Blueback Herring (*Alosa aestivalis*)

Ecological Risk Screening Summary

U.S. Fish and Wildlife Service, March 2023
Revised, April 2023
Web Version, 3/3/2025

Organism Type: Fish
Overall Risk Assessment Category: High

Image: Duane Raver. Used with permission. Available: https://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=488 (April 2023).

1 Native Range and Status in the United States

Native Range

From Fuller et al. (2019):

"**Native Range:** Atlantic Coast from Cape Breton, Nova Scotia [Canada], to the St. Johns River, Florida. Ascends coastal rivers during spawning season (Page and Burr 1991)."

Status in the United States

From NatureServe (2023):

"Large range in streams and coastal waters of the Atlantic coast of North America; drastic declines in abundance in recent decades; threats include dams, habitat degradation, fishing, and predation by striped bass."

"Range encompasses the North American Atlantic coast from Nova Scotia to the St. Johns River, Florida. The species has been introduced in reservoirs in several states, and in the Tennessee River system in Tennessee (Bozeman and Van Den Avyle 1989, Page and Burr 2011)."

According to Fuller et al. (2019), nonindigenous occurrences of *Alosa aestivalis* have been reported in the following U.S. jurisdictions. Range of observation years, number of watersheds (8-digit hydrologic unit), and population status where reported (one or more watersheds) in parentheses.

- Alabama (2012-2015; 3; established)
- District of Columbia (2010; 1; established)
- Florida (1962-1975; 2; established)
- Georgia (1992-1998; 2; established)
- Maryland (1968; 1; established)
- New York (1978-2008; 5; established)
- North Carolina (1964-2010; 5; established)
- Pennsylvania (1998; 1; established)
- South Carolina (1972-2009; 3; established)
- Tennessee (1998-2013; 3; established)
- Texas (1982-1998; 3; established)
- Vermont (1976-1997; 2; established)
- Virginia (1958-2012; 5; established)

From Fuller et al. (2019):

"Established in New York, North Carolina, South Carolina, Tennessee, Vermont, and Virginia. Extirpated in Texas."

"One of the most common fish species in the Hudson River estuary (Hurst et al. 2004). Detection of a small population of Blueback Herring in Lake Ontario would be difficult because of the size of the Lake relative to the area routinely sampled and the herring's superficial similarity with Alewife, a fish sampled in large enough numbers that only a fraction of the adults are examined closely enough to distinguish between the two species (Owens et al. 1998). Owens et al. (1998) also asserted that colonizing a lake with resident population of Alewife, a fish that would be in direct competition with Blueback Herring for space and resources, and a surfeit of piscivores, both stocked and unstocked, may prove too difficult for *A. aestivalis*."

From CABI (2023):

"In 1962, a specimen of *A. aestivalis* was collected in the Northern Gulf of Mexico [Gulf of America], off the Florida coast. USGS NAS (2015) suggests this to be part of the species' invaded range."

According to Hendrickson and Cohen (2022), *A. aestivalis* is suspected to occur in southeast Texas in the San Patricio and Nueces County area. Those occurrences are awaiting confirmation.

From Howells (2001):

"This species [*Alosa aestivalis*] was brought to Texas from South Carolina by TPW [Texas Parks and Wildlife Department] and stocked in Lake Theo (Red River drainage), Caprock Canyons State Park, Briscoe County, and in a second lake (12-D; Trinity River drainage) in the Lyndon B. Johnson National Grasslands, Wise County, in 1982 to study its value as a forage fish in place of threadfin and gizzard shads (*Dorosoma* spp.) (Guest 1983, 1988; Howells [1992]). The species was still present in Lake Theo in 1998 (C.R. Munger, TPW; pers. comm.); continued survival is possible, and there has been no indication of escapes from either stocking site."

From Schramm et al. (1991):

"A landlocked population of blueback herring (*Alosa aestivalis*) was established in 1982 in Lake Theo, Texas, and persisted for 7 years. Analysis of scales provided inaccurate ages for fish older than age 1. Analysis of otoliths provided valid ages of blueback herring, but protracted formation of annuli on otoliths limited the use of otoliths for back-calculating lengths of these fish. Fish in this landlocked population attained maximum total lengths of 240 mm, lived 2 years, and spawned only once. The disappearance of blueback herring in Lake Theo was attributed to their short life cycle and production of weak year classes. Future use of blueback herring as a forage fish may require additional stocking to supplement weak or missing year classes to maintain the population."

According to CABI (2023), blueback herring is harvested commercially and recreationally during spawning season and used as fishing bait and for human consumption.

Regulations

Alosa aestivalis is regulated in Arkansas (AGFC 2022), Delaware (DNREC 2022), New Hampshire (NHFG 2022), New Jersey (NJFW 2022), North Carolina (NCDEQ 2022), Oklahoma (ODWC 2022), and Tennessee (TWRA 2022). It is regulated at the family level (Clupeidae) in Arizona (Arizona Game and Fish Commission 2022) and Nevada (Nevada Board of Wildlife Commissioners 2022). Please refer back to state agency regulatory documents for details on the regulations, including restrictions on activities involving this species. While effort was made to find all applicable regulations, this list may not be comprehensive. Notably, it does not include regulations that do not explicitly name this species or its genus or family, for example, when omitted from a list of authorized species with blanket regulation for all unnamed species.

Means of Introductions within the United States

From Fuller et al. (2019):

"In most areas other than New York, these fish were intentionally stocked for forage. In New York these fish are expanding their range using ship locks and canals. Blueback Herring was first recorded in the Mohawk River upstream of Cohoes Falls in 1934 (Greeley 1935). They were reported from Lake Champlain on the New York side in the late 1970s, and from the Vermont side in 1997. Juveniles were apparently present in Oneida Lake by 1981 or 1982. Adults were first documented in 1994 by Cornell researchers based at Shackleton Point. Several thousand immature fish were also documented in 1994 at a power plant in Minetto on the Oswego River. Two immature fish caught in Lake Ontario near Oswego in October 1995 by were likely introduced by swimming up the Lake Erie Barge canal which connects Lakes Champlain and Ontario to the Mohawk-Hudson Rivers within the Blueback Herring's native range (Owens et al., 1998). Blueback Herring in Jocassee and Keowee Reservoirs, South Carolina, were accidentally included in Threadfin Shad (*Dorosoma petenense*) stockings in 1972 and 1974 (Prince and Barwick 1981); the population in Lake Murray, SC, is likely the result of a bait bucket introduction."

From CABI (2023):

"The spread of *A. aestivalis* outside of its native range does not comprise a large geographical area. Due to the fact that its introduction into new areas has mostly been a result of intentional stocking, the risk factor for further introduction is human-induced spread, via bait bucket contamination and stocking. Further spread from a point of introduction could then occur via the species' migration."

Remarks

From Fuller et al. (2019):

"Comparisons between morphological and genetic identification methods found that identification between Blueback Herring and Alewife may be incorrect up to 16% of the time when using morphological methods alone (Kan et al., 2017)."

Alosa aestivalvis has been intentionally stocked outside its native range within the United States by State fishery managers to achieve fishery management objectives. State fish and wildlife management agencies are responsible for balancing multiple fish and wildlife management objectives. The potential for a species to become invasive is now one important consideration when balancing multiple management objectives and advancing sound, science-based management of fish and wildlife and their habitat in the public interest.

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From ITIS (2023):

Kingdom Animalia
Subkingdom Bilateria
Infrakingdom Deuterostomia
Phylum Chordata
Subphylum Vertebrata
Infraphylum Gnathostomata
Superclass Actinopterygii
Class Teleostei
Superorder Clupeomorpha
Order Clupeiformes
Suborder Clupeoidei
Family Clupeidae
Subfamily Alosinae
Genus *Alosa* Linck, 1790
Species *Alosa aestivalis* (Mitchill, 1814)

According to Fricke et al. (2023), *Alosa aestivalis* is the current valid name for this species.

The following synonyms of *Alosa aestivalis* from Fricke et al. (2023) were used to search for information for this report: *Clupea aestivalis, Clupea fasciata, Alosa cyanonoton.*

Size, Weight, and Age Range

From Froese and Pauly (2023a):

"Max length : 40.0 cm SL [standard length] male/unsexed; [Robins and Ray 1986]; common length : 27.5 cm SL male/unsexed; [Whitehead 1985]; max. published weight: 200.00 g [Robins and Ray 1986]; max. reported age: 8 years [Hugg 1996]"

Environment

From NatureServe (2023):

"Adults occur in saltwater except during the breeding season; they occur up to at least 200 km offshore. Juveniles move to sea when about 1 month old."

From Fuller et al. (2019):

"Anadromous; living in marine systems and spawning in deep, swift freshwater with a hard substrate."

From Froese and Pauly (2023a):

“Marine; freshwater; brackish; pelagic-neritic; anadromous [Riede 2004]; depth range 5 - 55 m [Scott and Scott 1988].”

Climate

From Froese and Pauly (2023a):

“Subtropical; 41°N - 25°N, 84°W - 60°W [Whitehead 1985]”

Distribution Outside the United States

Native

From Fuller et al. (2019):

“**Native Range:** Atlantic Coast from Cape Breton, Nova Scotia, […]. Ascends coastal rivers during spawning season (Page and Burr 1991).”

Introduced

No records were found for introduction of *Alosa aestivalis* in the wild outside the United States.

Means of Introduction Outside the United States

No records were found of introduction of *Alosa aestivalis* in the wild outside the United States.

Short Description

From Fuller et al. (2019):

“This fish is silvery in color, has a series of scutes (modified scales that are spiny and keeled) along its belly, and is characterized by deep bluish green backs. The most distinguishing characteristic of this species is the black to dusky in color of its peritoneum (the lining of the abdominal cavity). Blueback Herring and Alewife are difficult to distinguish from one another and are often regarded collectively as river herring. Alewife has larger eyes, greater body depth, and pearly to white peritoneal linings. Jenkins and Burkhead (1994); Owens et al. (1998); Page and Burr (1991); Smith (1985); Whitehead (1985).”

From Froese and Pauly (2023a):

“Dorsal spines (total): 0; Dorsal soft rays (total): 15-20; Anal spines: 0; Anal soft rays: 15 - 21; Vertebrae: 47 - 53. Moderately compressed, belly with distinct keel of scutes. Upper jaw with a distinct notch; lower jaw rising steeply within mouth; minute teeth present at front of jaws (disappearing with age). Lower gill rakers 41 to 52 (fewer in fishes under 10 cm standard length), slender. Back dark blue, sometimes bluish-grey; a dark spot on shoulder [Whitehead 1985]. Peritoneum black [Robins and Ray 1986]. Branchiostegal rays 7 [Jones et al. 1978].”

Biology

From NatureServe (2023):

"Habitat includes riverine, estuarine, and Atlantic coastal waters; also in certain lakes and reservoirs in the southeastern United States. Adults occur in saltwater except during the breeding season; they occur up to at least 200 km offshore. Juveniles move to sea when about 1 month old."

"Spawning occurs in fresh or brackish water, in tidally influenced portions of coastal rivers (Bozeman and Van Den Avyle 1989). According to Lee et al. 1980, spawning occurs in deep swift water over hard substrates. According to Bozeman and Van Den Avyle 1989, spawning occurs in shallow areas covered with vegetation, old rice fields, and river swamps and small tributaries above tidal influence. Eggs sink and adhere to objects on the bottom (Scott and Crossman 1973); after a few hours the eggs unstick and drift downstream (Dadswell 1980). Larvae occur in or slightly downstream from spawning areas; juveniles may exhibit net upstream movement until emigration from freshwater in summer or fall (or, in some areas, the next spring) (Fay et al. 1983). Nursery areas in the Neuse River, North Carolina, were characterized by deep, black water draining hardwood swamps, with little salinity or current and with a mud or detritus bottom (Bozeman and Van Den Avyle 1989)."

From Fuller et al. (2019):

"Migrate to spawning grounds in the spring. In Connecticut, Blueback Herring spawn in 14–27[°]C temperatures. Usually spawns later in the spring than Alewife when water temperatures are slightly warmer. During spawning, many eggs are deposited over the stream bottom where they stick to gravel, stones, logs, or other objects. Juveniles spend 3–7 months in freshwater, then migrate to the ocean (Yako et al. 2002). Blueback Herring are a planktivorous forage species (Winkelman and Van Der Avyle 2002)."

"The landlocked Lake Theo, Texas population attained a smaller maximum size and had a shorter life span than anadromous native populations (Schramm et al. 1991)."

From Froese and Pauly (2023a):

"Form schools and possibly wintering near the bottom and out from the coast, approaching the shore in the late spring. Feed on small fishes, copepods and small shrimps. Spawn in brackish- or freshwaters of rivers, arriving in coastal waters a month or so later than *A. pseudoharengus* (in April at Chesapeake Bay, apparently when the water is above 70° [F] and later further north). Eggs are essentially pelagic, demersal in still water [Jones et al. 1978]. Larvae are found in fresh and brackish rivers [Jones et al. 1978]. Juveniles leave fresh and brackish nursery grounds at about 5 cm, migrating downstream [Jones et al. 1978]."

From CABI (2023):

"*A. aestivalis* can filter feed and also feed on particulate matter. Its gill rakers are very close together, making it a more effective filter feeder than *A. pseudoharengus*, thereby giving a

competitive advantage in areas of overlapping range (Owens et al., 1998). *A. aestivalis* is primarily a planktivorous fish, but fish, crustacean and insect eggs, insects and young fish also comprise an important part of its diet (Fay et al., 1983; Bozeman Jr and Van Den Avyle, 1989; Davis and Foltz, 1991; Simonin et al. 2007)."

"*A. aestivalis* larvae feed on zooplankton when they develop a large enough mouth, and eating larger prey as their mouth continues to grow (Bozeman Jr and Van Den Avyle, 1989; Fay et al., 1983). Crecco and Blake (1983) reported that *A. aestivalis* larvae feed mostly on rotifers of the genus *Keratella*. The stomach contents of young contained mostly remains of water fleas *Bosmina* sp. (Fay et al., 1983)."

"The diet of adults in the Lake Theo reservoir in Texas was composed primarily (89.4%) of cladocerans (Guest and Drenner, 1991). Domermuth and Reed (1980) reported that *A. aestivalis* feeds mostly on cladocerans, particularly the Daphnidae and Bosminidae families. Stomach contents indicated that they primarily consume planktonic and drift organisms and do not feed on benthic invertebrates or terrestrial insects. Juvenile fish sampled in the Hudson River estuary fed primarily on chironomid larvae, copepods and the gastropod *Amnicola* sp. (Grabe, 1996)."

Human Uses

From Froese and Pauly (2023a):

"Marketed mostly fresh and salted [Whitehead 1985]."

From CABI (2023):

"*A. aestivalis'* spawning run supports recreational and commercial fisheries across the eastern coast of North America (Crecco and Blake, 1983). River herring (*A. aestivalis* and *A. pseudoharengus*) is used for fish meal and fish oil to be added to fertilizer, pet food and domestic animal feed, with a smaller portion used for fishing bait and the remainder for human consumption (Fay et al., 1983)."

From Beaty (2014):

"Written records, oral histories, and place names suggest the importance of river herring as a food source in Downeast Maine going back hundreds of years, if not longer. […] The spring and summer months were busy times for harvesting marine fish, invertebrates, and birds, as well as river-running species such as alewives, bluebacks, shad, and sturgeon (Harper and Ranco 2009; Maine Historical Society 2010). River herring were an abundant and important food source in the spring when they entered Downeast Maine's rivers in large numbers and could be easily caught with weirs, traps, and nets (Collette and Klein-MacPhee 2002; Prins and McBride 2007; Harper and Ranco 2009). Each spring, large quantities of river herring were dried or smoked and set aside for later consumption. Many were also cooked fresh. Bones and what few other parts were not consumed were sometimes used to flavor soups and fertilize gardens (Harper and Ranco 2009)."

Diseases

No information was found associating *Alosa aestivalis* with any diseases listed by the World Organisation of Animal Health (2023).

From Froese and Pauly (2023a):

"Parasites found are acanthocephalan and nematodes [Bigelow et al. 1963]."

Froese and Pauly (2023b) lists *A. aestivalis* as a host of *Clavellisa cordata, Ergasilus clupeidarum, Lernaeenicus radiatus*.

According to Poelen (2014), the following are parasites of *Alosa aestivalis*: *Anisakis simplex*, *Derogenes varicus*, *Diplostomum spathaceum*, *Echinorhynchus gadi*, *Brachyphallus crenatus*, *Hemiurus appendiculatus*, *Lechithaster confuses*, *Mazocraeoides georgei*, *Pseudoterranova decipiens*, *Podocotyle*, *Scolex polymorphus*, *Scolex pleuronectis*.

Threat to Humans

From Froese and Pauly (2023a):

"Harmless"

3 Impacts of Introductions

The following information details actual impacts of introductions of *Alosa aestivalis*.

From CABI (2023):

"Following the introduction of *A. aestivalis* into the Lake Theo reservoir in Texas, USA, large bodied zooplankton species of the genera *Leptodora, Episcura, Mesocyclops* and *Daphnia* were eliminated, and smaller sized species increased in numbers (Guest and Drenner, 1991). The Lake Theo introduction resulted in a shift in the dominant species in the zooplankton community, and the feeding behaviour of *A. aestivalis* shifted the dominance from cladocerans to copepods (Guest and Drenner, 1991). These findings suggest that *A. aestivalis* introduction can result in changes in the zooplankton community balance, specifically in closed systems such as a reservoir."

The following information details potential impacts of introductions of *Alosa aestivalis*.

From Fuller et al. (2019):

"[Impacts to the Great Lakes] Unknown, very likely to find suitable habitat throughout the Great Lakes system. GARP models predict it could find the entire region as suitable habitat, except possibly the deeper waters of Lake Superior (USEPA 2008). If Blueback Herring became established in Lake Ontario, they could spread to other Great Lakes and impede recovery of depressed populations of indigenous fishes such as Cisco and Lake Trout (Owens et al. 1998). Cold water may prevent its establishment."

"Davis and Foltz (1991) assessed the possibility of competitive effects between threadfin shad, *Dorosoma petenense*, and *A. aestivalis* in the Jocassee Reservoir in South Carolina, USA. Both fish were stocked as prey for piscivorous fish. Davis and Foltz (1991) observed low dietary overlap between the species even though they are on the same trophic level. Despite their low competitive interactions, the study concluded that *A. aestivalis* are 'voracious planktivores' as well as piscivores, increasing the likelihood that it may affect zooplankton as well as small fish populations of any system where they may be introduced. It has also been suggested that invasive *A. aestivalis* can potentially affect native populations of smelt and forage fish (Marsden and Hauser, 2009)."

From Marsden and Hauser (2009):

"Other species, such as blueback herring, have invaded too recently for effects to be seen."

Alosa aestivalis is regulated by the following states (see Section 1): Arkansas (AGFC 2022), Arizona (Arizona Game and Fish Commission 2022), Delaware (DNREC 2022), Nevada (Nevada Board of Wildlife Commissioners 2022), New Hampshire (NHFG 2022), New Jersey (NJFW 2022), North Carolina (NCDEQ 2022), Oklahoma (ODWC 2022), and Tennessee (TWRA 2022).

4 History of Invasiveness

There are records of nonnative introductions of *Alosa aestivalis* outside their native range in New York, South Carolina, and Texas. These introductions led to established nonnative populations. The introduction of *A. aestivalis* in Lake Theo, Texas led to the elimination of several larger bodied zooplankton groups causing a shift in the zooplankton community from cladocerans to copepods. However, persistence of this population of Blueback Herring is uncertain. Due to the extirpation of groups of zooplankton due to an introduction of *Alosa aestivalis*, the History of Invasiveness for *Alosa aestivalis* is classified as High.

5 Global Distribution

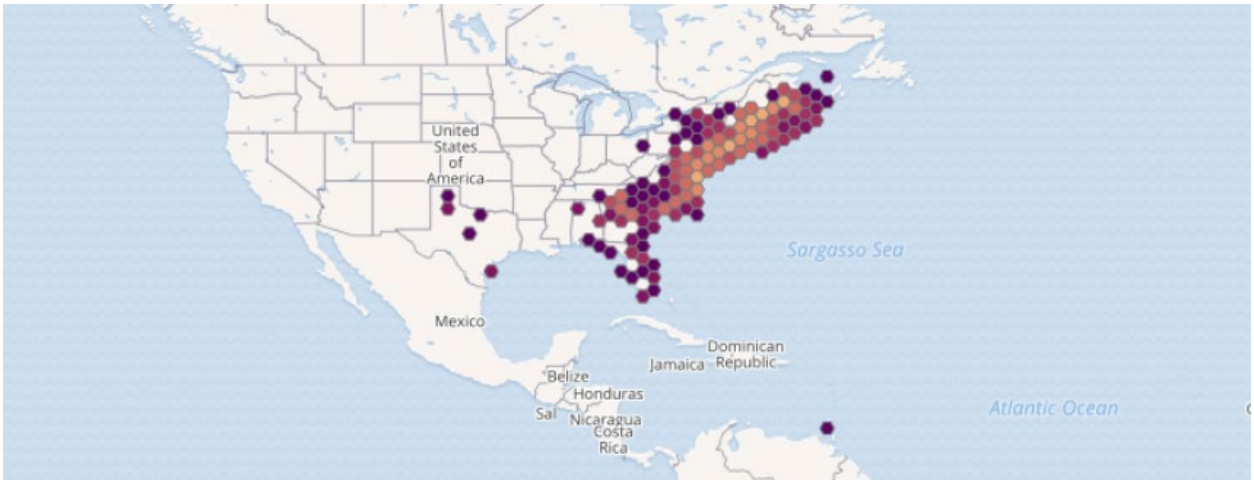

Figure 1. Reported global distribution of *Alosa aestivalis*. Map from GBIF Secretariat (2022). Observations are reported from New Brunswick, Prince Edward Island, and Nova Scotia of Canada, and the Eastern United States. Because the climate matching analysis (section 7) is not valid for marine waters, no marine occurrences were used in the climate matching analysis.

There is no additional literature to confirm the occurrence in Trinidad and Tobago representing an established population, as well as in the state of Ohio in the United States. Persistence of populations of *A. aestivalis* in northern Texas is uncertain (Schramm et al. 1991; Howells 2001). Observations in southeast Texas in the Corpus Christi Bay area are under further examination and awaiting confirmation (Hendrickson and Cohen 2022). Therefore, these occurrence points have been excluded from the source points used for the climate matching analysis.

6 Distribution Within the United States

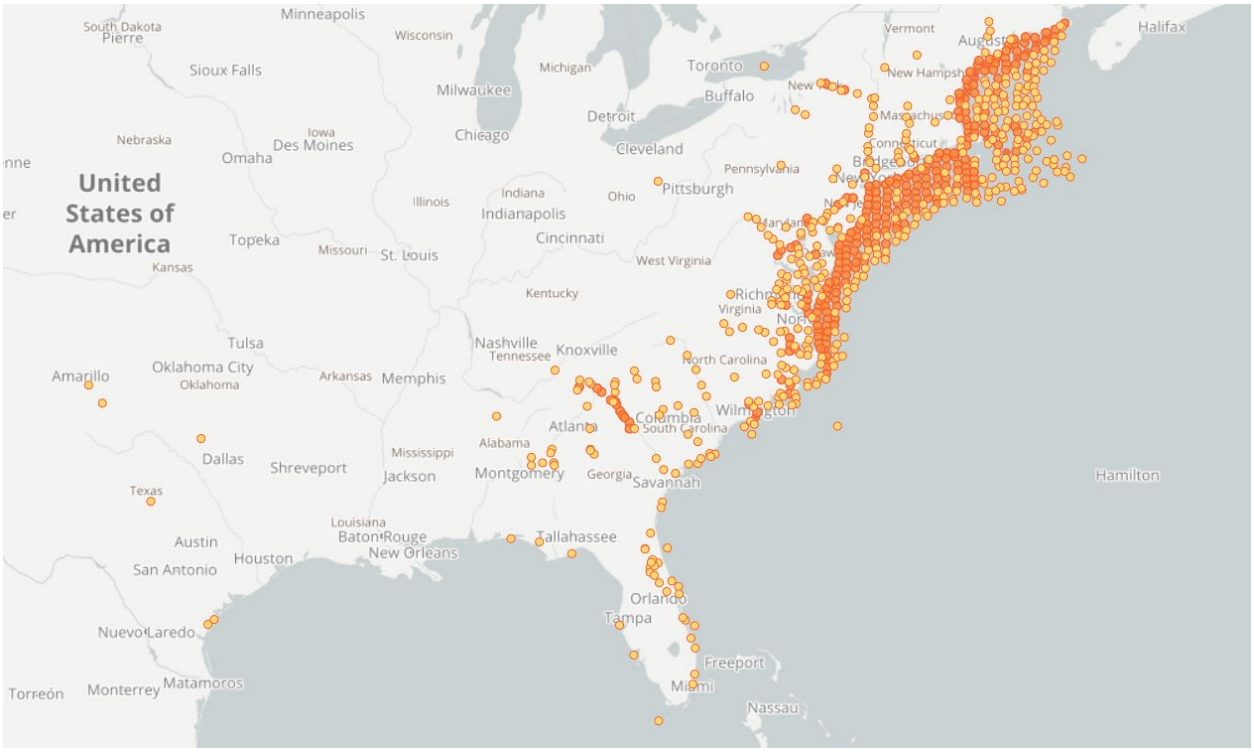

Figure 2. Reported distribution of *Alosa aestivalis* in the United States. Map from GBIF-US (2023). Observations are reported from along the Atlantic coast as well as the following states: Maine, Vermont, New Hampshire, New York, Rhode Island, Connecticut, Massachusetts, New Jersey, Pennsylvania, Ohio, Maryland, Delaware, Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Tennessee, and Texas. Observations of *A. aestivalis* in Ohio and Texas may not represent currently established populations and were not used to select source points in the climate match analysis. Because the climate matching analysis (section 7) is not valid for marine waters, no marine occurrences were used as source points in the climate matching analysis.

7 Climate Matching

Summary of Climate Matching Analysis

This species had a high climate match to the Atlantic Coast and coastal areas which comprise the native range of the species. Additional areas of high match were found outside of the species' native range in the Midwest, Great Lakes, and Gulf of America. Most of the contiguous United States west of the Mississippi River has medium to low climate matches. The overall Climate 6 score (Sanders et al. 2023; 16 climate variables; Euclidean distance) for the contiguous United States was 0.501, indicating that Yes, there is establishment concern for this species outside of its native range. The Climate 6 score is calculated as: (count of target points with scores ≥ 6)/(count of all target points). Establishment concern is warranted for Climate 6 scores greater than or equal to 0.002 based on an analysis of the establishment success of 356 nonnative aquatic species introduced to the United States (USFWS 2024).

Projected climate matches in the contiguous United States under future climate scenarios are available for *Alosa aestivalis* (see Appendix). These projected climate matches are provided as additional context for the reader; future climate scenarios are not factored into the Overall Risk Assessment Category.

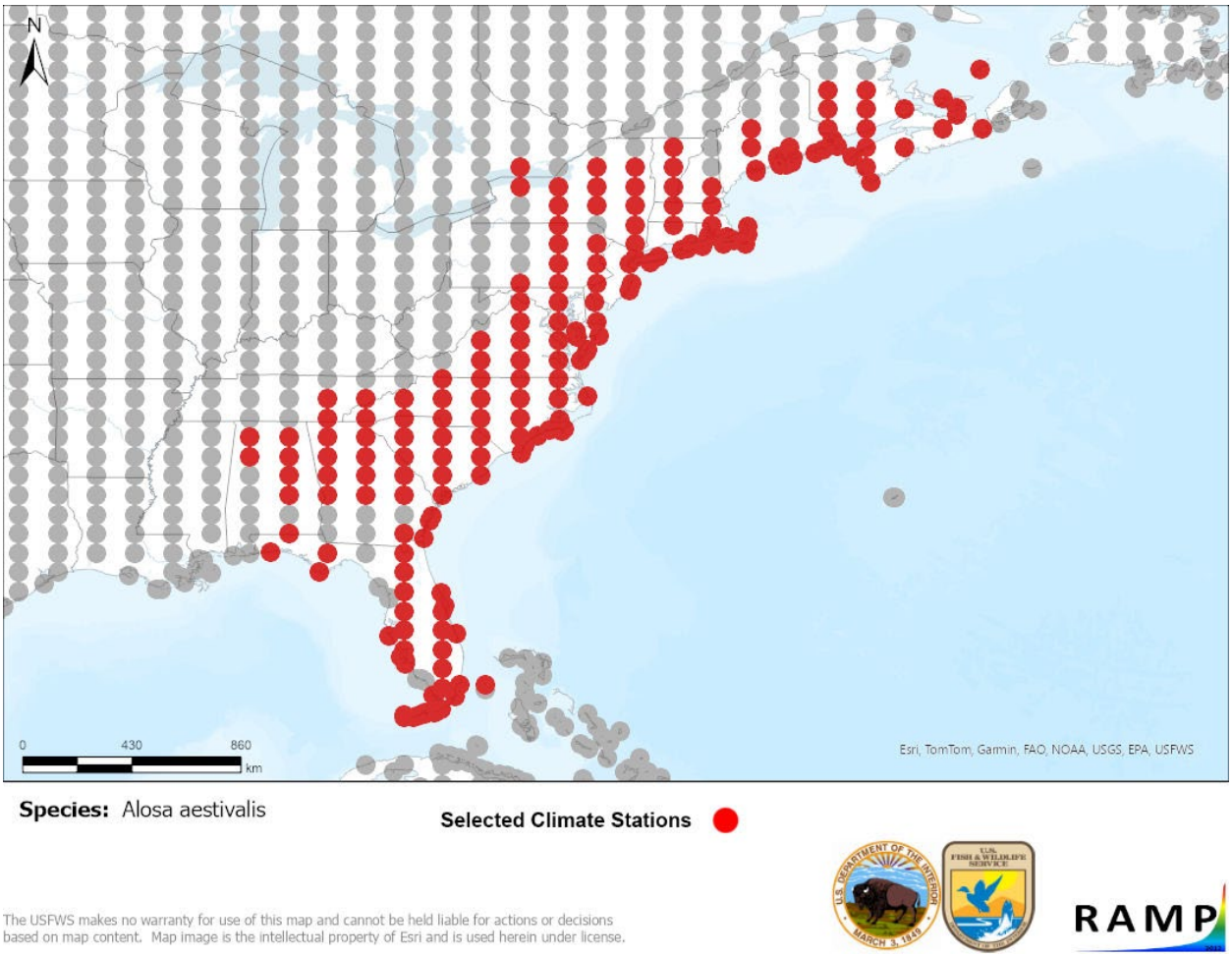

Figure 3. RAMP (Sanders et al. 2023) source map showing weather stations along the Atlantic coast selected as source locations (red; Canada, United States) and non-source locations (gray) for *Alosa aestivalis* climate matching. Source locations from GBIF Secretariat (2022). Selected source locations are within 100 km of one or more species occurrences, and do not necessarily represent the locations of occurrences themselves.

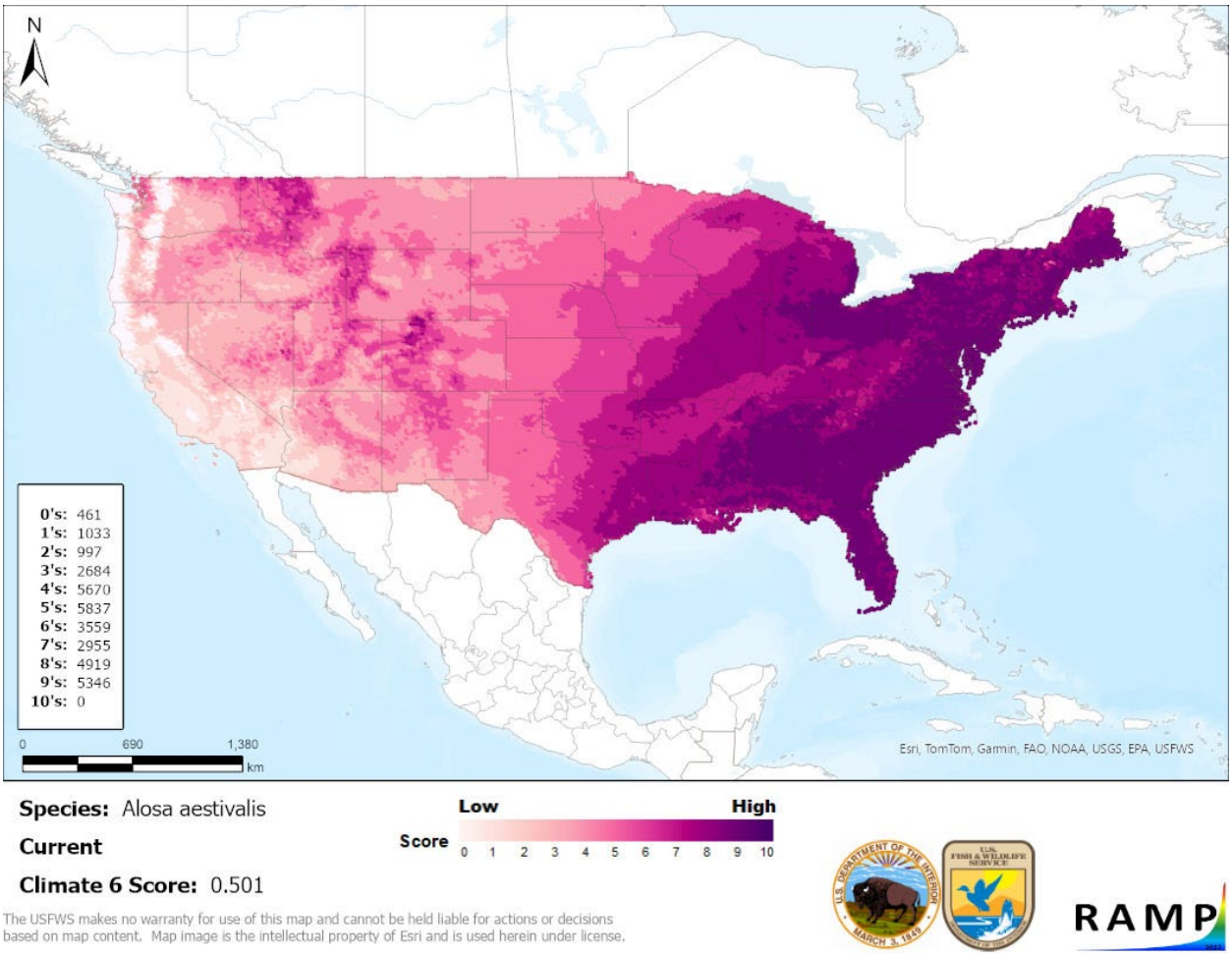

Figure 4. Map of RAMP (Sanders et al. 2023) climate matches for *Alosa aestivalis* in the contiguous United States based on source locations reported by GBIF Secretariat (2022). Counts of climate match scores are tabulated on the left. 0/Pale Pink = Lowest match, 10/Dark Purple = Highest match.

8 Certainty of Assessment

The Certainty of Assessment for *Alosa aestivalis* is classified as Medium. There is a reasonable amount of information regarding the biology, ecology, and distribution of blueback herring. Records of introductions and impacts were available. The impact information comes from a nonnative population that may be no longer extant, so the certainty of this screening is classified as Medium.

9 Risk Assessment

Summary of Risk to the Contiguous United States

Alosa aestivalis, Blueback Herring, is a fish that is native to the Atlantic coast from Nova Scotia to Florida. These fish are an anadromous species that live in both freshwater and saltwater ecosystems. Adults occur at least 200 km off the coast, while juveniles spend 3-7 months in freshwater before migrating to sea. During breeding season, adults will migrate up coastal rivers

to spawn. *A. aestivalis* primarily feed on plankton, as well as crustaceans, insects, insect eggs, and smaller fish. *A. aestivalis* are considered "voracious planktivores". Blueback herring are valuable to the commercial and recreational fishing industry. Historically, these fish were heavily used as a food source and bait to capture larger fish and lobsters and were even used as a fertilizer. Today, blueback herring is used in fish oil, fish meal, pet food, domestic animal feed, fishing bait, and a small remainder for human consumption. The importation, possession, or trade of *A. aestivalis* is regulated by nine States (see section 1). In Lake Theo, Texas, these fish were responsible for the elimination of several larger zooplankton species, causing a shift in the zooplankton community from cladocerans to copepods. The History of Invasiveness for *A. aestivalis* is classified as High due to the impact on native zooplankton. The climate match analysis for the contiguous United States indicates establishment concern outside the species' native range. The highest climate match was centered on the native range along the Atlantic coast, but expanded beyond the native range into the Midwest, the Gulf of America coastal areas, and the Great Lakes. The Certainty of Assessment for this ERSS is classified as Medium because the known impact information comes from a population that may not be extant. There is sufficient biological, ecological, and distribution information for this species. The Overall Risk Assessment Category for *A. aestivalis* in the contiguous United States is High.

Assessment Elements

- **History of Invasiveness (see section 4): High**
- **Establishment Concern (see section 7): Yes**
- **Certainty of Assessment (see section 8): Medium**
- **Remarks, Important additional information: Blueback Herring and Alewife are often difficult to distinguish from one another in areas with overlapping range, such as Lake Ontario (New York).**
- **Overall Risk Assessment Category: High**

10 Literature Cited

Note: The following references were accessed for this ERSS. References cited within quoted text but not accessed are included below in section 11.

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Appendix

Summary of Future Climate Matching Analysis

Future climate projections represent two Shared Socioeconomic Pathways (SSP) developed by the Intergovernmental Panel on Climate Change (IPCC 2021): SSP5, in which emissions triple by the end of the century; and SSP3, in which emissions double by the end of the century. Future climate matches were based on source locations reported by GBIF Secretariat (2022).

Under the future climate scenarios (figure A1), on average, high climate match for *Alosa aestivalis* was projected to occur in the Appalachian Range, Great Lakes, Mid-Atlantic, Northeast, Southeast, Southern Atlantic Coast, and Southern Florida regions of the contiguous United States. These areas encompass the species' native range. Areas of high match contracted north and eastward with time and between SSP3 and SPP5. Areas of low climate match were projected to occur in California, the Northern Pacific Coast, and Southwest regions. Other areas of low match were found in the western portions of the Northern and Southern Plains. The Climate 6 scores for the individual future scenario models (figure A2) ranged from a low of 0.365 (model: UKESM1-0-LL, SSP5, 2085) to a high of 0.501 (model: IPSL-CM6A-LR, SSP5, 2055). All future scenario Climate 6 scores were above the Establishment Concern threshold, indicating that Yes, there is establishment concern for this species under future scenarios. The Climate 6 score for the current climate match (0.501, figure 4) falls within the range of scores for future projections. The time step and climate scenario with the most change relative to current conditions was SSP5, 2085, the most extreme climate change scenario. Under all time step and climate scenarios, only minor or no increases in the climate match relative to the current match were observed. Under one or more time step and climate scenarios, areas within the Appalachian Range, Colorado Plateau, Great Lakes, Gulf Coast, Mid-Atlantic, Northeast, Northern Plains, Southeast, Southern Atlantic Coast, Southern Florida, Southern Plains, and Southwest saw a moderate decrease in the climate match relative to current conditions. No large decreases were observed regardless of time step and climate scenarios. Additional very small areas of large or moderate change may be visible on the maps (figure A3).

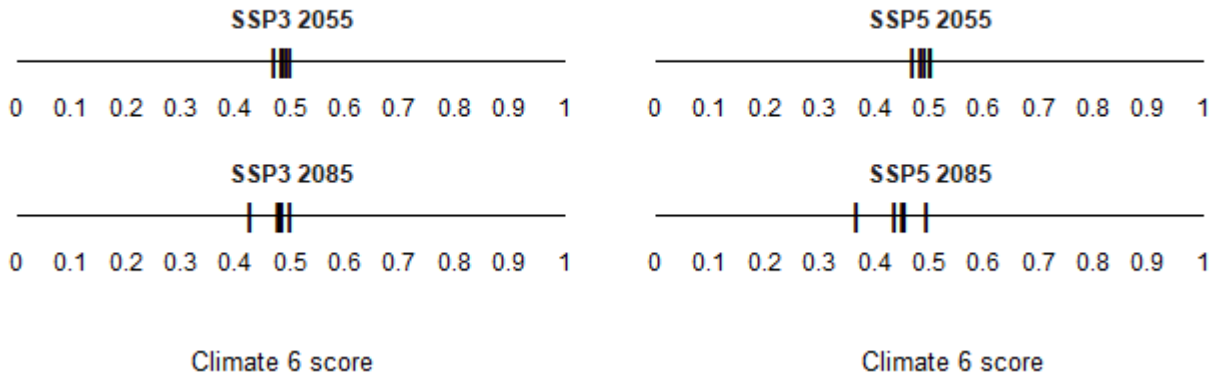

Figure A2. Comparison of projected future Climate 6 scores for *Alosa aestivalis* in the contiguous United States for each of five global climate models under four combinations of Shared Socioeconomic Pathway (SSP) and time step. SSPs used (from left to right): SSP3, SSP5 (Karger et al. 2017, 2018; IPCC 2021). Time steps: 2055 (top row) and 2085 (bottom row). Climate source data from CHELSA (Karger et al. 2017, 2018); global climate models used: GFDL-ESM4, UKESM1-0-LL, MPI-ESM1-2-HR, IPSL-CM6A-LR, and MRI-ESM2-0.

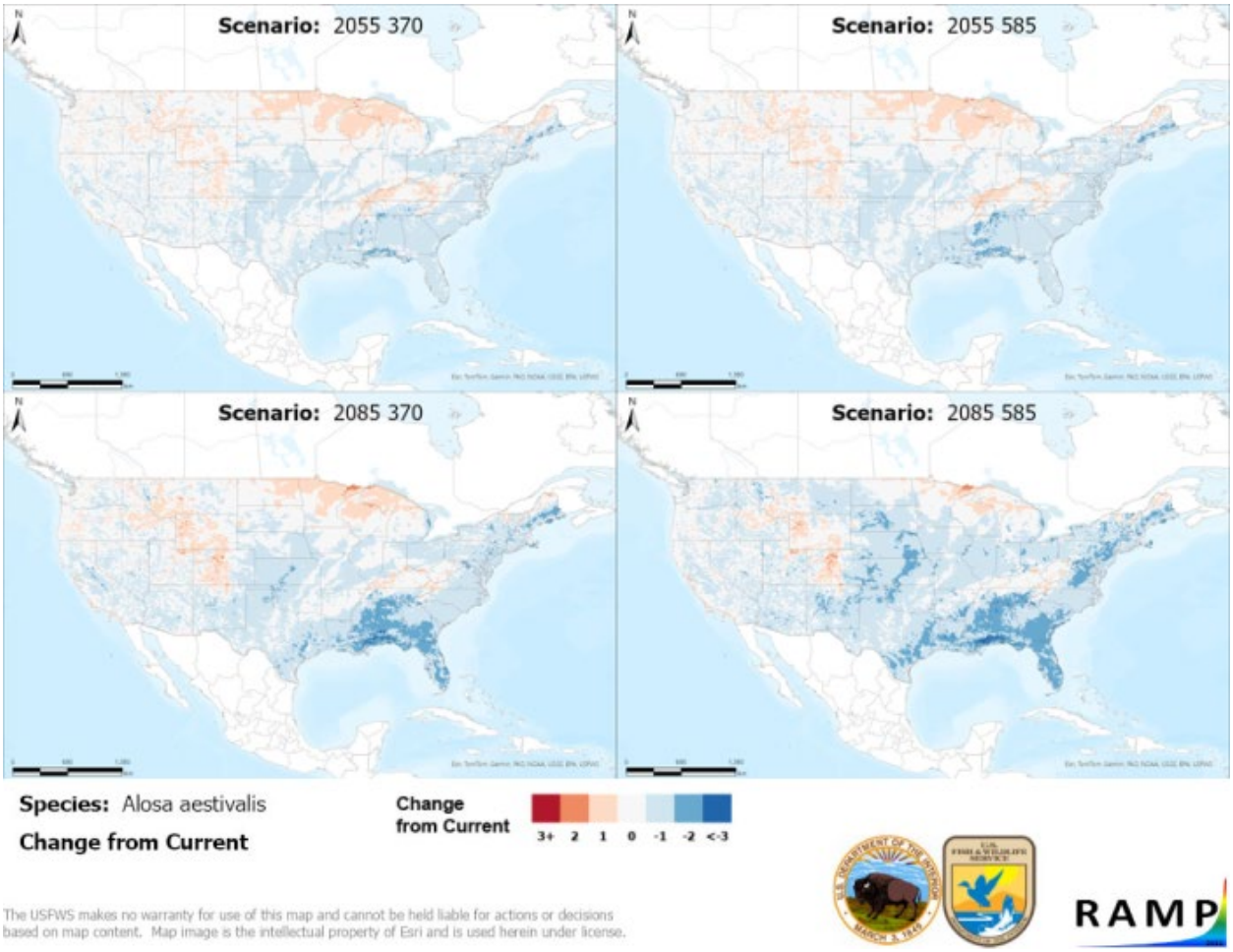

Figure A3. RAMP (Sanders et al. 2023) maps of the contiguous United States showing the difference between the current climate match target point score (figure 4) and the median target point score for future climate scenarios (figure A1) for *Alosa aestivalis* based on source locations reported by GBIF Secretariat (2022). Shared Socioeconomic Pathways (SSPs) used (from left to right): SSP3, SSP5 (IPCC 2021). Time steps: 2055 (top row) and 2085 (bottom row). Climate source data from CHELSA (Karger et al. 2017, 2018); global models used: GFDL-ESM4, UKESM1-0-LL, MPI-ESM1-2-HR, IPSL-CM6A-LR, and MRI-ESM2-0. Shades of blue indicate a lower target point score under future scenarios than under current conditions. Shades of red indicate a higher target point score under future scenarios than under current conditions. Darker shades indicate greater change.

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