DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

[Docket No. 170718681–9471–01]

RIN 0648–XF575

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; 12-month finding and availability of status review document.

SUMMARY: We, NMFS, have completed a comprehensive status review under the Endangered Species Act (ESA) for alewife (*Alosa pseudoharengus*) and blueback herring (*Alosa aestivalis*). The status review identified four alewife distinct population segments (DPSs): Canada, Northern New England, Southern New England, and Mid-Atlantic. Based on the best scientific and commercial data available including the Status Review Report, we have determined that listing the alewife rangewide or as any of the identified DPSs as threatened or endangered under the ESA is not warranted at this time. The status review also identified three blueback herring DPSs: Canada/Northern New England, Mid-Atlantic, and Southern Atlantic. Based on the best scientific and commercial data available, we have determined that listing blueback herring rangewide or as any of the identified DPSs as threatened or endangered under the ESA is not warranted at this time.

DATES: This finding was made on June 19, 2019.

ADDRESSES: The status review document for alewife and blueback herring is available electronically at: *www.nmfs.noaa.gov/pr/species/notwarranted.htm.* You may also obtain a copy by submitting a request to the Protected Resources Division, NMFS GARFO, 55 Great Republic Drive, Gloucester, MA 01930, Attention: Alewife and Blueback Herring 12-month Finding.

FOR FURTHER INFORMATION CONTACT: Jean Higgins, NMFS Greater Atlantic Regional Fisheries Office, 978–281–9345.

SUPPLEMENTARY INFORMATION:

Background

On August 12, 2013, we determined that listing alewife and blueback herring (collectively, ''river herring''): As threatened or endangered under the Endangered Species Act (ESA) (16 U.S.C. 1531 *et seq.*) was not warranted (78 FR 48943). However, we also noted that there were significant data deficiencies. In that determination, we committed to revisiting the status of both species in three to five years, a period after which ongoing scientific studies, including a river herring stock assessment update by the Atlantic States Marine Fisheries Commission (ASMFC), would be completed.

The Natural Resources Defense Council and Earthjustice (the Plaintiffs) filed suit against NMFS on February 10, 2015, in the U.S. District Court in Washington, DC, challenging our decision not to list blueback herring as threatened or endangered. The Plaintiffs also challenged our determination that the Mid-Atlantic stock complex of blueback herring is not a DPS. On March 25, 2017, the court vacated the blueback herring listing determination and remanded the listing determination to us *(Natural Resources Defense Council, Inc., et al.* v. *Samuel D. Rauch, National Marine Fisheries Services, 1:15–cv–00198 (D.D.C.)).* As part of a negotiated agreement with the Plaintiffs, we committed to publishing a revised listing determination for blueback herring by January 31, 2019; the publication date was extended by the court to June 19, 2019.

We announced the initiation of an alewife and blueback herring status review in the **Federal Register** on August 15, 2017 (82 FR 38672). At that time, we also opened a 60-day solicitation period for new scientific and commercial data on alewife and blueback herring to help ensure that we were informed by the best available scientific and commercial information.

Listing Species Under the ESA

We are responsible for determining whether species are threatened or endangered under the ESA (16 U.S.C. 1531 *et seq.*). To make this determination, we first consider whether a group of organisms constitutes a ''species'' under section 3 of the ESA (16 U.S.C. 1532), and then consider whether the status of the species qualifies it for listing as either threatened or endangered. Section 3 of the ESA defines species to include any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature. On February 7, 1996, NMFS and the U.S. Fish and Wildlife Service (USFWS; together, the Services) adopted a policy describing what constitutes a DPS of a taxonomic species (DPS Policy; 61 FR 4722). Under the DPS Policy, we consider the following when identifying a DPS: (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 species or subspecies to which it belongs.

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. 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).

Section 4(a)(1) of the ESA also requires us to determine whether any species is endangered or threatened as a result of any of the following five factors: The present or threatened destruction, modification, or curtailment of its habitat or range; overutilization for commercial, recreational, scientific, or educational purposes; disease or predation; the inadequacy of existing regulatory mechanisms; or other natural or manmade factors affecting its continued existence (16 U.S.C. 1533(a)(1)(A)–(E)). Section 4(b)(1)(A) of the ESA requires us to make listing determinations based solely on the best scientific and commercial data available after conducting a review of the status of the species and after taking into account efforts being made by any state or foreign nation or political subdivision thereof to protect the species. In evaluating the efficacy of formalized domestic conservation efforts that have yet to be implemented or demonstrate effectiveness, we rely on the Services' joint *Policy on Evaluation of Conservation Efforts When Making Listing Decisions* (PECE; 68 FR 15100; March 28, 2003).

Status Review

As noted above, we had committed to revisiting the listing determination for alewife and blueback herring in the 2013 listing determination; accordingly, although the Plaintiffs only challenged our findings related to blueback herring, we did a comprehensive status review of alewife and blueback herring. As part of the status review, we formed a status review team (SRT) composed of scientists from NMFS' Northeast Fisheries Science Center (NEFSC), USFWS, NMFS' Greater Atlantic Regional Fisheries Office, Delaware Division of Fish and Wildlife, Massachusetts Division of Marine Fisheries, New York Department of Environmental Conservation, and South Carolina Department of Natural Resources. SRT members had scientific expertise in river herring biology/ecology and/or expertise in population ecology or fisheries management. We tasked the SRT with multiple assessments for both species including the requests from the 2011 petition that NMFS list blueback herring rangewide or alternatively, as DPSs, and to provide a thorough status review for both species. First, the SRT was asked to compile and review the best available information and to assess the overall risk of extinction facing alewife and blueback herring rangewide now and in the foreseeable future. Second, the SRT was tasked with identifying any DPSs within these populations and asked to assess the risk of extinction facing each identified DPS of alewife and blueback herring now and in the foreseeable future. Third, the SRT was asked to consider whether, within the species rangewide or within any identified DPSs, a significant portion of the range may exist, and if so, whether the portion is at risk of extinction now or in the foreseeable future.

In order to complete the status review, the SRT considered a variety of scientific information from the literature, unpublished documents, and direct communications with researchers working on alewife and blueback herring, as well as technical information submitted to NMFS. Information that was not previously peer-reviewed was formally reviewed by the SRT. The SRT evaluated all factors highlighted by the petitioners as well as additional factors that may contribute to alewife and blueback herring vulnerability.

The Status Review Report for alewife and blueback herring (NMFS 2019), summarized in sections below, compiles the best available information on the status of the species as required by the ESA, provides an evaluation of the discreteness and significance of these populations in terms of the DPS Policy, and assesses the extinction risk of the species and any DPS, focusing primarily on threats related to the five statutory factors set forth above. The status review report is available electronically at the website listed in **ADDRESSES**.

The status review report underwent independent peer review as required by the Office of Management and Budget Final Information Quality Bulletin for Peer Review (M–05–03; December 16, 2004). The status review report was peer reviewed by three independent specialists selected from government, academic, and scientific communities, with expertise in biology, conservation and management, and specific knowledge of river herring and similar species. The peer reviewers were asked to evaluate the adequacy, quality, and completeness of the data considered and whether uncertainties in these data were identified and characterized in the status review report, as well as to evaluate the findings made in the ''Assessment of Extinction Risk'' section of the report. Peer Reviewers were also asked to identify any information missing or lacking justification, or whether information was applied incorrectly in reaching conclusions. The SRT addressed peer reviewer comments prior to finalizing the status review report. Comments received are posted online at *www.cio.noaa.gov/services_programs/prplans/IDXXX.html.*

We subsequently reviewed the status review report, the cited references, and the peer review comments, and believe the status review report, upon which this 12-month finding is based, provides the best available scientific and commercial information on alewife and blueback herring. Much of the information discussed below on alewife and blueback herring biology, genetic diversity, distribution, abundance, threats, and extinction risk is attributable to the status review report. However, in making the 12-month finding determination, we have independently applied the statutory provisions of the ESA, including evaluation of the factors set forth in section 4(a)(1)(A)–(E) and our regulations regarding listing determinations (50 CFR part 424).

Description, Life History, and Ecology of the Petitioned Species

Distribution and Habitat Use

Collectively, blueback herring and alewives are known as river herring. River herring are 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. Johns River, Florida, and alewives range from Labrador and Newfoundland south to North Carolina, though their occurrence in the extreme southern range is less common (Collette and Klein-MacPhee 2002, ASMFC 2009a). In Canada, river herring (often referred to as gaspereau) have been monitored at varying frequencies in the St. Croix, St. John, Gaspereau, Tusket, Margaree and Miramichi River (J. Gibson, pers. comm) and are reportedly most abundant in the Miramichi, Margaree, LaHave, Tusket, Shubenacadie and Saint John Rivers (DFO 2001). River herring are proportionally less abundant in smaller coastal rivers and streams (DFO 2001). Generally, blueback herring in Canada occur in fewer rivers than alewives and are less abundant in rivers where both species coexist (DFO 2001).

River herring are anadromous, meaning that they mature in the marine environment and then migrate up coastal rivers to estuaries and into freshwater rivers, ponds, and lake habitats to spawn (Collette and Klein-MacPhee 2002, ASMFC 2009a). In general, adult river herring are 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).

River herring are highly migratory, pelagic, schooling species with seasonal spawning migrations cued by water temperature (Collette and Klein-MacPhee 2002, Schultz *et al.* 2009). The spawning migration for alewives typically occurs when water temperatures range from 50–64 °F (10–18 °C) and for blueback herring when temperatures range from 57–77 °F (14–25 °C; Klauda *et al.* 1991). Due to this temperature-dependent spawning, river herring may return to rivers to spawn as early as December or January in the southern portions and as late as July and August in the northern portions of their ranges (ASMFC 2009a; DFO 2001).

Blueback herring and alewives consume a variety of zooplankton. Blueback herring subsist chiefly on ctenophores, calanoid copepods, amphipods, mysids and other pelagic shrimps, and small fishes while at sea (Bigelow and Schroeder 1953, Brooks and Dodson 1965, Neves 1981, Stone 1986, Stone and Daborn 1987, Scott and Scott 1988, Bowman *et al.* 2000). Alewives consume euphausiids, calanoid copepods, mysids, hyrperiid amphipods, chaetognaths, pteropods, decapod larvae, and salps (Edwards and Bowman, 1979, Neves 1981, Vinogradov 1984, Stone and Daborn 1987, Bowman *et al.* 2000).

Little is known about their habitat preference in the marine environment; however, marine distributions of fish are often linked to environmental variables, such as prey availability and predation, along with seascape features. Studies have shown that alewife and blueback herring distribution is linked to bottom temperature, salinity, and depth (Neves 1981, Bethoney *et al.* 2014, Lynch *et al.* 2015). Recent papers described marine co-occurrences of alewife and blueback herring with Atlantic herring and mackerel (Turner *et al.* 2016, Turner *et al.* 2017), providing further evidence, in addition to observed ''bycatch'' estimates (Bethoney *et al.* 2014), that river herring school with Atlantic herring and mackerel. Turner *et al.* (2016) modeled associations of alewife and blueback herring, finding that alewife and blueback herring distributions overlapped with Atlantic herring (68–72 percent correct predictions) and Atlantic mackerel (57–69 percent correct predictions).

Cieri (2012) analyzed NMFS bottom trawl survey data to identify seasonal population clusters of river herring along the East Coast of the United States (N Carolina to Maine; covering the continental shelf and the U.S. Exclusive Economic Zone (EEZ)). The spring trawl survey (1968–2008 NMFS Spring Bottom Trawl Survey) indicates that river herring are widespread across the survey area (sampling locations vary by year; the spring trawl occurs from North Carolina to Nova Scotia; sampling occurs at depths ~18 m to ~300 m (~60 ft to 984 ft)). Highest occurrences during the spring were off Maine's Downeast coast (roughly from Penobscot Bay north-eastwards to the Canadian border) and areas offshore, near Cape Ann and Cape Cod in Massachusetts, and a large area between Block Island, Rhode Island, and Long Island Sound. During the summer (1948–1995 NMFS Bottom Trawl Survey), river herring occurred less frequently across the survey area, with most river herring along the New England coast north of Rhode Island, and the highest occurrences off Downeast, Maine and south of Cape Cod, Massachusetts. During the fall survey (1963–2008 NMFS bottom trawl surveys), the occurrence of river herring shifted northward, with highest occurrences north of Cape Cod, along the Maine Coast to the Bay of Fundy, and another cluster off the eastern shore of Nova Scotia.

Seasonal migrations have been observed in the marine environment as described above but are not well understood (NMFS 2012a). Hypothesized overwintering areas and migration pathways were presented at the NMFS 2012 Stock Structure workshop, but little tagging data existed at that time to confirm any one theory. The working group from the 2012 workshop was not able to determine the migration patterns and mixing patterns of alewife and blueback herring in the ocean, though they strongly suspected regional stock mixing (NMFS 2012a). Therefore, the conclusion that came out of the 2012 Stock Structure workshop was that, based on available data, the ocean phase of alewife and blueback herring was of mixed stocks.

Sparse tagging data is available to help elucidate these marine migrations of alewife and blueback herring. In 1985–1986, approximately 19,000 river herring were tagged and released in the upper Bay of Fundy, Nova Scotia (Rulifson *et al.* 1987). With an overall recapture rate of 0.39, Rulifson *et al.* (1987) received returns of alewife tags from freshwater locations in Nova Scotia, and marine locations in Nova Scotia and Massachusetts; whereas, blueback herring tags were returned from freshwater locations in Maryland and North Carolina, and marine locations in Nova Scotia. The authors suspected from this 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 from outside of Nova Scotia (n=2) made it difficult to generalize about the natal rivers of blueback herring caught in the Bay of Fundy. More recent work with acoustic tags (n=13 alewives and n=12 blueback herring) in the Hudson River by Eakin (2017) demonstrated in-river residence times ranged from two to three weeks, with fish exiting the system three to six days post-spawn. Marine migration was also detected from four blueback herring (2 male, 2 female) showing coastal movements over a six-month period (June to November) from the Hudson River to Penobscot Bay off the coast of Maine. The study also demonstrates the potential of using acoustic tagging to tease out marine movements of alewife and blueback herring in future studies.

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 and Lackey 1974). Many landlocked alewife populations occur as a result of stocking to provide a forage base for game fish species (Palkovacs *et al.* 2007).

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). 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 evolved to 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.

The discrete life history and morphological differences between the two life history variants (anadromous and landlocked) provide substantial evidence that upon evolving to 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 that could provide passage over dams and access to historic spawning habitats restored for anadromous populations, where it did not previously exist.

A Memorandum of Understanding (MOU) between 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, NMFS did not include the landlocked populations of alewife and blueback herring in the review of the status of the species in 2013 (78 FR 48943) and did not include landlocked populations in this status review.

Reproduction and Growth

Overall, alewife and blueback herring are habitat generalists found over a wide variety of substrates, depths, and temperatures in freshwater lakes and ponds, river, estuaries, and the Atlantic Ocean. The substrate preferred for spawning varies greatly and can include gravel, detritus, and submerged aquatic vegetation. Alewives prefer spawning over sand or gravel bottoms (Galligan 1962), usually in quiet waters of ponds and coves (Marcy 1967, Loesch and Lund 1977). Blueback herring prefer spawning over hard substrates, where the flow is relatively swift (Loesch and Lund 1977). Nursery areas include freshwater and semi-brackish waters to fully saline waters for both species (Gahagan 2012, Turner *et al.* 2014, Payne Wynne *et al.* 2015).

Alewife and blueback herring are fast growing, quick to mature species with a high fecundity rate. Estimates of fecundity for alewife range from 45,800 to 400,000 eggs (Foster and Goodbred 1978, Klauda *et al.* 1991, Loesch and Lund 1977). Estimates of fecundity for blueback herring range from 30,000 to 400,000 eggs (Loesch 1981, Jessop 1993). Fecundity estimates range widely based on the length and weight of the females (Schmidt and Limburg 1989) and geographic recruitment (Gainias *et al.* 2015). Both species spawn three to four times throughout the spawning season (McBride *et al.* 2010, Gainias *et al.* 2015). Recent literature has shown that some Alosa species, including alewife, are indeterminate spawners (Hyle *et al.* 2014, Gainas *et al.* 2015, McBride *et al.* 2016). For indeterminate spawners, the potential annual fecundity is not fixed before the onset of spawning. In these species, eggs can develop at any time during the spawning season. This is likely the case for blueback herring but more research is needed.

Incubation time depends on temperature (*i.e.,* low water temperatures results in slow development) and is estimated to take two to four days after deposit for blueback herring (Klauda *et al.* 1991, Jones *et al.* 1978). Incubation time for alewives takes between two to six days depending on temperature (Mansueti 1956, Jones *et al.* 1978).

Population Structure

The population structure of these species has been examined using various tools, including otolith chemistry and genetics (see Population Structure section of the Status Review Report for additional information, NMFS 2019). While otolith chemistry studies focused largely on assigning fish to rivers of natal origin with some success (Gahagan *et al.* 2012, Turner *et al.* 2015), genetic analyses found evidence for regional structure within each species (McBride *et al.* 2014, Palkovacs *et al.* 2014, Hasselman *et al.* 2014; Hasselman *et al.* 2016; Ogburn *et al.* 2017, Baetscher *et al.* 2017, Reid *et al.* 2018). Early genetic studies relied largely on microsatellite markers and were limited in geographic scope (see Genetic Studies section of NMFS 2019 for a detailed account); however, recent studies using single nucleotide polymorphisms (SNP) have expanded the evaluation of population structure for these species across most of their ranges.

SNPs are small genetic variations that occur in a genome. These variations are used as molecular markers in genetic research and help to overcome limitations associated with microsatellite analyses when applied to fisheries management, which includes a lack of portability across laboratories and instruments (Reid *et al.* 2018).

SNPs were developed using 96 individual loci for alewife and for blueback herring by Baetscher *et al.* (2017). This study evaluated river herring samples across portions of the U.S. range for self-assignment to populations of origin and to three alewife and four blueback herring regional groupings identified by Palkovacs *et al.* (2014). While self-assignments to population of origin were lower (at around 67 percent), assignment to regional groupings was 93 percent for alewives and 96 percent for blueback herring. Structure cluster analysis showed similar results to previous regional stock structure groupings, with the addition of two additional blueback herring populations (Peticodiac and Margaree).

Recent work by Reid *et al.* (2018) built on Baetscher *et al.'*s work by increasing the geographic range and number of rivers sampled for each species, sampling across almost the entire range of these species. This study included river herring from 108 locations (genotyping over 8,000 fish) ranging from Florida to Newfoundland using SNP markers developed by Baetcher *et al.* (2017). A STRUCTURE analysis of the genetic data supported four distinct geographic groupings for alewife and five for blueback herring (STRUCTURE refers to software that is one of the most widely used population analysis tools for assessing patterns of genetic structure in samples). The study identified the following four regional groupings for alewife: (1) Canada, including: Garnish River and Otter Pond, Newfoundland to Saint John River, New Brunswick; (2) Northern New England, including: St. Croix River, ME to Merrimack River, NH; (3) Southern New England, including: Parker River, MA to Carll's River, NY; and (4) Mid Atlantic, including: Hudson River, NY to Alligator River, NC. The study also identified the following five regional groupings for blueback herring: (1) Canada/Northern New England, including: Margaree River, Nova Scotia to Kennebec River, ME; (2) Mid New England, including: Oyster River, NH to Parker River, MA; (3) Southern New England, including: Mystic River, MA to Gilbert-Stuart Pond, RI; (4) Mid Atlantic, including: Connecticut River, CT to Neuse River, NC; and (5) Southern Atlantic, including: Cape Fear River, NC to St. Johns River, FL.

Because the similarity in geographic naming of these stock complexes may make them difficult to distinguish between species, hereafter, we preface alewife regional groupings with Aw- and blueback herring regional groupings with Bb-. For example, the Mid Atlantic regional groupings of these two species would be referred to as Aw-Mid Atlantic and Bb-Mid Atlantic. We refer the reader to Figures 1 and 2 below for maps distinguishing the boundaries between stock complexes.

Self-assignment tests to these regional groups ranged from 86–92 percent for alewives and 76–95 percent for blueback herring (Reid *et al.* 2018). However, self-assignment to individual rivers was low. These results indicate that at larger spatial scales, there are regions of restricted gene flow within the range-wide populations; Reid *et al.* (2018) noted that this could be driven by environmental and habitat differences. However, the results also indicate that the extent of gene flow across regional groupings was higher than previously reported by Palkovacs *et al.* (2014), especially at the borders, and that proximate rivers are usually not demographically independent due to straying behaviors. Reid *et al.* (2018) noted transitional populations present between regions, with rivers such as the Hudson and the Connecticut Rivers acting as transition zones for alewife and blueback herring, respectively.

Genetic studies also demonstrate that stocking practices influence genetic differentiation among populations (McBride *et al.* 2014, McBride *et al.* 2015). McBride *et al.* (2015) used 12 microsatellite loci to evaluate the genetic structure of 16 alewife populations in Maine to determine whether past stocking influenced current populations and the genetic composition of alewives. Results showed a highly significant relationship between genetic differentiation and geographic distance among non-stocked populations, but a non-significant relationship among stocked populations (McBride *et al.* 2015).

The unusual genetic groupings of river herring in Maine are likely a result of Maine's complex stocking history. Alewife populations in Maine have been subject to considerable within-basin 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. This information further demonstrates that past stocking patterns influence contemporary genetic diversity, and stocking history should be taken into account when interpreting genetic groupings (Atkins and Goode 1887, McBride *et al.* 2014, McBride *et al.* 2015).

In summary, the best available genetic data suggest that alewife and blueback herring may be distinguished by regional groupings. Recent studies show a minimum of four stock complexes of alewife and five stock complexes of blueback herring. Transfer of river herring within-basin and out-of-basin has likely altered the genetic diversity of alewife and blueback herring observed today in several ways. First, stocked areas are most likely to have had already low populations (or local extirpation), and second, this reduced population is then stocked with a likely different genetic stock, further masking the previous population's genetics.

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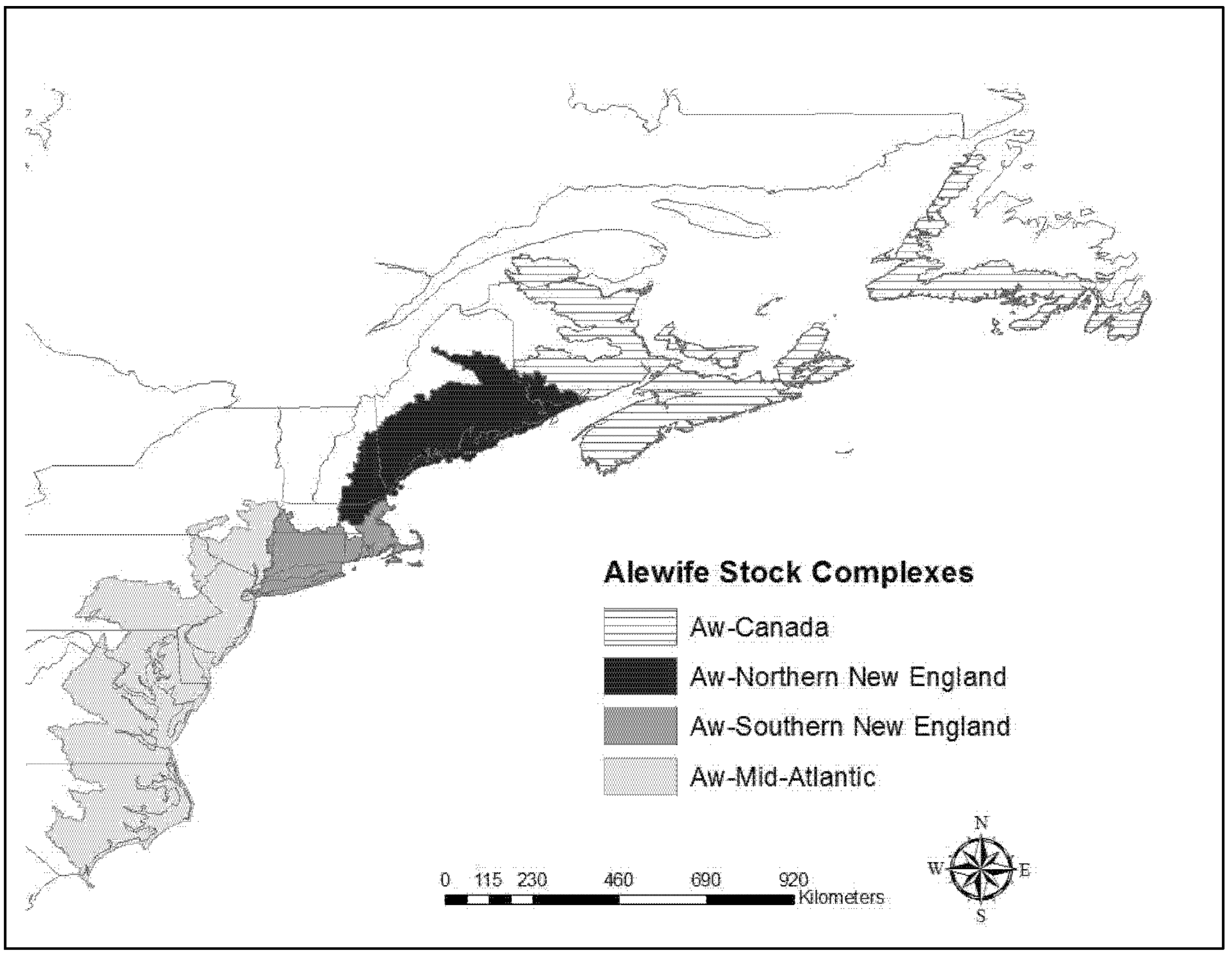

Figure 1. Map of Alewife regional stock complexes: Aw-Canada; Aw-Northern New England; Aw-Southern New England; and Aw-Mid-Atlantic.

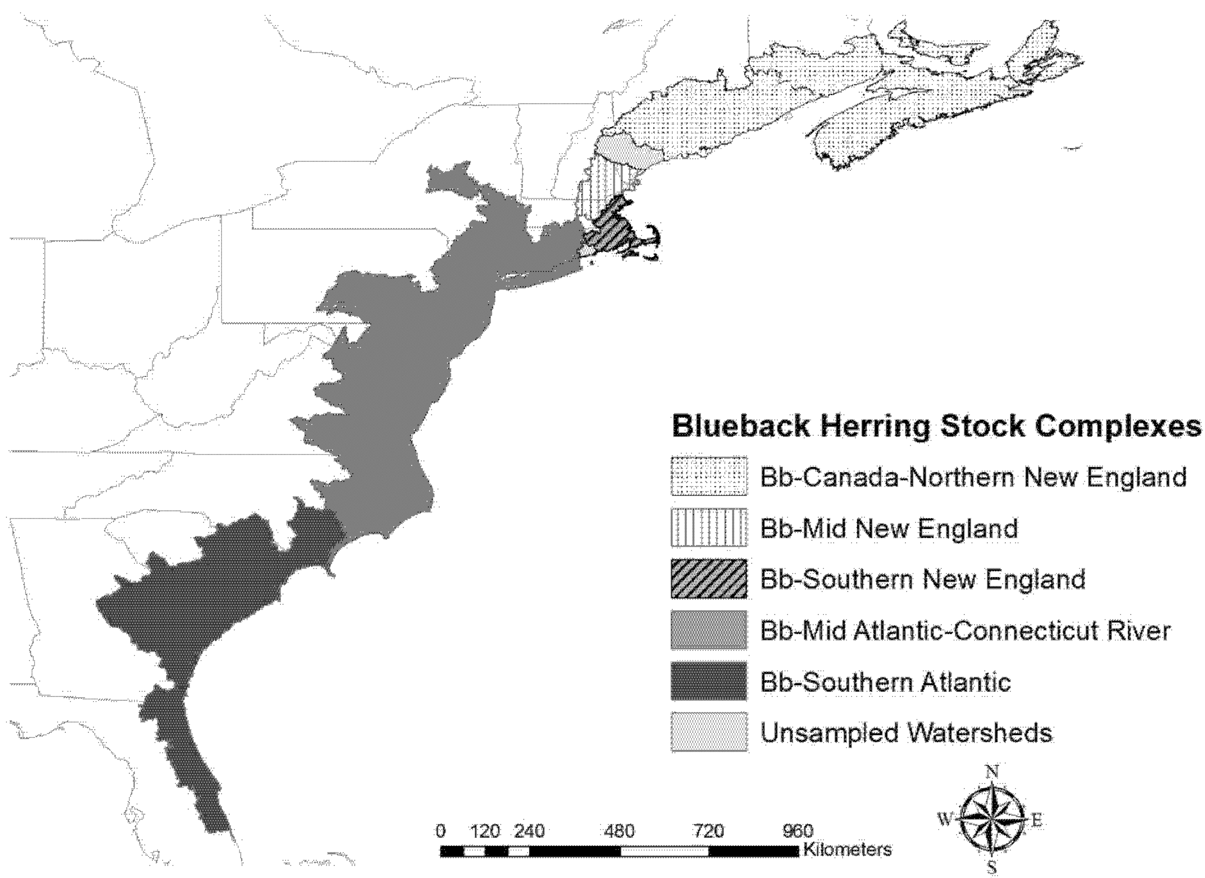

Figure 2. Map of Blueback herring regional stock complexes: Bb-Canada/Northern New England, Bb-Mid-New England, Bb-Southern New England, Bb-Mid-Atlantic; and, Bb-Southern Atlantic.

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Straying

River herring conform to a metapopulation paradigm (*i.e.,* a group of spatially separated populations of the same species that interact at some level) with adults frequently returning to their natal rivers for spawning with straying occurring between rivers (Jones 2006; ASMFC 2009a). There have been very few studies to quantify straying rates, despite evidence of straying in the literature (Jessop 1994, Palkovacs *et al.* 2014, McBride *et al.* 2014, Turner and Limburg 2014, McBride *et al.* 2015, Ogburn *et al.* 2017). Jessop (1994) reported straying rates of 3–37 percent in the St. John River, New Brunswick. McBride *et al.* (2014) and Palkovacs *et al.* (2014) reported greater isolation by distance for alewives than for blueback herring, suggesting higher overall straying rates for blueback herring. Additionally, isolation by distance evidence from Palkovacs *et al.* (2014) and McBride *et al.* (2015), suggest that genetic exchange (straying) is more likely to happen with nearest-neighbor rivers over such distances as 100–200 kilometers (km) (62–124 miles (mi)). Straying has also been reported in other anadromous fishes, such as American shad (Jolly *et al.* 2012) and striped bass (Gauthier *et al.* 2013). Pess *et al.* (2014) reviewed basic life history traits of diadromous fish and hypothesized recolonization rates. Alewife and blueback herring were considered to have a moderate to strong tendency to colonize new streams (Pess *et al.* 2014). Both species were considered to have the highest tendencies to colonize new streams of all the east coast diadromous fish, with blueback herring scoring slightly higher than alewife. Alewife and blueback herring were also considered to have strong tendencies to expand into habitat within existing streams; scoring higher than all other diadromous fish, except for sea lamprey.

Abundance and Trends

United States Waters

A 2017 alewife and blueback herring stock assessment update 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 2017 stock assessment followed the same methods and analyses outlined in the 2012 benchmark report (ASMFC 2012a) and updated the existing time series by adding data when available for the years 2011–2015. The subcommittee assessed the coastal stocks of alewife and blueback herring by individual rivers as well as coast-wide based on available data. As this assessment provides the most up-to-date abundance and trends data of river herring, the Status Review Report includes many excerpts from the 2017 ASMFC stock assessment (see sections on Commercial Catch Per Unit Effort (CPUE), Run Counts, Young-Of-The-Year Seine Surveys, Juvenile-Adult Fisheries-Independent Seine, Gillnet and Electrofishing Surveys, Juvenile and Adult Trawl Surveys, Mean Length, Maximum Age, Mean Length-at-Age, Repeat Spawner Frequency, Total Mortality (Z) Estimates, and Exploitation Rates) (NMFS 2019). For the full ASMFC stock assessment (including additional tables and figures), see River Herring Stock Assessment Update Volume I (*www.asmfc.org/uploads/file/59b1b81bRiverHerringStockAssessmentUpdate_Aug2017.pdf*). Of the 54 in-river stocks of river herring for which data were available, the 2017 ASMFC Stock Assessment indicates that from 2006 through 2015, 16 experienced increasing trends, two experienced decreasing trends, eight were identified as stable by the ASMFC working group, 10 experienced no discernible trend/high variability, and 18 did not have enough data to assess recent trends, including one that had no returning fish (see Table 2 in NMFS 2019; ASMFC 2017a). The coastwide meta-complex of river herring stocks on the U.S. Atlantic coast remains depleted to near historic 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. 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 is that the length of their time series did not overlap with the period of peak commercial landings (*i.e.,* prior to 1970); therefore, there is no accurate way of comparing historical landings to fisheries-independent surveys. There appears to be a consensus among various assessment methodologies that exploitation has decreased. 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 (See *Directed Commercial Harvest* below and State Regulations in the Status Review Report, NMFS 2019, for further detail).

Canadian Waters

The Department of Fisheries and Oceans (DFO) monitors and manages river herring runs in Canada. River herring monitoring in the Maritime region falls into two categories, rivers where abundances can be directly estimated (*e.g.,* monitoring at fishways), and rivers where information is available from the commercial fishery (Gibson *et al.* 2017). River herring runs in the Miramichi River in New Brunswick and the Margaree River in Cape Breton, Nova Scotia were monitored intensively from 1983 to 2000 (DFO 2001). More recently (1997 to 2017), 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). During the period of 1970 to 2017, Billard (2017) estimated run size of alewife in the Gaspereau from 265,000 to 1.2 million. The exploitation rate for this same period ranged from 33 percent to 89 percent. Billard (2017) classified the most recent years 2015 and 2016 as having healthy escapement rates, but overexploited as a fishery. 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 metric tons (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.

Species Finding

Based on the best available scientific and commercial data summarized above, we find that the alewife and blueback herring are currently considered as two taxonomically-distinct species (see Taxonomy and Distinctive Characteristics of NMFS 2019) and, therefore, meet the definition of ''species'' pursuant to section 3 of the ESA. Below, we evaluate whether each species warrants listing as endangered or threatened under the ESA throughout all or a significant portion of its range.

Distinct Population Segment Determination

In addition to evaluating whether each species is at risk of extinction, the SRT was asked to identify any DPSs of these species and evaluate whether such DPSs may be at risk of extinction throughout all or a significant portion of its range. As described above, the ESA's definition of ''species'' includes ''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.'' The DPS Policy requires the consideration of two elements: (1) The discreteness of the population segment in relation to the remainder of the species to which it belongs, and (2) the significance of the population segment to the species to which it belongs.

A population segment of a vertebrate species may be considered discrete if it satisfies either one of the following two conditions. The first condition is if the species 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. The second condition is if the species 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 segment is found to be discrete under one or both of the above conditions, its biological and ecological significance to the taxon to which it belongs is evaluated. Factors that can be considered in evaluating significance may include, but are not limited to: (1) Persistence of the discrete population segment in an ecological setting unusual or unique for the taxon; (2) evidence that the loss of the discrete population segment would result in a significant gap in the range of a 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.

Evaluation of Discreteness

The SRT evaluated whether any alewife or blueback herring DPSs, including those identified by the petitioner in 2011, exist. The Status Review Report, in particular the section on Population Structure, provides a summary of information they reviewed, including tagging and genetics data, as well as fisheries management information (NMFS 2019). As highlighted in the DPS Policy, quantitative measures of morphological discontinuity or differentiation can serve as evidence of marked separation of populations. After review of the best available information, the SRT found that genetic studies provide evidence of regional differentiation in both alewife and blueback herring by demonstrating discrete groupings at a large geographic scale. In particular, the SRT found that the study by Reid *et al.* (2018), which includes a large number of rivers across the species' ranges, provides the most comprehensive evidence of regional differentiation for these species, because STRUCTURE analyses demonstrate support for regional groupings, and because the self-assignment tests to regional groupings have high values ranging from 86–92 percent for alewife and 76–95 percent for blueback herring. The SRT found the following regional stock complexes for alewife represent discrete groupings: (1) Aw-Canada (Garnish River, Newfoundland to Saint John River, New Brunswick); (2) Aw-Northern New England (St. Croix River, ME to Merrimack River, NH); (3) Aw-Southern New England (Parker River, MA to Carlls River, NY) and; (4) Aw-Mid Atlantic (Hudson River, NY to Alligator River, NC). These four discrete groupings correspond to the stock complexes in Figure 1. In addition the SRT found the following regional stock complexes for blueback represent discrete groupings: (1) Bb-Canada/Northern New England (Margaree River, Nova Scotia to Kennebec River, ME); (2) Bb-Mid New England (Oyster River, NH to Parker River, MA); (3) Bb-Southern New England (Mystic River, MA to Gilbert-Stuart Pond, RI); (4) Bb-Mid Atlantic (Connecticut River, CT to Neuse River, NC), and; (5) Bb-Southern Atlantic (Cape Fear River, NC to St. Johns River, FL). These five discrete groupings correspond to the stock complexes shown in Figure 2.

While the SRT found that genetic information provides evidence for regional population separation and discreteness for these stock complexes (depicted in Figures 1 and 2), especially at a large spatial scale, the SRT noted some uncertainty associated with the level of discreteness of these groupings. Specifically, the high degree of admixture (mixture of two or more genetically differentiated populations) at the boundaries of each of these stock complexes, referred to earlier as transitions zones, makes separation between stocks unclear at finer spatial scales. Also spatial gaps exist where samples were not obtained or tested (*e.g.,* between the Aw-Southern New England and Aw-Mid Atlantic stock complexes, and between the Bb-Southern New England and Bb-Atlantic stock complexes) making the accuracy of these boundaries uncertain.

Additionally, the SRT noted that there is some uncertainty surrounding these groupings due to the methodology used by Reid *et al.* (2018) in the rangewide analysis where STRUCTURE was run on collection sites without binning into larger spawning habitats. For example, Black Creek, a tributary of the Hudson, was considered separate from the Hudson in the analysis even though these rivers share an estuary. Additionally, a number of small tributaries of the Connecticut River (*e.g.,* Wethersfield Cove, Mill Creek, and Mill Brook) were considered as separate independent populations.

Overall, the SRT relied upon the best available genetic information (see NMFS 2019 for complete discussion) to determine discreteness for the alewife and blueback herring. The SRT discussed but did not find evidence of physiological, ecological, behavioral factors or life history differences that would aid in further delineating discrete populations. In addition, the SRT discussed combining and/or further separating the genetic groupings outlined above, but did not find evidence to support modifying the genetic groups, despite the study limitations discussed (see above).

Evaluation of Significance

As noted above, the DPS Policy instructs that significance is evaluated in terms of the ecological and biological importance of the population segment to the species. The SRT considered the significance of each of the regional groupings (*i.e.,* stock complexes) found to be discrete. In reviewing the factors that support a finding of significance outlined above, the SRT found that the discrete groupings identified for both species are not found in areas that appear to have unique or unusual ecological settings. Although the petitioner suggested that the terrestrial ecoregions identified by The Nature Conservancy (Anderson 2003) may represent unique or unusual ecological settings for the species, the SRT found several ecoregions were not unique or unusual because they could be found within the range of more than one discrete group. For example, the Northern Appalachian/Acadian terrestrial ecoregion extends throughout both the Aw-Northern New England and Aw-Canada stock complexes. Additionally, the Northern Piedmont and North Atlantic Coastal ecoregions extended through the Bb-Mid-New England, Bb-Southern New England and into the Bb-Mid-Atlantic stock complexes. For ecoregions that existed entirely within one stock complex, the SRT found that the ecoregions appeared to have no unique or unusual bearing on the discrete grouping's biology, as the range of the group included more than one ecoregion. For example, the Chesapeake Bay Lowlands exist entirely within the range of the Aw-Mid-Atlantic stock complex; however, this range also contains a portion of the North Atlantic coast ecoregion (which spans three stock complexes). The SRT also considered whether other ecological factors, such as ocean currents or thermal regimes, existed within the boundaries of these complexes, and might point to persistence in a unique ecological setting. However, the SRT did not find that any of these stock complexes persist in a unique terrestrial ecoregions or other ''ecological settings,'' instead they noted that some of these stock complexes may share marine environments where oceanic features appear unique, and that terrestrial ecoregions do not align with the identified discrete stock complex boundaries.

Next, the SRT considered whether the loss of the population segments would result in significant gaps in the range of the taxa. The SRT agreed that the length of coastline or overall size of the habitat that the discrete grouping inhabited would be the greatest factor in determining whether a gap, or loss in the range, was significant to a taxon as a whole. Specifically, large gaps in the range across widespread watersheds might be difficult for either species to refill naturally (*i.e.,* through straying) and would be extremely difficult to fill through management efforts (*e.g.,* stocking).

Large gaps in the range may interfere with connectivity between populations, resulting in isolated populations that are more vulnerable to the impacts of large threats or catastrophic events (*e.g.,* storms, regional drought). 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). Further, a large gap on the periphery of the range would limit the distribution of the species, similarly reducing resiliency. For example, wide distributions may provide a diversity of habitats and buffer species against widespread threats such as changing temperatures by providing more opportunities for habitat refugia. Although there is no evidence currently available to suggest that genetic differences between these stock complexes represent adaptive traits (only neutral genetic markers have been used in the current population structure analyses), the SRT also noted that significant gaps could represent a loss of genetic adaptation if these regional groupings are also linked to adaptive traits (NMFS 2019).

As noted in the Status Review Report river herring discrete stock complexes could re-colonize spatial gaps in the range. Genetic studies provide evidence of straying (see Straying above) and suggest transition zones between populations (NMFS 2019). The SRT noted that gaps in the population would most likely be filled in a step-wise fashion with fish moving in from the borders of the nearest stock complexes, but that some straying may occur mid-range as well. Because river herring exhibit straying both from nearby rivers and over larger distances (Gardner *et al.* 2011, Hogg 2012, sensu Reid *et al.* 2018), the SRT noted that the significance of any particular gap will be primarily a factor of the geographic scope (or size of the gap).

The SRT noted that the life history, fecundity, and straying behavior of these species could lead to having river herring within individual rivers once occupied by the ''lost'' stock (*i.e.,* fish recolonizing the gap in the range) rather quickly, but perhaps at low or less than sustainable levels. For the purposes of considering the loss of each discrete stock complex, the SRT defined a significant gap to be a large geographic area of the range (considering the length of coastline or size of the watershed) that was unlikely to be recolonized with self-sustaining populations within at least 10 generations (40–60 years); the upper limit of time the SRT believed that the taxon could sustain without detrimental effects from loss of connectivity.

There is debate in the literature regarding the application of assigning a general number to represent when populations are sufficiently large enough to maintain genetic variation (Allendorf and Luikart 2007). The SRT settled on a self-sustaining population of around 1,000 spawning fish annually in currently occupied rivers within the area; a number close to the population of some smaller river systems where populations are able to maintain returns (*e.g.,* Little River, MA). This metric of 1,000 fish is close to, but greater than the ''500 rule'' introduced by Franklin (1980) for indicating when a population may be at risk of losing genetic variability.

The SRT reviewed each of the discrete stock complexes for both species and considered the overall size of the gap that would exist as well as the likelihood that the area would be filled in by neighboring stock complexes. The SRT noted that the nearest neighboring stock complex would be most likely to colonize in a step-wise fashion at the borders of any gap. The SRT also acknowledged that strays may colonize from any stock complex, as isolation by distance evidence from Palkovacs *et al.* (2014) and McBride *et al.* (2015) suggests that genetic exchange (straying) currently happens over such distances as 100–200 km (62–124 mi). However, while this is possible, this scenario was less likely than strays colonizing from the closest stock complex.

The loss of discrete stock complexes that were large in geographic scope and, therefore, unlikely to be filled in by neighboring stock complexes were considered likely to leave a significant gap in the species' range. These findings are summarized below in Table 1.

TABLE 1—SUMMARY OF SIGNIFICANT GAP DISCUSSION FOR ALEWIFE AND BLUEBACK HERRING STOCK COMPLEXES

Discrete stock complex	Estimates of geographic scope of the stock complex (watershed size (square kilometers (km^2) (square miles mi^2)); coastline distance (km) (mi); degrees latitude; percent of rangewide watershed area)	Likelihood of recolonization	Loss of the stock complex would result in a significant gap (yes or no)
Alewife Canada	169,000 km^2 (65,251 mi^2); 15,200 km (9,444 mi); 7.5 degrees latitude; 35 percent.	Recolonization is unlikely due to the large size of the gap and with only one neighboring complex to the south.	Yes.
Alewife Northern New England	74,000 km^2 (28,572 mi^2); 5,800 km (3,604 mi); 2.5 degrees latitude,15 percent.	Recolonization across this range is unlikely due to the large size of the gap despite having neighboring complexes to the south and north beginning to recolonize bordering areas.	Yes.
Alewife Southern New England	35,500 km^2 (13,707 mi^2); 7400 km (4,598 mi); 2.5 degrees latitude; 7 percent.	Recolonization is unlikely due to the large size of the gap and with only one neighboring complex to the north.	Yes.
Alewife Mid-Atlantic	211,500 km^2 (81,661 mi^2); 19,600 km (12,179 mi); 9 degrees latitude; 43 percent.	Recolonization is unlikely due to the large size of the gap and with only one neighboring complex to the north.	Yes.
Blueback Herring Canada/Northern New England.	137,000 km^2 (52,896 mi^2); 11,100 km (6,897 mi); 4 degrees of latitude; 26 percent.	Recolonization is unlikely due to the large size of the gap and with only one neighboring complex to the south.	Yes.
Blueback Herring Mid New England	12,000 km^2 (4,633 mi^2); 311 km (193 mi); 0.5 degrees of latitude; <3 percent.	Recolonization across this range is likely given the small size of the gap and because neighboring complexes can recolonize step-wise from the south and north.	No.
Blueback Herring Southern New England.	9,000 km^2 (3,475 mi^2); 2,900 km (1,802 mi); 1.5 degrees of latitude; <2 percent.	Recolonization across this range is likely given the small size of the gap and because neighboring complexes can recolonize step-wise from the south and north. Additionally, proximity to known river herring overwintering grounds might support further recolonization.	No.
Blueback Herring Mid Atlantic	211,000 km^2 (81,468 mi^2); 24,800 km (15,410 mi); 9 degrees of latitude; 40 percent.	Recolonization across this range is unlikely due to the large size of the gap despite neighboring complexes to the south and north beginning to recolonize bordering areas.	Yes.

TABLE 1—SUMMARY OF SIGNIFICANT GAP DISCUSSION FOR ALEWIFE AND BLUEBACK HERRING STOCK COMPLEXES—Continued

Discrete stock complex	Estimates of geographic scope of the stock complex (watershed size (square kilometers (km²) (square miles mi²)); coastline distance (km) (mi); degrees latitude; percent of rangewide watershed area)	Likelihood of recolonization	Loss of the stock complex would result in a significant gap (yes or no)
Blueback Herring Southern Atlantic	140,000 km² (54,054 mi²); 18,300 km (11,371 mi); 7 degrees of latitude, 26 percent.	Recolonization is unlikely due to the large size of the gap and with only one neighboring complex to the north.	Yes.

The SRT did not find evidence that discrete population segments outlined previously represent the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historic range. The SRT identified four alewife DPSs and three blueback herring DPSs. Therefore, none of the DPSs represent the only surviving natural occurrence of either alewife or blueback herring.

Finally, the SRT considered evidence to determine whether any of the discrete population segments differ markedly from other populations of the species (*i.e.,* the other identified stock complexes) in its genetic characteristics. The SRT discussed the methodology in the Reid *et al.* (2018) paper and inquired with one of the lead authors about information on the genetic diversity (*e.g.* heterozygosity among stock complexes) results from the study. The SNP markers in the Reid *et al.* (2018) paper used neutral genetic markers which do not convey adaptive traits, so the SRT was unable to find evidence that the discrete stock complexes differ markedly from other populations of the species in its genetic characteristics. The SRT also considered spawning timing, which has been shown to be heritable in steelhead and presumably could be heritable in other anadromous fish, including alewife or blueback herring. The SRT examined rangewide spawning strategies, and was not aware of differing life history strategies, such as winter and fall spawning timing in the species (as exhibited in steelhead). Alewives and blueback herring use thermal cues for spawning timing; however, this appears to be due to clinal patterns, with rivers in the southern portion of the range beginning spawning earliest in the year and the rivers at highest latitudes spawning latest in the year. Overall, the SRT did not find existing evidence to support heritable spawning timing in alewife or blueback herring.

After reviewing the significance criteria, the SRT did not find evidence to demonstrate these discrete stock complexes persist in a unique ecological setting or that they differ markedly from one another in their genetic characteristics. The SRT did find evidence that loss of the population segment would result in a significant gap in the range of the taxon for all four discrete stock complexes of alewife: Aw-Canada; Aw-Northern New England; Aw-Southern New England, and; Aw-Mid-Atlantic. In addition, the SRT also found evidence that loss of the population segment would result in a significant gap in the range of the taxon for three of the five discrete stock complexes of blueback herring: Bb-Canada/Northern New England, Bb-Mid-Atlantic, and bb-Southern Atlantic. However, due to the small size of the Bb-Mid-New England and Bb-Southern New England stock complexes and because this habitat is likely to be recolonized by blueback herring stock complexes to the north and to the south, the loss of one of these two discrete stock complexes did not represent a significant gap in the range of the taxon (which includes five discrete stock complexes across the range).

While the SRT applied the ''10 generations for recolonization'' formula (described above), we do not find that the use of such a formula is necessary given the large geographic scope (see Table 1 column 2) of the potential gaps caused by the loss of the Aw-Canada; Aw-Northern New England; Aw-Southern New England, or; Aw-Mid-Atlantic stock complex or the Bb-Canada/Northern New England, Bb-Mid-Atlantic, or Bb-Southern Atlantic stock complex. The potential loss of any of these stock complexes would create a large gap in the range of these species creating issues with connectivity between populations, lowering the diversity of habitats that these species span, and reducing the species' ability to overcome large threats or catastrophic events. In contrast, a small gap in the range, such as either the potential loss of the Bb-Mid New England or Bb-Southern New England stock complex, may be less important to these species because their straying behavior and fecundity may allow them to regain or even maintain connectivity between neighboring stock complexes. Accordingly, based on these considerations, we agree with the SRT's findings that the loss of the Aw Canada; Aw-Northern New England; Aw-Southern New England, or; Aw-Mid-Atlantic stock complex or the Bb-Canada/Northern New England, Bb-Mid-Atlantic, or Bb-Southern Atlantic stock complex would create a significant gap in the range of these species.

The SRT relied on the best available information throughout this analysis, but noted that future information on behavior, ecology, and genetic characteristics may reveal differences significant enough to show fish to be uniquely adapted to each stock complex.

Because the following stock complexes meet both the discreteness and significance prongs, the SRT identified, and we agree with, the following DPSs for alewife (Figure 3):

- Aw-Canada DPS the range includes Garnish River, Newfoundland to Saint John River, New Brunswick;
- Aw-Northern New England DPS—the range includes St. Croix River, ME to Merrimack River, NH;
- Aw-Southern New England DPS—the range includes Parker River, MA to Carll's River, NY; and
- Aw-Mid Atlantic DPS—the range includes Hudson River, NY to Alligator River, NC.

Because the three blueback herring stock complexes meet both the discreteness and significance prongs, the SRT recommends, and we agree, with the following DPSs for blueback herring (Figure 4):

- Bb-Canada-Northern New England DPS—the range includes Margaree River, Nova Scotia to Kennebec River, ME;
- Bb-Mid Atlantic DPS—the range includes Connecticut River, CT to Neuse River, NC; and
- Bb-Southern Atlantic DPS—the range includes Cape Fear River, NC.

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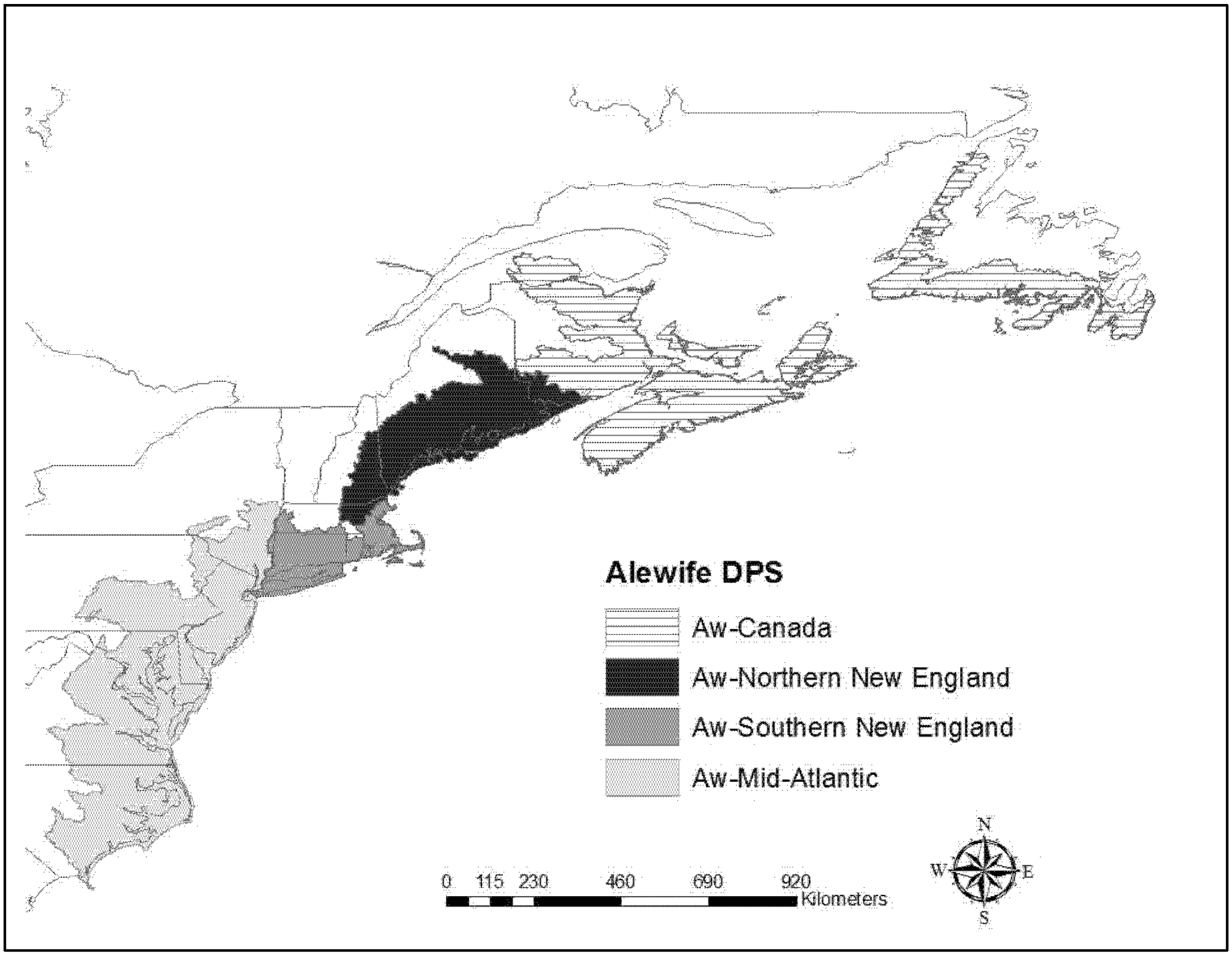

Figure 3. Map of Alewife Distinct Populations Segments (DPS): Aw-Canada DPS, Aw-Northern New England DPS, Aw-Southern New England DPS, and Aw-Mid-Atlantic DPS.

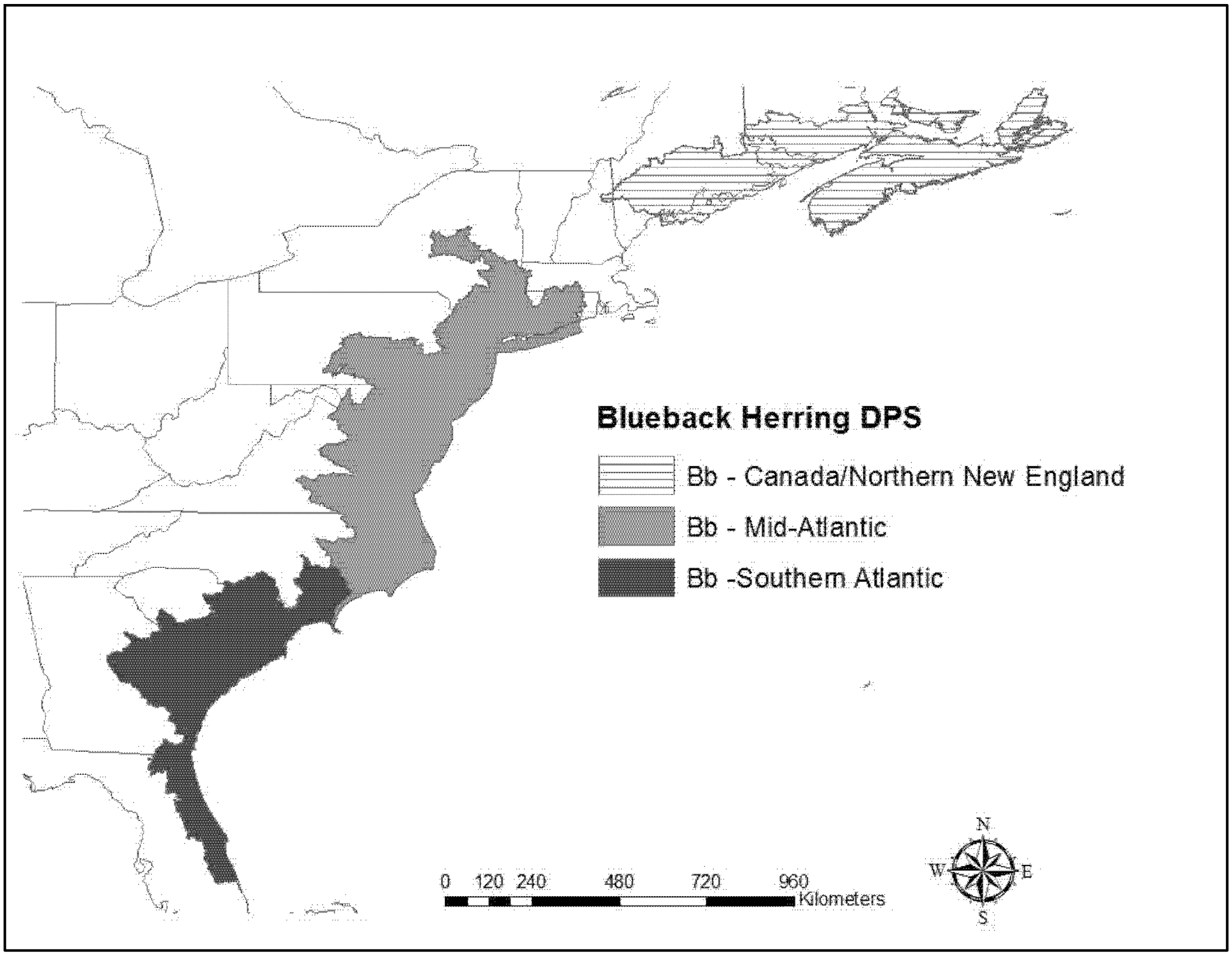

Figure 4. Map of Blueback herring Distinct Populations Segments (DPS): Bb-Canada/Northern New England DPS, Bb-Mid-Atlantic DPS, and, Bb-Southern Atlantic DPS.

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Assessment of Extinction Risk

Foreseeable Future

The ESA 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 any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range (16 U.S.C. 1532(6) and (20)). The term ''foreseeable future'' is not further defined or described within the ESA. However, consistent with our past practice, we describe the ''foreseeable future'' on a case-by-case basis, using the best available data for the particular species, and taking into consideration factors such as the species' life history characteristics, threat projection time frames, and environmental variability. We interpret the foreseeable future as extending only so far into the future as we can reasonably determine that both the threats and the particular species' responses to those threats are likely. Because a species may be susceptible to a variety of threats for which different data are available, or which operate across different time scales, the foreseeable future is not necessarily reducible to a particular number of years.

Highly productive species with short generation times (*e.g.,* river herring) 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). Consequently, given the high population variability among clupeids, projecting out further than a few generations could lead to considerable uncertainty in predicting the response to threats for each species.

As described below, the SRT determined that dams, water withdrawal, poor water quality, incidental catch, inadequacy of regulations, and climate change vulnerability are the main threats to both species. The SRT determined, and we agree, the foreseeable future is best defined by a 12 to 18 year time frame (*i.e.,* out to 2030–2036), or a three-generation time period, for each species for both alewife and blueback herring. This is a period in which impacts of present threats to the species could be realized in the form of noticeable population declines, as demonstrated in the available survey and fisheries data. This timeframe would allow for reliable predictions regarding the impact of current levels of mortality on the biological status of the two species.

Evaluation of Demographic Risks

In determining the extinction risk of a species, it is important to consider both the demographic risks facing the species as well as current and potential threats that may affect the species' status. To this end, a qualitative demographic analysis was conducted for the alewife and blueback herring. A demographic risk analysis is an assessment of the manifestation of past threats that have contributed to the species' current status, and it informs the consideration of the biological response of the species to present and future threats.

The approach of considering demographic risk factors to help frame the consideration of extinction risk has been used in many of our status reviews (see *http://www.nmfs.noaa.gov/pr/species* for links to these reviews). In this approach, the collective condition of individual populations is considered at the species level according to four demographic viability factors: Abundance, growth rate/productivity, spatial structure/connectivity, and diversity. These viability factors reflect concepts that are well founded in conservation biology and that individually and collectively provide strong indicators of extinction risk.

Using these concepts, the SRT evaluated demographic risks by individually assigning a risk score to each of the four demographic criteria (abundance, growth rate/productivity, spatial structure/connectivity, diversity). Qualitative reference levels with ranking scores of whole numbers from 1–5 of ''*very low,*'' ''*low,*'' ''*moderate,*'' ''*high,*'' and ''*very high*'' were used to describe the risk of demographic criteria. A factor (or viable population descriptor) was ranked (1) *very low* if it was unlikely that this descriptor contributed significantly to risk of extinction, either by itself or in combination with other viable population descriptors. A factor was ranked (2) *low* risk if it was unlikely that this descriptor contributed significantly to long-term or near future risk of extinction by itself, but there was some concern that it may, in combination with other viable population descriptors. A factor was ranked (3) *moderate* risk if this descriptor contributed significantly to long-term risk of extinction, but did not in itself constitute a danger of extinction in the near future. A factor was ranked (4) *high* risk if this descriptor contributed significantly to long-term risk of extinction and was likely to contribute to short-term risk of extinction in the near future, and a factor was ranked (5) *very high* risk if this descriptor by itself indicated danger of extinction in the near future.

Each SRT member scored each demographic factor individually. Each SRT member identified other demographic factors and/or threats that would work in combination with factors ranked in the higher categories to increase risk to the species. SRT members provided their expert opinions for each of the demographic risks, including considerations outlined in McElhany *et al.* (2000) and the supporting data on which it was based, and discussed their opinions with the other SRT members. SRT members were then given the opportunity to adjust their individual scores, if desired. These adjusted scores were tallied, reviewed, and then combined for an overall extinction risk determination (see below). This scoring was carried out for both species rangewide and for each DPS, and the demographic scoring summary is presented below. Here the SRT's qualitative ranking for each demographic factor is identified by rounding the mean ranking score, which is provided in parentheses. For example, a demographic factor falling between the *low* (2) and *moderate* (3) risk rankings with a mean ranking score of 2.1 will be identified as *low* (2.1), while a factor with a mean ranking score of 2.5 will be identified as *moderate* (2.5). As noted throughout this section and in the Threats Assessments section and in the corresponding sections of the Status Review Report, many of the mean ranking scores fall between *low* (2), and *moderate* (3). Only a few scores were found to be 3 or higher. As more fully explained in the Status Review Report, the SRT used a scale of whole numbers from 1 to 5 (NMFS, 2019).

Alewife

Abundance

The SRT members individually evaluated the available alewife abundance information, which is summarized in the *Abundance and Trends* section of this listing determination and additional detail can be found in the Status Review Report (NMFS 2019). Alewife abundance has declined significantly from historical levels throughout its range (ASMFC 2017a, ASMFC 2012a, Limburg and Waldman (2009).

While abundance is at or near historical lows, the recent stock assessment update reported few declining abundance trends by dataset in recent years (ASMFC 2017a). The ASMFC River Herring Stock Assessment assessed data from the last ten years (2006–2015) and reported that no run counts reflect declining trends with 11 of 29 showing increasing trends, 14 showing no trend, and four not being updated (two due to discontinuation and two due to agency recommendation to remove the rivers based on data discrepancies between observed river herring presences and fishway counts) (ASMFC 2017a and b). Because abundance is known to be highly variable from year to year for these species, in addition to the trend information, the SRT reviewed annual run count numbers and escapement information, when available, as part of its consideration of information that may inform the abundance estimates of these populations. Given the substantial number of runs with increasing trends and relatively large run counts reported in various portions of the range in recent years (in the hundreds of thousands throughout various regions) (ASMFC 2017a), there do not appear to be depensatory processes rangewide that result in low abundances such that the populations may be insufficient to support mate choice, sex-ratios, fertilization and recruitment success, reproductive or courting behaviors, foraging success, and predator avoidance behaviors. The SRT reviewed available abundance indices for each DPS (see NMFS 2019 for complete summary). The mean score calculated based on the SRT's scores for alewife rangewide (2.0), the Aw-Canada (2.0) DPS, the Aw-Northern New England (2.0) DPS, and the Aw-Southern New England DPS (2.1) all correspond to a *low* ranking, because the SRT found this factor is unlikely to contribute significantly to the risk of alewife extinction.

While abundance information is limited for alewife in the Aw-Canada DPS, data provide some indicators of population size in several rivers. Examples of data reviewed by the SRT included (but were not limited to): Gaspereau River, Nova Scotia time series (1970 to 2017) estimates that ranged from a low of 265,208 (1983) to 1.2 million (2016), (Billard 2017); St. John River, New Brunswick fixed escapement policy of 800,000 alewife released above the dam annually; and Tusket River in Nova Scotia estimated escapement for this stock in 2014–1015 in the range of 1.6 million to 2.3 million alewife.

For populations in the United States, comprehensive summaries of data that inform abundance reviewed by the SRT are available in the ASMFC State-Specific Reports (2017b).

The ASMFC Stock Assessment reports trends from select rivers along the

Atlantic Coast (see Table 1 of ASMFC 2017a); depending on sampling methods, these may be reported by species or in combination (*i.e.,* reported as just river herring). Within the Aw-Northern New England DPS, updated recent trends (2006–2015) for alewife were reported as increasing for the Androscoggin, Damariscotta, and Cocheco rivers. The ASMFC reported increasing trends for river herring as a whole from the Kennebec, Sebasticook, and Lamprey Rivers. The ASMFC also reported no trend for alewife in the Union River, stable river herring trends in the Exeter River, decreasing alewife trends in the Oyster River, no returns of river herring in the Taylor River, and unknown trends for the Winnicut River throughout this period (ASMFC 2017a).

Within the Aw-Southern New England DPS, updated recent trends (2006–2015) for alewife were reported as increasing for the Mattapoisett, Monument, Nemasket, Buckeye, and Bride Brook Rivers. The ASMFC reported stable river herring trends in the Parker and Gilbert Rivers; decreasing alewife trends in the Stony Brook and Nonquit Rivers; and no trends for alewife in the Mianus and Shetucket Rivers; and unknown trends in the Farmington and Naugatuck Rivers (ASMFC 2017a).

The Aw-Mid-Atlantic DPS abundance risk mean score corresponded to a *moderate* (2.7) ranking. Within the Aw-Mid-Atlantic DPS, updated recent trends (2006–2015) for alewife were reported as increasing for river herring in the Hudson River, no tend for alewife in the Delaware and Rappahannock Rivers, stable for alewife in the Nanticoke and Potomac Rivers, and unknown for alewife in the James, York, and Alligator Rivers (ASMFC 2017a). SRT members noted uncertainty about abundance in the Mid-Atlantic DPS, due to minimal available abundance information (with the exception of the Hudson, several rivers in Chesapeake Bay, and a few ASMFC time series). However, preliminary results from the Chesapeake Bay (Ogburn unpublished data) appear favorable, with abundance estimates in surveyed rivers in the 100,000s of fish. Recent estimates of alewife absolute abundance using hydroacoustics for the Roanoke River during 2008–2015 have ranged from 32,000 to 419,000 (Waine 2010, Hughes and Hightower 2015; McCargo 2018).

Growth Rate/Productivity

The SRT evaluated the available information on life history traits for alewife as they relate to this factor, as summarized in the Reproduction, Growth, and Demography section in the Status Review Report (NMFS 2019). Data are limited on growth rate/productivity, and there is little effort to systematically collect and standardize this type of data in most of the range of the species. The SRT considered previously discussed trends in abundance and reviewed trends in maximum age, average size-at-age, repeat spawners, and modeling results for the qualitative ranking of growth rate and productivity. ASMFC (2017a) reported alewife maximum age data indicate most runs had stable ages, and no trends appear reversed relative to the 2012 benchmark. Specifically, maximum age results showed no trends in the Androscoggin, Exeter, Cocheco, Monument, and Gilbert-Stuart Rivers; increasing trends in the Lamprey River (NH); and decreasing tends in the Nanticoke River (MD) and Chowan River (NC). Size at age results showed no trend in the Androscoggin, Cocheco (female), Lamprey, Winnicut, and Hudson Rivers; and decreasing trends in the Exeter (male), Monument, and Nanticoke Rivers. Additionally, for the Status Review Report, a population growth model (MARSS) was used for alewife rangewide. The MARSS model results show a population growth rate point estimate of 0.038, with the associated 95 percent confidence interval ranging from (0.005–0.071) (NMFS 2019).

The mean score calculated for this demographic factor based on SRT members' scores corresponds to a *low* ranking rangewide (2.1), and in each DPS (Aw-Canada DPS (2.0), Aw-Northern New England DPS (2.0), Aw-Southern New England DPS (2.1), and the Aw-Mid-Atlantic DPS (2.3)), as this factor is unlikely to contribute significantly to the risk of extinction for alewife. SRT members noted that rates of population growth for many rivers have shown growth in the past 5–10 years. Where mean age has been reduced, it is often in conjunction with recruitment of strong year classes as the populations rebuild. Some systems are beginning to have increases in age structure as older individuals persist. The SRT noted some runs in the southernmost portion of the range have not shown as strong or consistent improvement; this was reflected in the slightly higher numeric score and variability of the qualitative ranking for the growth rate of the Mid-Atlantic DPS (NMFS 2019).

Spatial Structure/Connectivity

The SRT evaluated the available information on alewife spatial structure (tagging and genetics information) summarized in the Population Structure section in the Status Review Report (NMFS 2019). Alewife range from North Carolina to Newfoundland, Canada. While the species exhibits homing, rates of straying and therefore dispersal help to buffer the species from threats related to loss of habitat and loss of spatial connectivity. The mean score calculated based on SRT members' scores corresponds to a *moderate* (2.6) ranking rangewide and for all DPSs (2.7–2.9), as this factor contributes significantly to long-term risk of extinction, but does not in itself constitute a danger of extinction in the near future. SRT members noted that habitat degradation and destruction threats related to human population growth will presumably continue to increase, and the cumulative effects will influence the species range wide. Reduced, restricted, and impacted spawning and nursery habitat will likely remain a limiting factor to population growth in many river systems.

Diversity

The SRT evaluated the available information on alewife diversity summarized in the Population Structure section in the Status Review Report (NMFS 2019). The available genetics studies indicate that there are a minimum of four genetic stock complexes rangewide and there is reproductive connectivity along a continuum rangewide. SRT members noted that, due to declines in abundance over the last several hundred years, the species has likely lost some genetic diversity, and therefore has lost some adaptive potential. This loss of diversity affects resilience, especially in the face of climate change. Additionally, SRT members determined that human activities of stocking and propagation have also contributed to reduced genetic diversity. Further, the SRT noted that stocking activities, coupled with habitat alterations (*e.g.,* in-river obstructions like dams), and reduced access to spawning and nursery habitat, may even result in the selection of characteristics in these fish that are conducive to survival in modified and dammed river systems.

The mean score calculated based on SRT members' scores corresponds to a *moderate* ranking rangewide (2.6) and in each of the DPSs (Aw-Canada (2.7), Aw-Northern New England (2.7), Aw-Southern New England (2.9) and Aw-Mid-Atlantic (2.9) DPS), as this descriptor contributes significantly to long-term risk of extinction, but does not in itself constitute a danger of extinction in the near future. Although still receiving a *moderate* ranking, SRT members noted that the Aw-Canada DPS may have a slightly lower risk in comparison to other areas, as this DPS has a very large range and access to a wide variety of stream size and temperature regimes. Additionally, the SRT noted the Aw-Canada DPS likely experiences less active stocking (which has been suggested to negatively affect genetic diversity); therefore, the risk to genetic diversity in this DPS was ranked slightly lower.

Blueback Herring

Abundance

The SRT individually evaluated the available blueback herring abundance information, which is summarized in the Description of Population Abundance and Trends section of the Status Review Report (NMFS 2019). SRT members noted that the available information indicated blueback herring abundance had declined significantly from historical levels throughout its range. The SRT reviewed the recent ASMFC stock assessment update and available abundance indices for each DPS (NMFS 2019; ASMFC 2017a). Blueback herring abundance estimates were lower than available estimates for alewife, but recent run count estimates documented hundreds of thousands of fish in the Chowan River, Chesapeake Bay (Ogburn unpublished data), Connecticut River, various Massachusetts rivers, and rivers in Maine (ASMFC 2017b) and New Brunswick (Gibson *et al.* 2017). The mean score calculated based on the SRT's scores corresponds to a *moderate* ranking rangewide (3.0) and in each DPS (Bb-Canada/Northern New England (3.0), Bb-Mid-Atlantic (3.0), and Bb-Southern Atlantic (3.0) DPSs), as this factor is contributing significantly to the blueback herring's risk of extinction, but does not in itself constitute a danger of extinction in the near future.

The SRT reviewed the best available data on blueback herring abundance in the Bb-Canada/Northern New England DPS. The SRT noted that blueback herring in the St. John River, New Brunswick are managed using a fixed escapement policy of 200,000 blueback herring moved above the dam each year; this number is not indicative of abundance, but can be viewed as a minimum when escapement targets are met. The Mactaquac time series (1999 to 2017) ranged from 192,000 to 515,000, with over 489,000 blueback herring passed upstream in 2017. Escapement estimates for the Tusket River in Nova Scotia during the period of 2014 to 2015 ranged from 200,000 to 600,000 blueback herring. As noted above for alewife, the ASMFC Stock Assessment reports trends from select rivers along the Atlantic Coast (see Table 1 of ASMFC 2017a); depending on sampling methods these may be reported by species or in combination (*i.e.,* reported as just river herring). There is little stock specific information on blueback herring in Maine. Within the U.S portion of the Bb-Canada/Northern New England DPS, the ASMFC (2017a) reported trends over 2006–2015 as increasing for river herring in the Kennebec and Sebasticook Rivers. Data reported from rivers throughout this range were also reviewed, and numbers varied widely from year to year, as expected for this species. According to the most recent stock assessment report (ASMFC 2017b), blueback herring estimates for the Kennebec and Sebasticook Rivers in Maine were over 1 million fish (reported as combined species). The state of Maine conducts an annual young-of-the-year survey for six Maine rivers (1979 to 2015). Relative abundance was near zero from 1979 to 1991, and increased gradually through 2004 before declining in recent years (ASMFC 2017a).

The SRT reviewed available abundance data for the Bb-Mid-Atlantic DPS, which ranges from Connecticut to North Carolina. The ASMFC (2017a) reported increasing blueback herring trends for the Mianus and Rappahannock Rivers; stable trends for the Connecticut River, Shetucket River, and Chowan River; no trends for the Delaware and Nanticoke Rivers; and unknown trends for the Farmington, Naugatuck, Potomac, James, York, Alligator, Scuppernog, and St. Johns Rivers. Additionally, trends for river herring were reported as increasing in the Hudson (ASMFC 2017a). Data reported from rivers throughout this range were also reviewed, and numbers varied widely from year to year as expected for this species. The SRT noted blueback herring abundance estimates ranging from 500,000–700,000 during 2013–2016 in the Choptank River; 18,000–54,000 during 2016–2017 in the Patapsco River; and 500,000–950,000 during 2013–2014 in the Marshyhope River (Ogburn unpublished data). Additionally, absolute abundance estimates of blueback herring in the Roanoake River using hydroacoustics ranged from 100,000–478,000 (Waine 2010, Hughes and Hightower 2015, McCargo 2018) across studies conducted in 2008, 2009, 2010, 2011, and 2015, with the high reported in 2015. Total blueback herring population estimates (for age 3+) in the Chowan River time series (1972 to 2015) ranged from a high of 157 million (1976) to a low of 593,693 (2007; ASMFC 2017b). The most recent estimate of blueback herring abundance in the Chowan River was 5,160,983 (2015). Commercial CPUE estimates for blueback herring in the Chowan River have declined since the 1980s.

The ASMFC (2017a) reported no trend for blueback herring in the Santee Cooper River and unknown trends for the St. Johns River. Due to limited trend information, the SRT reviewed available abundance data for the Bb-Southern Atlantic DPS, including young-of-the-year push trawl estimates from Florida (2007 to 2016); CPUE estimates from Santee-Cooper River (1969 to 2015), and minimum population size estimates from the Santee-Cooper River (1990 to 2015) (ASMFC 2017b). Minimum population size estimates from the Santee Cooper River ranged from 8,503 (1990) to 3.4 million (1996); the minimum population size was estimated at 410,000 in 2015. The SRT noted increased uncertainty for Bb-Southern Atlantic abundance risk due to the small number of available indices.

Growth Rate/Productivity

The SRT evaluated the available data for blueback herring as they relate to this factor, as summarized in the Reproduction, Growth, and Demography section in the Status Review Report (NMFS 2019). Data are limited on growth rate/productivity, and there has been limited effort to systematically collect and standardize this type of data in most of the range of the species. SRT members noted that in some populations the maximum age appears to be trending upward, and blueback herring maximum age data indicate most runs had stable ages (ASMFC 2017a). On a rangewide basis, the MARSS model (NMFS 2019) showed blueback herring population growth rates of 0.05 with a 95 percent confidence interval (−0.03 to 0.13). Also, while recent abundance trends have indicated positive growth rates, trends in demographic (maximum age) and reproductive rates (repeat spawners) are largely negative or stable; the combination of these two trends is an indicator of a potentially declining growth rate, given the paucity of high accuracy abundance data for blueback herring.

The mean score calculated based on SRT member's scores corresponds to a *moderate* ranking rangewide (2.75) and in all DPSs (Bb-Canada/Northern New England DPS (2.75), Bb-Mid-Atlantic DPS (2.88) and Bb-Southern Atlantic DPS (3.0)) as this factor is contributing significantly to the blueback herring's risk of extinction, but does not in itself constitute a danger of extinction in the near future. The lack of available data contributed to higher uncertainty around the growth rate for blueback herring.

Spatial Structure/Connectivity

The SRT evaluated the available information on blueback herring spatial structure (tagging and genetics information), summarized in the Population Structure section in the Status Review Report (NMFS 2019). Blueback herring range from Florida to Nova Scotia, spanning 20 degrees latitude and ranging thousands of kilometers along the Atlantic Coast. While the species exhibits homing, rates of straying and the resulting dispersal help to buffer the species from threats related to loss of habitat and loss of spatial connectivity. The SRT noted, however, that blueback herring likely have longer distances between populations in comparison to alewife populations (AMFC 2017a,b), which could result in less resiliency in comparison to alewife. Additionally, depending on natal river, some blueback herring have longer migratory distances from overwintering areas, thereby exposing them to a longer duration of threats in the marine environment in comparison to alewife.

Maintaining connectivity between genetic groups supports proper metapopulation function. Ensuring that populations are well represented across a variety of river systems help to maintain and enhance population resilience and genetic variability (McElhany *et al.* 2000). Blueback herring appear to have connected populations and genetic exchange with bordering populations. However, Reid *et al.* (2018) noted that the Bb-Southern Atlantic population appears to be the most distinct genetically from other populations, suggesting that gene flow and connectivity may be more limited in this DPS compared to other DPSs. Still the range of the Bb-Southern Atlantic population stretches over a wide area, and the SRT noted obstructions were more likely found farther up river in this region, providing more accessible habitat for the species.

The mean score calculated based on SRT member's scores rangewide (2.87) and in each DPS (Bb-Canada/Northern New England DPS (2.86), Bb-Mid-Atlantic DPS (2.88), and Bb-Southern Atlantic DPS (2.71)) corresponds to a *moderate* ranking rangewide, as this factor is contributing significantly to the blueback herring's risk of extinction, but does not in itself constitute a danger of extinction in the near future.

Diversity

The SRT evaluated the available information on blueback herring diversity summarized in the Population Structure section in the Status Review Report (NMFS 2019). The available genetics studies indicate that there are a minimum of five genetic stock complexes rangewide and there is evidence of reproductive connectivity along a continuum rangewide. However, blueback herring exhibit larger distances between populations when compared to alewives (ASMFC 2017a,b), thus in comparison, alewife may be better positioned to maintain genetic diversity (through mixing with bordering populations). The SRT noted that due to declines in abundance over the last several hundred years, the species has likely lost genetic diversity and therefore has lost some amount of adaptive potential. This loss of diversity affects resiliency, especially in the face of climate change. Additionally, SRT members felt that human activities of stocking and propagation have also contributed to reduced genetic diversity. The mean score calculated based on SRT member's scores correspond to a *moderate* ranking rangewide (3.1) and in each DPS (Bb-Canada/Northern New England DPS (3.14), Bb-Mid-Atlantic DPS (3.0), and Bb-Southern Atlantic DPS (3.14)), as this descriptor contributes significantly to long-term risk of extinction, but does not in itself constitute a danger of extinction in the near future.

Evaluation of Threats

Next the SRT considered whether any of the five factors (specified in section 4(a)(1) of the ESA) are contributing to the extinction risk of alewife or blueback herring. Threats considered included habitat destruction, modification, or curtailment; overutilization; disease or predation; inadequacy of existing regulatory mechanisms; and other natural or manmade threats, because these are the five factors identified in section 4(a)(1) of the ESA.

The SRT identified the following threats falling under the five factors reviewed for listing determinations (see section 4 of the Status Review Report, NMFS 2019): Climate change and variability, climate change and vulnerability, dams and other barriers, dredging/channelization, water quality, water withdrawal, directed commercial harvest, retained and discarded incidental catch (including slippage), recreational harvest, scientific research, educational use, disease, predation, inadequacy of existing regulations (international, Federal and state), competition, artificial propagation, hybrids, and landlocked populations. The SRT conducted a qualitative ranking of the severity of each of these threats to alewife and blueback herring rangewide and for each identified DPS. SRT members ranked the threats for the alewife and blueback herring at a rangewide scale and then by each DPS.

The SRT members used the ''likelihood point'' (Forest Ecosystem Management Assessment Team or FEMAT) method to allow individuals to express uncertainty in determining the contribution to extinction risk of each threat to the species (see Status Review Report, NMFS 2019). Each SRT member was allotted five likelihood points to rank each threat. SRT members individually ranked the severity of each threat through the allocation of these five likelihood points across five ranking criteria ranging from a score of ''*very low* contribution'' to ''*very high* contribution.'' A threat was given a rank of *very low* if it is unlikely that the threat contributes significantly to risk of extinction, either by itself or in combination with other threats. That is, it is unlikely that the threat will have population-level impacts that reduce the viability of the species. A threat was ranked as *low* contribution if it is unlikely that the threat contributes significantly to long-term or near future risk of extinction by itself, but there is some concern that it may do so, in combination with other threats. A threat was ranked as *medium* contribution if the threat contributes significantly to long-term risk of extinction, but does not in itself constitute a danger of extinction in the near future. A threat was ranked *high* contribution if the threat contributes significantly to long-term risk of extinction and is likely to contribute to short-term risk of extinction in the near future. Finally, a threat was ranked *very high* contribution if the threat by itself indicates a danger of extinction in the near future. Detailed definitions of the risk scores can be found in the Status Review Report (NMFS 2019).

The SRT also considered the ranking with respect to the interactions with other factors and threats. For example, the SRT found that threats due to the inadequacy of existing regulatory mechanisms may interact with the threat of overutilization and slow population growth rates (a demographic factor) to increase the risk extinction.

SRT members were asked to rank the effect that the threat was currently having on the extinction risk of the species. Each SRT member could allocate all five likelihood points to one ranking criterion or distribute the likelihood points across several ranking criteria to account for any uncertainty. Each individual SRT member distributed the likelihood points as she/he deemed appropriate, with the condition that all five likelihood points had to be used for each threat. SRT members also had the option of ranking the threat as ''0'' to indicate that, in their opinion, there was insufficient data to assign a score, 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 SRT member chose either N/A (Not Applicable) or 0 (Unknown) for a threat, all five likelihood points had to be assigned to that category only.

During the group discussion, the SRT members were asked to identify other threat(s) or demographic factor(s) that were interacting with the threats or demographic factors to increase the species' extinction risk. As scores were provided by individual SRT members, each individual stated his or her expert opinion regarding each of the threats, and the supporting data on which it was based.

We summarize the threats to alewife and blueback herring below. The SRT's qualitative ranking is identified by rounding the mean ranking score, which is provided in parentheses. For example, a threat falling between the *low* (2) and *medium* (3) rankings with a mean ranking score of 2.1 will be identified as *low* (2.1), while a threat with a mean score of 2.5 will be identified as *medium* (2.5). As noted throughout this section and in the Threats Assessments sections of the Status Review Report, many of the mean ranking scores fall between *very low* (1), *low* (2), and *medium* (3); only a few scores were found to be 3 or higher. A detailed account of the rankings is provided in section 6 of the Status Review Report (NMFS 2019).

A. Habitat Destruction, Modification, or Curtailment

The SRT assessed six different factors that may contribute to destruction, modification or curtailment of habitat: Climate change and variability, climate change and vulnerability, dams and other barriers, dredging/channelization, water quality, and water withdrawal. All threats listed in this category scored in the *low* or *medium* contribution to extinction risk categories. Dams and other barriers and water withdrawal were the highest ranked alewife threats in this category. Dams and other barriers, water quality, and water withdrawal were the highest ranked blueback herring threats in this category.

Climate Change and Variability

Climate change and variability are discussed in section 4.1.1 of the Status Review Report (NMFS 2019); below we provide a summary. The SRT evaluated the available information on climate change and climate variability as summarized in the status review (NMFS 2019). River herring range from Canada through Florida in both marine and freshwater environments, and, in many of these areas, there has been reported environmental change. For example, the climate of the Northeast U.S. continental shelf (U.S. Northeast Shelf) is changing both as a result of anthropogenic climate change and natural climate variability (Hare *et al.* 2016a, Hare *et al.* 2016b). Ocean temperature over the last decade in the U.S. Northeast Shelf and surrounding Northwest Atlantic waters have warmed faster than the global average (Pershing *et al.* 2015). New projections also suggest that this region will warm two to three times faster than the global average from a predicted northward shift in the Gulf Stream (Saba *et al.* 2016). Hare *et al.* (2016a) provides a literature summary of how the climate system is changing on the U.S. Northeast Shelf; changes include a high rate of sea-level rise, as well as increases in annual precipitation and river flow, magnitude of extreme precipitation events, and magnitude and frequency of floods. NMFS (2017a) provides a literature summary of climate change drivers in the South Atlantic, which include warming ocean temperatures and sea level rise. The combination of increases in water temperature, coupled with associated changes in water composition, is believed to be one of the most significant risk drivers in the oceans and freshwater habitats in Canada (DFO 2012). Both natural climate variability and anthropogenic-forced climate change will affect river herring. For example, the species is likely to be impacted by climate change through changes in the amount of preferred marine habitat (Lynch *et al.* 2015).

Changes to riverine flows and habitat due to extreme events will impact both spawning and early life stages of fish (Tommasi *et al.* 2015), while migratory patterns and food availability will be two of many impacts of a changing climate on the ocean stages. As water temperatures continue to increase, river herring's coastal ranges may shrink and shift northward. A contraction of their range could result in natural or anthropogenic catastrophic events having a larger impact on the species' extinction risk.

Alewife

The SRT ranked climate change variability as *low* (2.4) rangewide and *medium* (2.5–2.7) in each DPS. The SRT noted uncertainty makes it difficult to determine the degree to which current limitations in predicting the specific changes that will occur within river herring habitat across the range may impact river herring in the foreseeable future. While mean rankings scores were close rangewide and across the DPSs, the SRT ranked the Aw-Southern New England (*medium,* 2.6) and the Aw-Mid-Atlantic (*medium,* 2.7) DPSs threat score for climate variability slightly higher. The SRT noted the large estuary ecosystems within the Aw-Southern New England DPS could be severely impacted by river/ocean warming and sea level rise. Additionally, rivers in this DPS are situated in areas with high population densities and with predicted population growth, which will likely decrease the amount of water available for river herring and lead to juveniles being unable to emigrate from nursery habitats. Increased impervious surfaces, as well as anthropogenic responses to rising sea levels are likely to increase flow variability in this DPS. The Aw-Mid-Atlantic DPS constitutes the southern edge of the range. It will likely be the first to see extreme riverine temperatures during spawning and juvenile phases. In addition, many of the known runs in this DPS are in larger river systems, and spawning success will likely be negatively impacted by the extreme spring flows as well as the increased summertime salt intrusions predicted to occur due to climate change.

Blueback Herring

The overall mean blueback herring rangewide score for climate change variability corresponded to a *low* (2.1) ranking rangewide and in the Bb-Canada/Northern New England DPS (*low,* 2.2) and Bb-Mid-Atlantic DPS (*low,* 2.1). The Bb-Southern Atlantic DPS score for climate change and variability corresponded to a *medium* (2.6) ranking. The Bb-Southern Atlantic DPS constitutes the southern edge of the range and will be the first to experience extreme riverine temperatures during spawning and juvenile phases. In addition, many of the known runs in this DPS are in larger river systems, and spawning success will likely be negatively impacted by the extreme spring flows as well as the increased summertime salt intrusions predicted to occur due to climate change. The interacting effects of climate change with anthropogenic changes, especially in relation to temperature and flow, carry a potentially significant threat.

Climate Change and Vulnerability

Climate change and vulnerability is discussed in section 4.1.2 of the Status Review (NMFS 2019), and below we provide a summary.

Alewife

The mean scores for climate change and vulnerability for alewife rangewide corresponded to a *medium* (2.6) ranking rangewide and in each DPS (2.7–2.8). While mean ranking scores were close rangewide and across the DPSs, the SRT predicted that alewives in more southern portions of the range were at a slightly higher risk from climate change and vulnerability due to the reduced timeline of predicted impacts from this threat.

Alewife in the Aw-Mid-Atlantic DPS (*medium,* 2.8) will likely be the first to see extreme riverine temperatures during spawning and juvenile phases. Additionally, fish at the edges of the range will be most impacted by changes in ocean currents due to climate change, as these fish have the longest ocean migrations to known overwintering areas. Alewife populations could expand northward, however it is unknown if expansion could occur fast enough to preserve genetic integrity of this DPS. This threat is magnified because there will be minimal opportunity to control negative climatic effects as they become more apparent.

Blueback Herring

The overall mean score for climate change and vulnerability corresponded to a *medium* (2.5) ranking rangewide and in each DPS (2.5–2.9). The SRT noted that blueback herring currently persist in warmer habitats than alewives and therefore may be more resilient to warmer temperatures. However, the largest populations of blueback herring appear to be concentrated farther south (Mid-Atlantic) than alewives, therefore the SRT expected the threats from climate change vulnerability to be greater for blueback herring than that experienced by alewives. Early life stage growth/survival and successful spawning events are temperature dependent. Increasing and irregular water temperature regimes will have large impacts at these stages. While mean ranking scores were close rangewide and across the DPSs, the SRT predicted that climate change and vulnerability threats would be greatest in the Bb-Southern Atlantic DPS (*medium,* 2.9) because this region will be the first to experience extreme temperatures during spawning and juvenile phases. Numerous shifts in range and other signs of thermal stress have been observed in fish species in this region, and the same can be expected for blueback herring. Being at the southern end of the species' range, one would expect that they are already at the maximum tolerance for temperature effects. Additionally, anthropogenic responses to climate change may include construction of floodgates, berms around cities, and changes in water structures, which may further reduce access to spawning habitat. This threat is magnified because there will be minimal opportunity to control negative climatic effects as they become more apparent.

Dams and Other Barriers

Dams and other barriers are discussed in section 4.1.3 of the Status Review Report (NMFS 2019), and below we provide a summary. Dams and other barriers to upstream and downstream passage (*e.g.,* culverts, tidal and amenity barrages) 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. As described in more detail in the Status Review Report (NMFS 2019), dams are also known to impact river herring through various mechanisms, such as habitat alteration, fish passage delays, and entrainment (injury from transport along with the flow of water) and impingement (injury related to colliding with any part of a dam; Ruggles 1980, NRC 2004). River herring can experience delayed 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). 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 herring 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). Mattocks *et al.* (2017) estimated that, due to damming, only 6.7 percent and 7.9 percent of stream habitat in the Connecticut and Merrimack Rivers, respectively, is accessible. The Merrimack and Thames-Pawtucket watersheds had the greatest losses in lake habitat due to damming, with 2.8 percent and 6.4 percent, respectively, of available habitat in 1900. Total biomass lost due to damming from 1630 to 2014 was estimated to be 7 million mt (freshwater) and 2.4 million mt (marine; Mattocks *et al.* 2017).

Dams prevent access to historical spawning habitat (*e.g.,* Hall *et al.* 2012, Mattocks *et al.* 2016), and also alter stream continuity and impair water quality on a number of levels. Dams and other barriers often affect migration rates, influencing both upstream and downstream migration of adults and downstream migration of juveniles. Delayed migration can have serious impacts at both life stages, including impacts on the timing of forage (zooplankton availability) as well as on predator avoidance for juveniles, and preferred spawning temperatures for adults (McCord 2005). Finally, dams often have detrimental nutrient and temperature impacts on downstream river communities affecting both adult and early life stages (MEOEA 2005).

The passage solutions to get fish above dams can have a wide range of efficacy, and in some instances can be quite ineffective. Constructed fish passage also does not restore full riverine continuity or address water quality concerns. Further, both nature-like and technical fishways are engineered and built to function on flows modeled from historical records. Deviations in future flow patterns due to climate change could greatly reduce fishway efficacy.

Alewife

Because dams and other man-made barriers may result in a variety of impacts (discussed above), the overall mean score corresponded to a *medium* (2.9) threat for alewife rangewide ranking and in each of the DPSs (3.1–3.4). While the SRT noted that risks to the two species are similar in nature, there is some evidence, that, of the two river herring species, alewife are better adapted to navigating fishways (K. Sullivan, pers. comm; B.Gahagan, unpublished). Specific barriers vary across the range, and threats related to the Aw- Canada DPS include (1) head-of-tide dams that block access to freshwater habitat and (2) increased prevalence of dams and tidal barrages in the Bay of Fundy, Minas Basin, and the St. Croix River. The SRT noted that there were limited data on barriers in this region to be able to assess the threat on alewife. A majority of SRT members spread their ranking scores to reflect greater uncertainty regarding the severity of this threat across this region.

The SRT determined that threats to alewife posed by dams and other barriers within the range of the Aw-Northern New England (*medium,* 3.3) and the Aw-Southern New England (*medium,* 3.4) DPS are more severe compared to those on a rangewide scale. The SRT took into account that these regions were the epicenters of colonial and industrial era dam building, and many of these structures remain in this area.

In the Aw-Northern New England DPS, the ASFMC (2017b) reports dam construction in Maine during the last century isolated many of the inland waters currently stocked with alewives. The historical significance of anadromous fish to these waters was eventually lost, and freshwater fish communities, especially recreationally important game fish, began dominating these habitats. Access to much of the river herring habitat in Maine is still blocked by dams (without upstream fish passage) and other impediments (ASFMC 2017b).

According to ASFMC (2017b), resource agencies in Maine are making progress by installing upstream and downstream fish passage facilities, especially in the Sebasticook River watershed and smaller coastal watersheds. In recent years, rock-ramp or nature-like fishways have become increasingly popular for passing river herring in Maine. In New Hampshire, restoration of diadromous fish populations began with construction of fishways in the late 1950s and continued through the early 1970s by the New Hampshire Fish and Game Department (NHFGD) in the Exeter, Lamprey, Winnicut, Oyster, and Cocheco Rivers in the Great Bay Estuary and the Taylor River in the Hampton-Seabrook Estuary. These fishways re-opened acres of freshwater spawning and nursery habitat for river herring (ASFMC 2017b).

The SRT determined that threats posed by dams and other barriers within the range of the Aw-Southern New England DPS are more severe compared to those on a rangewide scale. According to ASMFC (2017b), there are over 500 dams within the historic range of river herring in Connecticut. Access to habitat previously blocked has been restored through construction of fishways and dam removal, providing more spawning habitat to increase production. Since 1990, 11 dams have been removed and 53 fishways have been constructed throughout the state, with more projects being completed each year.

In Rhode Island, the Division of Fish and Wildlife is partnering with government agencies, NGOs, and private entities on a variety of anadromous habitat restoration projects throughout the state. Projects include constructing new fishways, culvert modifications, and dam removals to enhance spawning and nursery habitat (ASFMC 2017b). Gilbert Stuart and Nonquit Rivers river herring stocks are predominantly alewives. At Gilbert Stuart River, the Alaskan steeppass has been the primary survey site for monitoring adult river herring since 1981. Edwards (2015) reported that the fishway passed over 290,000 fish in 2000, and in recent years estimates of one thousand fish per hour have been observed. The Denil fishway at Nonquit River has been the primary survey site for monitoring adult river herring since 1999. In 1999, the fishway passed over 230,000 fish (Edwards 2015). Buckeye Brook (RI) is a free-flowing system, and river herring migrate to Warwick Pond without obstruction (ASFMC 2017b).

Despite the aforementioned state-run fish passage solutions, the SRT determined that dams and other barriers are a more pertinent threat to the species in this DPS because alewife are typically more reliant on habitats upstream of dams for reproductive success. The SRT noted that the Aw-Southern New England DPS, like the Aw-Northern New England DPS, has many more dams located closer to the head of tide compared to the other DPSs. As a result, there is limited spawning habitat below these dams, and spawning runs are heavily influenced by management practices (*e.g.* truck and transport, fish lifts, fishway maintenance).

The average score for dams and other barriers in the Aw-Mid-Atlantic DPS (*medium,* 3.1) was slightly lower than the two northern DPSs' scores. Specific barrier threats related to this DPS include the presence of man-made barriers within the historic range of river herring. While dams and other barriers to fish migration are widely distributed throughout this DPS, the SRT noted that the existing dams are generally further upstream, leaving relatively more habitat below the dams. As such, the SRT determined that barrier threats related to the Aw-Mid-Atlantic DPS are similar (and possibly less severe) compared to those considered in the rangewide analysis.

In New Jersey, restoration programs for river herring have been limited to the installation of fish ladders and occasional minor trap and transport programs or dam removal. Fish ladders have also been installed in Delaware to restore river herring runs. Twelve tidal streams located within the Delaware River/Bay watershed have fish ladders installed (eight in Delaware and four in New Jersey) at the first upstream dam to allow for river herring passage into the non-tidal impoundments above the dams.

In addition to fish passage installations, dam removal has been the focus of restoration effort is some states. In May 2016, the first dam upstream of the confluence with the Hudson River was removed from the Wynants Kill, a relatively small tributary in Troy, NY, downstream of the Federal Dam. According to ASMFC (2017b) within days of the removal, hundreds of river herring moved past the former dam location into upstream habitat. Subsequent sampling efforts yielded river herring eggs, providing evidence that river herring were actively spawning in the newly available habitat. This dam removal will provide an additional half km (0.3 mi) of spawning habitat for river herring that has not been available for 85 years (ASMFC 2017b). Similarly, Maryland DNR's Fish Passage program has completed 79 projects, reopening a total 735.5 km (457 mi) of upstream spawning habitat in Maryland since 2005.

In Pennsylvania, dam removals along with installation of fish passage have opened up 100 river miles to migratory fish. In 2000 and 2001, river herring were transported to the Conestoga River, a tributary of the Susquehanna River in Pennsylvania. The transported river herring left the Conestoga River, moved up the mainstem Susquehanna River, and were observed at the Safe Harbor Dam. Transports to the Conestoga River included 1,820 alewives in 2000.

Several states within the range of this DPS have implemented restoration programs focused on a range of solutions to fish passage. These solutions include fish passage installation, dam removal, and trap-and-transport initiatives. An abundance of available coastal and estuarine habitat and the presence of long undammed sections of major rivers within the range of this DPS led the SRT to determine that the threat of dams was slightly reduced in this region compared to other DPSs.

Blueback Herring

The overall mean score for dams and other barriers corresponded to a *medium* (3.1) threat ranking rangewide and in each DPS (2.6–3.3).

The SRT ranked the Bb-Canada/Northern New England slightly elevated (*medium,* 3.3) compared to the rangewide score. Specific barrier threats related to the Bb-Canada/Northern New England DPS include (1) head-of-tide dams that block access to freshwater habitat, and (2) increased prevalence of dams and tidal barrages in the Bay of Fundy, Minas Basin, and St. Croix River. The SRT took into account that the region was one of the epicenters of colonial and industrial era dam building and that many of these structures remain in this area. According to ASFMC (2017a), dam construction in Maine during the last century isolated many of the inland waters. The historical significance of anadromous fish to these waters was eventually lost, and freshwater fish communities, especially recreationally important game fish, began dominating these habitats.

Access to much of river herring habitat in Maine is still blocked by dams without upstream fish passage and other impediments (ASFMC 2017a). The SRT took into account high mortality associated with the tidal barrages present in the Canadian portion of the range. The SRT noted that, compared to other DPSs, there are many more dams closer to the head of tide in this region. As a result, there is limited spawning habitat below these dams, and spawning runs are heavily influenced by management practices (*e.g.,* truck and transport, fish lifts, fishway maintenance).

According to ASFMC (2017a), resource agencies in Maine are making progress by installing upstream and downstream fish passage facilities, especially in the Sebasticook River watershed and smaller coastal watersheds. In recent years, rock-ramp or nature-like fishways have become increasingly popular for passing river herring in Maine. In Maine, blueback herring populations appear to be increasing in the upper regions of the state's watersheds (ASFMC 2017a).

The overall mean score for dams and other barriers corresponded to a *medium* (3.0) threat ranking in the Bb-Mid-Atlantic DPS, slightly lower than the rangewide score. Specific barrier threats related to this DPS include the presence of man-made barriers within the historic range of river herring. While dams and other barriers to fish migration continue to be present in states within the range of this DPS, the SRT noted that the dams that do exist in the region are further upriver, leaving a lot of blueback herring habitat below the dams. As such, the SRT determined that barrier threats related to the Bb-Mid-Atlantic DPS are similar (and possibly less severe) compared to those considered in the rangewide analysis.

Several states within the range of this DPS have implemented restoration programs focused on a range of solutions to fish passage. These solutions include fish passage installation, dam removal, and trap-and-transport initiatives.

In Connecticut, the largest blueback herring run has historically been found in the Connecticut River. Between 1849 and 1955, anadromous fish had no access above the Holyoke Dam, in Holyoke, Massachusetts. Today, the Connecticut River blueback herring population size below the Holyoke Dam is unknown, and there are insufficient historical data to make an estimate. However, according to ASFMC (2017a), there continues to be stable juvenile blueback herring production in recent years with index values comparable to values produced with passage of several hundred thousand of fish at the lift despite the lack of adults passed at the Holyoke Dam. It is unknown as to whether or not the peak values of passage at the Holyoke Dam are a sustainable population for the Connecticut River above the Holyoke Dam, since there is not enough historical population data.

The SRT ranked the threat of dams in Bb-Southern Atlantic DPS as a *medium* (2.6), with a slightly lower score than the rangewide and other DPS scores. An abundance of available coastal and estuarine habitat and the presence of long undammed sections of major rivers within the range of this DPS led the SRT to rank the mean score lower. Specific barrier threats related to this DPS include habitat loss and alterations occurring in tributaries of Winyah Bay, the Santee-Cooper River system, and the Savannah River. The SRT noted that dams in this region are often very high in river systems and in many cases are not likely to block an abundance of blueback herring habitat. The SRT also considered this threat somewhat mitigated in this DPS by the ability of blueback herring to use successfully lotic spawning habitats such as those found below dams. The SRT added that alterations to flow regimes and thermal effects of dams are still of concern, and these concerns may grow in importance with climate change.

Documented impacts of past flow manipulations support the SRT's assessment. In 1938, a large diversion project to move water from the Santee River to the Cooper River was initiated. The project resulted in the construction of the Wilson Dam for flood control on Santee River at km 143, which created Lake Marion, and the construction of Pinopolis Dam at km 77 on the Cooper River, which is a hydroelectric facility with a navigation lock. According to Cooke and Coale (1996), large numbers of blueback herring that utilized the Cooper River before rediversion, switched to the Santee River after rediversion.

Dredging and Habitat Alteration

Dredging and habitat alteration are discussed in section 4.1.4 of the Status Review Report (NMFS 2019), and below we provide a summary.

Wetlands provide migratory corridors and spawning habitat for river herring. The combination of incremental losses of wetland habitat, changes in hydrology, and inputs of nutrients and chemicals over time, can be extremely harmful, resulting in diseases and declines in the abundance and quality of habitat. 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 square kilometer (km^2)) per year. The Clean Water Act and state wetland protection programs helped decrease wetland losses to 117,000 acres (473 km^2) per year between 1985 and 1995. Estimates of total wetland loss vary according to the different agencies. The U.S. Department of Agriculture attributes 57 percent of wetland loss to development, 20 percent to agriculture, 13 percent to 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.

Similar to dams, dredging has affected historical spawning and nursery habitats. Maintenance dredging continues to reduce available habitat, negatively affect water quality, and s change river flows. Although regulated through Federal and state permitting, dredging and shoreline hardening associated with estuary/coastline development are not likely to decrease in spatial extent or scope through the next century. Both practices reduce wetland and nearshore habitats, impacting nursery habitats for river herring, including the macrophytes and natural streamflow important to nearshore ecosystem health.

Alewife

The SRT ranked the threat of dredging/channelization rangewide and in each DPS as *low* (1.5–1.7). The SRT ranked the threat of dredging in the Aw-Mid-Atlantic DPS (*low,* 1.7) to be at slightly higher risk compared to other DPSs. The increased volume of industrial activity and growing number of dredge projects in the Aw-Mid-Atlantic DPS may pose a greater risk to alewife compared to other regions. This DPS encompasses several hundred miles of dredged river channels, as well as the ports of New York and New Jersey, Baltimore Harbor, the Hudson and Delaware Rivers, and the Chesapeake Bay, all of which are subject to regular dredging.

Blueback Herring

The SRT ranked the threat of dredging/channelization as *low* (2.0–2.3) rangewide and in each DPS. For the same reasons stated above for the Aw-Mid-Atlantic DPS, the SRT ranked the threat of dredging slightly higher in the Bb-Mid-Atlantic DPS (*low,* 2.3) compared to the blueback herring rangewide and other DPS scores.

Water Quality

Risks associated with changes to water quality are discussed in section 4.1.5 of the Status Review (NMFS 2019), and below we provide a summary.

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, and groundwater, and move into streams and coastal waters. Nutrient inputs 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.

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). 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 from dams and other barriers, and nutrient and chemical inputs produced over time can be extremely harmful to marine and estuarine biota, including river herring, and can result in diseases and declines in the abundance and quality of the affected resources.

Poor water quality is an important threat in some parts of the species' range. While the large scale acute water quality issues that fueled the creation of the EPA and enactment Clean Water Act have, in many areas, been remedied, the wide impacts of increasing urbanization on the eastern coast of the United States has led to widespread deleterious conditions (*e.g.,* perennial hypoxic and anoxic areas in estuaries and nurseries, eutrophication of freshwater systems, invasive plants and eutrophication altering spawning habitat). Siltation—resulting from erosional land use practices as well as natural disturbances such as hurricanes and/or flood events reduces survival of aquatic vegetation and impacts streamflow. Additionally, climate variability may increase sedimentation in natal rivers, contributing to poorer water quality. These types of effects, often from non-point sources, occur over entire landscapes and are often more difficult to detect, measure, test, and remedy.

Alewife

The overall mean score for water quality corresponded to a *medium* (2.8) ranking rangewide and in each DPS (2.7–3.2). The threat from poor water quality was slightly elevated in the Aw-Mid-Atlantic DPS (*medium* 3.2) compared to the rangewide ranking. Many of the major estuaries in the Aw-Mid-Atlantic DPS have documented water quality issues. This DPS also has many growing population centers, and anthropogenic threats are predicted to increase in the foreseeable future. Similar to climate change and variability, the interactions between anthropogenic change and climate change are likely to have severe detrimental effects on water quality, especially water temperature, in regions at the edge of the species' tolerance.

Blueback Herring

The overall mean score for water quality corresponded to a *medium (2.9)* ranking rangewide and in each DPS (2.9–3.2). For the same reasons stated above for the Aw-Mid-Atlantic DPS, the threat of water quality was slightly elevated in the Bb-Mid-Atlantic DPS (*medium,* 3.2) compared to the rangewide ranking.

Water Withdrawal/Outfall (Physical)

Water withdrawal facilities and toxic and thermal discharges have also been identified as a threat that is impacting river herring. This threat is discussed in section 4.1.6 of the Status Review Report (NMFS 2019), and below we provide a summary of impacts to river herring.

Water withdrawal facilities impact natural streamflow and result in impingement/entrainment mortality of river herring. Disrupting streamflow can influence migratory timing as well as water quality downstream of the facility. Additionally, water withdrawal (for agriculture or other human activities) degrades or destroys habitat for river herring and poses a significant threat to their survival, especially when coupled with other threats. The threat is likely to increase alongside coastal population growth, which, in conjunction with climate change effects, will likely result in reduced base flows. Water withdrawals and reduced flows can disrupt connectivity between habitats and cause ontogenetic shifts in life history. For alewives and blueback herring to be successful, adults must be able to immigrate to nursery areas, spawn, and then emigrate. Juveniles should have adequate flow to emigrate volitionally. In this way, withdrawals act much like dams and other barriers, even though their effects are less obviously visible.

Alewife

The overall mean score for water withdrawal corresponded to a *medium* (3.2) ranking for alewife rangewide and in each DPS (2.8–3.3). The threat of water withdrawal was slightly reduced in the Aw-Canada DPS (*medium,* 2.8) compared to the rangewide ranking. Human population density and the resulting anthropogenic effects on water quality (including animal husbandry and agriculture) and the demands for water withdrawals/diversions are likely less of a threat to the species in this DPS compared to rangewide average.

Because of the lower human population density in the Aw-Northern New England DPS (*medium,* 3.0) and corresponding demands on water resources, there is a diminished risk related to water withdrawals for the species in this region compared to the rangewide average. However, the presence of numerous head-of-tide-dams, where emigration is related to fall flows/water levels from head ponds, remains a threat.

The threat of water withdrawal was slightly elevated in the Aw-Southern New England (*medium,* 3.3) DPS compared to the rangewide ranking. Water withdrawal may be higher in the Aw-Southern New England DPS than in other areas due to high population density. Water withdrawal can lead to reduced stream flow, and the water storage capacities of impoundments can further affect temporal variability of stream flow. Similar to populations further north, populations here face an increased risk from artificially manipulated water levels in head ponds, where summer and fall emigration is dependent on adequate stream flows. As water transfers/withdrawals increase in the future, this threat will increase.

The threat of water withdrawal in the Aw-Mid-Atlantic DPS (*medium,* 3.2) was similar to the rangewide score for alewife. The SRT noted predicted high population growth rate in this region. Demand for water and anthropogenic pressures will likely increase, resulting in reduced stream flows, which affect juvenile emigration and survival.

Blueback Herring

The overall mean score for water quality corresponded to a *medium* (2.9) ranking for blueback herring rangewide and in each DPS (2.8–2.9). Because of the lower human population density in the Bb-Canada/Northern New England DPS (*medium,* 2.8) and corresponding demands on water resources, there is a diminished risk to the species as compared to the rangewide average. Human population density and the resulting anthropogenic effects on water quality (including animal husbandry and agriculture) and the demands and for water withdrawals/diversions are likely less of a threat to the species in this DPS compared to the rangewide average. The threat ranking for water withdrawal in the Bb-Mid-Atlantic DPS (*medium,* 2.9) was similar to the rangewide score. The SRT noted that predicted population growth rate in this region will drive future demand for water. As anthropogenic pressures increase, it will negatively affect water quality (hypoxia, eutrophication) in most major estuaries. Further, the interactions between anthropogenic change and climate change are likely to severely affect water quality in portions of the species' range where water quality is already impaired. The threat ranking for water withdrawal in the Bb-Southern DPS (*medium,* 2.9) was similar to the rangewide score. The SRT noted that utility water intake may be a larger issue in the Bb-Southern Atlantic DPS compared to water withdrawals rangewide.

B. Overutilization

The SRT assessed five different factors that may contribute to the overutilization of alewife: Directed commercial harvest, retained and discarded incidental catch (including slippage), recreational harvest, scientific research and educational harvest. Although ranked separately, the SRT's assessments for scientific research and educational harvest are discussed in combination below due to the limited information and similarity in overall rankings for these factors.

Directed Commercial Harvest

This threat is discussed in sections 4.2.1 of the Status Review Report (NMFS 2019). Below, we provide a summary of impacts on river herring.

Information on river herring fisheries in the United States was gathered largely from the ASMFC's benchmark assessment of river herring stocks of the U.S. Atlantic Coast from Maine through Florida (ASMFC 2012) and the River Herring Stock Assessment update (ASMFC 2017a). The ASMFC (2017a) report provides an update to the 2012 benchmark assessment of river herring. Both documents were prepared by the River Herring Stock Assessment Subcommittee (SAS) of the ASMFC's Shad and Herring Technical Committee (TC).

Domestic commercial landings of river herring were presented in the stock assessment update by state and by gear from 1887 to 2015 where available (ASMFC 2017a). 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 period and are likely underestimates, particularly for the first third of the time series, because not all river landings were reported (ASMFC 2012, ASMFC 2017a).

During 1887 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 to VA). The dominance of the mid-Atlantic region is, in part, due to the apparent bias in the spatial coverage of the reported landings. During this early 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, the Potomac River, the York River, and offshore harvest.

Severe declines in landings began coast-wide in the early 1970s and, where still allowed, 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 Fishery Management Plan, were closed. (Note as anadromous alosines of the east coast, shad, alewife, and blueback herring are managed under the same Fisheries Management Plan; ASMFC 1987). As a result, prohibitions on harvest (commercial or recreational) were extended to New Jersey, Delaware, Pennsylvania, Maryland, DC, Virginia, Georgia and Florida (ASMFC 2012, ASMFC 2017a,b).

The ASMFC stock assessment committee 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 (ASMFC 2012). Exploitation rates were highest (range: 0.53 to 0.98) in the Damariscotta River and Union River prior to 1985, while the exploitation was lowest (range: 0.26

to 0.68) in the Monument River. In Massachusetts, 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 moratorium was imposed. Exploitation rates of alewives in the Damariscotta River were low (<0.05) during the period from 1993 to 2000, but they increased steadily through 2004 and remained greater than 0.34 through 2008. Exploitation in the Damariscotta River dropped to 0.15 in 2009 to 2010. In-river exploitation of alewives has continued to decline in the Damariscotta River, with the lowest levels occurring in the last five years (2011–2015), with the exception of very low values that occurred in the 1990s (due to lack of harvest) (ASMFC 2017a). Exploitation rates of alewives in the Union River declined through 2005 but have remained above 0.50 since 2007 (ASMFC 2012). In-river exploitation of alewives has remained relatively stable in the Union River, but it did decline to the lowest level of the time series (2010–2015) in the terminal year of the update. Exploitation has essentially ceased on other rivers assessed during the benchmark due to moratoria (MA rivers) (ASMFC 2017a).

The coastwide index of relative exploitation also declined following a peak in the late 1980s and has remained fairly stable over the past decade. In all model runs except for one, exploitation rates coastwide declined. Exploitation rates estimated from the statistical catch-at-age model for blueback herring in the Chowan River (see Status of River Herring in North Carolina in the ASMFC 2017b 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 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 2017a).

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 lbs (11,577 mt) in 1980, 23.1 million lbs (10,487 mt) in 1988, and 11 million lbs (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 lbs (1,000 mt) (DFO 2001).

There is little directed effort on river herring across the Northwest Atlantic. 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 <190 millimeters (mm) (7.5 inches) in length) by foreign fleets began in the late 1960s and landings peaked at about 80 million lbs (36,320 mt) in 1969 (ASMFC 2017a). After the Fishery Conservation and Management Act of 1976 (16 U.S.C. 1801 *et seq.*), later retitled the Magnuson Fishery and Conservation and Management Act, and the formation of the Fishery Conservation Zone in 1977, foreign allocation of river herring (to both foreign vessels and joint venture vessels) between 1977 and 1980 was 1.1 million lbs (499 mt). The foreign allocation was reduced to 220,000 lbs (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, amendment 4 to the Atlantic Mackerel, squid and butterfish fisheries management plan added area restrictions 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 (50 CFR part 611.50; ASMFC 2012). There have been no reported landings by foreign fleets since 1990 (ASMFC 2012, ASMFC 2017). From 1991 to 2015, the only reported catch in Areas 5 and 6 was from the United States.

Alewife

The overall mean score for alewife directed harvest corresponded to a *low* (1.7) ranking rangewide and for all DPS (1.2–2.1). Overutilization for commercial purposes was once considered one of the primary threats to alewife and blueback herring populations. Significant declines have been documented throughout much of the range for both species due to historic fishing pressure and other threats. Directed harvest does still occur in several states (see State Regulations in the Status Review Report for Maine, New Hampshire, New York, the Potomac River Fisheries Commission/District of Columbia, North Carolina, and South Carolina (NMFS 2019), and the fishing occurs during migration to spawning grounds. Amendment 2 to the ASMFC Shad and River Herring Interstate Fishery Management Plan requires states to have a sustainable fishery management plan (SFMP) for each river with a river herring fishery (beginning in 2012). SFMPs must be reviewed by the ASMFC Shad and River Herring Technical Committee for adequate sustainability measures and approved by the ASMFC Management Board. Monitoring is required on all harvested runs in the U.S. Overall, SRT members found that the current directed harvest was well regulated and occurred only on stocks that have demonstrated sustainability.

The threat ranking for directed commercial harvest was higher in the Aw-Canada DPS (*low,* 2.1) compared to the rangewide ranking and other DPSs (1.2–1.7). SRT members noted increased uncertainty related to directed harvest levels within Canada. Gibson *et al.* (2017) indicated high annual removal rates where recorded or reported. Additionally, Gibson *et al.* (2017) indicated that previous reporting and collection methods do not provide consistent and accurate information, increasing concern and uncertainty for this threat. Finally, the Department of Fisheries and Oceans still allows some fishing on mixed stocks in Canadian waters, which makes managing impacts to individual populations more difficult.

The threat ranking for directed commercial harvest was slightly higher in the Aw-Northern New England DPS (*low,* 1.7) compared to the rangewide ranking. Maine and New Hampshire currently have approved ASMFC sustainable fishing management plans within this DPS. The SRT noted uncertainty related to lack of publicly available commercial harvest data for Maine due to confidentiality; therefore, the total removals and removal rates by river system are largely unknown.

The threat ranking for directed commercial harvest was lower in the Aw-Southern New England DPS (*low,* 1.2) compared to the rangewide ranking. There is currently no directed commercial harvest conducted within the Aw-Southern New England DPS. The Nemasket River, in southern Massachusetts, has an ASMFC approved SFMP, but no harvest has occurred to date, largely due to variability in run strength. SRT members noted uncertainty related to whether further directed harvest of alewife would be permitted within the Aw-Southern New England DPS in the foreseeable future.

The threat ranking for directed commercial harvest was lower in the Aw-Mid-Atlantic DPS (*low,* 1.6) compared to the rangewide ranking. New York is the only state to have an approved ASMFC sustainable fishing management plan within this DPS.

Blueback Herring

For the same reasons stated above for alewife, the overall mean score for blueback herring directed harvest corresponded to a *low* (1.8) ranking rangewide and for all DPS (1.5–1.9). The threat ranking for directed commercial harvest was slightly higher in the Bb-Canada/Northern New England DPS (*low,* 1.9) compared to the rangewide ranking, for the same reasons stated above for the Aw-Canada and the Aw-Northern New England DPSs including the lack of publicly available commercial harvest data for Maine. Likewise, for the same reason stated above for the Aw-Mid-Atlantic DPS ranking, this threat ranked in the *low* (1.6) category for the Bb-Mid-Atlantic DPS.

Retained and Discarded Incidental Catch (Including Slippage)

River herring are caught incidentally at sea in Federal fisheries targeting other species such as Atlantic herring, squid, and mackerel. In this section, we refer to several terms: Retained incidental catch, discarded incidental catch, slippage and bycatch. Retained incidental catch is the capture and mortality of a non-targeted species. Discarded incidental catch is the portion of the non-targeted catch brought on board and then returned to sea. Slippage is a term used to describe a process in which a boat does not bring the entire catch on board and releases part of the catch into the water, thereby potentially biasing estimates of retained and discarded incidental catch. Bycatch, under National Standard 9, refers to fish that are harvested in a fishery, but that are not sold or kept for personal use (50 CFR part 600).

The magnitude of this ocean catch is highly uncertain because of the short time series of incidental data, underreporting, and a lack of observer coverage. In addition, there are limited data on the stock composition of the incidentally caught fish and, thus, no way to partition estimates of bycatch among river systems. With no estimates of coastwide or regional stock complex abundances, it is also difficult to assess the significance of these removals on the overall population or segments of it (ASMFC 2017a).

Because bycatch occurs in marine waters, and alewife and blueback herring stock complexes overlap in their distribution in the ocean, the retained and discarded incidental catch occurs on a mixed stock complex fishery (that is, there is no ‘‘oceanic’’ stock of alewife or blueback herring, the alewife and blueback herring in the ocean come from all of the stock complexes described herein). Recent studies have also shown that alewife and blueback herring incidentally caught in a number of statistical areas were from several genetic stock complexes (Hasselman *et al.* 2016, Palkovacs unpublished). This finding increases the probability that alewife and blueback herring are being exploited from populations that do not meet sustainable harvest requirements approved through the ASMFC.

Several studies estimated river herring retained and discarded 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 information to quantity total catch estimates. Cieri *et al.* (2008) estimated the kept (*i.e.,* landed) portion of river herring incidental catch in the Atlantic herring fishery with an estimated average annual landed river herring catch of approximately 71,290 lbs (32.4 mt) for 2005–2007, and the corresponding coefficient of variation (CV) was 0.56. Cournane *et al.* (2012) extended this analysis with additional years of data. Further work is needed to elucidate how the incidental 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 and 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 with an estimated approximately 105,820 lbs (48 mt) discarded during the 12 months (July 2007 to August 2008); 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 lbs (1,498 mt)/yr from 2000–2008. Lessard and Bryan (2011) analyzed NEFOP data 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. The 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 standardized bycatch reporting methodology (SBRM). SBRM is a methodology to assess the amount and type of bycatch in a fishery. 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 no trips will exhibit the same attributes. Lessard and Bryan (2011) also did not provide precision estimates, which are imperative for estimation of incidental catch.

The stock assessment update (ASMFC 2017a, b) presents the total incidental catch of river herring updated through 2015 following methods described in the benchmark assessment. These methods were developed during Amendment 14 to the Atlantic Mackerel, Squid and Butterfish (MSB) Fishery Management Plan, which includes measures to address incidental catch of river herring and shads (ASMFC 2017a). The stock assessment update presents the total incidental catch estimates by species.

From 2005 to 2015, the total annual incidental catch of alewife ranged from 36.5–531.7 m (80,469–1,172,198 lbs) in New England and 10.9–295.0 mt (24,030–650,364 lbs) in the Mid-Atlantic region (ASMFC 2017a). The dominant gear varied across years between paired midwater trawls and bottom trawls (ASMFC 2017a). Corresponding estimates of precision exhibited substantial inter-annual variation and ranged from 0–10.6 across gears and regions. Between 2005 and 2015, total annual blueback herring incidental catch ranged from 8.2–186.6 mt

(18,078–411,383 lbs) in New England and 1.4–388.3 mt (3,086–856,055 lbs) in the Mid-Atlantic region (ASMFC 2017a). Across years, paired and single midwater trawls exhibited the greatest blueback herring incidental catches (ASMFC 2017a). Corresponding precision estimates ranged from 0–3.6.

The temporal distribution of incidental catch was summarized by quarter and fishing region for the most recent 10-year period (2005 to 2015). River herring catches occurred primarily in midwater trawls (62 percent, of which 48 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 (37 percent). The percentages of midwater trawl catches of river herring were similar between New England (31.3 percent) and the Mid-Atlantic region (30.5 percent). However, catches in New England small mesh bottom trawls were almost three times higher (27 percent) than those from the Mid-Atlantic (10 percent). Overall, the highest quarterly catches of river herring occurred in midwater trawls during Quarter 1 in the Mid-Atlantic (28 percent), followed by catches in New England during Quarter 4 (12 percent) (ASMFC 2017). Quarterly catches in small mesh bottom trawls were highest in New England during Quarter 1 (9 percent) and totaled 5 to 7 percent during each of the other three quarters (ASMFC 2017a). 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.

Partitioning incidental bycatch in U.S. waters to river of origin or proposed stock complex is an ongoing area of research. Using the 15 microsatellites previously identified (Palkovacs *et al.* 2014), Hasselman *et al.* (2016) applied genetic stock identification (GSI) to determine potential regional stock composition of river herring bycatch from the New England Atlantic herring fishery (2012–2013). GSI is a biological tool to determine the composition of mixed stocks and the origin of individual fish. Results showed assignment of over 70 percent to the Aw-Southern New England stock complex for alewife and 78 percent assignment to the Bb-Mid-Atlantic stock complex for blueback herring. The study also gives a marine spatial snapshot of stock complexes in the NOAA statistical areas sampled during 2012–2013, though the authors noted extreme inter-annual variability in both the magnitude and composition of incidental catch, demonstrating that marine distributions for both species are highly dynamic from year to year.

Retained and discarded incidental catch (including slippage) is likely negatively affecting some river herring populations. Slippage was defined as catch that is discarded prior to it being brought aboard a vessel and/or prior to making it available for sampling and inspection by a NOAA-approved observer. The SRT noted that historical declines in river herring abundance were not likely driven by incidental catch, but because of current depleted abundances, incidental catch may impede population growth. As with all of the threats, the true magnitude of incidental catch remains largely unknown because there is no estimate of rangewide abundance. While some monitoring of incidental catch does occur in the Atlantic herring and mackerel fisheries, it has been estimated that monitored fisheries may only constitute half the discards in a given year (Wigley 2009). Further, the contribution of slippage also remains unknown because it is not currently reported.

Alewife

Based on the best available information, noted above, the SRT concluded that the threat from incidental catch corresponded to a *medium* (2.5) contribution to extinction risk to alewife rangewide and in the Aw-Canada DPS (2.7), the Aw-Northern New England DPS (2.4), the Aw-Southern New England DPS (2.7), and the Aw-Mid-Atlantic DPS (2.5). However, the SRT noted the highest uncertainty around the contribution of incidental catch to extinction (expressed in variability and range of scores; see NMFS 2019), due to uncertainties around the estimates of exploitation, future monitoring coverage, and future use of bycatch avoidance programs.

Incidental catch data available from the herring and mackerel fisheries for the years 2012–2015 (Palkovacs, unpublished) showed large proportions of Aw-Mid-Atlantic and Aw-Southern New England alewife captured by mid-water trawl and small mesh bottom trawl in the Atlantic herring/mackerel fisheries compared to other DPSs. Aw-Northern New England alewife made up a minimal amount of indirect catch (Palkovacs, unpublished). Much of the incidental catch from these fisheries was concentrated around Block Island Sound, which is located closest to the Aw-Mid-Atlantic DPS. SRT members noted that the results presented by Palkovacs are representative of the bycatch samples in the Atlantic herring and mackerel fisheries, which are concentrated generally in the Mid-Atlantic and Northeast.

Hasselman *et al.* (2016) estimated that incidental catch from rivers south of the Hudson River ranged from 400,000 in 2012 to 1.3 million in 2013. However, these previous estimates assumed that the Hudson River grouped with the Aw-Southern New England DPS, rather than the Aw-Mid-Atlantic DPS, where it is now grouped. Therefore, if the analysis were rerun with the new boundaries, the estimates of incidental catch would be greater for this DPS. The study did not collect samples from other small-mesh coastal fisheries in this DPS, which may also catch alewife.

Blueback Herring

Based on the best available information, as noted above, the SRT concluded that the threat from incidental catch rangewide (2.4) and for the Bb-Southern Atlantic DPS (1.7) corresponded to a *low* ranking. The mean score for the Bb-Canada/Northern New England DPS and the Bb-Mid-Atlantic DPS corresponded to *medium* (2.6 for each). Again, the SRT noted uncertainty in assessing incidental catch because of the uncertainty in estimating exploitation, future monitoring coverage, and future use of bycatch avoidance programs.

Limited information is available to estimate the impacts of incidental catch in the Bb-Canada/Northern New England DPS. Though fewer fish from this Bb-Canada/Northern New England DPS are reported in the Atlantic herring/mackerel fisheries (Palkovacs, unpublished data), other small mesh fisheries in this region may incidentally catch river herring.

Data available from the herring and mackerel fisheries for the years 2012–2015 (Palkovacs, unpublished) suggest that blueback herring from the Bb-Mid-Atlantic DPS are also caught as bycatch in the Atlantic herring fishery. SRT members noted uncertainty due to limited information regarding the magnitude of small mesh coastal fisheries. Additional uncertainty comes from the limited sample area (Atlantic Herring Management Area 2 fisheries). Numerous small mesh fisheries exist in Atlantic Herring Management Areas 1 and 2, and new information regarding bycatch in those fisheries would be very beneficial to understanding the level of impact on river herring populations in this DPS.

Recreational Harvest

Section 4.2.3 of the Status Review Report provides a state-by-state summary of recreational landing information for river herring. Recreational fishing in Canada for river herring is limited by regulations providing for area, gear, and seasonal closures, and 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.

Alewife

The SRT noted recreational harvest has largely been eliminated in the U.S. range, and where it does exist, it is well regulated. Amendment 2 to the ASMFC Shad and River Herring Interstate Fishery Management Plan requires states to have a sustainable fishery management plan for each river with a river herring fishery (beginning in 2012). Plans must be reviewed by the ASMFC Shad and River Herring technical committee for adequate sustainability measures and must be approved by the ASMFC management board (see *Directed Commercial Harvest* above). Historical rangewide recreational catch is largely unknown, and the recent ASMFC assessment (2017a) deemed recreational catch estimates unreliable.

Based on the best available information, the SRT concluded that the threat from recreational harvest corresponded to a *low* (1.5) contribution to extinction risk rangewide and in all DPSs (1.3–2.1). However, the SRT noted that illegal and unmonitored recreational harvest could have significant local impacts for individual rivers with extremely low abundance. The SRT also noted higher uncertainty in the Aw-Canada DPS in comparison to the rangewide score due to uncertainty surrounding monitoring and reporting of recreational fisheries in Canada.

Blueback Herring

For the same reasons stated above for alewife rangewide, the SRT concluded that the threat from recreational harvest corresponded to a *low* (1.5) contribution to extinction risk rangewide and in all DPSs (1.3–1.8) for blueback herring. However, as noted above, the SRT noted that illegal and unmonitored recreational harvest could have significant local impacts for individual rivers with extremely low abundance. The SRT noted increased uncertainty in the Bb-Canada/Northern New England DPS due to uncertainties surrounding monitoring and reporting of recreational fisheries in Canada.

Scientific Research and Educational Harvest

The states of Maine, New Hampshire, Massachusetts, and Rhode Island estimate run sizes using electronic counters or visual methods. In Massachusetts, various counting methods are used at the Holyoke Dam fish lift and fish ways on the Connecticut River. Young-of-the-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 both 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.

As noted previously, there is insufficient information available on river herring in many areas. Research needs were recently identified in the ASMFC River Herring Stock Assessment Reports (ASMFC 2012, 2017); NMFS Stock Structure, Climate Change and Extinction Risk Workshop/Working Group Reports (NMFS a, b, c 2012) and associated peer reviews; and New England and Mid-Atlantic Fishery Management Council documents (NEFMC 2012, MAFMC 2012).

Alewife and Blueback Herring Rangewide and All DPSs

There is little information linking scientific and educational use to declines in alewife or blueback herring populations. Therefore, based on the best available information, the SRT concluded that neither scientific use nor educational use is contributing to the species' risk of extinction. Both threats ranked in the *very low* (1.0) category.

C. Disease or Predation

The SRT (section 4.3.2) assessed the available information on disease and predation of alewife and blueback herring summarized in the Status Review Report (NMFS 2019).

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 pre-spawning and 10 percent of post-spawning 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). Lovy and Friend (2015) characterized two intestinal coccidians, *Goussia* *ameliae* and G. *alosii* in alewives of the Maurice River, New Jersey. *G. ameliae* infected both landlocked and anadromous alewives. The parasites were prevalent in both juveniles and adult fish. While significant mortality seemed not to occur, researchers suggest that the energetic costs of these parasites should be considered when estimating impacts of climate change and habitat loss.

Another parasite recently discovered in New Jersey, *Myxobolus mauriensis,* attacks the ribs of juvenile river herring and can spread to other tissues (Lovy and Hutcheson 2016). This new species of *Myxobolus* was found mostly in the Maurice River (20 percent), but was also present in two other New Jersey river systems.

Alewife and Blueback Herring Rangewide and all DPSs

The overall mean score for disease corresponded to a *low* (alewife 1.5, blueback 1.7) ranking rangewide and in all DPSs for both alewife and blueback herring. The SRT could find little information linking disease to declines in alewife and blueback herring populations in any specific areas of the range. SRT members noted disease is of biggest concern at low population levels; however, warmer summer temperatures, changing fish communities, and changing migratory patterns due to climate change may make alewife and blueback herring populations more susceptible to disease in the future.

Predation

While alewife and blueback herring are an important forage species, predators on the Northeast U.S. shelf are generally opportunistic (versus specialized) and will consume prey species in relation to their abundance in the environment. At high population levels, predation is likely not an issue; however, as populations decline predation can become a larger threat, especially locally. Recent papers focus on the predation impacts of striped bass; however, the predatory impact by striped bass is likely localized to areas and times of overlap (Davis *et al.* 2012, Ferry and Mather 2012, Overton *et al.* 2008).

Two recent papers with contradictory conclusions discussed 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). Ferry and Mather (2012) discuss the results of a 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. The contradictory findings of these two 2012 studies echo the findings of previous studies showing a wide variation in predation by striped bass with spatial and temporal effects.

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 as extensively, making it more difficult to assess the importance of river herring in both the freshwater and marine food webs. As a result, some models found 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 system that were introduced into rivers on the Atlantic coast. They 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 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.

Alewife and Blueback Herring Rangewide and All DPSs

While alewife and blueback herring are important forage species, predators on the Northeast U.S. shelf are generally opportunistic (versus specialized) and will consume prey species in relation to their abundance in the environment. At high population levels, predation is likely not an issue; however, as populations decline, predation can become a larger threat, especially locally. Recent papers focus on the predation impacts of striped bass; however, the predatory impact by striped bass is likely localized to areas/times of overlap (Davis *et al.* 2012, Ferry and Mather 2012, Overton *et al.* 2008).

The overall mean score for predation corresponded to a *low* ranking for both species rangewide and in all DPSs. The SRT noted uncertainty surrounding introduced or invasive piscivores such as snakeheads or blue catfish, which could have larger impacts if they dramatically expand their ranges. Alterations to fish behavior were also noted as components of predation that have not been well described in the literature to date. For example, little is known about how increased predator abundance (including an abundance of introduced predators) may influence anadromous fish species' ability to access fish passage. Additionally, the effects of predation can be highly localized, as noted in the striped bass predation examples provided above (Davis *et al.* 2012, Ferry and Mather 2012, Overton *et al.* 2008); therefore, while the SRT characterized the rangewide and DPS threat risk as *low* (alewife 1.7–1.8, blueback herring 1.8–2.0), individual river populations may experience greatly increased threat levels.

D. Inadequacy of Existing Regulatory Mechanisms

The ESA requires an evaluation of existing regulatory mechanisms to determine whether they may be inadequate to address threats to river herring. Numerous Federal (U.S. and Canadian), state and provincial, tribal, and inter-jurisdictional laws, regulations, and agency activities regulate impacts to alewife and blueback herring as wide-ranging anadromous species. The status review SRT assessed the adequacy of regulatory mechanisms by examining regulations at three different governmental levels: international regulations, Federal regulations, and state regulations. Section 4.4 of the Status Review Report provides a summary of how these regulatory mechanisms—international regulations, Federal regulations, and state regulations—may provide protections for river herring populations (NMFS 2019).

International Regulations

The Canadian Department of Fisheries and Oceans (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 include 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 limitations on the total number of licenses (DFO 2001). Logbooks are issued to commercial anglers 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 stated that additional management measures may be required if increased effort occurs in response to stock conditions or favorable markets, and noted that fishery exploitation rates have been above reference levels, while 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 being harvested at or below the reference point (*e.g.,* St. John River at Mactaquac Dam). The DFO (2001) believed precautionary management involving no increase or decrease in exploitation was important for Maritime river herring fisheries, given that biological and harvest data were not widely available. DFO (2001) added that river-specific management plans based on stock assessments should be prioritized over general management initiatives.

Eastern New Brunswick appeared to be the only area in the Canadian Maritimes with a river herring integrated fishery management plan (DFO 2012). The DFO used Integrated Fisheries Management Plans (IFMPs) to guide the conservation and sustainable use of marine resources (DFO 2010). An IFMP managed 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 was implemented in conjunction with annual updates to specific fishery management measures (*e.g.,* seasons). It is unclear if this management plan has been updated or discontinued.

Alewife and Blueback Herring Rangewide and All DPSs

The inadequacy of regulatory mechanisms to control the harvests of alewife and blueback herring was once considered a significant threat to their populations. The best available information indicates limited fishing is permitted in Canada, though uncertainties remain about the efficacy of international fishing regulations. The inadequacy of international regulations was ranked rangewide as *low* (alewife 2.1, blueback herring 2.0) contribution to extinction risk category. The threat was also ranked as *low* for the Aw-Northern New England (2.3), Aw-Southern New England (2.1), Aw-Mid Atlantic (2.0), Bb-Canada/Northern New England (2.3), and Bb-Mid Atlantic (2.0). SRT members ranked the threat of international regulations as a slightly higher risk with a *medium* ranking (2.7) within the Aw-Canada DPS. This DPS is located entirely within Canada; therefore, international regulations are predicted to directly affect this DPS more than the other DPSs. Canada does not routinely separate river herring species and less reported monitoring compared to the United States.

Federal Regulations

River herring stocks are managed 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 that, in the absence of an approved and implemented Fishery Management Plan (FMP) under the Magnuson-Stevens Fishery Conservation and Management 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 EEZ, *i.e.,* from 3 to 200 nautical mi (nm) (~5.6–370 km) offshore. The regulations must be: (1) Compatible with the effective implementation of an American Shad and River Herring Interstate Fisheries Management Program (ISFMP) by the ASMFC; and (2) consistent with the national standards set forth in section 301 of the MSA.

The MSA is the primary law governing marine fisheries management in Federal waters. The MSA was first enacted in 1976 and amended in 1996 and 2007. 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. The 1996 amendment focused on rebuilding overfished fisheries, protecting essential fish habitat, and reducing bycatch. The 2007 amendment mandated the use of annual catch limits and accountability measures 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. Alewife and blueback herring are encountered as both bycatch and incidental catch in Federal fisheries. While there is no directed fishery for alewife or blueback herring in Federal waters, they co-occur with other species that have directed fisheries (Atlantic mackerel, Atlantic herring, whiting) and are either discarded or retained in those fisheries.

Commercial fisheries that incidentally catch river herring in Federal waters are managed by the New England Fisheries Management Council (NEFMC), the Mid-Atlantic Fishery Management Council (MAFMC), and NMFS. Several management measures intended to reduce commercial fisheries interactions with river herring and shad in Federal waters are currently in place. These management measures have been developed by the NEFMC, the MAFMC, the Greater Atlantic Regional Fisheries Office, and the Northeast Fisheries Science Center (NEFSC) and promulgated through Federal fishery management plans (FMP) for Atlantic Herring and Atlantic Mackerel, Squid, and Butterfish.

The types of management measures currently in place or being considered fall into several general categories: Limitations on total river herring and shad catch; improvements to at-sea sampling by fisheries observers; river herring avoidance program; increased monitoring of the Atlantic herring fishery; and including river herring in a Federal FMP.

Vessels fishing for Atlantic mackerel and Atlantic herring can encounter river herring and shad. The MAFMC and NEFMC recommended river herring and shad catch caps for these fisheries, and NMFS implemented catch caps for these fisheries beginning in 2014 to minimize bycatch and incidental catch. Managers do not currently have enough data to determine biologically based river herring and shad catch caps or to assess the potential effects of such catch caps on river herring and shad populations coastwide. However, the Councils and NMFS find that river herring and shad catch caps provide a strong incentive for the mackerel and herring fleets to continue avoiding river herring and shad. These catch caps are intended to allow for the full harvest of the mackerel and herring annual catch limits while reducing river herring and shad incidental catch and bycatch.

In December 2014, NMFS implemented river herring and shad catch caps for the Atlantic herring fishery for 2014–2015, and allowed the NEFMC to set river herring and shad catch caps and associated measures in future years though specifications or frameworks, as appropriate (79 FR 71960, December 4, 2014). Catch of river herring and shad on fishing trips that landed more than 6,600 lbs (3 mt) of Atlantic herring counted towards the caps. Caps were area- and gear-specific. Upon a NMFS determination that 95 percent of a river herring and shad cap has been harvested, a 2,000-lb Atlantic herring possession limit for that area and gear would become effective for the remainder of the fishing year. This possession limit has been imposed twice due to achieving the river herring and shad catch caps (both for midwater trawl vessels in 2018) since the catch caps were implemented in 2014. The river herring and shad catch caps for the Atlantic herring fishery for 2019 (set in the 2019 Adjustment to the Atlantic Herring Specifications; 84 FR 2760, February 8, 2019) are as follows:

A midwater trawl cap for the Gulf of Maine Catch Cap Area (76.7 mt) (169,094 lbs);

A midwater trawl cap for Cape Cod Catch Cap Area (32.4 mt) (71,430 lbs);

A midwater trawl cap for Southern New England Mid-Atlantic Catch Cap Area (129.6 mt) (285,719 lbs); and

A bottom trawl cap for Southern New England Catch Cap Area (122.3 mt) (269,625 lbs).

The river herring and shad catch cap for the mackerel fishery is set through annual specifications. NMFS set the 2018 river herring and shad cap for the mackerel fishery at 82 mt (180,779 lbs) as part of a final rule to implement the 2016 through 2018 Atlantic mackerel specifications (81 FR 24504, April 4, 2016). The 2018 Atlantic mackerel specifications, including the river herring and shad catch cap, apply to 2019 until Framework 13 to the Atlantic mackerel, squid, and butterfish FMP is finalized (84 FR 26634, June 7, 2019). Catch of river herring and shad on fishing trips that land greater than 20,000 lbs of mackerel count towards the cap. If NMFS determines that 95 percent of the river herring and shad cap has been harvested, a 20,000-lb mackerel possession limit will become effective for the remainder of the fishing year. In 2019, the river herring and shad cap was met in March, and the Atlantic mackerel possession limit was reduced starting on March 12, 2019 (84 FR 8999; March 13, 2019). The 2019 river herring and shad catch cap will be adjusted in the final rule implementing Framework Adjustment 13 to the Atlantic Mackerel, Squid, and Butterfish Fishery Management Plan. Framework 13 proposes an initial 89-mt (196,211 lbs) catch cap. The cap could be increased to 129 mt (284,396 lbs) if commercial mackerel landings exceed 10,000 mt (22,046,200 lbs). The increased cap reflects a proportional increase to the proposed increase in the Atlantic mackerel commercial landings limit. Framework 13 will be in place by fall of 2019.

Under the MSA, there is a requirement to describe and identify Essential Fish Habitat (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 (62 FR 19723; April 23, 1997 and 67 FR 2343; January 17, 2002).

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 benefit river herring either directly or indirectly. 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 necessary for river herring throughout 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 mid-Atlantic south to Cape Hatteras out to the offshore U.S. boundary of the EEZ (NEFMC 1998). These areas incorporate nearly all of the U.S. marine areas most frequently used by river herring for growth and maturity. Accordingly, conservation measures aimed at improving or minimizing impacts to habitats in these areas for the benefit of Atlantic salmon or Atlantic herring may provide similar benefits to river herring.

A number of other Federal laws provide habitat-related protections that may benefit river herring. Further information on the protections associated with these laws is summarized in section 4.4.2 of the Status Review Report (NMFS 2019).

Alewife and Blueback Herring Rangewide and All DPSs

The inadequacy of regulatory mechanisms to control the harvests of alewife and blueback herring was once considered a significant threat to their populations. However, the best available information indicates an adequate regulatory framework now exists within ASMFC to effectively manage alewife and blueback herring directed harvest, and there are multiple forms of habitat-related regulatory protections for these fish. The SRT ranked Federal regulations in the *medium* category rangewide (2.6) and for most DPSs (2.7–2.8). The Aw-Canada DPS was ranked as *low* (2.3), because this DPS fell entirely within Canada where U.S. Federal regulations may have slightly less influence in comparison to other areas overlapping or within the United States.

SRT members noted that in the framework of inter-jurisdictional management, these fish may not receive as much protection as more commercially valuable species. The SRT noted uncertainty around future catch caps (catch caps are scheduled to be recalculated in 2019) monitoring coverage, and the use of bycatch avoidance programs.

The SRT also considered other Federal non-fishery regulations such as the Clean Water Act and the Federal Power Act. Despite current regulations, habitat alterations, such as dams and culverts, excess nutrient loading and sedimentation due to poor land use practices, dredging, and coastal development, continue to affect both marine and freshwater habitats, potentially limiting population growth. The SRT also noted that habitat improvements related to long-term regulatory processes, such as relicensing of hydropower facilities through the Federal Energy Regulatory Commission that may result in dam removal or fish passage facilities, would not be immediately realized.

In tandem with the predicted effects of climate change, such as increased precipitation and warming ocean temperatures, the importance of Federal regulations to alewife and blueback herring sustainability will likely increase in the future.

State Regulations

A historical review of state regulations was compiled and published in Volume I of the stock assessment (ASMFC 2012, 2017b); an excerpt has been added to section 4.4.3 of the Status Review Report, which provides an overview of state regulations that may provide protections to river herring (NMFS 2019).

Alewife and Blueback Herring Rangewide and All DPSs

SRT members noted that, as with Federal regulations, existing state regulations related to fisheries provide structure for protection of river herring through ASMFC. However, like Federal regulations (discussed above), state regulations related to habitat loss remain a large concern for the future of the species with the predicted effects of climate change, especially since spawning and nursery habitats are found in state waters.

The SRT expressed uncertainty about the effectiveness of state regulations related to the reliability of enforcement of existing state laws and concerns for non-fishing regulations that authorize modifications to coastal and riverine habitat in the face of increasing populations and coastal development. State regulations were ranked in the *medium* (alewife, 1.6–2.7; blueback herring 2.5–2.7) contribution to extinction risk category, with state regulations having the lowest impact on the Aw-Canada DPS (1.6).

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

The Status Review identifies four different threats that may contribute to other natural or manmade factors affecting the alewife and blueback herring continued existence: artificial propagation/stocking, competition, hybrids, and landlocked populations.

Artificial Propagation

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 (McBride *et al.* 2014); however, the extent to which this poses a threat to river herring locally or coast-wide is unknown. Stocking river herring directly affects a specific river/watershed system for river herring in that it can result in passing fish above barriers into suitable and new spawning and rearing habitat and in expanding populations into other watersheds.

The alewife restoration program in Maine focuses primarily on stocking in Androscoggin and Kennebec watersheds. 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. In 2017, the majority of fish were stocked in the Kennebec (150,121), Androscoggin (97,083), and Sebasticook (50,450) watersheds. An additional 23,784 adult fish were stocked into locations out of basin, using fish collected from the Androscoggin (16,584) or Kennebec (7,200) Rivers. 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. Since 2015, the annual adult stocking rate has been 315,000 fish. Adult river herring are trapped at 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).

In New Hampshire, from 1984 to 2015, approximately 55,600 adult river herring have been stocked in coastal rivers (Cocheco, Winnicut, Exeter, Lamprey, and Salmon Falls) (ASMFC 2017b). The transfers that occurred were either in-basin transfers to previously unoccupied habitat or out-of-basin transfers to help supplement spawning runs in rivers with lower return numbers. Fish were stocked from various rivers including the Connecticut, Cocheco, Lamprey, Kennebec, and Androscoggin Rivers.

The Massachusetts Division of Marine Fisheries (DMF) conducts a trap and transport-stocking program for alewife and blueback herring in Massachusetts. The three major objectives are to: (1) Maintain and enhance existing populations, (2) restore historically important populations and (3) create new populations where feasible. Stocking of gravid river herring where river access has been provided or improved is generally conducted for three or more consecutive years per system. Prior to the moratorium in 2012, the program transported between 30,000 and 50,000 fish per year into 10–15 different systems. Since the moratorium, a DMF stocking protocol was developed and implemented in 2013 that provided criteria for stocking decisions and a focus to allow remnant populations present at restoration sites to naturally recolonize habitat prior to the introduction of donor stock genetics. The protocol has reduced stocking activity, with most recent efforts occurring within drainage, moving fish upstream past multiple obstructions to the headwater-spawning habitat (ASMFC 2017b).

Rhode Island's Department of Environmental Management (DEM) conducts trap and transport utilizing out-of-state and in-state broodstock sources to supplement existing runs or restore extirpated systems where habitats have been restored. Gilbert Stuart River was Rhode Island's only broodstock source for river herring between 1966 and 1972, and today it is still an important source. Nonquit River has not been utilized as a broodstock source, but was considered in 2001, prior to the drastic decrease in spawning stock size. Between 1990 and 1993, both Gilbert Stuart and Nonquit Rivers received supplemental stockings from the Agwam and Bourne rivers located in Massachusetts. Since 2001, it has become increasingly difficult to obtain available out-of-state and in-state broodstock sources, due to the declines in river herring run sizes. In 2015, the following locations were stocked: Kickemuit, Turner Reservoir, Woonsquatucket, Potowamut, and Watchaug with 1,000 fish each, and Pawtucket with 2,000 fish.

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.

Alewife and Blueback Herring Rangewide and DPSs

Artificial propagation ranked as a *very low* threat to alewife and blueback rangewide (alewife, 1.2; blueback herring, 1.3) and in all DPSs (alewife, 1.2–1.3; blueback herring, 1.2), except for the Aw-Northern New England DPS (1.7) and Bb-Canada/Northern New England DPS (1.8) where artificial propagation was ranked as a *low* threat.

SRT members noted that artificial propagation/stocking has detrimental effects on river herring populations. First, hatchery efforts often take focus and importance away from on-the-ground issues with a fish and its habitat, which would be harmful in the long term. Second, artificial propagation would almost certainly lead to a significant loss of genetic diversity, which is already likely substantially lower than most times in the past.

The SRT ranked the threat of artificial propagation/stocking slightly higher in the alewife Aw-Northern New England DPS and the Bb-Canada/Northern New England DPS compared to the rangewide and other DPS' risk scores. As noted in the abundance discussion of the Extinction Risk Assessment within the Status Review Report (NMFS 2019), the persistence of many populations in Maine are reliant on active management strategies (*e.g.* truck and transport, fish lifts, fishway maintenance) rather than on volitional passage. Therefore, a change in management strategy, especially related to stocking/truck and transport would have dramatic impacts on these runs, and therefore raises uncertainty associated with this area. However, there is no information to suggest that these stocking efforts would be discontinued, as these efforts are economically and recreationally important to these areas. The intensive stocking in this region has likely reduced genetic variability in the U.S. portion of this DPS.

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 from blueback herring in prey selection, given that these fish 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.

Alewife and Blueback Herring Rangewide and All DPSs

Competition among fish species is difficult to determine because it requires demonstration of a limiting resource(s). Given the diet and generalist nature of alewife and blueback herring, prey are likely not limiting. However, there is some possibility that space could be limiting for these species (*e.g.* dams, poor fish passage, etc.). Competition ranking fell between *very low* to *low* rangewide and for all DPSs (alewife, 1.4–1.5; blueback herring, 1.4–1.6).

Hybrids

Genetic studies indicate that interbreeding, or hybridization, between alewife and blueback herring may be occurring in some instances where populations overlap (see for example, NMFS 2012a). Though interbreeding among closely related species is relatively uncommon, it does occasionally occur (Levin 2002) and has been reported at rates of 1.8 to 2.4 percent (Hasselman *et al.* 2014, Hasselman *et al.* 2016). Most often, different reproductive strategies, home ranges, and habitat differences of closely related species 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 typically less fit in terms of survival or their ability to breed successfully (Levin 2002). Other times, environmental conditions can provide an environment where hybrids can thrive. Though available evidence indicates that some alewife and blueback herring hybrids are found in the wild (Hasselman *et al.* 2014, Hasselman *et al.* 2016) there is not enough evidence to conclude whether or not hybridization poses a threat to one or both species of river herring.

Alewife and Blueback Herring Rangewide and All DPSs

Hybrids have likely been a natural occurrence throughout the history of alewife and blueback herring. In most cases, they occur at low to very low rates in natural and impacted systems (McBride *et al.* 2014, Hasselman *et al.* 2014). The SRT ranked hybrids in the *very low* category rangewide and for all DPSs (1.0–1.1).

Landlocked Populations

Alewives and blueback herring maintain two life history variants: anadromous and landlocked. It is thought 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 and 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 to an anadromous life history if they had the opportunity to do so.

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 as related 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.

Alewife and Blueback Herring Rangewide and All DPSs

Landlocked populations are discrete from anadromous blueback herring, occupy different ecological niches, and have differing morphological features. The SRT ranked landlocked populations as a *very low* contribution to extinction risk rangewide and for all DPSs.

Overall Risk Summary

Guided by the results from the demographics risk analysis as well as threats assessment, the SRT members used their informed professional judgment to make an overall extinction risk determination for each species, now and in the foreseeable future. The SRT used a ''likelihood analysis'' to evaluate the overall risk of extinction. Each SRT member had 10 likelihood points to distribute among the following overall extinction risk categories: *low* risk, *moderate* risk, or *high* risk. These categories are described in Section 6.1.4 Overall Level of Extinction Risk Analysis of the Status Review Report (NMFS 2019). As noted earlier, the team was asked to review the demographic risks and threats to the species, and to consider and discuss how these threats, acting in combination, may increase risk to the species. For example, the SRT noted how climate variability may enhance sedimentation in river systems, increasing the threat associated with poor water quality, and how climate change effects may enhance the threat of water withdrawal in regions. The SRT noted higher uncertainty around how the combination of such threats may impact the two species, and this uncertainty is reflected in a wider range in their distribution of likelihood points for these threats (largely those associated with habitat-related threats). The SRT's uncertainty about how the demographic risks and the combination of threats may impact the species (or DPSs) is also reflected in a wider distribution of likelihood points for the overall risk to the species.

We have independently reviewed the best available scientific and commercial information, including the status review report (NMFS 2019), and other published and unpublished information reviewed by the SRT. As described earlier, an endangered species is ''any species which is in danger of extinction throughout all or a significant portion of its range'' and a threatened species is one ''which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.'' We reviewed the results of the SRT and concurred with the SRT's findings regarding extinction risk. We then applied the statutory definitions of ''threatened species'' and ''endangered species'' to the SRT findings and other available information to determine if listing alewife or blueback herring rangewide or in any of their respective DPSs was warranted.

Alewife

The mean scores based on the SRT members' individual scores indicate that the level of extinction risk to the alewife rangewide is *low,* with 75 percent of the SRT members' likelihood points allocated to the *low* risk category. The SRT allocated 22 percent of their likelihood points to the *moderate* extinction risk category. The SRT allocated 3 percent of their likelihood points to the *high* extinction risk category. SRT members attributed the *high* extinction risk points to concerns associated with the species' complex anadromous fish life history, uncertainty in climate change and vulnerability, incidental catch, potential habitat modification (*e.g.* increased coastal development and water use), and concern about the adequacy of current and future regulatory mechanisms, including fisheries rangewide. As noted throughout the Extinction Risk Analysis section, the SRT expressed considerable uncertainty about the demographics risk to the species and the threats, with a majority of the mean scores for ranking threats falling between the *very low* (1) to *medium* (3) categories. Overall the SRT acknowledged that alewife are at historical low levels, but noted that improved fisheries management efforts in recent years have reduced fishing mortality rates in alewife stocks and that hundreds of habitat improvement projects have been completed in the past 20 years. Many relatively robust populations of alewife exist, and genetic data show connectivity among populations (genetic continuum along the coastline) despite regional groupings.

Given this level of extinction risk, which is based on an evaluation of the contribution of alewife's demographic parameters and threats to extinction risk, we have determined that the alewife rangewide does not meet the definition of an endangered or threatened species and, as such, listing under the ESA is not warranted at this time.

SRT members also applied the same likelihood point method to each alewife DPS. The mean overall risk scores for alewife in the Aw-Canada DPS correspond to a 77 percent likelihood of a *low* risk and 23 percent *moderate* risk of extinction. The mean overall risk scores for alewife in the Aw-Northern New England DPS correspond to a 74 percent likelihood of a *low* risk and 26 percent *moderate* risk of extinction. The mean overall risk scores for alewife in the Aw-Southern New England DPS correspond to a 69 percent likelihood of a *low* risk and 31 percent *moderate* risk of extinction. The mean overall risk scores for alewife in the Aw-Mid-Atlantic DPS correspond to a 70 percent likelihood of a *low* risk and 30 percent *moderate* risk of extinction.

Given this level of extinction risk for all alewife DPSs, which is based on an evaluation of the contribution of demographic parameters and threats to extinction risk, we have determined that the Canada, Aw-Northern New England, Aw-Southern New England and Aw-Mid-Atlantic DPSs do not meet the definition of an endangered or threatened species and, as such, listing under the ESA is not warranted at this time.

Blueback Herring

For blueback herring rangewide, SRT members indicated that there was a 66 percent *low* risk of extinction, a 30 percent *moderate* risk of extinction, and a 4 percent *high* risk of extinction. SRT members attributed the *high* extinction points to concerns associated with the complex anadromous fish life history, uncertainty in climate change and vulnerability, incidental catch, potential habitat modification (*e.g.* increased coastal development and water use), and concern about the adequacy of current and future regulatory mechanisms, including fisheries rangewide. As noted throughout the Extinction Risk Analysis section, the SRT expressed considerable uncertainty about the demographics risk to the species and the threats, with a majority of the mean scores for ranking threats falling between the *very low* (1) to *medium* (3) categories. The SRT noted blueback herring have been subjected to habitat impacts for centuries and to considerable fishing pressure for many decades. The SRT also acknowledged that blueback herring are at historically low levels, but noted that improved fisheries management efforts in recent years have reduced fishing mortality rates for blueback herring stocks and that hundreds of habitat improvement projects have been completed in the past 20 years. While over one third of the SRT's allocation points were in the *moderate/high* categories, indicating that blueback herring are at a greater risk of extinction compared to alewives due to lower overall abundances, increased vulnerability to anthropogenic disturbances in combination with climate change, greater distances between populations, poorer performance at fishways, and uncertainties surrounding accurate distribution information rangewide, a majority of the points were still allocated to the *low* risk category based on resilient life history traits and current abundance information.

Given this level of extinction risk, which is based on an evaluation of the contribution of blueback herring's demographic parameters and threats to extinction risk, we have determined that the blueback herring rangewide does not meet the definition of an endangered or threatened species and, as such, listing under the ESA is not warranted at this time.

SRT members also applied the same likelihood point method to each blueback herring DPS. The mean overall risk scores for blueback herring in the Bb-Canada/Northern New England DPS correspond to a 67 percent *low* risk of extinction, a 30 percent *moderate* risk of extinction, and a 3 percent *high* risk of extinction. The mean overall risk scores for blueback herring in the Bb-Mid-Atlantic DPS correspond to a 69 percent *low* risk of extinction, a 30 percent *moderate* risk of extinction, and a 1 percent *high* risk of extinction. The mean overall risk scores for blueback herring in the Bb-Southern Atlantic DPS correspond to a 69 percent *low* risk of extinction, a 30 percent *moderate* risk of extinction, and a 1 percent *high* risk of extinction.

Given this level of extinction risk for all blueback herring DPSs, which is based on an evaluation of the contribution of blueback herring's demographic parameters and threats to extinction risk, we have determined that the Bb-Canada/Northern New England, Bb-Mid-Atlantic and Bb-Southern Atlantic DPSs do not meet the definition of an endangered or threatened species and, as such, listing under the ESA is not warranted at this time.

Significant Portion of Its Range

As the definitions of ''endangered species'' and ''threatened species'' make clear, the determination of extinction risk can be based on either assessment of the rangewide status of the species, or the status of the species in a ''significant portion of its range'' (SPR). Because the SRT determined that alewife and blueback herring are at a *low* risk of extinction rangewide and in each DPS, we asked the SRT to also consider whether a significant portion of the range may exist in either species and whether the species in those portions are in danger of extinction now or in the foreseeable future (79 FR 37578; July 1, 2014).

In 2014, the Services adopted a joint SPR Policy that outlines a step-wise analysis to be used to determine whether a portion of the range is ''significant.'' (79 FR 37578; July 1, 2014). The SRT followed the process outlined in the policy when it considered whether any portions of the ranges of alewife and blue back herring are significant.

Consistent with the policy, when we conduct an SPR analysis, we first identify any portions of the range that warrant further consideration. The range of a species can theoretically be divided into portions in an infinite number of ways. However, as noted in the policy, there is no purpose to analyzing portions of the range that are not reasonably likely to be significant or in which a species may not be endangered or threatened. To identify only those portions that warrant further consideration we consider whether there is substantial information indicating that (1) the portions may be significant, and (2) the species may be in danger of extinction in those portions or is likely to become so within the foreseeable future. We emphasize that answering these questions in the affirmative is not a determination that the species is endangered or threatened throughout a significant portion of its range; rather, it is a step in determining whether a more detailed analysis of the issue is required (79 FR 37578; July 1, 2014). Making this preliminary determination triggers a need for further review, but does not prejudge whether the portion actually meets these standards such that the species should be listed.

If this preliminary determination identifies a particular portion or portions for potential listing, those portions are then fully evaluated under the ''significant portion of its range'' authority to determine whether the portion in question is biologically significant to the species *and* whether the species is endangered or threatened in that portion.

The SPR Policy further provides that, depending on the particular facts of each situation, we may find it is more efficient to address the significance issue first, but in other cases, it will make more sense to examine the status of the species in the potentially significant portions first. Whichever question is asked first, an affirmative answer is required to proceed to the second question. (79 FR 37587). If we determine that a portion of the range is not ''significant,'' we will not need to determine whether the species is endangered or threatened there; if we determine that the species is not endangered or threatened in a portion of its range, we will not need to determine if that portion is ''significant.'' Thus, if the answer to the first question is negative—whether it addresses the significance question or the status question—then the analysis concludes, and listing is not warranted.

In making a determination of ''significance,'' we consider the contribution of the individuals in that portion to the viability of the species. The SPR Policy established a threshold for ''significance'' (*i.e.,* the portion's contribution to the viability is so important that, without the members in that portion, the species would be in danger of extinction or likely to become so in the foreseeable future). In two recent District Court cases challenging listing decisions made by the USFWS, the definition for ''significant'' in the SPR Policy was invalidated. The courts held that the threshold component of the definition was ''impermissible,'' because it set too high a standard. Specifically, the courts held that under the threshold in the policy, a species would never be listed based on the status of the portion, because in order for a portion to meet the threshold, the species would be threatened or endangered rangewide. *Center for Biological Diversity, et al.* v. *Jewell,* 248 F. Supp. 3d 946, 958 (D. Ariz. 2017); *Desert Survivors* v. *DOI* 321 F. Supp. 3d. 1011 (N.D. Cal., 2018). Accordingly, while the SRT used the threshold identified in the policy, which was effective at the time the SRT met, our analysis does not rely on the definition in the policy, but instead responds to the second *Desert Survivors* case (336 F. Supp. 3d 1131, 1134–1136; N.D. CA August, 2018), in which the Court stated that there is no geographic limitation to the holding that the definition of ''significant'' is impermissible. As such, our analysis independently construes and applies a biological significance standard, drawing from the record developed by the SRT with respect to viability characteristics (*i.e.,* abundance, productivity, spatial distribution, and genetic diversity) of the members of the portions, in determining if a portion is a significant portion of a species' range.

As described previously, based on abundance estimates in the recent stock assessment update (ASMFC 2017a) and the SRT's extinction risk results, the

SRT determined that alewife are at low risk of extinction rangewide and in each of the four DPSs. Applying the SPR Policy to the alewife, the SRT first evaluated whether there is substantial information indicating that any portions of the species' range are threatened or endangered. In light of the earlier findings that all four DPSs, which span the range of this species, are at low risk of extinction, and finding no other evidence of areas within the species range where there is a concentration of threats, the SRT did not identify portions of the alewife range that were at a *high* risk of extinction, nor could the SRT identify threats that significantly affected one portion of the range.

The SRT then applied the SPR Policy to each alewife DPS. In other words, the SRT evaluated whether there is substantial information indicating that any portions of any singular DPS may have a concentration of threats and should be further evaluated under the SPR Policy. After reviewing the best available data, the SRT found no information to suggest that any portion of the Aw-Canada, Aw-Northern New England, Aw-Southern New England, or Aw-Mid-Atlantic DPSs stood out as having a heightened risk of extinction now or in the foreseeable future, and the SRT found no reason to further evaluate areas of any particular DPS under the SPR Policy.

After reviewing the SRT's findings, we agree that there is no evidence to suggest that alewife are at heightened risk of extinction, now or in the foreseeable future, in any particular area rangewide or in a DPS. Thus, we find no evidence that a significant portion of this species or one the DPSs is threatened or endangered.

As discussed in the Assessment of Extinction Risk section previously, the SRT determined that rangewide blueback herring have a 66 percent low risk of extinction, a 30 percent *moderate* risk of extinction and a 4 percent *high* risk of extinction. Applying the SPR Policy to the blueback herring, the SRT first identified geographic areas where there may be a concentration of threats. The SRT then evaluated whether there is substantial information indicating that any of these portions of the species' range may be facing a risk of extinction now or in the foreseeable future.

The SRT specifically considered whether recent information about the Bb-Mid-Atlantic stock complex of blueback herring suggested this region of the range may constitute an SPR. The SRT considered threats to this region (see previous *Evaluation of Threats* section). While some threats were ranked slightly higher numerically in the Mid-Atlantic compared to other areas (including, but not limited to water quality and water withdrawal), the scoring varied from other areas only by tenths of a point. Accordingly, the identified qualitative rankings (*i.e., very low* to *medium*) always matched at least one or more other areas for the particular threat category. Additionally, the SRT completed an overall extinction risk assessment for the Bb-Mid-Atlantic portion of the range (see previous *Overall Risk Summary* section). The SRT allocated a 69 percent *low* risk of extinction, a 30 percent *moderate* risk of extinction and a 1 percent *high* risk of extinction. Overall, the best available data indicate blueback herring in the Bb-Mid-Atlantic stock complex are not at risk of extinction now or in the foreseeable future. Therefore, the SRT did not proceed to consider the biological significance of the Bb-Mid-Atlantic stock to the species.

Additionally, because in 2011 the petitioner identified the Long Island Sound portion of the range as a potential DPS, the SRT considered if this portion of the Bb-Southern New England stock complex would be considered ''significant'' under the SPR Policy. The petitioners considered this area to consist of the Monument, Namasket, Mattapoiset, Gilbert-Stuart, Shetucket, Farmington, Connecticut, Naugatuck and Mianus Rivers.

The SRT considered the threats affecting the Long Island Sound area, including habitat loss due to dams and other barriers, water withdrawal due to high population densities, and bycatch. Notably, this area is found within the Mid-Atlantic DPS (discussed above and reviewed in *Evaluation of Threats*), and much of the information that may differ in the Long Island portion of the range is expressed in the above descriptions with additional detail provided in the Status Review Report (NMFS 2019).

The SRT analyzed the available run data for the time series for the Long Island trawl survey, Connecticut juvenile seine survey, and Monument River run counts. Overall blueback herring abundance for this portion is difficult to estimate accurately and managers have reported a mismatch of river wide trend in abundance in this region when comparing juvenile seine survey data from the Connecticut River and Holyoke fishway counts (ASMFC 2017b). While the Connecticut River watershed may act or has acted as a source for blueback herring in this region, many other rivers in this portion of the range are smaller coastal runs that drain directly into the ocean and are not expected to be large production rivers for blueback herring on the same scale. Over the full time series (2006–2015) in the most recent ASMFC assessment, run trends for blueback herring have decreased in the Monument River, were variable in the Connecticut River, and were stable in the Shetucket River and Mianus Rivers (ASMFC 2017a).

When considering spatial distribution of blueback herring in this portion, the SRT noted that although the abundances are low, blueback herring were distributed through this entire portion and appear to be reasonably well connected with rivers to the south of the Connecticut and rivers to the north, which also have blueback herring populations. Recent genetic work by Reid *et al.* (2018) places river populations from this portion into at least two separate genetic groups. The Connecticut River and Mianus Rivers were assigned to the Mid Atlantic stock complex, and the Gilbert-Stuart and Monument Rivers were assigned to the Southern New England stock complex (Reid *et al.* 2018). The most recent genetic studies do not indicate that this portion is unique in its genetic diversity.

Finally, the SRT completed an overall extinction risk assessment for the Long Island portion identified by the petitioners. Overall, the SRT concluded that there is a *low* risk of extinction in the Long Island Sound portion currently and in the foreseeable future. The Long Island Sound population is not threatened or endangered, nor is it likely to become so in the foreseeable future. Therefore, the SRT did not proceed to consider whether the portion may be biologically significant to the species rangewide.

After reviewing the SRT's findings for the Bb-Mid-Atlantic stock and the Long Island Sound portion of the range, we agree that there is no evidence to suggest that blueback herring in these areas are at heightened risk of extinction. Thus, we find that the Mid-Atlantic stock and the Long Island Sound portion are not significant portions of the blueback herring range because they are not in danger of extinction or likely to become so in the foreseeable future.

Next, the SRT considered the extinction risk of blueback herring in the Bb-Mid-New England stock complex (see Figure 2) due to recent concerns related to very low run counts in New Hampshire rivers. The SRT considered the best available information on abundance, growth rates/productivity, spatial distribution, and diversity contained in the recent stock assessment update (ASMFC 2017a, b). The SRT examined trends for the Oyster, Winnicut, Taylor, Lamprey, and Cocheco Rivers in New Hampshire and discussed threats in this region. For a more detailed description of population trends see the Status Review Report (NMFS 2019). The SRT questioned whether the fisheries-independent surveys that are currently conducted by the state adequately target blueback herring, but the reported indices in the most recent stock assessment (ASMFC 2017b) are the best available information. The best available data show low blueback herring run count estimates for rivers in this portion, and the SRT noted that recent sampling in the Lamprey River resulted in zero blueback herring counted at the fishway. SRT members noted that there is likely some blueback herring spawning below the fishway, but the monitoring design only counts fish which ascend the fishway. However, this issue is not unique to this river system.

The most recent genetic information classified blueback herring in this portion of the species' range as belonging to the Bb-Mid New England stock complex (Reid *et al.* 2018) (see Figure 2). The Bb-Mid New England portion is adjacent to stock complexes in the north (Bb-Canada/Northern New England) and south (Bb-Mid Atlantic), though the precise boundaries and distribution of this stock complex are not fully understood due to the unsampled blueback herring populations located between the Oyster River and the Sebasticook River.

The SRT considered the threats affecting the Bb-Mid New England area, including habitat loss due to dams and other barriers, threats to water quality, incidental catch, and inadequacies of state and Federal regulations. Notably, this area overlaps with the southern portion of the Aw-Northern New England (noted above and reviewed in *Evaluation of Threats*), and additional detail can be found in the Assessment of the ESA Section 4(a)(1) Factors of the Status Review Report, which reviews information for each threat along the coastline (NMFS 2019).

The SRT completed an overall extinction risk estimate for the Bb-Mid-New England stock complex of blueback herring and allocated 51 percent of the likelihood points to the *high* risk of extinction, 39 percent to *moderate* risk of extinction and 10 percent to low risk of extinction. The allocation of likelihood points in the *high* risk category was primarily due to declining run trends and poor population metrics.

Because the SRT found the Bb-Mid-New England stock complex of blueback herring to be at a *high* risk of extinction, they considered the questions outlined in the Status Review Guidance (NMFS 2017) to determine if the Bb-Mid-New England stock complex might be considered biologically ''significant'' *i.e.,* whether the portion's contribution to the viability of the species is so important that, without the members in that portion, the species would be in danger of extinction or likely to become so in the foreseeable future. Specifically, the SRT considered a number of questions that inform the viability characteristics: Abundance, productivity, spatial distribution, and genetic diversity. The SRT considered how the loss of the portion, given the current available information on abundance levels, would affect the species rangewide in a variety of ways. The SRT also considered how the loss of the portion would affect the spatial distribution of the species (*i.e.,* would there be a loss of connectivity, would there be a loss of genetic diversity, or would there be an impact on the population growth rate of the remainder of the species).

The SRT found that the Bb-Mid-New England portion of blueback herring was unlikely to contribute in such a way as to be considered significant to the blueback herring rangewide. More specifically, the Bb-Mid-New England portion is very small compared to the rest of the range, spanning approximately 311 km (193 mi) of coastline and encompassing less than 3 percent of the estimated watershed area of the species (see Table 1). Additionally, the current run sizes in this portion in the last decade have numbered in the 10,000s and more recently in the 1,000's and are estimated at less than 1 percent of overall rangewide abundance. The historical contribution of the Mid-New England portion to the rangewide abundance is assumed to be a similar proportion, as historical declines were noted across the blueback herring's range. However, the historical contribution may have been slightly higher than one percent due to the intense current and historic industrial development (*e.g.,* dam construction near head of tide for mills) in this region (see *Evaluation of Threats*). Additional uncertainty exists as unsampled adjacent rivers may be attributed to this stock complex (see Figure 2). The SRT noted that due to the small abundance in the Bb-Mid-New England portion and its small contribution to the overall population size, they would not expect deleterious effects to the remainder of the species from its loss. The SRT also noted that the loss of the Bb-Mid-New England portion would not cause the species as a whole to be below replacement rate. Loss of the Bb-Mid-New England portion could potentially disrupt connectivity in the very short term. However, the SRT noted that straying rates would allow for recolonization of the rivers in the foreseeable future and therefore maintain overall spatial diversity. Populations from the north (Bb-Canada/Northern New England DPS) and south (Bb-Mid-Atlantic DPS) contain hundreds of thousands of blueback herring and would likely be the first recolonizers of this 311 km (193 mi) stretch of coastline.

If the Bb-Mid-New England portion was lost, blueback herring rangewide would lose one of five known regional stock complexes and potential genetic adaptation. However, four stock complexes would remain providing genetic diversity to the species as whole. Further, there is no evidence to indicate that the loss of genetic diversity from the Bb-Mid-New England stock complex would result in the remaining populations lacking enough genetic diversity to allow for adaptations to changing environmental conditions. In considering this portion of the range, the SRT was unaware of any particular habitat types that the species occupies that are found only in the Bb-Mid-New England portion (see *Distinct Population Segment,* significance discussion). In conclusion, the SRT determined that the Bb-Mid-New England stock is not a significant portion of the range because the loss of the members in the portion would not render the species in danger of extinction, nor make the species likely to become so in the foreseeable future.

In light of these recent court decisions noted above that invalidated the threshold for ''significant'' in the SPR Policy that the SRT applied, we have independently reviewed and have considered the biological importance or value that this stock complex provides to the conservation of the species rangewide to determine if this portion may be ''significant'' as contemplated by the ''significant portion of its range'' phrase in the ESA. The foundation of the policy of defining ''significant'' in terms of biological significance to the species has not been invalidated by any court, and we continue to rely on the principles of biological significance as the corner stone of this SPR analysis. Specifically, we consider how this portion contributes to the conservation of the species by analyzing the abundance, spatial distribution, genetic diversity and productivity of the members in the portion and the value these factors and other relevant factors contribute to the conservation of the species overall.

Regarding abundance estimates from this stock complex, while exact numbers of individuals are not available, the current indices show that this stock complex likely has a low level of biological importance to the rangewide abundance estimates. Due to the small geographic size of the area that it inhabits, this stock contributes a small proportion of the overall geographic distribution of the blueback herring rangewide. Specifically, this stock does not have the population numbers or habitat capacity to buffer surrounding stocks against environmental threats such as droughts, or flooding. We found only low abundance, and we did not find unique threats to this stock complex.

We also examined spatial distribution and genetic diversity. This stock complex bridges connectivity between the Bb-Canada/Northern New England and Bb-Southern New England stock complexes by habitat between these two stocks. However, blueback herring have been observed to migrate this distance previously (*e.g.,* Eakin 2017), and the importance of this bridge between stock complexes is likely low given the species' straying behavior. Overall, we find that the contribution that this stock makes to spatial distribution of the species is low because it inhabits a small area compared to other stock complexes of this species and to the rangewide distribution.

According to the most recent genetic study (Reid *et al.* 2018), the Bb-Mid-New England stock complex represents one of five distinguishable groupings of genetic diversity for blueback herring. While it is likely that this unique genetic signature conveys some type of adaptive potential to the species rangewide, we do not currently have evidence of this. Because we do not know the adaptive potential of the genetic signature for the Bb-Mid-New England complex, we are not able to determine whether the genetic diversity contributes in a significant way to the persistence of the species rangewide. The available genetic research currently suggests that there is overlap in genetic signatures at the boundaries of all five stock complexes, such that we observe a coastwide continuum where each river is most similar to its nearest neighbors.

Summarizing our analysis, we find that the Bb-Mid-New England stock complex contributes a low level of importance to the species rangewide in terms of abundance, productivity, and spatial distribution. As one of five of the stock complexes, we find that the Bb-Mid-New England stock complex contributes genetic diversity to the species; however, the importance of that diversity is unclear because there is no evidence at this time indicating that the genetic differences between stocks are linked to adaptive traits. Further, genetic mixing at the boundaries of these stock complexes obscures the importance of each group with regard to the genetic diversity for the species as a whole. Overall, we find that the Bb-Mid-New England stock complex's contribution to the population in terms of abundance and spatial distribution is of low biological importance and overall does not appear significant to blueback herring as a whole. Thus, we find that the Mid-New England stock complex does not represent a significant portion of the blueback herring range.

In summary, we find that there is no portion of the blueback herring's range that is both significant to the species as a whole and endangered or threatened. Thus, we find no reason to list this species based on a significant portion of its range.

Protective Efforts

In the *Evaluation of Threats* section, we describe ongoing efforts that provide for the conservation of alewife and blueback herring either indirectly or directly (see, specifically, discussions under *A. Habitat Destruction, Modification, or Curtailment,* and *B. Overutilization*). In these sections we describe efforts to restore alewife and blueback herring habitat (*e.g.,* with connectivity projects such as dam removal and fish passage installation and improvements) and to manage threats associated with harvest. Protective efforts that are likely to be most effective in supporting the long-term growth of these species center on ensuring connectivity in spawning rivers. While hundreds of restoration projects have occurred over the last 20 years to improve access to alewife and blueback herring habitat across the range, these efforts often take many years to accomplish, and the likelihood of projects occurring (in the long term) are not easy to predict due to confounding factors associated with funding and political/community will. Further, once accomplished, the efforts may only have localized effects on independent rivers. While we have reviewed the states' efforts that may convey protections for these species into the future, we do not find that these future efforts are certain to significantly alter the extinction risk for alewife or blueback herring.

Final Determination

Section 4(b)(1) of the ESA requires that listing determinations be based solely on the best scientific and commercial data available after conducting a review of the status of the species and taking into account those efforts, if any, being made by any state or foreign nation, or political subdivisions thereof, to protect and conserve the species. We have independently reviewed the best available scientific and commercial information, including information provided in the petition, information submitted in response to the request for comments (82 FR 38672; August 15, 2017), the status review report (NMFS 2019), and other published and unpublished information cited herein, and we have consulted with species experts and individuals familiar with the alewife and blueback herring. We identified four DPSs of the alewife and three DPSs of the blueback herring. We considered each of the section 4(a)(1) factors to determine whether any one of the factors contributed significantly to the extinction risk of the species. We also considered the combination of those factors to determine whether they collectively contributed significantly to extinction risk. As previously explained, we could not identify any portion of the species' range that met both criteria of the SPR Policy. Therefore, our determination set forth below is based on a synthesis and integration of the foregoing information, factors and considerations, and their effects on the status of the species throughout their ranges and within each DPS.

Alewife and blueback herring have been subjected to habitat impacts for centuries and to considerable fishing pressure for many decades. We acknowledge that they are at historically low levels, but note that improved fisheries management efforts in recent years have reduced fishing mortality rates on alewife and blueback herring stocks.

Many relatively robust populations of alewife exist, and genetic data show connectivity among populations (genetic continuum along the coastline) despite regional groupings. Demographic risks are low to *moderate* and significant threats have been reduced. Blueback herring are at a greater risk of extinction (as evidenced by over one third of the SRT likelihood points in the *moderate*/*high* categories), as indicated by lower overall abundances, increased vulnerability to anthropogenic disturbances in combination with climate change, greater distances between populations, poorer performance at fishways, and uncertainties surrounding accurate distribution information rangewide. However, based upon the available information summarized here, blueback herring have an overall low risk of extinction rangewide and in each DPS, assuming the dominant threats to their populations continue to be managed.

We conclude that the alewife and blueback herring are not in danger of extinction, nor likely to become so in the foreseeable future throughout all or a significant portion of their ranges or in any of the DPSs. We summarize the factors supporting this conclusion as follows: (1) The species are broadly distributed over a large geographic range within the Northwest Atlantic Ocean and along the U.S. and Canadian Atlantic coasts, with no marine barriers to dispersal; (2) genetic data indicate that populations are not isolated and that both species demonstrate a nearest neighbor genetic continuum along the coast; (3) while both the species possesses life history characteristics that increase vulnerability to overutilization, overfishing is not currently occurring within the range; (4) while the current population size has significantly declined from historical numbers, the population size is sufficient to maintain population viability into the foreseeable future and consists of at least millions of individuals in several DPSs and hundreds of thousands in other DPSs; (5) there is no evidence that disease or predation is contributing to increasing the risk of extinction; and (6) there is no evidence that the species is currently suffering from depensatory processes (such as reduced likelihood of finding a mate or mate choice or diminished fertilization and recruitment success) or is at risk of extinction due to environmental variation or anthropogenic perturbations.

Since the alewife is not in danger of extinction throughout all or in a significant portion of its range, including DPSs, or likely to become so within the foreseeable future, it does not meet the definition of a threatened species or an endangered species. Therefore, the alewife does not warrant listing as threatened or endangered at this time.

Additionally, since the blueback herring is not in danger of extinction throughout all or a significant portion of its range, including DPSs, or likely to become so within the foreseeable future, it does not meet the definition of a threatened species or an endangered species. Therefore, the blueback herring does not warrant listing as threatened or endangered at this time.

References

A complete list of all references cited herein is available upon request (see **FOR FURTHER INFORMATION CONTACT**).

Authority

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

Dated: June 13, 2019.

Christopher Wayne Oliver,

Assistant Administrator for Fisheries, National Marine Fisheries Service.

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