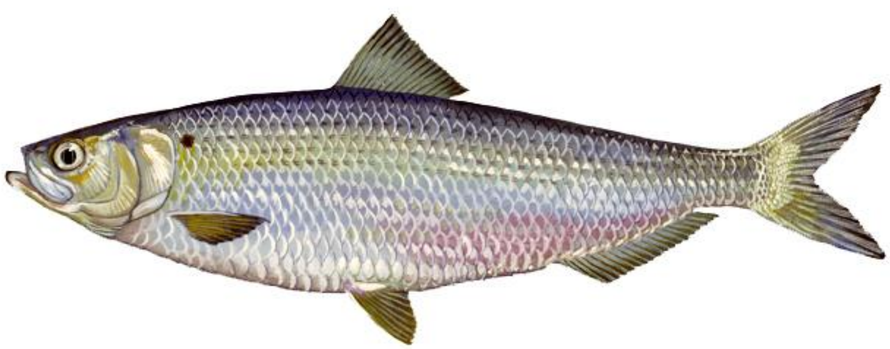
Before the Secretary of Commerce

Petition to List Alewife (*Alosa pseudoharengus*) and Blueback Herring (*Alosa aestivalis*) as Threatened Species and to Designate Critical Habitat

Alewife (*Alosa pseudoharengus*)

Blueback Herring (*Alosa aestivalis*)



Source: U.S. Fish and Wildlife Service

August 1, 2011

EXECUTIVE SUMMARY

This is a petition to list the alewife (*Alosa pseudoharengus*) and the blueback herring (*Alosa aestivalis*) each as a threatened species throughout all or a significant portion of its range pursuant to the federal Endangered Species Act ("ESA"). In the alternative, the National Marine Fisheries Service ("NMFS") should designate distinct population segments ("DPSs") of alewives and blueback herring as specified in this petition and list each DPS as a threatened species.

Alewives and blueback herring (collectively known as "river herring") were once highly abundant in coastal waters, rivers and streams of the eastern United States. From 1950 through 1970, total commercial landings of alewives and blueback herring in Atlantic coastal states averaged more than 50 million pounds per year. Most Atlantic coastal streams and rivers were inhabited by one or both of the species. In the larger rivers, spawning runs could reach well into the millions of individual fish – according to one historical account, three quarters of a *billion* river herring were landed from the Potomac River in 1832.

Populations of alewives and blueback herring are now a tiny fraction of their historical abundance. Overall coastal landings of alewives and blueback herring have averaged a little more than a million pounds over the last decade, a decline of more than 98 percent from the 1950 to 1970 average. In many rivers and streams, including several of the most historically important, river herring populations are either collapsed or entirely extirpated. In most of the others, populations are extremely depleted. Particularly alarmingly, declines have continued or even accelerated over the last decade in many cases. For example:

- On the Maine-Canada border, the run of alewife in the St. Croix River, which once numbered over two million counted fish in a single year, has been at or near zero in recent years and is considered collapsed.

- In New Hampshire's Taylor River, what had been the state's largest river herring run dropped by 97 percent between just 2000 and 2003 and has continued to decline.

- The alewife count in two of Massachusetts' most important remaining river herring runs, in the Monument and Mattapoisett Rivers, dropped almost 85 and 95 percent, respectively, between just 2000 and 2010.

- The huge blueback herring run in the Connecticut River, which averaged 5.4 million fish annually from 1981 to 1995, dropped to just over one million fish per year on average from 1996 to 2001, and then to just over 300,000 fish per year on average between 2002 and 2008 – an overall decline of almost 95 percent. In 2009, seven years after Connecticut instituted a fishing moratorium, state officials still described river herring stocks as "very low with no signs of an imminent recovery."

- The river herring fisheries of Chesapeake Bay and its tributaries – historically the country's largest – have been virtually eliminated, with landings in Virginia, Maryland, and from the Potomac River down 99 percent or more from their 1950 to 1970 averages.

In the Susquehanna River, which drains into Chesapeake Bay, blueback herring passed by the Conowingo Dam East fish passage dropped from almost 285,000 counted fish in 2001 to just 4 fish in 2010.

- By 2007, river herring landings from North Carolina's Albemarle Sound and its tributaries – which once rivaled those from Chesapeake Bay – had dropped by 98 percent or more, prompting the state to close its river herring fisheries. Since that time, North Carolina catch rates for bluebacks and alewives from independent gill net surveys have not shown any meaningful improvement in the populations.

- In South Carolina, the alewife is considered extirpated.

Alewives and blueback herring are imperiled by the present and threatened destruction, modification, and curtailment of their habitat and range; by overutilization for commercial, recreational, and scientific purposes; by predation and disease; by the insufficiency of existing regulatory authorities, laws, and policies; and by other natural and manmade factors. Existing stressors that most endanger the survival of alewives and blueback herring include fishing-related mortality, water pollution, dams, and dredging. In addition, recent studies indicate that global warming is already harming certain alewife and blueback herring subpopulations and will become an increasingly significant stressor in the future, including by exacerbating harmful water quality conditions and increasing flooding. Without substantial mitigation and management of these stressors, the alewife and the blueback herring are likely to become endangered and eventually extinct throughout all or significant portions of their ranges.

NMFS should list the alewife and the blueback herring each as a threatened species as a whole. The alewife and the blueback herring are unitary species likely to become endangered within the foreseeable future throughout all or significant portions of their ranges, including rivers in Maine, New Hampshire, Massachusetts, Connecticut, the Chesapeake Bay and its tributaries, and many coastal river systems in the Carolinas.

If NMFS does not list the alewife and the blueback herring each as a threatened species as a whole, the agency should designate four DPSs of alewife and three DPSs of blueback herring as threatened as follows: Central New England DPS of alewives, Long Island Sound DPS of alewives, Chesapeake Bay DPS of alewives, and Carolina DPS of alewives; Central New England DPS of blueback herring, Long Island Sound DPS of blueback herring, and Chesapeake Bay DPS of blueback herring. These DPSs encompass fish that originate from a river within the DPS and include the marine range of such fish.

The Central New England DPSs for alewives and for blueback herring would include the Winnicut River, Exeter River, Cocheco River, Taylor River, Oyster River, and Lamprey River in New Hampshire, and the Parker River in Massachusetts. These DPSs should be listed as threatened species because they are likely to become endangered within the foreseeable future throughout all or significant portions of this range, including as a result of fishing-related mortality, dams, dredging and blasting, water pollution, and global warming.

The Long Island Sound DPSs for alewives and for blueback herring would include the Monument River, Nemasket River, and Mattapoisett River in Massachusetts, the Nonquit River and Gilbert-Stuart River in Rhode Island, and the Shetucket River, Farmington River, Connecticut River, Naugatuck River, and Mianus River in Connecticut. These DPSs should be listed as threatened species because they are likely to become endangered within the foreseeable future throughout all or significant portions of this range, including as a result of fishing-related mortality, dams, dredging and blasting, water pollution, and global warming.

The Chesapeake Bay DPSs for alewives and blueback herring would include the Bay itself, and the Nanticoke, Potomac, Susquehanna, Rappahannock, York, and James Rivers. These DPSs should be listed as threatened species because they are likely to become endangered within the foreseeable future throughout all or significant portions of this range, including as a result of fishing-related mortality, dams, dredging and blasting, water pollution, and global warming.

The Carolina DPS for alewives would include the Chowan River and Albemarle Sound, Roanoke River, Pamlico Sound/Pamlico, Tar and Neuse Rivers, and Cape Fear River in North Carolina and the Winyah Bay (including the Waccamaw, Pee Dee, and Sampit rivers), Santee River, and Cooper River in South Carolina. This DPS should be listed as a threatened species because it is likely to become endangered within the foreseeable future throughout all or a significant portion of its range, including as a result of fishing-related mortality, dams, dredging and blasting, water pollution, and global warming.

NOTICE OF PETITION

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PETITIONER:

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The Petitioner Natural Resources Defense Council ("NRDC" or "Petitioner") hereby formally petitions the Secretary of the United States Department of Commerce ("Secretary"),[1] pursuant to 5 U.S.C. § 553(e) and 50 C.F.R. § 424.14, to list the alewife (*Alosa pseudoharengus*) and the blueback herring (*Alosa aestivalis*) each as threatened species under the Endangered Species Act, 16 U.S.C. §§ 1531, *et seq*. In the alternative, Petitioner petitions the Secretary to delineate four DPSs of alewives and three DPSs of blueback herring as described in the attached petition and to list them as follows: the Central New England, Long Island Sound, Chesapeake Bay and Carolina DPSs for alewife should be listed as threatened species; and the Central New England, Long Island Sound, and Chesapeake Bay DPSs for blueback herring should be listed as threatened species.

[1] Pursuant to the 1974 NMFS-U.S. Fish and Wildlife Service policy, NMFS should be the lead agency reviewing this petition.

Petitioner also requests that critical habitat be designated for alewife and for blueback herring concurrently with listing, pursuant to 16 U.S.C. § 1533(a)(3)(A) and 50 C.F.R. § 424.12.

I. Petitioner

NRDC is a national, non-profit environmental organization with more than 1.2 million members and online activists nationwide, including more than 373,000 members and activists in the Atlantic coastal states. In these Atlantic coastal states, NRDC actively works to improve the management of marine and estuarine resources. NRDC's members regularly visit alewife habitat and blueback herring habitat for recreational and related purposes, seek to view both alewives and blueback herring in the wild, and are concerned about the drastic decline in each species' numbers and each species' risk of extinction. NRDC can be contacted in New York City at 40 West 20th Street, New York, NY 10011, (212) 727-2700.

II. Specific Requested Actions

Petitioner requests that NMFS:

A. List alewife as threatened.

B. List blueback herring as threatened.

C. In the alternative, designate and list as threatened the following DPSs: Central New England, Long Island Sound, Chesapeake Bay, and Carolina DPSs for alewives; Central New England, Long Island Sound, and Chesapeake Bay DPSs for blueback herring; or, alternatively, NMFS should conduct its own DPS analysis and list the DPSs that meet the legal criteria.

D. Designate critical habitat for alewives and all identified DPSs of alewives.

E. Designate critical habitat for blueback herring and for all identified DPSs of blueback herring.

III. NMFS must issue an initial finding that this petition "presents substantial scientific or commercial information indicating that the petitioned action may be warranted."

NMFS must make this initial finding "[t]o the maximum extent practicable, within 90 days after receiving the petition." *See* 16 U.S.C. § 1533(b)(3)(A).

Petitioner need not demonstrate that listing is warranted; rather, Petitioner must only present information demonstrating that such listing may be warranted. While Petitioner believes that the best available science demonstrates that listing the alewife and the blueback herring or, alternatively, listing each of the requested DPSs as a threatened species is in fact warranted, there can be no reasonable dispute that the available information indicates that listing the two species or the requested DPSs as threatened may be warranted.

NMFS must promptly make a positive initial finding on the petition as required by 16 U.S.C. § 1533(b)(3)(A).

_______________________ Date: This 1st day of August 2011

Bradford H. Sewell
Senior Attorney

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I. INTRODUCTION

One of the country's spine-tingling migratory spectacles once unfolded each spring in rivers and streams up and down the Atlantic coast. Huge numbers of alewife and blueback herring would return from the ocean to the waterways in which they were hatched and head upstream to spawn a new generation. The great schools of silvery, foot-long fish would be greeted by an array of predators hungry after a long winter, including striped and largemouth bass, ospreys, bald eagles, herons, harbor seals and river otters. Native Americans harvested the bounty as well, salting and smoking the herring to eat later and using them to fertilize spring plantings. European settlers developed their own harvest traditions, including the election of an "alewife queen" in some communities.

Today, what was a vital part of both our Atlantic coastal ecosystems and cultural heritage has nearly disappeared. A fishery that dates back at least 350 years has declined almost 99 percent over just the last fifty. As NMFS' parent agency, the National Oceanic and Atmospheric Administration ("NOAA") (2010), has stated, populations of alewives and blueback herring "have exhibited drastic declines throughout much of their range." Particularly alarmingly, their numbers in more than a few rivers have dropped significantly in just the last decade. Up and down the coast, rivers that once had runs of hundreds of thousands – even millions – of river herring now have just a few thousand or even just a few hundred fish.

The exact causes of the alewife's and blueback herring's precipitous decline remain uncertain. Early on, industrial development along the waterways used by spawning river herring was mostly to blame. Mill dams and other obstructions and water pollution sharply reduced the quantity and quality of available spawning habitat. Some runs were wiped out; others persisted, albeit at lower levels. In the 1960s, a new threat arrived offshore. By the end of the decade, foreign commercial fishing fleets had nearly doubled the overall recorded harvest of river herring and had sent populations into a freefall. It took the forced exit of foreign fishing operations and the adoption of stringent conservation measures over the course of the following decade to finally arrest the collapse. As for the sudden drop in river herring counts seen in many rivers over just the last decade, many point to increased bycatch and incidental catch of the species in certain ocean fisheries occurring in federal waters, such as the New England and Mid-Atlantic herring and mackerel fisheries, in which such catch of alewives and blueback herring has been estimated by some to be two to three times the total catch in the entire coastwide river herring fishery.[2] It is likely that different factors are affecting different subpopulations to varying degrees.

Looking ahead, climate change poses a grave threat to both species. Warming water temperatures will accelerate the spread and severity of hypoxic zones in spawning and nursery

[2] With respect to river herring, the term "bycatch" is sometimes used to refer to river herring that are caught as non-target species and are either discarded at sea or retained and sold. Alternatively, bycatch is used to refer only to discarded river herring and the term "incidental catch" is used to refer to caught river herring if they are retained and sold. To avoid confusion, this petition uses both terms, which collectively are intended to encompass river herring that are caught as non-target species and are either discarded or sold.

areas such as in the Chesapeake Bay and Delaware River. Changing weather patterns will increase water flow patterns and pollutant loadings to such an extent that these and other water bodies may no longer provide hospitable habitat. Changes to ocean, estuarine, and riverine environments may interfere with migratory cues. As anadromous species that segregate out into river-specific populations, the alewife and the blueback herring have limited capacity to shift range, particularly in the short-term, in response to changing environmental conditions. The highly-depleted status of most of these river populations also means relatively low genetic diversity, which further limits capacity to evolve and spread out in response to changing environmental conditions. The alewife has already been extirpated from South Carolina, historically the southern end of the species' range, and is now threatened in North Carolina as well.

The recent dramatic declines in alewife and blueback herring populations have prompted four states – Massachusetts, Rhode Island, and Connecticut, as well as the aforementioned North Carolina – to impose fishing moratoriums in their state waters. Numerous additional states, including New Jersey, Pennsylvania, Maryland, Delaware, Virginia, Georgia and Florida, are likely to follow suit over the next year. In May 2009, NOAA listed the alewife and the blueback herring as "Species of Concern." Although these actions have likely benefitted certain populations of alewives and blueback herring and have made clear how dire the status of these species is, they are not nearly enough. There continues to be a lack of coordinated, effective, and comprehensive management measures that will adequately protect alewife and blueback herring populations throughout their ranges and life cycles and that will halt these populations' decline.

II. SPECIES ACCOUNTS

A. Biology and Status

1. Physical Descriptions

Alewife

Alewives are anadromous fish that reside offshore for most of the year and return to freshwater and coastal rivers to spawn (ASMFC 2008). They reach an average length of 10 to 11 inches and an average weight of 8 to 9 ounces (Bigelow and Schroeder 1953; ASMFC 2008). They have a grayish-green dorsal surface, which is distinguishable from the dark bluish-green dorsal surface of blueback herring, and paler and silvery ventral surface and sides (Bigelow and Schroeder 1953). The peritoneum of an alewife is pale grey or pink, or white, rather than the sooty or blackish color of the peritoneum of the blueback herring (Bigelow and Schroeder 1953). Alewives have much larger eyes and deeper bodies than blueback herring (ASMFC 2008).

Blueback Herring

Blueback herring are anadromous fish that reside offshore for most of the year and return to freshwater and coastal rivers to spawn (ASMFC 2008). They reach an average length of 11 inches and an average weight of 7 to 8 ounces (Bigelow and Schroeder 1953; ASMFC 2008). They have a dark bluish-green dorsal surface, which is distinguishable from the grayish-green dorsal surface of alewives, and paler and silvery ventral surface and sides (Bigelow and

Schroeder 1953). The peritoneum of a blueback herring is sooty or blackish in color, rather than the pale grey, pink, or white peritoneum of an alewife (Bigelow and Schroeder 1953). Blueback herring have smaller eyes and, on average, more slender bodies than alewives (Bigelow and Schroeder 1953). The fins of blueback herring are slightly lower than those of alewives (ASMFC 2008).

2. Historic Range, Present Range, and Stock Structure

Historic Range

Prior to the turn of the 20th century, multiple historical accounts indicate that alewives and blueback herring inhabited the vast majority of coastal rivers and estuaries along the Atlantic Coast.[3] Additionally, historical commercial landings records show that significant catches of alewives and blueback herring were landed in each Atlantic coastal state in years prior to 1950 (ASMFC 2008).

Alewife

The alewife was present historically in rivers located along the Atlantic coast, from northeastern Newfoundland to South Carolina.

The alewife historically occurred in significant numbers throughout the Bay of Fundy and the northern Gulf of Maine (Bigelow and Schroeder 1953; Flagg 2007; ASMFC 2008). Historical records indicate that alewives were commonly harvested in waters around Yarmouth, Nova Scotia; in the Annapolis Basin; in the Minas Channel; and farther up the Bay of Fundy (Bigelow and Schroeder 1953). For example, in 1896, the reported commercial catch for alewives in the Bay of Fundy was over 11.6 million alewives for the New Brunswick shore of the Bay of Fundy; and over 3.2 million individual alewives for the Nova Scotian side of the Bay of Fundy and for the west coast of Nova Scotia (Bigelow and Schroeder 1953).

The St. John River system in New Brunswick, Canada, historically supported a very significant population of alewives. Significant populations of alewives also historically occurred throughout the central and southern Gulf of Maine. For example, commercially-exploitable alewife populations are reported to have historically occurred in the St. Croix, Pennamaquan, Dennys, Orange, East Machias, Narraguagus, Tunk, Union, Orland, Penobscot, Ducktrap, Megunticook, Pemaquid, Damariscotta, St. George, Medomak, Sheepscot, Kennebec, Androscoggin, Presumpscot, Saco, Kennebunk, Mousam, Salmon Falls Rivers, West Harbor Creek, Nequasset, Cobboseecontee Stream, Walker Pond Stream, Carleton Stream, Allen Mill Stream, Patten Stream, Prospect Harbor Stream, and Pleasant River in Maine; the Piscataqua, Newmarket, and Exeter Rivers in New Hampshire; in the mouth of the Merrimack River between Massachusetts and New Hampshire; and in Cape Cod Bay (Kircheis *et al.* 2002; Bigelow and Schroeder 1953;

[3] In the case of a number of historical accounts cited in the petition, it is not clear whether alewives were being accurately distinguished from blueback herrings and vice versa. Depending on the river system being referred to, the description may actually reflect the presence and abundance, at least in part, of the other species.

United States Congressional Serial Set ("Cong. Serial Set"), Issue 3816; Rounsefell and Stringer 1945). In 1896, reported commercial catches were over 5.8 million individual alewives from Maine waters; over half a million individual alewives from New Hampshire streams; and over 2.6 million individual alewives for Cape Cod Bay and for the Merrimack River combined (Bigelow and Schroeder 1953). Of the reported catches of alewives in 1896, the largest was recorded in the Damariscotta River in Maine, followed by the Connecticut River, Taunton River, Merrimack River, St. George River, and Penobscot River (Cong. Serial Set, Issue 3816). Historical alewife fisheries are also reported to have occurred in the following rivers in Massachusetts: Essex River, Merrimack River, Charles River, Mystic River, Neponset River, Connecticut River, Taunton River, Mill River, Herring River, Agawam River, Wareham River, Mattapoisett River, Monument River, and Town Brook (Belding 1920).

Further south, significant populations of alewives also occurred in rivers along the Long Island Sound and in the middle Atlantic. Commercially-exploitable populations of alewives historically occurred in rivers and streams in Rhode Island; on the shores of Long Island, in the Hudson and St. Lawrence Rivers; on the shores of New Jersey; and in the Delaware River and Bay (Cong. Serial Set, Issue 3816; Rounsefell and Stringer 1945; Kraft *et al.* 2006a; Buckley *et al.* 2001). A 1608 historical account described that several billion anadromous fish, including alewives and blueback herring, entered the rivers of the Chesapeake Bay to spawn and ran far upstream, "reaching deep into central Pennsylvania and even into south-central New York, as well as the eastern slopes of the Blue Ridge Mountains and the Alleghany Plateau" (Chesapeake Bay Foundation ("CBF") 2010). Commercial alewife fisheries operating in the Chesapeake Bay historically yielded large catches of alewives (Cong. Serial Set, Issue 3816). According to commercial catch records, "the basin of the Chesapeake Bay (in Maryland, Virginia, Delaware, Pennsylvania, and the District of Columbia) yielded more than half of the entire catch of [alewives in] the United States," of which "[u]pwards of one third of the output … was taken in the Potomac [River]" (Cong. Serial Set, Issue 3816). Historical information indicates that, in 1896, the Potomac River was the "leading alewife stream" in the United States (Cong. Serial Set, Issue 3816). Large commercial catches of alewives also historically occurred in the Susquehanna, Elk, Chester, Choptank, Nanticoke, Wicomico, Pocomoke, and Patuxent Rivers in Maryland; the Potomac River between Maryland and Virginia; and in the Rappahannock, York, and James Rivers in Virginia (Cong. Serial Set, Issue 3816).

In the southern Atlantic, alewife populations historically occurred in North Carolina and South Carolina. In North Carolina, rivers and tributaries in the Albemarle Sound historically "rank[ed] next to the Chesapeake [Bay area] in production of alewives in 1896," with "more than one-fifth of the aggregate catch of the [United States]" (Cong. Serial Set, Issue 3816). In particular, the Chowan River had a very large alewife fishery that "rank[ed] next to that of the Potomac in extent" in 1896 (Cong. Serial Set, Issue 3816). Other waters in North Carolina also supported commercially exploitable populations of alewives (Cong. Serial Set, Issue 3816). For example, commercial landings records indicate that large populations of river herring historically occurred in the Albemarle, Croatan, Currituck, and Pamlico Sounds and in the Chowan, Roanoke, and Pamlico Rivers (NCDMF 2007: 15-16, Table 4.1; NCDMF 2010a: 4-6, Table 1). These records also indicate historical populations of river herring in the Neuse and Cape Fear Rivers (NCDMF 2007: 15-16, Table 4.1; NCDMF 2010a: 4-6, Table 1). Relatively recently, in 1994, populations of alewife occurred in North Carolina in the North, Pasquotank, Little, Perquimans, Yeopim, Chowan, Meherrin, Roanoke, Cashie, Scuppernong, and Alligator Rivers (all tributaries to Albemarle Sound); Lake Mattamuskeet and canals to the lake, Tar-Pamlico, Pungo, Neuse, and Trent Rivers (tributaries to the Pamlico Sound); and the New, White, Cape Fear, Northeast Cape Fear, and Brunswick Rivers (NCDMF 2007: 28).

Populations of alewives also historically occurred in waters in South Carolina, which was the southernmost portion of the species' range (ASMFC 2008).

Blueback Herring

The blueback herring was present historically in rivers located along the Atlantic coast, from northeastern Nova Scotia to northern Florida. Although the blueback herring is believed to occur in higher abundances in mid-Atlantic and southern waters, Bigelow and Schroeder (1953) found blueback herring populations widespread throughout the Gulf of Maine, with "schools of bluebacks … expected anywhere between Cape Sable and Cape Cod."

In Canada, populations of blueback herring historically occurred in waters throughout Nova Scotia and New Brunswick. Bigelow and Schroeder (1953) reported that river herring from Yarmouth, Nova Scotia, St. John Harbor, and Shubenacadie River appeared to be blueback herring. Blueback herring were also "reported, at least by name, from the St. Croix River" (Bigelow and Schroeder 1953). The blueback herring historically occurred, and was the dominant river herring species, in the St. John River estuary of New Brunswick, Canada, and in the Gulf of St. Lawrence in Nova Scotia (Klauda *et al.* 1991; Jessop *et al.* 1983). Within the St. John River system, populations of blueback herring occurred in the Kennebecasis Bay; in the Washademoak, Grand, and Indian Lakes; and in the Oromocto River (Jessop *et al.* 1983).

In the northern and southern portions of the Gulf of Maine, blueback herring were historically reported in "[the] Dennys River, Eastport; Bucksport; Casco Bay; Small Point; Freeport; and sundry other localities along the coast of Maine, as well as from the shores of Massachusetts, including Cape Cod" (Bigelow and Schroeder 1953). In Massachusetts, blueback herring populations historically occurred in coastal rivers, including the Merrimack, Parker, Mattapoisett, Nemasket, Monument, and Blackstone Rivers (ASMFC 2008; Meade 2007).

Significant populations of blueback herring historically occurred in rivers along the Long Island Sound, the mid-Atlantic coastal area, and the Chesapeake Bay. Historical information indicates that blueback herring populations occurred in the Gilbert-Stuart, Nonquit, Annaquatucket, and Blackstone Rivers in Rhode Island; in the Connecticut, Naugatuck, Farmington, Shetucket, and Mianus Rivers and in Bride, Latimer's and Mill Brooks in Connecticut; in the Mohawk and Hudson Rivers in New York; in the Delaware River; and in Chesapeake Bay's Nanticoke (including its tributaries Deep Creek and Broad Creek), Susquehanna, Potomac, Rappahannock, York, and James Rivers (ASMFC 2008; Meade 2007; Kraft *et al.* 2006b; Buckley, *et al.* 2001). The Connecticut River, in particular, historically supported a very significant blueback herring population (ASFMC 2008). Historical information indicates that, while the alewife was the dominant species in many New England rivers, the blueback herring has been the dominant species in the Connecticut River (Klauda *et al.* 1991). In the Chesapeake Bay, a 1608 account described that several billion anadromous fish, including alewives and blueback herring, entered the Chesapeake's rivers to spawn and ran up far upstream, "reaching deep into central Pennsylvania and even into south-central New York, as well as the eastern slopes of the Blue Ridge Mountains and the Alleghany Plateau" (CBF 2010).

In the southern Atlantic, populations of blueback herring historically occurred from North Carolina to Florida. In North Carolina, commercial landings records indicate that river herring – many, if not most, of which were likely blueback herring – were landed from the Albemarle, Croatan, Currituck, and Pamlico Sounds and from the Chowan, Roanoke, Pamlico, Neuse, and Cape Fear Rivers (NCDMF 2007: 15-16, Table 4.1; NCDMF 2010a: 4-6, Table 1). In addition, and as described *supra*, historical information indicates that North Carolina's Albemarle Sound and Chowan River historically supported a very large alewife fishery. Given the range and distribution of the alewife and the blueback herring, it is likely that the Albemarle Sound and other waters in North Carolina also historically supported large populations of blueback herring. Blueback herring have generally been more prevalent than alewives in Albemarle Sound rivers and tributaries (ASMFC 2008: 483). Relatively recently, in 1994, populations of blueback herring occurred in North Carolina in the North, Pasquotank, Little, Perquimans, Yeopim, Chowan, Meherrin, Roanoke, Cashie, Scuppernong and Alligator rivers (all tributaries of the Albemarle Sound); the Tar-Pamlico, Pungo, Neuse, and Trent Rivers (tributaries to the Pamlico Sound); and in the New River, White Oak River, Cape Fear River, North East Cape Fear River, and Brunswick River (NCDMF 2007: 34).

In South Carolina, distribution records and anecdotal information indicate that populations of blueback herring historically occurred in rivers and estuaries throughout the state (USFWS/SCDNR 2001). A minimum of eight populations of blueback herring are believed to have historically occurred in South Carolina waters – in the Waccamaw-Pee Dee, Santee-Cooper, Ashley, Edisto, Ashepoo, Combahee, Coosawhatchie, and Savannah River systems (USFWS/SCDNR 2001). Populations of blueback herring also likely occurred in the major tributaries of the Waccamaw-Pee Dee River basin, including the Waccamaw, Little Pee Dee, Great Pee Dee, Lynches, Black, and Sampit Rivers (USFWS/SCDNR 2001). Available evidence indicates that populations of blueback herring occurring in the Waccamaw-Pee Dee, Santee, and Savannah Rivers historically ascended these larger river basins well inland of the fall line and into North Carolina and Georgia (USFWS/SCDNR 2001).

The blueback herring historically occurred as far south as the St. John's River in Florida (ASMFC 2008).

Present Range

Alewife

The alewife currently occurs in certain Atlantic coastal rivers and estuaries, from northeastern Newfoundland to North Carolina. Alewives are most abundant relative to blueback herring in the Mid-Atlantic and New England states. Spawning alewife populations are monitored in the following United States river systems: the Androscoggin River (ME), Damariscotta River (ME), Kennebec River (ME), Sebasticook River (ME), Saco River (ME), St. Croix River (ME), Union River (ME), Exeter River (NH), Cocheco River (NH), Oyster River (NH), Taylor River (NH), Lamprey River (NH), Winnicut River (NH), Bellamy River (NH), Salmon Falls (NH), Piscataqua River (NH), Acushnet River (MA), Agawam River (MA), Back River (MA, combined passage with bluebacks), Bound Brook (MA), Coonamessett River (MA), First Herring Brook (MA), Second Herring Brook (MA), Third Herring Brook (MA), Herring Brook (MA), Herring River (MA), Jones River (MA), Little River (MA), Marston-Mills River (MA), Pilgrim Lake (MA), Quashnet River (MA), Sippican River (MA), South River (A), Stony Brook (MA), Town River (MA), Trunk River (MA), Wankinco River (MA), Ipswich River (MA), Monument River (MA), Mattapoisett River (MA), Parker River (MA), Nemasket River (MA), Town Brook (MA), Mystic River (MA), Gilbert-Stuart River (RI), Nonquit River (RI), Buckeye Brook (RI), Connecticut River (CT and MA), Naugatuck River (CT), Farmington River (CT), Shetucket River (CT), Bride Brook (CT), Roaring Brook (CT), Mianus River (CT), Mill Brook (CT), Latimer's Brook (CT), Hudson River (NY), Delaware River (NJ and DE), Nanticoke River (DE), Nanticoke River (MD), Susquehanna River (MD), Potomac River (MD, DC and VA), Chesapeake Bay (MD and VA), Anacostia River (DC), Rock Creek (DC), Rappahannock River (VA), York River (VA), James River (VA), and Chowan River (NC) (ASMFC 2008; Chilakamarri 2005; District of Columbia Fisheries & Wildlife Management Division ("DCFWMD") 2010; Maine Department of Marine Resources ("MEDMR") 2010b; Massachusetts Department of Marine Fisheries ("MADMF") 2010; MADMF 2011; New Hampshire Fish and Game Department ("NHFGD") 2011b).

The alewife is believed to have been extirpated from waters in South Carolina, as the species has not been documented in any waters south of North Carolina in recent years (ASMFC 2008). The historical alewife populations in the Presumpscot River, Pembrok River, Nehumkeag Brook, and Cobboseecontee Stream in Maine; the Saugus River in Massachusetts; the Magothy River, Honga River, and Wye River in Maryland; and the Wicomico River, Port Tobacco River, and Anacostia River are believed to be either virtually nonexistent or extirpated (Klauda *et al.* 1991; Rounsefell and Stringer 1945; Bigelow and Schroeder 1953; Purinton *et al.* 2003). Gray (1992) noted that 14 out of 20 alewife runs in Rhode Island were either remnant or non-existent as of 1991. Klauda *et al.* (1991) also related that, as of that time, only remnant populations of alewives at very low levels of abundance remained in the following rivers and tributaries in the Chesapeake Bay region: the Susquehanna River's Deer and Octoraro Creeks; the Bush, Gunpowder, Patapsco, Severn, South, West, Patuxent, Pocomoke, Choptank, Chester, Sassafras, Bohemia, Elk, and Northeast Rivers; the Potomac River's Nanjemoy and Piscataway Creeks; and the Mattaponi and Pamunkey Rivers.

Alewife populations are also found in several inland freshwater bodies, where they were introduced (ASMFC 2009b; USDA 2010). Evidence indicates that landlocked and anadromous populations of alewives are genetically divergent (ASMFC 2009b).

Blueback Herring

The blueback herring currently occurs in certain Atlantic coastal rivers and estuaries, from northeastern Nova Scotia to northern Florida. Blueback herring are most abundant in river systems in the Chesapeake Bay and southward (ASMFC 2009a). Spawning blueback herring populations are monitored in the following United States river systems, sometimes as part of combined passage with alewives: the Androscoggin River (ME), Damariscotta River (ME), Kennebec River (ME), Sebasticook River (ME), Union River (ME), Exeter River (NH), Cocheco River (NH), Oyster River (NH), Taylor River (NH), Lamprey River (NH), Winnicut River (NH), Bellamy River (NH), Salmon Falls (NH), Piscataqua River (NH), Acushnet River (MA), Agawam River (MA), Back River (MA, combined passage with alewives), Charles River (MA), Coonamessett River (MA), Third Herring Brook (MA), Herring Brook (MA), Herring River (MA), Jones River (MA), Little River (MA), Mystic River (MA), Merrimack River (NH/MA), Quashnet River (MA), Wankinco River (MA), Marston-Mills River (MA), Monument River (MA), Town Brook (MA), South River (MA), Stony Brook (MA), Town River (MA), Wankinco River (MA), Gilbert-Stuart River (RI), Nonquit River (RI), Connecticut River (CT and MA), Naugatuck River (CT), Farmington River (CT), Shetucket River (CT), Bride Brook (CT), Mianus River (CT), Mill Brook (CT), Latimer's Brook (CT), Hudson River (NY), Delaware River (NJ and DE), Nanticoke River (DE), Nanticoke River, including its tributaries Deep Creek and Broad Creek (MD), Susquehanna River (MD), Potomac River (MD, DC and VA), Chesapeake Bay (MD and VA), Anacostia River (DC), Rock Creek (DC), Rappahannock River (VA), York River (VA), James River (VA), Chowan River (NC), Santee-Cooper river system (SC), the Winyah Bay tributaries (Sampit, Lynches, Pee Dee, Bull Creek, Black, and Waccamaw Rivers) (SC), Ashepoo River (SC), Combahee River (SC), Edisto River (SC), Savannah River (SC), and St John's River (FL) (ASMFC 2008; Chilakamarri 2005; DCFWMD 2010; MADMF 2011; NHFGD 2011b; SCDNR 2010a).

As of 1991, the blueback herring populations in the Magothy River in Maryland were believed to be extirpated (Klauda *et al.* 1991; Rounsefell and Stringer 1945; Bigelow and Schroeder 1953). Only remnant populations of blueback herring at very low levels of abundance remained in the Annaquatucket River in Rhode Island (ASMFC 2008); and in the following rivers and tributaries in the Chesapeake Bay region: the Susquehanna River's Deer and Octoraro Creeks; in the Bush, Gunpowder, Patapsco, Severn, South, West, Patuxent, Pocomoke, Honga, Chester, Sassafras, Bohemia, Elk, and Northeast Rivers; and in the Potomac River's Nanjemoy and Piscataway Creeks and Wicomico, Port Tobacco, and Anacostia River's Deer Creek, Octoraro Creek, Bush River, Gunpowder River, Patapsco River, Severn River, South River, West River, Patuxent River, Pocomoke River, Chester River, Sassafras River, Bohemia River, Elk River, and Northeast River (Klauda *et al.* 1991).

In addition to coastal river systems, blueback herring populations are also found in several inland freshwater bodies, where they are believed to have been introduced (ASMFC 2009b). It is likely that landlocked and anadromous populations of blueback herring genetically diverged as they evolved in their respective habitats.

Figure 1: Map of U.S. Atlantic coast, showing current and historic significant spawning runs of alewives and blueback herring

Stock Structure

The alewife and the blueback herring exhibit natal philopatry, which means that individual alewife and blueback herring return to spawn in the rivers or estuaries where they were hatched (ASMFC 2009a; ASMFC 2008). It has been observed that alewives return with accuracy both to their natal river systems and to their natal areas within those rivers (Jessop (1994), as cited in

NOAA 2009); olfactory clues appear to play an important role in this high rate of natal site fidelity (Chilakamarri 2005). Messieh (1977) also reported support for natal river homing by alewives. Natal philopatry keeps alewife and blueback herring populations reproductively isolated by river. Clear genetic differences between anadromous alewife populations in the St. Croix River and populations in the LaHave and Gaspereau Rivers further support natal philopatry among alewife populations and at least partial reproductive isolation between alewife spawning runs (Bentzen and Paterson 2005). Studies have also shown genetic and physiological differences among anadromous alewife populations in two rivers in Connecticut, Bride Brook and Roaring Brook, with the differences suggesting that although there is some gene flow between the neighboring Connecticut River populations, selection is nonetheless strong enough to differentiate them (Chilakamarri 2005).

Evidence indicates that landlocked alewife stocks are distantly related to anadromous stocks (ASMFC 2009b). Statistical tests confirmed that anadromous and landlocked populations of alewives in the St. Croix River are genetically divergent, which implies that very little, if any, interbreeding occurs between the two populations (ASMFC 2009b). Similar findings show anadromous stocks of alewives in Connecticut rivers are genetically distinct from Lake Michigan's landlocked population, as no inbreeding can occur between the populations (Chilakamarri 2005). Landlocked stocks of blueback herring occur in some areas of the southeastern United States but they are rarer than those of alewives (ASMFC 2009b).

3. Life History, Longevity and Growth

Individual alewife and blueback herring can live as long as ten years and may reach a maximum length of approximately 15 inches (38 cm). The alewife and the blueback herring are dependent on river and estuary habitats for reproduction (ASMFC 2008).

Alewives and the blueback herring return to their natal rivers to spawn in fresh water (ASMFC 2009b). Blueback herring rarely use brackish or tidal waters for spawning (ASMFC 2009b). Olfaction appears to be the primary factor affecting homing behavior for both species (ASMFC 2008, ASMFC 2009b). Although the timing of sexual maturity may vary regionally, most alewives are sexually mature at age 4 or 5 (ASMFC 2008; ASMFC 2009b). Most female blueback herring are sexually mature by age 4 or 5, and most male blueback herring are sexually mature by age 3 or 4 (ASMFC 2008; ASMFC 2009b). Fecundity increases with age and size; older fish are more fecund than younger fish (ASMFC 2008: 139-40). Each female alewife produces between 60,000 and 100,000 eggs annually, depending on the age and size of the fish (ASMFC 2008). Each female blueback herring produces between 60,000 and 103,000 eggs annually, depending on the age and size of the fish (ASMFC 2008). Young alewives and young blueback herring have very high mortality rates, as less than 1 percent of eggs survive to produce young fishes that reach the ocean (USFWS 2001; MEDMR 2003).

The onset of spring spawning for the alewife and the blueback herring is related to water temperature and varies with latitude (ASMFC 2008). Alewives spawn at lower temperatures than other alosines and typically migrate earlier (ASMFC 2008). They are usually the first anadromous species available for harvest each year in most rivers along the Atlantic Coast (ASMFC 2008). In the spring, alewives spawn when water temperatures are between 16 and 19 degrees Celsius (60.8 to 66.2 degrees Fahrenheit) (NOAA 2009). Alewives spawn from late-February to June in the southern end of their range and from June through August in the northern portion of their range (ASMFC 2008). Blueback herring spawn when water temperatures are approximately 20 and 25 degrees Celsius (68 to 77 degrees Fahrenheit) (ASMFC 2009b). Blueback herring spawn as early as December in Florida (ASMFC 2009b). Blueback herring begin spawning in early-March in South Carolina, in early-April in the lower tributaries and in late-April in the upper tributaries of the Chesapeake Bay, in late-April in the mid-Atlantic river systems, in mid-May in Connecticut and the surrounding area, and in June in the northern reaches of its range, where blueback herring may spawn through August (ASMFC 2009b). In areas where alewives and blueback herring co-occur, blueback herring generally spawn 3 to 4 weeks after alewives (ASMFC 2009b).

With respect to spawning habitat, blueback herring will ascend freshwater far upstream (ASMFC 2009b). In some tributaries, such as the Rappahannock River in Virginia, upstream areas were found to be more important for blueback herring spawning than downstream areas (ASMFC 2009b). Alewives spawn in more lacustrine areas (*e.g.*, ponded habitats or slow sections) of river systems, while blueback herring generally spawn in the main stream flow of river systems (*i.e.*, where water flow is fairly swift) and actively avoid areas with slow-moving or standing water (ASMFC 2008). In the allopatric range, where there is no co-occurrence with alewife (*i.e.*, South Carolina, Georgia, and Florida), blueback herring have been found to select a great variety of spawning habitat types where the substrate is soft and detritus is present (ASMFC 2009b). Blueback herring generally do not spawn in ponds in the northern portion of their range (ASMFC 2009b).

Alewives and blueback herring leave the spawning grounds immediately after spawning and reach deep water by fall (ASMFC 2008; ASMFC 2009b). According to Watts (2003), alewives can spawn up to four times. However, it is unknown how many times the majority of individual alewives spawn. In certain areas, blueback herring experience high post-spawning mortality (ASMFC 2009a). Post-spawning mortality is highest in the states south of North Carolina, and most of these populations of blueback herring are considered to be semelparous, which means that individual fish spawn once and then die (ASMFC 2009a: 4).

Alewives and blueback herring are broadcast spawners, which means that they release their eggs randomly over a variety of substrates such as sand, gravel, organic detritus, and submerged aquatic vegetation (ASMFC 2008; ASMFC 2009b). Pardue (1983) suggested that substrates with 75 percent silt (or other soft material containing detritus and vegetation) and slow-moving waters are optimal spawning conditions for alewives and blueback herring because the substrates provide cover for their eggs and larvae (ASMFC 2009b). But others found that blueback herring eggs adhered to sticks, stones, gravel, and aquatic vegetation along the bottom of a fast-flowing stream in the Gulf of St. Lawrence (Johnston and Cheverie (1988), as cited in ASMFC (2009b: 117)). Fertilized alewife and blueback herring eggs remain demersal and adhesive for several hours before they become pelagic and are transported downstream (ASMFC 2009b). Alewife eggs usually hatch within 80 to 95 hours (3 to 4 days) after spawning (ASMFC 2008). However, depending on water temperature, alewife eggs may hatch anywhere from 50 to 360 hours (2 to 15 days) after spawning (ASMFC 2008). Blueback herring eggs usually hatch within 38 to 60 hours (within 2.5 days) after spawning (ASMFC 2008). For both species, within 2 to 5 days of hatching, the yolk-sac is absorbed and the larvae begin to feed externally (ASMFC 2009b; ASMFC 2008).

Juvenile alewives and blueback herring typically spend 3 to 9 months in their natal rivers before returning to the ocean (ASMFC 2009b). Alewives begin migrating from their nursery areas as water temperatures decline in the fall (ASMFC 2009b). Juvenile blueback herring begin migrating from their nursery areas as water temperatures decline in the late summer through early winter, depending on geographic area (ASMFC 2009b). Other factors that may also trigger downstream migration include changes in water flow, water levels, precipitation, and light intensity (ASMFC 2008; ASMFC 2009b). Juvenile alewives respond negatively to light and observe diel movement patterns (ASMFC 2009b). There is some evidence that a high abundance of juvenile alewives or blueback herring may trigger a very early (*e.g.*, summer) migration of large numbers of small juveniles from their nursery area (ASMFC 2008). Juvenile blueback herring are believed to migrate gradually in response to environmental cues, although a population of juvenile blueback herring has been observed to migrate out of a river system rapidly (*e.g.*, within a 24-hour period in the Connecticut River) (ASMFC 2009b).

Little information is available concerning the life history of sub-adult and adult alewives and blueback herring once they migrate to the sea (ASMFC 2008). It is believed that most juvenile alewives and blueback herring join adult populations at sea within the first year of their lives and follow a north-south seasonal migration along the Atlantic coast (ASMFC 2009b). Alewives typically congregate in large schools of similar-sized fish to migrate and may form mixed schools with other herring populations (ASMFC 2009b).

Alewives and blueback herrings suffer high rates of mortality throughout their life cycle, as less than 1 percent of eggs survive to produce young that reach the ocean (USFWS 2001; MEDMR 2003). Ross (1991) estimated annual mortality of all adult alewives to be 70 percent. Annual mortality of adult and juvenile alewives may be currently higher as a result of increased bycatch and incidental catch mortalities caused by the introduction of more efficient commercial fishing gear since 1995 and the increasing use of mid-water trawls in ocean fisheries operating off the mid-Atlantic and New England coast.

Year-class strength for alewives and blueback herring is driven primarily by environmental factors (ASMFC 2009b). It has been suggested that, if the parent stock size falls below a critical level due to natural and anthropogenic environmental impacts, the size of the spawning stock will likely become a factor in determining juvenile abundance (Kosa and Mather (2001), as cited in ASMFC (2009b: 81)).

4. Habitat and Feeding Habits

Alewife and the blueback herring require a variety of habitats throughout their lifecycle. Alewives spawn in quiet, slower-moving water, with water temperatures ranging from 16 and 19 degrees Celsius (60.8 and 66.2 degrees Fahrenheit) and depths of less than one meter (ASMFC 2009b). Blueback herring spawn in swifter-moving freshwater (*e.g.*, in the main stem of a river system), with optimal water temperatures ranging from 20 to 25 degrees Celsius (68 to 77 degrees Fahrenheit) (ASMFC 2009b). Alewives and blueback herring require spawning areas with substrates that consist primarily of sand, pebbles, and cobbles (*i.e.*, substrates that are usually associated with high-gradient streams) (ASMFC 2009b). Pardue (1983) suggests that water with substrates comprised of 75 percent silt (or other soft material containing detritus and vegetation) provide optimal spawning conditions for alewives and blueback herring. More recently, spawning areas for alewives and blueback herring around the Rappahannock River, Virginia, were found to have substrates that consisted primarily of sand, pebbles, and cobbles, while little or no spawning occurred in areas with high concentrations of organic matter and finer sediments (*i.e.*, substrates that are usually associated with lower-gradient streams and comparatively more agricultural land use) (ASMFC 2009b: 113, citing Boger (2002)).

Alewives and blueback herring require freshwater or semi-brackish portions of rivers and their associated bays and estuaries for nursery habitat (ASMFC 2008). Nursery habitats occur in non-tidal freshwater, tidal freshwater, and semi-brackish areas during spring and early summer, with locations moving upstream during periods of decreased flows and encroachment of saline waters (ASMFC 2008). Juvenile blueback herring have been found to remain in freshwater up to one month longer than juvenile alewife (Loesch (1968) and Kissil (1968), as cited in ASMFC (2009b)).

Juvenile alewives and blueback herring occur in various water depths, depending on the time of day and the season. Juvenile alewives in the Potomac River were observed to be abundant near surface waters during the day in the summer (Warriner *et al.* (1970), as cited in ASMFC (2009b: 85)). They shifted to mid-water and bottom depths in September and remained there until they emigrated in November. In contrast, juvenile blueback herring in the Potomac River were found to remain at the surface or at mid-water depths during daylight hours from July through November, with almost no fish appearing at the bottom (ASMFC 2009b).

When water temperatures begin to drop in the late summer through early winter (depending on geographic area), alewives and blueback herring begin to move downstream, initiating their first phase of seaward migration (ASMFC 2009b). Changes in water flow, water levels, precipitation, and light intensity are believed to encourage seaward migration of juvenile alewives and blueback herring, although the precise combination of migration cues remains unknown (ASMFC 2009b). The influence and magnitude of environmental changes on the migration of juvenile alewives may vary considerably (ASMFC 2009b). Extremely high water discharges may adversely affect juvenile migration, and high or fluctuating water discharges may lead to a decrease in the relative abundance of adult and juvenile fish (ASMFC 2009b). In addition, high water temperatures may negatively affect alewives (ASMFC 2009b). The upstream migration of alewives slows as water temperatures rise and has been reported to cease when water temperatures reach 21 degrees Celsius (ASMFC 2009b). Alewife spawning ceases altogether at 27.8 degrees Celsius (ASMFC 2009b). In general, average time to median hatch for alewife eggs varies inversely with water temperature (ASMFC 2009b). Evidence indicates that optimal hatching performance for alewife eggs occurs between 17.2 and 21.1 degrees Celsius (ASMFC 2009b).

Although alewives and blueback herring spawn in freshwater, they spend most of their adult lives in the marine environment. Sub-adult and non-spawning adult alewives and blueback herring reside in open ocean waters, although they have rarely been found more than 130 meters from the coast, and the extent to which alewife and blueback herring populations overwinter in deep water off the continental shelf is unknown (ASMFC 2009b; ASMFC 2008). Alewives and blueback herring in offshore waters are caught most frequently in water depths of 56 to 110 meters (ASMFC 2009b). However, alewives offshore of Nova Scotia, the Bay of Fundy, and the Gulf of Maine were found in water depths of 101 to 183 meters in the spring; shallower, near-shore water depths of 46 to 82 meters in the summer; and deeper, offshore water of 119 to 192 meters in the fall (Stone and Jessop (1992), as cited in ASMFC (2009b)). The water depth distribution of alewives and blueback herring may depend on the size and age of the fish as well as on zooplankton concentrations (ASMFC 2009b). Stone and Jessop (1992) found that smaller fish (i.e., sexually immature) occurred in shallow regions (<93 meters) during the spring and fall and larger fish were found in deeper areas (≥ 93 meters) throughout the year (Stone and Jessop (1992), as cited in ASMFC (2009b)). While the number of zooplankton per liter consumed is assumed to be critical for the survival and growth of juvenile alewives and blueback herring, feeding intensity decreases with increasing age of a fish (ASMFC 2009b). Temperature may also play a role in depth distributions: adult alewives and blueback herring have been caught in offshore waters, from Nova Scotia to Cape Hatteras, North Carolina, where surface temperatures ranged from 2 to 23 degrees Celsius (35.6 to 73.4 degrees Fahrenheit) and bottom temperatures ranged from 3 to 17 degrees Celsius (37.4 to 62.6 degrees Fahrenheit) (ASMFC 2009b). Catches in this area were most frequent where the bottom temperature was between 4 and 7 degrees Celsius (39.2 to 44.6 degrees Fahrenheit) (ASMFC 2009b).

Distribution of alewife and blueback herring populations offshore in Atlantic coastal waters varies depending on the time of year. In general, alewives are found from North Carolina to Labrador, Nova Scotia, and northeastern Newfoundland (ASMFC 2009b). Sixteen years of catch data showed blueback herring populations are generally to be found from Cape Hatteras, North Carolina, to Nova Scotia during the spring, with most found south of Cape Cod, and no fish collected south of 40° N in the summer (ASMFC 2009b). Both alewives and blueback herring can migrate along the Atlantic seaboard for as many as 2000 kilometers to return to their natal rivers to spawn (ASMFC 2009b).

The spring adult alewife spawning migration progresses seasonally from south to north, with alewives typically spawning from late February to June in the south and from June through August in the north, with populations further north returning later in the season as water temperatures rise (ASMFC 2009b). During spring, much of the alewife population that overwinters on the Scotian Shelf (and possibly some of the U.S. Gulf of Maine population) moves inshore to spawn in Canadian waters, and alewives from waters offshore of middle Atlantic States generally move inshore and north of 40 degrees latitude to Nantucket Shoals, Georges Bank, coastal Gulf of Maine, and the inner Bay of Fundy. Alewives from waters offshore north of Cape Hatteras may move south along the Atlantic coast for homing to southern rivers (ASMFC 2009b). The blueback herring follows the same pattern – generally moving inshore and north – with spawning in southernmost areas beginning as early as December and in its northernmost reaches beginning in June and running until August (ASMFC 2009b).

Canadian spring surveys have found alewives and blueback herring primarily distributed along the Scotian Gulf, southern Gulf of Maine, and off southwestern Nova Scotia, from the Northeast Channel to the central Bay of Fundy; the fishes are found to a lesser degree along the southern edge of Georges Bank and in the canyon between Banquereau and Sable Island Banks (ASMFC 2009b). By early fall, blueback herring populations have been found concentrated along the northwest perimeter of the Gulf of Maine and also along Nantucket Shoals, Georges Bank, and the inner Bay of Fundy (ASMFC 2009b). In later fall, alewives and blueback herring move offshore and southward to the mid-Atlantic coast between latitudes 40 and 43 degrees north (ASMFC 2009b). They remain in this area until early spring (ASMFC 2009b).

Alewives and blueback herring are opportunistic feeders (ASMFC 2009a; ASMFC 2008). They feed largely on particulate zooplankton (*e.g.*, euphausiids, calanoids, copepods, mysids, hyperiid amphipods, chaetognaths, pteropods, decapod larvae, and salps) and may also consume small fish (ASMFC 2009b). Juvenile alewives and blueback herring either select their prey individually or non-selectively filter-feed (ASMFC 2009b). An individual fish's feeding mode depends primarily on prey density, prey size, and water visibility, although it also partially depends on size of the individual fish (ASMFC 2009b). Adult alewives feed most actively during daylight hours (ASMFC 2009b). Nighttime predation occurs but is usually restricted to larger zooplanktons that are easier to detect (ASMFC 2009b). It is believed that adult blueback herring follow the diel movement of zooplankton while at sea (ASMFC 2009b). However, direct evidence of this behavior is lacking for the species (ASMFC 2009b).

5. Ecological Role

During all of their life stages, alewife and the blueback herring play an important role in the dynamics of food chains in freshwater, estuarine, and marine ecosystems, and in maintaining the health of these ecosystems (ASMFC 2009a). While at sea, alewives and blueback herring are forage for many species, including sharks, tunas, mackerel, and for marine mammals, including porpoise and dolphin (ASMFC 2009a). Sufficient abundance of river herring is believed important for the recovery of New England cod (Cournane 2010). In fresh and brackish waters, American eel and striped bass consume both adult and juvenile alewives and blueback herring (ASMFC 2009a). Juvenile alewives and blueback herring are high quality prey for largemouth bass (*Micropterus salmoides*); accelerated growth of young bass occurs when herring consumption is high (ASMFC 2009a). Tissues taken from predatory fish in tidal freshwaters following the residency of migrating alosines, such as alewife and the blueback herring, had between 35 and 84 percent of their carbon-biomass derived from marine sources (ASMFC 2009a).

Alewife and blueback herring populations along the Atlantic coast, particularly populations in the southeast where post-spawning mortality is highest, provide vital nutrients and carbon into riverine systems, similar to nutrient dynamics provided by salmon in the Pacific Northwest (ASMFC 2009a). For example, the James River in Virginia may have received annual biomass input from alosines of 155 kg/ha (138 pounds/acre) before dams blocked migrations above the fall line (ASMFC 2009a).

More than 40 species of birds and mammals congregate to feed on migrating anadromous fish in southeastern Alaska (ASMFC 2009a). Similar relationships likely occur between populations of alewife and blueback herring along the Atlantic coast and birds and mammals (ASMFC 2009a). Fish-eating birds like osprey (*Pandion haliaetus*) and bald eagle (*Haliaeetus leucocephalus*), prey upon alewives and blueback herring and may have evolved their late winter and spring nesting strategies in response to the availability of food resources supplied by pre- and post-spawning alosines (ASMFC 2009a). Alewives and blueback herring also provide cover for upstream migrating adult salmon that may be preyed on by eagles or osprey, and for young salmon in the estuaries and open ocean that might be captured by seals (MEDMR 2008). Nutrients released from carcasses of post-spawning alosines can substantially subsidize aquatic food webs by stimulating productivity of bacteria and aquatic vegetation, thereby stimulating the assimilation of marine derived nutrients into aquatic invertebrates and fish (ASMFC 2009a).

Importantly, researchers have documented that forage fishes like alewives and blueback herring may be at significant risk at population sizes that are a fraction of their historical levels but are still large compared to what would be considered normal for other ESA listed species (Dulvy *et al.* 2004). For instance, research from other marine fishes (Sadovy 2001) suggests that there is likely a biological requirement for a critical threshold density of herring during spawning to ensure adequate synchronization of spawning, mate choice, gonadal sterol levels, and fertilization success. In the case of an anadromous Pacific herring, the euchalon, scientists believe that high minimum viable population sizes are necessary to: (1) ensure a critical threshold density of adults are available during breeding events for maintenance of normal reproductive processes, (2) produce enough offspring to counteract high in-river egg and larval mortality and planktonic larval mortality in the ocean, and (3) produce enough offspring to buffer against the variability of local environmental conditions which may lead to random ‘‘sweepstake recruitment’’ events where only a small minority of spawning individuals contribute to subsequent generations (NMFS 2009c: 74 Fed. Reg. 10857: 10868-69).

6. Population Trends for the Alewife and the Blueback Herring[4]

Alewives and blueback herring were historically very abundant along the Atlantic coast (ASMFC 2008). Both species, however, have suffered dramatic population declines throughout their Atlantic coastal ranges, including over the last four decades (ASMFC 2008; ASMFC 2009a).

The significant decline in abundance of alewives and of blueback herring is reflected in commercial landing trends. From 1930 through 1970, total commercial landings of alewives and blueback herring in Atlantic coastal states averaged almost 43 million pounds per year (ASMFC 2008: 55-57, Table 1.5.1.1).[5] During years of peak recorded harvests (late 1940s and early 1950s to 1970), annual commercial landings of alewives and blueback herring were consistently the highest in Virginia and North Carolina (ASMFC 2008: 55-57, Table 1.5.1.1). During some of these peak years, annual commercial landings of alewives and blueback herring numbered over 36 million pounds in Virginia and over 12 million pounds in North Carolina (ASMFC 2008: 55-57, Table 1.5.1.1). In addition, high annual commercial landings of alewives and blueback

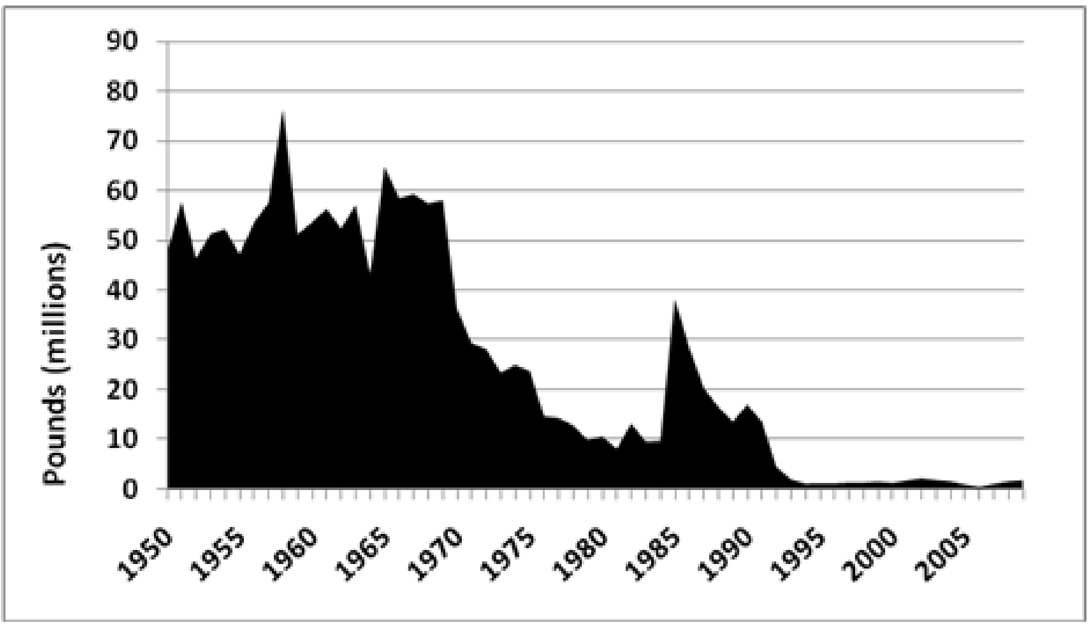
[4] Unless otherwise noted, and for the purposes of this section, the terms, “alewife and blueback herring,” “alewives and blueback herring,” or “river herring” will be used when the available data either does not distinguish between the species or refers to both species collectively as “river herring.”
[5] This would equal approximately 86 million fish landed annually on average, if 8 ounces is assumed as the average weight for an individual alewife or blueback herring (Bigelow and Schroeder 1953).

herring were consistently recorded in Maine, Massachusetts, and Maryland during this time period (ASMFC 2008: 55-57, Table 1.5.1.1).

Starting in the early 1970s, however, commercial landings of alewives and blueback herring went into sharp decline. Since 1994, annual coastwise landings have totaled 2 million pounds or less (ASMFC 2008: 55-57, Table 1.5.1.1). Figure 2 shows the sharp drop-off in total coastwide landings of both species from 1950 to 2009.

Figure 2. Total (in-river and ocean) commercial landings (pounds) of river herring for the U.S. Atlantic coast (domestic), 1950-2009

Source: NMFS (2010a). Note: Prior to 1998, NMFS landings data do not differentiate between alewife and blueback herring and all river herring landings are listed as "alewife" landings; after 1998, the data are available separately and the chart below sums the data for both species.



As further discussed below, population declines have also occurred in the majority of the specific alewife and blueback herring populations for which trend analysis is possible. Many rivers have seen a significant decline in abundance of both species since the 1990s.

<u>United States/Canada River Systems</u>

St. Croix River

The St. Croix River, which runs through Maine and Canada, historically supported a significant population of alewives that once numbered over two million fish in a single year (Flagg 2007; ASMFC 2008). However, in the mid-1990s, the Woodland Dam and Grand Falls fishways on the St. Croix Rover were closed to upstream passage of spawning alewives into spawning habitat, which resulted in the collapse of the fishery (ASFMC 2008: 140). While hundreds of thousands of river herring passed through fishways on the St. Croix River through 1998, numbers tumbled in 1999 to just over 25,000 fish and continued to fall thereafter, averaging only 5,970 fish from 2000 through 2009 (MEDMR 2010a: 10, Table 2) – even with active management efforts (including the annual stocking of 2,000 fish) by Canadian fisheries agencies (ASFMC 2008: 140-41). Another report notes the run size of alewives as only 900 fish in 2004 (Flagg 2007), approximately a 99.9 percent decline from its high of over 2.6 million fish in 1987 (Flagg 2007).[6]

<u>United States River Systems</u>

Maine Rivers

Reported landings of Maine river herring have declined from historical levels in the 1950s. The reasons for the decline in river herring stocks are not clear, though habitat loss, poor fish passage, predation, directed fisheries, and incidental catch/bycatch in ocean fisheries all affect Maine river herring populations (ASMFC 2008: 132). Average "catch per unit effort" ("CPUE") for bluebacks was at or below average for all river segments in Maine in 2009; average CPUE for alewives was below average for all river segments in Maine, except the Upper Kennebec River, in 2009 (ASFMC 2010: 14). Maine rivers are home to both alewives and blueback herring, but alewives appear to dominate catches: commercial in-river river herring fisheries are 97 percent alewives and 3 percent blueback herring (MEDMR 2010c: 6).[7]

The MEDMR has a goal of stocking approximately 120,000 to 500,000 alewives in Maine rivers each year, with the majority of fish stocked in the Androscoggin and Sebasticook rivers; it has generally stocked between 400,000 and 500,000 fish per year in rivers throughout the state, though these numbers may have declined with the recent removal of barriers to upstream river passage in some watersheds (ASMFC 2008: 141-42, 144). The stocking locations in these two watersheds do not have upstream migration and require the transport of spawning fish around existing barriers (ASMFC 2008: 141-42). The MEDMR has been actively involved in the restoration of anadromous fish in the Androscoggin River since 1983 (ASMFC 2008).

Union River

A sizable population of alewives is believed to have spawned in the Union River watershed in the 19th century (College of the Atlantic ("COA") 2004).

The MEDMR has been able to maintain a commercial fishery in Union River through the annual stocking of 90,000-100,000 adult alewives above the hydropower dam at the head-of-tide (ASMFC 2008: 148; MEDMR 2010a: Table 10). The in-river exploitation rate for alewives and blueback herring in the Union River has historically been very high (ASMFC 2008). For example, in-river exploitation rates for the Union River ranged from approximately 0.90 to 0.98 during the 1980s (ASMFC 2008: 131). As recently as 2007, the in-river exploitation rate was

[6] MEDMR (2010a) indicates the year the alewife run was 900 fish was 2002, not 2004 (MEDMR 2010a: 10, Table 2).
[7] However, because Maine state law defines both alewives and blueback herring as "alewives," river herring counts for Maine river systems, including the St. Croix River, may overestimate the proportion of alewives relative to blueback herring.

above 0.50 (ASMFC 2008: 131); as of 2009, it remained at 46 percent (MEMDR 2010c: 8). In addition, despite the ongoing stocking, the size of the Union River alewife population remains historically low (COA 2004: Figure 2). For example, the size of the Union River alewife population in 2003 was over 75 percent smaller than it was at its peak in 1986 (COA 2004: Figure 2). It has continued to vary around these historically low levels through 2009 (MEDMR 2010a: Table 10).

Damariscotta River

The Damariscotta River system historically supported a significant commercial run of alewife (Rounsefell and Stringer 1945). Available information indicates that the Damariscotta River alewife population rapidly increased, and became commercially exploitable, following its establishment in 1803 and that it was once "the most consistent large commercial run in Maine" (Rounsefell and Stringer 1945). The historical significance of the run is evidenced by its cultural significance to local communities, with one such community holding an annual alewife festival that included the election of an "alewife queen" who received two bushels of alewives as a prize (COA 2004). According to some sources, "Damariscotta" is derived from the Native American word meaning "place of an abundance of alewives."

Commercial harvest records for Damariscotta Lake support the historical significance of the alewife population in the Damariscotta River. Large commercial harvests of alewives occurred in Damariscotta Lake up until the early 1980s (ASMFC 2008: 147, Figure 2.15.2). According to the ASMFC (2008), from 1952 to 1981, commercial harvests of alewives from Damariscotta Lake ranged from 1,543,000 pounds and 551,000 pounds (ASMFC 2008: 147, Figure 2.15.2).[8]

From 1981 to 1983, however, the alewife harvest from Damariscotta Lake precipitously declined to near zero (ASMFC 2008: 147, Figure 2.15.2). It has remained at a similarly low level since 1983 (ASFMC 2008: 147, Figure 2.15.2). The in-river exploitation rate for alewife and the blueback herring in the Damariscotta River is high (ASMFC 2008). During the late 1980s, in-river exploitation rates greater than 0.6 were recorded in the Damariscotta River system (ASMFC 2008: 131, Figure 1.12.1). After a slight decline in the rate during the 1990s, the in-river exploitation rate in the Damariscotta River has significantly increased since 2000 (ASMFC 2008: 131, Figure 1.12.1). In 2007, the in-river exploitation rate was over 0.5 (ASMFC 2008: 131, Figure 1.12.1); it has been greater than 37 percent since 2004 (MEDMR 2010b: 8)

Kennebec River System (Sebasticook River)

The Kennebec river system historically supported abundant runs of anadromous fish (ASMFC 2008). Immense numbers of alewives were reported to have once ascended the Kennebec River well inland (Kircheis, *et al.* 2002; Rounsefell and Stringer 1945). Today, aside from one tributary of the Kennebec River (the Sebasticook River) that appears to still support a healthy alewife population, alewife populations in the main stem of the Kennebec River and the river's other tributaries are much smaller than historic levels (ASMFC 2008).

[8] Calculations based on 700,000 kilograms of alewives commercially harvested in 1952 and 250,000 kilograms harvested in 1981 (ASMFC 2008: 147, Figure 2.15.2), converted to 1,543,000 pounds and 551,000 pounds, respectively.

In 1986, the MEDMR implemented a restoration plan for alewives in the Kennebec River watershed above Augusta that involved stocking alewives in the initial years of the plan to increase the population size. The restoration plan was implemented in response to an agreement with hydroelectric dam owners in the Kennebec watershed (ASMFC 2008: 143). According to ASMFC (2008: 142-43), stocking of alewives in the Kennebec river system continues today. Such stocked fish may account for a portion of what are recorded generally as “river herring” passing through certain fishways located at dams in the Kennebec river system. Petitioner was unable to locate information regarding the percentage of non-stocked alewives and/or blueback herring returning to the Kennebec river system, but at least 152,198 alewives were stocked in the Kennebec River watershed in 2009 (MEDMR 2010a: Table 8).

The Sebasticook River is a major tributary in the Kennebec river system and has historically supported abundant runs of anadromous fish (ASMFC 2008: 155). It is one of the few remaining rivers on the east coast that supports an abundant run of alewives, supported at least in part by Maine’s stocking program, and it currently supports the largest run of alewives on the east coast (MEDMR 2009). The Sebasticook River is the only river in Maine that supports an alewife population that numbers over one million fish per year. This dwarfs the alewife populations in the other Maine rivers.

In 2009, the number of alewives that passed at the Benton Falls dam on the Sebasticook River was approximately 1.6 million fish, which is the largest recorded population on the east coast (MEDMR 2009). Commercial harvesters operating near Benton Falls took approximately 500,000 fish in 2009, which means that the alewife population was likely at least 1.7 million fish (MEDMR 2009). In 2009, over 40,000 blueback herring passed at the Benton Fall dam on the 16 days sampled from June 8 to July 28 (MEDMR 2009: 2-11, Table 2). The majority of these blueback herring passed the dam in mid-June (MEDMR 2009: 2-11, Table 2).

Data collected in 2009 indicate that the age distribution of both the alewife and the blueback herring in the Sebasticook River is relatively young. In 2009, the age distribution of alewives collected at the Benton Falls dam on the Sebasticook River ranged from age 3 to age 6, with only one age 6 fish collected (MEDMR 2009). The mean sample age was 4.2 years for male alewives and 4.5 years for female alewives (MEDMR 2009). The age distribution for blueback herring collected at the Benton Falls dam in 2009 ranged from age 3 to age 7, with only one age 6 fish and one age 7 fish collected (MEDMR 2009). The mean sample age was 4.2 years for male blueback herring and 4.3 years for female blueback herring (MEDMR 2009). Loss of age structure and reliance on younger year classes – as is the case with many river herring populations up and down the coast – likely increases their vulnerability to perturbations and provides less of a buffer against year-class failure.

The Sebasticook River alewife population serves as a source of broodstock for state restoration projects east of the Kennebec River (ASMFC 2008).

Androscoggin River

The alewife run count for the Androscoggin River in Maine peaked during the late 1980s and then dropped to a near-historic low in the early 1990s (ASMFC 2008). The annual run of alewives on the Androscoggin River over the past 28 years has averaged 42,261 (MEDMR 2010c: 14). It is unclear whether this alewife population is sustained by stocking conducted by the MEDMR or is self-sustaining: in 2006, about 74 percent of the river herring passing through the Brunswick fishway on the Androscoggin River was stocked by way of truck-and-transfer operations to inaccessible nursery pond habitat; in 2007, at least 41 percent of the river herring passing through the fishway was stocked; in 2008, at least 29 percent were stocked; and in 2009, at least 52 percent were stocked (MEDMR 2010a: Table 9; MEDMR 2010c: 13, Table 1).[9] Age data collected at fish passage facilities on the Androscoggin and Sebasticook rivers indicates that most returning alewives and blueback herring range from age 4 to age 6 (ASMFC 2008: 155). Fish over age 6 represented only a small proportion of the fish sampled (ASMFC 2008). According to the ASMFC (2008), this is "an apparent shift in the age structure for all Maine alewife and blueback herring runs, commercial and non-commercial" (ASMFC 2008: 155). According to the ASMFC (2008), scale samples collected from 15 commercial fisheries in 2008 had few fish over age 6, whereas commercial catches during the 1980s commonly had fish as old as age 8 (ASMFC 2008: 155). This trend appeared to continue in 2009, with only 4 of 200 sampled at age 7, and no sampled fish over age 7 (MEDMR 2010c: 33, Table 15).

According to the ASMFC (2008), the maximum age of male and female alewives in the Androscoggin River was historically older than age 6 but has decreased by approximately one age year since the late 1990s and early 2000s. A significant decrease in mean length-at-age was observed for age 3 female alewives in the Androscoggin River from 2000 to 2008 (ASMFC 2008). Mean length-at-age for alewives in age classes 4, 5, and 6 was lower in 2008 than in 2000, although trend analysis did not detect a significant change in any of these age classes (ASMFC 2008).

Saco River

Fish passage on the Saco River became available in 1993 when fish passage facilities were built (ASFMC 2008: 143). The number of adult river herring passing through fish passage facilities on the Saco River increased to a peak of almost 67,000 fish in 2001 and has declined since then, dropping to 2,012 fish in 2009 (MEDMR 2010a: 10, Table 2).

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[9] Important alewife spawning habitat is located in lakes and ponds associated with tributaries of the Androscoggin River – the Sabattus and Little Androscoggin – that are not currently accessible due to impassable dams (ASFMC 2008: 141). To assist in restoration efforts, MEDMR captures alewives at the Brunswick fishway (a vertical slot fish passage facility) and transports them to the currently inaccessible upstream nursery pond habitat (ASFMC 2008: 141; MEDMR 2010c: 13, Table 1). In operation since the 1980s, since 2004 the transfer program has carried between 16,000 and 25,000 fish per year to upstream ponds (MEDMR 2010c: 13, Table 1). In addition, between 300 and 7,500 fish per year have been taken from the fishway and stocked in out-of-basin nursery locations (ASFMC 2008: 141; MEDMR 2010c: 13, Table 1). The adult release target for the Androscoggin watershed for river herring has been achieved in recent years with fish from the Brunswick fishway so there has been no need for stocking with fish from outside the watershed (MEDMR 2010c: 16-17).

New Hampshire Rivers

The majority of alewife and blueback herring populations in New Hampshire rivers and tributaries have declined since the early 2000s, with observed declines beginning much earlier in some rivers (ASMFC 2008). According to NHFGD (2009: 5), the number of alewives and blueback herring returning to New Hampshire rivers declined by approximately 45 percent between just 2004 to 2008; recently updated data show that decline appears to have continued through 2010, with numbers of fish counted in the ladders dropping another 12 percent (NHFGD 2011a).[10] Only a remnant fishery remains in state waters, with as few as 2000 fish estimated to have been harvested in recent years (NHFGD 2011).

Taylor River

Historically, the Taylor River supported the state's largest alewife and blueback herring population in New Hampshire, with a population once numbering at least 450,000 fish (NHFGD 2009: 16, Table 1-1). The Taylor River alewife and blueback herring population has dramatically declined since around 1980 and remains at historic low levels (ASMFC 2008: 104, Figure 1.6.1.1). From a peak of 450,000 fish in 1976, the number of counted Taylor River alewives and blueback herring dropped to 675 fish in 2010 – a decline of more than 99 percent (NHFGD 2009: 16, Table 1-1; NHFGD 2011a). Although flood conditions in 2005, 2006, and 2007 likely decreased the number of alewives and blueback herring returning to the Taylor River during each of those years, population levels of the alewife and the blueback herring were already at historic lows prior to 2005 (NHFGD 2009: 16, Table 1-1). From just 2000 (44,010 fish) to 2003 (1,397 fish), the monitored run declined 97 percent (NHFGD 2009: 16, Table 1-1). The population has continued to drop, with only 675 fish counted in the river's fish ladders in 2010 (NHFGD 2011a). According to NHFGD (2009: 6), the monitored Taylor River run is currently comprised almost entirely of blueback herring (except 2007, when 100% of fish sampled were alewives).

Samples collected from the Taylor River indicate a decline in the age structure in the blueback herring populations. In 2004, blueback herring comprised 98.5 percent of the samples collected from the Taylor River and 17.5 percent of the sampled fish were age 6 or older (NHFGD 2009: 17-18, Table 1-2 and 1-3). In 2005, blueback herring comprised 100 percent of the samples and there were no fish that were age 6 or older; all of the fish were age 3 to 4 (NHFGD 2009: 17, Table 1-2). In 2008, blueback herring again comprised 100 percent of the samples collected and all of the fish were ages 3 to 4 (NHFGD 2009: 17, Table 1-2). The only year in which the age structure in the samples collected from the Taylor River changed was in 2007, when 100 percent of the samples collected were alewives (NHFGD 2009: 18, Table 1-3). In that year, 42.2 percent

[10] Count data for alewives and blueback herring are presented in tables included in annual reports (*e.g.*, NHFGD 2009: 16, Table 1-1). Petitioners believe they have the most recent data (from 2010) in a standalone table (NHFGD 2011a). Although the data in the charts from 2009 and 2011 are generally the same, there are some minor discrepancies. For example, the table included in the 2009 report indicates 174 fish were found on the Exeter River in 2008; the 2011 chart has only 168 fish that year. Where there are discrepancies and petitioners are making calculations based on the counts, petitioners rely on NHFGD (2011a).

of the fish sampled were age 6 or older (NHFGD 2009: 17, Table 1-2). There were no samples collected from the Taylor River in 2006.

Oyster and Exeter Rivers

Alewife and the blueback herring populations in the Oyster River and Exeter River – two adjacent rivers that drain into the Little and Great Bay near Portsmouth, New Hampshire – have significantly declined in size within the past decade (NHFGD 2009: 16, Table 1-1; NHFGD 2011a). According to NHFGD (2009: 5-6), the run in the Oyster River is dominated by alewives and Exeter River by blueback herring. Population levels of the alewife and the blueback herring in the Oyster River have historically been the second largest in New Hampshire (after the Taylor River). After averaging 102,571 fish per year from 1990 through 1999, the Oyster River count dropped to an average of only 35,277 fish per year from 2000 to 2010 (NHFGD 2011a). Recent data updates show the downward trend continuing, with the Oyster River river herring count averaging only 15,207 fish in 2009 and 2010 (NHFGD 2011a). The river herring count in the Exeter River has experienced a similar drop since 2001, with the spawning count decreasing by 99 percent from 2001 to 2010 (NHFGD 2011a). In 2010, only 69 individual alewives and blueback herring were counted returning to the Exeter River (NHFGD 2011a).

From 2004 to 2008, river herring samples collected from the Oyster River were dominated by blueback herring (ranging from 100 percent in 2005, 2006, and 2007 to 97 percent in 2008) (NHFGD 2009: 18, Table 1-3). The percentage of sampled fish in the Oyster River that were age 6 or older declined by 40 percent from 2004 to 2008 (NHFGD 2009: 17, Table 1-2). In 2008, an estimated 88 percent of the sampled fish were age 3 to 5 (NHFGD 2009: 17, Table 1-2). In the Exeter River, an estimated 89 percent of sampled alewives and blueback herring in the Exeter River were age 5 or older in 2004 (NHFGD 2009: 17, Table 1-2). By 2008, only an estimated 43 percent of the sampled fish were age 5 or older (NHFGD 2009: 17, Table 1-2).

From 2002 through 2005 repeat spawners comprised 51 percent of spawners on the Oyster River and 33 percent of spawners on the Exeter (NHFGH 2011b: Table 6). From 2006 through 2009, repeat spawners only comprised 42 percent of spawners on the Oyster River and 24 percent of spawners on the Exeter (NHFGD 2011b).

Cocheco, Lamprey, and Winnicut Rivers

Although there were three rivers in New Hampshire that supported a relatively stable or increasing alewife and blueback herring population from 2000 to 2010 – the Cocheco, Lamprey, and Winnicut rivers – herring populations in all three rivers number fewer than 34,000 fish, with one of the rivers (Winnicut) supporting a population of fewer than 5,000 fish in 2009 (NHFGD 2011a). The increase in the abundance of alewives and blueback herring in the Lamprey River is believed to be partially related to enhanced stocking in an upper impoundment of the river system, which allows alewives and blueback herring to utilize inaccessible spawning and nursery habitat within the Lamprey River drainage system (NHFGD 2009: 8). According to NHFGD, both the Cocheco and Lamprey are dominated by alewives and the Winnicut has more alewives than blueback herring, although these relative proportions may be influenced by each species' relative use of fish ladders (NHFGD 2011).

Merrimack River

Similar trends can be seen on New Hampshire's Merrimack River (which also runs down through Massachusetts). According to USFWS (2011), from 1987 through 1992, river herring counts at the Essex Dam Fish Lift in Lawrence, Massachusetts on the Merrimack River averaged 258,865 fish; from 1998 through 2004, river herring counts at that fish lift on the Merrimack River averaged 8094 fish, and from 2005 through 2009, counts averaged 818 fish. Other sources have recent counts even lower – averaging 792 fish from 2005 through 2009 (MADMF 2010: 29-30, Tables 1 and 2).

Massachusetts Rivers

Historical information indicates that river herring historically occurred in the majority of coastal rivers and tributaries in Massachusetts (Watts 2003). From 1955 to 1961, commercial landing records indicate that an average of over 16 million pounds of river herring was landed per year in Massachusetts alone. According to Belding (1921), twenty-seven streams along the Gulf of Maine coast once had significant river herring runs.

The overwhelming majority of the state's river herring runs are extirpated or reduced to remnant levels. In recent years, and particularly since 2000, the alewife populations and blueback herring populations in the remaining Massachusetts rivers with meaningful runs have declined to historic low levels (ASMFC 2008). MADMF (2011) noted specifically the "precipitous decline" in alewife abundance in three rivers: the Parker River, the Monument River and the Mattapoisett River. In 2005, the MADMF implemented a 3-year moratorium on the harvest, possession, and sale of alewives and blueback herring throughout the state as an emergency conservation measure (ASMFC 2008). This moratorium was extended in October 2008 for an additional three years (*i.e.*, through 2011) because of a lack of recovery of alewife and blueback herring runs in both the state and the surrounding region (MADMF 2008).

Parker River

The Parker River alewife population has dramatically declined from its population size during the 1970s and has been at historically low levels since 2001 (ASMFC 2008: 195, Table 4.4; MADMF 2011: 53, Appendix Table 4).[11] From 1972 to 1978, the average size of the alewife run in the Parker River was 20,390 counted fish. By 2000 to 2005, the average size had shrunk to 2,889 fish – a decline of 86 percent (MADMF 2011: 52, Appendix Table 4). The alewife count dropped to 500 fish in 2006 and to 60 fish in 2007 (MADMF 2011: 52, Appendix Table 4). According to MADMF (2010), stream weir failure affected fish passage in 2006, skewing the count low. However, the Parker River alewife population was already at historic lows during the four years prior to 2006, and has remained low since 2007, with only 485 counted fish in 2008, 800 in 2009 and 1,800 in 2010 (MADMF 2011: 53, Appendix Table 4).

[11] The Parker River fish count data in ASFMC (2008) differ (sometimes they appear to be rounded) from the numbers included in MADMF (2011). Petitioners use the data from the MADMF (2011) where there are discrepancies.

Monument River

The alewife population and the blueback herring population in the Monument River have precipitously declined since 2000 (ASMFC 2008: 195, Table 4.3). Prior to 2001, the average size of the Monument River alewife run was 312,965 counted fish per year, with a peak of 597,937 alewives returning to the Monument River in 2000 (ASMFC 2008: 195, Table 4.3). The average size of the Monument River alewife run declined to 205,088 counted fish per year from 2001 to 2004 (ASMFC 2008: 195, Table 4.3). From 2005 to 2010, the alewife run in the Monument River further declined to an average of only 89,404 counted fish per year – a decline of 71 percent from its average size prior to 2001 (ASMFC 2008: 195, Table 4.3; MADMF 2011: 52, Appendix Table 4). Comparing its peak size in 2000 with its size in 2010, the alewife run in the Monument River has declined in size by 84 percent (ASMFC 2008: 195, Table 4.3; MADMF 2011: 52, Appendix Table 4).

The blueback herring run in the Monument River has experienced a similarly precipitous decline. Prior to 2001, the average size of the Monument River blueback herring run was 46,989 counted fish per year, with a peak of 99,646 counted blueback herring in 1991 (ASMFC 2008: 195, Table 4.3). From 2001 to 2004, the Monument River blueback herring run averaged 45,447 counted fish per year (ASMFC 2008: 195, Table 4.3). From 2005 to 2010, the blueback herring run in the Monument River averaged only 18,617 counted fish (ASMFC 2008: 195, Table 4.3; MADMF 2011: 52, Appendix Table 4). Comparing its peak size in 1991 to its size in 2010, the blueback herring run in the Monument River has declined in size by 91 percent (ASMFC 2008: 195, Table 4.3; MADMF 2011: 52, Appendix Table 4).

The age structure of the alewife population and the blueback herring population in the Monument River has significantly declined since the 1980s (ASMFC 2008: 204, Table 4.9). From 1985 to 1987, female alewives that were age 6 or older comprised approximately 28 percent of the samples collected from the Monument River (ASMFC 2008: 204, Table 4.9). Male alewives that were age 6 or older comprised 13 percent of the samples collected from 1985 to 1987 (ASMFC 2008: 204, Table 4.9). From 2004 to 2010, there were only six female alewives and one male alewife that were older than age 6 in the samples collected; in that period, female alewives that were age 6 or older comprised only 5.41 percent of the samples collected, while male alewives that were age 6 or older comprised only 2.1 percent of the samples collected (ASMFC 2008: 204, Table 4.9; MADMF 2011: 63, Appendix Table 10). In the Monument River blueback herring population, female fish that were age 6 or older comprised 15.4 percent of the samples collected from 1985 to 1987 (ASMFC 2008:204, Table 4.9). Male fish that were age 6 or older comprised 4.8 percent of the samples collected (ASMFC 2008: 204, Table 4.9). From 2004 to 2010, there were only two female blueback herring that were older than age 6 and no male blueback herring that were older than age 6 (ASMFC 2008: 204, Table 4.9). Age 6 and older female blueback herring (five fish total) comprised only 1 percent of the samples collected; age 6 male blueback herring comprised only 0.2 percent of the samples collected (ASMFC 2008: 204, Table 4.9; MADMF 2011: 63, Appendix Table 10). The average age of female and male alewives in the Monument River peaked in 1987 at 5.2 years and 4.7 years, respectively; in 2010, the average age of female alewives was only 4.4 years and male alewives was only 3.9 years (MADMF 2011: 64, Appendix Table 11). The average age of female and male blueback herring in the Monument River in 1987 were 5.1 years and 4.3 years, respectively; in 2010, the average

age of female and male bluebacks had declined to all-time lows of 3.7 years and 3.3 years, respectively (MADMF 2011: 64, Appendix Table 11).

The numbers of repeat spawning alewife and repeat spawning blueback herring in the Monument River have significantly declined over the past three decades. From 1986 to 1987, female alewives that were returning to spawn in the Monument River for their third or fourth time represented 18.4 percent of the female alewife repeat spawners (ASMFC 2008: 205, Table 4.10). From 2004 to 2010, less than 2 percent of female alewife repeat spawners were returning for their third or fourth time to spawn (ASMFC 2008: 205, Table 4.10; MADMF 2011: 67, Appendix Table 13). Female alewives that returned to the Monument River to spawn for their second time represented 26 percent of the female alewife repeat spawners from 1986 to 1987 but less than 10 percent from 2004 to 2010 (ASMFC 2008: 205, Table 4.10; MADMF 2011: 67, Appendix Table 13). Male alewives returning to spawn in the Monument River for the third or fourth time represented less than 11 percent of the male alewife repeat spawners from 1986 to 1987 but less than 1 percent from 2004 to 2010 (ASMFC 2008: 205, Table 4.10; MADMF 2011: 67, Appendix Table 13). Second-time male alewife repeat spawners comprised almost 30 percent of the male alewife repeat spawning population on the Monument from 1986 to 1987 but less than 8 percent from 2004 to 2010 (ASMFC 2008: 205, Table 4.10; MADMF 2011: 67, Appendix Table 13). Blueback herring returning to spawn in the Monument River for the third or fourth time has declined to zero since the late 1980s. From 1986 to 1987, blueback herring returning to spawn in the Monument River for the third or fourth time represented more than 11 percent of the female blueback herring repeat spawners and almost 4 percent of the male blueback herring repeat spawners (ASMFC 2008: 205, Table 4.10). From 2004 to 2010, however, there were no male or female blueback herring that returned to spawn for the third or fourth time (ASMFC 2008: 205, Table 4.10; MADMF 2011: 67, Appendix Table 13). Blueback herring returning to spawn in the Monument River for a second time represented more than 27 percent of the female blueback herring repeat spawners and 17 percent of the male blueback herring repeat spawners from 1986 to 1987 (ASMFC 2008: 205, Table 4.10). However, from 2004 to 2010, blueback herring returning to spawn in the Monument River for a second time represented less than 6 percent of both female and male blueback herring repeat spawners (ASMFC 2008: 205, Table 4.10; MADMF 2011: 67, Appendix Table 13).

The size of female and male alewives and blueback herring in the Monument River has also declined over the past three decades. On average, male and female alewives and blueback herring are approximately 20 to 27 mm smaller than fish of the same species and sex sampled from 1984 to 1987 (ASMFC 2008: 199-200, Table 4.5). Trend analyses of mean lengths indicate significant decreases in mean lengths for male and female alewives and blueback herring (ASMFC 2008: 34).

Mattapoisett River

The Mattapoisett River alewife population has precipitously declined in size during the past decade. From 1998 to 2000, the Mattapoisett River alewife run averaged 113,667 counted fish per year (MADMF 2011: 52, Appendix Table 4).[12] From 2001 to 2003, the average size of the

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[12] The Mattapoisett River fish count data in ASFMC (2008) differ from the numbers included in MADMF (2011). Petitioners use the data from the MADMF (2011) where there are discrepancies.

Mattapoisett River alewife run dropped by more than 55 percent (to an average of 50,667 counted fish per year) (MADMF 2011: 52, Appendix Table 4). From 2004 to 2010, the average size of the Mattapoisett River alewife run dropped to an average of 8,333 counted fish per year, an estimated 93 percent decline from its 1998 to 2000 average size (ASMFC 2008: 195, Table 4.3; MADMF 2011: 52, Appendix Table 4).

The number of repeat spawners has also dropped. In 1995, the rate was 0.33 for females and 0.19 for males; in 2007, it was 0.04 for females and 0.03 for males. Recent 2006 to 2007 Z estimates for alewives are also significantly higher compared to 1995.

Nemasket River

Although the Nemasket River alewife run is relatively large compared with the size of the alewife and the blueback herring runs in other rivers in Massachusetts and the surrounding region, the current Nemasket River alewife run is much smaller than its historic size and has significantly declined in size since 2002. The average size of the Nemasket River alewife run from 2003 to 2010 (663,791 fish) dropped almost 40 percent from its average prior to 2003 (1,037,583 fish) (MADMF 2011: 52, Appendix Table 4).[13]

The age structure and length frequencies of the alewife population, as well as the number of repeat spawners, in the Nemasket River have also declined in the last several years. From 2004 to 2010, there was a significant shift in the age structure of samples of male and female alewives collected from the Nemasket River that indicates that the Nemasket River alewife population is currently comprised of younger fish than it has been historically (ASMFC 2008: 203, Table 4.8; MADMF 2011: 61, Appendix Table 9). For example, in 2004, there were no age 3 female fish in the samples collected from the Nemasket River (ASMFC 2008: 203, Table 4.8; MADMF 2011: 61, Appendix Table 9). Female alewives that were age 4 and 5 comprised 61 percent of the samples collected, while female fish that were age 6 and 7 comprised 39 percent of the samples collected (ASMFC 2008: 203, Table 4.8; MADMF 2011: 61, Appendix Table 9). By 2010, female fish that were age 3 increased to comprise 12 percent of the samples collected, while female fish age 4 and 5 increased to comprise 80 percent of the samples collected and female fish age 6 and 7 decreased to 8 percent of the samples collected (MADMF 2011: 61, Appendix Table 9). Male alewives in the samples collected from the Nemasket River experienced a similar decline in age structure (ASMFC 2008: 203, Table 4.8). In 2004, age 3 male fish comprised just under 3 percent of the samples collected, age 4 and 5 male fish comprised almost 75 percent of the samples collected, and age 6 and 7 male fish comprised almost 23 percent of the samples collected (ASMFC 2008: 203, Table 4.8). In 2010, male fish that were age 3 comprised 22 percent of the samples collected and male fish age 6 and 7 decreased to 4 percent of the samples collected (MADMF 2011: 61, Appendix Table 9). Although the percentage of male fish age 4 and 5 stayed the same at approximately 74 percent of the samples collected, the number of age 4 and 5 fish were reversed: in 2004 age 4 fish comprised 28 percent and age 5 fish 47 percent of

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[13] Data was available for 1996 and 1998 through 2003 (ASMFC 2008). Fish count data for 2007 for the Nemasket River in ASFMC (2008) differ slightly from that included in MADMF (2011). Petitioners use the data from the MADMF (2011) for 2007.

samples collected, while in 2010 age 4 fish comprised 47 percent and age 5 fish only 27 percent of samples collected (MADMF 2011: 61, Appendix Table 9).[14]

The length frequencies among female and male alewives in the Nemasket River also has declined from 2004 to 2010 (ASMFC 2008: 196, Table 4.4; MADMF 2011: 54, Appendix Table 5). Overall, the percentage of larger (*i.e.*, older) fish among male and female alewife samples collected from the Nemasket River declined between 2004 and 2010 (ASMFC 2008: 195, Table 4.3; MADMF 2011: 54, Appendix Table 5). For example, in 2004, just over 33 percent of the female fish and about 11 of the male fish measured 300mm or longer (MADMF 2011: 54, Appendix Table 5). In 2007, only just under 7 percent of the female fish and less than 4 of the male fish collected measured 300mm or longer (MADMF 2011: 54, Appendix Table 5). By 2010, just under 5 percent of the female fish (11 of 231 fish) and less than 1 percent of the male fish (one of 276 fish) collected measured 300mm or longer (MADMF 2011: 54, Appendix Table 5). Overall mean size of alewives decreased by 13mm (from 254mm FL and 214g to 241mm FL and 187g) from 2004 to 2009 (MADMF 2010: 21).

Finally, the number of repeat spawners for alewives in the Nemasket River has also decreased significantly over the last several years, from 0.43 for females and 0.44 for males in 2004 to 0.23 for females and 0.16 for males in 2010 (MADMF 2011).

Other Massachusetts Rivers

The Ipswich River has historically supported healthy populations of alewives and blueback herring that helped to shape the region's culture from pre-colonial times until the early 1800s (Ipswich River Watershed Association ND). River herring runs in the Ipswich River were once capable of supporting a commercial fishery that exported thousands of barrels of fish (Frank 2009: 7). Alewives and bluebacks disappeared from the river in the early 1900s, because of a lack of both spawning habitat and passage to this habitat (Frank 2009). The MADMF began restocking efforts in the 1990s; despite stocking over 46,000 fish in the Ipswich River from 1990 through 2007, returns remained low, with only between 98 and 420 adults per year counted returning to spawn (Frank 2009: 7, Figure 1.A.1). Although alewives were the dominant species historically, from 1990 through 2003, blueback herring were restocked; from 2003 through 2007, alewives were restocked (Frank 2009: Table 1.A.1). Besides an isolated event where spawning behaviors were observed in a downstream tidal reach, there has been no evidence of fish spawning or juveniles reported upstream of the Ipswich Mills Dam (Frank 2009: 32).

Mill River's runs of alewives and blueback herring and Penn Brook's alewife run are considered eliminated (Tomczyk 2002: 18-22, 37-41). Only a remnant population is left of what had historically been a large run of alewives in Monatiquot River (Gomez and Sullivan Engineers, P.C. 2001: *i*).

[14] The age data in MADMF (2011) are the same as those in ASFMC (2008) with the following notable exceptions: (1) 2006 data for the Mystic River appear not to have been entered in ASFMC (2008), and (2) 2005 data for the Nemasket River and Town Brook are different in the two reports for unclear reasons. Petitioners rely on the more recent publication (MADMF 2011) when there are discrepancies.

In the Charles River, the proportion of male river herring repeat spawners was 0.49 in 1985 and 0.25 in 1993; for females, the proportion was 0.54 in 1985 and 0.44 in 1993. Mortality on both sexes also increased and average age decreased significantly over this period (1985-1993) (MADMF 2011).

Rhode Island Rivers

Currently there is a moratorium on harvest of alewives and bluebacks in Rhode Island's fresh and marine waters. Due to drastic declines in the spawning size of monitored stocks beginning in 2001, Rhode Island passed regulations in March 2006 that implemented the complete closure of the fisheries. The Annaquatucket River once had a spawning river herring population of over 300,000 fish – it now has only a remnant population, despite stocking efforts (ASMFC 2008). The Nonquit and Gilbert-Stuart rivers are now home to the largest river herring runs in the state. Counts since 2003 have also documented river herring on Buckeye Brook, with counts averaging just over 20,660 fish annually from 2003 through 2011 (Rhode Island Department of Environmental Management ("RIDEM")/Fish and Wildlife 2010: Figure 3; RIDEM/Fish and Wildlife 2011).

Nonquit River

The estimated alewife spawning stock in the Nonquit River has drastically declined since 1999, when it numbered an estimated 230,853 fish (ASMFC 2008: 251, Table 5.6). The average size of the Nonquit River alewife spawning stock has dropped in size by more than 54 percent, from an average of 160,835 fish per year from 1999 to 2002 to an average of 73,719 fish per year from 2003 to 2010 (ASMFC 2008: 251, Table 5.6; RIDEM/Fish & Wildlife 2011).

The percent of river herring repeat spawners – likely all or mostly alewives – in the Nonquit River has declined since the beginning of the time series in 2000 (ASMFC 2008: 259, Figure 5.6). According to the ASMFC (2008), the percent of repeat spawners in the Nonquit River was at or near 18 percent in 2000 and 2003 (ASMFC 2008: 259, Figure 5.6). However, since 2003, the percent of repeat spawners in the Nonquit River has been near or under 10 percent (ASMFC 2008: 259, Figure 5.6). The five-year average, from 2003 to 2007, for repeat spawners in the Nonquit River was under 7 percent (ASMFC 2008: 242).

The mean length-at-ages of Nonquit River river herring observed in 2000 were lower than those observed in 1976, which was when the mean lengths were last reported (ASMFC 2008: 242).

Gilbert-Stuart River

The estimated alewife spawning stock in the Gilbert-Stuart River has drastically declined over the last decade (ASMFC 2008: 251, Table 5.6). The average size of the Gilbert-Stuart River alewife run dropped in size by approximately 82 percent, from an average of 243,894 counted fish per year from 1998 to 2002 to an average of 44,087 counted fish per year from 2003 to 2010 (ASMFC 2008: 251, Table 5.6; RIDEM/Fish & Wildlife 2011).

The catch rate for juvenile river herring – likely all or mostly alewives – in the Gilbert-Stuart River averaged 170.01 catches per hour per year for the five-year period from 1988 to 1992, which included a peak of 343.30 catches per hour in 1992 (ASMFC 2008: 254, Table 5.10). In 2007, the catch rate for juvenile river herring in the Gilbert-Stuart River was only 94.90 catches per hour, which is 72 percent lower than the 1992 catch rate and 44 percent lower than the 1988-1992 average catch rate (ASMFC 2008: 254, Table 5.10).

The percent of river herring repeat spawners in the Gilbert-Stuart River has decreased significantly since the 1980s (ASMFC 2008: 259, Figure 5.6). According to the ASMFC (2008: 259, Figure 5.6), the percent of repeat spawners in the Gilbert-Stuart River was at or near 70 percent in the mid-1980s. However, since 2002, the percent of repeat spawners in the Gilbert-Stuart River has been under 20 percent (ASMFC 2008: 259, Figure 5.6).

The mean length-at-ages of Gilbert-Stuart River river herring observed since 2000 have been consistently lower for all age classes than those observed in 1992 (ASMFC 2008: 242). In addition, pooled age data (1980 to 1992) from the Gilbert-Stuart River indicated that 15 percent of the river herring collected as samples were ages 6, 7, or 8 (ASMFC 2008: 242). From 2003 to 2007, age data indicated that there were no age 7 or age 8 river herring and that there were very low percentages of age 6 fish (ASMFC 2008: 242).

Connecticut Rivers

Observations by the Connecticut Department of Environmental Protection ("CTDEP") indicate that there have been significant declines in the run sizes of alewives and blueback herring at a majority of sites in Connecticut (Davis and Schultz 2009: 91, citing Gephard *et al.* 2004). Most of these declines have been relatively recent.

Connecticut River

The Connecticut River is the largest river system in Connecticut. The alewife and the blueback herring historically occurred throughout the lower Connecticut River basin (Connecticut River Atlantic Salmon Commission ("CRASC") 2004). In the Connecticut River, blueback herring are currently found in the main stem of the Connecticut River up to Bellows Falls, Vermont (CRASC 2004). Unlike blueback herring, alewives currently occur in the Connecticut River south of Holyoke, Massachusetts and are rarely found north of the Holyoke dam (CRASC 2004).

The blueback herring population in the Connecticut River has precipitously declined over the last two decades. During the 1980s, the Connecticut River supported a blueback herring population estimated to consistently number over 5 million fish per year, with a peak of approximately 9.4 million fish in 1985 (ASMFC 2008: 283, Table 6.1). After averaging an estimated 5.4 million fish from 1981 to 1995, the Connecticut River blueback herring population dropped to an estimated average of just over one million fish per year from 1996 to 2001 (ASMFC 2008: 283, Table 6.1). From 2002 to 2008, the Connecticut River blueback herring population declined further, averaging only an estimated 311,997 fish per year (ASMFC 2008: 283, Table 6.1). Overall, the average size of the Connecticut River blueback herring population has declined by 94 percent since its 1981 to 1995 estimated average size (ASMFC 2008: 283, Table 6.1).

The status of the alewife population in the Connecticut River is unclear because the Connecticut state status report included in ASMFC (2008) considered fish counts from only a couple of tributaries of the Connecticut River and based its conclusions regarding the Connecticut River alewife population primarily on data from Long Island Sound trawl surveys (ASMFC 2008: 261). The Connecticut state status report also did not provide any historical data on the abundance of alewives in the Connecticut River.

Juvenile young-of-the-year surveys for blueback herring in the Connecticut River indicate that the relative abundance of “young of the year” (“YOY”) blueback herring has significantly decreased since the 1980s (ASMFC 2008: 283, Table 6.1). The geometric mean for YOY blueback herring has declined by 96 percent since its peak in 1984 (ASMFC 2008: 283, Table 6.1). Juvenile Abundance Index (“JAI”) geometric mean CPUE for blueback herring on the Connecticut River has declined significantly from 1990 to 2009. From 1990 to 1994, it averaged 12.8 annually, from 1995 to 1999, it averaged 6.1; from 2000 to 2004, it averaged 4.0; and from 2005 to 2009 it averaged 3.6 (CTDEP 2010). It was the lowest on record – 1.77 – in 2009 (CTDEP 2010; ASMFC 2010).

In 2002, the State of Connecticut imposed a moratorium on the commercial and recreation harvest of alewives and blueback herring in all Connecticut waters (ASMFC 2008: 266). The moratorium has been extended each year and continues to the present (CTDEP, Press Release, Mar. 24, 2010; CTDEP 2011). According to the Connecticut Department of Environmental Protection, the “monitoring conducted during 2009 indicated that the river herring stocks remain very low with no signs of an imminent recovery” (CTDEP, Press Release, Mar. 24, 2010, citing William Hyatt, Chief of CTDEP’s Bureau of Natural Resources).

Bride Brook

A case study examining temporal shifts in the demography and life history within the Bride Brook alewife population found declines in the population’s abundance, age, mean length, and the likelihood of repeat spawning (Davis and Schultz 2009). The Bride Brook alewife population in recent years had lower abundance and consisted of smaller fish that were less likely to be repeat spawners (Davis and Schultz 2009). While the 1966 run of spawning alewives in Bride Brook was dominated by age 5, 6, and 7 fish, the recent alewife spawning runs were dominated by age 3 and 4 fish (Davis and Schultz 2009). The Bride Brook alewife population recruited to the spawning run at younger ages and at smaller sizes (Davis and Schultz 2009). In recent years, first-time spawners have primarily been age 3 fish whereas first-time spawners have been dominated by age 5 fish in 1966 (Davis and Schultz 2009). In addition, the mean length in the Bride Brook alewife population decreased by 10 percent between 1966 and 2006 (Davis and Schultz 2009).

New York Rivers

Hudson River

The alewife and the blueback herring populations in the Hudson River are much reduced from historic levels (ASMFC 2008: 324). According to the New York State Department of Environmental Conservation ("NYSDEC"), there has been a steady decline in total commercial landings in New York while total effort has increased at a high rate (ASMFC 2008: 315). Because total catches should rise with total effort in a lightly exploited population and the opposite is occurring in New York, the NYSDEC has expressed concern regarding the status of the state's alewife and blueback herring populations (ASMFC 2008: 315).

Relative abundance of alewives and blueback herring in the Hudson River is tracked by observed CPUE statistics of fish taken in the commercial fixed gill net, drift gill net, and scap net fisheries in the Hudson River Estuary (ASMFC 2008: 312). Total effort has increased for all gear types since 1996 (ASMFC 2008: 314; 375, Figure 7.8; 335, Table 7.7). However, since 2000, annual CPUE has dropped dramatically for all gear types (ASMFC 2008: 314; 376, Figure 7.9; 334, Table 7.6).

From 2001 to 2007, mean total length and weight for alewives and blueback herring in the Hudson River declined (ASMFC 2008: 341-43, Table 7.11; 344-46, Table 7.12). Monitoring data from commercial vessels (which may understate the decline, as these vessels use selective gill nets that tend to capture the relatively similar size ranges of fish with little inter-annual change (ASMFC 2008: 319)) found average length of alewives from 2001to 2005 was 271.7mm; since 2005, that average has been 264.4mm (NYSDEC 2010: Table 12).[15] Mean length of bluebacks has also declined during the decade: average length from 2001-2005 was 264.7mm; since 2005, that average has been 259.5mm (NYSDEC 2010: Table 12).[16] Data from Hudson River estuary spawning stock surveys show an even more dramatic decline for alewives: average length from 2001 to 2005 was 261.6mm for alewives and 251.6mm for bluebacks; since 2005, that average has been 251.3mm for alewives and 246.3mm for bluebacks (NYSDEC 2010: Table 22). The observed decline in the size of Hudson River alewives is greater than that of Hudson River blueback herring (ASMFC 2008: 319). According to the NYSDEC, this occurrence may be the result of higher fishing pressure on Hudson River alewives because they are the first species to return to the Hudson River when the demand for striped bass bait is at its highest (ASMFC 2008: 319).

The NYSDEC has measured relative abundance of YOY alewives and YOY blueback herring in the Hudson River Estuary since 1980 (ASMFC 2008: 322). NYSDEC data indicates significant fluctuations in both the YOY alewife and the YOY blueback herring indices for which there is no clear explanation, though the blueback YOY indices show a slightly declining trend over all years (ASMFC 2008: 322-23; NYSDEC 2010: 5). The same erratic trend observed in the YOY alewife and YOY blueback herring indices from 1998 to 2007 also occurred in the YOY indices for American shad (ASMFC 2008: 323). According to the NYSDEC, the co-occurrence of these

[15] No data were available for 2006 and 2008 (NYSDEC 2010: Table 12).
[16] No data were available for 2001 and 2003 (NYSDEC 2010: Table 12).

erratic YOY indices trends may be indicative of a change in the overall stability of the ecosystem (ASMFC 2008: 323).

Delaware River

The Delaware River once hosted abundant populations of alewives and blueback herring. ASMFC (2008: 392) includes accounts of how alewives and blueback herring were so numerous in Delaware River tributaries that the fishes "often flipped onto the creek banks of Delaware River tributaries each spring." Although the numbers were considerably reduced from those in the 19th century, all of the major tributaries of the Delaware River and Delaware Bay contained spawning runs of alewives and blueback herring as recently as 1990 (ASMFC 2008: 395). Both species occurred in the Delaware River and Bay on the east side of the state and in the Nanticoke River, including its main tributaries, Deep Creek and Broad Creek, and some small tributaries (Delaware Department of Natural Resources and Environmental Control ("DDNREC") 2010). Blueback herring are most abundant in Nanticoke River drainage, whereas alewives predominate in the Delaware estuary (DDNREC 2010: 5).

Since 1990, available information indicates a significant decline in alewife and blueback herring abundances in the Delaware River. Indices of the adult alewife and the blueback herring populations indicate a particularly marked decline from 2001 to 2007 (ASMFC 2008: 399; 409, Figure 8.6). The commercial CPUE for Delaware River alewives and blueback herring landed in Delaware has been in decline since the early 1990s, with three of the lowest data points occurring within the last three years of the time series (2005 to 2009) (ASMFC 2008:399; DDNREC 2010: 5, Figure 1[17]). From 1991 to 2001, commercial landings averaged 19,688 pounds (DDNREC 2010: Table 1).[18] From 2002 to 2008, commercial landings averaged 5,270 pounds (DDNREC 2010: Table 1).[19] In 2009, they dropped to 1,453 pounds, a 93 percent reduction from the 1991 to 2001 average (DDNREC 2010: Table 1).[20] The commercial CPUE for Delaware River alewives and blueback herring landed in New Jersey has also remained low throughout the time series (1997 to 2007), with the exception of 2000, with two of the lowest data points occurring with the last three years of the time series (ASMFC2008: 403, Table 8.3; 408, Figure 8.4). Commercial landings in New Jersey[21] have also declined: they averaged 3,459 pounds annually from 1995 through 2000, 3,066 pounds on average annually from 2001 to 2006, and 867 pounds on average annually from 2007 to 2009 (New Jersey Department of Environmental Protection ("NJDEP") 2010: 9, Table 13).

[17] The report mistakenly labels this figure as "Table 1", although there is another "Table 1" and the text refers to it as "Figure 1."
[18] Calculation based on average of 8,929 kilograms of river herring (alewives and bluebacks), converted to 19,688 pounds.
[19] Calculation based on average of 2,390 kilograms of river herring (alewives and bluebacks), converted to 5,270 pounds.
[20] Calculation based on 659 kilograms of river herring (alewives and bluebacks), converted to 1,453 pounds.
[21] Landing estimates for river herring were obtained from the NMFS for 1995 to 1999 while estimates for 2000 to 2009 were obtained from mandatory logbooks of the New Jersey small mesh gill net fishery (New Jersey Department of Environmental Protection (NJDEP) 2010: 9).

The recreational CPUE for Delaware River alewives and blueback herring landed in Delaware has declined by approximately 65 percent or more in recent years (2001 to 2003, 2007) compared with the CPUEs recorded from 1996 to 1998 (ASMFC 2008:399; 404, Table 8.4). No surveys have been conducted since 2007 (DDNREC 2010: 7).

The juvenile index of relative abundance for the Delaware River alewife population declined, on average, from 2002 to 2007, compared with its average indices from 1980 to 2000 and from 1990 to 2000 (ASMFC 2008: 405, Table 8.5). However, as with most juvenile indices of relative abundance, the Delaware River indices for alewife and blueback herring fluctuated throughout the time series without a discernable long-term trend (ASMFC 2008: 400). According to the ASMFC (2008), the observed fluctuations are mostly due to the environmental conditions around the time of alewives and blueback herring spawning through the early nursery period (ASMFC 2008: 400). Juvenile blueback herring recruitment for 2009 (3.55) (derived from New Jersey's Striped Bass Recruitment Survey in the Delaware River) remained below average for the fourth year in a row, with the juvenile index from 2006 to 2009 representing the lowest average of any four year period except 1980 to 1983 and showing a serious decline in the overall health of the blueback herring stock within the Delaware river and its tributaries (NJDEP 2010: 9, Table 14). Alewife recruitment for 2009 (0.06) (also from New Jersey) was also very poor for the third time in four years (NJDEP 2010: 9, Table 14). Juvenile numbers (YOY and age 1 fish) in the Delaware estuary in Delaware for both alewives and bluebacks generally remained low in 2008 and 2009 (DDNREC 2010: 11-13).

According to the ASMFC (2008), the overall assessment of data indicates that the Delaware River alewife and blueback herring populations are declining (ASMFC 2008: 401). In addition, the assessment of data indicates that the blueback herring population in the Delaware River is declining to a greater extent than the Delaware River alewife population, particularly in recent years (ASMFC 2008: 401).

Chesapeake Bay

Upper Chesapeake Bay, including Nanticoke River

Significant populations of alewife and blueback herring historically spawned in rivers and tributaries of the Upper Chesapeake Bay (ASMFC 2008: 416). An average of 3,568,710 pounds of alewives and blueback herring were commercially landed per year in Maryland from 1950 to 1970 (ASMFC 2008: 56, Table 1.5.1.1). An average of only 180,426 pounds of alewives and blueback herring were commercially landed per year in Maryland in 2000 and 2001 and, from 2002 to 2009, the average amount of alewives and blueback herring commercially landed per year in Maryland dropped again to only 45,570 pounds per year – an overall decline of 99 percent from the 1950 to 1970 landings average (ASMFC 2008: 57, Table 1.5.1.1; MDNR 2010: 21, Table 12).

The mean YOY for alewives in the Upper Chesapeake Bay has declined over time, from an annual average of 0.440 for 1959 to 1984 to an annual average of 0.305 for 1985 to 2009

(ASMFC 2008: 444-45, Figures 9.11 and 9.12).[22] The mean YOY indices for blueback herring in the Upper Chesapeake Bay have also declined, with an annual average of 0.923 for 1985 to 2009 compared to an annual average of 1.426 for 1959 to 1984 (ASFMC 2008: 445-46, Figures 9.13 and 9.14).[23]

Available data indicates that, in the last few years, older alewives and blueback herring are no longer present in the Nanticoke River and mean length-at-age for male and female alewives and blueback herring is decreasing (ASMFC 2008: 423). This trend continued in 2009, with none of the 216 alewives or 66 bluebacks sampled in the Nanticoke River over 7 years of age (no male alewives were over 6 years of age, and no male bluebacks were over 5) (MDNR 2010: 20, Table 11). In general, through 2007, ages 4 and 5 were the most prevalent fish in the samples but alewives and blueback herring were generally not fully recruited to the spawning population until age 5, as shown with the freshwater spawning mark not present on all five year-old fish (ASMFC 2008: 423). In 2009, age group 4 was the most abundant year class for both alewives and bluebacks, and, again, some five year-old fish were first-time spawners (MDNR 2010: 10-11; 19-20, Tables 10 and 11). Calculated CPUEs for both alewives and blueback herring on the Nanticoke River are trending downward (MDNR 2010: 11). In the Delaware portion of the Nanticoke River, the JAI increased for blueback herring in 2009, it remained at low levels for alewives (DDNREC 2010: 14).

Potomac River

Alewives and blueback herring were historically extremely abundant in the Potomac River (ASMFC 2008: 449). Significant numbers of alewives and blueback herring were landed in the 19th century, with an estimated 750,000,000 individual fish landed in 1832 (ASMFC 2008: 449, citing the 1835 Gazetteer of Virginia).

The number of alewives and blueback herring commercially landed under the jurisdiction of the Potomac River Fisheries Commission has drastically declined since the mid 1960s (ASMFC 2008: 449; 55-57, Table 1.5.1.1). From 1960 to 1970, such commercial landings of alewives and blueback herring averaged approximately 6,770,878 pounds per year (ASMFC 2008: 55-57, Table 1.5.1.1). By the early 2000s, commercial landings of alewives and blueback herring declined by 99.5 percent – to an average of approximately 32,810 pounds from 2000 to 2004 (ASMFC 2008: 55-57, Table 1.5.1.1). From 2005 to 2009, the average number of alewives and blueback herring commercially landed per year declined further to an average of 7,148 pounds per year (ASMFC 2008: 55-57, Table 1.5.1.1; PRFC 2010, Table 1).

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[22] Calculations based on numbers for the Nanticoke River provided in spreadsheets available under the "alewife herring (YOY)" section of the web page http://www.dnr.state.md.us/fisheries/juvindex/index.asp, at the link identified as "Abundance Data and Graphs."

[23] Calculations based on numbers for the Nanticoke River provided in spreadsheets available under the "blueback herring (YOY)" section of the web page http://www.dnr.state.md.us/fisheries/juvindex/index.asp, at the link identified as "Abundance Data and Graphs."

Mean YOY indices also indicate a significant decline in alewife and blueback herring abundance in the Potomac River. Available data indicates that, from 1959 to 1996, the mean YOY indices for the Potomac River alewife population averaged 0.558 per year but declined to an average of 0.33 per year for the subsequent fourteen year period (1997 to 2010) (Durell, E.Q., and Weedon, C. 2010 (alewife herring abundance data and graphs)).[24] Available data indicates that, from 1959 to 1996, the mean YOY indices for the Potomac River blueback herring population averaged 1.59 per year but declined to an average of 0.92 per year for the subsequent 1997 to 2010 period (Durell, E.Q., and Weedon, C. 2010 (blueback herring abundance data and graphs)).[25]

Susquehanna River

Historical reports indicate that river herring were very abundant in the Susquehanna River and provided for an important historical fishery (Susquehanna River Anadromous Fish Restoration Cooperative ("SRAFRC") 2010: 8). In 1920, alewives were ranked first – above American shad, Atlantic croaker, striped bass, weakfish, and white perch – in terms of Maryland's harvest from the river, with 6.7 million pounds harvested (SRAFRC 2010: 11).

By 1928, what had been the most productive river herring run on the Atlantic Coast was closed off to migrating fish by dams, except for its lowermost 10 miles (SRAFRC 2010: 12, 34-35). In 1991, the Pennsylvania Electric Company (PECO, now the Exelon Corporation) completed construction of a fish passage facility at the Conowingo Dam – the Conowingo Dam East Fish Passage Facility – as a result of a 1988 settlement agreement (SRAFRC 2010: 15). The west fish passage facility, a fish trapping facility also built and operated by PECO, has operated each spring since 1972; it was designed to trap fish for trucking upstream to spawning areas, but has experienced mixed success with these efforts (SRAFRC 2010: 18). For example, from 1990 to 2001, river herring were transported to four upstream areas, but as few juveniles were found in those areas in annual monitoring efforts, the project was deemed unsuccessful and terminated (SRAFRC 2010: 19). Other data confirm little reproduction above the Conowingo Dam facility; netting efforts from 1997 to 2003 suggested only one year of possible blueback herring reproduction, with 134 bluebacks netted in 2001 (SRAFRC 2010: 27).

Data for the Susquehanna River show dramatic declines in fish passage since the late 1990s. At the Conowingo Dam East Fish Passage Facility,[26] blueback herring passage declined from a recent high of almost 285,000 in 2001 to 4 in 2010; alewife passage declined from almost 7,500 fish in 2001 to 1 in 2010. Even looking at the data from the time the fish passage was constructed in 1991, passage declined from 13,149 blueback herring and 323 alewives to 4 and 1

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[24] Calculations based on numbers for the Potomac River provided in spreadsheets available under the "alewife herring (YOY)" section of the web page http://www.dnr.state.md.us/fisheries/juvindex/index.asp, at the link identified as "Abundance Data and Graphs."

[25] Calculations based on numbers for the Potomac River provided in spreadsheets available under the "blueback herring (YOY)" section of the web page http://www.dnr.state.md.us/fisheries/juvindex/index.asp, at the link identified as "Abundance Data and Graphs."

[26] The Conowingo Dam, built in 1928, is about 6 miles below the Pennsylvania/Maryland border and 10 miles from the mouth of the river at the head of the Chesapeake Bay.

respectively. The west lift facility also shows a dramatic decline starting in the late 1990s and early 2000s, with more than 133,000 bluebacks passing in 1997 and only 7 in 2008; there was a recent high of just over 9,000 alewives passing in 2000, but only 2 in 2008 (ASFMC 2008: 440, Table 9.2; SRAFRC 2010: Table 4; Summary of selected operation and fish catch statistics at the Conowingo Dam East Fish Passage Facility, 1991 to 2010: Table 4; Operations and fish catch at Conowingo West Fish Lift, 1985 – 2010: Table 5).[27]

Virginia Rivers

Lower Chesapeake Bay, including the Rappahannock, York, and James Rivers

Significant populations of alewife and blueback herring historically spawned in rivers and tributaries of the Lower Chesapeake Bay (ASMFC 2008: 4). According to commercial landings records, an average of approximately 24,923,657 pounds of alewife and blueback herring were commercially landed per year in Virginia from 1950 to 1970 (ASMFC 2008: 55-57, Table 1.5.1.1).

By the early 2000s, commercial landings of alewives and blueback herring in Virginia had plummeted. Between 1996 and 2004, an average of only 132,676 pounds of river herring per year was caught – a decline of more than 99 percent (ASMFC 2008: 55-57, Table 1.5.1.1). From 2005 to 2007, landings declined further to an average of 84,948 pounds of river herring per year (ASMFC 2008: 55-57, Table 1.5.1.1).

One commercial fisherman's voluntary logbook records (1995 to 2008) support a significant decline in the abundance of alewives and blueback herring in the Lower Chesapeake Bay (ASMFC 2008: 455). According to these records, average annual total catches of alewives and blueback herring from the Rappahannock River from 2005 to 2008 declined approximately 85 percent from those from 1999 to 2002 (ASMFC 2008: 469, Figure 11.9). Experimental surveys conducted by the Virginia Institute of Marine Science similarly show that the annual relative abundance of adult alewives and blueback herring in the Rappahannock River has significantly declined since the mid 1990s and remains at historically low levels, despite a slight increase in 2008 (ASMFC 2008: 470, Figure 11.12).

Annual mean JAIs also show a decline in alewife and blueback herring populations in the Lower Chesapeake Bay. From 1979 to 1987, the mean JAIs averaged 3.5 per year for the Mattaponi River alewife population and 1.8 per year for the Pamunkey River alewife population, but declined to an average of 1.4 and 0.49 per year, respectively, for the period 1991 to 2002 (ASMFC 2008: 464, Table 11.5) . From 1979 to 1987, the mean JAIs averaged 10.6 per year for the Mattaponi River blueback herring population and 37.0 per year for the Pamunkey River blueback herring population, but declined to an average of 6.6 and 9.3 per year, respectively, for the period 1991 to 2002 (ASMFC 2008: 464, Table 11.5). The annual JAIs for the alewife populations in the Rappahannock, York, and James River have fluctuated at historically low levels since the early 1990s (ASMFC 2008: 472, Figure 11.16). Although the annual JAIs for

[27] According to ASFMC (2008), some of this decline may be due to changes in flows designed to prioritize passage of shad, as well as because the fish lifts are operated in April after alewives' peak spawning time (ASFMC 2008: 420).

the blueback herring populations in the Rappahannock, York, and James River have fluctuated at higher levels than those of the alewife populations, the annual blueback herring JAIs have been at near-historically low levels since the mid 1990s (ASMFC 2008: 472, Figure 11.16).

According to Hewitt *et al.* (2009: 100), juvenile alewives are less abundant than juvenile blueback herring in the York River system's Mattaponi and Pamunkey Rivers. As of 1991, only remnant populations of alewives at very low levels of abundance were recorded in the Mattaponi and Pamunkey (Klauda *et al.* 1991).

North Carolina Rivers

River herring were documented in many waterbodies in North Carolina in the 1960s. In 1962, commercial landings included more than 3,262,600 pounds of river herring from Albemarle Sound; 20,000 pounds from Croatan Sound; 25,000 pounds from Currituck Sound; 10,786,000 pounds from the Chowan River; 122,000 pounds from the Roanoke River; 16,200 pounds from Pamlico Sound; 62,100 pounds from the Pamlico River; 2000 pounds from the Neuse River; and 100 pounds from the Cape Fear River (NCDMF 2010a: 4-5, Table 1). By 2006, however, the only river with a documented river herring fishery was the Chowan River. Even the Chowan River had suffered a decline in landings of more than 99 percent with just over 67,404 pounds landed; landings from Albemarle Sound (the only other location in North Carolina with landings greater than 10,000 pounds) had also declined by more than 99 percent (to just 22,573 pounds) by 2006 (NCDMF 2010a: 5-6, Table 1).

In 2007, and in response to declining stock levels, the North Carolina Marine Fisheries Commission implemented a statewide moratorium on the harvesting of alewives and blueback herring in waters within its jurisdiction (ASMFC 2008: 17). The North Carolina Wildlife Resources Commission also enacted regulations prohibiting the harvest of alewives and blueback herring (6 inches and longer) within its jurisdictional waters in the coastal river systems (ASMFC 2008: 17).

Albemarle Sound and Chowan River

Significant populations of alewives and blueback herring historically spawned in the Chowan River and Albemarle Sound in North Carolina (ASMFC 2008: 473). This region has historically had the largest alewife and blueback herring fisheries in the country, with blueback herring historically being more prevalent than alewives (ASMFC 2008: 483).

Over the last three decades, the average amount of alewives and blueback herring landed overall in North Carolina dropped from an estimated 12,879,871 pounds of alewives and blueback herring per year from 1950 to 1970 to an estimated 308,347 pounds of alewives and blueback herring per year from 1996 to 2006 – a decline of 98 percent (ASMFC 2008: 55-57, Table 1.5.1.1). Landings of both alewives and blueback herring from the Chowan River experienced a particularly dramatic decline in abundance between 1972 and 2004 (ASMFC 2008: 495, Table 3). From 1972 to 2004, Chowan River alewife landings dropped by 98 percent and Chowan River blueback herring landings declined by 99 percent (ASMFC 2008: 495, Table 3). Catch rates for bluebacks and alewives from independent gill net surveys have not shown any significant increases since the harvest moratorium was implemented in 2007 (NCDMF 2010b: Figure 22).

Sustained high exploitation of both the alewife and the blueback herring population in the Chowan River over the past three decades has reduced the spawning stock biomass ("SSB") to the extent that the current population levels of both species are insufficient to produce even moderate recruitment (ASMFC 2008: 488). Annual estimates of recruitment for Chowan River blueback herring and Chowan River alewife are significantly lower than both species' historic recruitment (ASMFC 2008: 508-09, Figures 17 and 18). Estimated average annual recruitment for blueback herring in the period 1999-2003 was 98 percent lower than in the period 1972-1985 (ASMFC 2008: 481; 508, Figure 17). Estimated average annual recruitment for the alewife in the period 1999-2003 was 96 percent lower than in the period 1972-1986 (ASMFC 2008: 481-82; 509, Figure 18). The SSBs for the alewife and the blueback herring populations in the Chowan River indicate a rapidly decreasing trend for both species (ASMFC 2008: 482).

Annual catch curve analyses for blueback herring and for alewives in the Chowan River suggest a high total mortality, averaging 1.44 for blueback herring and 1.48 for alewives from 1972 to 2003 (ASMFC 2008: 480-81). Cohort based catch curves plotted by fishing year illustrate both the steep decline in abundance and the relative similarity of the declining slopes of each blueback herring and alewife cohort (ASMFC 2008: 480-81).

According to the ASMFC (2008), available data from the Chowan River pound net fishery indicated a decline in mean sizes of male and female alewives and of male and female blueback herring (ASMFC 2008: 35). Female and male alewives and blueback herring sampled from 2004 to 2007 were approximately 15 to 20 millimeters smaller, on average, than alewives and blueback herring of the same sex sampled from 1971 to 1978 (ASMFC 2008: 35). Trend analysis indicates significant decreases in mean length-at-age for males and females ages 3 to 6 for both species (ASMFC 2008: 37). Mean sizes of male and female alewives and bluebacks from ages 4 through 6 have stayed low or continued to trend lower since the statewide harvest moratorium was implemented in 2007 (NCDMF 2010b: Figures 20 and 21).

The maximum age of male and female blueback herring in the Chowan River was generally greater than age 7 prior to 1984 but declined thereafter to age 6 to age 7 through 2003 (ASMFC 2008: 36). Since 2003, the maximum age of Chowan River blueback herring has declined further to ages 5 to 6 (ASMFC 2008: 36). Similarly, the maximum age observed for male and female alewives in the Chowan River ranged from age 6 to age 9 prior to 1983, but declined to ages 6 to 7 by 2005 (ASMFC 2008: 36). Since the statewide moratorium on harvesting both species was implemented in 2007, maximum ages for both species have remained low. Sampling in the Chowan River in 2009 showed a maximum age of 6 in males and 7 in females for both blueback herring and alewives (NCDMF 2010b: Tables 36 and 37). In that Chowan River sampling, virgin fish – first time spawners – comprised 80 percent of bluebacks and 69 percent of alewives; about 2 percent of bluebacks were repeat spawners and 11 percent of alewives were repeat spawners (NCDMF 2010b: Tables 36 and 37).

Sampling in Albemarle Sound in 2009 showed a maximum age of 7 for female bluebacks and 6 for male bluebacks, and 7 for both male and female alewives (NCDMF 2010b). In the same

2009 sampling, virgin fish comprised 71 percent of bluebacks and 52 percent of alewives; about 5 percent of bluebacks were repeat spawners and 16 percent of alewives were repeat spawners (NCDMF 2010b: Tables 38 and 39).

A downward trend in annual JAIs for both alewives and blueback herring in the Albemarle Sound is apparent in recent years (ASMFC 2008: 476). Fishery-independent surveys from 1972 to 2004 show a decline in the blueback herring JAIs to levels near zero since the mid 1990s (ASMFC 2008: 476). The average annual blueback herring JAI for 1972 to 1985 was over 75 percent higher than its level in 2004 (ASMFC 2008: 519, Figure 5). The annual JAIs for Albemarle Sound alewives also show a similar decline, with JAIs levels near zero during the early 1990s (ASMFC 2008: 519, Figure 6). The alewife JAIs have continued to fluctuate at historically low levels since the mid 1990s (ASMFC 2008: 519, Figure 6). This trend has not reversed since the harvest moratorium was implemented in 2007. According to recent data available on the NCDMF website, the Albemarle Sound JAIs from 2000 to 2010 for bluebacks averaged 3.11 and for alewives averaged 0.98 (NCDMF 2011; NCDMF 2010b: Table 40); the average from 2007 through 2010 for blueback herring was 1.05, and for alewives was 1.07 (NCDMF 2011; NCDMF 2010b, Tables 40 and 41).[28] The mean JAI for bluebacks from 1972 to 1980 was180.52; the mean for the same time period for alewives was 5.7 (NCDMF 2010b; Tables 40 and 41).

South Carolina Rivers (Santee-Cooper River System)

Both the alewife and the blueback herring historically occurred in most of South Carolina's major rivers (ASMFC 2008: 537; SCDNR 2010a). However, only the blueback herring presently occurs in South Carolina waters (ASMFC 2008: 537). Alewife populations in South Carolina are believed to be extirpated, as no alewives have been documented in waters south of North Carolina in recent years (ASMFC 2008: 537). Historical distribution records and anecdotal information on abundance strongly indicate that all populations of alosines, including the blueback herring, in South Carolina are reduced compared to historic levels (USFWS/SCDNR 2001).

Commercial landings data from South Carolina indicate that the average amount of blueback herring landed per year has declined 75 percent over the last decade, from an average of 392,274 pounds of blueback herring per year from 1995 to 2000 to an average of 96,619 pounds of blueback herring per year from 2001 to 2007 (ASMFC 2008: 556, Table 13.2). Historically, blueback herring were even more numerous: more than 2.2 million pounds of bluebacks – over 1,000,000 kg – were harvested in 1969 (SCDNR 2010a: 3; ASMFC 2008: 545, 556, Table 13.2).[29]

[28] The slight increase in alewife JAI is the result of a spike up in 2010 (NCDMF 2011).

[29] These data appear to be based on commercial creel surveys conducted by SCDNR starting on the Santee River in 1969, although they may include data reported to NMFS as well (SCDNR 2010a: 2-3; ASMFC 2008: 543-44). The wholesale dealer reporting system utilized by NMFS probably did not include inland landings before 1979 and may not include all herring landings because herring sold as bait to licensed bait dealers may not be reported (SCDNR 2010a: 2; ASMFC 2008: 543-44). Although landings (in weight and numbers of fish) are estimated based on number of bushels (using the average weight of a bushel and the average weight of a blueback herring in South Carolina) and some landings are

Available data indicates an overall decreasing trend in mean length for male bluebacks in the Santee Rediversion Canal (ASMFC 2008: 126, Figure 1.7.2; 559, Table 13.6); these trends continued in 2009 (SCDNR 2010a: 20). Available data also indicates a decline in mean weight of blueback herring in South Carolina rivers since the late 1990s (ASMFC 2008: 557, Tables 13.4 and 13.5).

Blueback herring are currently managed by the SCDNR in the Winyah Bay tributaries (the Sampit, Lynches, Pee Dee, Bull Creek, Black, and Waccamaw Rivers) and in the Santee-Cooper Rivers complex (SCDNR 2010a). Recreational fisheries also exist on the Ashepoo River, the Combahee River, the Edisto River, and the Savannah River (SCDNR 2010a: 3). The bulk of the reported landings since 1989 have come from the Santee-Cooper system. Reported landings for the Pee Dee River of the Winyah Bay system have remained at less than 1,200 pounds per year – 500 kg – since mandatory reporting was initiated in 1998 (SCDNR 2010a: 3). A declining trend has been observed in the commercial CPUE estimates for blueback herring in the Santee River (ASMFC 2008:86, Table 1.13.1; SCDNR 2010: Figure 3).

Florida Rivers (St. Johns River)

A blueback herring population in the St. Johns River in Florida is the southernmost blueback herring population in the United States (ASMFC 2008: 586). Blueback herring have been largely ignored by fishermen in Florida, and there is no recorded Florida fishery for blueback herring (ASMFC 2008:586).

Electrofishing CPUE for blueback herring in the St. Johns River declined precipitously from 2001 to 2002 and remains at very low levels (ASMFC 2008: 30; 114, Figure 1.6.3.3).

B. Distinct Population Segments

For vertebrate species, the ESA defines species to include "distinct population segments" or DPSs. *See* 16 U.S.C. § 1532 (defining "species" to include a "distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature"). To determine the existence of a DPS, NMFS considers the "1) 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." *See Policy Regarding the Recognition of Distinct Vertebrate Population Segments Under the Endangered Species Act*, 61 Fed. Reg. 4722, 4724 (Feb. 7, 1996) ("*DPS Policy*").

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occasionally missed during the creel survey, the survey is intended to produce the most reliable estimates of catch and effort available for South Carolina waters (SCDNR 2010a: 2; ASMFC 2008: 544). In 1998, SCDNR mandated reporting of commercial catch and effort, but questions regarding the reliability of these data have hindered successful development of total catch and effort statistics by river from these data. (SCDNR 2010a: 2; ASMFC 2008: 543-44). These by-river reporting data appear to be the basis of 2009 catch statistics included in South Carolina's 2009 annual report to the ASMFC on the status of its river herring fishery (SCDNR 2010b: 33, Table 3).

A population segment is considered "discrete" if it is "markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors. Quantitative measures of genetic or morphological discontinuity may provide evidence of this separation." *See, e.g., Northwest Ecosystem Alliance v. United States Fish & Wildlife Serv*., 475 F.3d 1136, 1150 (9th Cir. 2007). The meaning of "markedly" in this context is "appreciably." *See Nat'l Ass'n of Home Builders v. Norton*, 340 F.3d 835, 851 (9th Cir. 2003). "Appreciably," in turn, means "capable of being perceived or measured." *See Merriam-Webster Online Dictionary* (2009).

A population segment is considered significant based on: 1) "persistence of the discrete population segment in an ecological setting unusual or unique for the taxon," 2) "evidence that loss of the [DPS] would result in a significant gap in the range of a taxon," 3) "evidence that the [DPS] 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 [DPS] differs markedly from other populations of the species in its genetic characteristics." *See Home Builders,* 340 F.3d at 851. These factors are non-exclusive; if any one factor is satisfied, a discrete population must be considered significant. *See Maine v. Norton*, 257 F. Supp. 2d 357, 388 (D. Me. 2003). A "gap in the range of a taxon" is defined as "empty geographic space in the range of the taxon." *Home Builders,* 340 F.3d at 846 (upholding FWS' "gap in the fence" interpretation as reasonable). A gap may be considered if it would "decrease the genetic variability of the taxon," substantially reduce the current geographical or historical range of the taxon, result in a gap at the edge of the species range, or cause the loss of a population that is numerous and a large percentage of total taxon members. *See id.*

If a population segment is discrete and significant, then it is a distinct population segment and must be evaluated for endangered and threatened status. It "may be appropriate to assign different classifications to different [DPSs] of the same vertebrate taxon." *DPS Policy* at 4724.

1. If NMFS Does Not List the Alewife and the Blueback Herring Each as Threatened Species as a Whole, NMFS Should Designate Four DPSs of Alewife and Three DPSs of Blueback Herring as Described in this Petition or as Determined by NMFS.

If NMFS does not list the alewife and the blueback herring as threatened species as a whole, the agency should designate four DPSs of alewife and three DPSs of blueback herring as follows: Central New England DPS of alewife, Long Island Sound DPS of alewife, Chesapeake Bay DPS of alewife, and the Carolina DPS of alewife; Central New England DPS of blueback herring, Long Island Sound DPS of blueback herring, and Chesapeake Bay DPS of blueback herring. These DPSs are described as follows and depicted in Figures 3 and 4:

Central New England DPSs for alewives and for blueback herring: River systems in these DPSs include the Winnicut River; Exeter River; Cocheco River; Taylor River; Oyster River; Lamprey River; and Parker River.

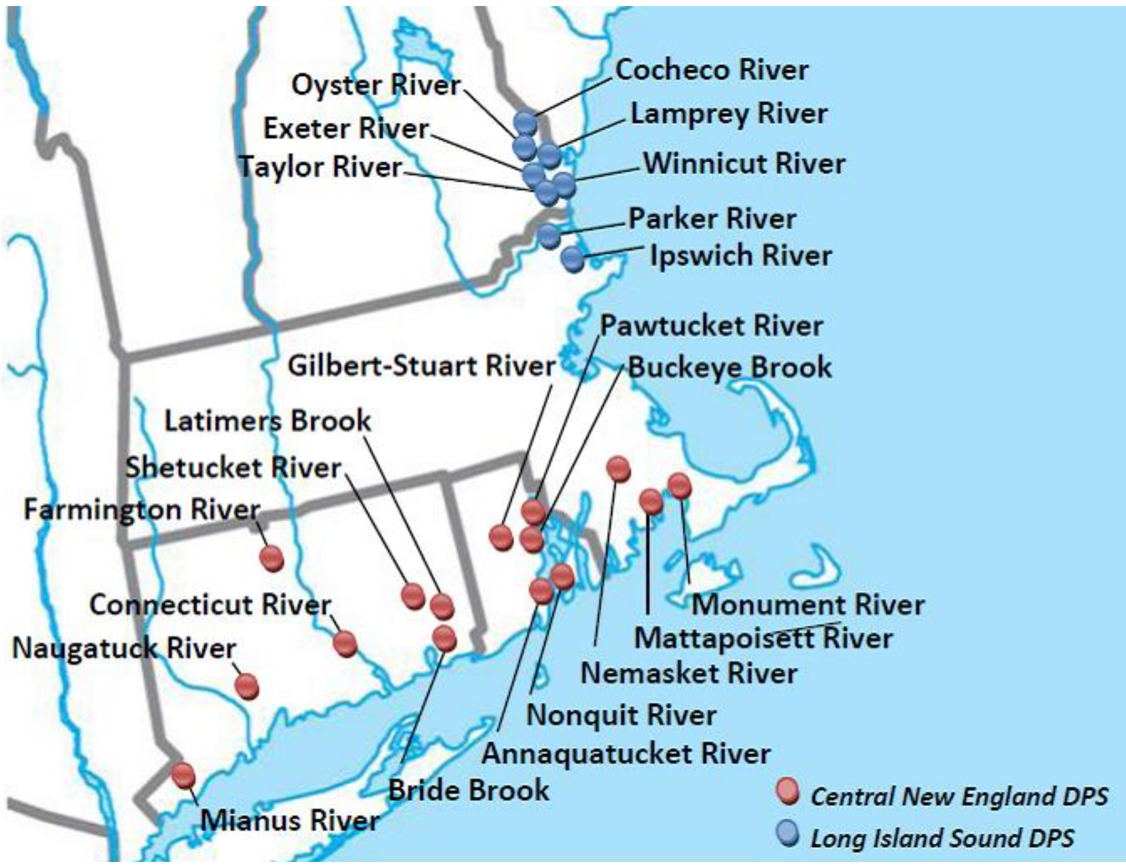
Long Island Sound DPSs for alewives and for blueback herring: River systems in these DPSs include the Monument River; Nemasket

River; Mattapoisett River; Shetucket River; Farmington River; Connecticut River; Naugatuck River; and Mianus River.

Chesapeake Bay DPSs for alewives and blueback herring: River systems in these DPSs would include the Nanticoke, Potomac, Susquehanna, Rappahannock, York, and James Rivers.

Carolina DPS for alewives: River systems in this DPS include the Roanoke River, Chowan River and Albemarle Sound; Pamlico Sound/Pamlico/Tar and Neuse Rivers; Cape Fear River; Winyah Bay/Waccamaw, Pee Dee, and Sampit rivers; Santee River; and Cooper River.

Figure 3: Proposed Central New England and Long Island Sound DPSs



These DPSs encompass fish that originate from a river within the DPS and include the marine range of such fish. NMFS may modify the boundaries of the requested DPSs based on its technical expertise.

The requested four DPSs of alewife and three DPSs of blueback herring are discrete pursuant to the ESA for the following reasons. The alewife populations and the blueback herring populations in each of these DPSs are behaviorally and physiologically discrete from other members of their respective taxon because they return to their natal rivers in their specific DPS to spawn, which leads to separation by river. As discussed *supra*, evidence indicating that alewives maintain fidelity to their natal rivers and do not stray to adjacent rivers during their spawning runs supports reproductive isolation among alewife and blueback herring populations according to their natal rivers (Messieh 1977; NOAA 2009).

Figure 4:   Proposed Chesapeake Bay and Carolina DPSs

Like other anadromous fish, and as NMFS similarly discussed in recently listing a DPS for the eulachon, a Pacific anadromous herring (NMFS 2009c: 74 Fed. Reg. 10857, 10861), populations of alewives and blueback herring have adapted to the unique ecological features, *i.e.*, selective pressures, of their different freshwater/estuarine environments by developing distinguishable behavioral and physiological traits. For example, evidence indicates that northern populations of alewives have a greater tolerance for colder water temperatures than southern populations of alewives, due to antifreeze activity in the blood of the fish in the northern populations that is lacking from the blood of members of more southern populations (Duman and DeVries 1974). Variation in spawning timing among rivers is also indicative of local adaption. Moreover, if sporadic straying does occur, available evidence indicates that individual fish will only stray to adjacent streams or return to a nearby stream in which they were previously extirpated (ASMFC 2008; NOAA 2009).

The geographic distance between each DPS maintains the behavioral and physiological discreteness of the alewife and blueback herring populations in each DPS because it isolates the alewife and blueback herring populations in each DPS from those populations in other DPSs and leads to local adaptations in the fish populations. For example, in 2005, a biological review team ("BRT") studying the status of Atlantic salmon populations along the northern Atlantic coast delineated three DPSs of Atlantic salmon – the Gulf of Maine ("GOM"), Central New England ("CNE"), and Long Island Sound ("LIS") DPSs– based mostly on physiogeographic differences in aquatic environments and the geographic separation between each DPS (Atlantic Salmon BRT ("ASBRT") 2006). The 2005 BRT found that "marine communities to the north of Cape Cod are shaped by substantially different physical factors and thermal regimes than those to the south" and that the "nearshore areas north of Cape Cod are rockier and colder than those south of Cape Cod" (ASBRT 2006: 38). In contrast, the southerly latitude of LIS and its shallow nature (24 m average depth) provide substantially warmer nearshore waters than in the Gulf of Maine through which juvenile and adult fish would have to migrate (ASBRT 2006). This thermal regime likely imposes different time windows for juveniles and adults to use to successfully complete their migrations (ASBRT 2006: 41). In addition, groundwater temperatures are also generally higher in the LIS DPSs than in more northern DPSs (Meisner *et al.* 1988 and Meisner 1990, as cited in ASBRT 2006). Warmer groundwater influences the ecological factors such as food availability, assimilation efficiency, and ultimately growth rates (Allan 1995, as cited in ASBRT 2006). Historically, this likely resulted in proportionally younger juveniles being produced in the LIS DPSs than in DPSs to the north because smolt age is strongly linked to temperature (Forseth *et al.* 2001, as cited in ASBRT 2006). These local differences in both freshwater and nearshore temperature regimes likely resulted in local adaptations (*S*, run timing) that differed substantially from stocks to the north (ASBRT 2006).

Furthermore, the significant geographic distance between the CNE and the LIS DPSs described herein, as well as the barrier resulting from Cape Cod, makes it highly likely that any potential straying of individual alewife or blueback herring will occur solely within a specific alewife or blueback herring DPS, rather than between such DPSs. This phenomenon further increases the discreteness of the DPSs. For example, the 2005 BRT found that Atlantic salmon populations in the LIS and CNE DPSs were distinct due to the geographic separation between the DPSs and their relative isolation (ASBRT 2006).

The area encompassed by the Central New England DPSs is also distinguishable from areas to the north based on ecological factors. For example, the northern Gulf of Maine area (*i.e.*, the area along the Atlantic Coast that includes the Penobscot-Kennebec-Androscoggin and more northern ecological drainage area) differs from the Central New England area (*e.g.*, Saco-Merrimack-Charles, Lower Connecticut, Middle Connecticut, and Upper Connecticut) with regard to basin geography, climate, groundwater temperatures, hydrography, and zoogeography (NMFS 2009b: 74 Fed. Reg. 29344, 29346). These differences are believed to have had a "strong effect" upon Atlantic salmon ecology and production (NMFS 2009b: 74 Fed. Reg. 29344, 29346), and it is probable that these differences exert a similar influence upon other species of anadromous fish such as the alewife and the blueback herring. These differences "would influence the structure and function of aquatic ecosystems [in the northern Gulf of Maine area] … and create a different environment for the development of local adaptations than [existed in] rivers, such as the Saco and Merrimack, to the south" (NMFS 2009b: 74 Fed. Reg. 29344, 29346).

To similar effect, in designating a Chesapeake Bay DPS for Atlantic Sturgeon, NMFS found the area was "markedly separate" from areas to the north and south "as a consequence of physical factors" (NMFS 2010b: 75 Federal Register 61872, 61876). And in designating a Carolina DPS for Atlantic Sturgeon in 2010, NMFS emphasized that it believed the distinction it was drawing between a Carolina DPS and a Southern Atlantic DPS to the south was supported by the Nature Conservancy's determination that those two areas were separate and distinct from one another by way of habitat, climate, geology, and physiographic characteristics of the region (NMFS 2010c: 75 Fed. Reg. 61904, 61909). Relative to the more northern proposed DPSs, the Chesapeake DPSs and the Carolina DPSs encompass populations exposed to warmer water temperatures and other different ecological factors; exposure to these relative physical extremes is likely to have created selection pressures that influence the distribution of genotypes in these populations.

These four DPSs of alewife and three DPSs of blueback herring are significant pursuant to the ESA because alewives and blueback herring are each found in these four unique ecological settings.[30] In each of these settings, the ecological significance of the alewife and/or blueback community extends beyond the unique features of the populations themselves and includes the ecosystem context in which they are located. As cornerstone forage species in these ecosystems, both alewives and blueback herring play a vital role in the estuarine and riverine food web. The collapse of the populations in each of these DPSs unquestionably impacts other species to which it is trophically linked. Given the importance of the four unique ecological settings in supporting numerous other at-risk populations and species, a loss of the populations of either blueback herring in the three requested DPSs or alewives in the four requested DPSs would represent a significant impact to conservation of other endangered and/or threatened species.

Available data also indicates that alewife and blueback herring populations are each unlikely to stray to rivers beyond their existing DPS; and, due to low gene flow among populations, the loss of one or more of these populations could negatively impact the species as a whole. Since there is little gene flow among populations from different rivers and estuaries, the loss of even a single population – and certainly the loss of the populations within the entirety of any of the requested DPSs – will result in the removal of a section of the species' range where it has been viable and will therefore reduce the genetic diversity of the taxon as a whole. This is especially significant given the expected changes in climate and habitat due to global warming. The ability of the alewife and the blueback herring to each adapt to climate change depends on genetic and

[30] As NMFS noted in proposing DPSs for the Atlantic Sturgeon in 2010, the Central New England DPS, Chesapeake Bay DPS, and the Carolina DPS each persists in unique ecological taxon, as each proposed grouping is found in a separate and distinct ecoregion identified by The Nature Conservancy (NMFS 2010b: 75 Federal Register 61872, 61877; NMFS 2010c: 75 Fed. Reg. 61904, 61909).

geographic diversity, as maximum gene variation increases the odds that genes will carry traits amenable to climate change adaptation, such as for thermal tolerance.

Specifically, the Central New England DPSs for the alewife and for the blueback herring are significant because of the abundant populations of alewives and bluebacks that historically occurred (and served as a significant bait source for commercial and recreational fisheries) in rivers within the boundaries of these DPSs (NHFGD 2009: 3, 16, Table 1-1). For example, the Taylor River in New Hampshire was once home to a run of almost a half million river herring, and the Oyster River saw more than 100,000 river herring annually make their way upriver to spawn as recently as the 1990s (NHFGD 2009: 16, Table 1-1; NHFGD 2011a). Although the runs in these two rivers – a few decades ago, the two largest in the DPSs -- have been decimated, they remain important with the Oyster containing a run of approximately fifteen thousand fish (reportedly dominated by bluebacks) (NHFGD 2011). The Central New England DPSs contain other important alewife populations, including the Cocheco and the Lamprey in New Hampshire.

For alewives in particular, many of the rivers in the Central New England DPS were historically key spawning habitat and the populations in these rivers were a key part of why this species is of such cultural and historical importance for the region. Historically important rivers in this DPS like the Parker River in Massachusetts still retain spawning populations of alewives, even if at a small fraction of their historic size.

The Long Island Sound DPSs for both the alewife and the blueback herring are significant given the numerous intact spawning populations of alewife and blueback herring in the Connecticut River system, which has the largest drainage basin in Long Island Sound, and in other river systems within the DPSs. The Connecticut River has recently supported the largest known population of spawning blueback herring north of the Chesapeake Bay. Several historically and currently important Massachusetts spawning rivers – the Nemasket, the Monument, and the Mattapoisett rivers – also drain to LIS and would be included in these DPSs. River herring were historically one of the most valuable anadromous fishes harvested and sold commercially in Massachusetts (MADMR 2011: 2). Fish counts on the Monument once numbered more than half a million alewives and almost 100,000 blueback herring, and Mattapoisett River alewife counts numbered in the 100,000s as recently as the late 1990s (ASMFC 2008: 195, Table 4.3; MADMF 2011: 52, Appendix Table 4). The Nemasket River has seen an average of almost 800,000 counted spawning alewives annually since 2000 (MADMF 2011: 52, Appendix Table 4).

The Chesapeake Bay DPSs for both the alewife and the blueback herring are significant as demonstrated by the region's unparalleled historic river herring fishery. An average of more than 28 million pounds of alewife and blueback herring were commercially landed per year in Virginia and Maryland from 1950 to 1970, and during these peak harvest years Virginia consistently boasted the highest river herring catches of any state (ASMFC 2008: 55-57, Table 1.5.1.1). The traditional river herring fisheries have cultural significance (ASFMC 2008: 453; SRAFRC 2010: 8); in Virginia, alewives are generally the first anadromous species available for harvest each year, and the spring spawning runs of both alewives and blueback herring are important cultural and culinary events (ASFMC 2008: 453). Although commercial fisheries in this region have declined, populations persist in rivers that drain to the Bay.

The Carolina DPS for alewife is significant because of both its historical importance (it boasted the second largest river herring catches in the peak harvest period from the 1950s to 1970s (ASMFC 2008: 55-57, Table 1.5.1.1)) and its remaining population levels, based on available data. Although now much depleted, sampling in the Chowan River and Albemarle Sound in 2009 showed alewives continuing to spawn in the region. In the Chowan River, alewives had a maximum age of 6 in males and 7 in females, and 11 percent of alewives were repeat spawners (NCDMF 2010b: Tables 36 and 37). In Albemarle Sound, samplers found alewives as old as 7; 16 percent of alewives were repeat spawners (NCDMF 2010b: Tables 38 and 39). The Carolina DPS is also significant because it is comprised of the southernmost populations of alewives that are at the highest risk of extirpation, given that alewives are currently absent from rivers where they spawned historically in the southernmost portion of this DPS, as well as in waters south of this DPS.

In the alternative, NMFS should delineate alewife DPSs and blueback herring DPSs based on its expertise and list each DPS pursuant to the ESA listing criteria.

III. THE ALEWIFE AND THE BLUEBACK HERRING SATISFY THE STATUTORY CRITERIA FOR LISTING AS THREATENED SPECIES

To determine whether a species is endangered or threatened, NMFS must consider five statutorily prescribed factors:

> (A) the present or threatened destruction, modification, or curtailment of its habitat or range; (B) overutilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) the inadequacy of existing regulatory mechanisms; or (E) other natural or manmade factors affecting its continued existence.

16 U.S.C. § 1533(1)(A)-(E). The agency "must consider each of the listing factors singularly and in combination with the other factors." *Carlton v. Babbitt*, 900 F. Supp. 526, 530 (D.D.C. 1995). "Each factor is equally important and a finding by the Secretary that a species is negatively affected by just one of the factors warrants a non-discretionary listing as either endangered or threatened." *Nat'l Wildlife Fed. v. Norton*, 386 F. Supp. 2d. 553, 558 (D. Vt. 2005) (citing 50 C.F.R. § 424.11(c)). Likewise, a species must be listed if it is endangered or threatened because of "a combination of" factors. *See, e.g.*, 50 C.F.R. § 424.11(c).

As further discussed below, the alewife and the blueback herring and each of the requested DPSs are likely to become an endangered species within the foreseeable future in all or a significant portion of each species' ranges as a result of the statutorily-prescribed factors.

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

Alewives and blueback herring, like all anadromous fish, are vulnerable to a variety of habitat impacts because they use rivers, estuaries, bays, and ocean waters at various points of their life. Habitat alterations potentially affecting alewives and blueback herring include dam construction and operation, dredging and disposal, and water quality modifications such as changes in levels of DO, water temperature, and contaminants. Loss of habitat and impaired water quality has contributed to the decline of the alewife and the blueback herring since colonial times, and climate change poses an increasing threat to both species.

Industrial development adjacent to waterways along the Atlantic coast contributed to early declines in alewife and blueback herring populations. For example, the construction of mill dams and other blockages prohibited the upstream migration of alewives and blueback herring and significantly reduced their spawning habitat (Watts 2003; ASMFC 2008). In addition, industrial pollution degraded the water quality in coastal rivers and rendered many waters unsuitable as spawning and nursery habitat (Watts 2003; ASMFC 2008). Increased wastewater discharges from a rapidly-expanding population along the Atlantic seaboard, particularly from coastal cities, further impaired many water bodies, including through the formation of dissolved oxygen blocks that prohibited the migration of alewives and blueback herring (ASMFC 2008).

1. Dams and Turbines

Dams are significantly impairing populations of alewife and blueback herring by blocking access to spawning and foraging habitat, changing water flow, quality and temperature, and physically injuring and killing fish as they migrate. Dams, particularly hydropower dams (those associated with hydroelectric facilities that respond to daily changes in electricity use), often produce daily water flows and temperatures that substantially differ from natural seasonal flows. Variations in natural seasonal water flows and temperatures can disrupt productivity and availability of zooplankton needed for larval and early juvenile forage for fish such as alewives and blueback herring (USFWS/SCDNR 2001; Limburg 1996: 223, 232, 235; ASMFC 2009b: 344 and Chapter 4). Flow variations can also adversely affect the survival of larvae and young juveniles by displacing eggs and/or larvae from otherwise highly productive habitats and disrupting both upstream and downstream migration patterns for adult and juvenile alosines (ASMFC 1999; USFWS/SCDNR 2001; ASMFC 2009b: 344 and Chapter 4). Low flows can reduce the suitability of habitat for spawning by reducing minimum flows or dewatering otherwise productive habitats (ASMFC 1999; NMFS 1998; USFWS/SCDNR 2001). Too much water flow also poses a problem at dams with fishways, adversely affecting juvenile migration; at one South Carolina dam, congregating adult blueback herring were unable to locate the entrance to the fish passage due to high turbulence caused by dam discharges (ASMFC 2009b). Water releases from deep reservoirs may be poorly oxygenated and/or of below normal seasonal water temperature, thereby causing loss of suitable spawning or nursery habitat in otherwise suitable river reaches, and thermal effluent from power plants can cause disruptions of fish schooling behavior, disorientation, and death (ASMFC 1999; NMFS 1998; ASMFC 2009b: 344; USFWS/SCDNR 2001). Other problematic water quality changes often related to dams include accelerated eutrophication, artificially destratified waters, and changes in sediment loads and nutrient cycling (ASMFC 1999; NMFS 1998; USFWS/SCDNR 2001; ASMFC 2009b: 344)

Damming rivers used by alewives and blueback herring can result in the loss of access to significant portions of their spawning and foraging habitat. Dams, both hydropower and other types, have cut off access to large portions of alewife and/or blueback herring habitat in such rivers as the Sebasticook, Taylor, Delaware, Susquehanna, and Santee-Cooper.

Entrainment in turbines also causes injury and mortality to eggs, larvae, and juvenile and adult alewives and blueback herring as they drift or migrate upstream and downstream. Turbines can slash migrating fish, harming or killing them, and additional injuries and deaths occur from changing water pressures. Evidence suggests that changes in pressure can have a pronounced effect on juveniles with thinner and weaker tissues as they move through turbines and that, as a result, some fish may die later from stress or become weakened and more susceptible to predation (ASMFC 2009b: 330-31). Turbines are used with both hydropower dams and tidal power plants. Tidal hydroelectric power plants located at the mouths of rivers can directly impact alewives and blueback herring, as well as other anadromous fish, because fish may move into and out of the impacted area with each tidal cycle. Repeated passage into and out of these facilities may cumulatively result in substantial overall mortalities (ASMFC 2009b: 333).

2. Dredging and Blasting

Dredging and blasting operations in riverine, coastal, and offshore areas are a significant threat to the alewife and the blueback herring. These operations are conducted to support commercial shipping and recreational boating, construction, and mining. Harmful environmental impacts from dredging include direct removal/burial of organisms; turbidity/siltation effects; contaminant resuspension; noise/disturbance; alterations to hydrodynamic regime and physical habitat and actual loss of riparian habitat. Specific impacts to important habitat features for the alewife and the blueback herring include increased levels of suspended sediments, changes in water velocities, and alteration of substrates (ASMFC 2009b). Migrating adult alewives and blueback herring have been found to avoid channelized areas with increased water velocities (ASMFC 2009b: 349). Migrating alosines are known to avoid waters with high sediment loads (ASMFC 2009b: 349). The alewife and the blueback herring, as well as other filter-feeding fish, can be negatively impacted by suspended sediments on gill tissues, which can clog gills that provide oxygen and result in lethal and sub-lethal effects to the fish (ASMFC 2009b: 349).

Indirect harm to the alewife and the blueback herring resulting from dredging can include disruption of spawning migrations, releases of contaminants, reduced DO levels, and deposition of re-suspended sediments in spawning habitat. Siltation from dredging can reduce spawning success by causing mortality of eggs or by coating substrates needed for attachment of adhesive eggs (NMFS 1998). Dredging operations that include the draining and filling (or both) of wetlands adjacent to spawning habitat can harm alewives and blueback herring by adversely modifying spawning habitat. Survival of larval alosines decreases as turbidity or suspended sediments increase above 50 mg/l (USFWS/SCDNR 2001).

3. Water Quality

Adverse water quality conditions have resulted in, and will continue to result in, the loss and adverse modification of alewife and blueback herring habitat and significant harm to both species. Water quality threats to the alewife and the blueback herring include hypoxia (low oxygen), due in part to high nutrient loadings; toxic and/or bioaccumulative pollutants, including metals and organic chemicals; excessive runoff of silt and soil; and harmful changes to water temperature and flow (ASMFC 2009b). These water quality threats are the result of activities both in riparian zones and in watersheds as a whole, including nutrient runoff and erosion from residential and industrial development; discharges of toxic pollutants and changes to water temperature and flow as a result of industrial activities; and erosion, runoff of nutrients and agricultural chemicals, and changes to water flow as a result of agricultural and forestry activities (ASMFC 2009b). Poor water quality alone can significantly impact an entire population of alewife or blueback herring. For example, it is believed that the heavy organic loading near Philadelphia, Pennsylvania during the 1940s and 1950s caused severe declines in DO levels and made parts of the lower Delaware River uninhabitable for the alewife and the blueback herring during the warmer months of the year (ASMFC 2008: 392).

Hypoxic water quality conditions pose a particular threat to the alewife and the blueback herring. Both the minimum dissolved oxygen concentration for alewife and blueback herring eggs and larvae and the suggested minimum dissolved oxygen concentration for adult alewives and blueback herring are 5.0 mg/L (ASMFC 2009b). Adult and juvenile alewives become stressed when dissolved oxygen concentrations drop below 3.0 mg/L and 2.0 mg/L, respectively (ASMFC 2009b). Hypoxic water quality conditions in alewife and blueback herring habitat have generally increased in spatial extent and frequency over the last century (ASMFC 2009b: 149). According to the ASMFC (2008), there is a historical correlation between low alewife and blueback herring abundances and an increase in hypoxic conditions. A lack of dissolved oxygen can significantly affect the abundance of anadromous fish generally (ASMFC 2009b: 344). It can also prevent migration upriver or prevent adults from migrating to sea and returning to spawn (ASMFC 2009b: 344). Everett (1983) found that, during times of low water flow when pulp mill effluent comprised a large percentage of the flow, alewives and blueback herring avoided the effluent (ASMFC 2009b). Pollution may be diluted when the water flow increases, but fish that reach the polluted waters downriver before water has flushed the area will typically succumb to suffocation (Miller *et al.* 1982, as cited in ASMFC 2009b).

The alewife and the blueback herring are also susceptible to toxic chemicals and metals that are released into their habitat. The substrate of a significant portion of alewife and blueback herring habitat, particularly habitat near urbanized areas or large industrial discharges, is contaminated with dioxins, polychlorinated aromatic hydrocarbons ("PAHs"), organophosphate and organochlorine pesticides, polychlorinated biphenyls ("PCBs"), and other chlorinated hydrocarbon compounds, as well as toxic metals, such as lead, mercury and arsenic. Alewives and blueback herring are exposed to such contaminants via diet, water, and dermal contact. In 1999, ASMFC (1999: 12) reported that pollution comprised of heavy metals and various organic chemicals had increased over the preceding 30 years in nearly all estuarine waters along the Atlantic coast due to industrial, residential, and agricultural development in the watersheds. This pollution occurs in alewife and blueback herring spawning and nursery habitat and is believed to be harmful to aquatic life (ASMFC 1999:12; NMFS 2010b: 75 Fed. Reg. 61872, 61885).

Effects of chlorinated hydrocarbons and/or metals on fish include acute lesions, growth retardation, malformations, reproductive impairment, reduced egg and larval survival, and behavioral (including homing) impacts (ASSRT 2007; NMFS 2010b: 75 Fed. Reg. 61872, 61885). Exposure to heavy metals specifically can cause increased mortality in fish species, and chronic toxicity can also lead to reproductive failure, changes to physiology, and increased vulnerability to predation and infection (ASSRT 2007; NMFS 2010b: 75 Fed. Reg. 61872, 61885 (noting "correlation between low abundances of sturgeon during this century and decreasing water quality caused by increased nutrient loading and increased spatial and temporal frequency of hypoxic conditions"). Heavy metals have affected fish species by reducing their reproductive success by as much as a factor of three, and by causing oxidative stress, brain lesions, altered behavior, and vertebrae fragility (ASSRT 2007).

4. Climate Change

Global warming is harming the alewife and the blueback herring and each species' habitat. The severity of these harms will increase in the future. According to NMFS (2009b: 74 Fed, Reg. 29344, 29356), "[s]ince the 1970s, there has been a historically significant change in climate (Greene *et al.* 2008). Climate warming has resulted in increased precipitation, river discharge, and glacial and sea-ice melting (Greene *et al.* 2008)." More recently, NMFS has specifically acknowledged the adverse effects of climate change on fish species that travel along the Atlantic coast (NMFS 2010b: 75 Fed. Reg. 61872, 61886). For example, a 2005 study found that a "1 °C increase of water temperature in the Chesapeake Bay would reduce available sturgeon habitat by 65 percent." (NMFS 2010b: 75 Fed. Reg. 61872, 61887). The Intergovernmental Panel on Climate Change ("IPCC") (2007) has concluded that global warming caused by humans is already impacting the habitats and biology of species worldwide. Such effects are occurring faster than scientists had previously predicted (Boesch *et. al.* 2007).

As early as 2001, the IPCC (2001: 670) noted that "[d]etailed analyses of fish physiological response to water temperature have shown that the potential impact of climate change on freshwater and marine fish is large. . . . High sensitivity to water temperature of fish larval and juvenile stages, combined with the higher susceptibility of headwaters and smaller rivers to air temperature rise, implies important effects of climate change on cold and temperate anadromous species . . . ." More recently, the IPCC (2007: 275) stated that it has a high level of confidence that "[r]egional changes in the distribution and productivity of particular fish species are expected due to continued warming and local extinctions will occur at the edges of ranges, particularly in freshwater and diadromous species . . . ."

Higher water temperatures as a result of global warming may affect the spatial distribution, migration, and reproduction of alewife and blueback herring populations. As discussed *supra*, for example, the upstream migration of alewives slows as water temperatures rise and has been reported to cease when water temperatures reach 21 degrees Celsius (ASMFC 2009b).

Global warming is also causing increased precipitation in many estuary systems along the Atlantic coast (Kerr *et al.* 2009). In the Northeast United States, annual precipitation is expected to increase by 10 percent (Kerr *et al.* 2009), winter precipitation by 10 to 15 percent (Hayhoe *et al.* 2007), with higher increases in certain areas like Maryland (Center for Integrative Environmental Research ("CIER") 2008). Precipitation in the Northeast has increased 3.3 inches, or 8 percent, over the past 100 years, with eight of the ten wettest years occurring since 1970 and the greatest increases tending to be either near the Atlantic Coast or major bodies of water (Markham and Wake 2005: 16-17). An increase in the number of heavy precipitation events is also predicted (Kerr *et al.* 2009).

The greater intensity of floods, as well as droughts, will lessen the frequency of successful annual reproduction for anadromous fishes (Limburg and Waldman 2009). As discussed *supra,* high and/or fluctuating water flows are believed to adversely affect river herring migration (ASMFC 2009b). For example, global warming is believed to be already changing river flows in New England, resulting in earlier winter/spring seasonal center-of-volume dates because of greater rainfall and earlier snowmelts (Markham and Wake 2005: 11). According to MADMF (2011):

> Changes in weather as a result of climate change can impact many aspects of the alewife and blueback life stages. Changes in rainfall patterns could affect the food production in the nursery areas and cause higher mortality of juveniles as competition for limited zooplankton resources is believed a major factor affecting survival and growth of juveniles (Walton 1983). Such changes can cause shifts in the carrying capacity of a nursery ground and ultimately affect recruitment.

Further, global warming increases the occurrence of and/or severity of hypoxic conditions in estuaries, bays, and rivers (Boesch *et al*. 2007). The capacity of water to absorb oxygen decreases as it warms; in the Chesapeake Bay, for example, the capacity to dissolve oxygen decreases by about 1.1 percent with each degree Fahrenheit that the water warms (EPA ND: 5). Greater precipitation also results in greater discharges of nutrient pollution into rivers and estuaries, leading to increased eutrophication and hypoxic conditions (Howarth *et al.* 2006). These effects have been accelerating in recent years and are expected to continue to accelerate (Howarth *et al.* 2006).

In a recent NMFS study, clear shifts in spatial distribution were observed in the majority of fish stocks studied on the northeast United States continental shelf (Nye *et al.* 2009: 124). Twenty-four of the 36 stocks studied, including the alewife, displayed statistically significant changes consistent with warming, as indicated by a poleward shift in the center of biomass, an increase in mean depth of occurrence, and/or an increase in mean temperature of occurrence (Nye *et al.* 2009: 124). The alewife demonstrated a notable poleward shift in the center of biomass and an increase in mean depth of occurrence (Nye *et al.* 2009: 120). The lack of an increase in mean temperature of occurrence for the alewife suggests that the species shifted their distribution to remain within their preferred temperature range (Nye *et al.* 2009: 125).

The distributional response to higher water temperatures differed between northern populations and southern populations of fish species, with a much larger poleward shift in the center of biomass observed in the southern stocks than in the northern stocks (Nye *et al.* 2009: 124). In response to higher water temperatures, northern populations of fish appeared to respond by shifting to deeper depths and, in general, to experience a range contraction relative to southern populations of fish species (Nye *et al.* 2009: 121,124). Distributional responses were most pronounced in southern species for which their centers of biomass were historically in Southern New England and the Mid-Atlantic Bight, with the center of biomass for most of the southern stocks shifted to the northwest over the time series (Nye *et al.* 2009: 125). Furthermore, because of the influence of temperature as a migratory and reproductive cue, increased temperatures are also likely to substantially alter reproductive timing and possibly reproductive success of many fish species (Kerr *et al.* 2009).

According to Limburg and Waldman (2009), the tendency of most anadromous fish species to segregate out into smaller river-specific populations "makes them more susceptible to population level extirpations, and, if these extirpations occur serially, species extinction may occur." As NMFS similarly discussed in listing a DPS of the eulachon, a Pacific anadromous herring, because alewives and blueback herring show fidelity to particular spawning rivers, adult and larval/juvenile alewives and blueback herring must respond to local changes in spawning and nearshore-rearing conditions, respectively, and cannot simply shift their "distribution and geographical center of spawning in response to environmental changes" as fully marine species might (NMFS 2010d: 75 Fed. Reg. 13012, 13017). Moreover, migration between freshwater and the ocean exposes them to sources of harm in two different environments. Limburg and Waldman (2009) note that global warming seems to be pushing anadromous fish towards earlier spawning runs, which may disrupt their established relationships, and may intensify floods and droughts and thereby impair fish reproduction. In listing the Gulf of Maine DPS for Atlantic salmon, NMFS itself has concluded that climate change is already causing environmental changes in the Gulf of Maine, including earlier spring runoff and decreased water flow, and that such changes may be causing changes in run timing for such species as Atlantic salmon.

Global warming is also believed to have caused recent sharp declines in phytoplankton levels, which are down by 40 percent since the 1950s (Borenstein 2010). A sustained decline of phytoplankton threatens the food supply of forage fish species, such as the alewife and the blueback herring, as well as the health of the entire marine ecosystem that depends on forage fish species to convert energy from zooplankton and phytoplankton to sustain larger predatory species.

Other adverse impacts of climate change include (1) as a result of rising sea levels, reduced habitat complexity and quality in alewife and blueback herring spawning and nursery habitat (*e.g.*, Weaver 2009); (2) a further decline in repeat spawners in areas such as North Carolina as energy needs increase for migration because of decreasing habitat quality in downstream areas (Weaver 2009); (3) an increased likelihood that a severe storm will occur during the critical "hatch-out stage" leading to more frequent year class failures (Gephard ND: 4); (4) increased adverse effects from severe storms as a result of habitat destruction and existing dams (Gephard ND: 4 (for example, when severe storms occur, dams are more likely to fail or allow the release of deleterious substances like sand, oil, plastics and sewage into fish habitat; this is more likely with "more severe weather predicted with climate change as well as the deterioration of aging dams that were built in the 1800s")); (5) the implementation of flood mitigation measures, such as dikes to counter rising sea levels, that will interfere with migration and impair a variety of habitats (Gephard ND: 6); and (6) increased prevalence and severity of certain marine diseases (Kerr *et al.* 2009; Hoegh-Gulberg *et al.* 2010).

Increasing atmospheric carbon dioxide concentrations are also causing a decrease in ocean water pH (Feely *et al.* 2004). Studies to date indicate that such "ocean acidification" will generally have negative effects on marine organisms (Kroeker *et al.* 2010). Impacts on fish species such as river herring will be both indirect, such as a result of food web disruptions, and direct. Early fish life stages are considered particularly vulnerable. In a study of early developmental stages of Atlantic herring, Franke and Clemmesen (2011) found that increased carbon dioxide partial pressure in seawater and decreased pH can affect the metabolism of herring embryos negatively and reduce somatic growth of larvae.

The ability of the alewife and the blueback herring to adapt to climate change and ocean acidification depends on genetic and geographic diversity, as maximum gene variation increases the odds that genes will carry traits amenable to climate change and ocean acidification adaptation. Moreover, both species' ability to withstand the stresses that will be brought by climate change and ocean acidification will depend on the species' resilience and relative vitality. Where fish species have both high fertility and mortality, high minimum population sizes may be needed in part to produce enough offspring to buffer against the variability of local environmental conditions that may lead to random ''sweepstake recruitment'' events where only a small minority of spawning individuals contribute to subsequent generations – and climate change, for example, may intensify extreme weather events like floods and droughts that can lead to such events (NMFS 2009c: 74 Fed. Reg. 10857: 10868-69). Since many alewife and blueback herring populations are disappearing or extremely depleted, climate change and ocean acidification are threats to each of these species as a whole. In part for these reasons, in a recent determination to list another anadromous forage fish, the eulachon, as threatened, climate change specifically was identified as the most significant threat to the species and its habitat (NMFS 2009c: 74 Fed. Reg. 10857: 10870.)

5. Threats to Specific Rivers and Estuaries Affecting the Alewife and the Blueback Herring

St. Croix River

In the mid-1980s, the alewife population in the St. Croix River was estimated at approximately 2.6 million fish (ASMFC 2008). The closures of fishways at the Vanceboro dam in 1988 and at the Woodland and Grand Falls dams in 1995 blocked the upstream migration of alewives(as well as other anadromous fish), preventing them from reproducing (Flagg 2007). Following these closures, the St. Croix alewife population collapsed (ASMFC 2008).

Damariscotta River System

The FWS recently indicated that the fishway at Damariscotta Lake is in need of modification and/or repair (ASMFC 2008). Abnormally high or low water levels at the fishway prevent alewives, especially female alewives, from successfully ascending the fishway (ASMFC 2008).

Kennebec River System

Numerous hydroelectric dams in the Kennebec River and its tributaries present a significant threat to the Kennebec River alewife and blueback herring populations. Even with "effective" upstream and downstream passage facilities, the MEDMR estimates a loss of 10 percent of migrating American shad, much like alewives, at each main-stem Kennebec River hydropower dam due to turbine entrainment, injury and mortality (MEDMR 2009: 3-1).

The Army Corps of Engineers routinely dredges the lower part of the Kennebec River, and Bath Iron Works conducts maintenance dredging. Dredging, which occurs from November through April, can disrupt the spawning migrations of alewives returning to the Kennebec River and its tributaries.

The head-of-tide to mid-estuary regions of the Kennebec River suffered DO levels of zero ppm during summer months in the late 1960s and early 1970s, causing frequent fish kills (ASSRT 2007). Although DO levels have improved since that time, multiple other water quality problems remain. Dioxin and other dioxin-like compounds were found in fish samples as recently as 2008 and the Kennebec River remains subject to fish consumption advisories (Maine Department of Environmental Protection ("MEDEP") 2006: 4-6, 22; MEDEP 2009: 5-8, 18-21).

Significant salinity changes occurred in the early 1990s in "the Northwest Atlantic, where … a dramatic shift in shelf ecosystems occurred" (NMFS 2009b: 74 Fed. Reg. 29344, 29376). "The major shifts observed specifically in the [Gulf of Maine] and Scotian shelf ecosystems in the early 1990s [were] specifically linked to these changes in salinity and lower trophic communities" (NMFS 2009b: 74 Fed. Reg. 29344, 29376). Changes in salinity may hamper the recovery of fish species in the Northwest Atlantic, as it is believed that such changes – specifically, the entrance of cold, low-salinity Arctic waters – in the Northwest Atlantic hampered the recovery of cod after its collapse in early 1990s due to overfishing (NMFS 2009b: 74 Fed. Reg. 29344, 29376). According to NMFS, studies indicate that "small thermal changes may substantially alter reproductive performance, smolt development, species distribution limits, and community structure of fish populations." (NMFS 2009b: 74 Fed. Reg. 29344, 29377).

Androscoggin River

Numerous hydropower dams between the head-of-tide and spawning and nursery habitat exist on the main stem of the Androscoggin River and on the Little Androscoggin River (ASMFC 2008). These hydropower stations are believed to have significant negative impacts on the survival of downstream adult alewife and blueback herring migrations (ASMFC 2008). These hydropower stations are assumed to significantly impact survival of downstream adult migration of the Androscoggin alewife and blueback herring populations (ASMFC 2008).

The head-of-tide to mid-estuary regions of the Androscoggin Rivers suffered DO levels of zero ppm during summer months in the late 1960s and early 1970s, causing frequent fish kills (ASSRT 2007). Although DO levels have improved since that time, multiple other water quality problems remain and adversely affect the population. For example, the Androscoggin holds the record for the highest levels of dioxin found in fish in the state of Maine. Dioxin and other dioxin-like compounds were found in fish samples as recently as 2008 and the river remains subject to fish consumption advisories (NMFS 20101b: 75 Fed. Reg. 61872, 61885; MEDEP 2006: 4-6, 15-20; MEDEP 2009: 5-8, 15-17).

New Hampshire Rivers

In 2008, the EPA concluded that bacterial and nutrient contamination, toxic contaminants, the loss or fragmentation of habitat, and degraded salt marshes remain high-priority problems for fish and other wildlife inhabiting New Hampshire rivers and estuaries (EPA 2008). These problems are, in large part, the result of a recent rate of population growth in the surrounding area that has been six times the rate for coastal counties in the Northeast as a whole (EPA 2008).

Water quality in New Hampshire rivers and estuaries is relatively poor when compared to other Gulf of Maine coastal areas in the EPA's National Estuary Program (EPA 2008). Non-point source pollution (*e.g.*, stormwater runoff) affects the majority of alewife and blueback herring habitats in New Hampshire and is a major factor affecting the water quality of the Taylor River and other coastal rivers in southern New Hampshire (EPA 2008).

Nutrient pollution in particular has been a growing problem in New Hampshire waterways. NHFGD (2011) cited eutrophication in the impoundment on the Oyster River, which serves as nursery habitat, as well as the use of the river for water supply, as possible reasons for the decline of river herring in the river since the mid-1990s. Poor water quality was also documented in nursery habitat above the Great Dam in the Exeter River (NHFGD 2011). Between 1992 and 2001, nitrogen concentrations increased in the Lamprey River and other rivers around the Great Bay (EPA 2008). According to a 2009 report, the total nitrogen load to the Great Bay Estuary increased by 42 percent in the prior five years, dissolved inorganic nitrogen concentrations increased in Great Bay by 44 percent in the past 28 years, and dissolved oxygen concentrations have consistently failed to meet water quality standards in tidal rivers (Piscataqua Region Estuaries Partnership ("PREP") 2009: 3-4). The significant and continuing population growth in these areas – development has created new impervious surfaces at an average rate of nearly 1,500 acres per year in recent years (PREP 2009: 3, 26) – further suggests that rivers in these areas have an increased risk of eutrophication in the future.

Finally, the fragmentation of open lands due to new roads and sprawling patterns of development pose substantial threats to habitat and hydrologic functions in New Hampshire's coastal watershed (EPA 2008).

Massachusetts Rivers

MADMF (2004) (2005) discussed the multiple obstructions to passage of alewives and blueback herring to spawning habitat on multiple rivers and streams in the state.

Buzzards Bay (Monument River and Mattapoisett River)

In 2007, the EPA rated the sediment toxicity in Buzzards Bay as poor (EPA 2008). There were high levels of contaminants in fish tissue sampled from 2000 to 2001, with 83 percent of fish samples analyzed exceeding EPA Advisory Guidance values for at least one contaminant (EPA 2008). A 2005 study of eelgrass, which is an indicator species for changes in water quality and for tracking the overall health of a marine ecosystem, showed a clear trend in declining eelgrass coverage with increased nitrogen loadings (EPA 2007: 91).

Ipswich River

The Ipswich River has been named one of the most threatened rivers in the nation, and has been listed as impaired under the Clean Water Act (Ipswich River Fisheries Restoration Task Group 2002). River herring on the Ipswich River are adversely affected by water withdrawals and diversions, dams, changes in land use, low dissolved oxygen levels (Ipswich River Fisheries Restoration Task Group 2002).

Narragansett Bay (Nonquit River and Gilbert-Stuart River)

In 2007, the EPA National Estuary Program rated the estuarine conditions in Narragansett Bay as poor (EPA 2008: 266). Major environmental concerns for rivers and tributaries draining into Narragansett Bay include eutrophication, nutrient loading, and pathogens. An increasing array of eutrophic-associated symptoms have been observed, including low DO levels and fish shellfish kills caused by excess nitrogen and other nutrients; a 2005 study compared current DO levels to those from 1959 and determined that the presently observed low DO conditions are likely a relatively new feature of Narragansett Bay (EPA 2008: 255-56).

Low DO levels have occurred in upper portion of Narragansett Bay every summer for at least the past decade (EPA 2008). Since data collection began in 1999, fish kills have been reported every year but one (2000) in the upper portion of Narragansett Bay (EPA 2008). In 2003, hypoxia caused a massive fish kill of more than one million fish (EPA 2008). These events put extreme stress on the marine ecosystem, altering fish distribution and affecting juvenile growth.

EPA has rated the sediment quality in Narragansett Bay as poor (EPA 2008: 266). Moderate and high concentrations of metals and organochlorine chemicals, such as DDT and PCBs, were measured in about half of the Bay’s sediment samples. More than ninety percent of fish tissue samples collected in 2000-2001 contained PCB levels that exceeded the EPA’s Advisory Guidance values for fish consumption (EPA 2008: 266).

Connecticut River and Long Island Sound

The Connecticut River is the most significant drainage basin for Long Island Sound, which the EPA National Estuary Program rated as in poor condition in 2007 (EPA 2008). Toxic substances, such as metal and organic chemicals, from manufacturing sources, stormwater runoff, household cleaning and pest-control products, and automobile and power plant emissions continue to enter Long Island Sound (EPA 2008). The loss of wetlands, forests, farm areas, and other open spaces to increased population, development, and urban sprawl has increased pollution and stormwater runoff to the Sound.

A 2006 review of the contaminants in the Connecticut River indicated high levels of total mercury and dioxin-like (coplanar) PCB in the river (ASSRT 2007). The lower portion of the Connecticut River is also dredged every six to seven years to maintain a federal navigation project.

Global warming will increasingly adversely affect alewife and blueback herring habitat in the Connecticut River. Temperatures in Connecticut have been increasing over the last century and are expected to increase an additional 4 or more degrees Fahrenheit in all seasons by 2100 (EPA 1997a; Frumhoff *et. al.* 2007). Precipitation is also predicted to increase by 10 to 20 percent (EPA 1997a). Increased temperatures and precipitation will lead to increased hypoxic conditions in the river, which impairs the use of river habitat by alewives and blueback herring. Marshall and Randhir (2008) modeled the impacts of expected climate change on the Connecticut River watershed. The simulation results showed significant impacts of climate change on the available quantity of water, decreasing water storage during the winter months and impacting surface runoff rates. The change in water availability would place severe strain on spring anadromous fish runs. According to Marshall and Randhir, climate change also will have significant impacts on water quality, increasing sediment loading up to 50 percent and decreasing volumes of receiving water by up to 19 percent. Climate change will also impact nutrient cycles and the N: P ratio of annual loading, likely resulting in increased algal growth. Under two different climate change scenarios, the watershed is more nitrogen limited and has a higher risk of eutrophication.

Hudson River

The EPA's 2004 National Coastal Condition Report noted particular concern about water quality, sediment, and tissue contaminants in the Hudson River, and the 2008 National Coastal Condition Report rated the NY/NJ region's water quality as poor (EPA 2008). PCBs, the chief Hudson River contaminant of concern, cause fin erosion, epidermal lesions, anemia, immune system disorders, reproductive failure, and mortality in fish. While the PCB levels have declined since the 1970s, fish consumption advisories based on PCB contamination are still in place for fish caught between Troy Dam and Catskill. Fish consumption advisories for three species of Hudson River fish based on mercury, PCB, and cadmium contamination are in place in other parts of the river.

Sewage discharge into parts of the Hudson River has been increasing due to population growth in certain adjacent communities, and the decomposition of the sewage has caused hypoxic areas to form in multiple parts of the river (ASSRT 2007). Climate change will likely exacerbate these problems, including by increasing precipitation, and therefore discharges of nutrients, into the river, resulting in increased occurrence and/or severity of eutrophic conditions (Howarth *et al.* 2006).

The Hudson River populations of alewives and blueback herring may also be adversely affected by Verdant Power's proposal to build a marine turbine project on the East River, New York. The company tested two slow speed tidal turbines from 2006 to 2007 and has since installed four more (Ordóñez 2008). At least at one time, the ultimate goal of Verdant Power was to build up to 300 turbines within a one-mile section of the river near Roosevelt Island.

Delaware River

The alewife and blueback herring populations in the Delaware River lost spawning habitat in every tidal stream of the Delaware River in Delaware due to the construction of low-head dams that formed mill ponds dating to the 1800s or early 1900s (ASMFC 2008: 395). All of these Delaware River tidal streams are relatively short in length (with the longest being approximately 10 to 12 miles from the river or bay to the first dam), which results in a fairly steep salinity gradient (ASMFC 2008: 395). Thus, all spawning in these tidal streams in Delaware is usually restricted to the short distance of freshwater near the dam and immediately downstream (ASMFC 2008: 395).

Dredging operations in the Delaware River also adversely affect the river's populations of alewife and blueback herring. Hydrodynamic alterations from past dredging operations, including in conjunction with water sharing agreements with upstream towns, has caused salt water encroachment, modified water flows, and made certain areas unsuitable spawning habitat for anadromous species, including the alewife and the blueback herring, for periods of time (ASSRT 2007).

According to Delaware Riverkeeper (2010), the deepening of the Delaware River main channel for navigational purposes and its maintenance dredging has increased the tidal range of the Delaware Estuary. Hydraulic dredging can entrain anadromous fish species, taking them up into the dredge drag-arms and impeller pumps and resulting in death (Delaware Riverkeeper 2010). Consumptive use and water diversions up river have reduced freshwater flows (Delaware Riverkeeper 2010). The combination of increased tidal fluctuation and reduced freshwater flows has caused saltwater to intrude into the freshwater tidal reach of the estuary, depriving anadromous fish species of freshwater habitat important for spawning (Delaware Riverkeeper 2010). Ongoing dredging continues to change salinity (Delaware Riverkeeper 2010), which can affect the behavior of anadromous fish such as the alewife and the blueback herring.

A planned major dredging project, known as the Delaware River "Deepening Project," will exacerbate many of the adverse effects of past dredging activities and will further harm the river's alewife and blueback herring populations. The Deepening Project will deepen the river's main shipping channel by 50 feet over 102 miles. Agency comments and technical reports with respect to the dredging project indicate that the dredging operations are expected to result in the resuspension of high levels of PCBs and other contaminants that had been absorbed by the sediment; may result in changes to the salinity and bottom habitat that could negatively impact anadromous fishes that rely on such habitat for spawning and nursery habitat; and may exacerbate the sediment deficit in the Delaware River system (current maintenance dredging removes more sediment from the estuary than is supplied to the estuary and the new 45 foot channel would likely require increased maintenance dredging) (NMFS 2010b: 75 Fed. Reg. 61872, 61884, 61897).

The Southport Marine Terminal Development project further threatens populations of alewife and blueback herring in the Delaware River. The Southport Development project involves filling in 12.28 acres of open water (0.2 of which is emergent wetlands, 1.08 acres of which is shallow water habitat, and 3.62 of which is deep water habitat), 3.75 acres of non-tidal wetlands, and 0.73 acres of a tidal drainage area; filling in an unspecified amount of floodplain lands with 3 to 4 feet of fill in order to raise the area to above the 100-year floodplain (in fact to raise it to the 200-year floodplain); dredging a 35-acre area within the Delaware River to a 40+2foot depth; impacts to approximately 4,600 linear feet of existing shoreline; and the permanent loss of 1.08 acres of submerged aquatic vegetation (Delaware Riverkeeper 2010).

The Southport project will further degrade water quality and habitat in the Delaware River. The water quality effects from this project include impacts on dissolved oxygen levels through the removal of water celery, an important plant that contributes oxygen to the water, and the introduction of contaminants from both resuspension of sediments and disposal in the Fort Mifflin CDF, a known source of contaminants due to the sediments disposed there (Delaware Riverkeeper 2010). According to the U.S. Fish and Wildlife Service, sediments to be used in the Southport project contain contaminant concentrations high enough to pose unacceptable ecological risk to aquatic organisms (Delaware Riverkeeper 2010). This means that these sediments should only be used in areas where they will not be inundated during high water events and in a way that reduces their potential for leaching from precipitation (Delaware Riverkeeper 2010). However, the spoils from the Southport project are planned for disposal at the Fort Mifflin CDF (Delaware Riverkeeper 2010). Fort Mifflin has been shown to effectively discharge pollution back into the River from sediments disposed there rather than filtering it out prior to discharge (Delaware Riverkeeper 2010). Among the toxics discharged to the River by the CDF are cadmium, lead, copper, zinc and total suspended solids (Delaware Riverkeeper 2010). Delaware Riverkeeper (2010) also discusses NMFS' concerns about other water quality concerns from dredging and vessel operations associated with the Southport project, including increased turbidity, lowered dissolved oxygen levels, and release/resuspension of chemical contaminants from sediments.

The proposed construction and operation of a Liquefied Natural Gas (LNG) import terminal on the Delaware River near Logan, New Jersey, by Crown Landing, LLC will also impact the populations of alewife and of blueback herring in the Delaware River. This proposal was approved by the FERC in 2006. Construction of the LNG terminal will require hydraulic dredging of 1.24 million cubic meters ("m3") in the first year followed by maintenance dredging of 67-97,000 m3/year. Dredging will occur from August through December and threatens to significantly harm alewife and blueback herring populations in the Delaware, including by impacting migration patterns and distribution. In addition, it is believed the facility will receive up to 150 shipments per year (Delaware Riverkeeper 2010). LNG carriers take on ballast water as they offload in order to maintain stability – an estimated 8 million gallons will be pumped from the River over a 10 hour period while at the berth with an additional 5 to 11 million gallons being taken on after undocking downstream of the berth area (Delaware Riverkeeper 2010). These activities may result in entrainment and impingement of alewife and blueback herring larvae.

The Delaware River alewife and blueback herring populations are also threatened by exceptionally poor water quality. Petroleum pollution and pollution from dye manufacturing is believed to have contributed to the long-term decline of the river's alewife and blueback herring populations (ASMFC 2008). In addition, heavy organic loading near Philadelphia, Pennsylvania during the 1940s and 1950s caused severe declines in DO levels and made parts of the Delaware River uninhabitable for fish during the warmer months of the year (ASMFC 2008). In giving the Northeast region an overall grade of F for water quality and coastal habitat, the EPA's National Coastal Condition Report (2004) noted particular concern about water pollution and fish tissue contaminants in the Delaware River (EPA 2004). EPA's National Coastal Condition Report (2008) rated the water quality in the Delaware River as poor because of high nitrogen and phosphorous levels; several tributaries of Delaware Bay were also given a poor rating (EPA 2008). The Delaware River also has high levels of PCBs, dioxins, mercury, and chlorinated pesticides in its sediments and is subject to numerous fish consumption advisories. Part of the Roebling-Trenton stretch of the river is a designated EPA Superfund site because of contamination originating from the Roebling Steel plant.

Increased withdrawals from the Delaware River, increasing salt water intrusion and affecting flow patterns, also pose a threat. For example, there has been an explosion of natural gas extraction activity using hydraulic fracturing techniques in the basin (Delaware Riverkeeper 2010). Each natural gas well, when hydraulically fractured, is estimated to use 1 to 9 million gallons of water, with an average of 4.5 million gallons, from the Delaware River system or groundwater supplies (Delaware Riverkeeper 2010).

Climate scientists predict that the impacts of global warming will be particularly significant for coastal and riverine environments in the Northeast and mid-Atlantic regions, including the Delaware River. As discussed *supra*, among other impacts, global warming will exacerbate hypoxic conditions by increasing precipitation and nutrient inputs into water bodies in these regions, including the Delaware (Howarth *et al.* 2006).

Impingement and entrainment at two power plants (the Connectiv Power Plant at Edgemoor, and the Motiva (now Valero) Refinery at Delaware City) are also significant threats. A recent report by Entrix (2008) indicated substantial losses of river herring at the Connectiv Power Plant with the absolute numbers of river herring mortality found to be in excess of 600 million (Entrix (2008), as cited in DDNREC 2010: 8).

Susquehanna River

In Maryland, the construction of two dams in the early 1900s on the Susquehanna River cut off alewife and blueback herring populations from their historical spawning habitat until 1972, when the lower dam was retrofitted with a fish elevator and the fish were trucked above the upper most mainstream dam (ASMFC 2008: 416, 418).

Chesapeake Bay (Nanticoke, Potomac, Rappahannock, York, and James Rivers)

Dams that permanently blocked anadromous fish passage and those with ineffective fishways have significantly reduced the amount of spawning habitat available for alewife and blueback herring populations in rivers and tributaries along the Chesapeake Bay (ASMFC 2008).

Chesapeake Bay's nutrient pollution problem is one of the most egregious in the country. Excessive nutrient loading into the Bay stimulates heavy growths of phytoplankton, and the death and decay of phytoplankton blooms involve high rates of dissolved oxygen consumption, resulting in low DO levels in the Bay and its tidal tributaries, particularly in the summer months (Klauda *et al.* 1991; EPA 2008; CBP 2009; Reay 2009). These hypoxic conditions adversely affect alewives and blueback herring, including by affecting migration and distribution patterns. The Bay experienced "record-sized hypoxic zones" in 2003 and 2005 (Boesch *et al.* 2007:2). Kemp *et al.* (2005: 9) stated that:

> the Bay has become less able to assimilate N inputs without developing hypoxia, a change that may have arisen from the degradation of key ecological processes sensitive to eutrophication effects. Potential mechanisms include (1) loss of benthic plant biomass due to increased turbidity and loss of oyster biomass, both of which tend to retain nutrients and organic matter in shallow waters; [and] (2) increased efficiency of N and P recycling with marked decreases in denitrification and P precipitation in response to recent severe and persistent hypoxia.

Reay (2009) also identified elevated TSS concentrations and poor water clarity resulting from high sediment loadings as persistent and widespread in the Bay. Such excessive sediment loadings into the Bay inhibit alewife and blueback herring spawning (ASMFC 2008). Sediment loadings also serve to transport contaminants and pathogens, exacerbating pre-existing contamination problems in certain portions of the Bay (Reay 2009).

Similar water quality problems exist in many of the Bay's tributaries, including those utilized by the alewife and the blueback herring. Much of the York River system fails to meet Submerged Aquatic Vegetation ("SAV") habitat requirements, and degraded nutrient water quality conditions exist in the York River estuary (Reay 2009; ASSRT 2007). Nitrogen levels have increased by 20 percent and phosphorus levels by 122 percent in the Pamunkey River (Reay 2009). In addition, Hirsch *et al.* (2010) found that phosphorus fluxes increased from 2000 to 2008 in the Susquehanna, James, Rappahannock, Appomattox, Patuxent, and Choptank Rivers. While investments in advanced wastewater treatment in the watershed appear to have stabilized nitrogen trends in some rivers, in other rivers, such as the Choptank, nitrogen pollution is still increasing (Hirsch *et al.* 2010).

In addition, there are reoccurring harmful algal red tides in the summer months in the lower York River, and the cyanobacteria *Microcystis aeruginosa* that causes algal blooms in the Chesapeake Bay is common in the York River (Reay 2009). Diel variations in dissolved oxygen concentration in shallow waters can be significant (Reay 2009). Harmful hypoxic conditions also occur in the Potomac River (ASSRT 2007). Finally, fish consumption advisories for PCBs in fish are in place in the James, Potomac, Rappahannock, and York River basins.

Chesapeake Bay's severe water quality problems have been comprehensively chronicled by EPA (2004; 2008) and the Chesapeake Bay Program ("CBP") (2009). EPA (2004) gave Chesapeake Bay a score of F in the areas of water quality, sediment, benthos, and fish tissue contamination. EPA (2008) rated the northern and western tributaries of the Bay as poor. According to CBP (2009), the Bay continues to have poor water quality, degraded habitats and low populations of many species of fish and shellfish. Based on these three areas, the overall health of the Bay was rated at 38 percent, with 100 percent representing a fully restored ecosystem (CBP 2009: 4). The Chesapeake Bay Program states that "[w]ater quality is the most important measure of the Chesapeake Bay's health" (CBP 2009: 6), and, in 2008, water quality was again very poor, meeting only 21 percent of the goals, the same as 2007 (CBP 2009: 6). Chemical contaminants also impaired more water in 2008, resulting in a 6 percent decrease in that goal area (CBP 2009: 6). One of the greatest challenges to restoration is that the rate of population growth and development, and resulting increases in pollutant inputs, continues to offset cleanup efforts (CBP 2009: 8).

Climate change is a significant "emerging stress" for Chesapeake Bay (Preston 2004: 126). Water temperatures within Chesapeake Bay during the 20th century were 2° C to 3° C warmer than over the past millennium, and increased 0.8° C to 1.1° C between just 1949 and 2002 with "unambiguous and prominent estuarine warming over at least the past two decades" (Preston 2004: 134). Observed average annual water temperatures in the Patuxent River have increased 0.22° C per decade for the period from 1938 to 2006 and in the two most recent decades by ~0.5° C in the winter and spring (Kerr *et al.* 2009). Najjar *et al.* (2010) estimates a water temperature rise for the Bay of 2 to 6° C. Models predict air temperature will be 3 to 4.5° C warmer by the end of the present century, with potential summer increases of 6.5º C in combination with more extremely warm days and more modest winds (Boesch *et al.* 2007).

These temperature changes in the Bay are anticipated to result in increased frequency and intensity of precipitation, increased intensity of tropical and extratropical storm events, increased sea-level variability, and changes in streamflow (Najjar *et al.* 2010; CIER 2008; Reay 2009). For example, precipitation is expected to increase 20 percent in Maryland by the end of the century (CIER 2008). Temperature increases and altered precipitation patterns will also result in reductions in salinity in certain portions of the Bay and a reduction in oxygen exchange between warmer surface waters and cooler deep waters (CIER 2008), as well as a reduction in the amount of oxygen that can be dissolved in the water, enhanced stratification and increased rates of production, decomposition, and nutrient cycling (Boesch *et al.* 2007; Preston 2004).

These changes will, in turn, cause an increase in the severity and extent of hypoxia, an increase in coastal flooding and submergence of estuarine wetlands that filter pollutants, increased sediment and nutrient loading during winter and spring, changes in salinity regimes, including variability, an increase in harmful algae, decreases in water clarity, and likely alterations in fish habitat favoring subtropical fish and shellfish species (Najjar *et al.* 2010; CIER 2008; Reay 2009). For example, as a result of higher precipitation and run-off levels, nitrogen flux within the Susquehanna River, which is the major source of nitrogen discharge into Chesapeake Bay, is expected to increase by as much as 17 percent by 2030 (Howarth 2006). Boesch *et al.* (2007) found that climate change has already exacerbated hypoxic conditions in parts of the Chesapeake Bay. For example, the "record-sized hypoxic zones" in 2003 and 2005 were caused or exacerbated by climate change-induced high river inflows, warm temperatures, and calm winds (Boesch *et al.* 2007: 2).

Warming temperatures can also affect recruitment and the distribution of pathogens (Preston 2004; Kerr 2009). This may make alewives and blueback herring in the Bay more vulnerable to disease, particularly in conjunction with the additional stress brought on by suboptimal environmental conditions (Preston 2004).

According to Najjar *et al.* (2010), Chesapeake Bay will likely experience a sea level rise of 0.7 to 1.6 meters. The Bay is particularly vulnerable to the impacts of such sea-level rise due to its geography (Glick *et al.* 2008). Many of the Bay's coastal marshes and small islands have been lost already, and many more are at risk of being lost soon (Kemp *et al.* 2005). The loss of tidal marshes adversely affects alewives and blueback herring in the Bay, including because tidal marshes maintain water quality through uptake of excess nutrients that contribute to hypoxia and dead zones in the Bay (Kemp *et al.* 2005). Sea level rise also affects hypoxic conditions by increasing stratification via changes in the ratio of salt to fresh water (Boesch *et al.* 2007).

Glick *et al.* (2008) applied the Sea Level Affecting Marshes Model (SLAMM) 5.0 model, developed in 2006/2007, to the entire Chesapeake Bay region and Delaware Bay. Assuming 69 cm of sea-level rise by 2100 (the IPCC's A1B Max Scenario), brackish marsh throughout the region declines by 83 percent and the overall area of all tidal marshes declines by 36 percent. Under the 1.5 meter scenario, virtually all of the region's ocean beach and brackish marshes are projected to disappear by 2100, as would three fourths of tidal swamp and about half of the tidal flats, tidal fresh marsh, and estuarine beaches. Most of the habitat lost would convert to open water. In the Susquehanna River and northern Chesapeake Bay, the dominant marsh is already precarious, and 97% is predicted to be lost at a sea-level rise of 69 cm. In the eastern Bay region, one fourth of the marshes are expected to be lost even with a lower 39 cm sea-level rise, and 60% are expected to be lost with higher levels of sea-level rise. An earlier (2005) study – referenced by NMFS in its 2010 proposal to list certain distinct population segments of Atlantic sturgeon as endangered and threatened – found that a 1 °C increase of water temperature in the Chesapeake Bay would reduce available sturgeon habitat by 65 percent (NMFS 2010b: 75 Fed. Reg. 61872, 61886-87).

Cumulatively, the adverse impacts on alewives and blueback herring in Chesapeake Bay from climate change are likely to be significant. Boesch *et al.* (2007: 10) warns that "[p]rolonged shifts in climate and its variability, or in the biota inhabiting the Bay, may have unprecedented effects that drive the ecosystem to a new state."

Albemarle Sound and Chowan River

According to the North Carolina Wildlife Resources Commission (2005), poor water quality negatively affects the alewife and the blueback herring populations in the Chowan River. The Chowan River was the site of North Carolina's first known large-scale coastal algae bloom in

1972 (North Carolina Wildlife Action Plan ("NCWAP") 2005), which resulted from excessive levels of nitrogen and phosphorus in wastewater and runoff. During this event, lowered dissolved oxygen levels from excessive nutrient inputs killed fish and led to fish diseases (NCWAP 2005). Agricultural and urban runoff, including runoff of fertilizer and animal waste, further degrade the water quality in the Chowan River (NCWAP 2005). This runoff increases water concentrations of nitrogen and phosphorous, which can cause harmful algae blooms and low DO levels. In 1979, the Chowan River was the first water body in North Carolina to receive the "nutrient sensitive waters" classification by the NC Division of Water Quality (NCWAP 2005).

During most years, chronic episodes of hypoxia occur in the Chowan River and its tributaries from late June through September (NCWAP 2005). Dissolved oxygen levels frequently fall below 3.0 mg/l, which negatively affects aquatic biota (NCWAP 2005). Extreme storm events have occurred repeatedly within the basin since 1995. The accompanying rainfall, storm surge, inundation and flushing of bottomland swamp habitats have increased stress on an already fragile summer ecosystem, including by lowering dissolved oxygen levels, which has produced major fish kills within the basin (NCDWQ 2002, as cited in NCWAP 2002).

Santee-Cooper River System

The Santee River, formed by the Wateree and Congaree Rivers, was historically one of the longest river systems on the Atlantic coast and, at one time, supported abundant spawning runs of anadromous fish to Great Falls (km 438) on the Wateree River and up to river km 602 on the Congaree River (ASMFC 2008). After the South Carolina Public Service Authority completed a large diversion project to move water from the Santee River to the Cooper River to maintain discharge control and hydroelectric power generation, the number of fish that passed upstream drastically declined (USFWS/SCDNR 2001). The Santee-Cooper diversion project blocked access to all but 87 miles of the Santee River (USFWS 2001). It blocked the blueback herring population from historical nursery and spawning grounds and reduced the Santee River's natural water flow in the thirty-seven miles upstream of the rediversion canal by approximately 97 percent, destroying much of the historical aquatic habitat (American Rivers 2003). Efforts to restore fish passage numbers to pre-diversion project levels in recent years have failed to achieve their goals.

Dredging occurs in the Cooper River without any seasonal restrictions. As discussed by SCDNR as part of its 2005 Comprehensive Wildlife Conservation Strategy, dredging has numerous adverse effects on alosines:

> Dredging can . . . negatively affect alosine populations by producing suspended sediments (Reine *et al.* 1998). Behaviorally, chronic turbidity from frequent or prolonged dredging can also affect fish migration, spawning, conspecific interactions, and foraging (Coen 1995). Migrating alosines are known to avoid waters of high sediment load (ASMFC 1985; Reine *et al.* 1998). Suspended sediments have been linked to a variety of lethal and sublethal responses in juvenile and adult fishes that are consistent with oxygen deprivation due to gill clogging (Sherk *et al.* 1975; Sherk *et al.*

> 1974). Filter-feeding fishes such as alosines are particularly susceptible to negative impacts of suspended sediments on gill tissues (Cronin *et al.*1970).

(SCDNR ND). In addition, contaminated sediment from past industrial operations and military facilities has led to fish consumption advisories in the river for three species due to mercury contamination (ASSRT 2007).

St. John's River

The Kirkpatrick Dam now blocks migration of anadromous fish to extensive potential spawning habitat upstream (ASSRT 2007). Frequent dredging has reduced submerged aquatic vegetation in the river (ASSRT 2007). The river's water quality is degraded and DO is frequently at low levels in summer months (ASSRT 2007).

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

1. Direct Harvest

At one time, alewives and blueback herring were commercially harvested in the majority of Atlantic coastal river systems. The alewife and blueback herring fishery is one of the oldest fisheries in North America (NOAA 2006). U.S. commercial landings in this fishery peaked in the late 1950s at nearly 75 million pounds (NOAA 2006).[31] Beginning in the late 1960s, offshore exploitation of alewives and blueback herring by foreign commercial fishing vessels led to a dramatic reduction in alewife and blueback herring populations along the Atlantic coast (ASMFC 2008). Commercial landings of alewives and blueback herring by foreign fleets peaked at about 80 million pounds in 1969, and the total combined commercial harvest of alewives and blueback herring in 1969 by U.S. and foreign fleets was 140 million pounds (ASMFC 2008). By the time the U.S. instituted its Fishery Conservation Zone in the late 1970s, commercial landings had plummeted to less than 9 million pounds[32] (NOAA 2006).

More recently, from 1996 to 2009, annual commercial landings have varied between about 300,000 pounds and 2 million pounds (NMFS 2010a). Maine, North Carolina and Virginia typically have accounted for more than 90 percent of total commercial landings of alewives and blueback herring (NOAA 2006). Dominant uses of alewives and blueback herring are for bait, including for striped bass and lobster, and human consumption (ASMFC 2008).

Commercial overharvesting has played and continues to play a major role in the profound decline in the abundance of both alewives and blueback herring. Direct harvesting of alewives and blueback herring is currently allowed in Maine, New Hampshire, New York (except the Delaware River basin), New Jersey, Delaware, Maryland, Virginia (except river systems flowing into North Carolina), and South Carolina (ASMFC 2008). The PRFC, which manages fisheries in the main stem of the river, has not adopted specific regulations that limit the harvesting of

[31] 34,000 metric tons converted to pounds, using a conversion factor of 2,204.6 pounds per metric ton.
[32] 4,000 metric tons converted to pounds, using a conversion factor of 2,204.6 pounds per metric ton.

alewives and blueback herring in the Potomac River or otherwise directly addressed the threat of overfishing the river's populations of alewives and blueback herring (ASMFC 2008; PRFC 2010: 1). There are also no size or possession limits for alewives and blueback herring in Virginia and Maryland tributaries of the Potomac River (VMRC 2009; MDNR 2010: 10). Maryland's seasonal restriction on the commercial harvesting of alewives and blueback herring permits harvesting during the species' spawning migration, which reduces the number of spawning adults that are able to reach their freshwater spawning habitat (MDNR 2010: 10). South Carolina's commercial fishery targets adult pre-spawning blueback herring for bait and human consumption, particularly roe (ASMFC 2009a; SCDNR 2010b: 18-19).

2. Bycatch and Incidental Catch

Significant mortality of alewives and blueback herring occurs as a result of bycatch and incidental catch. This bycatch and incidental catch occurs in both state waters and the nation's exclusive economic zone ("EEZ"). The alewife and the blueback herring, as anadromous species, are particularly vulnerable to bycatch and incidental catch, and such bycatch and incidental catch is difficult to monitor, because it occurs in multiple habitats. Both species' schooling behavior further increases susceptibility to bycatch and incidental catch mortality. Ocean fisheries present a particularly substantial threat to alewife and blueback herring populations because such fisheries utilize gear types that have the potential to incidentally catch large numbers of migrating alewives and blueback herring. Both species are believed to congregate in certain areas at certain times of year, which is believed to make the species susceptible to large bycatch and incidental catch events. A recent study of alosine bycatch/incidental catch in the Gulf of Maine, Georges Banks, Southern New England and Mid-Atlantic (Lessard *et al.* 2011: 17) found evidence of such "hotspots" with river herring bycatch/incidental catch concentrated in winter in the northern extent of the region south of Cape Cod to Cape Hatteras; with higher blueback densities in the southern region in the spring, especially along the shore; and with fall bycatch/incidental catch of river herring concentrated in the Gulf of Maine and Georges Banks (Lessard *et al.* 2011: 11-12, 19, Figures 1-10, 11-12).[33]

Information concerning alewife and blueback herring bycatch/incidental catch is available from a variety of sources, including landing records, fishing log books, portside sampling efforts (which currently occur in Maine, New Hampshire, Massachusetts, Rhode Island, and New Jersey), and the NMFS observer program. Sources of information that rely on voluntary reporting, such as fishing log books, likely provide underestimates of alewife and blueback herring bycatch and incidental catch. The NMFS observer program may also provide underestimates of bycatch/incidental catch because of limited coverage and current rules permitting net slippage without catch sampling in certain ocean trawl fisheries, as discussed *infra*.

The ASMFC and a number of states have identified and expressed concern regarding the role of bycatch and incidental catch in ocean fisheries in causing the precipitous decline of alewife and blueback herring populations (ASMFC 2008; ASMFC 2009c; Mid-Atlantic Fishery Management

[33] Data compiled for the August 2011 ASFMC meeting (data that are not always consistent with those reported in ASFMC 2008) show continuing high levels of bycatch in recent years (ASFMC 2011c: 2). In 2008 and 2009, listed total annual incidental catch (in pounds) across all fleets and regions for river herring was equal to almost 80 and 50 percent of reported landings, respectively (ASFMC 2011c: 2).

Council ("MAFMC") 2009). In most recent years, such bycatch/incidental catch has primarily occurred in the Atlantic herring, Atlantic mackerel, longfin squid, and shortfin squid fisheries (ASMFC 2008; Harrington *et al.* 2005: 47-50, Figures 14-17, Tables 21-22). In 2002, four sampled trips from the Atlantic mackerel fishery recorded an estimated 18,179,906 pounds of blueback herring and 66,550 pounds of alewives as bycatch/incidental catch (ASMFC 2008). In the same year, thirty-five sampled trips from the longfin squid fishery recorded an estimated 2,813,841 pounds of blueback herring as bycatch/incidental catch (ASMFC 2008). Twelve sampled trips from the Atlantic herring fishery in 2000 recorded an estimated 1,167,362 pounds of alewives and 63,541 pounds of blueback herring as bycatch/incidental catch (ASMFC 2008). According to the ASMFC (2008: 24), annual estimates of alewife and blueback herring bycatch/incidental catch for all gears in the Atlantic herring fishery ranged from 171,973 pounds (2005) to 1,686,617 pounds (2007) and are similar in range to the bycatch/incidental catch estimates provided by Harrington *et al.* (2005) for the same fishery in 2000 and 2003. A 2011 review of available data from a variety of gear types used in the Gulf of Maine, Southern New England, and Mid-Atlantic regions that used a different method of estimating bycatch/incidental catch (seeking to eliminate certain biases in earlier studies (Lessard *et al.* 2011: 24-25)) found that bycatch/incidental catch of alewives and blueback herring from 2000 to 2008 was approximately 13 million and 14.7 million pounds respectively (Lessard *et al.* 2011: 23, Tables 4 and 5).

Limited observer coverage makes it difficult to determine the exact extent of the bycatch/ incidental catch problem of alewives and blueback herring in these fisheries. Because of the highly depleted status of the alewife and the blueback herring, however, even infrequent bycatch/incidental catch events in a high volume fishery like the Atlantic herring fishery poses a threat. In some years, such catch of alewives and blueback herring in the Atlantic herring fishery can be equal to, or exceed, the total of all in-river landings (Cieri *et al.* 2008: 5-6; 9, Table 2). It is likely that bycatch/incidental catch affects different river subpopulations to varying degrees (Miller, T.J. 2010: 2-3).

Most alewife and blueback herring bycatch/incidental catch in commercial marine fisheries occurs in the single and pair mid-water trawl fisheries (ASMFC 2008; Cieri *et al.* 2008: 5; 17, Table 10). A report completed in early 2011 that evaluated river herring bycatch/incidental catch from a variety of gear types in New England waters found that otter trawls, including mid-water paired otter trawls, accounted for the majority of this catch of alewives and blueback herring; bycatch/incidental catch in mid-water otter trawls appears be increasing for both alewife and blueback herring from 2000 to 2008 (Lessard *et al.* 2011: 22, Figures 25-26). These mid-water trawls have CPUEs that are 10 to 100 times more fish per haul than some other gear types, which overwhelms the lower number of hauls with this gear (Lessard *et al*. 2011: 27, Figures 13-18). The 2011 study finds that annual bycatch/incidental catch of alewives and bluebacks likely hovers around half a million to 2.5 million pounds (Lessard *et al.* 2011: 28).

The increased use of mid-water trawlers in the Atlantic herring fishery, as well as the Atlantic mackerel fishery, correlates with the most recent decline in populations of alewife and blueback herring. With respect to the Atlantic herring fishery, it historically was conducted primarily in state waters using fixed gears (*e.g.*, purse seine gear) (NEFMC 1999). Since 1994, however, the Atlantic herring fishery has increased its use of single and pair mid-water trawlers (PEG 2008).

The increased use of mobile gear to target Atlantic herring has resulted in an effort shift into federal waters and a sharp increase in commercial landings and revenue (NEFMC 1999). In addition, the Atlantic herring fishery has increasingly deployed trawlers that are much larger and more efficient than traditional fishing vessels. Compared with traditional fishing vessels, which are typically 40 to 50 feet in length and tow much smaller nets, contemporary mid-water trawlers in the Atlantic herring fishery can reach up to 165 feet in length and tow nets as wide as a football field and the height of a five-story building. These vessels make the fishery considerably more efficient, and the fishery's increasing use of pair mid-water trawls – a large net that is towed between two fishing vessels – in recent years further increases its efficiency. The recent explosive growth of Atlantic herring landings demonstrates the increases in effort and efficiency in the fishery. In 1994, the Atlantic herring fishery landed about 1 million pounds of fish. By 2000, the fishery was landing more than 225 million pounds of fish (NEFMC 1999).

Alewife and blueback herring bycatch/incidental catch also occurs in the bottom trawl fisheries (ASMFC 2008). Warriner *et al.* (1970) found that, at night, over half of juvenile alewife and blueback herring in the Potomac River were taken in bottom trawls (Warriner *et al.* (1970) , as cited in ASMFC 2009b: 123). Although the mid-water trawl fishery results in the most river herring bycatch/incidental catch, the directed Atlantic herring bottom-trawl fleet removes a relatively large amount of river herring given their low Atlantic herring landings (this fishery only accounts for approximately 16 percent of the total catch of Atlantic herring in the Southern New England management area); that fishery's bycatch/incidental catch rate is far higher than the mid-water trawl fishery per pound of Atlantic herring landed, and sometimes exceeds river herring bycatch/incidental catch in the mid-water trawl fleet in the Southern New England area by almost fourfold (Cournane *et al.* 2010: 13, Figure 4).

3. Threats to Specific Rivers and Estuaries Affecting the Alewife and the Blueback Herring

Damariscotta River System

In 1990, scientists determined the alewife population in the Damariscotta River was overharvested to the extent that recruitment failure became apparent (ASMFC 2008: 136). The ASMFC (2008) similarly concluded that alewife in the river were subjected to high in-river exploitation rates prior to 1985. After a slight decline during the 1990s, the in-river exploitation rate increased steadily from 2000 through 2004 (ASMFC 2008).

Hudson River

The present commercial fishery for alewives and blueback herring in the Hudson River exploits the spawning migration of both species (ASMFC 2008). The fishery harvests adults each year from March to early June, with some catch reported as late as July, thereby preventing this portion of the population from reproducing (ASMFC 2008). The fixed gear fishery locates itself downriver of the species' spawning habitats, intercepting and harvesting alewife and blueback herring before they can reach their spawning habitats (ASMFC 2008). The active gear fishery typically sets directly into schools of fish as they migrate upstream to spawn (ASMFC 2008).

Total effort for all gears in the Hudson River commercial fishery has increased since 1996 (ASMFC 2008). Total commercial landings for all gears in the fishery peaked in 2002 and declined thereafter even as the total effort for all gears in the fishery steadily increased (ASMFC 2008).

The recreational fishery that exists throughout the Hudson River and its tributaries also contributes to the total number of alewives and blueback herring harvested each year. Recent estimates of the number of alewives and blueback herring taken by and used in the recreational fishery indicates the magnitude of use by the bait fishery and the potential impacts of such use on the Hudson River alewife and blueback herring populations (ASMFC 2008: 317). The NYSDEC estimated that the total number of river herring used in the striped bass fishery was approximately 197,000 in 2001 and 265,000 in 2005 (ASMFC 2008: 317). A creel survey conducted by a contractor hired by NYSDEC (Normandeau Associates, Inc.) in 2005 estimated a harvest of 134,142 river herring and a retention rate of 75 percent (ASMFC 2008: 316-17).

The taking of alewives and blueback herring remains mostly unregulated in New York, and there are no limits on recreational or commercial harvest (ASMFC 2008).

Delaware River

According to the ASMFC (2008), overharvesting is believed to be one of the main factors contributing to the decline of alewife and blueback herring populations in the Delaware River. In Delaware, commercial landings in the fishery occur annually from January to June, with peak landings occurring in March (ASMFC 2008). The peak in commercial landings corresponds with the migrations of alewife and blueback herring populations to their spawning habitat and prevents a portion of the adults from reproducing. In New Jersey, it is believed that the commercial landings of alewife and blueback herring are “grossly underreported” (ASMFC 2008: 396). Neither New Jersey nor Delaware have adopted specific regulations to reduce or restrict commercial landings of alewives and blueback herring in the Delaware River (ASMFC 2008).

Commercial discards and landings categorized as “bait” are potentially significant sources of mortality for alewives and blueback herring in the Delaware River (ASMFC 2008). The use of alewives and blueback herring as bait for striped bass fishing has increased in popularity in recent years and is an additional source of mortality for both species (ASMFC 2008). According to the ASMFC (2008), such mortality could be significant.

Chesapeake Bay (Nanticoke, Potomac, Rappahannock, York, and James Rivers)

Overharvesting has been identified as one of the factors contributing to the recent declines in alewife and blueback herring populations in the Chesapeake Bay (USFWS 2009). Maryland’s commercial and recreational fisheries annually harvest alewives and blueback herring from January to June (ASMFC 2008). The commercial and recreational open harvest season in Maryland corresponds with the spawning migrations of both species, likely preventing a portion of the adults from reaching their spawning habitats to reproduce. Currently, there are no state limits on total alewife and blueback herring catches (ASMFC 2008). Crecco and Gibson (1990) conclude that the alewife population in the Nanticoke River was overharvested prior to 1990 and severely depleted as a result.

As a result of new regulations that allow the use of alewives and blueback herring as live bait to target striped bass in the upper Chesapeake Bay, a directed commercial alewife and blueback herring fishery has developed in at least one Chesapeake Bay tributary since 2006 (ASMFC 2008). Commercial fishermen have been permitted to target alewives and blueback herring on their spawning grounds using small mesh gill nets, although the significant decline in both species' populations has resulted in most fishermen catching alewives and blueback herring only incidentally when targeting another species (ASMFC 2008).

The increasing popularity of using alewives and blueback herring as live bait in the Delaware striped bass fishery has resulted in the development of a significant recreational fishery developing in the larger tributaries of the Nanticoke River (ASMFC 2008). The recreational fishery has targeted alewives and blueback herring exclusively below blockages in the tributaries during the species' spawning runs (ASMFC 2008). Delaware continues to permit the use of nets in its alewife and blueback herring recreational fishery, and it is unclear whether the daily possession limit that the state recently imposed on its recreational fishery will prevent overharvesting (ASMFC 2008).

Potomac River

Historically, alewife and blueback herring populations in the Potomac River were abundant (ASMFC 2008). In the late 1980s and early 1990s, annual harvests of alewives and blueback herring sharply declined and they have remained low since then (ASMFC 2008).

Overharvesting is believed to be one of the main factors contributing to this sharp decline in Potomac River alewife and blueback herring landings. A 1990 assessment of river herring in selected east coast rivers determined that the alewife population in the Potomac River was overfished and blueback herring populations in the river were severely depleted(Crecco and Gibson (1990), as cited in ASFMC 2009a: 5, Table 1). Bycatch of the Potomac River alewife and blueback herring populations also occurs in fisheries in federal waters and could be substantial. Currently, there are no limits on the amounts of alewives and blueback herring caught as bycatch/incidental catch in ocean waters.

Albemarle Sound and Chowan River

The ASMFC (1990) reported that the alewife population in the Chowan River had been overfished to the extent that recruitment failure became apparent. The 2005 North Carolina River Herring Stock Assessment determined that alewife and blueback herring populations in North Carolina were overharvested and that overharvesting was continuing to occur (ASMFC 2008). Sustained high exploitation over the 25 years before the moratorium was put in place in 2007 reduced the SSBs of both the alewife and the blueback herring populations in the river system to the extent that current levels are insufficient to produce even moderate recruitment for either species (ASMFC 2008: 488; NCDMF 2007).

Santee-Cooper River System

According to the ASMFC (2008), blueback herring from the Santee-Cooper River are likely caught as bycatch/incidental catch in ocean fisheries along the Atlantic coast, from North Carolina to the Gulf of Maine and Canadian waters (ASMFC 2008).

St. John's River

Crecco and Gibson (1990) concluded that the populations of alewives and blueback herring in the St. John's River had been overfished to the extent that recruitment failure became apparent (Crecco and Gibson (1990), as cited in ASFMC (2009a: 5, Table 1).

C. Predation and Disease

1. Predation

Documented predators of alewives and blueback herring include striped bass, bluefish, tuna, cod, haddock, halibut, American eel, brook trout, rainbow trout, brown trout, lake trout, landlocked salmon, smallmouth bass, largemouth bass, pickerel, pike, white and yellow perch, seabirds, bald eagle, osprey, great blue heron, gulls, terns, cormorants, seals, whales, otter, mink, fox, raccoon, skunk, weasel, fisher, and turtles (MEDMR 2003).

Increased predation has been cited as a cause of the decline of at least certain populations of alewife and blueback herring. ASMFC (2008) noted particular concern with respect to striped bass predation. Striped bass are known to feed actively on alewives and blueback herring during their spawning migrations, and the abundance of striped bass along the Atlantic coast has risen to record high levels since 1995 (ASMFC 2008). According to ASMFC (2008), striped bass predation may be a significant factor contributing to the declining population sizes of alewives and blueback herring in the Connecticut and Monument rivers. In addition, the abundance and range extent of cormorants has increased significantly over the past decade (ASMFC 2009b). Cormorants have been shown to feed heavily on alosines (USFWS/SCDNR 2001). Small alosines can comprise up to 65 percent of the cormorant's diet (Johnson *et al.* 1999). Erkan (2002) notes that predation of alosines has increased dramatically in Rhode Island rivers in recent years, particularly by the double-crested cormorant, which often takes advantage of fish staging near the entrance to fishways (ASMFC 2009b). Double-crested cormorants have been observed immediately below many dams, particularly those dams with fish passages and during the winter-spring alosine migration period, in other areas as well (USFWS/SCDNR 2001). Dalton, *et al.* (2009) concluded, however, that, while important predators for alewives in south-central Connecticut, double-crested cormorants did not pose an immediate threat to the recovery of the regional alewife stocks.

2. Disease

The alewife and the blueback herring have been identified as species that are vulnerable to *viral hemorrhagic septicemia* ("VHS") (NY Sea Grant 2009). VHS is a viral infection that is known to infect certain anadromous fishes and that may result in significant cumulative mortality (USGS 1990). In addition, the rate of alewife egg infection by a naturally occurring fungus is significantly increased when there are high levels of suspended solids during and after spawning (ASMFC 2009b).

Concurrent physical stressors likely exacerbate the impacts of disease and parasites on the alewife and the blueback herring. For example, high nutrient levels result in low dissolved oxygen levels harmful to alewife and blueback herring in many water bodies. High nutrient levels have also been linked to outbreaks of the toxic organism *Pfiesteria,* causing numerous significant fish kills in these same locations.

D. Insufficiency of Existing Regulatory Mechanisms

As discussed below, insufficient state and federal regulatory mechanisms are contributing to the precipitous and continued decline of the alewife and the blueback herring throughout all or significant portions of their ranges.

1. State Measures

The ASMFC has the authority, pursuant to 16 U.S.C. §§ 5108-5108, to develop and issue interstate fishery management plans ("FMPs") for in-shore fisheries, which are then administered by state agencies, and to coordinate such management with management in federal waters. In 1985, the ASMFC implemented a coast-wide FMP for American Shad and River Herring to facilitate cooperative management and restoration plans between the Atlantic coastal states; Amendment 1 to this FMP was adopted in 1999 (ASMFC 1999). In 2009, the ASMFC adopted Amendment 2 specifically to address declines in alewife and blueback herring stocks throughout their Atlantic coastal ranges (ASMFC 2009a). In the amendment, the ASMFC (2009a: 1) stated that:

> [t]he closure of river herring fisheries by Atlantic coastal states (*i.e.*, Massachusetts, Rhode Island, Connecticut, Virginia, North Carolina) and observed declines in river herring abundance have led to questions about the adequacy of current management of the species to promote healthy fish stocks. Amendment 1 to the FMP states in its objectives that existing regulations for river herring fisheries "should keep fishing mortality sufficiently low to ensure survival and enhancement of depressed stocks and the maintenance of stabilized stocks" (ASMFC 1999); however, questions regarding mortality levels and whether they are low enough to prevent further stock declines have arisen. The [ASMFC] and the public have also expressed concern over the lack of monitoring of river herring populations, fisheries and bycatch.

Under Amendment 2, commercial and recreational fisheries in state waters that do not have an approved management plan in place, or are not covered by an approved management plan, by January 1, 2012 will be closed (ASMFC 2009a). Amendment 2 does not propose any definitions of "overfishing" with regard to alewife and blueback herring stocks. Rather, the amendment requires submitted plans to clearly demonstrate that the alewife and the blueback herring fisheries in the state or jurisdiction are "sustainable" through the development of sustainability targets, which must be achieved and maintained (ASMFC 2009a). A sustainable fishery is defined as "a commercial and/or recreational fishery that will not diminish the potential future stock reproduction and recruitment" (ASMFC 2009a). Amendment 2 also requires states to implement fisheries-dependent and fisheries-independent monitoring programs for the alewife and the blueback herring that are similar to current requirements for American shad (ASMFC 2009a). It also contains recommendations to member states and jurisdictions to conserve, restore, and protect critical alewife and blueback herring habitat (ASMFC 2009a).

Maine, New Hampshire, Washington D.C., North Carolina, and South Carolina submitted management plans by the January 1, 2010 deadline (ASMFC 2011a). The ASMFC approved the plans submitted by North and South Carolina and requested revisions to the plans submitted by Maine, New Hampshire and Washington D.C. in August 2010 (ASMFC 2011a). Maine and New Hampshire submitted revised plans for review in September 2010; Maine's plan was approved, and New Hampshire submitted a revised plan in January for review (ASMFC 2011a). The ASMFC approved New Hampshire's revised plan in March 2011, despite some reservations and recommendations for additional monitoring (ASMFC Technical Committee 2011; ASFMC 2011b: 5).

Amendment 2 is not likely to sufficiently protect the alewife and the blueback herring either alone or conjunction with other planned protection measures. The amendment does not require, and is not likely to result in, adequate measures to reduce significant incidental catch and bycatch/bycatch mortality of these species, particularly in federal waters. Amendment 2 also does not meaningfully address the non fishing related stressors to alewives and to blueback herring.

Significantly, prohibitions on the harvest of alewives and blueback herring that have already been put in place in four states – Connecticut, Massachusetts, Rhode Island, and North Carolina – have not been successful in reversing the species' decline. For example, Massachusetts put in place a moratorium on the harvest, possession, or sale of alewives and blueback herring in 2005. In 2008, citing the lack of recovery of the species' populations both in the state and in the surrounding region, Massachusetts extended its moratorium for an additional three years. The stories in the other states are similar, *i.e.*, moratoriums have been put in place and maintained after populations of alewives and blueback herring have failed to respond.

2. Federal Measures

The Magnuson-Stevens Fishery Conservation and Management Act ("MSA"), 16 U.S.C. §§ 1801 *et seq*., authorizes regional fishery management councils to prepare FMPs for conserving and managing federally-managed fisheries in the EEZ. For such federally-managed fish stocks, overfishing is prohibited, and fish stocks that are already overfished must be rebuilt within statutorily-prescribed time frames. At present, alewife and the blueback herring are not managed under a federal FMP as stocks in a fishery and thus are not being subjected to the MSA's requirements concerning overfishing and rebuilding depleted fisheries.

Although federal FMPs must contain measures related to monitoring and minimizing bycatch, it has been disputed whether such provisions apply to alewives and blueback herring that are caught and sold. Even assuming the applicability of the MSA's bycatch-related provisions, such provisions have proven ineffectual to date with regard to alewives and blueback. Specifically, while federal FMPs must establish standardized reporting methods for bycatch, it is widely recognized that such bycatch reporting is limited and generally inadequate and particularly so with respect to non-federally managed fish species such as alewife and blueback herring. Federal FMPs must also include "practicable" measures to minimize bycatch and bycatch mortality. In practice, the "practicability" threshold means that significant bycatch reduction measures are rarely included as required management measures in FMPs unless necessary to prevent overfishing or to rebuild a federally-managed fish stock. No FMPs implemented pursuant to the MSA currently contain any provisions specifically intended to reduce the incidental catch or bycatch and bycatch mortality of alewives and blueback herring.

Draft versions of Amendment 5 to the Atlantic Herring FMP, currently under development by the New England Fishery Management Council ("NEFMC"), and Amendment 14 to the Squid, Mackerel, and Butterfish FMP, currently under development by the Mid-Atlantic Fishery Management Council ("MAFMC"), both contain proposals that would improve monitoring of alewife and blueback herring bycatch/incidental catch in these fisheries and potentially reduce such catch of the two species. It is currently uncertain when these FMP amendments will be approved and take effect, whether the amendments will ultimately contain provisions intended to reduce bycatch mortality of alewives and/or blueback herring, reduce incidental catch, and the extent of such bycatch mortality/incidental catch reduction (if any).

NMFS has declined to initiate emergency rulemaking or take other action under the MSA or under the Atlantic Coast Fisheries Act (which authorizes NMFS, in the absence of a federal FMP, to implement regulations in federal waters compatible with the relevant interstate FMP and consistent with the MSA's national standards, 16 U.S.C. § 5103(b)(1)) to increase the monitoring of, and to take action to reduce, bycatch/incidental catch of alewives and blueback herring in small-mesh fisheries in the Northeast. In 2009, the ASMFC requested that the Secretary of Commerce take emergency action to improve monitoring of and the regulation of bycatch/incidental catch of alewives and blueback herring in these small-mesh fisheries and to provide additional resources to support the cooperative efforts between the ASMFC, MAFMC, and NEFMC to better manage anadromous fisheries for purposes of reducing bycatch-related mortality and reducing incidental catch (NMFS 2009a). The MAFMC (2009) and NEFMC (2009) supported this request. Also in 2009, multiple non-governmental organizations petitioned NFMS for an emergency rulemaking per ASMFC's request (NMFS 2009a; Cape Cod Commercial Hook Fishermen's Association *et al.* 2009). NMFS (2009) denied the request, stating that "emergency rulemaking under section 305(c) or general rulemaking under section 402(a)(2) of the Magnuson-Stevens Act to increase monitoring or observer coverage of river herring bycatch/incidental catch in small-mesh fisheries in New England or the Mid-Atlantic is not warranted or justified at this time."

The MSA also requires regional fishery management councils to designate "essential fish habitat" for federally-managed stocks. But because they are not federally-managed, alewife and the blueback herring are not subject to this requirement. Under 1996 amendments to the MSA, a regional council is required to comment on activities likely to substantially affect the habitat of anadromous fishery resources under the council's authority. To date, based on the information provided by the ASMFC (2008) and ASMFC (2009a) and to the best of Petitioner's knowledge, this provision has not resulted in meaningful modification of any projects or activities with adverse effects on alewife and blueback herring habitat.

Various federal laws and regulations contain requirements and provisions relating to threats to the alewife's and the blueback herring's habitat, including resulting from poor water quality, dredging, and/or altered water flows. As detailed *supra* and further discussed below, however, such regulatory mechanisms have failed to adequately address these habitat threats.

The federal Clean Water Act ("CWA"), 33 U.S.C. §§ 1251-1387, authorizes the EPA and states with delegated CWA programs to limit the discharge of pollutants into navigable waters. The CWA has produced notable progress in reducing discharges of toxic pollutants from industrial sources, but is widely-recognized to have not adequately regulated nutrients and toxic pollutants originating from non-point sources. The CWA's Section 404 also requires entities to obtain a federal permit from the ACOE before discharging dredged or fill material into navigable waters; section 10 of the Rivers and Harbors Act of 1899 similarly requires issuance of ACOE permits in order to place structures in navigable waters or to conduct excavation or filling activities in navigable streams. Such permits, which are routinely granted, sometimes contain restrictions on the timing and location of dredging operations in habitats utilized by alewives and blueback herring, resulting in limited incidental benefits to the species.

The Federal Power Act ("FPA"), 16 U.S.C. §§ 791-828, has provisions for protecting and enhancing fish and wildlife affected by hydroelectric facilities regulated by FERC. Section 10(j) of the FPA requires licenses issued by FERC to include conditions for protecting, mitigating damages to, and enhancing fish and wildlife, and Section 18 requires the construction and operation of fishways. However, the lack of effective and/or maintained fish passage devices for alewives and blueback herring and the degradation of upstream habitat due to impoundment of formerly free-flowing rivers limit opportunities for alewives and blueback herring to benefit from the FPA's fishway requirements.

The Anadromous Fish Conservation Act, 16 U.S.C. §§ 757a-757f, authorizes the Secretaries of Interior and Commerce to contract with states and other entities for the conservation, development, and enhancement of anadromous fish, primarily through research, surveys, and the construction and operation of hatcheries. It does not require measures to improve habitat or reduce bycatch or mitigate other threats facing alewife and the blueback herring. Similarly, the Fish and Wildlife Coordination Act, 16 U.S.C. §§ 661-666, authorizes the Secretaries of Interior and Commerce to advise agencies engaged in federal water project development on the potential effects of projects on fish and wildlife habitat. While the law requires construction agencies to file these reports and recommendations with requests for congressional authorization, the recommendations are not binding.

A number of federal and international laws and policies are intended to control the potential spread of fish pathogens from one geographic area to another, such as 50 C.F.R. § 16, the FWS Health Policy, and the North Atlantic Salmon Conservation Organization Williamsburg Resolution but they are focused on salmonid species. The ASMFC FMP recommends that public aquaculture facilities be certified as disease-free and that states submit annual reports regarding such certification, but, to the best of Petitioner's knowledge, this recommendation has not been acted on to date.

Various federal protections exist for other anadromous species with ranges overlapping those of alewife and the blueback herring, such as the shortnose sturgeon and Atlantic salmon. These protections may provide some benefits to alewife and blueback herring but such benefits are limited and not sufficient to stop the species' declines.

E. Other Natural or Manmade Factors

1. Invasive Species

Invasive species may threaten food sources for alewives and blueback herring (ASMFC 2009b). For example, the introduction of zebra mussels to the Hudson River, and their subsequent explosive growth in the river, quickly caused pervasive changes in populations of phytoplankton (80 percent drop) and micro- and macro- zooplankton (76 percent and 50 percent drop, respectively) communities (ASMFC 2008: 310). Water clarity improved dramatically (up by 45 percent), and shallow water zoobenthos increased by 10 percent (ASMFC 2008: 310). Following these significant changes in habitat, Strayer *et al.* (2004) observed decreases in the growth rate and abundance of young-of-the-year fishes, including both alewives and blueback herring (Strayer *et al.* (2004) , as cited in ASMFC 2008: 310-311).

Alewives and blueback herring may face increased threats from invasive species due to changes in ocean conditions and the marine ecosystem as a result of climate change and other impacts related to increasing carbon dioxide emissions and levels in the atmosphere.

2. Impingement, Entrainment, and Water Temperature

Operations that withdraw water from rivers or other bodies or water can impinge or entrain alewife and blueback herring larvae, YOY, and small juveniles on intake screens, especially when intake structures are located in or near spawning grounds. Large volume water withdrawals (*e.g.,* drinking water, pumped-storage hydroelectric projects, irrigation, and snow-making), especially at pumped-storage facilities, can drastically alter local current characteristics (*e.g.,* reverse river flow) (ASMFC 2009a). This can cause delayed movement past the facility, or entrainment where the intakes occur (ASMFC 2009a). Planktonic eggs and larvae entrained at water withdrawal projects experience high mortality rates due to pressure changes, shear and mechanical stresses, and heat shock (ASMFC 2009a). Well-screened facilities are unlikely to cause serious mortality to juveniles; however, large volume withdrawals can entrain significant numbers (ASMFC 2009a). Impingement of fish can trap them against water filtration screens, leading to asphyxiation, exhaustion, removal from the water for prolonged periods of time, or removal of protective mucous and descaling (ASMFC 2009a). According to the ASMFC (2009a and 2009b), alewife and blueback herring populations can be threatened by entrainment or impingement by commercial, agricultural, or municipal water intake structures.

Studies of three power plant facilities – the Seabrook nuclear power facility in southern New Hampshire, which draws water through pipes from Ipswich Bay; the Pilgrim nuclear power plant in Massachusetts on southern Cape Cod Bay, which draws water directly from Plymouth Bay; and Brayton Point Station, located in Massachusetts on Mount Hope Bay near the Taunton River – showed that significant impingement and entrainment of alewives and their larvae and eggs occurred in and on the power stations' cooling water intake structures. Mean impingement of alewives at Seabrook was 508 fish annually between 1990 and 1998 (EPA 2002: Table G3-2). Mean impingement of alewives at Pilgrim was 3,250 fish annually between 1974 and 1999, although there were no data available from 1975 through 1989 (EPA 2002: Table G3-10). The little data available on entrainment at Pilgrim suggested high levels of entrainment of alewives (larvae and eggs) as well (EPA 2002: Table G3-14). EPA's estimate of mean impingement of alewives at Brayton Point was 5,998 annually from 1978 to 1983 (EPA 2002: Table F3-2). EPA's estimated mean annual entrainment of alewives' eggs and larvae at Brayton Point was 1,076,500 annually (EPA 2002: Table F3-6).

Studies conducted along the Connecticut River found that larvae and early juveniles of alewife, blueback herring, and American shad suffered 100 percent mortality when temperatures in the cooling system of a power plant were elevated above 28°C; 80 percent of the total mortality was caused by mechanical damage and 20 percent was due to heat shock (ASMFC 2009a). Ninety-five percent of the fish near the intake were not captured by the screen, indicating that it may not be possible to screen fish larvae effectively (ASMFC 2009a).

Water withdrawals can also alter physical characteristics of streams, including: decreased stream width, depth, and current velocity; altered substrate; and temperature fluctuations (ASMFC 2009a). In rivers that are drawn upon for water supply, water is often released downstream during times of decreased river flow (usually summer) (ASMFC 2009a). Additionally, failure to release water during times of low river flow and higher than normal water temperatures can cause thermal stress, leading to fish mortality (ASMFC 2009a). Consequently, water flow disruption can result in less freshwater input to estuaries, which are important nursery areas for many anadromous species (ASMFC 2009a).

In addition, cold water releases often decrease the water temperature of the river downstream, which has been shown to cause some juvenile anadromous fish to abandon their nursery areas (ASMFC 2009a). At the Cannonsville Reservoir on the West Branch of the Delaware River, cold-water releases from the dam resulted in the elimination of nursery grounds below the dam for American shad (ASMFC 2009a). The same factors could negatively affect alewives and blueback herring. Facilities that release heated water also cause changes in alewife and blueback herring habitat that can cause mortalities or impairment.

IV. Requested Listings

NMFS must list a species as "threatened" under the ESA if the species is "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." *See* 16 U.S.C. § 1532(20).

Appropriate Time Frames

In choosing a time frame, *e.g.,* what is the "foreseeable future" in which a species is likely to become endangered for classification purposes, NMFS must choose a time frame that is reasonable, given the species' characteristics and the nature of the threats. *Cf. Black's Law Dictionary*, 8th ed. 2004 (definition of foreseeable is "reasonably anticipatable"). The time frame should also ensure protection of the petitioned species, and give the benefit of the doubt regarding any scientific uncertainty to the species.

The timeframe for alewife and the blueback herring should be similar to that used for other anadromous fish species. Because global warming is one of the foremost threats to alewife and the blueback herring, NMFS should also use a timeframe that is appropriate for such impacts and relied upon in climate modeling (such a time frame is, for example, inherently "foreseeable"). The minimum time period that meets these criteria is 100 years. The 100 year time frame has been used for fish with shorter lifespans, such as Columbia River steelhead, Chinook salmon, and, most recently, the GOM DPS of Atlantic Salmon (NMFS 2009b: 74 Fed. Reg. 29344, 29356). Courts have approved the use of the 100 year time-frame for multiple other species as well. *See Western Watersheds Project v .United States Fish and Wildlife Service*, 535 F. Supp. 2d 1173, 1184 (D. Id. 2007) ("To be a 'threatened' species under the ESA, the sage-grouse must be 'likely' to 'be in danger of extinction' within 100 years"); *Southwest Center for Biological Diversity v. Norton*, 2002 WL 1733618, at *12 (D.D.C. July 29, 2002) (for the Queen Charlotte goshawk, the FWS determined that the goshawk would be "threatened" "if at any point in the next 100 years there is a 20 percent chance that the species would become extinct."); *Western Watersheds Project v. Foss*, 2005 WL 2002473, at *15 (D. Id., Aug. 19, 2005) (court ruled that FWS' decision not to list a plant with 64 percent chance of extinction within 100 years as threatened was untenable).

The IUCN species classification system also uses a timeframe of 100 years. For example, a species must be classified as "vulnerable" under the IUCN system if there is a probability of extinction of at least 10% within 100 years. Further, a species must be listed as "endangered" if the probability of extinction is at least 20% within 20 years or five generations, whichever is the longer (up to a maximum of 100 years).

Moreover, in planning for species recovery, agencies routinely consider a 75-200 year foreseeable future threshold (Suckling 2006). For example, the FWS used 100 years in connection with recovery of the Steller's Eider (*e.g.*, the Alaska-breeding population of the species will be considered for delisting from threatened status when it has <1% probability of extinction in the next 100 years, and certain populations have <10% probability of extinction in 100 years and are stable or increasing) and 200 years in connection with recovery of the Utah prairie dog, and NMFS used 150 years in connection with the recovery of the Northern right whale (Suckling 2006).

Perhaps most importantly, the time period that NMFS uses in its listing decision must be long enough so that actions can be taken to ameliorate the threats to the petitioned species and prevent extinction. Slowing and reversing impacts from anthropogenic greenhouse gas emissions in particular, a primary threat to alewife and the blueback herring, will be a long-term process for a number of reasons, including the long lived nature of carbon dioxide and other greenhouse gases and the lag time between emissions and climate changes. For all these reasons, Petitioner recommends a minimum of 100 years as the time frame for analyzing the threats to the continued survival of alewife and the blueback herring.

Significant Portion of Its Range

A "significant portion of [a species'] range" (also "SPOIR") can include both current and historical habitat. *See, e.g., Northwest Ecosystem Alliance v. United States Fish and Wildlife Serv.*, 475 F.3d 1136, 1148 (9th Cir. 2007) ("major geographical areas in which it is no longer viable but once was"), citing *Defenders of Wildlife v. Norton,* 258 F.3d 1136, 1145 (9th Cir. 2001). A danger of extinction to a species within a SPOIR is sufficient to require listing. 16 U.S.C. § 1532(6); *Defenders*, 258 F.3d at 1141-42.

Cumulative Impacts of Stressors

Consistent with the ESA's requirements, while each factor and each individual stressor may be discussed separately, they must be considered together in making listing decisions. To only consider them "piecewise, one or two at a time . . . is flawed because the interaction among components may yield critical insight into the probability of extinction. . . . the synergism among processes—such as habitat reduction, inbreeding depression, demographic stochasticity, and loss of genetic variability—is exactly what will be overlooked by viewing only the pieces." Boyce (1992: 495-6); *see also Western Watersheds Project v. Fish and Wildlife Serv.*, 535 F. Supp. 2d 1173, 1179 (D. Id. 2007) ("It is the 'cumulative impacts of the disturbances, rather than any single source, [that] may be the most significant influence on the trajectory of sagebrush ecosystems.'"). NMFS has considered cumulative risk in prior listing determinations (NMFS 2009b: 74 Fed. Reg. 29344, 29382-83).

For the alewife and the blueback herring, cumulative risk must be accounted for by considering risks posed by individual stressors and harms in the aggregate. Alewives and blueback herring have a broad geographic range and are susceptible to varied threats throughout their life stages. The ASMFC (2009b) indicates that bycatch/incidental catch in ocean fisheries, predation by other species, direct harvest, barriers to upstream and downstream migration (*e.g.*, dams and hydropower facilities), and habitat degradation can impact the abundance and distribution of alewife and blueback herring populations in Atlantic coastal areas (ASMFC 2009b). Habitat degradation can be caused by pollution (*e.g.*, non-point source, industrial, etc.), agriculture (*e.g.*, sediment load alterations, chemicals, etc.), channelization and dredging, and urbanization (ASMFC 2009b). Climate change may also pose risks to alewife and blueback herring populations. If a population of alewife or blueback herring can sustain only a certain number of mortalities per year and/or over the course of several years but is faced with mortalities that exceed that amount over a sustained period of time, the population is threatened with collapse. This only becomes adequately apparent by adding together the risks posed by different stressors.

In addition, the interaction between individual stressors, and possible synergistic effects, must be considered. For example, dams can compound the risk of predation as large numbers of alewives and blueback frequently congregate in areas immediately below dams and thus become more vulnerable to predators. Boesch *et al.* (2007) stated that "the interaction between climate and anthropogenic nutrient loading [is] particularly important in determining future hypoxic events."

The alewife and the blueback herring are particularly vulnerable to a variety of anthropogenic and natural disturbances throughout their life cycles. While individual factors may negatively affect the stability or growth of a particular population(s) of alewife and blueback herring, it is likely that a combination of factors negatively affecting multiple populations of alewives and blueback herring could threaten the species' sustained stability and growth. Alewives and blueback herring are likely able to sustain only a certain level of anthropogenic sources of mortality, and a combination of factors negatively affecting alewives and blueback herring at different life stages could exceed their total mortality threshold and inhibit the species' stability or growth. In addition, research indicates that forage fish species, such as alewife and the blueback herring, may be at a significant risk when their population sizes are at only a fraction of their historical levels but are still large compared to what would be considered normal for other ESA-listed species (NMFS 2009c: 74 Fed. Reg. 10857, 10868-69).

A. The Alewife and the Blueback Herring Should Each Be Listed as Threatened Species as a Whole.

For the reasons set forth in this petition, NMFS should list both the alewife and the blueback herring as threatened species as a whole because both the alewife and the blueback herring are likely to become endangered in the foreseeable future throughout all or a significant portion of their respective ranges.

As discussed *supra*, significant reductions in and/or the extirpation of populations of alewives and of blueback herring exposes each species as a whole to a much greater risk of becoming endangered within the foreseeable future throughout all or a significant portion of its range. For example, the ability of alewives and blueback herring to adapt to climate change depends on genetic and geographic diversity, as maximum gene variation increases the odds that genes will carry traits amenable to climate change adaptation. The disappearance and/or depletion of alewife and blueback herring populations in many rivers, and the significant risk of increasing rates of depletion and extirpation of such populations, leaves each species as a whole vulnerable to being unable to adapt to changes caused by climate change.

The precipitous and sustained declines of both the alewife and the blueback herring throughout the species' respective ranges despite efforts to stabilize and rebuild populations of both species, indicate that it is necessary to protect alewives and blueback herring using the protections available under the ESA in order to save and recover each species. Accordingly, the alewife and the blueback herring should each be listed as a threatened species as a whole.

B. In the Alternative, the Four Alewife DPSs and the Three Blueback Herring DPSs Should Be Listed as Threatened.

In the alternative, NMFS should list the four alewife DPSs and three blueback herring DPSs as threatened. Each of these DPSs is likely to become endangered within the foreseeable future throughout all or a significant portion of its range for the reasons set forth in this petition.

As discussed *supra*, coastal rivers in the Central New England DPSs, the Long Island Sound DPSs, the Chesapeake Bay DPSs, and the Carolina DPS historically supported abundant populations of both alewives and blueback herrings. Because of multiple stressors, including climate change, fishing-related mortality, and habitat impairment, such as from dams and poor water quality, these populations have significantly declined and are continuing to decline or to persist at unsustainable low levels.

For example, in the proposed Central New England DPSs, the Taylor River supported the New Hampshire's largest alewife and blueback herring population, with a population once numbering at least 450,000 fish, but it has dramatically declined since around 1980 and remains at historic low levels (NHFGD 2009: 16, Table 1-1; ASMFC 2008: 104, Figure 1.6.1.1). From a peak of 450,000 fish in 1976, the Taylor River alewife and blueback herring population (almost entirely bluebacks, according to NHFGD (2011)) dropped to 675 counted fish in 2010 – a decline of more than 99 percent (NHFGD 2009: 16, Table 1-1; NHFGD 2011a). In addition, the monitored alewife and blueback herring populations in the Exeter River, Lamprey River, and Oyster River – three rivers that are located in close proximity to each other – have experienced a combined decline of over 50 percent since just 2004 (NHFGD 2009: 16, Table 1-1; NHFGD 2011a). Historically, the Oyster River was the most important of the three rivers, but its 2009 and 2010 run counts (mostly bluebacks, according to NHFGD (2011)) were just ~15 percent of what they were in the 1990s (NHFGD 2011). To similar effect, between just 2004 and 2008, the age structure of the alewife and the blueback herring populations in the Taylor River, Exeter River, and Oyster River has declined significantly (NHFGD 2009: 17, Table 1-2). Throughout the central and southern portion of these DPSs, alewives and blueback herring have been extirpated or reduced to remnant populations in most rivers and streams. In the Parker River, the average alewife count over the last three years is just 5% of what it was in the mid-1970s (MADMF 2011).

In the proposed Long Island Sound DPSs, coastal rivers that once boasted significant alewife and blueback herring populations include the Monument River, Mattapoisett River, Nemasket River, Nonquit River, Gilbert-Stuart River, and Connecticut River (ASMFC 2008). Today, available data indicates that there is only one river in these DPSs (the Nemasket River) that supports a sizeable alewife population and only one river in these DPSs (the Connecticut River) that supports a sizeable blueback herring population (ASMFC 2008). According to the ASMFC (2008), available data indicates that the other rivers in these DPSs support depleted alewife populations that are an estimated 87 percent to 99 percent smaller than the Nemasket River alewife population (ASMFC 2008; MADMF 2011: 52-53, Appendix Table 4). The blueback herring population in the Monument River, for example, was an estimated 97 percent smaller than the Connecticut River population (ASMFC 2008). Historically, the Monument's alewife run numbered almost 600,000 counted fish and its blueback run more than 100,000 counted fish. In 2010, fish counts in the river showed declines of 84 percent and 91 percent, respectively, from those peaks (ASMFC 2008: 195, Table 4.3; MADMF 2011: 52, Appendix Table 4). These declines (as well as those in other rivers) led the MADMF in 2005 to prohibit the harvest, possession, or sale of alewives and blueback herring throughout the state as an emergency conservation measure – prohibitions which have been continued as a result of continuing population declines (ASMFC 2008; MADMF 2008).

In the proposed Chesapeake Bay DPSs, commercial landings from Maryland's Chesapeake Bay and tributaries have declined more than 99 percent from pre-1970s harvests of more than 3 million pounds (MDNR 2010: 21, Table 12). In Virginia, once the leader in river herring landings on the Atlantic seaboard, commercial landings of river herring have declined from peaks of almost 25 million pounds to recent lows averaging under 100,000 pounds per year (ASMFC 2008: 55-57, Table 1.5.1.1). Historical overharvesting has been identified as one of the factors contributing to the recent declines in alewife and blueback herring populations in the Chesapeake Bay (USFWS 2009). Bycatch and incidental catch – an ongoing concern – likely contributes to this overharvesting problem as there are no limits on the amounts of alewives and blueback herring caught as bycatch and incidental catch in ocean waters. In addition, the Bay's nutrient pollution problem is one of the most egregious in the country, and dams that permanently blocked anadromous fish passage and those with ineffective fishways have significantly reduced the amount of spawning habitat available for alewife and blueback herring populations in rivers and tributaries along the Chesapeake Bay (ASMFC 2008).

In the Carolina DPS, the story is the same for alewives. The fish appears to have been effectively extirpated in South Carolina, and river herring landings data from North Carolina suggest population declines of about 98 to 99 percent from 1950 to 1970 harvest levels (ASMFC 2008: 55-57, Table 1.5.1.1; 495, Table 3; and 537; SCDNR 2010a; NCDMF 2010a: 4-6, Table 1). Data specific to alewives in North Carolina show that average size has decreased significantly in the past 3 decades: female and male alewives sampled from 2004 to 2007 were approximately 15 to 20 millimeters smaller, on average, than alewives of the same sex sampled from 1971 to 1978; mean sizes of male and female alewives from ages 4 through 6 have stayed low since the statewide harvest moratorium was implemented in 2007 (ASMFC 2008: 35, 129, Figure 1.7.1; NCDMF 2010b: Figures 20 and 21). The mean JAI in Albemarle Sound for alewives from 1972 to 1980 was 5.7; between 2000 and 2010, it averaged only 0.98 (NCDMF 2011; NCDMF 2010b: Table 40). Even with the river herring harvest moratorium in North Carolina starting in 2007, populations do not appear to have rebounded. Significant threats include fishing mortality in ocean waters and adverse modification of habitat. For example, poor water quality, especially from urban and agricultural runoff, negatively affects alewives in the Chowan River (NCWAP 2005). In South Carolina rivers, dams block or complicate passage by river herring to traditional spawning habitat and have been found to contribute to dramatic declines seen in river herring spawning runs (USFWS/SCDNR 2001).

Notably, climate change serves as a particularly significant threat to the alewife in the southernmost portion of its range, as discussed *supra*. In a recent NMFS study of different fish species' responses to climate change trends, the alewife demonstrated a notable poleward shift in the center of biomass and an increase in mean depth of occurrence (Nye *et al.* 2009: 120). Another study in North Carolina noted the potential for climate change to, as a result of rising sea levels, further reduce habitat complexity and quality in alewife spawning and nursery habitat and thus also reduce the number of repeat spawners as energy needs increase for migration because of decreasing habitat quality in downstream areas (Weaver 2009). In designating a Carolina DPS for Atlantic Sturgeon in 2010, NMFS noted that the Carolinas region in particular was significantly threatened by climate change and rising sea level, as well as altered surface hydrology caused in part by dams, and a regionally receding water table, probably resulting from both over-use and inadequate recharge (NMFS 2010c: 75 Fed. Reg. 61904, 61910).

In short, these DPSs are likely to become endangered in the foreseeable future, given their small size, declining status, and the multiple significant threats they face. As discussed supra, bycatch/incidental catch, hydropower dams, poor water quality, and climate change independently pose substantial threats to the alewife and the blueback herring populations occurring in these waters. For all of these reasons, and those discussed supra, NMFS should list these four DPSs of alewives and three DPSs of blueback herring as threatened.

V. RECOVERY PLAN ELEMENTS

NMFS should establish a recovery plan for the alewife and for the blueback herring that addresses bycatch/incidental catch, habitat degradation, climate change, disease, and other key threats, including the following components:

- Changes in gear and gear deployment, including catch monitoring, gear restricted areas, closed areas, and catch/bycatch caps in mid-water trawl fisheries believed to cause significant alewife and blueback herring mortality;

- Mitigation and management to improve habitat and water quality, particularly in river systems where habitat and water quality is severely degraded, including specifically: 1) elimination of barriers to spawning habitat through dam removal or breaching, or installation of effective fish passage options; 2) operation of water control structures to provide flows beneficial to alewife and blueback herring habitat use in lower portions of rivers (especially during the spawning season); 3) imposition of restrictions on dredging, including seasonal restrictions and avoidance of spawning/nursery habitat; and 4) mitigation of water quality parameters that are restricting alewife and blueback herring use of a river (*i.e.*, DO);

- Measures to address the current and future effects of global warming on the alewife and on the blueback herring, including measures to reduce nutrient loads and otherwise improve water quality conditions; and

- Enhanced implementation and enforcement of fishery restrictions.

VI. Critical Habitat Designation

Petitioner requests the designation of critical habitat for the alewife and the blueback herring concurrent with the requested listings, as required by 16 U.S.C. § 1533(b)(6)(C). *See also* 16 U.S.C. § 1533(a)(3)(A). Alewife and blueback herring populations have already precipitously declined from their historic levels throughout the species' ranges. Critical habitat should encompass all known and potential spawning rivers. It should also encompass all estuarine and marine habitats in which alewives and blueback herring are known to forage.

Critical habitat is defined by Section 3 of the ESA as: "(i) the specific areas within the geographical area occupied by the species, at the time it is listed in accordance with the provisions of section 1533 of this title, on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and (ii) specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the provisions of section 1533 of this title, upon a determination by the Secretary that such areas are essential for the conservation of the species." *See* 16 U.S.C. § 1532(5).

The designation and protection of critical habitat is one of the primary ways to achieve the fundamental purpose of the ESA, "to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved." *See* 16 U.S.C. § 1531(b). In adding the critical habitat provision to the ESA, Congress clearly saw that species-based conservation efforts must be augmented with habitat-based measures: "It is the Committee's view that classifying a species as endangered or threatened is only the first step in insuring its survival. Of equal or more importance is the determination of the habitat necessary for that species' continued existence . . . If the protection of endangered and threatened species depends in large measure on the preservation of the species' habitat, then the ultimate effectiveness of the Endangered Species Act will depend on the designation of critical habitat." *See* House Committee on Merchant Marine and Fisheries, H.R. Rep. No. 887, 94th Cong. 2nd Sess. at 3 (1976).

The alewife and the blueback herring will benefit from the designation of critical habitat in all of the ways described above. Designated critical habitat will allow NMFS to designate reasonable and prudent alternatives to activities that are impeding recovery but not necessarily causing immediate jeopardy to the continued survival of the species. For these reasons and as already stated, we request critical habitat designation concurrent with these species listings.

VII. Conclusion

For all of the reasons discussed in this petition, NMFS should list the alewife and the blueback herring each as threatened species as a whole. In the alternative, NMFS should list the four DPSs of the alewife and the three DPSs of the blueback herring, as described *supra*, each as threatened species. In the alternative to listing the DPSs as described in this petition, NMFS should delineate alternative DPSs for the alewife and for the blueback herring based on the best available technical information and the agency's expertise.

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