as the blue and flathead catfish. Some predation and multispecies models have estimated an effect of predation on river herring, while others have not. In general, the effect of predation on the persistence of river herring is not fully understood; however, predation may be affecting river herring populations and consequently, it is included as a threat in the qualitative threats assessment described below.

D. Inadequacy of Existing Regulatory Mechanisms

As wide-ranging anadromous species, alewife and blueback herring are subject to numerous Federal (U.S. and Canadian), state and provincial, Tribal, and inter-jurisdictional laws, regulations, and agency activities. These regulatory mechanisms are described in detail in the following section.

International

The Canadian DFO manages alewife and blueback herring fisheries that occur in the rivers of the Canadian Maritimes under the Fisheries Act (R.S.C., 1985, c. F–14). The Maritime Provinces Fishery Regulations includes requirements when fishing for or catching and retaining river herring in recreational and commercial fisheries (DFO, 2006; *http://laws-lois.justice.gc.ca*).

Commercial and recreational river herring fisheries in the Canadian Maritimes are regulated by license, fishing gear, season and/or other measures (DFO, 2001). Since 1993, DFO has issued few new licenses for river herring (DFO, 2001). River herring are harvested by various gear types (e.g., gillnet, dip nets, trap) and the regulations depend upon the river and associated location (DFO, 2001). The primary management measures are weekly closed periods and limiting the number of licenses to existing levels in all areas (DFO, 2001). Logbooks are issued to commercial fishermen in some areas as a condition of the license, and pilot programs are being considered in other areas (DFO, 2001). The management objective is to maintain harvest near long-term mean levels when no specific biological and fisheries information is available (DFO, 2001).

DFO (2001) stated that additional management measures may be required if increased effort occurs in response to stock conditions or favorable markets. There has been concern as fishery exploitation rates have been above reference levels and fewer licenses are fished than have been issued (DFO, 2001). In 2001, DFO reported that in some rivers river herring were being harvested at or above reference levels (e.g., Miramichi), while in other rivers river herring were harvested at or below the reference point (e.g., St. John River at Mactaquac Dam). DFO (2001) believes precautionary management involving no increase or decrease in exploitation is important for Maritime river herring fisheries, given that biological and harvest data are not widely available. Additionally, DFO (2001) added that river-specific management plans based on stock assessments should be prioritized over general management initiatives.

Eastern New Brunswick is currently the only area in the Canadian Maritimes with a river herring integrated fishery management plan (DFO, 2006). The DFO uses Integrated Fisheries Management Plans (IFMPs) to guide the conservation and sustainable use of marine resources (DFO, 2010). An IFMP manages a fishery in a given region by combining the best available science on the species with industry data on capacity and methods for harvesting (DFO, 2010). The 6-year management plan (2007–2012) for river herring for Eastern New Brunswick is implemented in conjunction with annual updates to specific fishery management measures (e.g., seasons). For example, it notes a management problem of gear congestion in some rivers and an approach to establish a carrying capacity of the river and find a solution to the gear limit by working with fishermen (DFO, 2006). At this time, an updated Eastern New Brunswick IFMP is not available.

Federal

ASMFC and Enabling Legislation

Authorized under the terms of the Atlantic States Marine Fisheries Compact, as amended (Pub. L. 81–721), the purpose of the ASMFC is to promote the better utilization of the fisheries (marine, shell, and anadromous) of the Atlantic seaboard ''by the development of a joint program for the promotion and protection of such fisheries, and by the prevention of the physical waste of the fisheries from any cause.''

Given management authority in 1993 under the Atlantic Coastal Fisheries Cooperative Management Act (16 U.S.C. 5101–5108), the ASMFC may issue interstate FMPs that must be administered by state agencies. If the ASMFC believes that a state is not in compliance with a coastal FMP, it must notify the Secretaries of Commerce and Interior. If the Secretaries find the state not in compliance with the management plan, the Secretaries must declare a moratorium on the fishery in question.

Atlantic Coastal Fisheries Cooperative Management Act

We manage river herring stocks under the authority of section 803(b) of the Atlantic Coastal Fisheries Cooperative Management Act (Atlantic Coastal Act) 16 U.S.C. 5101 *et seq.*, which states, in the absence of an approved and implemented FMP under the Magnuson-Stevens Act (MSA, 16 U.S.C. 1801 *et seq.*) and, after consultation with the appropriate Fishery Management Council(s), the Secretary of Commerce may implement regulations to govern fishing in the Exclusive Economic Zone (EEZ), i.e., from 3 to 200 nautical mi (nm) offshore. The regulations must be: (1) Compatible with the effective implementation of an Interstate Fishery Management Plan for American Shad and River Herring (ISFMP) developed by the ASMFC; and (2) consistent with the national standards set forth in section 301 of the MSA.

The ASMFC adopted Amendment 2 to the ISFMP in 2009. Amendment 2 establishes the foundation for river herring management. It was developed to address concerns that many Atlantic coast populations of river herring were in decline or are at depressed but stable levels, and that the ability to accurately assess the status of river herring stocks is complicated by a lack of fishery independent data.

Amendment 2 requires states to close their waters to recreational and commercial river herring harvest, unless they have an approved sustainable management plan in place. To be approved, a state's plan must clearly meet the Amendment's standard of a sustainable fishery defined as ''a commercial and/or recreational fishery that will not diminish the potential future stock reproduction and recruitment.'' The plans must meet the definition of sustainability by developing and maintaining sustainability targets. States without an approved plan were required to close their respective river herring fisheries as of January 1, 2012, until such a plan is submitted and approved by the ASMFC's Shad and River Herring Management Board. Proposals to re-open closed fisheries may be submitted annually as part of a state's annual compliance report. Currently, the states of ME, NH, RI, NY, NC, and SC have approved river herring management plans (see ''State section of Factor D'' for more information).

In addition to the state sustainability plan mandate, Amendment 2 makes recommendations to states for the conservation, restoration, and protection of critical river herring habitat. The Amendment also requires states to implement fisheries-dependent and independent monitoring programs, to provide critical data for use in future river herring stock assessments.

While these measures address problems to the river herring populations in coastal areas, incidental catch in small mesh fisheries, such as those for sea herring, occurs outside state jurisdiction and remains a substantial source of fishing mortality according to the ASMFC. Consequently, the ASMFC has requested that the New England and Mid-Atlantic Fishery Management Councils (NEFMC and MAFMC) increase efforts to monitor river herring incidental catch in small-mesh fisheries (See section on ''NEFMC and MAFMC recommendations for future river herring bycatch reduction efforts'').

Magnuson-Stevens Fishery Conservation and Management Act (MSA)

The Magnuson-Stevens Fishery Conservation and Management Act (MSA) is the primary law governing marine fisheries management in Federal waters. The MSA was first enacted in 1976 and amended in 1996 and 2006. Most notably, the MSA aided in the development of the domestic fishing industry by phasing out foreign fishing. To manage the fisheries and promote conservation, the MSA created eight regional fishery management councils. A 1996 amendment focused on rebuilding overfished fisheries, protecting Essential Fish Habitat (EFH), and reducing bycatch. A 2006 amendment mandated the use of Annual Catch Limits (ACL) and Accountability Measures (AM) to end overfishing, provided for widespread market-based fishery management through limited access privilege programs, and called for increased international cooperation.

The MSA requires that Federal FMPs contain conservation and management measures that are consistent with the ten National Standards. National Standard #9 states that conservation and management measures shall, to the extent practicable, (A) minimize bycatch and (B) to the extent bycatch cannot be avoided, minimize the mortality of such bycatch. The MSA defines bycatch as fish that are harvested in a fishery, but which are not sold or kept for personal use. This includes economic discards and regulatory discards. River herring is encountered both as bycatch and incidental catch in Federal fisheries. While there is no directed fishery for river herring in Federal waters, river herring co-occur with other species that have directed fisheries (Atlantic mackerel, Atlantic herring, whiting, squid and butterfish) and are either discarded or retained in those fisheries.

Essential Fish Habitat Under the MSA

Under the MSA, there is a requirement to describe and identify EFH in each Federal FMP. EFH is defined as ''. . . those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.'' The rules promulgated by the NMFS in 1997 and 2002 further clarify EFH with the following definitions: (1) Waters—aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate; (2) substrate—sediment, hard bottom, structures underlying the waters, and associated biological communities; (3) necessary—the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem; and (4) spawning, breeding, feeding, or growth to maturity—stages representing a species' full life cycle.

EFH has not been designated for alewife or blueback herring, though EFH has been designated for numerous other species in the Northwest Atlantic. Measures to improve habitats and reduce impacts resulting from those EFH designations may directly or indirectly benefit river herring. Conservation measures implemented in response to the designation of Atlantic salmon EFH and Atlantic herring EFH likely provide the most conservation benefit to river herring over any other EFH designation. Habitat features used for spawning, breeding, feeding, growth and maturity by these two species encompasses many of the habitat features selected by river herring to carry out their life history. The geographic range in which river herring may benefit from the designation of Atlantic salmon EFH extends from Connecticut to the Maine/Canada border. The geographic range in which river herring may benefit from the designation of Atlantic herring EFH designation extends from the Maine/Canada border to Cape Hatteras.

The Atlantic salmon EFH includes most freshwater, estuary and bay habitats historically accessible to Atlantic salmon from Connecticut to the Maine/Canada border (NEFMC, 2006). Many of the estuary, bay and freshwater habitats within the current and historical range of Atlantic salmon incorporate habitats used by river herring for spawning, migration and juvenile rearing. Among Atlantic herring EFHs are the pelagic waters in the Gulf of Maine, Georges Bank, Southern New England, and middle Atlantic south to Cape Hatteras out to the offshore U.S. boundary of the EEZ (see NEFMC 1998). These areas incorporate nearly all of the U.S. marine areas most frequently used by river herring for growth and maturity. Subsequently, in areas where EFH designations for Atlantic salmon and Atlantic herring overlap with freshwater and marine habitats used by river herring, conservation benefits afforded through the designation of EFH for these species may provide similar benefits to river herring.

Federal Power Act (FPA) (16 U.S.C. 791–828) and Amendments

The FPA, as amended, provides for protecting, mitigating damages to, and enhancing fish and wildlife resources (including anadromous fish) impacted by hydroelectric facilities regulated by the Federal Energy and Regulatory Commission (FERC). Applicants must consult with state and Federal resource agencies who review proposed hydroelectric projects and make recommendations to FERC concerning fish and wildlife and their habitat, e.g., including spawning habitat, wetlands, instream flows (timing, quality, quantity), reservoir establishment and regulation, project construction and operation, fish entrainment and mortality, and recreational access. Section 10(j) of the FPA provides that licenses issued by FERC contain conditions to protect, mitigate damages to, and enhance fish and wildlife based on recommendations received from state and Federal agencies during the licensing process. With regard to fish passage, Section 18 requires a FERC licensee to construct, maintain, and operate fishways prescribed by the Secretary of the Interior or the Secretary of Commerce. Under the FPA, others may review proposed projects and make timely recommendations to FERC to represent additional interests. Interested parties may intervene in the FERC proceeding for any project to receive pertinent documentation and to appeal an adverse decision by FERC.

While the construction of hydroelectric dams contributed to some historical losses of river herring spawning habitat, only a few new dams have been constructed in the range of these species in the last 50 years. In some areas, successful fish passage has been created; thus, restoring access to many habitats once blocked. Thus, river herring may often benefit from FPA fishway requirements when prescriptions are made to address anadromous fish passage and during the re-licensing of existing hydroelectric dams when anadromous species are considered.

Anadromous Fish Conservation Act (16 U.S.C. 757a–757f) as Amended

This law authorizes the Secretaries of Interior and Commerce to enter into cost sharing with states and other non-Federal interests for the conservation, development, and enhancement of the nation's anadromous fish. Investigations, engineering, biological surveys, and research, as well as the construction, maintenance, and operations of hatcheries, are authorized. This Act was last authorized in 2002, which provided 5 million dollars for the fiscal years 2005 and 2006 (Pub. L. 107–372). There was an attempt to reauthorize the Act in 2012; however, this action has not yet been authorized.

Fish and Wildlife Coordination Act (FWCA) (16 U.S.C. 661–666)

The FWCA is the primary law providing for consideration of fish and wildlife habitat values in conjunction with Federal water development activities. Under this law, the Secretaries of Interior and Commerce may investigate and advise on the effects of Federal water development projects on fish and wildlife habitat. Such reports and recommendations, which require concurrence of the state fish and wildlife agency(ies) involved, must accompany the construction agency's request for congressional authorization, although the construction agency is not bound by the recommendations.

The FWCA applies to water-related activities proposed by non-Federal entities for which a Federal permit or license is required. The most significant permits or licenses required are Section 404 and discharge permits under the Clean Water Act and Section 10 permits under the Rivers and Harbors Act. The USFWS and NMFS may review the proposed permit action and make recommendations to the permitting agencies to avoid or mitigate any potential adverse effects on fish and wildlife habitat. These recommendations must be given full consideration by the permitting agency, but are not binding.

Federal Water Pollution Control Act, and amendments (FWPCA) (33 U.S.C. 1251–1376)

Also called the ''Clean Water Act,'' the FWPCA mandates Federal protection of water quality. The law also provides for assessment of injury, destruction, or loss of natural resources caused by discharge of pollutants.

Of major significance is Section 404 of the FWPCA, which prohibits the discharge of dredged or fill material into navigable waters without a permit. Navigable waters are defined under the FWPCA to include all waters of the United States, including the territorial seas and wetlands adjacent to such waters. The permit program is administered by the Army Corps of Engineers (ACOE). The Environmental Protection Agency (EPA) may approve delegation of Section 404 permit authority for certain waters (not including traditional navigable waters) to a state agency; however, the EPA retains the authority to prohibit or deny a proposed discharge under Section 404 of the FWPCA.

The FWPCA (Section 401) also authorizes programs to remove or limit the entry of various types of pollutants into the nation's waters. A point source permit system was established by the EPA and is now being administered at the state level in most states. This system, referred to as the National Pollutant Discharge Elimination System (NPDES), sets specific limits on discharge of various types of pollutants from point source outfalls. A non-point source control program focuses primarily on the reduction of agricultural siltation and chemical pollution resulting from rain runoff into the nation's streams. This effort currently relies on the use of land management practices to reduce surface runoff through programs administered primarily by the Department of Agriculture.

Like the Fish and Wildlife Coordination and River and Harbors Acts, Sections 401 and 404 of the FWPCA have played a role in reducing discharges of pollutants, restricting the timing and location of dredge and fill operations, and affecting other changes that have improved river herring habitat in many rivers and estuaries over the last several decades. Examples include reductions in sewage discharges into the Hudson River (A. Kahnle, New York State DEC, Pers. comm. 1998) and nutrient reduction strategies implemented in the Chesapeake Bay (R. St. Pierre, USFWS, Pers. comm. 1998).

Rivers and Harbors Act of 1899

Section 10 of the Rivers and Harbors Act requires a permit from the ACOE to place structures in navigable waters of the United States or modify a navigable stream by excavation or filling activities.

National Environmental Policy Act of 1969 (NEPA) (42 U.S.C. 4321–4347)

The NEPA requires an environmental review process of all Federal actions. This includes preparation of an environmental impact statement for major Federal actions that may affect the quality of the human environment. Less rigorous environmental assessments are reviewed for most other actions, while some actions are categorically excluded from formal review. These reviews provide an opportunity for the agency and the public to comment on projects that may impact fish and wildlife habitat.

Coastal Zone Management Act (16 U.S.C. 1451–1464) and Estuarine Areas Act

Congress passed policy on values of estuaries and coastal areas through these Acts. Comprehensive planning programs, to be carried out at the state level, were established to enhance, protect, and utilize coastal resources. Federal activities must comply with the individual state programs. Habitat may be protected by planning and regulating development that could cause damage to sensitive coastal habitats.

Federal Land Management and Other Protective Designations

Protection and good stewardship of lands and waters managed by Federal agencies, such as the Departments of Defense, Energy and Interior (National Parks and National Wildlife Refuges, as well as state-protected park, wildlife and other natural areas), contributes to the health of nearby aquatic systems that support important river herring spawning and nursery habitats. Relevant examples include the Great Bay, Rachel Carson's and ACE Basin National Estuarine Research Reserves, Department of Defense properties in the Chesapeake Bay, and many National Wildlife Refuges.

Marine Protection, Research and Sanctuaries Act of 1972 (MPRSA), Titles I and III and the Shore Protection Act of 1988 (SPA)

The MPRSA protects fish habitat through establishment and maintenance of marine sanctuaries. The MPRSA and the SPA regulate ocean transportation and dumping of dredge materials, sewage sludge, and other materials. Criteria that the ACOE uses for issuing permits include considering the effects dumping has on the marine environment, ecological systems and fisheries resources.

Atlantic Salmon ESA Listing and Critical Habitat Designation

In 2009, the Gulf of Maine (GOM) DPS of Atlantic salmon was listed as endangered under the Endangered Species Act (74 FR 29344). The GOM DPS includes all anadromous Atlantic salmon whose freshwater range occurs in the watersheds from the Androscoggin River northward along the Maine coast to the Dennys River. Concurrently in 2009, critical habitat was designated for the Atlantic salmon GOM DPS pursuant to section 4(b)(2) of the ESA (74 FR 29300; August 10, 2009). The critical habitat designation includes 45 specific areas occupied by Atlantic salmon at the time of listing, and includes approximately 12,160 miles (19,600 km) of perennial river, stream, and estuary habitat and 308 square miles (495 sq km) of lake habitat within the range of the GOM DPS in the State of Maine.

Measures to improve habitats and reduce impacts to Atlantic salmon as a result of the ESA listing may directly or indirectly benefit river herring. Atlantic salmon are anadromous and spend a portion of their life in freshwater and the remaining portion in the marine environment. River herring occupy a lot of the same habitats as listed Atlantic salmon for spawning, breeding, feeding, growth and maturity. Therefore, protection measures such as improved fish passage or reduced discharge permits may benefit river herring.

The critical habitat designation provides additional protections beyond classifying a species as endangered by preserving the physical and biological features essential for the conservation of the species in designated waters in Maine. One of the biological features identified in the critical habitat designation for Atlantic salmon was freshwater and estuary migration sites with abundant, diverse native fish communities to serve as a protective buffer against predation. Co-evolved diadromous fish species such as alewives and blueback herring are included in this native fish community. Because the ESA also requires that any Federal agency that funds, authorizes, or carries out an action ensure that the action does not adversely modify or destroy designated critical habitat, the impacts to alewife and blueback herring populations must be considered during consultation with NMFS to ensure that Atlantic salmon critical habitat is not adversely affected by a Federal action.

Atlantic Sturgeon ESA Listing

In 2012, five distinct population segments of Atlantic sturgeon were listed under the ESA (77 FR 5914; 77 FR 5880). The Chesapeake Bay, New York Bight, Carolina, and South Atlantic DPSs of Atlantic sturgeon are listed as endangered, while the Gulf of Maine DPS is listed as threatened.

Measures to improve habitats and reduce impacts to Atlantic sturgeon may directly or indirectly benefit river herring. Atlantic sturgeon are anadromous; adults spawn in freshwater in the spring and early summer and migrate into estuarine and marine waters where they spend most of their lives. As with Atlantic salmon, many of the habitats that Atlantic sturgeon occupy are also habitats that river herring use for spawning, migration and juvenile rearing. The geographic range in which river herring may benefit from Atlantic sturgeon ESA protections extends from the Maine/Canada border to Florida. Therefore, any protection measures within this range such as improved fish passage or a reduction of water withdrawals may also provide a benefit to river herring.

State Regulations

A historical review of state regulations was compiled and published in Volume I of the stock assessment. The following section on state regulations includes current requirements only and is cited from Volume I of the assessment as compiled by Dr. Gary Nelson and Kate Taylor (ASMFC, 2012). Otherwise, updates are provided by Kate Taylor, supplemental information from state river herring plans or state regulations.

Maine

In Maine, the Department of Marine Resources (DMR), along with municipalities granted the rights to harvest river herring resources, cooperatively manage municipal fisheries. Each town must submit an annual harvesting plan to DMR for approval that includes a 3-day per week escapement period or biological equivalent to ensure conservation of the resource. In some instances, an escapement number is calculated and the harvester passes a specific number upstream to meet escapement goals. River herring runs not controlled by a municipality and not approved as sustainable by the ASMFC River Herring and American Shad Management Board, as required under Amendment 2, are closed. Each run and harvest location is unique, either in seasonality, fish composition, or harvesting limitations. Some runs have specific management plans that require continuous escapement and are more restrictive than the 3-day closed period. Others have closed periods shorter than the 3-day requirement, but require an escapement number, irrespective of the number harvested during the season. Maine increased the weekly fishing closure from a 24-hour closure in the 1960s to a 48-hour closure beginning in 1988. The closed period increased to 72 hours beginning in 1995 to protect spawning fish. Most towns operate a weir at one location on each stream and prohibit fishing at any other location on the stream. The state landings program compiles in-river landings of river herring from mandatory reports provided by the municipality under each municipal harvest plan or they lose exclusive fishing rights. The state permitted 22 municipalities to fish for river herring in 2011. The river specific management plans require the remaining municipalities to close their runs for conservation and not harvest. There are several reasons for these state/municipal imposed restrictions on the fishery. Many municipalities voluntarily restrict harvest to increase the numbers of fish that return in subsequent years. Some of these runs are large but have the potential to become even larger. The commercial fishery does not exploit the estimated 1.5 to 2.0 million river herring that return to the East Machias River annually. These regulations have been approved through a sustainable fisheries management plan, as required under ASMFC Amendment 2 to the Shad and River Herring FMP (Taylor, Pers. Comm., 2013).

Recreational fishermen are allowed to fish for river herring year-round. The limit is 25 fish per day and gear is restricted to dip net and hook-and-line. Recreational fishermen may not fish in waters, or in waters upstream, of a municipality that owns fishing rights. Recreational fishermen are not required to report their catch. The MRFSS and MRIP programs do sample some of these fishermen based on results queried from the database. Recreational fishing for river herring in Maine is limited and landings are low. These regulations have been approved through a sustainable fisheries management plan, as required under ASMFC Amendment 2 to the Shad and River Herring FMP (Taylor, Pers. Comm., 2013).

New Hampshire

The current general regulations are: (1) No person shall take river herring, alewives and blueback herring, from the waters of the state, by any method, between sunrise Wednesday and sunrise Thursday of any week; (2) any trap or weir used during a specified time period, shall be constructed so as to allow total escapement of all river herring; and (3) any river herring taken by any method during the specified time period shall be immediately released back into the waters from which it was taken. Specific river regulations are: Taylor River—from the railroad bridge to the head of tide dam in Hampton shall be closed to the taking of river herring by netting of any method; and Squamscott River—during April, May and June, the taking of river herring in the Squamscott River and its tributaries from the Rt. 108 Bridge to the Great Dam in Exeter is open to the taking of river herring by netting of any method only on Saturdays and Mondays, the daily limit shall be one tote per person (''tote'' means a fish box or container measuring 31.5 in (80.01cm) × 18 in (45.72 cm) × 11.5 in (29.21cm)) and the tote shall have the harvester's coastal harvest permit number plainly visible on the outside of the tote. These regulations have been approved through a sustainable fisheries management plan, as required under ASMFC Amendment 2 to the Shad and River Herring FMP.

Massachusetts

As of January 1, 2012, commercial and recreational harvest of river herring was prohibited in Massachusetts, as required by ASMFC Amendment 2 to the Shad and River Herring FMP (Taylor, Pers. Comm., 2013). The exception is for federally permitted vessels which are allowed to land up to 5 percent of total bait fish per trip (Taylor, Pers. Comm., 2013).

Rhode Island

The Rhode Island Division of Fish and Wildlife (RIDFW) will implement a 5 percent bycatch allowance for Federal vessels fishing in the Atlantic herring fishery in Federal waters. RIDFW will also implement a mandatory permitting process that will require vessels wanting to fish in the Rhode Island waters Atlantic herring fishery to, amongst other requirements, integrate in to the University of Massachusetts Dartmouth, School for Marine Science and Technology, river herring bycatch monitoring program to ensure monitoring of the fishery and minimize bycatch. As of Jan 1, 2013, there is a prohibition to land, catch, take, or attempt to catch or take river herring which is a continuation of measures that RIDFW has had in place since 2006 when a moratorium was originally established (Taylor, Pers. comm., 2013).

Connecticut

Since April 2002, there has been a prohibition on the commercial or recreational taking of migratory alewives and blueback herring from all marine waters and most inland waters. As of January 1, 2012, commercial and recreational harvest of river herring was prohibited in Connecticut, as required by ASMFC Amendment 2 to the Shad and River Herring FMP (Taylor, Pers. Comm., 2013).

New York

Current regulations allow for a restricted river herring commercial and recreational fishery in the Hudson River and tributaries, while all other state waters prohibit river herring fisheries. These regulations have been approved through a sustainable fisheries management plan, as required under ASMFC Amendment 2 to the Shad and River Herring FMP.

New Jersey/Delaware

As of January 1, 2012, commercial harvest of river herring was prohibited in New Jersey and Delaware, as required by ASMFC Amendment 2 to the Shad and River Herring FMP. Additionally, only commercial vessels fishing exclusively in Federal waters while operating with a valid Federal permit for Atlantic mackerel and/or Atlantic herring may possess river herring up to a maximum of five percent by weight of all species possessed (Taylor, Pers. Comm.).

Maryland

As of January 1, 2012, commercial harvest of river herring was prohibited in Maryland, as required by ASMFC Amendment 2 to the Shad and River Herring FMP. However, an exception is provided for anyone in possession of river herring as bait, as long as a receipt indicating where the herring was purchased is in hand (Taylor, Pers. comm). This will allow bait shops to sell, and fishermen to possess, river herring for bait that was harvested from a state whose fishery remains open, as an ASMFC approved sustainable fishery (Taylor, Pers. Comm).

Potomac River Fisheries Commission (PRFC)/District of Columbia

The PRFC regulates only the mainstem of the river, while the tributaries on either side are under Maryland and Virginia jurisdiction. The District of Columbia's Department of the Environment (DDOE) has authority for the Potomac River to the Virginia shore and other waters within District of Columbia. Today, the river herring harvest in the Potomac is almost exclusively taken by pound nets. In 1964, licenses were required to commercially harvest fish in the Potomac River. After Maryland and Virginia established limited entry fisheries in the 1990s, the PRFC responded to industry's request and, in 1995, capped the Potomac River pound net fishery at 100 licenses. As of January 1, 2010, harvest of river herring was prohibited in the Potomac River, with a minimal bycatch provision of 50 lb (22 kg) per licensee per day for pound nets. These regulations have been approved through a sustainable fisheries management plan, as required under ASMFC Amendment 2 to the Shad and River Herring FMP.

Virginia

Virginia's Department of Game and Inland Fisheries (VDGIF) is responsible for the management of fishery resources in the state's inland waters. As of January 1, 2008, possession of alewives and blueback herring was prohibited on rivers draining into North Carolina (4 VAC 15–320–25). The Virginia Marine Resources Commission (VMRC) is responsible for management of fishery resources within the state's marine waters. As of January 1, 2012, commercial and recreational harvest of river herring was prohibited in all waters of Virginia, as required by ASMFC Amendment 2 to the Shad and River Herring FMP. Additionally, it is unlawful for any person to possess river herring aboard a vessel on Virginia tidal waters, or to land any river herring in Virginia (4 VAC 20–1260–30).

North Carolina

A no harvest provision for river herring, commercial and recreational, within North Carolina was approved in 2007. A limited research set aside of 7,500 lb (3.4 mt) was established, and to implement this harvest, a Discretionary Herring Fishing Permit (DHFP) was created. Individuals interested in participating had to meet the following requirements: (1) Obtain a DHFP, (2) harvest only from the Joint Fishing Waters of Chowan River during the harvest period, (3) must hold a valid North Carolina Standard Commercial Fishing License (SCFL) or a Retired SCFL, and (4) participate in statistical information and data collection programs. Sale of harvested river herring had to be to a licensed and permitted River Herring Dealer. Each permit holder was allocated 125–250 lb (56–113 kg) for the 4-day season during Easter weekend. These regulations were approved through a sustainable fisheries management plan, as required under ASMFC Amendment 2 to the Shad and River Herring FMP. The North Carolina Wildlife Resources Commission (NCWRC) has authority over the Inland Waters of the state. Since July 1, 2006, harvest of river herring, greater than 6 inches (15.24 cm) has been prohibited in the inland waters of North Carolina's coastal systems.

South Carolina

In South Carolina, the South Carolina Division of Natural Resources (SCDNR) manages commercial herring fisheries using a combination of seasons, gear restrictions, and catch limits. Today, the commercial fishery for blueback herring has a 10-bushel daily limit (500 lb (226 kg)) per boat in the Cooper and Santee Rivers and the Santee-Cooper Rediversion Canal and a 250-lb-per-boat (113 kg) limit in the Santee-Cooper lakes. Seasons generally span the spawning season. All licensed fishermen have been required to report their daily catch and effort to the SCDNR since 1998.

The recreational fishery has a 1-bushel (49 lb (22.7 kg)) fish aggregate daily creel for blueback herring in all rivers; however, very few recreational anglers target blueback herring. These regulations have been approved through a sustainable fisheries management plan, as required under ASMFC Amendment 2 to the Shad and River Herring FMP.

Georgia

The take of blueback herring is illegal in freshwater in Georgia. As of January 1, 2012, harvest of river herring was prohibited in Georgia, as required by ASMFC Amendment 2 to the Shad and River Herring FMP.

Florida

The St. Johns River, Florida, harbors the southernmost spawning run of blueback herring. There is currently no active management of blueback herring in Florida. As of January 1, 2012, harvest of river herring was prohibited, as required by ASMFC Amendment 2 to the Shad and River Herring FMP.

Tribal and First Nation Fisheries

We have identified thirteen federally recognized East Coast tribes from Maine to South Carolina that have tribal rights to sustenance and ceremonial fishing, and which may harvest river herring for sustenance and ceremonial purposes and/or engage in other river herring conservation and management activities. The Mashpee Wampanoag tribe is the only East Coast tribe that voluntarily reported harvest numbers to the State of MA that were incorporated into the ASMFC Management Plan as subsistence harvest. The reported harvest for 2006 and 2008 ranged between 1,200 and 3,500 fish per year, with removals coming from several rivers. Aside from the harvest reported by ASMFC for the Mashpee Wampanoag tribe, information as to what tribes may harvest river herring for sustenance and/or ceremonial purposes is not available. Letters have been sent to all 13 potentially affected tribes to solicit any input they may have on the conservation status of the species and/or health of particular riverine populations, tribal conservation and management activities for river herring, biological data for either species, and comments and/or concerns regarding the status review process and potential implications for tribal trust resources and activities. To date, we have not received any information from any tribes.

Summary and Evaluation for Factor D

As described in Factor A, there are multiple threats to habitat that have affected and may continue to affect river herring including dams/culverts, dredging, water quality, water withdrawals and discharge. However, many of these threats are being addressed to some degree through existing Federal legislation such as the Federal Water Pollution Control Act, also known as the Clean Water Act, the Coastal Zone Management Act, the Rivers and Harbors Act, the FPA, Marine Protection, Research and Sanctuaries Act of 1972, the Shore Protection Act of 1988, EFH designations for other species and ESA listings for Atlantic salmon and Atlantic sturgeon.

Commercial harvest of alewife and blueback herring is occurring in Canada with regulations, closures, and quotas in effect. In the United States, commercial harvest of alewife and blueback herring is also currently occurring in a few states with regulations that have been approved through a sustainable fisheries management plan, as required under ASMFC Amendment 2 to the Shad and River Herring FMP. All other states had previously established moratoria or, as of January 1, 2012, harvest of river herring was prohibited, as required by ASMFC Amendment 2 to the Shad and River Herring FMP. However, river herring are incidentally caught in several commercial fisheries, but the extent to which this is occurring has not been fully quantified. The New England and Mid-Atlantic Fishery Management Councils have adopted measures for the Atlantic herring and mackerel fisheries intended to decrease incidental catch and bycatch of alewife and blueback herring. In the United States, thirteen federally recognized East Coast tribes from Maine to South Carolina have tribal rights to sustenance and ceremonial fishing, and may harvest river herring for sustenance and ceremonial purposes and/or engage in other river herring conservation and management activities. We have further evaluated the existing international, Federal, and state management measures in the qualitative threats assessment section below.

E. Other Natural or Manmade Factors Affecting the Continued Existence of the Species

Competition

Intra- and inter-specific competition were considered as potential natural threats to alewife and blueback herring. The earlier spawning time of alewife may lead to differences in prey selection from blueback herring, given that they become more omnivorous with increasing size (Klauda *et al.,* 1991a). This could lead to differences in prey selection given that juvenile alewife would achieve a greater age and size earlier than blueback herring. Juvenile American shad are reported to focus on different prey than blueback herring (Klauda *et al.,* 1991b). However, Smith and Link (2010) found few differences between American shad and blueback herring diets across geographic areas and size categories; therefore, competition between these two species may be occurring. Cannibalism has been observed (rarely) in landlocked systems with alewife. Additionally, evidence of hybridization exists between alewife and blueback herring, but the implications of this are unknown. Competition for habitat or resources has not been documented with alewife/blueback herring hybrids, as there is little documentation of hybridization in published literature, but given the unknowns about their life history, it is possible that competition between non-hybrids and hybrids could be occurring.

Artificial Propagation and Stocking

Genetics data have shown that stocking alewife and blueback herring within and out of basin in Maine has had an impact on the genetic groupings within Maine (Bentzen, 2012, unpublished data); however, the extent to which this poses a threat to river herring locally or coast-wide is unknown. Stocking river herring directly impacts a specific river/watershed system for river herring in that it can result in passing fish above barriers into suitable spawning and rearing habitat, expanding populations into other watersheds, and introducing fish to newly accessible spawning habitat.

The alewife restoration program in Merrymeeting Bay, Maine, focuses on stocking lakes and ponds in the Sebasticook River watershed and Seven Mile Stream drainage. The highest number of stocked fish was 2,211,658 in 2009 in the Sebasticook River and 93,775 in 2008 in the Kennebec River. The annual stocking goal of the restoration projects range from 120,000 to 500,000 fish, with most fish stocked in the Androscoggin and Sebasticook watersheds. The Union River fishery in Ellsworth, Maine, is sustained through the stocking of adult alewives above the hydropower dam at the head-of-tide. Fish passage is not currently required at this dam, but fish are transported around the dam to spawning habitat in two lakes. The annual adult stocking rate (from 2011 forward) is 150,000 fish. Adult river herring are trapped at a commercial harvest sites below the dam and trucked to waters upstream of the dam. The highest number of stocked fish in the Union River was 1,238,790 in 1986. In the Penobscot River watershed, over 48,000 adult fish were stocked into lakes in 2012, using fish collected from the Kennebec (39,650) and Union Rivers (8,998). The New Hampshire Fish and Game stocks river herring into the Nashua River, the Pine Island Pond, and the Winnisquam Lake using fish from various rivers which have included the Connecticut, Cocheco, Lamprey, Kennebec, and Androscoggin Rivers. MA Division of Marine Fisheries (DMF) conducts a trap and transport stocking program for alewife and blueback herring. Prior to the moratorium in the state, the program transported between 30,000 and 50,000 fish per year into 10–15 different systems. Since the moratorium, effort has been reduced to protect donor populations and approximately 20,000 fish per year have been deposited into five to ten systems. Many of the recent efforts have been within system, moving fish upstream past multiple obstructions to the headwater spawning habitat. Rhode Island's Department of Environmental Management (DEM) has been stocking the Blackstone River with adult broodstock which was acquired from existing Rhode Island river herring runs and other sources out of state. In April 2012, over 2,000 river herring pre-spawned adults were stocked into the Blackstone River. A small number of alewife (200–400 fish) were stocked in the Bronx River, NY, in 2006 and 2007 from Brides Brook in East Lyme, CT. Furthermore, an experimental stocking program exists in Virginia where hatchery broodstock are marked and stocked into the Kimages Creek, a tributary to the James River. A total of 319,856 marked river herring fry were stocked in this creek in 2011.

The Edenton National Fish Hatchery (NFH) in North Carolina and the Harrison Lake NFH in Virginia have propagated blueback herring for restoration purposes. Edenton NFH is currently rearing blueback herring for stocking in Indian Creek and Bennett's Creek in the Chowan River watershed in Virginia. This is a pilot project to see if hatchery contribution makes a significant improvement in runs of returning adults (S. Jackson, USFWS, Pers. comm., 2012). Artificial propagation through the Edenton NFH for the pilot program in the Chowan River watershed is intended for restoration purposes, and it is not thought that negative impacts to anadromous blueback herring populations will be associated with these efforts.

Landlocked Alewife and Blueback Herring

As noted above, alewives and blueback herring maintain two life history variants; anadromous and landlocked. It is believed that they diverged relatively recently (300 to 5,000 years ago) and are now discrete from each other. Landlocked alewife populations occur in many freshwater lakes and ponds from Canada to North Carolina as well as the Great Lakes (Rothschild, 1966; Boaze & Lackey, 1974). Landlocked blueback herring occur mostly in the southeastern United States and the Hudson River drainage. At this time, there is no substantive information that would suggest that landlocked populations can or would revert back to an anadromous life history if they had the opportunity to do so (Gephard and Jordaan, Pers. comm., 2012). The discrete life history and morphological differences between the two life history variants provide substantial evidence that upon becoming landlocked, landlocked herring populations become largely independent and separate from anadromous populations. Landlocked populations and anadromous populations occupy largely separate ecological niches, especially in respect to their contribution to freshwater, estuary and marine food-webs (Palkovacs and Post, 2008). Thus, the existence of landlocked life forms does not appear to pose a significant threat to the anadromous forms.

Interbreeding Among Alewife and Blueback Herring (Hybridization)

Recent genetic studies indicate that hybridization may be occurring in some instances among alewife and blueback herring where populations overlap (discussed in the River Herring Stock Structure Working Group Report, NMFS, 2012a). Though interbreeding among closely related species is uncommon, it does occasionally occur (Levin, 2002). Most often, different reproductive strategies, home ranges, and habitat differences of closely related species either prevent interbreeding, or keep interbreeding at very low levels. In circumstances where interbreeding does occur, natural selection often keeps hybrids in check because hybrids are less fit in terms of survival or their ability to breed successfully (Levin, 2002). Other times, intermediate environmental conditions can provide an environment where hybrids can thrive, and when hybrids breed with the member of the parent species, this can lead to ''mongrelization'' of one or both parent species; a process referred to as introgressive hybridization (Arnold, 1997). Introgressive hybridization can also occur as a result of introductions of closely related species, or man-made or natural disturbances that create environments more suitable for the hybrid offspring than for the parents (e.g., the introduction of mallards has led to the decline of the American black duck through hybridization and introgression) (Anderson, 1949; Rhymer, 2008).

Though evidence has come forward that indicates that some hybridization may be occurring between alewife and blueback herring, there is not enough evidence to conclude whether or not hybridization poses a threat to one or both species of river herring. Most importantly, there is not enough evidence to show whether hybrids survive to maturity and, if so, whether they are capable of breeding with each other or breeding with either of the parent species.

Summary and Evaluation of Factor E

The potential for inter- and intra-specific competition has been investigated with respect to alewife and blueback herring. Differences have been observed in the diel activity patterns and in spawning times of anadromous alosids, and this may reduce inter- and intra- specific competition. However, it is possible that competition is occurring, as similarities in prey choice have been identified. Stocking is a tool that managers have used for hundreds of years with many different species of fish. This tool has been used as a means of supporting restoration (e.g., passing fish above barriers into suitable spawning and rearing habitat, expanding populations into other watersheds, and introducing fish to newly accessible spawning habitat). In addition, stocking has been used to introduce species to a watershed for recreational purposes. Stocking of river herring has occurred for many years in Maine watersheds, but is less common throughout the rest of the range of both species. Stocking in the United States has consisted primarily of trap and truck operations that move fish from one river system to another or over an impassible dam. Artificial propagation of river herring is not occurring to a significant extent, though blueback herring are being reared on a small scale for experimental stocking in North Carolina.

We have considered natural or manmade factors that may affect river herring, including competition, artificial propagation and stocking, landlocked river herring, and hybrids. Several potential natural or manmade threats to river herring were identified, and we have considered the effects of these potential threats further in the qualitative threats assessment described below.

Threats Evaluation for Alewife and Blueback Herring

During the course of the Status Review for river herring, 22 potential threats to alewife and blueback herring were identified that relate to one or more of the five ESA section 4(a)(1) factors identified above. The SRT conducted a qualitative threats assessment (QTA) to help evaluate the significance of the threats to both species of river herring now and into the foreseeable future. NMFS has used qualitative analyses to estimate extinction risk in previous status reviews on the West Coast (e.g., Pacific salmon, Pacific herring, Pacific hake, rockfish, and eulachon) and East Coast (e.g., Atlantic sturgeon, cusk, Atlantic wolffish), and the River Herring SRT developed a qualitative ranking system that was adapted from these types of qualitative analyses. The results from the threats assessment have been organized and described according to the above mentioned section 4(a)(1) factors. They were used in combination with the results of the extinction risk modeling to make a determination as to whether listing is warranted.

When ranking each threat, Team members considered how various demographic variables (e.g., abundance, population size, productivity, spatial structure and genetic diversity) may be affected by a particular threat. While Factor D, ‘‘inadequacy of existing regulatory mechanisms,’’ is a different type of factor, the impacts on the species resulting from unregulated or inadequately regulated threats should be evaluated in the same way as the other four factors.

QTA Methods

All nine SRT members conducted an independent, qualitative ranking of the severity of each of the 22 identified threats to alewives and blueback herring. NERO staff developed fact sheets for the SRT that contained essential information about the particular threats under each of the five ESA section 4(a)(1) factors, attempts to ameliorate these threats, and how the threats are or may be affecting both species. These fact sheets were reviewed by various experts within NMFS to ensure that they contained all of the best available information for each of the factors.

Team members ranked the threats separately for both species at a rangewide scale and at the individual stock complex level. Each Team member was allotted five likelihood points to rank each threat. Team members ranked the severity of each threat through the allocation of these five likelihood points across five ranks ranging from ‘‘low’’ to ‘‘high.’’ Each Team member could allocate all five likelihood points to one rank or distribute the likelihood points across several ranks to account for any uncertainty. Each individual Team member distributed the likelihood points as he/she deemed appropriate with the condition that all five likelihood points had to be used for each threat. Team members also had the option of ranking the threat as ‘‘0’’ to indicate that in their opinion there were insufficient data to assign a rank, or ‘‘N/A’’ if in their opinion the threat was not relevant to the species either throughout its range or for individual stock complexes. When a Team member chose either N/A (Not Applicable) or 0 (Unknown) for a threat, all 5 likelihood points had to be assigned to that rank only. Qualitative descriptions of ranks for the threats listed for alewife and blueback herring (Table 1, 2) are:

- N/A—Not Applicable.
- 0—Unknown.
- 1 Low—It is likely that this threat is not significantly affecting the species now and into the foreseeable future, and that this threat is limited in geographic scope or is localized within the species/stock complex’ range.
- 2 Moderately Low—Threat falls between rankings 1 and 3.
- 3 Moderate—It is likely that this threat has some effect on the species now and into the foreseeable future, and it is widespread throughout the species/stock complex’ range.
- 4 Moderately High—Threat falls between rankings 3 and 5.
- 5 High—It is likely that this threat is significantly affecting the species now and into the foreseeable future, and it is widespread in geographic scope and pervasive throughout the species/stock complex’ range.

The SRT identified and ranked 22 threats to both species both rangewide and for the individual stock complexes. Threats included dams and barriers, dredging, water quality and water withdrawals, climate change/variability, harvest (both directed and incidental), disease, predation, management internationally, federally, and at the state level, competition, artificial propagation and stocking, hybrids, and from landlocked populations.

QTA Results

The SRT unequivocally identified dams and barriers as the most important threat to alewife and blueback herring populations both rangewide and across all stock complexes (the qualitative ranking for dams and barriers was between moderately high and high). Incidental catch, climate change, dredging, water quality, water withdrawal/outfall, predation, and existing regulation were among the more important threats after dams for both species, and for all stock complexes (qualitative rankings for these threats ranged between moderately low and moderate). Water quality, water withdrawal/outfall, predation, climate change and climate variability were generally seen as greater threats to both species in the southern portion of their ranges than in the northern portion of their ranges. In addition, the Team identified commercial harvest as being notably more important in Canada than in the United States. The results of the threats analysis for alewives are presented in Tables 1–5 and Figure 3. The results of the threats analysis for blueback herring are presented in Tables 6–10 and Figure 4.

QTA Conclusion

The distribution of rankings across threat levels provides a way to evaluate certainty in the threat level for each of the threats identified. The amount of certainty for a threat is a reflection of the amount of evidence that links a particular threat to the continued survival of each species. For threats with more data, there tended to be more certainty surrounding the threat level, whereas threats with fewer data tended to have more uncertainty. The same holds true for datasets that were limited over space and/or time.

The results of the threats assessment rangewide and for all stock complexes reveal strong agreement and low uncertainty among the reviewers that dams and barriers are the greatest threat to both alewives and blueback herring. There was also strong agreement that tribal fisheries, scientific monitoring, and educational harvest currently pose little threat to the species. For the threats of state, Federal and international management, dredging, climate change, climate variability, predation, and incidental catch, there was more uncertainty.

Among alewife and blueback stock complexes, Canada, the Mid-Atlantic, and South Atlantic diverged the most from the other stock complexes with respect to certainty of threats. In Canada there was more certainty surrounding the threats of climate change and climate variability for both species, and less certainty surrounding the threat of directed commercial harvest and incidental catch for alewives compared to the certainty surrounding these threats for the other stock complexes. In the mid-Atlantic for alewives and South-Atlantic for bluebacks, there was more uncertainty surrounding climate variability and climate change compared to the certainty surrounding these threats for the other stock complexes.

Based on the Team member rankings, dams and other barriers present the greatest and most persistent threat rangewide to both blueback herring and alewife (Tables 12–13). Dams and culverts block access to historical migratory corridors and spawning locations, in some instances, even when fish passage facilities are present. Centuries of blocked and reduced access to spawning and rearing habitat have resulted in decreased overall production potential of watersheds along the Atlantic coast for alewives and blueback herring (Hall *et al.,* 2012). This reduced production potential has likely been one of the main drivers in the decreased abundance of both species. The recent ASMFC Stock Assessment (2012) attempted to quantify biomass estimates for both alewife and blueback herring but was unable to develop an acceptable model to complete a biomass estimate. Therefore, it is difficult to accurately quantify the declines from historical biomass to present-day biomass, though significant declines have been noted. Studies from Maine show that dams have reduced accessible habitat to a fraction of historical levels, 5 percent for alewives and 20 percent for blueback herring (Hall *et al.,* 2011).

Rangewide, for alewife and blueback herring, no other threats rose to the level of dams, but several other stressors ranked near the moderate threat level. The Team ranked incidental catch, water quality, and predation as threats likely to have some effect on the species now and into the foreseeable future that are widespread throughout the species' range. Incidental catch is primarily from fisheries that use small-mesh mobile gear, such as bottom and midwater trawls. Sources of water quality problems vary from river to river and are therefore unique to each of the stock complexes. And finally, predation by striped bass, seals, double-crested cormorants (and other fish-eating avian species, e.g., northern gannets) and other predators is known to exist, but data are lacking on the overall magnitude. Overall, the degree of certainty associated with these mid-level threats is much lower, primarily due to lack of information on how these stressors are affecting both species.

The SRT's qualitative rankings and analysis of threats for alewife rangewide and for each stock complex:

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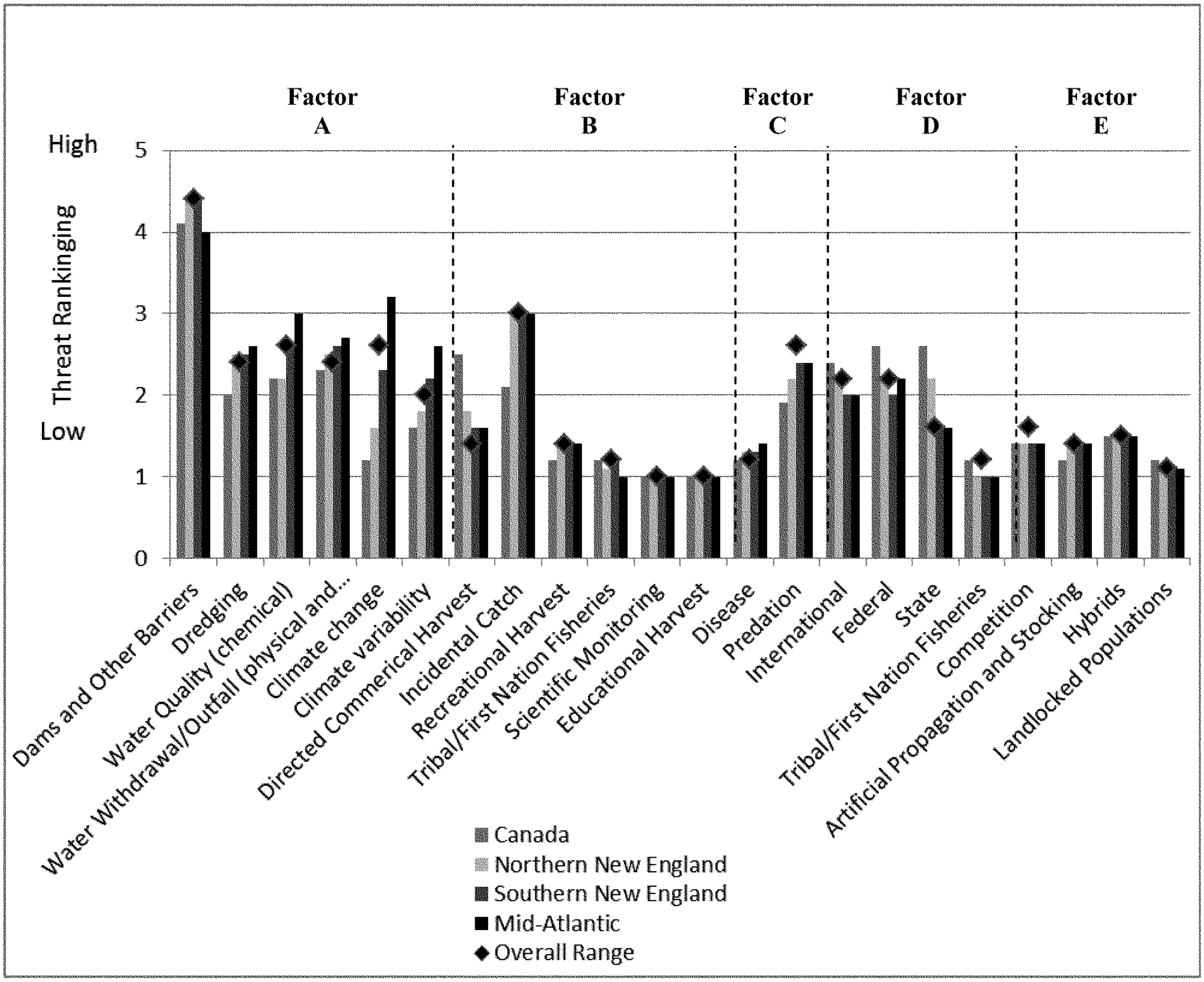

Figure 3. Median qualitative ranking of threats to alewives range-wide and for each stock complex.

Table 1. Qualitative ranking of threats for the alewife rangewide. Status Review Team members ranked threats by distributing 5 likelihood points among 5 ranks: 1- low, 2- medium/low, 3- medium, 4-medium/high, 5-high. The mean represents the overall Team average rank, mode represents the rank which received the most likelihood points, and range represents the range of ranks that were assigned likelihood points for each threat. N=number of Team members who ranked the threat between 1 and 5; likelihood points for threats that Team members ranked as either unknown or not applicable are not included.

Threats	Mean	SD	Mode	Range	N
Dams and Other Barriers	4.3	0.7	5	3-5	9
Water Quality (chemical)	2.8	1.0	3	1-5	9
Incidental Catch	2.7	0.9	3	1-5	9
Predation	2.6	1.1	3	1-5	9
Water Withdrawal/Outfall (physical and temp.)	2.4	0.8	2	1-5	9
Dredging	2.4	1.0	2	1-4	9
Climate change	2.4	0.9	3	1-4	8
Climate variability	2.3	1.1	2	1-5	9
Federal Management	2.3	1.1	2	1-5	9
International Management	2.3	1.1	2	1-5	9
State Management	2.2	1.2	1	1-5	9
Directed Commercial Harvest	1.8	0.8	2	1-3	9
Competition	1.6	0.7	1	1-4	9
Artificial Propagation and Stocking	1.5	0.7	1	1-3	9
Hybrids	1.5	0.7	1	1-3	2
Recreational Harvest	1.4	0.6	1	1-3	9
Tribal/First Nation Fisheries Management	1.3	0.5	1	1-3	7
Disease	1.3	0.4	1	1-2	8
Landlocked Populations	1.2	0.5	1	1-3	8
Tribal/First Nation Fisheries Utilization	1.2	0.4	1	1-2	8
Scientific Monitoring	1.0	0.2	1	1-2	9
Educational Harvest	1.0	0.1	1	1-2	9

Table 2. Qualitative ranking of threats for the Canadian stock complex of alewife. Status Review Team members ranked threats by distributing 5 likelihood points among 5 ranks: 1- low, 2-medium/low, 3- medium, 4-medium/high, 5-high. The mean represents the overall Team average rank, mode represents the rank which received the most likelihood points, and range represents the range of ranks that were assigned likelihood points for each threat. N=number of Team members who ranked the threat between 1 and 5; likelihood points for threats that Team members ranked as either unknown or not applicable are not included.

Threats	Mean	SD	Mode	Range	N
Dams and Other Barriers	4.0	0.9	5	2-5	8
State Management	2.4	0.9	2	1-4	6
Incidental Catch	2.4	1.2	1	1-5	6
Federal Management	2.4	0.9	2	1-4	6
Water Withdrawal/Outfall (physical and temp.)	2.3	0.7	2	1-3	6
Directed Commercial Harvest	2.2	0.9	2	1-4	8
International Management	2.2	0.9	2	1-4	8
Water Quality (chemical)	2.1	0.7	2	1-3	7
Predation	2.1	1.0	2	1-5	8
Dredging	2.0	0.7	2	1-4	6
Climate variability	1.9	0.9	2	1-5	8
Climate change	1.6	0.7	1	1-4	8
Hybrids	1.5	0.7	1	1-3	2
Competition	1.4	0.5	1	1-3	9
Disease	1.3	0.5	1	1-2	7
Artificial Propagation and Stocking	1.3	0.5	1	1-3	7
Tribal/First Nation Fisheries Management	1.2	0.4	1	1-2	5
Recreational Harvest	1.2	0.4	1	1-2	6
Tribal/First Nation Fisheries Utilization	1.2	0.4	1	1-2	6
Landlocked Populations	1.1	0.3	1	1-2	7
Scientific Monitoring	1.0	0.2	1	1-2	6
Educational Harvest	1.0	0.0	1	1	6

Table 3. Qualitative ranking of threats for the Northern New England stock complex of alewife. Status Review Team members ranked threats by distributing 5 likelihood points among 5 ranks: 1- low, 2-medium/low, 3- medium, 4-medium/high, 5-high. The mean represents the overall Team average rank, mode represents the rank which received the most likelihood points, and range represents the range of ranks that were assigned likelihood points for each threat. N=number of Team members who ranked the threat between 1 and 5; likelihood points for threats that Team members ranked as either unknown or not applicable are not included.

Threats	Mean	SD	Mode	Range	N
Dams and Other Barriers	4.3	0.7	5	3-5	9
Incidental Catch	2.9	0.8	3	1-5	7
Water Withdrawal/Outfall (physical and temp.)	2.5	0.9	3	1-5	8
Dredging	2.4	0.9	2,3	1-4	8
State Management	2.4	1.1	2	1-5	9
Predation	2.4	1.2	2	1-5	9
Federal Management	2.4	1.1	2	1-5	9
International Management	2.2	0.9	2	1-4	9
Water Quality (chemical)	2.1	1.0	1	1-5	9
Climate variability	2.0	1.0	2	1-5	9
Directed Commercial Harvest	1.9	0.9	1	1-4	9
Climate change	1.8	0.8	1	1-4	8
Artificial Propagation and Stocking	1.6	0.7	1	1-3	9
Hybrids	1.5	0.7	1	1-3	2
Competition	1.5	0.6	1	1-3	9
Recreational Harvest	1.3	0.5	1	1-3	9
Disease	1.3	0.5	1	1-2	8
Landlocked Populations	1.2	0.4	1	1-2	8
Tribal/First Nation Fisheries Management	1.2	0.4	1	1-2	7
Tribal/First Nation Fisheries Utilization	1.1	0.3	1	1-2	8
Scientific Monitoring	1.0	0.1	1	1-2	9
Educational Harvest	1.0	0.0	1	1	9

Table 4. Qualitative ranking of threats for the Southern New England stock complex of alewife. Status Review Team members ranked threats by distributing 5 likelihood points among 5 ranks: 1- low, 2-medium/low, 3- medium, 4-medium/high, 5-high. The mean represents the overall Team average rank, mode represents the rank which received the most likelihood points, and range represents the range of ranks that were assigned likelihood points for each threat. N=number of Team members who ranked the threat between 1 and 5; likelihood points for threats that Team members ranked as either unknown or not applicable are not included.

Threats	Mean	SD	Mode	Range	N
Dams and Other Barriers	4.2	0.7	4	3-5	9
Incidental Catch	2.9	0.8	3	1-5	7
Water Withdrawal/Outfall (physical and temp.)	2.7	0.8	3	1-5	8
Water Quality (chemical)	2.5	0.9	3	1-5	9
Predation	2.5	1.1	2	1-5	9
Dredging	2.5	0.9	3	1-4	8
Federal Management	2.2	1.1	2	1-5	9
Climate variability	2.2	1.0	2	1-5	9
State Management	2.2	1.1	2	1-5	9
Climate change	2.2	1.0	1,3	1-4	8
International Management	2.0	0.8	2	1-4	9
Directed Commercial Harvest	1.7	0.8	1	1-3	9
Hybrids	1.5	0.7	1	1-3	2
Artificial Propagation and Stocking	1.5	0.6	1	1-3	9
Competition	1.4	0.6	1	1-3	9
Disease	1.3	0.5	1	1-2	8
Recreational Harvest	1.3	0.5	1	1-3	9
Landlocked Populations	1.2	0.4	1	1-2	8
Tribal/First Nation Fisheries Management	1.2	0.4	1	1-2	7
Tribal/First Nation Fisheries Utilization	1.2	0.4	1	1-2	8
Scientific Monitoring	1.0	0.1	1	1-2	9
Educational Harvest	1.0	0.0	1	1	9

Table 5. Qualitative ranking of threats for the Mid-Atlantic stock complex of alewife. Status Review Team members ranked threats by distributing 5 likelihood points among 5 ranks: 1- low, 2-medium/low, 3- medium, 4-medium/high, 5-high. The mean represents the overall Team average rank, mode represents the rank which received the most likelihood points, and range represents the range of ranks that were assigned likelihood points for each threat. N=number of Team members who ranked the threat between 1 and 5; likelihood points for threats that Team members ranked as either unknown or not applicable are not included.

Threats	Mean	SD	Mode	Range	N
Dams and Other Barriers	3.8	1.0	4	3-5	9
Incidental Catch	2.9	0.8	3	1-5	7
Water Quality (chemical)	2.9	0.9	3	1-5	9
Water Withdrawal/Outfall (physical and temp.)	2.8	0.8	3	1-5	8
Climate change	2.7	1.2	3	1-5	8
Climate variability	2.6	1.2	2	1-5	9
Predation	2.5	1.1	2	1-5	9
Dredging	2.5	0.9	3	1-4	8
Federal Management	2.3	1.1	2	1-5	9
State Management	2.2	1.1	2	1-5	9
International Management	1.8	0.8	1	1-4	9
Directed Commercial Harvest	1.7	0.8	1	1-3	9
Hybrids	1.5	0.7	1	1-3	2
Artificial Propagation and Stocking	1.5	0.7	1	1-3	9
Competition	1.4	0.6	1	1-3	9
Disease	1.4	0.5	1	1-3	8
Recreational Harvest	1.3	0.5	1	1-3	9
Landlocked Populations	1.2	0.4	1	1-2	8
Tribal/First Nation Fisheries Management	1.2	0.4	1	1-3	7
Tribal/First Nation Fisheries Utilization	1.1	0.3	1	1-2	7
Scientific Monitoring	1.0	0.1	1	1-2	9
Educational Harvest	1.0	0.0	1	1	9

The SRT's qualitative rankings of threats for blueback herring rangewide and for each stock complex:

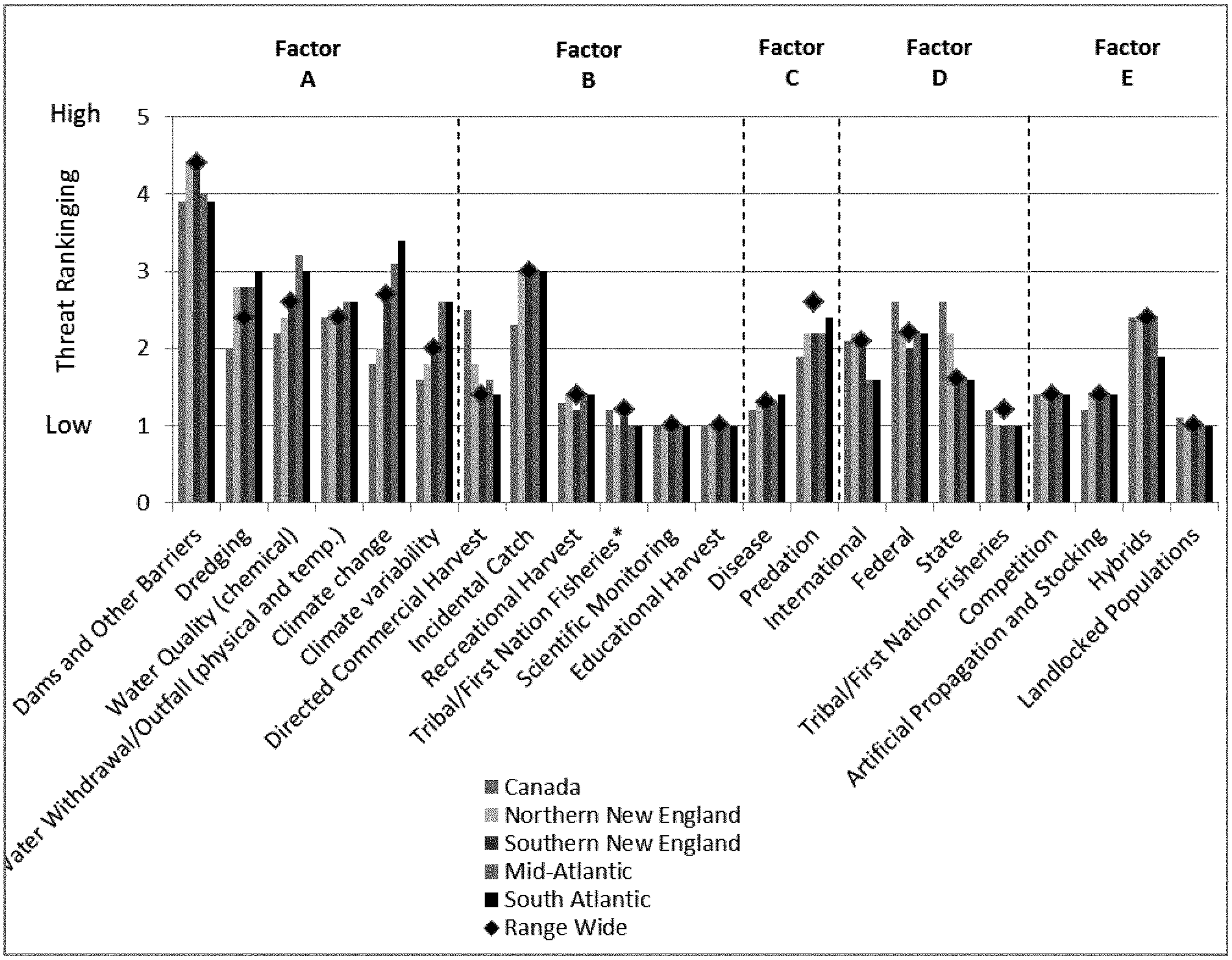

Figure 4. Median qualitative ranking of threats to blueback herring rangewide and for each stock complex.

Table 6. Qualitative ranking of threats for blueback herring rangewide. Status Review Team members ranked threats by distributing 5 likelihood points among 5 ranks: 1- low, 2-medium/low, 3- medium, 4-medium/high, 5-high. The mean represents the overall Team average rank, mode represents the rank which received the most likelihood points, and range represents the range of ranks that were assigned likelihood points for each threat. N=number of Team members who ranked the threat between 1 and 5; likelihood points for threats that Team members ranked as either unknown or not applicable are not included.

Threats	Mean	SD	Mode	Range	N
Dams and Other Barriers	4.2	0.8	4,5	3-5	9
Water Quality (chemical)	2.8	1.0	3	1-5	9
Incidental Catch	2.7	0.9	3	1-5	9
Climate change	2.7	1.2	3,4	1-5	8
Predation	2.6	1.1	3	1-5	9
Climate variability	2.4	1.2	1,2,3	1-5	9
Water Withdrawal/Outfall (physical and temp.)	2.4	0.8	2	1-5	9
Dredging	2.4	1.0	2	1-4	9
Hybrids	2.4	1.0	3	1-4	2
Federal Management	2.3	1.1	2	1-5	9
International Management	2.3	1.1	2	1-5	8
State Management	2.2	1.1	1	1-5	9
Directed Commercial Harvest	1.8	0.8	1	1-3	9
Competition	1.5	0.6	1	1-3	9
Artificial Propagation and Stocking	1.5	0.7	1	1-3	9
Tribal/First Nation Fisheries Management	1.3	0.5	1	1-3	7
Recreational Harvest	1.3	0.5	1	1-3	9
Disease	1.3	0.5	1	1-2	8
Landlocked Populations	1.2	0.5	1	1-3	7
Tribal/First Nation Fisheries Utilization	1.2	0.4	1	1-2	8
Scientific Monitoring	1.0	0.2	1	1-2	9
Educational Harvest	1.0	0.1	1	1-2	9

Table 7. Qualitative rankings of threats for the Canadian stock complex of blueback herring. Status Review Team members ranked threats by distributing 5 likelihood points among 5 ranks: 1- low, 2-medium/low, 3- medium, 4-medium/high, 5-high. The mean represents the overall Team average rank, mode represents the rank which received the most likelihood points, and range represents the range of ranks that were assigned likelihood points for each threat. N=number of Team members who ranked the threat between 1 and 5; likelihood points for threats that Team members ranked as either unknown or not applicable are not included.

Threats	Mean	SD	Mode	Range	N
Dams and Other Barriers	3.9	0.9	4	2-5	8
Incidental Catch	2.4	1.2	1,3	1-5	6
State Management	2.4	0.9	2	1-4	6
Hybrids	2.4	1.0	3	1-4	2
Water Withdrawal/Outfall (physical and temp.)	2.4	0.6	2	1-3	6
Federal Management	2.4	0.9	2	1-4	6
Directed Commercial Harvest	2.4	0.8	3	1-4	8
Water Quality (chemical)	2.2	0.7	2	1-3	7
Climate variability	2.2	1.2	1	1-5	8
Predation	2.1	1.0	2	1-4	8
International Management	2.1	0.9	2	1-4	8
Dredging	2.0	0.7	2	1-3	6
Climate change	2.0	1.0	1	1-4	8
Competition	1.5	0.6	1	1-4	9
Recreational Harvest	1.3	0.5	1	1-2	6
Disease	1.3	0.5	1	1-2	7
Artificial Propagation and Stocking	1.3	0.5	1	1-3	7
Tribal/First Nation Fisheries Utilization	1.2	0.4	1	1-2	6
Tribal/First Nation Fisheries Regulation	1.2	0.4	1	1-3	5
Landlocked Populations	1.1	0.3	1	1-2	6
Scientific Monitoring	1.0	0.2	1	1-2	6
Educational Harvest	1.0	0.0	1	1	6

Table 8. Qualitative ranking of threats for the Northern New England stock complex of blueback herring. Status Review Team members ranked threats by distributing 5 likelihood points among 5 ranks: 1- low, 2-medium/low, 3- medium, 4-medium/high, 5- high. The mean represents the overall Team average rank, mode represents the rank which received the most likelihood points, and range represents the range of ranks that were assigned likelihood points for each threat. N=number of Team members who ranked the threat between 1 and 5; likelihood points for threats that Team members ranked as either unknown or not applicable are not included.

Threats	Mean	SD	Mode	Range	N
Dams and Other Barriers	4.3	0.7	5	3-5	9
Incidental Catch	2.8	0.9	3	1-5	7
Dredging	2.6	1.0	3	1-4	8
Water Withdrawal/Outfall (physical and temp.)	2.5	0.9	3	1-5	8
State Management	2.4	1.1	2	1-5	9
Hybrids	2.4	1.0	3	1-4	2
Water Quality (chemical)	2.4	1.1	3	1-5	9
Predation	2.4	1.2	2	1-5	9
Federal Management	2.4	1.1	2	1-5	9
Climate variability	2.2	1.2	2	1-4	9
Climate change	2.1	1.0	2	1-4	8
International Management	2.0	0.9	2	1-4	9
Directed Commercial Harvest	1.9	0.9	1	1-3	9
Artificial Propagation and Stocking	1.6	0.7	1	1-3	9
Competition	1.5	0.7	1	1-3	9
Recreational Harvest	1.3	0.5	1	1-3	9
Disease	1.3	0.5	1	1-2	8
Landlocked Populations	1.2	0.4	1	1-2	7
Tribal/First Nation Fisheries Management	1.1	0.4	1	1-2	7
Tribal/First Nation Fisheries Utilization	1.1	0.3	1	1-2	8
Scientific Monitoring	1.0	0.1	1	1-2	9
Educational Harvest	1.0	0.0	1	1	9

Table 9. Qualitative ranking of threats for the Southern New England stock complex of blueback herring. Status Review Team members ranked threats by distributing 5 likelihood points among 5 ranks: 1- low, 2-medium/low, 3- medium, 4-medium/high, 5-high. The mean represents the overall Team average rank, mode represents the rank which received the most likelihood points, and range represents the range of ranks that were assigned likelihood points for each threat. N=number of Team members who ranked the threat between 1 and 5; likelihood points for threats that Team members ranked as either unknown or not applicable are not included.

Threats	Mean	SD	Mode	Range	N
Dams and Other Barriers	4.3	0.7	4,5	3-5	9
Incidental Catch	2.8	0.9	3	1-5	7
Water Withdrawal/Outfall (physical and temp.)	2.6	0.8	2,3	1-5	8
Dredging	2.6	1.0	3	1-4	8
Water Quality (chemical)	2.6	1.0	3	1-5	9
Predation	2.4	1.1	2	1-5	9
Hybrids	2.4	1.0	3	1-4	2
Climate change	2.3	1.0	2	1-4	8
Climate variability	2.3	1.1	2	1-5	9
Federal Management	2.2	1.1	2	1-5	9
State Management	1.9	1.1	1	1-5	9
International Management	1.9	0.8	2	1-4	9
Directed Commercial Harvest	1.6	0.8	1	1-3	9
Artificial Propagation and Stocking	1.6	0.7	1	1-3	9
Competition	1.5	0.7	1	1-4	9
Disease	1.3	0.5	1	1-2	8
Recreational Harvest	1.2	0.4	1	1-2	9
Landlocked Populations	1.2	0.4	1	1-2	7
Tribal/First Nation Fisheries Management	1.1	0.4	1	1-2	7
Tribal/First Nation Fisheries Utilization	1.1	0.3	1	1-2	8
Scientific Monitoring	1.0	0.1	1	1-2	9
Educational Harvest	1.0	0.0	1	1	9

Table 10. Qualitative ranking of threats for the Mid-Atlantic stock complex of blueback herring. Status Review Team members ranked threats by distributing 5 likelihood points among 5 ranks: 1- low, 2-medium/low, 3- medium, 4-medium/high, 5-high. The mean represents the overall Team average rank, mode represents the rank which received the most likelihood points, and range represents the range of ranks that were assigned likelihood points for each threat. N=number of Team members who ranked the threat between 1 and 5; likelihood points for threats that Team members ranked as either unknown or not applicable are not included.

Threats	Mean	SD	Mode	Range	N
Dams and Other Barriers	3.9	1.0	4	3-5	9
Water Quality (chemical)	3.0	0.9	3	1-5	9
Incidental Catch	2.8	0.9	3	1-5	7
Water Withdrawal/Outfall (physical and temp.)	2.7	0.8	3	1-5	8
Climate change	2.7	1.2	3	1-5	8
Dredging	2.6	1.0	3	1-4	8
Climate variability	2.6	1.2	2,3	1-5	9
Predation	2.4	1.1	2	1-5	9
Hybrids	2.4	1.0	3	1-4	2
Federal Management	2.3	1.1	2	1-5	9
State Management	2.2	1.1	2	1-5	9
Directed Commercial Harvest	1.9	0.9	1	1-4	9
International Management	1.7	0.8	1	1-4	9
Competition	1.5	0.7	1	1-3	9
Artificial Propagation and Stocking	1.5	0.7	1	1-3	9
Disease	1.4	0.5	1	1-3	8
Recreational Harvest	1.3	0.5	1	1-3	9
Landlocked Populations	1.2	0.4	1	1-2	7
Tribal/First Nation Fisheries Management	1.1	0.4	1	1-2	7
Tribal/First Nation Fisheries Utilization	1.1	0.3	1	1-2	7
Scientific Monitoring	1.0	0.1	1	1-2	9
Educational Harvest	1.0	0.0	1	1	9

Table 11. Qualitative ranking of threats for the Southern Atlantic stock complex of blueback herring. Status Review Team members ranked threats by distributing 5 likelihood points among 5 ranks: 1- low, 2-medium/low, 3- medium, 4-medium/high, 5-high. The mean represents the overall Team average rank, mode represents the rank which received the most likelihood points, and range represents the range of ranks that were assigned likelihood points for each threat. N=number of Team members who ranked the threat between 1 and 5; likelihood points for threats that Team members ranked as either unknown or not applicable are not included.

Threats	Mean	SD	Mode	Range	N
Dams and Other Barriers	3.8	1.1	4	3-5	8
Water Quality (chemical)	3.0	0.9	3	1-5	9
Climate change	3.0	1.3	4	1-5	8
Climate variability	2.8	1.4	2,4	1-5	9
Water Withdrawal/Outfall (physical and temp.)	2.8	0.8	3	1-5	8
Dredging	2.7	1.0	3	1-4	8
Incidental Catch	2.6	1.0	3	1-5	7
Predation	2.6	1.2	3	1-5	9
Federal Management	2.3	1.1	2	1-5	9
State Management	2.2	1.1	2	1-5	9
Hybrids	1.9	0.7	2	1-3	2
Directed Commercial Harvest	1.8	0.8	1	1-3	9
International Management	1.7	0.8	1	1-4	9
Competition	1.6	0.7	1	1-3	9
Disease	1.5	0.6	1	1-3	8
Artificial Propagation and Stocking	1.5	0.7	1	1-3	9
Recreational Harvest	1.3	0.5	1	1-3	9
Landlocked Populations	1.2	0.4	1	1-2	7
Tribal/First Nation Fisheries Management	1.1	0.3	1	1-2	7
Tribal/First Nation Fisheries Utilization	1.1	0.3	1	1-2	7
Scientific Monitoring	1.0	0.1	1	1-2	9
Educational Harvest	1.0	0.0	1	1	9

Table 12. Summary table of threat ranking for alewife rangewide.

Threat	Threat Level	Section 4 Factor
Dams and Other Barriers	Medium High	A
Water Quality (chemical)	Medium	A
Incidental Catch	Medium	B
Predation	Medium	C
Dredging	Medium Low	A
Water Withdrawal/Outfall (physical and temp.)	Medium Low	A
Climate change	Medium Low	A
Climate variability	Medium Low	A
Directed Commercial Harvest	Medium Low	B
International Management	Medium Low	D
Federal Management	Medium Low	D
State Management	Medium Low	D
Competition	Medium Low	E
Artificial Propagation and Stocking	Medium Low	E
Recreational Harvest	Low	B
Tribal/First Nation Fisheries Management	Low	B
Scientific Monitoring	Low	B
Educational Harvest	Low	B
Disease	Low	C
Tribal/First Nation Fisheries Utilization	Low	D
Hybrids	Low	E
Landlocked Populations	Low	E

Table 13. Summary table of threat ranking for blueback herring rangewide.

Threat	Threat Level	Section 4 Factor
Dams and Other Barriers	Medium High	A
Climate change	Medium	A
Water Quality (chemical)	Medium	A
Incidental Catch	Medium	B
Predation	Medium	C
Water Withdrawal/Outfall (physical and temp.)	Medium Low	A
Dredging	Medium Low	A
Climate variability	Medium Low	A
Directed Commercial Harvest	Medium Low	B
International Management	Medium Low	D
Federal Management	Medium Low	D
State Management	Medium Low	D
Competition	Medium Low	E
Hybrids	Medium Low	E
Recreational Harvest	Low	B
Tribal/First Nation Fisheries Management	Low	B
Scientific Monitoring	Low	B
Educational Harvest	Low	B
Disease	Low	C
Tribal/First Nation Fisheries Utilization	Low	D
Artificial Propagation and Stocking	Low	E
Landlocked Populations	Low	E

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Extinction Risk Analysis

In order to assess the risk of extinction for alewife and blueback herring, trends in the relative abundance of alewife and blueback herring were assessed for each species rangewide, as well as for each species-specific stock complex. As noted previously, for alewife, the stock complexes include Canada, Northern New England, Southern New England and the mid-Atlantic. For blueback herring, the stock complexes are Canada, Northern New England, Southern New England, mid-Atlantic and Southern.

Criteria Established by SRT for Evaluating Risk

Prior to conducting the trend analysis modeling, the SRT established criteria that would be used to evaluate the risk to both species as well as to the individual stock complexes. At the SRT's request, the NEFSC conducted modeling to develop trends in relative abundance by estimating the population growth rate for both species both rangewide and for each individual stock complex. The SRT established two tiers that could be used separately or in combination to interpret the results of the modeling in order to assess risk to alewife and blueback herring rangewide and for the individual stock complexes. We concur that these tiers are appropriate. Tier A relates to what is known about the geographic distribution, habitat connectivity and genetic diversity of each species, and Tier B relates to the risk thresholds established for the trend analysis that was conducted by the NEFSC. These tiers are subject to change in the future as more information becomes available. For example, Tier A is based on preliminary genetic data addressing possible stock complexes, which could change in the future. Data related to both tiers were assessed to determine if sufficient information was available to make a conclusion under one or both of the tiers. The SRT decided that, because of significant uncertainties associated with the available data and a significant number of data deficiencies for both species, it was not necessary to have information under both tiers in order to make a risk determination, and we concur with this decision.

The goal of Tier A was to maintain three contiguous stock complexes that are stable or increasing as this: (1) Satisfies the need to maintain both geographic closeness and geographic distance for a properly functioning metapopulation (see McElhany *et al.,* 2000); (2) ensures that the recovered population does not include isolated genetic groups that could lead to genetic divergence (McDowall, 2003, Quinn, 1984); (3) provides some assurance that the species persists across a relatively wide geographic area supporting diverse environmental conditions and diverse habitat types; and (4) ensures that the entire population does not share the same risk from localized environmental catastrophe (McElhany *et al.,* 2000).

Tier B information was used to directly interpret the results of the trends in relative abundance modeling conducted by the NEFSC. As described below, relative abundance of both alewife and blueback herring was used to estimate growth rate (along with the 95 percent confidence intervals for the growth rates) for each species rangewide and for each stock complex. Tier B established risk criteria depending on the outcomes of the population growth rate modeling. As indicated in the foreseeable future section above, a 12- to 18-year timeframe (e.g., 2024–2030) for each species was determined to be appropriate. After subsequent discussions, the SRT decided that the projections into the foreseeable future would not provide meaningful information for the extinction risk analysis. As noted previously, the trend analysis provides a steady population growth rate. If the population growth rate is positive and everything else remains the same into the foreseeable future (e.g., natural and anthropogenic mortality rates do not change), the abundance into the foreseeable future will continue to increase. If the population growth rate is negative, then the abundance into the foreseeable future will continue to decline. Currently, there is insufficient information available to modify any of the factors that may change the growth rates into the foreseeable future, and thus, performing these projections will not provide meaningful information for the extinction risk of either of these species.

The baseline for the overall risk assessment assumes that there has already been a significant decline in abundance in both species due to a reduction in carrying capacity and overfishing as indicated in various publications (Limburg and Waldman, 2009; Hall *et al.,* 2012), as well as other threats. The estimated population growth rates reflect the impacts from the various threats to which the species are currently exposed. The SRT recommended that NEFSC use data from 1976 through the present to minimize the overfishing influence from distant water fleets that occurred in earlier years but has since been curtailed by fisheries management measures. The SRT recommended that the NEFSC also run a trajectory using a plus/minus 10-percent growth rate to test model sensitivity with respect to changes in the model variables. This approach has been used in analyses for other species (e.g., Atlantic croaker, Atlantic cod) and can serve as a means of showing sensitivities in the model to potential variables (e.g., population growth rate changes, climate change) (Hare and Able, 2007; Hare, NMFS Pers. comm., 2012). Following completion of the model results, we determined that the plus/minus 10-percent change in population growth rate would not provide additional information that would change the conclusions as to whether the populations are significantly increasing, stable or decreasing. Without the projections of the population growth rate into the foreseeable future, the plus/minus 10-percent would merely provide an additional set of bounds around the population growth rate estimate, and, therefore, we determined that running the model with the plus/minus 10-percent was not necessary.

The population growth rates derived from the analysis help identify whether stability exists within the population. Mace *et al.* (2002) and Demaster *et al.* (2004) recognized that highly fecund, short generation time species like river herring may be able to withstand a 95 to 99 percent decline in biomass. Both alewives and blueback herring may already be at or less than two percent of the historical baseline (e.g., Limburg and Waldman, 2009), though these estimates are based on commercial landings data, which are dependent upon management and are not a reliable estimate of biomass. However, recognizing historical declines for both species, the modeled population growth rates were used to gauge whether these stock complexes are stable, significantly increasing or decreasing. Relative abundance of a stock is considered to be significantly increasing or decreasing if the 95-percent confidence intervals of the population growth rate do not include zero. In contrast, if the 95-percent confidence intervals do contain zero, then the population is considered to be stable, as the increasing or decreasing trend in abundance is not statistically significant.

The SRT determined and we agree that a stable or significantly increasing trajectory suggests that these species may be within the margins of being self-sustainable and thus, if all of the growth rates for the coast-wide distribution and the stock complexes are stable or significantly increasing, the species is at low risk of extinction (the risk categories were defined by adapting the categories described above for the QTA—Low risk—it is likely that the threats to the species' continued existence are not significant now and/or into the foreseeable future; Moderately Low—risk falls between low and moderate rankings; Moderate—it is likely that the threats are having some effect on the species continued existence now and/or into the foreseeable future; Moderately High—the risk falls between moderate and high; High—it is likely that the threats are significantly affecting the species' continued existence now and/or into the foreseeable future). If the coast wide population growth rate is stable or significantly increasing and one stock complex is significantly decreasing but all others are stable or significantly increasing, the species is at a moderate-low risk. A significantly decreasing population growth rate for several stock complexes would be an indicator that the current abundance may not be sustainable relative to current management measures and, therefore, may warrant further protections. Thus, if the population growth rates for two of the stock complexes are significantly decreasing but the coast-wide index is significantly increasing, the species is at moderate-high risk. If the growth rates for three or more of the stock complexes are significantly decreasing and/or the coast-wide index is significantly decreasing, the species is at high risk.

Risk Scenarios

- Low risk
  - Coast wide trajectory—Stable to significantly increasing
  - Stock complex trajectories—All stable to significantly increasing
- Moderate-Low risk
  - Coast wide trajectory—Stable to significantly increasing
  - Stock complex trajectories—One significantly decreasing, all others stable to significantly increasing
- Moderate-High risk
  - Coast wide trajectory—Stable to significantly increasing
  - Stock complex trajectories—Two or more significantly decreasing
- High risk
  - Coast wide trajectory—Significantly decreasing
  - Stock complex trajectories—Three or more significantly decreasing

Trend Analysis Modeling

The sections below include summaries/excerpts from the NEFSC Report to the SRT, ''Analysis of Trends in Alewife and Blueback Herring Relative Abundance,'' June 17, 2013, 42 pp. (NEFSC, 2013). For detailed information on the modeling conducted, please see the complete report which can be found at *http://www.nero.noaa.gov/prot_res/CandidateSpeciesProgram/RiverHerringSOC.htm* or see **FOR FURTHER INFORMATION CONTACT** section above for contacts.

Data Used in the Trend Analysis Modeling

Rangewide Data

Relative abundance indices from multiple fishery-independent survey time series were considered as possible data inputs for the rangewide analysis. These time series included the NEFSC spring, fall, and winter bottom trawl surveys as well as the NEFSC shrimp survey. For alewife, two additional time series were available: Canada's DFO summer research vessel (RV) survey of the Scotian Shelf and Bay of Fundy (1970–present), and DFO's Georges Bank RV survey (1987–present, conducted during February and March).

For the NEFSC spring and fall bottom trawl surveys, inshore strata from 8 to 27 m depth and offshore strata from 27 to 366 m depth have been most consistently sampled by the RV *Albatross IV* and RV *Delaware II* since the fall of 1975 and spring of 1976. Prior to these time periods, either only a portion of the survey area was sampled or a different vessel and gear were used to sample the inshore strata (Azarovitz, 1981). Accordingly, seasonal alewife and blueback herring relative abundance indices were derived from these trawl surveys using both inshore and offshore strata for 1976–2012 in the spring and 1975–2011 in the fall. Additional relative abundance indices were derived using only offshore strata for 1968–2012 in the spring and 1967–2011 in the fall (from 1963–1967 the fall survey did not extend south of Hudson Canyon). These time series were developed following the same methodology used in the ASMFC river herring stock assessment (ASMFC, 2012).

Through 2008, standard bottom trawl tows were conducted for 30 minutes at 6.5 km/hour with the RV *Albatross IV* as the primary survey research vessel (Despres-Patanjo *et al.,* 1988). However, vessel, door and net changes did occur during this time, resulting in the need for conversion factors to adjust survey catches for some species. Conversion factors were not available for net and door changes, but a vessel conversion factor for alewife was available to account for years where the RV *Delaware II* was used. A vessel conversion factor of 0.58 was applied to alewife weight-per-tow indices from the RV *Delaware II.* Alewife number-per-tow indices did not require a conversion factor (Byrne and Forrester, 1991).

In 2009, the survey changed primary research vessels from the RV *Albatross IV* to the RV *Henry B. Bigelow.* Due to the deeper draft of the RV *Henry B. Bigelow,* the two shallowest series of inshore strata (8–18 m depth) are no longer sampled. Concurrent with the change in fishing vessel, substantial changes to the characteristics of the sampling protocol and trawl gear were made, including tow speed, net type and tow duration (NEFSC, 2007). Calibration experiments, comprising paired standardized tows of the two fishing vessels, were conducted to measure the relative catchability between the two vessel-gear combinations and develop calibration factors to convert Bigelow survey catches to *RV Albatross* equivalents (Miller *et al.,* 2010). In the modeling, the NEFSC developed species-specific calibration coefficients which were estimated for both catch numbers and weights using the method of Miller *et al.* (2010) (Table 14). The calibration factors were combined across seasons due to low within-season sample sizes from the 2008 calibration studies (fewer than 30 tows with positive catches by one or both vessels).

Table 14. Coefficients and associated standard errors used to convert RV Bigelow catches of alewife and blueback herring to RV Albatross IV equivalents for the 2009-2011 NEFSC bottom trawl surveys.

	Number		Biomass	
Species	**Coefficient**	**SE**	**Coefficient**	**SE**
Alewife	1.05	0.16	0.72	0.11
Blueback herring	0.87	0.17	1.59	0.45

Bottom trawl catches of river herring tend to be higher during the daytime due to diel migration patterns (Loesch *et al.,* 1982; Stone and Jessop, 1992). Accordingly, only daytime tows were used to compute relative abundance and biomass indices. In addition, the calibration factors used to convert RV *Bigelow* catches to RV *Albatross* equivalents were estimated using only catches from daytime tows. Daytime tows, defined as those tows between sunrise and sunset, were identified for each survey station based on sampling date, location, and solar zenith angle using the method of Jacobson *et al.* (2011). Although there is a clear general relationship between solar zenith and time of day, tows carried out at the same time but at different geographic locations may have substantially different irradiance levels that could influence survey catchability (NEFSC, 2011). Preliminary analyses (Lisa Hendrickson, NMFS, 2012—unpublished data) confirmed that river herring catches were generally greater during daylight hours compared to nighttime hours.

In addition to the NEFSC spring and fall trawl surveys, the NEFSC winter and shrimp surveys were considered for inclusion in the analysis. For the winter survey (February), the sampling area extended from Cape Hatteras, NC, through the southern flank of Georges Bank, but did not include the remaining portion of Georges Bank or the Gulf of Maine. With the arrival of the RV *Bigelow* in late 2007, the NEFSC winter survey was merged with the NEFSC spring survey and discontinued. Alewife and blueback herring indices of relative abundance were developed for the winter survey from 1992–2007 using daytime tows from all sampled inshore and offshore strata. The shrimp survey is conducted during the summer (July/August) in the western Gulf of Maine during daylight hours. Relative abundance indices were derived for alewife and blueback herring from 1983–2011 using all strata that were consistently sampled across the survey time series in the NEFSC winter and shrimp surveys.

Stratified mean indices of relative abundance of alewife from Canada's summer RV survey and Georges Bank RV survey were provided by Heath

Stone of Canada's DFO. In these surveys, alewife is the predominant species captured; however, some blueback herring are likely included in the alewife indices because catches are not always separated by river herring species (Heath Stone, DFO Pers. comm., 2012). Furthermore, some Georges Bank strata were not sampled in all years of the survey due to inclement weather and vessel mechanical problems (Stone and Gross, 2012).

Due to the restricted spatial coverage of the winter, shrimp and Canadian Georges Bank surveys, these surveys were not used in the final rangewide analyses. Accordingly, relative abundance (number-per-tow) from the NEFSC spring and fall surveys was used in the rangewide models for blueback herring, and number-per-tow from the NEFSC spring survey, NEFSC fall survey, and the Canadian summer survey were used in the rangewide models for alewife.

Data from 1976 through the present were incorporated into the trend analysis. This time series permitted the inclusion of the spring and fall surveys' inshore strata. In addition, with this time series, the required assumption that the population growth rate will remain the same was reasonable. Prior to 1976, fishing intensity was much greater due to the presence of distant water fleets on the East Coast of the United States.

Years with zero catches were treated as missing data. For alewife, there were no years with zero catches in the spring, fall and Scotian shelf surveys. Zero catches of blueback herring occurred in the fall survey in 1988, 1990, 1992 and 1998.

Stock-Specific Data

Stock-specific time series of alewife and blueback herring relative abundance were obtained from the ASMFC and Canada's DFO. Available time series varied among stocks and included run counts, as well as young-of-year (YOY), juvenile and adult surveys that occurred solely within the bays or sounds of the stock of interest (for alewife see Table 15 in the NEFSC's ''Analysis of Trends in Alewife and Blueback Herring Relative Abundance,'' and for blueback herring, see Table 16). All available datasets were included in the stock-specific analyses, with the exception of run counts from the St. Croix and Union Rivers. These datasets were excluded due to the artificial impacts of management activities on run sizes. The closure of the Woodland Dam and Great Falls fishways in the St. Croix River prevented the upstream passage of alewives to spawning habitat. In contrast, fluctuations in Union River run counts were likely impacted by lifting and stocking activities used to maintain a fishery above the Ellsworth Dam. In the southern Gulf of St. Lawrence trawl survey, all river herring were considered to be alewife because survey catches were not separated by river herring species (Luc Savoie DFO, Pers. comm., 2012). No blueback herring abundance indices were available for the Canadian stock. Select strata were not used to estimate stock-specific indices from the NEFSC trawl surveys because mixing occurs on the continental shelf. Accordingly, any NEFSC trawl survey indices, even estimated using only particular strata, would likely include individuals from more than one stock.

Each available dataset in the stock-specific analyses represented a particular age or stage (spawners, young-of-year, etc.) of fish. Consequently, each time series was transformed using a running sum over 4 years. The selection of 4 years for the running sum was based on the generation time of river herring. For age- and stage-specific data, a running sum transformation is recommended to obtain a time series that more closely approximates the total population (Holmes, 2001). In order to compute the running sums for each dataset, missing data were imputed by computing the means of immediately adjacent years. For both species 4 years were imputed for the Monument River, and 1 year was imputed for the DC seine survey. For alewife, 1 year was also imputed for the Mattapoisett River, Nemasket River, and the southern Gulf of St. Lawrence trawl survey. For blueback herring, 1 year was also imputed for the Long Island Sound (LIS) trawl survey and Santee-Cooper catch-per-unit-effort (CPUE).

If possible data from 1976 through the present were incorporated into each stock-specific model, with the first running sum incorporating data from 1976 through 1979. However, for some stocks, observation time series began after 1976. In these cases, the first modeled year coincided with the first running sum of the earliest survey.

MARRS Model Description

Multivariate Autoregressive State-Space models (MARSS) were developed using the MARSS package in R (Holmes *et al.,* 2012a). This package fits linear MARSS models to time series data using a maximum likelihood framework based on the Kalman smoother and an Expectation Maximization algorithm (Holmes *et al.,* 2012b).

Each MARSS model is comprised of a process model and an observation model (Holmes and Ward, 2010; Holmes *et al.,* 2012b). The model is described in detail in the NEFSC (2013) final report to the SRT (posted on the Northeast Regional Office's Web site—*http://www.nero.noaa.gov/prot_res/CandidateSpeciesProgram/RiverHerringSOC.htm*). *Population projections and model analysis.*

For each stock complex, the estimated population growth rate and associated 95 percent confidence intervals were used to classify whether the stock's relative abundance was stable, significantly increasing or decreasing. As noted previously, relative abundance of a stock was considered to be significantly increasing or decreasing if the 95 percent confidence intervals of the population growth rate did not include zero. In contrast, if the 95 percent confidence intervals included zero, the population was considered to be stable because the increasing or decreasing trend in abundance was not significant.

Model Results

Rangewide Analyses

For the rangewide analysis, as shown in Table 15 below, the preferred model run for alewife indicates that the 95-percent confidence intervals spanning the estimated population growth rate do not include 0 and are statistically significantly increasing. For blueback herring rangewide, however, the 95-percent confidence intervals do include 0, and thus, it is not possible to state that the trend rangewide for this species is increasing. We, therefore, conclude based on our criteria described above that blueback herring rangewide are stable.

Table 15. Population growth rate maximum likelihood estimates (ML.Est), associated standard errors (Std.Err) and lower and upper 95 percent confidence intervals (low.CI, up.CI) for each rangewide model run. The preferred model run (lowest AIC) for each species is highlighted in grey.

Species	Run	ML.Est	Std.Err	low.CI	up.CI
Alewife	Independent with equal variances	0.034	0.006	0.022	0.046
	Independent with unequal variances	0.032	0.006	0.020	0.043
	Unconstrained	0.030	0.005	0.020	0.041
	Unequal variances with one covariance term	0.035	0.013	0.009	0.062
	Equal variance and covariance	0.034	0.005	0.023	0.045
Blueback herring	Independent with equal variances	0.039	0.040	-0.040	0.119
	Independent with unequal variances	0.022	0.036	-0.047	0.093
	Unconstrained	0.026	0.045	-0.063	0.112
	Equal variance and covariance	0.040	0.052	-0.064	0.144

Stock-Specific Analyses

As shown in Table 16 below, the 95-percent confidence intervals spanning the estimated population growth rate for the Canadian stock complex do not include 0 and are statistically significantly increasing. For the other three stock complexes, however, the confidence intervals do include 0, and thus, the Northern New England, Southern New England and mid-Atlantic alewife stock complexes are stable.

As Canada does not separate alewife and blueback herring in their surveys (e.g., they indicate that all fish are alewife), we were unable to obtain data from Canada specifically for blueback herring. For three of the remaining four stock complexes, the 95-percent confidence intervals spanning the estimated population growth rate do include 0 and thus, the trend for these stock complexes is stable. For the mid-Atlantic stock complex, the population growth rate and both 95-percent confidence intervals are all statistically significantly decreasing. Thus, we conclude that this stock complex is significantly decreasing.

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Table 16. Population growth rate maximum likelihood estimates (ML.Est), associated standard errors (Std.Err) and lower and upper 95-percent confidence intervals (low.CI, up.CI) for each stock-specific model run. The preferred model run (lowest AIC) for each stock is highlighted in grey.

Species	Stock	Run	ML.Est	Std.Err	low.CI	up.CI
Alewife	Mid Atlantic	Independent with equal variances	0.004	0.034	-0.061	0.073
		Independent with unequal variances	-0.021	0.036	-0.092	0.048
		Unconstrained	-0.013	0.029	-0.071	0.044
		Unequal variances with one covariance term	-0.021	0.035	-0.088	0.054
		Equal variance and covariance	-0.004	0.046	-0.092	0.088
	Southern New England	Independent with equal variances	0.008	0.032	-0.052	0.072
		Independent with unequal variances	0.017	0.028	-0.038	0.071
		Equal variance and covariance	0.005	0.032	-0.057	0.069
	Northern New England	Independent with equal variances	0.036	0.038	-0.041	0.109
		Unconstrained	0.038	0.036	-0.034	0.108
		Equal variance and covariance	0.036	0.041	-0.048	0.114
	Canada	Independent with equal variances	0.111	0.031	0.050	0.170
Blueback herring	Southern	Independent with equal variances	-0.004	0.047	-0.091	0.091
		Independent with unequal variances	0.022	0.041	-0.058	0.102
		Unconstrained	0.024	0.042	-0.058	0.103
		Equal variance and covariance	-0.001	0.046	-0.091	0.092
	Mid Atlantic	Independent with equal variances	-0.070	0.008	-0.085	-0.055
		Independent with unequal variances	-0.048	0.003	-0.054	-0.042
		Equal variance and covariance	-0.072	0.013	-0.097	-0.046
	Southern New England	Independent with equal variances	-0.033	0.035	-0.101	0.036
	Northern New England	Independent with equal variances	-0.076	0.058	-0.185	0.041

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Model Assumptions and Limitations

The available data for each analysis varied considerably among species and stocks. Some stocks such as Southern New England blueback herring had only one available data set; however, other stocks such as Southern New England alewife and mid-Atlantic blueback herring had eight or more available time series. Within each analysis, all input time series must be weighted equally, regardless of the variability in the dataset. Furthermore, only the annual point estimates of relative abundance are inputs to the model; associated standard errors for the time series are not inputted.

However, some observation time series may be more representative of the stock of interest than other time series. For example, for Northern New England alewife, available datasets included run counts from five rivers and Maine's juvenile alosine seine survey. Each time series of run counts represents the spawning population in one particular river, whereas the juvenile seine survey samples six Maine rivers including Merrymeeting Bay (ASMFC, 2012). Accordingly, it is possible that the juvenile seine survey provides a better representation of Northern New England alewife than the run counts from any particular river because the seine survey samples multiple populations. Likewise, for Southern New England alewife, available datasets included the Long Island Sound (LIS) trawl survey, New York juvenile seine survey, and run counts from six rivers. The LIS trawl survey samples Long Island Sound from New London to Greenwich Connecticut with stations in both Connecticut and New York state waters, including the mouths of several rivers including the Thames, Connecticut, Housatonic, East and Quinnipiac (CTDEP, 2011; ASMFC, 2012). The NY juvenile seine survey samples the Hudson River estuary (ASMFC, 2012), and run counts are specific to particular rivers. As a consequence, the LIS trawl survey may be more representative of the Southern New England alewife stock because it samples not only a greater proportion of the stock, but also samples LIS where mixing of river-specific populations likely occurs.

Several sources of uncertainty are described in detail in the modeling report. It is important to understand and document these sources of uncertainty. However, even with several assumptions and these sources of uncertainty, we are confident that the model results are useful in determining the population growth rates both coast-wide and for the individual stock complexes, and thus, for providing information to be used in assessing the risk to these species and stock complexes.

Extinction Risk Conclusion

In performing our analysis of the risk of extinction to the species, we considered the current status and trends and the threats as they are impacting the species at this time. Currently, neither species is experiencing high rates of decline coast-wide as evidenced by the rangewide trends (significantly increasing for alewife and stable for blueback herring). Thus, using the extinction risk tiers identified by the SRT, we have concluded the following:

Alewife—

• Tier A: There is sufficient information available to conclude that there are at least three contiguous populations that are stable to significantly increasing.

• Tier B: The species is at ''Low risk'' as the coast-wide trajectory is significantly increasing and all of the stock complexes are stable or significantly increasing.

Blueback herring—

• Tier A: There is insufficient information available to make a conclusion under Tier A as we were unable to obtain data from Canada to determine the population growth rate for rivers in Canada. Thus, we were only able to obtain information for four of the five stock complexes identified for the species.

• Tier B: The species is at ''Moderate-low risk ''as the coast-wide trajectory is stable and three of the four stock complexes are stable. The estimated population growth rate of the mid-Atlantic stock complex is significantly decreasing based on the available information. However, the relative abundance of the species throughout its range (as demonstrated through the coast-wide population growth rate) is stable, and thus, the SRT concluded that the mid-Atlantic stock complex does not constitute a significant portion of the species range. We concur with this conclusion. In other words, the data indicate that the mid-Atlantic stock complex does not contribute so much to the species that, without it, the entire species would be in danger of extinction.

Many conservation efforts are underway that may lessen the impact of some of these threats into the foreseeable future. One of the significant threats identified for both species is bycatch in Federal fisheries, such as the Atlantic herring and mackerel fisheries. The New England and Mid Atlantic Fishery Management Councils have recommended management measures under the MSA that are expected to decrease the risk from this particular threat. Under both the Atlantic Herring Fishery Management Plan and the Mackerel/Squid/Butterfish Fishery Management Plan, the Councils have recommended a suite of reporting, vessel operation, river herring catch cap provisions, and observer provisions that would improve information on the amount and extent of river herring catch in the Atlantic herring and mackerel fisheries. NMFS has partially approved the measures as recommended by the New England Council and will be implementing the measures in September or October 2013. Another threat that has been identified for both species is loss of habitat or loss of access to spawning habitats. We have been working to restore access to spawning habitats for river herring and other diadromous fish species through habitat restoration projects. While several threats may lessen in the future, given the extensive decline from historical levels, neither species is thought to be capable of withstanding continued high rates of decline.

Research Needs

As noted above, there is insufficient information available on river herring in many areas. Research needs were recently identified in the ASMFC River Herring Stock Assessment Report (ASMFC, 2012); NMFS Stock Structure, Climate Change and Extinction Risk Workshop/Working Group Reports (NMFSa, 2012; NMFSb, 2012; NMFSc, 2012) and associated peer reviews; and New England and Mid-Atlantic Fishery Management Council documents (NEFMC, 2012; MAFMC, 2012). We have identified below some of the most critical and immediate research needs to conserve river herring taking the recently identified needs into consideration, as well as information from this determination. However, these are subject to refinement as a coordinated and prioritized coast-wide approach to continue to fill in data gaps and conserve river herring and their habitat is developed (see ''Listing Determination'' below).

• Gather additional information on life history for all stages and habitat areas using consistent and comprehensive coast-wide protocols (i.e., within and between the United States and Canada). This includes information on movements such as straying rates and migrations at sea. Improve methods to develop biological benchmarks used in assessment modeling.

• Continue genetic analyses to assess genetic diversity, determine population stock structure along the coast (U.S. and Canada) and determination of river origin of incidental catch in non-targeted ocean fisheries. Also, obtain information on hybridization and understand the effects of stocking on genetic diversity.

• Further assess human impacts on river herring (e.g., quantifying bycatch through expanded observer and port sampling coverage to quantify fishing impact in the ocean environment and improve reporting of commercial and recreational harvest by waterbody and gear, ocean acidification)

• Continue developing models to predict the potential impacts of climate change on river herring. This includes, as needed to support these efforts, environmental tolerances and thresholds (e.g., temperature) for all life stages in various habitats.

• Develop and implement monitoring protocols and analyses to determine river herring population responses and targets for rivers undergoing restoration (e.g., dam removals, fishways, supplemental stocking). Also, estimate spawning habitat by watershed (with and without dams).

• Assess the frequency and occurrence of hybridization between alewife and blueback herring and possible conditions that contribute to its occurrence (e.g., occurs naturally or in response to climate change, dams, or other anthropogenic factors).

• Continue investigating predator prey relationships.

Listing Determination

The ESA defines an endangered species as any species in danger of extinction throughout all or a significant portion of its range, and a threatened species as any species likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. Section 4(b)(1) of the ESA requires that the listing determination be 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 those efforts, if any, that are being made to protect such species.

We have considered the available information on the abundance of alewife and blueback herring, and whether any one or a combination of the five ESA factors significantly affect the long-term persistence of these species now or into the foreseeable future. We have reviewed the information received following the positive 90-day finding on the petition, the reports from the stock structure, extinction risk analysis, and climate change workshops/working groups, the population growth rates from the trends in relative abundance estimates and qualitative threats assessment, the Center for Independent Experts peer reviewers' comments, other qualified peer reviewer submissions, and consulted with scientists, fishermen, fishery resource managers, and Native American Tribes familiar with river herring and related research areas, and all other information encompassing the best available information on river herring. Based on the best available information, the SRT concluded that alewife are at a low risk of extinction from the threats identified in the QTA (e.g., dams and other barriers to migration, incidental catch, climate change, dredging, water quality, water withdrawal/outfall, predation, and existing regulation), and blueback herring are at a moderate-low risk of extinction from similar threats identified and discussed in the QTA discussion above. We concur with this conclusion, and we have determined that as a result of the extinction risk analysis for both species, these two species are not in danger of extinction or likely to become so in the foreseeable future. Therefore, listing alewife and blueback herring as either endangered or threatened throughout all of their ranges is not warranted at this time.

Significant Portion of the Range Evaluation

Under the ESA and our implementing regulations, a species warrants listing if it is threatened or endangered throughout all or a significant portion of its range. In our analysis for this listing determination, we initially evaluated the status of and threats to the alewife and blueback herring throughout the entire range of both species. As stated previously, we have concluded that there was not sufficient evidence to suggest that the genetically distinct stock complexes of alewife or blueback constitute DPSs. We also then assessed the status of each of the individual stock complexes in order to determine whether either species is threatened or endangered in a significant portion of its range.

As noted above in the QTA section, the SRT determined that the threats to both species are similar and the threats to each of the individual stock complexes are similar with some slight variation based on geography. Water quality, water withdrawal/outfall, predation, climate change and climate variability were generally seen as greater threats to both species in the southern portion of their ranges than in the northern portion of their ranges. In light of the potential differences in the magnitude of the threats to specific areas or populations, we next evaluated whether alewife or blueback herring might be threatened or endangered in any significant portion of its range. In accordance with our draft policy on ''significant portion of its range,'' our first step in this evaluation was to review the entire supporting record for this listing determination to ''identify any portions of the range[s] of the species that warrant further consideration'' (76 FR 77002; December 9, 2011). Therefore, we evaluated whether there is substantial information suggesting that the hypothetical loss of any of the individual stock complexes for either species (e.g., portions of the species' ranges) would reasonably be expected to increase the demographic risks to the point that the species would then be in danger of extinction, (i.e., whether any of the stock complexes within either species' range should be considered ''significant''). As noted in the extinction risk analysis section, all of the alewife stock complexes as well as the coastwide trend are either stable or increasing. For blueback herring, 3 of the stock complexes and the coastwide trend are all stable, but the mid-Atlantic stock complex is decreasing. The SRT determined that the mid-Atlantic stock complex is not significant to the species, given that even though it is decreasing, the overall coastwide trend is stable. Thus, the loss of this stock complex would not place the entire species at risk of extinction. We concur with this conclusion. Because the portion of the blueback herring stock complex residing in the mid-Atlantic is not so significant that its hypothetical loss would render the species endangered, we conclude that the mid-Atlantic stock complex does not constitute a significant portion of the blueback herring's range. Consequently, we need not address the question of whether the portion of the species occupying this portion of the range of blueback herring is threatened or endangered.

Conclusion

Our review of the information pertaining to the five ESA section 4(a)(1) factors does not support the assertion that there are threats acting on either alewife or blueback herring or their habitat that have rendered either species to be in danger of extinction or likely to become so in the foreseeable future, throughout all or a significant portion of its range. Therefore, listing alewife or blueback herring as threatened or endangered under the ESA is not warranted at this time.

While neither species is currently endangered or threatened, both species are at low abundance compared to historical levels, and monitoring both species is warranted. We agree with the SRT that there are significant data deficiencies for both species, and there is uncertainty associated with available data. There are many ongoing restoration and conservation efforts and new management measures that are being initiated/considered that are expected to benefit the species; however, it is not possible at this time to quantify the positive benefit from these efforts. Given the uncertainties and data deficiencies for both species, we commit to revisiting both species in 3 to 5 years. We have determined that this is an appropriate timeframe for considering this information in the future as a 3- to 5-year timeframe equates to approximately one generation time for each species, and it is therefore unlikely that a detrimental impact to either species could occur within this period. Additionally, it allows for time to complete ongoing scientific studies (e.g., genetic analyses, ocean migration patterns, climate change impacts) and for the results to be fully considered. Also, it allows for the assessment of data to determine whether the preliminary reports of increased river counts in many areas along the coast in the last 2 years represent sustained trends. During this 3- to 5-year period, we intend to coordinate with ASMFC on a strategy to develop a long-term and dynamic conservation plan (e.g., priority activities and areas) for river herring considering the full range of both species and with the goal of addressing many of the high priority data gaps for river herring. We welcome input and involvement from the public. Any information that could help this effort should be sent to us (see **ADDRESSES** section above).

References Cited

A complete list of all references cited in this rulemaking can be found on our Web site at *http://www.nero.noaa.gov/prot_res/CandidateSpeciesProgram/RiverHerringSOC.htm* and is available upon request from the NMFS office in Gloucester, MA (see **ADDRESSES**).

Authority: The authority for this action is the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*).

Dated: August 6, 2013.

Alan D. Risenhoover,

Director, Office of Sustainable Fisheries, performing the functions and duties of the Deputy Assistant Administrator for Regulatory Programs National Marine Fisheries Service.

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