River Herring and Shad Comments that Arrived After the Briefing Book Mail-Out Deadline

Additional Web Comments

Submitted On	Name	Email Address	Message
9/19/2013 20:28:01	michael deckard	michaeljdeckard@comcast.net	Please take immediate action to protect the river herring before they are totally wiped out & extinction occurs on your watch!!
9/29/2013 14:31:32	John Toth	tothjohn@verizon.net	Members of the MAFMC, stocks of river herring, American shad are in decline and we recreational anglers need your help in protecting them. Please help these stocks recover by advancing Amendment 15, and move it forward by developing an Environmental Impact Statement as an important step in restoring these species. Thank You!

Ranchera

Fiestas en área regional
Situado en Newark, Delaware

RECEIVED
OCT - 1 2013
Mid-Atlantic Fishery
Management Council

September 24, 2013

On behalf of the Ranchera, a small, coastal catering business located in Delaware, we urge the Mid-Atlantic Fishery Management Council to develop and pass Amendment 15 to the Mackerel, Squid Butterfish Plan (MSB), and designate river herring and shad as stocks in the MSB Fishery Management Plan.

Our most requested dishes and meals are seafood dishes, many of which rely on forage fish for nourishment. Once forage fish like river herring and shad deplete (even more than they already have) the cost of the fish we often use will go up, as supply will diminish.

River herring and shad are major cultural, economic and ecological resources along the Atlantic Coast of the United States, where we primarily cater events. They are key components of the food web in our river and coastal waters, serving as prey for sport fish, such as striped bass and tuna, birds, like eagles, osprey and herons, and marine mammals. River herring and shad have long been important to the economic and cultural heritage of Delaware. However today, river herring and shad have declined to near historic lows and showing little signs of recovery, but designating them as stocks in the MSB Fishery Management Plan will significantly help rebuild these important yet imperiled species.

Please designate river herring and shad as stocks in the MSB Fishery Management Plan. Thank you for your time and consideration on this matter.

Sincerely,

Cresenzo Alonso
Co-owner

Didden, Jason T.

Subject: FW: Amendment 15 to the Mackerel, Squid, Butterfish FMP
Attachments: Amendment15_Earthjustice_Part1.pdf; Amendment15_Earthjustice_Part2.pdf

From: Brian Smith [mailto:bsmith@earthjustice.org]
Sent: Wednesday, September 25, 2013 4:26 PM
To: Moore, Christopher
Cc: Clark, Mary
Subject: Amendment 15 to the Mackerel, Squid, Butterfish FMP

Dr. Chris Moore, Executive Director
Mid-Atlantic Fishery Management Council
800 N. State St., Suite 201
Dover, DE 19901

Dear Dr. Moore,

Earthjustice, a public interest law organization, collected 5,367 public comments on current issues including Amendment 15 to the Mackerel, Squid, Butterfish FMP.

The default comment letter is below. The entire set of comments from the Mid-Atlantic region has been compiled into two attached pdf files. Thank you for carefully considering these arguments.

I strongly support, and urge NOAA Fisheries to approve, the New England and Mid-Atlantic Fishery Management Councils' efforts to establish federal management of river herring and shad in the Atlantic mackerel and herring fisheries.

I urge NOAA Fisheries to approve the Mid-Atlantic Council's Amendment 14 to the Mackerel, Squid, Butterfish Fishery Management Plan in its entirety. This plan includes a strong catch cap, 100 percent observer coverage on all mid-water trawl vessels, accurate dealer weighing of catch, a cap on at-sea dumping (slippage) of unobserved catch, and related accountability measures. NOAA Fisheries should also reverse its recent disapproval of 100 percent observer coverage, slippage caps, and dealer weighing requirements in the New England Council's Amendment 5 to the Atlantic herring plan or offer alternative, equally effective solutions. In both regions, all parts of these amendments are necessary to foster river herring and shad conservation, and they were the result of an extensive public process and thoughtful deliberations.

Although these two amendments are an important start, the Magnuson-Stevens Act also requires, and I fully support, the designation of river herring and shad as stocks in federal herring and mackerel fishery management plans. The Mid-Atlantic Council is currently considering this designation in Amendment 15 to the Mackerel, Squid, Butterfish FMP, and New England has placed a priority on consideration of a similar amendment to its Atlantic herring plan. I strongly urge you to support adding river herring and shad to federal fishery management plans.

This designation would enable the councils and NOAA Fisheries to:

* Set science-based annual catch limits.
* Identify and protect essential fish habitat.
* Gather better data and improve the population estimates of these fish.
* Coordinate with state efforts to restore river herring and shad.

Please take this action as soon as possible.

Brian Smith
Campaign Manager
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San Francisco, CA 94111
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[cid:image001.gif@01CEBB77.4E51F760]

Because the earth needs a good lawyer

Maria Karsou
Mamaroneck, NY 10543-1514

September 18, 2013

Christopher M. Moore, PhD
Mid-Atlantic Fishery Management Council
800 North State St.
Dover, DE 19901

Dear Dr. Moore,

I strongly support, and urge NOAA Fisheries to approve, the New England and Mid-Atlantic Fishery Management Councils' efforts to establish federal management of river herring and shad in the Atlantic mackerel and herring fisheries.

I urge NOAA Fisheries to approve the Mid-Atlantic Council's Amendment 14 to the Mackerel, Squid, Butterfish Fishery Management Plan in its entirety. This plan includes a strong catch cap, 100 percent observer coverage on all mid-water trawl vessels, accurate dealer weighing of catch, a cap on at-sea dumping (slippage) of unobserved catch, and related accountability measures. NOAA Fisheries should also reverse its recent disapproval of 100 percent observer coverage, slippage caps, and dealer weighing requirements in the New England Council's Amendment 5 to the Atlantic herring plan or offer alternative, equally effective solutions. In both regions, all parts of these amendments are necessary to foster river herring and shad conservation, and they were the result of an extensive public process and thoughtful deliberations.

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* Set science-based annual catch limits.
* Identify and protect essential fish habitat.
* Gather better data and improve the population estimates of these fish.
* Coordinate with state efforts to restore river herring and shad.

Please take this action as soon as possible.

Sincerely,

Maria Karsou

October 4, 2013

John Bullard
Regional Administrator, NOAA Fisheries Northeast Region
Northeast Regional Office
55 Great Republic Drive
Gloucester, MA 01930
john.bullard@noaa.gov

Richard Robins, Chairman
Chris Moore, Executive Director
Mid-Atlantic Fishery Management Council
Suite 201
800 State Street
Dover, DE 19901
cmoore@mafmc.org

Dear Mr. Bullard, Mr. Robins, and Dr. Moore:

We are writing in response to the recent white paper, *River Herring and Shad – Potential Management by the Mid-Atlantic Fishery Management Council* (White Paper), written by staff to guide the Mid-Atlantic Fishery Management Council (Council) in its October 8th decision regarding whether to continue development of Amendment 15 to the Mackerel, Squid, and Butterfish (MSB) Fishery Management Plan (FMP). We are also including for the record and your consideration a recent scientific paper with new data and analysis supporting the need to add river herring and shad to the MSB FMP. While the White Paper contains more than sufficient information justifying the continued development of Amendment 15 and its Draft Environmental Impact Statement (DEIS), it relies on flawed legal advice from the National Marine Fisheries Service (NMFS)[1] that could lead the Council to a decision to discontinue development of Amendment 15 based on the wrong legal standard under the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act).

Specifically, the White Paper strongly suggests that the decision regarding whether or not to include river herring and shad as managed stocks in the MSB FMP should be based on application of the National Standards and their (non-binding) guidelines. This is inconsistent with the plain language of the Act and the legal analysis in the only court case directly on

[1] *See* NMFS June 6, 2013 Letter to Dr. Chris Moore, Executive Director MAFMC, available at: http://www.mafmc.org/s/Letter-to-MAFMC-Guidance-on-MSB-Am-15-June-6-2013.pdf.

point.[2] The decision whether to add stocks to a plan is covered by Section 302(h) of the Act, 16 U.S.C. § 1852(h)(1), which states: "for each fishery under its authority that requires conservation and management, [the Council shall], prepare and submit to the Secretary [] a fishery management plan." Thus, the decision of whether to add a stock to an FMP is based on the need for conservation and management. The Act provides a definition of conservation and management, which is defined to include the need for rebuilding, restoring, or maintaining any fishery resource and the marine environment; assuring among other things, a food supply and recreational benefits; and avoiding long-term adverse effects on fishery resources and the marine environment. [3] Although the White Paper reproduces the statutory definition of "conservation and management," it contains no analysis based on the definition's applicable criteria.

As prior letters have demonstrated, the record is clear that river herring and shad are in need of strong federal conservation and management.[4] For example, the most recent river herring stock assessment found that 23 of 24 adequately assessed stocks are "depleted," including 10 stocks that are listed as "overfished."[5] NMFS listed river herring as "Species of Concern" in 2006 due to dramatic declines in landings and abundance,[6] and considered listing them as "threatened" under the Endangered Species Act.[7] The most recent shad assessment found "that stocks were at all-time lows and did not appear to be recovering to acceptable levels."[8] The Atlantic States Marine Fisheries Commission (ASMFC) concluded that river herring and shad are "depleted on a coast-wide basis" and implemented a moratorium on river herring and shad fishing within state waters unless sustainability of such catch can be demonstrated.[9]

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[2] *See Flaherty v. Bryson,* 850 F. Supp. 2d 38, 55 (D.D.C. 2012) ("In other words, in developing an FMP, the Council must decide which species or other categories of fish are capable of management as a unit, and therefore should be included in the fishery and managed together in the plan. This decision entails two basic determinations. The Council must decide (1) which stocks 'can be treated as a unit for purposes of conservation and management' and therefore should be considered a 'fishery' and (2) which fisheries 'require conservation and management.' 16 U.S.C. §§ 1802(13), 1852(h)(1).").

[3] *See* 16 U.S.C. § 1802 (5).

[4] Prior letters written by Earthjustice and the Herring Alliance contain a more complete analysis of the need for federal management for river herring and shad. *See* June 4, 2012 Letter from Herring Alliance to MAFMC re DEIS for Amendment 14; *see also* December 5, 2012 Letter from Herring Alliance re Scoping Comments on Amendment 15. In addition, the MAFMC has previously agreed there is need for conservation and management of river herring and shad. *See* June 18, 2013 MAFMC Press Release re First-Ever Catch Cap for River Herring and Shad ("Although there is little debate about the need for river herring and shad conservation, their decline is likely the result of a combination of several factors, including dams, predation, water quality, climate change, and fishing effort. A variety of analyses have suggested that the Atlantic mackerel fishery can have substantial river herring and shad catch in some years.").

[5] *See* ASMFC *River Herring Stock Assessment Overview* (May 2012); *see also* ASMFC, *Stock Assessment Report No. 12-02, River Herring Benchmark Stock Assessment, Volume II* (May 2012), at 412 (finding 9 of 15 river herring stocks in Maryland and the Upper Chesapeake Bay to be "overfished"); *id.*, at 549-550 (stating that the Chowan River blueback herring population "remains overfished" and is "less than 5% of the amount necessary to replace itself in the complete absence of fishing.").

[6] *See* 71 Fed. Reg. 61022 (Oct. 17, 2006).

[7] Ultimately, the Status Review Team denied listing based on data insufficiencies and uncertainty associated with available data. *See* 78 Fed. Reg. 48944 (August 12, 2013).

[8] MAFMC Amendment 14 to the Mackerel, Squid, and Butterfish Fishery Management Plan (April 2012), at 213.

[9] ASFMC, *Overview of Stock Status of River Herring and Shad, available at* http://www.asmfc.org/speciesDocuments/shad/shad_RiverHerring_StockStatus.pdf.

A recently published scientific article provides further support for the need for conservation of river herring in the Mid-Atlantic where alewife and blueback herring have undergone severe population declines.[10] Based on genetic distinctions, the authors found that populations of Mid-Atlantic blueback herring deserve "high" conservation prioritization and alewives deserve "medium" conservation prioritization to prevent further declines. Citing catch in marine fisheries as a "major emerging concern," and noting that "recent alewife and blueback herring declines may have been triggered by overharvest in marine fisheries," this article recommends an increased focus on these marine processes. Similarly, the science underlying NMFS's recent denial of the Endangered Species Act listing petition for river herring showed Mid-Atlantic populations of blueback herring were "significantly decreasing." However NMFS ultimately determined that because in its view the *entire* species would not be in danger of extinction if the Mid-Atlantic populations were lost forever, they declined to list them as a threatened species.[11] This Council cannot afford to write off Mid-Atlantic blueback herring. The best available science shows Mid-Atlantic populations of these species are particularly in need of conservation and management in federal waters, and this Council must act to bring them in the MSB FMP.

Unfortunately, the White Paper relies on the flawed NMFS legal guidance provided to the Council in a June 6, 2013 letter which recommends that the analysis regarding whether to add a stock of fish to an FMP should be based on the Act's National Standards, rather than the applicable statutory standards provided in the Act's definition of for conservation and management. This approach is incorrect not just because it ignores the applicable criteria from the definition of conservation and management, but also because the Magnuson-Stevens Act's national standards plainly state that they apply not to the decision as to what species comprise the fishery, but to the conservation and management measures that are developed as part of the management plan.[12]

Of particular concern is its reliance on National Standard 7[13] and its guidelines[14] because such reliance unlawfully introduces a "cost-benefits" analysis into the decision of which stocks

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[10] Palkovacs, E.P., et al 2013. Combining genetic and demographic information to prioritize conservation efforts for anadromous alewife and blueback herring. Evolutionary Applications ISSN 1752-4571, p. 1 ("Analysis of available time series data for spawning adult abundance and body size indicate declines across the US ranges of both species, with the most severe declines having occurred for populations belonging to the Southern New England and the Mid-Atlantic Stocks. While all alewife and blueback herring populations deserve conservation attention, those belonging to these genetic stocks warrant the highest conservation prioritization."), at p. 13.

[11] *See* 78 Fed. Reg. 48944, 48993 (August 12, 2013).

[12] Several of the National Standards, including National Standard 7, make this clear by stating that it is the "[c]onservation and management measures" that must meet the standard. 16 U.S.C. § 1851 (a)(7).

[13] 16 U.S.C. § 1851(a)(7).

[14] *See* White Paper at 2 ("the question of whether river herrings and shads require additional Council management and conservation via a fishery management plan (FMP) is considered via the framework described by the National Marine Fisheries Service (NMFS) in the National Standard 7 guidelines."). Although this white paper is careful to note that National Standard 7 is "in the law," it fails to note that the guidelines do not have the force and effect of law. *See* 16 U.S.C. 1851(b). Notably, the National Standard guidelines were written before new, stronger FMP requirements like ACLs and AMs were put in place under the MSRA in 2007, which may explain in part why they discuss when "management" may be required. Since that time, Congress has tightened the specific FMP requirements, thus there is less discretionary decision-making allowed for management measures.

comprise the "fishery"[15] and should be added to a plan. Section 302(h), however, requires the decision be based on the need for conservation and management, and that definition does not include a cost benefit analysis. Thus there is risk, for example, that while it is undisputed that stocks are depleted and that the current abundance of Mid-Atlantic blueback herring is "significantly decreasing,"[16] the analysis in the White Paper could lead the Council to conclude that it has the discretion not to add this species based on its belief that the costs of doing so will be too high. Another example of the risk created by reliance on the NMFS faulty advice is the speculative examination of the costs and benefits of recent and proposed state and Federal management measures. This analysis concludes that there would be "substantial costs"[17] associated with adding river herring and shad as stocks to a plan (listed as personnel opportunity costs), yet minimizes the benefits because they could not be quantified. Even if this were true, a cost benefit analysis is not a factor under the applicable law for the primary decision whether to add the stocks to the MSB FMP.

There is no doubt that existing state and Federal management is insufficient given that the coast-wide meta complexes of river herring and shad stocks in the United States are depleted to near historical lows, state moratoriums along the Atlantic seaboard are common, and the best available science shows that depleted populations of river herring and shad have contributed to the decline of other populations that depend upon them for food. As forage, healthy river herring and shad populations support populations of other commercially and recreationally important target fish, as well as birds and marine mammals. In rivers, these species provide much needed food after the winter as surviving fish create a second wave of protein as the young-of-the year migrate downstream to the sea. All of these facts support the need for conservation and management under the appropriate statutory criteria.

Moreover, the effectiveness of the recently proposed new catch cap in the MSB fishery will be seriously compromised without 100 percent observer coverage and slippage caps, which appear likely to be disapproved in Amendment 14. As the Amendment 14 DEIS acknowledged, a stock in the fishery designation provides significant benefits beyond what would be provided in even a sufficiently monitored catch cap, including: 1) additional federal support of management and coordination among partners including more federal involvement in stock assessments; 2) explicit consideration of river herring and shad observer coverage needs; 3) direct controls through annual catch limits and accountability measures on federal catch of river herring and shad; 4) an ability to address the catch and/or discarding in other fisheries; and 5) the designation of essential fish habitat. [18]

The analysis contained in the White Paper and a fully developed amendment and DEIS will be valuable in examining how to design the required conservation and management measures consistent with the National Standards, including in the most cost effective way.

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[15] *See* 16 U.S.C. § 1802(13)("The term 'fishery' means (A) one or more stocks of fish which can be treated as a unit for purposes of conservation and management….").
[16] *See* 78 Fed. Reg. 48944, 48990 (August 12, 2013).
[17] *See* White Paper at 31 ("Under (a-b), direct management, there would be substantial costs associated in developing, implementing, and running a federal FMP. The primary cost would likely be in the form of personnel opportunity costs.").
[18] *See* Amendment 14 DEIS (April 2012), p. 440.

However, the decision whether to add must be based on Section 302(h) of the Act, and the definition of conservation and management, not National Standard 7 and related guidelines.

Thank you for considering these comments and the attached scientific paper.

/s/ Roger Fleming
Roger Fleming
Erica Fuller
Earthjustice

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ORIGINAL ARTICLE

Combining genetic and demographic information to prioritize conservation efforts for anadromous alewife and blueback herring

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Keywords
demography, distinct population segments, ecological restoration, microsatellites, population genetics, population trends, stock structure, time series

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Abstract

A major challenge in conservation biology is the need to broadly prioritize conservation efforts when demographic data are limited. One method to address this challenge is to use population genetic data to define groups of populations linked by migration and then use demographic information from monitored populations to draw inferences about the status of unmonitored populations within those groups. We applied this method to anadromous alewife (*Alosa pseudoharengus*) and blueback herring (*Alosa aestivalis*), species for which long-term demographic data are limited. Recent decades have seen dramatic declines in these species, which are an important ecological component of coastal ecosystems and once represented an important fishery resource. Results show that most populations comprise genetically distinguishable units, which are nested geographically within genetically distinct clusters or stocks. We identified three distinct stocks in alewife and four stocks in blueback herring. Analysis of available time series data for spawning adult abundance and body size indicate declines across the US ranges of both species, with the most severe declines having occurred for populations belonging to the Southern New England and the Mid-Atlantic Stocks. While all alewife and blueback herring populations deserve conservation attention, those belonging to these genetic stocks warrant the highest conservation prioritization.

Introduction

The inherent value of integrating genetic and demographic data in the design of conservation and recovery plans has been recognized for some time, particularly in the context of evaluating extinction risk in small, isolated populations (Lande 1988; Jamieson and Allendorf 2012). A somewhat different perspective that has received less attention is the combination of genetic and demographic information to define management units and prioritize populations within those units for conservation action (Wood and Gross 2008). This approach recognizes that population genetic structure is the outcome of demographic nonindependence caused by migration (Waples and Gaggiotti 2006). The complementarity of genetic and demographic data may be especially useful when demographic data are limited, yet broad conservation prioritization is required. In this circumstance, population genetic data can be used to define demographically linked groups of populations (e.g., clusters or stocks), and then, demographic information from a subset of populations can be used to draw inferences about the status of other populations within those groups. This approach allows both monitored and unmonitored populations to be included in conservation prioritizations, which is critical for the management of species for which long-term demographic data are limited to just a few populations.

Here, we apply this framework to define management units and prioritize conservation actions for anadromous alewife (*Alosa pseudoharengus*) and blueback herring (*Alosa aestivalis*) – species for which demographic information is limited to a handful of rivers Atlantic States Marine Fisheries Commission (ASMFC 2012). River herring (as the species are collectively known) are native to the Atlantic Coast of North America. Historically, blueback herring ranged from the southern Gulf of St. Lawrence to the St. Johns River, Florida and alewife ranged from Labrador to South Carolina (Loesch 1987). These species represent an important ecological component of coastal marine and freshwater ecosystems. They are keystone species in coastal lakes (Post et al. 2008), an important agent of nutrient transport between marine and freshwater food webs (West et al. 2010), and a prey resource for coastal birds and fishes (Walter and Austin 2003; Jones et al. 2010). The local ecological benefits derived from anadromous alewife and blueback herring depend on abundant spawning runs throughout their ranges.

The fishery for alewife and blueback herring is one of the oldest in North America. Population declines became pronounced as early as the mid-1700s and included overall reductions in abundance (Hall et al. 2012) as well as the loss of unique spawning forms (or morphs) that may have represented genetically distinct subpopulations (Chapman 1884). Early declines were likely the result of overharvest, dam construction, and reduced water quality (Hightower et al. 1996; Limburg and Waldman 2009; Hall et al. 2011, 2012). Despite early declines, US coastwide fisheries landings remained stable from 1950–1969 (ASMFC 2012). Starting in 1970, landings declined sharply and have since fallen by 93% (ASMFC 2012). In addition, there is evidence for harvest-induced changes in life history traits (Davis and Schultz 2009), climate-induced shifts in migration timing (Ellis and Vokoun 2009), and an ongoing southern range contraction in alewife that has resulted in population extirpations from South Carolina and possibly southern North Carolina (E. P. Palkovacs, T. F. Schultz and A. S. Overton, unpublished data).

The rate and magnitude of the decline in commercial river herring landings is on par with well-publicized declines of Atlantic cod (*Gadus morhua*) (Mayo and Col 2006; O'Brien et al. 2006). However, river herring declines were largely overlooked until recently. Between 2005 and 2007, alewife and blueback herring were declared Species of Concern by the National Marine Fisheries Service (NMFS), and harvest restrictions were put in place in Massachusetts, Rhode Island, Connecticut, and North Carolina. Starting in 2012, harvest restrictions were extended to all coastal states. The ecological and cultural importance of alewife and blueback herring and the magnitude of recent declines make clear the need for conservation action, but how to designate management units and prioritize recovery efforts across those units has been equivocal. For example, Distinct Population Segments proposed in a recent Endangered Species Act petition [NRDC (Natural Resources Defense Council) 2011] were based on regional differences in habitat, climate, and geology but included no biological justifications based on population genetic structure or other characteristics of populations. By assessing population genetic structure at multiple spatial scales, and associating that structure with recent demographic trends in spawning adult abundance (run size) and body size (mean length), we provide important information to designate management units and to prioritize populations within those units for restoration efforts.

Materials and methods

Study system

Alewife and blueback herring belong to the family Clupeidae. Their predominant life history form is anadromy, although both species can form freshwater resident populations. Mature adults migrate from the ocean into coastal streams and rivers in the spring to spawn. The onset of spawning begins about 3–4 weeks earlier in the year for alewife than for blueback herring (Loesch 1987). Juveniles typically rear in freshwater for several months before migrating to the ocean to mature at between 3 and 6 years of age. Both species are iteroparous, although decreased rates of repeat-spawning have been observed for some populations (Davis and Schultz 2009; ASMFC 2012).

Genetic analysis

Sample collections

We sampled across the US range of anadromous alewife and blueback herring from 2008–2012 (Fig. 1) and targeted 50 specimens per collection. Sampling effort provided muscle or fin tissue from 947 alewife and 1183 blueback herring from 20 spawning rivers per species (Table 1). Tissue samples were obtained from adult and juvenile specimens captured on or near their freshwater spawning grounds and preserved in 95% ethanol until DNA extraction.

Laboratory protocols

Genomic DNA was extracted from tissues using one of two methods: Promega Wizard® SV Genomic DNA Purification System or 10% Chelex 100 (Bio-Rad, Richmond, CA). Genomic DNA was stored at −20° C. Specimens were genotyped at 15 polymorphic microsatellite loci (*Aa046, Aa070, Aa074, Aa081, Aa082, Aa091, Aa093, Ap010, Ap033, Ap037, Ap038, Ap047, Ap058, Ap070, Ap071*). Amplification, size-fragment analysis, and scoring were conducted following A'Hara et al. (2012). To confirm consistency in

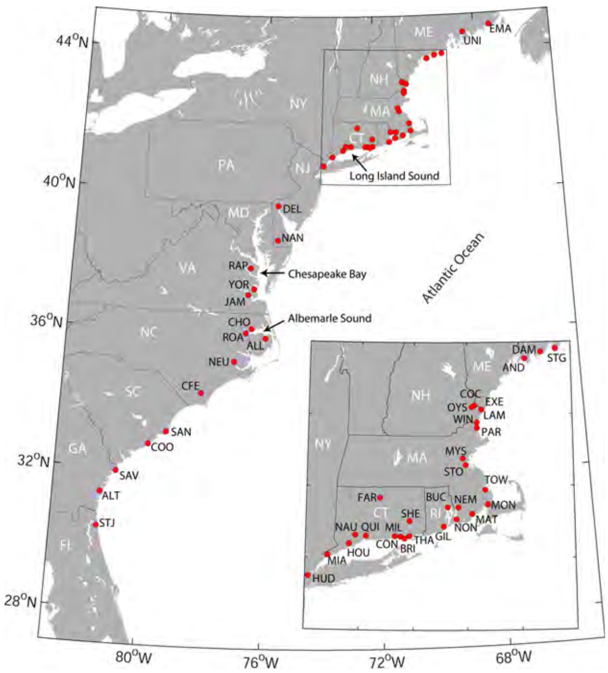

Figure 1 Coastal rivers in Eastern North America examined in this study spanned the US range of alewife and blueback herring. Sites indicated on the map include rivers sampled for genetic analysis and rivers included in the analysis of demographic time series data. River names and datasets associated with each sample code are provided in Table 1.

scoring and reproducibility of genotypes, positive and negative controls were used.

Population genetic analysis

Data conformance to model assumptions

Genotyping artifacts were assessed using MICROCHECKER v.2.2.3 (Van Oosterhout et al. 2004). Tests for departures from Hardy–Weinberg equilibrium (HWE) and linkage disequilibrium (LD) were performed with GENEPOP v.4.0.6 (Rousset 2008) using default parameters for all tests. Sequential Bonferroni adjustments were used to judge significance levels for all simultaneous tests (Holm 1979; Rice 1989). Selective neutrality of the microsatellite markers used in this study was evaluated using relative variance in repeat number (lnRV) and heterozygosity (lnRH) (Schlotterer 2002; Schlotterer and Deiringer 2005).

Genetic diversity

For each river, the number of alleles per locus (N_a), observed heterozygosity (H_O), an unbiased estimate of expected heterozygosity (H_E) (Nei 1978), and inbreeding coefficient (F_{IS}) (Weir and Cockerham 1984) were calculated using GENETIX v.4.05 (Belkhir et al. 2004). Allelic richness (R) per locus was calculated for each river using FSTAT 2.9.3.2 (Goudet 2001) standardized to a minimum sample size of 24 individuals for alewife, and 26 individuals for blueback herring (Leberg 2002).

Genetic differentiation

The statistical power and realized α-error for testing the null hypothesis of genetic homogeneity among rivers was assessed using POWSIM (Ryman and Palm 2006). Allelic heterogeneity among rivers was assessed via genic tests in GENEPOP v.4.0.6 (Rousset 2008) using default parameters for all tests. Tests were combined across loci or collections using Fisher's method. Hierarchical AMOVA was conducted to partition components of genetic variation among rivers, among collections, and among individuals within collections, using a permutation procedure (10 000 iterations) in Arlequin 3.1 (Excoffier 2005).

Overall and pairwise F_{ST} values (θ) (Weir and Cockerham 1984) were estimated using FSTAT (Goudet 2001). The effect of variation in genetic diversity on genetic differentiation (Hedrick 2005) was accounted for by calculating standardized estimates of differentiation (F'_{ST}) using RECODEDATA v.0.1 (Meirmans 2006) together with FSTAT to estimate $F_{ST(max)}$ for each pairwise comparison. Standardized estimates of differentiation were then calculated as $F'_{ST} = F_{ST}/F_{ST(max)}$ (Hedrick 2005).

Relationships among populations

Genetic affinities among rivers were examined using principal coordinates analysis (PCoA) of the pairwise genetic distance matrix for D_A (Nei et al. 1983) implemented in GenAlEx v.6.0 (Peakall and Smouse 2006).

Population structure

Two Bayesian model-based clustering methods, implemented in STRUCTURE v.2.3.3 (Pritchard et al. 2000; Falush et al. 2003) and BAPS v.5.3 (Corander et al. 2006), respectively, were used concomitantly in a hierarchical approach to infer the number of genetically homogenous clusters among rivers (Latch et al. 2006). For STRUCTURE, a burn-in of 50 000 replicates was followed by 250 000 replicates of the Markov Chain Monte Carlo (MCMC) simulation, employing the admixture model and correlated allele frequencies among populations. Three iterations of this parameter set were performed for K (number of clusters) from 1 to 13, allowing an estimation of the most likely number of clusters. Both the plateau of likelihood values (Pritchard et al. 2000) and ΔK (i.e., second order rate of change between successive K values) (Evanno et al. 2005) were estimated.

For BAPS, the mixture model was first applied to cluster groups of individuals based on their multilocus genotypes. Three iterations of K (1–13) were conducted among populations to determine the number of genetically homogeneous groups. Admixture analysis was then conducted to

Table 1. Datasets included in population genetic and demographic analyses

	River	Code	State	Microsatellites		Demographic time series		
				Sample year(s)	*N*	Mean length	Run size (Counts)	Run size (CPUE)
Alewife								
1	East Machias	EMA	ME	2010	58			
2	Union	UNI	ME				1982–2010	
3	St George	STG	ME	2010	69			
4	Damariscotta	DAM	ME				1977–2010	
5	Androscoggin	AND	ME			1986–2010	1983–2010	
6	Coheco	COC	NH			1992–2010		
7	Exeter	EXE	NH			1992–2010		
8	Lamprey	LAM	NH	2010	47	1990–2010		
9	Winnicut	WIN	NH			1998–2009		
10	Parker	PAR	MA				1972–78, 1997–2010	
11	Mystic	MYS	MA	2010	68			
12	Stony Brook	STO	MA			1979–2004		
13	Town Brook	TOW	MA	2011	46			
14	Monument	MON	MA	2011	49	1984–2010	1980–2010	
15	Mattipoisett	MAT	MA				1988–2010	
16	Nemasket	NEM	MA				1996–2010	
17	Nonquit	NON	RI				1999–2010	
18	Buckeye Brook	BUC	RI				2003–2010	
19	Gilbert Stuart	GIL	RI	2011	44		1981–2010	
20	Thames	THA	CT	2009	36			
21	Shetucket	SHE	CT				2003–2010	
22	Bride Brook	BRI	CT	2009	34		2003–2010	
23	Mill Brook	MIL	CT				2002–2010	
24	Connecticut	CON	CT	2009, 2011	7, 26			
25	Farmington	FAR	CT				2003–2010	
26	Quinnipiac	QUI	CT	2009	25			
27	Naugatuck	NAU	CT				2003–2006	
28	Housatonic	HOU	CT	2008, 2009	13, 25			
29	Mianus	MIA	CT	2009	25		2005–2010	
30	Hudson	HUD	NY	2009, 2012	13, 48	1980–2010		
31	Delaware	DEL	NJ	2011	42			
32	Nanticoke	NAN	MD	2011	58	1991–2007		
33	Rappahannock	RAP	VA	2011	62			1994–2010
34	York	YOR	VA					1994–2010
35	James	JAM	VA					1994–2010
36	Chowan	CHO	NC	2011	54	1972–2009	1972–2003	1977–2006
37	Roanoke	ROA	NC	2011	49			
38	Alligator	ALL	NC	2011	49			
Blueback herring								
1	East Machias	EMA	ME	2010	57			
2	St George	STG	ME	2010	42			
3	Exeter	EXE	NH	2010	41			
4	Cocheco	COC	NH			1992–2008		
5	Oyster	OYS	NH			1992–2010		
6	Winnicut	WIN	NH			1998–2009		
7	Mystic	MYS	MA	2010	66			
8	Monument	MON	MA	2011	50	1984–2010	1980–2010	
9	Gilbert Stuart	GIL	RI	2011	38			
10	Shetucket	SHE	CT				2003–2010	
11	Connecticut	CON	CT	2008, 2009, 2011	34, 62, 46		1966–2011	
12	Farmington	FAR	CT				2003–2010	
13	Naugatuck	NAU	CT				2003–2010	

(continued)

Table 1 (continued)

	River	Code	State	Microsatellites		Demographic time series		
				Sample year(s)	N	Mean length	Run size (Counts)	Run size (CPUE)
14	Mianus	MIA	CT				2005–2010	
15	Hudson	HUD	NY	2009	77	1976–2010		
16	Delaware	DEL	NJ	2011	48			
17	Nanticoke	NAN	MD	2011	24	1989–2007		
18	Rappahannock	RAP	VA	2011	58			
19	James	JAM	VA	2011	97			
20	Chowan	CHO	NC	2010, 2011	12, 58	1972–2009	1972–2009	1977–2006
21	Roanoke	ROA	NC	2011	50			
22	Neuse	NEU	NC	2011	65			
23	Cape Fear	CFE	NC	2011	57			
24	Santee	SAN	SC	2011	61	1991–2010	1980–1990	1990–2010
25	Cooper	COO	SC					1969–2008
26	Savannah	SAV	GA	2011	51			
27	Altamaha	ALT	GA	2011	52			
28	St Johns	STJ	FL	2011	37	1972–73, 2001–07		

For genetic analyses, the collection year(s) and sample sizes per year (N) are given. For demographic time series, the years spanning each time series are indicated.

estimate individual admixture proportions with regards to the most likely number of K clusters identified (Corander and Marttinen 2006), and visualized using DISTRUCT v.1.1 (Rosenberg 2004). Results from STRUCTURE and BAPS were used to delineate stocks for the purpose of examining stock-specific demographic trends in mean length of spawning adults and spawning adult run size.

Isolation by distance

Analysis of isolation by distance (IBD) was conducted among rivers to test for correlations between geographic distance and genetic differentiation using 10 000 permutations of the Mantel test implemented in IBDWS v.3.15 (Jensen et al. 2005). Pairwise F'_{ST} values were linearized ($F'_{ST}/(1-F'_{ST})$) following Rousset (2008). Geographic distance between river mouths was measured using the Gebco 1-min global bathymetry grid to identify land and ocean pixels. A Multistencil Fast Marching Method algorithm implemented in MATLAB (MathWorks, Natick, MA) was then used to find the distances from each river mouth to each other pixel on the globe. The shortest path distance between river mouths was then calculated by summing the Euler distances for each pixel step and converting from degrees to kilometers.

Demographic analysis

Data collection

We obtained demographic time series data from the ASMFC River Herring Benchmark Stock Assessment (hereafter Stock Assessment; ASMFC 2012). For alewife, we analyzed demographic time series from 27 rivers from Maine to North Carolina (Table 1). For blueback herring, we analyzed time series from 15 rivers from Maine to Florida (Table 1). For demographic variables, we examined the mean total length of spawning adults and spawning adult run size. Other demographic variables involving age estimates (maximum age, length-at-age, age-at-maturity) were reported in the Stock Assessment but are not analyzed here because inconsistencies in aging techniques were deemed to make age data unreliable (ASMFC 2012). For mean length, data were collected for females and males separately, with one exception (Stony Brook, Massachusetts alewife). For run size estimates, data were based either on adult run counts (for fisheries-independent data) or measures of catch-per-unit effort (CPUE; for fisheries-dependent data). Run size data were normalized [(observed−mean)/standard deviation] as reported in the Stock Assessment (ASMFC 2012).

Time series analysis

Demographic trends by time series

For each time series, we estimated the nonparametric linear regression slope (Theil-Sen slope) and tested for significant trends over time using Mann–Kendall tests. Both procedures were conducted using Package ‘rkt’ (Marchetto 2012) implemented in R (R Development Core Team 2011). We examined trends for each time series independently across all years sampled.

Demographic trends by species and stock

We used general linear models to test for differences in demographic trends between species and among stocks within each species. Many populations for which we had time series information were also included in our genetic analysis, making stock assignments unambiguous (Table 1). Populations not sampled for genetics were assigned to stocks based on geographic proximity to sampled rivers. The nonparametric linear regression slope (hereafter slope) of each time series was used as the dependent variable. We conducted analyses using slope values estimated from each time series, with 'species' or 'stock' included as fixed factors in the model. For among-stock comparisons of mean length, we also included 'sex' in the model as a fixed factor. We used *post hoc* Tukey's HSD tests to examine pairwise differences between stocks. General linear models and *post hoc* tests were conducted using PASW Statistics 18.0 (IBM Corporation, Somers, NY).

Conservation prioritization

We combined genetic and demographic data to develop a quantitative conservation prioritization for river herring populations that the Stock Assessment identified as being of current or historical importance. We examined the distribution of slope values for mean length and run size time series (both species examined together). We considered demographically increasing populations (slope > 0) to be low priority (i.e., at low risk), stable or slightly declining populations as medium priority, and steeply declining populations as high priority. We set the thresholds between medium and high priority populations at slope = −0.75 for mean length and slope = −0.05 for run size. These values resulted in approximately equal numbers of cases being categorized as medium and high priority. In cases where mean length and run size data were both available but designations did not agree (e.g., mean length gave a prioritization of 'medium' and run size gave a prioritization of 'high'), we applied the more conservative designation (e.g., in this case 'high') due to the precautionary principle. We used genetic information to extend conservation prioritization to demographically unmonitored populations. We assigned all populations to genetic stocks as described above and calculated the average slope values for each genetic stock. These average slope values were used to designate stock-level prioritizations, which were then applied to any unmonitored rivers within a given stock.

Results

Genetic analysis

Data conformance to model assumptions

Evidence for null alleles resulted in the exclusion of loci for both alewife (*Aa082*, *Ap037, Ap047, Ap070*) and blueback herring (*Aa081, Ap058*) prior to further analyses. Remaining loci were retained as evidence for null alleles was sporadically distributed among loci and rivers. Exact tests revealed that genotypic frequencies were largely in accordance with HWE for both species ($P > 0.05$; sequential Bonferroni correction for 20 comparisons). HWE departures for alewife and blueback herring remained for 11 and 20 locus river comparisons, respectively, and were due to heterozygote deficiencies from sporadic null alleles. Exact tests of LD revealed that loci were physically unlinked and statistically independent ($P > 0.05$; sequential Bonferroni correction for 1100 and 1560 comparisons for alewife and blueback herring, respectively). Relative variance in repeat number (lnRV) and heterozygosity (lnRH) failed to detect outlier loci for either species, and provided no evidence of non-neutrality.

Genetic diversity

Genetic polymorphism varied for both alewife and blueback herring depending on the locus and river considered (Tables S1 and S2). For alewife, the number of alleles per locus ranged from 5 (*Aa046*) to 19 (*Ap010*). H_o varied from 0.50 (Town Brook) to 0.67 (Delaware), and R from 4.00 (Lamprey) to 5.49 (Delaware) (Table S1). For blueback herring, the number of alleles per locus ranged from 7 (*Ap047, Aa091*) to 28 (*Ap037*). H_O varied from 0.50 (Gilbert Stuart) to 0.57 (Nanticoke), and R from 4.59 (Monument) to 6.81 (Delaware) (Table S2).

Genetic differentiation

An assessment of statistical power indicated that our microsatellite loci provided sufficient resolution to detect weak differentiation among alewife and blueback herring populations. The probability of obtaining a significant ($P < 0.05$) result in contingency tests among populations with an F_{ST} of 0.001 was 0.86 and 0.98 (χ^2) for alewife and blueback herring, respectively, while maintaining the realized α-error at the intended level (0.05) for tests of genetic homogeneity.

For alewife, significant ($P < 0.05$) genic differentiation between populations was observed for 179/190 pairwise comparisons, with nonsignificant comparisons occurring among neighboring and geographically proximal populations (Table 2). For blueback herring, significant ($P < 0.05$) genic differentiation between populations was observed for 178/190 pairwise comparisons, with nonsignificant comparisons occurring predominately among neighboring and geographically proximal rivers in the center of the species range (Table 3).

For alewife, standardized pairwise estimates of genetic differentiation (F'_{ST}) ranged from −0.003 to 0.352 (F_{ST} = −0.002 to 0.148) (Table S3); multilocus global F'_{ST} = 0.119 (F_{ST} = 0.049). Nonsignificant ($P > 0.05$) genetic differentiation was observed primarily among pairwise comparisons of neighboring and geographically proximal alewife populations (Table S3). For blueback herring, F'_{ST} ranged from −0.008 to 0.233 (F_{ST} = −0.003 to 0.106) (Table S4); multilocus global F'_{ST} = 0.067 (F_{ST} = 0.030).

Table 2. Probability values for pairwise tests of genic heterogeneity among alewife populations.

	EMA	STG	LAM	MYS	MON	TOW	GIL	THA	BRI	CON	QUI	HOU	MIA	HUD	DEL	NAN	RAP	CHO	ROA
STG	0.000																		
LAM	0.000	**0.585**																	
MYS	0.000	0.000	0.000																
MON	0.000	0.000	0.000	0.000															
TOW	0.000	0.000	0.000	0.000	0.000														
GIL	0.000	0.000	0.000	0.000	0.002	0.000													
THA	0.000	0.000	0.000	0.000	0.000	0.000	0.026												
BRID	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.208**											
CON	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.024	0.000										
QUI	0.000	0.000	0.000	0.000	0.000	0.000	0.003	**0.512**	**0.070**	0.003									
HOU	0.000	0.000	0.000	0.020	0.000	0.000	0.000	**0.176**	0.002	0.001	**0.089**								
MIA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000							
HUD	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000	0.014	**0.062**	0.000						
DEL	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.004	0.013	0.000	0.030					
NAN	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.077**				
RAP	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.000			
CHO	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		
ROA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.456**	
ALL	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.292**	**0.135**

Instances of nonsignificant ($P > 0.05$) genic heterogeneity are in bold.

Nonsignificant ($P > 0.05$) genetic differentiation was observed predominately (27/28) among pairwise comparisons of neighboring and geographically proximal blueback herring populations in the center of the species' range (Table S4).

For both species, hierarchical AMOVA revealed a significant ($P < 0.05$) proportion of genetic variance partitioned among populations, and among individuals within populations (Table S5). Nonsignificant variation among temporal replicates for both alewife and blueback herring suggested stable population structure over at least short (i.e., 1–2 years) temporal scales.

Relationships among populations

For alewife, PCoA revealed three factors that explained 92.25% of the variation in genetic distance (D_A) among populations (Fig. 2A). Axis-1 explained 62.66% of this variation, and linear regression revealed a significant ($r^2 = 0.85$; $P < 0.001$) relationship with latitude (Fig. 2B). For blueback herring, three factors explained 85.66% of the variation in genetic distance (D_A) among populations (Fig. 2C). Axis-1 explained 49.40% of this variation, and linear regression revealed a significant ($r^2 = 0.81$; $P < 0.001$) relationship with latitude (Fig. 2D).

Population structure

For alewife, the maximum value of $\ln\Pr(X|K)$ using STRUCTURE was observed at $K = 4$ (−24465.20). However, this estimate was only slightly greater than at $K = 3$ (−24470.13) but had considerably more variation, suggesting that $K = 3$ was more accurate (Fig. S1a). BAPS corroborated this result with significant ($P < 0.001$) support for three genetically distinguishable clusters. Both methods identified the same three clusters (hereafter referred to as stocks): Northern New England, Southern New England, and Mid-Atlantic (Fig. 3A). Further investigation using hierarchical STRUCTURE (Vaha et al. 2007) and BAPS analyses failed to detect additional structure within any of these stocks. Estimates of ΔK revealed the largest increase in the likelihood of the number of clusters at $K = 2$ (Fig. S1a). AMOVA revealed more variation among these three stocks (4.70%; $P < 0.001$) than among rivers within stock (1.30%; $P < 0.001$) (Table S5). The detection of significant variation among rivers within stocks is consistent with the significant genic differentiation detected among most populations (Table 2).

For blueback herring, the maximum value of $\ln\Pr(X|K)$ using STRUCTURE was observed at $K = 6$ (−35108.260). However, this estimate was only slightly greater than when $K = 4$ (−35189.77), or $K = 5$ (−35163.20) (Fig. S1b). BAPS had some difficulty resolving population structure and provided nearly equivalent support for either $K = 4$ ($P = 0.503$) or $K = 5$ ($P = 0.497$). However, the greater

Table 3. Probability values for pairwise tests of genic heterogeneity among blueback herring populations.

	EMA	STG	EXE	MYS	MON	GIL	CON	HUD	DEL	NAN	JAM	RAP	CHO	ROA	NEU	CFE	SAN	ALT	SAV
STG	0.000																		
EXE	0.000	0.000																	
MYS	0.000	0.000	0.000																
MON	0.000	0.000	0.000	0.000															
GIL	0.000	0.000	0.000	0.000	0.000														
CON	0.000	0.000	0.000	0.000	0.000	0.000													
HUD	0.000	0.000	0.000	0.000	0.000	0.000	0.000												
DEL	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000											
NAN	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.126**	**0.671**										
JAM	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.571**									
RAP	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.072**	**0.044**	**0.794**	0.001								
CHO	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.273**	0.000	0.003							
ROA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	**0.091**	**0.418**	**0.117**	**0.060**	0.017						
NEU	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.025	0.001	0.013	0.010	**0.603**					
CFE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000				
SAN	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000			
ALT	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006		
SAV	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.008	
STJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Instances of nonsignificant ($P > 0.05$) genic heterogeneity are in bold.

variation in estimates for $K = 5$ (Fig. S1b) suggests four clusters across the US range for blueback herring. Both STRUCTURE and BAPS identified the same four clusters (hereafter referred to as stocks): Northern New England, Southern New England, Mid-Atlantic, and South Atlantic (Fig. 3B). At $K = 5$, the St Johns separated from the South Atlantic Stock to represent a distinct cluster, as also suggested by PCoA (Fig. 2C, D). Further investigation using hierarchical STRUCTURE and BAPS analyses failed to detect additional structure within stocks. Estimates of ΔK revealed the largest increase in the likelihood of the number of clusters at $K = 2$ (Fig. S1b) and suggested 'deep-rooted' structure among the populations surveyed. AMOVA revealed more variation among the four stocks (2.45%; $P < 0.001$) than among rivers within stocks (0.82%; $P < 0.001$) and was comparable with the among river component of variation (3.21%, $P < 0.05$) when populations were not grouped into stocks (Table S5). That AMOVA detected significant variation among rivers within stocks was consistent with the significant genic differentiation observed among most populations sampled (Table 3).

Isolation by distance

Mantel tests revealed a highly significant ($P < 0.001$) pattern of IBD for both alewife ($r = 0.73$) and blueback herring ($r = 0.71$) across their US range. The slope of the IBD relationship was steeper in alewife (slope = 2.3 e-4) compared with blueback herring (slope = 8.9 e-5), suggesting greater genetic isolation among alewife populations or, conversely, more gene flow among blueback herring populations (Fig. 4).

Demographic analysis

Demographic trends by time series

Time series revealed an overall pattern of demographic declines in alewife and blueback herring. For alewife, of a total of 40 time series analyzed, 11 showed significant declines, 16 showed nonsignificant declines, 2 showed no change, 10 showed nonsignificant increases and 1 showed a significant increase (Table S6). Mann–Kendall tests revealed that mean length for spawning adult alewives has declined significantly in 4 of 10 rivers examined (Stony Brook, Monument, Hudson, and Chowan; Fig. S2), and results were similar for males and females (Table S6). Alewife run size declined significantly in 3 of 20 rivers examined (Parker, Nonquit, and Chowan; Fig. S3) and increased significantly in one river (York; Fig. S3, Table S6).

Of a total of 29 time series analyzed for blueback herring, 18 showed significant declines, six showed nonsignificant declines, one showed no change, three showed nonsignificant increases, and none showed significant increases (Table S7). Mann–Kendall tests revealed that mean length

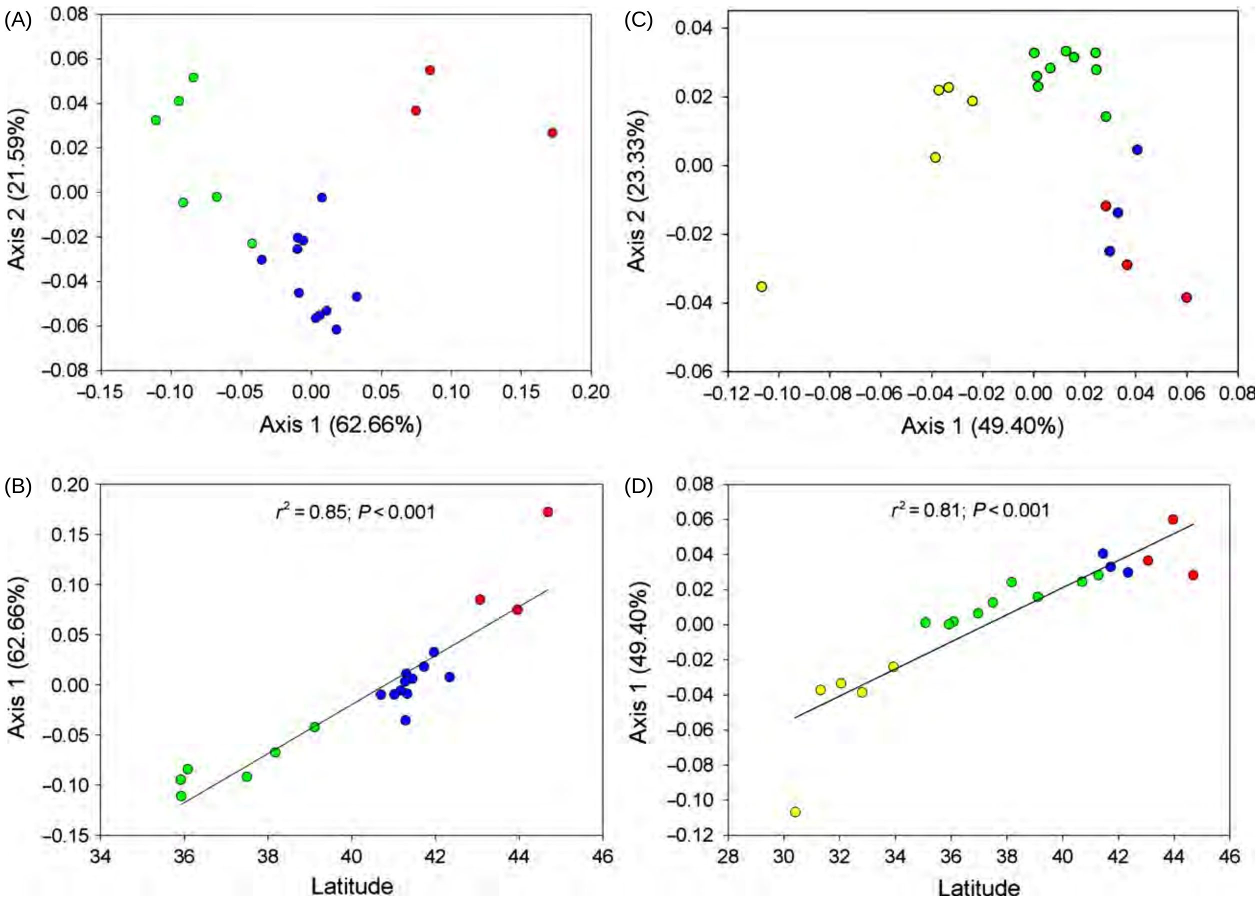

Figure 2 Results of principal coordinates analysis (PCoA) of multilocus microsatellite data for alewife (A, B) and blueback herring (C, D). Populations are color coded according to stock designations: Northern New England (red), Southern New England (blue), Mid-Atlantic (green), and South Atlantic (yellow). For both species, there is a significant relationship between latitude and PCoA Axis 1, indicating an effect of geography on patterns of population differentiation.

for spawning adult blueback herring has declined significantly in seven of nine rivers examined (Oyster, Monument, Hudson, Nanticoke, Chowan, Santee and St. Johns; Fig. S4). Results were similar for males and females with the exception of the St. Johns, for which declines were significant for females only (Table S7). Blueback herring run size declined significantly in four of nine rivers examined (Monument, Shetucket, Chowan, and Cooper; Fig. S5, Table S7).

Demographic trends by species and stock

Time series clearly show declines over time and general linear models revealed significant differences in the magnitude of declines between species and among stocks. For both species, all stocks showed average declines in mean length and run size over time (i.e., although a few individual rivers increased, the average trend for all stocks was negative). Overall, declines have been most dramatic in the central portions of each species range, especially for mean length of spawning adults (Fig. 5).

When comparing between species, the mean length of spawning adults has declined significantly more in blueback herring compared with alewife ($F_{1,\ 35} = 4.159$, $P = 0.049$; Fig. 5A, C). Declines in adult run counts over time did not differ between the species ($F_{1,\ 30} = 1.158$, $P = 0.290$; Fig. 5B, D).

For alewife, changes in mean length differed significantly among stocks ($F_{2,\ 14} = 12.558$, $P = 0.001$), with the Southern New England Stock showing more dramatic declines than either the Northern New England Stock (Tukey's HSD: $P = 0.001$) or the Mid-Atlantic Stock (Tukey's HSD: $P = 0.011$) (Fig. 5A; Fig. S2). Changes in the mean length of spawning adult alewives did not differ between females and males ($F_{1,\ 14} = 0.474$, $P = 0.503$). Declines in mean alewife run size were evident across all stocks but did not differ among stocks ($F_{2,\ 18} = 0.799$, $P = 0.465$) (Fig. 5B; Fig. S3).

For blueback herring, changes in mean length showed marginally significant differences among stocks ($F_{3,\ 13} = 2.861$, $P = 0.078$), with the Southern New

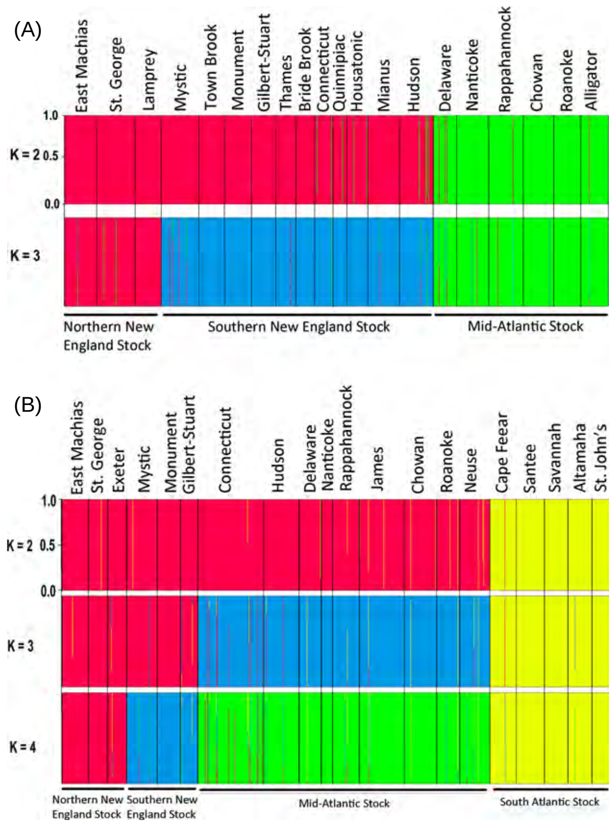

Figure 3 Alewife and blueback herring population structure and stock delineation inferred from Bayesian analyses. Individual specimens are indicated by a thin vertical line, which is partitioned into K-colored segments representing a specimen's estimated assignment fraction to each cluster. For alewife (A), analyses identified the most likely number of clusters at $K = 3$. For blueback herring (B), analyses identified the most likely number of clusters at $K = 4$.

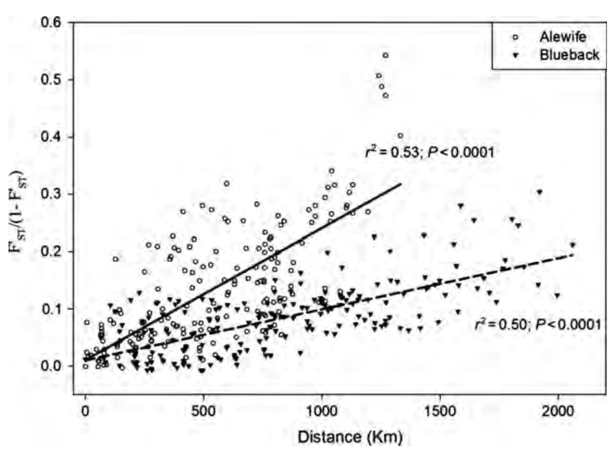

Figure 4 Isolation by distance (IBD) relationships for alewife and blueback herring. Both species show significant IBD, with alewife displaying a steeper slope of the relationship, indicating less gene flow among alewife populations.

England and Mid-Atlantic Stocks declining more steeply than the Northern New England and Southern Atlantic Stocks (although Tukey's HSD did not reveal any pairwise differences to be significant) (Fig. 5C; Fig. S4). Declines in the mean length of spawning adult blueback herring did not differ between females and males ($F_{1,\ 13} = 0.001$, $P = 0.981$). Declines in blueback herring run size were observed across all stocks but did not differ among stocks ($F_{2,\ 8} = 0.978$, $P = 0.417$) (Fig. 5D; Fig. S5).

Conservation prioritization

For alewife stock-level prioritizations, the Southern New England Stock was designated as high priority and the Northern New England and Mid-Atlantic Stock were designated as medium priority. Conservation prioritization of specific rivers within stocks highlights the genetic distinctiveness observed among populations. At the population level (for a total of 45 alewife populations), six populations were designated as low priority, 23 as medium priority, and 15 as high priority (Table 4). High-priority populations are located in the middle of the US range, with the addition of several high-priority populations at the extreme southern end of the alewife distribution. At this end of the distribution, the Roanoke and Alligator were given high prioritizations due to genetic similarity to the Chowan, which has declined dramatically (Fig. 5; Table S6). For blueback herring stock-level prioritizations, the Southern New England and Mid-Atlantic Stocks were designated as high priority, and the Northern New England and South Atlantic Stocks were designated as medium priority. At the population level (for a total of 55 blueback herring populations), 0 populations were designated as low priority, 26 as medium priority, and 29 as high priority (Table 4). High-priority blueback herring stocks and populations are located in the middle of the US range, with the addition of the St Jonhs in Florida. This population was given high prioritization due to its genetic uniqueness (Fig. 2) and declines observed for mean length (Fig. 5; Table S7).

Discussion

We analyzed population genetic structure and recent demographic trends in anadromous alewife and blueback herring to designate management units and prioritize populations within those units for conservation efforts. Our results show that the majority of rivers examined comprise genetically distinguishable groups (Tables 2 and 3). This finding is consistent with microsatellite studies of other anadromous alosine species (Jolly et al. 2012; Hasselman et al. 2013). For alewife, notable exceptions to this pattern (i.e., rivers showing nonsignificant genic differentiation) include some rivers associated with Long Island Sound (see also Palkovacs et al. 2008) and Albemarle Sound (Table 2).

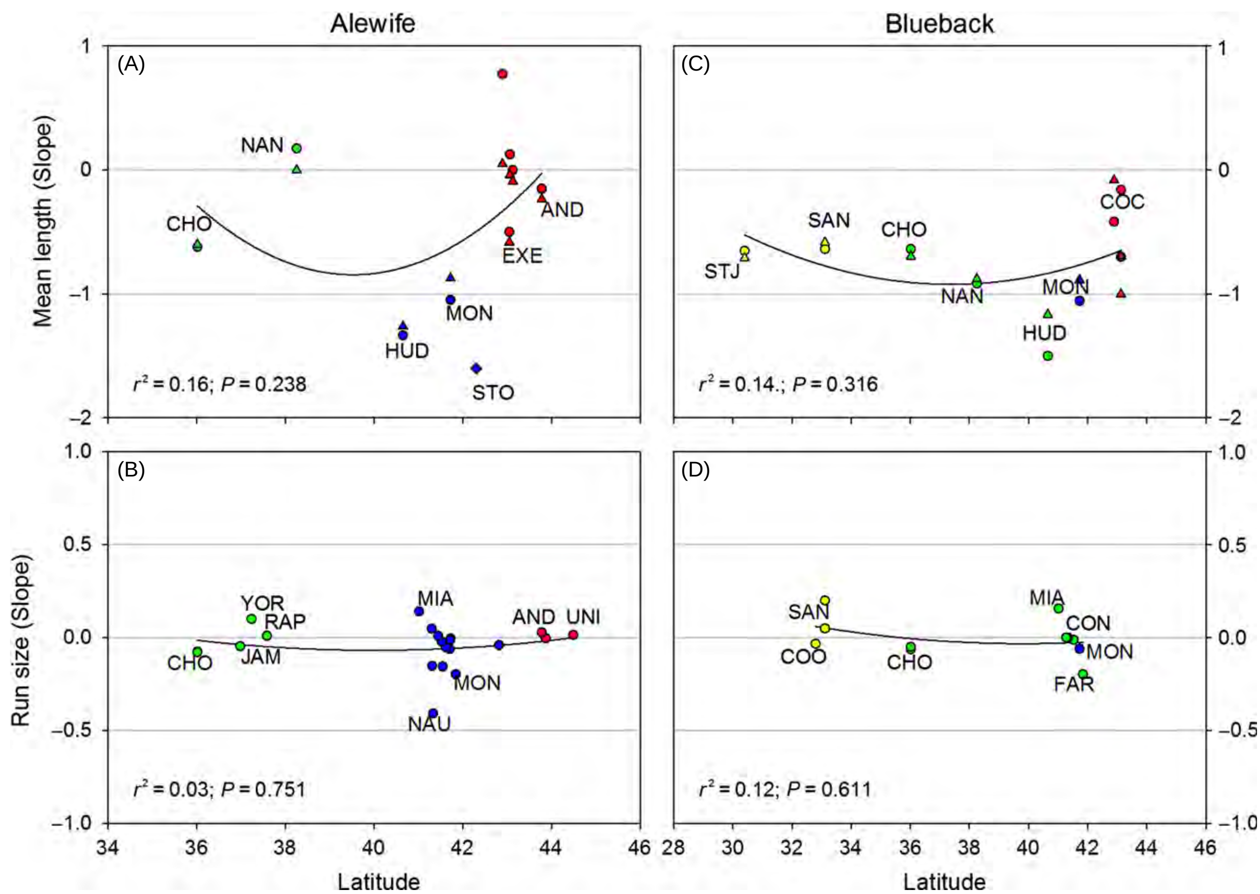

Figure 5 Slope values estimated from demographic time series for alewife (A, B) and blueback herring (C, D) plotted against latitude and color coded by stock: Northern New England (red), Southern New England (blue), Mid-Atlantic (green), South Atlantic (yellow). River codes are given for a subset of the time series analyzed. Negative slopes indicate declines over time. For mean length of spawning adults, slopes were estimated separately for males (triangles) and females (circles), with one exception where the sexes were grouped (diamond). Quadratic linear regressions show the tendency for declines to be more severe at the center of the sampled distribution, especially for mean length.

For blueback herring, instances of nonsignificant genic differentiation are found in the middle of the range, with most occurring in the vicinity of Chesapeake Bay (Table 3). The higher frequency of nonsignificantly differentiated rivers found for blueback herring is supported by isolation-by-distance (IBD) patterns, which also suggest greater gene flow among blueback herring populations (Fig. 4). The finding of significant differentiation among most rivers suggests that alewife and blueback herring should be managed at the river-level where possible, with the possible exceptions of Long Island Sound and Albemarle Sound for alewife, and Chesapeake Bay for blueback herring, which could be managed as units.

Our results indicate the presence of three distinct genetic stocks in alewife and four distinct genetic stocks in blueback herring (Figs 2 and 3). The presence of high-level population genetic structure indicates that gene flow is not continuous across all parts of these species ranges. In alewife, genetic stocks include a Northern New England Stock, a Southern New England Stock, and a Mid-Atlantic Stock (Fig. 3A). In blueback herring, genetic stocks include a Northern New England Stock, a Southern New England Stock, a Mid-Atlantic Stock, and a South Atlantic Stock (Fig. 3B). There is a high level of congruence between what F_{ST}-based methods (Tables 2, 3, S3 and S4) and Bayesian clustering methods (Fig. 3) identify as genetically distinguishable stocks. Thus, we have confidence that we have identified the major genetic stocks within the US portions of these species ranges.

Demographic information for alewife and blueback herring exists for a relatively small number of populations. We analyzed existing data for mean length of spawning adults and spawning adult run size in the context of genetic stock structure. This analysis reveals that declines have occurred across all stocks. Overall, variation between populations and stocks was greater for mean length data compared with run size data (Fig. 5). The magnitude of declines has been greater in blueback herring compared with alewife, espe-

Table 4. Conservation prioritizations for alewife and blueback herring populations.

		Alewife			Blueback herring		
State	River	Demographic data	Genetic stock	Prioritization	Demographic data	Genetic stock	Prioritization
ME	Dennys	N	NNE	Medium	N	NNE	Medium
ME	East Machias	N	NNE	Medium	N	NNE	Medium
ME	Narraguagus	N	NNE	Medium	N	NNE	Medium
ME	Union	Y	NNE	Low	N	NNE	Medium
ME	Orland	N	NNE	Medium	N	NNE	Medium
ME	Penobscot	N	NNE	Medium	N	NNE	Medium
ME	Soudabscook	N	NNE	Medium	N	NNE	Medium
ME	St George	N	NNE	Medium	N	NNE	Medium
ME	Damariscotta	Y	NNE	Medium	N	NNE	Medium
ME	Sheepscot	N	NNE	Medium	N	NNE	Medium
ME	Kennebec	N	NNE	Medium	N	NNE	Medium
ME	Androscoggin	Y	NNE	Medium	N	NNE	Medium
ME	Presumpscot	N	NNE	Medium	N	NNE	Medium
ME	Saco	N	NNE	Medium	N	NNE	Medium
NH	Cocheco	Y	NNE	Medium	Y	NNE	Medium
NH	Oyster	N	NNE	Medium	Y	NNE	High
NH	Exeter	Y	NNE	Medium	N	NNE	Medium
NH	Lamprey	Y	NNE	Low	N	NNE	Medium
NH	Winnicut	Y	NNE	Low	Y	NNE	Medium
MA	Merrimac	N	SNE	High	N	SNE	High
MA	Parker	Y	SNE	Medium	N	SNE	High
MA	Mystic	N	SNE	High	N	SNE	High
MA	Charles	N	SNE	High	N	SNE	High
MA	Stony Brook	Y	SNE	High	N	SNE	High
MA	Town Brook	N	SNE	High	N	SNE	High
MA	Monument	Y	SNE	High	Y	SNE	High
MA	Mattipoisett	Y	SNE	High	N	SNE	High
MA	Nemasket	Y	SNE	High	N	SNE	High
RI	Nonquit	Y	SNE	High	N	SNE	High
RI	Gilbert Stuart	Y	SNE	Low	N	SNE	High
CT	Connecticut	N	SNE	High	Y	MAT	Medium
CT	Quinnipiac	N	SNE	High	N	MAT	High
CT	Housatonic	N	SNE	High	N	MAT	High
NY	Hudson	Y	SNE	High	Y	MAT	High
NJ	Raritan	N	MAT	Medium	N	MAT	High
NJ/DE/PA	Delaware	N	MAT	Medium	N	MAT	High
MD	Nanticoke	Y	MAT	Medium	Y	MAT	High
MD	Susquehanna	N	MAT	Medium	N	MAT	High
MD/VA	Potomac	N	MAT	Medium	N	MAT	High
VA	Rappahannock	Y	MAT	Low	N	MAT	High
VA	York	Y	MAT	Low	N	MAT	High
VA	James	Y	MAT	Medium	N	MAT	High
NC	Chowan	Y	MAT	High	Y	MAT	High
NC	Roanoke	N	MAT	High	N	MAT	High
NC	Alligator	N	MAT	High	N	MAT	High
NC	Tar-Pamlico	–	–	–	N	MAT	High
NC	Neuse	–	–	–	N	MAT	High
NC	Cape Fear	–	–	–	N	SAT	Medium
SC	Pee Dee	–	–	–	N	SAT	Medium
SC	Santee	–	–	–	Y	SAT	Medium
SC	Cooper	–	–	–	Y	SAT	Medium
SC	Edisto	–	–	–	N	SAT	Medium
SC/GA	Savannah	–	–	–	N	SAT	Medium
GA	Altamaha	–	–	–	N	SAT	Medium
FL	St Johns	–	–	–	Y	SAT	High

For each population, the availability of demographic data and genetic stock assignments are given: Stocks = Northern New England (NNE), Southern New England (SNE), Mid-Atlantic (MAT), and South Atlantic (SAT).

cially for mean length, and most severe toward the center of each species US range (between about 40–42°N latitude for both species; Fig. 5).

In alewife, declines have been most dramatic and widespread for the Southern New England Stock. We recommend high conservation prioritization for most alewife populations in this stock (Table 4). Although the Mid-Atlantic Stock has performed somewhat better, alewife populations associated with Albemarle Sound (Chowan, Roanoke, Alligator) were given high conservation priority due to dramatic declines observed in the genetically similar Chowan (Figs 4, S3 and S4). A possible southern range contraction in alewife puts these Albemarle Sound populations at particular risk. Compared with other alewife stocks, the Northern New England alewife stock is performing relatively well, with some populations remaining stable and some even showing recent (albeit modest) hints of recovery (Figs 4, S3 and S4).

In blueback herring, declines have been most severe and widespread for the Southern New England and Mid-Atlantic Stocks. We recommend high conservation prioritization for most blueback herring populations belonging to these stocks (Table 4). The Northern New England and South Atlantic Stocks appear to have declined less dramatically. Nonetheless, the St Johns in Florida was given high prioritization due to its genetic uniqueness, declines observed in mean length, and vulnerable location at the extreme southern end of the blueback herring range. It is important to note that demographic information for blueback herring populations is particularly limited. For example, demographic information for the Northern New England and South Atlantic Stocks is limited to just three rivers per stock, and demographic information for the Southern New England Stock is limited to just a single river. Expansion of data collection efforts for river herring, particularly for blueback herring, is critical for setting and achieving future conservation goals.

Recent alewife and blueback herring declines may have been triggered by overharvest in marine fisheries, but earlier human actions including in-river harvest, dam construction, pollution, and landscape change undoubtedly reduced the resiliency of populations (Limburg and Waldman 2009; Hall et al. 2012). Current threats include marine bycatch, rebounding populations of natural predators, urbanization of coastal watersheds, climate change, and changes to marine ecosystems (ASMFC 2012). Recent restoration efforts such as fishway projects on main stem dams of large rivers have largely failed to increase populations (Brown et al. 2013). We recommend systematic monitoring and evaluation of ongoing freshwater restoration projects and increased focus on marine processes. A major emerging concern is bycatch in marine fisheries, which overlaps geographically with regions we found to be declining most precipitously (Bethoney et al. 2013; Cournane et al. 2013).

Our findings have important implications for managing interbasin transfers of gravid adults, a strategy that is being increasingly implemented in the name of alewife and blueback herring restoration (Hasselman and Limburg 2012). Interbasin transfers should not occur across major stock or watershed boundaries for either species. Higher straying rates inferred for blueback herring (Fig. 4) make the effects of stocking across drainages perhaps less disruptive for population structure in this species. However, greater straying also makes natural recolonization of watersheds more likely (and hence stocking less necessary to re-establish spawning runs). Interbasin transfers will be least disruptive to population structure in river complexes not showing significant differentiation, including Long Island Sound and Albemarle Sound for alewife and Chesapeake Bay for blueback herring. However, interbasin transfers may still disrupt local adaptation even when neutral genetic structure is minimal, an effect which may be hindering the recovery of American shad (*Alosa sapidissima*) (Hasselman and Limburg 2012). Thus, interbasin stocking should be used judiciously, for the re-establishment of extirpated runs, and source populations should be as geographically proximate as possible.

We combined genetic and demographic information to define management units and prioritize populations within those units for conservation action. The rationale for this approach is based on the fact that population genetic structure is the legacy of demographic nonindependence caused by migration. Specifically, linking 'evolutionary measures' of population genetic structure and 'ecological measures' of demographic nonindependence remain challenging because the power to detect population structure using genetic data varies between methods and marker types (Waples and Gaggiotti 2006). Nonetheless, our results show that this approach can be useful, especially when demographic information must be generalized from just a few populations and conservation decisions are urgent, as is the case for anadromous alewife and blueback herring.

Acknowledgements

We thank the people and organizations that provided assistance with sample collection (Table S8). E. M. Labbe, S. Blienbry and L. Thornton helped with data collection. A. Boustany and D. Fryxell assisted with data analysis. Funding was provided by the National Fish and Wildlife Foundation.

Data archiving

Microsatellite data are available from the DRYAD Digital Repository: http://dx.doi.org/10.5061/dryad.8v0c3.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Figure S1. Bayesian inference of the number of clusters (K) among populations sampled for alewife (a) and blueback herring (b) using plateau of log probability of data L(K) (● ± SD; Pritchard et al. 2000) and ΔK (★; Evanno et al. 2005).

Figure S2. Alewife time series data for mean length of spawning adult females for the Northern New England Stock (a), Southern New England Stock (b), and Mid-Atlantic Stock (c).

Figure S3. Alewife time series data for run size for the Northern New England Stock (a), Southern New England Stock (b), and Mid-Atlantic Stock (c).

Figure S4. Blueback herring time series data for mean length of spawning adult females for the Northern New England Stock (a), Southern New England Stock (b), and Mid-Atlantic Stock (c), and South Atlantic Stock.

Figure S5. Blueback herring time series data for run size for the Southern New England Stock (a), and Mid-Atlantic Stock (b), and South Atlantic Stock (c).

Table S1. Alewife genetic diversity statistics: number of specimens genotyped (N), number of alleles per locus (N_a), allelic richness (R; standardized to N = 24), observed heterozygosity (H_O), expected heterozygosity (H_E), and inbreeding coefficient (F_{IS}).

Table S2. Blueback herring genetic diversity statistics: number of specimens genotyped (N), number of alleles per locus (N_a), allelic richness (R standardized to N = 26), observed heterozygosity (H_O), expected heterozygosity (H_E), and inbreeding coefficient (F_{IS}).

Table S3. Alewife genetic differentiation. Pairwise F_{ST} values (θ; Weir and Cockerham 1984) below diagonal (nonsignificant values in bold) and standardized F_{ST} values (F'_{ST}; Hedrick 2005) above diagonal.

Table S4. Blueback herring genetic differentiation. Pairwise F_{ST} values (θ; Weir and Cockerham 1984) below diagonal (non-significant values in bold) and standardized F_{ST} values (F'_{ST}; Hedrick 2005) above diagonal.

Table S5. AMOVA results. Clusters refer to genetic stocks identified using STRUCTURE v.2.3.3 (Pritchard et al. 2000; Falush et al. 2003) and BAPS v.5.3 (Corander et al. 2006).

Table S6. Alewife demographic time series results with genetic stock assignments listed for each river (NNE-Northern New England, SNE-Southern New England, MAT-Mid-Atlantic). Non-parametric linear regression slopes are given (significant values in bold).

Table S7. Blueback herring demographic time series results with genetic stock assignments listed for each river (NNE-Northern New England, SNE-Southern New England, MAT-Mid-Atlantic, SAT-South Atlantic).

Table S8. Organizations and individuals that provided assistance with sample collection.

CITIZENS CAMPAIGN FOR THE ENVIRONMENT
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516-390-7150
19 Court Street, Lower Level • White Plains, NY 10601
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716-831-3206
466 Westcott Street, 2nd Floor • Syracuse, NY 13210
315-472-1339
129 Church Street, Suite 221 • New Haven, CT 06510
203-785-9080

Empowering Communities, Advocating Solutions.

Dr. Christopher Moore, Executive Director
Mid-Atlantic Fishery Management Council
800 North State St.
Dover, DE 19901

September 20, 2013

Dear Dr. Moore,

Citizens Campaign for the Environment (CCE) is an 80,000 member, not-for-profit, grassroots environmental organization working to protect public health and the natural environment in New York and Connecticut for 28 years. CCE is dedicated to ensuring healthy rivers, bays, and estuaries. We are active members of the NY Ocean Coalition, the Long Island Sound Study Citizens Advisory Committee and Chair the South Shore Estuary Reserve Citizens Advisory Committee.

Forage fish, river herring and shad are an important source of food for wildlife and other fish. They are critical in maintaining healthy ecosystems and balanced food chains. In addition, these fish also help support commercial and recreational fishing industries. Unfortunately, despite the efforts of a number of Northeast States to stabilize the populations of these important fish, we continue to see their populations decline in federal waters. Reversing this trend and maintaining stable populations of these fish species will strengthen our coastal ecosystem and should be given high priority.

In 1998, the Long Island Sound Study (LISS) adopted a goal to restore 100 miles for fish passage in rivers where dams and other structures have blocked fish from swimming upstream to reproduce. To date 158 miles of fish passage have been created. On the South Shore, Long Island's first permanent fish ladder on the Carmans River in Brookhaven Town was installed. The fish ladder permits fish to move upstream beyond a previously impassable barrier to spawn in Hards Lake in Southhaven County Park, now connecting two isolated parts of this important SSER ecosystem. As soon as the fish ladder opened, alewives were sited using the ladder and spawning upstream. These initiatives are critical for protecting and restoring populations of river herring. ***But New York cannot be alone in protecting these critically important fish.*** These efforts are being compromised by a lack of federal protection of these species.

Federal protection of river herring and shad, by inclusion in the Mackerel and Squid Butterfish Fishery Management Plan, is necessary for their recovery and proliferation. Increased monitoring of industrial trawlers, enforceable catch limits placed on river herring and shad, and improved accountability measures are all potential benefits derived from federal protection through the passage of Amendment 15.

Please give these species, which are in critical condition, a chance at rehabilitation and recovery by passing Amendment 15.

Thank You,

Adrienne Esposito
Executive Director

Natural Resources Defense Council
40 West 20th Street
New York, NY 10011
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Via First Class Mail and Electronic Mail

October 3, 2013

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Re: Amendment 15 to the Mackerel, Squid & Butterfish FMP

Dear Chairman Robins and Dr. Moore,

On behalf of the Natural Resources Defense Council (NRDC), I am writing to reiterate our support for federal management of river herring and shad through Amendment 15 to the Atlantic Mackerel, Squid, and Butterfish (MSB) Fishery Management Plan (FMP). The highly depleted status of river herring and shad, combined with their significant unregulated catch in the MSB fishery, requires immediate and robust conservation and management in federal waters. When Mid-Atlantic Fishery Management Council (Council) convenes next week, we urge it to press forward with development of Amendment 15.

The Magnuson-Stevens Fishery Conservation and Management Act (MSA) calls for management of a stock in a FMP in certain instances, including when the stock is overfished or, pursuant to 16 U.S.C. § 1852(h)(1), when it is in need of "conservation and management." The statutory criteria for such conservation and management include the need to rebuild, restore, or maintain a fishery resource or the marine environment, and the usefulness of doing so; assuring food supply and recreational benefits; and avoiding irreversible or long-term adverse effects on fishery resources and the marine environment. 16 U.S.C. § 1802(5). Although the staff white paper, dated September 30, 2013 (White Paper), relies primarily on National Standard 7 for direction on providing advice on this issue, National Standard 7 is inapplicable in this instance because this National Standard – as the White Paper acknowledges (p. 6) – addresses how, not whether, to manage a stock. While the National Marine Fisheries Service (NMFS) did see fit to discuss in its guidelines for National Standard 7 that separate issue of whether a stock should be federally managed, this discussion cannot supersede the statutory instructions on the issue. We fear that the White Paper, while providing a great deal of helpful information, has unnecessarily and inappropriately complicated the Council's decision-making by framing this information in the nature of a cost-benefit analysis.[1]

The current conservation and management status of river herring (alewife and blueback herring) and shad (American shad and hickory shad) satisfy the criteria for federal management. While not formally so designated, populations of these species are clearly overfished. For example, river herring populations are potentially at or less than 2 percent of historical size, based on catch levels.[2] Although the 2012 Atlantic States Marine Fisheries Commission (ASMFC) stock assessment for river herring could not provide precise biological reference points on a coast-wide basis for each species of river herring, and thus was unable to determine whether the species are currently overfished or subject to overfishing on a coast-wide basis, the assessment was able to determine that 23 of 24 adequately-assessed river herring populations are depleted.[3] In addition, at least ten river herring stocks were specifically determined to be "overfished."[4]

The ASMFC stock assessment report found that additional management of river herring is required:

> "Due to the poor condition of many river herring stocks, management actions to reduce total mortality are needed. These could include reductions in directed commercial or recreational fishery mortalities, reductions in total incidental catch (retained and discarded fish), habitat restoration, and improvements in upriver and downstream fish passage."[5]

[1] Even if one were to conduct a cost-benefit analysis in this instance, and even though many of the costs and the benefits are not quantified and can only be speculated on in the White Paper, it is our view that, for the reasons set out in the text of this letter, the benefits of federal management of river herring and shad outweigh the costs.
[2] NMFS, *Endangered and Threatened Wildlife and Plans; Endangered Species Act Listing Determination for Alewife and Blueback Herring,* 78 Fed. Reg. 48944, at 48987 (Aug. 12, 2013)
[3] Atlantic States Marine Fisheries Commission (ASMFC), *River Herring Stock Assessment Overview* (May 2012).
[4] *See* ASMFC, *Stock Assessment Report No. 12-02, River Herring Benchmark Stock Assessment, Volume II* (May 2012), at 412 (finding 9 of 15 river herring stocks in Maryland and the Upper Chesapeake Bay to be "overfished"); *id.*, at 549-550 (stating that the Chowan River blueback herring population "remains overfished" and is "less than 5% of the amount necessary to replace itself in the complete absence of fishing."). More recently, NMFS designated eight stock complexes for the two species (four each) and calculated population trends; for four of the eight complexes, the maximum likelihood trend estimate was decreasing. NMFS, *Endangered and Threatened Wildlife and Plans; Endangered Species Act Listing Determination for Alewife and Blueback Herring*, 78 Fed. Reg. 48944, at 48991 (Aug. 12, 2013).
[5] ASFMC, Stock Assessment Report No. 12-02, *River Herring Benchmark Stock Assessment, Volume I*, *Section C, River Herring Stock Assessment Report for Peer Review, at* 58 (May 2012).

The most recent American shad stock assessment also found severely-depleted population levels, as the FEIS for Amendment 14 summarizes:

> "The most recent shad stock assessment report identified that shad stocks are highly depressed from historical levels. Of the 24 stocks of American and hickory shad for which sufficient information was available, 11 were depleted relative to historic levels, 2 were increasing, and 11 were stable (but still below historic levels). … Taken in total, American shad stocks do not appear to be recovering. The assessment concluded that current restoration actions need to be reviewed and new ones need to be identified and applied. These include fishing rates, dam passage, stocking, and habitat restoration."[6]

Various factors have contributed to the severe decline of river herring and shad populations along the Atlantic. While the relative contribution of each of these sources to the decline is difficult to estimate precisely, it is beyond dispute that fishing mortality from fisheries in ocean-intercept fisheries continues to play a significant role. Incidental catch of river herring and shad by ocean-intercept fisheries – averaging an estimated 459 metric tons of river herring and 63 metric tons of shad per year – comprises a substantial share of overall fishing mortality of these species.[7] By comparison, from 2005-2010, river herring and shad annual landings averaged 601 and 581 metric tons, respectively.[8]

Amendment 14 and the White Paper recognize the shortcomings of current management of river herring and shad, including negative impacts on populations of these species specifically from the MSB fishery. Both Amendment 14 and the White Paper also recognize many of the benefits that would result from the recovery of river herring and shad stocks, including: additional commercial and recreational fishing opportunities, an expanded forage base for important species like striped bass, and the preservation of cultural heritage, non-market existence value and subsistence fishing for Native American communities. Federal management could help realize these benefits through a combination of improved stock assessments; improved monitoring and data collection, including specifically with respect to catch and bycatch; reference points based on the best available science; a better understanding of the relative contribution of various factors for the decline of river herring and shad; minimization of bycatch; annual catch limits (ACLs) based on the best available science, including the advice of the Council's Science and Statistical Committee, and set at levels to prevent overfishing and attain optimum yield, including rebuilding; consideration of river herring and shad mortality in the setting of ACLs in other fisheries in addition to the MSB fishery; robust accountability measures (AMs); and measures to protect essential fish habitat.

[6] Mid-Atlantic Fisheries Management Council, *Amendment 14 to the Atlantic Mackerel, Squid, and Butterfish MSB FMP, Final Environmental Impact Statement (2013) (Amendment 14)*, at 211.
[7] *Amendment 14* at 215.
[8] *Amendment 14* at 215.

In sum, a significant federal fishery exists for river herring and shad. Because of the absence of management and conservation of this fishery (at least in part), populations of these species are severely depleted. Accordingly, federal conservation and management is needed. Recent steps by the ASMFC and by the Council to improve management and conservation of river herring and shad cannot be counted on to adequately fill this regulatory void. Measures to provide "sustainable fisheries" and moratoria adopted by the ASMFC member states may not sufficiently control directed catch in state waters, do not address bycatch in state waters, and do not address catch in federal waters. Proposed new federal regulations, such as the "catch cap" in the MSB fishery, will be significantly compromised if 100 percent observer coverage and slippage caps are disapproved. Informal, voluntary or ad hoc measures are also not sufficient, given the dire current status of many populations of these species and the country's long-term stake in their recovery.

We understand that federal management of river herring and shad will require resources and poses a number of scientific and management complexities. But many of these issues are not unique to these species or their management, and can be overcome (particularly over time, as the sustainability of the region's fisheries continues to improve and their management streamlined, and as our scientific knowledge about river herring and shad increases). They are also not sufficient reason, in our view, to fail to do what is required by law and in the long-term interest of the fishery and the ocean ecosystem.

Thank you for the opportunity to comment on this important matter.

Sincerely,

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Summary: Managing River Herring and Shad by the Mid Atlantic Fishery Management Council under the Magnuson Stevens Act

Prepared by Environmental Stewardship Concepts, LLC October 2013

Introduction

Estimates of the stocks of RH/S indicate greater than 90% depletion, based on information from historical data. While the states' plans are a very good foundation for RH/S management, there is no existing management in federal waters; Amendment 15 to the SMB FMP would include RH/S as managed stocks in the fishery. RH/S have faced many challenges historically, including heavy fishing both commercially and recreationally, dams that prevent spawning, pollution, habitat loss, and depletion as incidental catch of the Mackerel and Atlantic Herring Fisheries.

Pacific Precedents

In identifying the best tactics to manage overfished species, we can look to precedents set by other fishery councils: The Pacific Fishery Management Council's (PFMC) and the North Pacific Fishery Management Council's (NPFMC) plans have been forerunners in fishery management.

Previous East Coast Bycatch Management

The South Atlantic Fishery Management Council (SAFMC) has experience dealing with significant bycatch in the shrimp fishery.

Commercial/Recreational Benefits

A healthy RH/S population supports healthy populations of other commercially and recreationally caught target fish species. Especially affected is the diet of striped bass, a recently restored fishery, as well as northern pike, pickerel and lake trout. The herring runs provide much needed food after the winter, and those RH that survive create a second wave of protein downstream when the young-of-the year migrate to sea.

Ecosystem Benefits

Many other organisms rely on RH, including ospreys, loons, herons, bald eagles, egrets, kingfishers, harbor seals, and river otters. RH are less contaminated than the freshwater resident fish, reducing bioaccumulation of contaminants. Spawning RH provide nutrients to freshwater ecosystems by way of their eggs, sperm, and decaying bodies. Zooplankton, bryozoans, clams, and insect larvae feed on these important proteins, and may come back to these same areas because of the RH. RH also play an important and unique role in the survival of a freshwater mussel, the "alewife floater". The larvae of this mussel must attach to a host fish to survive and have been found to only attach to RH/S. These freshwater mussels are important to filtering freshwater bodies and are able to remove harmful amounts of algae, bacteria, and sediments.

Efficacy of federal management to protect and restore the RH/S stocks

Even in the absence of perfect knowledge of the multiple factors affecting RH/S, the Council can act to mitigate those factors under their control.

<u>Two examples of restoration in the face of uncertainty and multiple causes:</u>

- In the mid 1970s, the ASMFC took the bold step of instituting a moratorium on striped bass fishing in the Chesapeake Bay region because the population was so depleted. The ASMFC acted, instituted a moratorium, and the stocks recovered.
- In the face of multiple threats from fishing mortality, disease mortality, habitat degradation, and poor water quality, Virginia pursued restoration of Bay oysters. In 2012, Virginia recorded an annual harvest more than 10x the harvest of a decade before.

Coordination with state programs to restore RH/S

The Mid Atlantic FMC has a long and successful record of coordinating with other management partners to achieve notable successes in restoring the species under Council jurisdiction.

Management of River Herring and Shad as Stocks in the Mackerel, Squid and Butterfish Plan by the Mid Atlantic Fishery Management Council under the Magnuson Stevens Act

Prepared by Environmental Stewardship Concepts, LLC October 2013

Introduction

The dramatic decline of River Herring and Shad (RH/S) stocks came to the attention of the National Marine Fisheries Service (NMFS), the New England Fishery Management Council (NEFMC) and the Mid-Atlantic Fisheries Management Council (MAFMC), in no small part because the issue has been before the states for years. Estimates of the stocks of these species indicate greater than 90% depletion, based on information from historical data. State agencies and the Atlantic States Marine Fisheries Commission (ASMFC) had been taking actions to limit harvests and state and federal agencies (e.g. the US Fish and Wildlife Service, USFWS) have efforts to restore riverine habitat, largely via fish passages. The efforts to restore RH/S populations have focused on inshore habitat improvement and state harvest limits. Until recently, no federal actions had addressed the stocks of RH/S in federal waters, despite data that indicate RH/S are caught in several East Coast fisheries.

Consistent with the information on RH/S, the MAFMC took up the matter of what, if anything, NMFS could and should do to address the serious problem. The Council created an ad hoc committee, chaired by Chris Zeman, on River Herring to explore the problems associated with RH/S and consider the need for Council action (and subsequent NMFS action). The committee recommended via a report that Council action was appropriate and timely.

At the June 2012 Council meeting, the MAFMC took two steps regarding RH/S. The first action was to proceed with Amendment 14 (AM 14) that includes a cap on bycatch/incidental catch of RH/S. The second vote was to direct Council staff to develop an amendment (number 15) to the Squid/Mackerel/Butterfish Fishery Management Plan (SMB FMP) that would include RH/S as managed stocks in the fishery. During the discussion leading up to the June 2012 Council meeting and decision, both Council members and NMFS staff raised questions about practical aspects of including RH/S as managed stocks. Subsequent discussion and official input from NMFS repeated issues concerning how the MAFMC would implement such a decision. NMFS recommended justification that addressed specific provisions of Magnuson Stevens Act.

Council staff prepared a white paper to address the items raised by NMFS in their June 2013 letter to the MAFMC and the white paper on RH/S is part of the material before the Council for the October 2013 meeting. The Council staff memo addresses the items raised by NMFS, upon which the Council decision will presumably be based, but does not include all of the issues raised over the past year or more of Council discussion and debate.

Background

River herring (RH), a term that applies to both the alewife and the blueback herring species, are anadromous fish species, along with American and Hickory shad. Anadromous fish spend the majority of their lives in the ocean, but return to the freshwater rivers where they were born to reproduce, or to spawn. New research by Palkovacs et al. (2013) indicates that both RH species may not be strictly faithful to natal rivers, but rather to "regions" that include adjacent rivers. RH/S have faced many challenges historically, including heavy fishing both commercially and recreationally, dams that prevent spawning, pollution, habitat loss, and depletion as incidental catch of the Mackerel and Atlantic Herring Fisheries. Since 1965, commercial RH landings have fallen drastically, from nearly 70 million pounds to under 2 million in 2007 (ASMFC *River Herring Stock Assessment Overview*, May 2012). The ASMFC completed a stock assessment for American shad in 2007 that showed that stocks have significantly declined from historic levels (1-2 million pounds, nearly two orders of magnitude lower than in the late 19th century) and were at an all-time low, and did not appear to be recovering (ASMFC *Amendment 3 to the Interstate Fishery Management Plan for Shad and River Herring (American Shad Management)* 2010).

There is a difference between bycatch and incidental catch, the former discarded and the latter are fish that are harvested in a fishery and kept, not discarded. Incidental catch can be confused with bycatch; the principal difference being that bycatch is discarded. Incidental catch of non-target organisms, or fish that are not the subject of a directed fishery, typically occurs because they school together with the targeted catch. The incidental catch of RH/S species has increasingly become a problem over the past few decades, contributing to 23 of the 52 assessed stocks earning the label of depleted. While one stock is rebounding, there are not enough data on the remaining 28 in the Atlantic to determine their status (ASMFC *River Herring Stock Assessment Overview*, May 2012). The increased data collection and analysis that will result from Amendment 15 would help fill this data gap, providing a background for more effective, substantiated management.

Currently, RH/S stocks are managed only in state waters by the states, most of which have management plans in place that have been approved by the ASMFC. Amendment 2 to the Atlantic Mackerel, Squid and Butterfish (MSB) FMP addressed river herring and Amendment 3 addressed shad. These actions required states to create sustainable management plans that address fishing mortality, monitoring, and may include habitat conservation (ASMFC *River Herring Stock Assessment Overview*, May 2012). Beginning January 1, 2013, RH/S landings would not be allowed in states without management plans. Currently, ASMFC has approved sustainable plans for Maine, New Hampshire, limited parts of New York, North Carolina and South Carolina that include restrictions on gear and river closures. Rhode Island's is currently under review, while New Jersey and Massachusetts allow incidental catches, and Virginia has a full ban on possession. Only Maine's management plan allows for the continued directed harvest of RH/S (MAFMC *Scoping Document for Amendment 15*, Oct. 2012). While the states' plans are a foundation for RH/S management, there is no existing meaningful management in federal waters, which is needed to cohesively and effectively manage these species.

Pacific Precedents

In identifying the best tactics to manage overfished non target species, we can look to precedents set by other fishery councils. The Pacific Fishery Management Council's (PFMC) and the North Pacific Fishery Management Council's (NPFMC) plans have been forerunners in fishery management due to intensive commercial fishing activity and subsequent need for regulations and oversight, often going beyond the MSA's requirements for sustainable fisheries. Management approaches that have been tried and tested in the Pacific fisheries include non target species as managed stocks and range from seasonal area closures and protected habitat, to catch limits and gear restrictions. The two councils' actions have been a model for the nation as they have implemented conservative hard Total Allowable Catch Limits (TAC) management in many fisheries dating back over thirty years (DiCosimo 2010).

The NPFMC recognizes the importance of non-target stocks, fish that are often caught in directed fisheries as incidental catch or bycatch. Non-target stocks may have a low economic value, but have ecological importance and could be a directed commercial fishery in the future (Reuter 2010). The NPFMC's Bering Sea and Aleutian Islands (BSAI) FMP (2013) for groundfish includes multiple amendments to manage non-target stocks of this directed fishery: Pacific halibut and herring, octopus, squid, and shark. Non-target stocks have been managed by the council using ACLs since the early 1990s (Reuter 2010). These species require management since they are important to other fisheries as directed catch or as prey for directed catch. The groundfish FMP recognizes that non-target stocks can be important in a variety of ways by creating different categories for managing the stocks. The first are target species, which support species in another target fishery, and have commercial importance and adequate data to allow individual management. Otherwise, the stock is categorized as an Ecosystem component, and then either as Prohibited, meaning it must be returned immediately to the sea, or as a forage fish species, meaning it is critical prey for other marine species and cannot become a directed fishery. This ecosystem-based approach has helped control non-target stock bycatch through catch limits, area closures, gear modifications and "proactive real-time fishery closures" (Heltzel 2011). Similarly, RH/S stocks are important forage for predator fish, many of which are economically significant fisheries in the Atlantic.

For the salmon and halibut stock specifically, the groundfish FMP mentioned above set a prohibited species catch limit based on the Acceptable Biological Catch (ABC). When this limit is met, bycatch zones or specified management areas are closed for the remainder of the year or season. When unavoidable bycatch does occur, the salmon or halibut landings can be donated to economically disadvantaged individuals through the Prohibited Species Donation Program, providing a public service and presumably reducing any economic incentive not to 'fish clean'.

In managing data-poor species, as are the RH/S, the NPFMC's groundfish FMPs for the Gulf of Alaska (GOA) (2013) and BSAI (2013) has grouped such species into one complex to facilitate management. The "Other Species Complex" includes skate, shark, squid, octopus and sculpin, some of which have very little available data on abundance (Reuter 2010). Adding to the difficulty, these species, unlike RH/S, have little in common biologically. However, by using data available from a few species to create ACLs for all concerned is an effective, short-term solution while monitoring continues to accumulate numbers on the species. Once the need for stronger management is substantiated, a species can be moved from the "other species" category to the target species, as the NPFMC did for skates with its 2010 Amendments 95 and 96 to the BSAI groundfish FMP, and in Amendment 87 to the GOA FMP (NOAA Fishereis 2013). This particular arrangement of species groupings has challenging features based on the way in which NPFMC deals with categories. The MAFMC could easily improve the approach here with a simplified and streamlined category.

The NPFMC's Salmon FMP (2012) does include closures for specific areas during certain times of the year for which bycatch in that area have been determined to be the highest. The NPFMC has been using seasonal closures to manage stocks dating back to 1989 with Amendment 13 to the BSAI groundfish FMP. The salmon fishery also requires gear that allows for the release of bycatch with limited mortality. This multi-faceted approach for bycatch of the economically vital Salmon fishery shows the importance of long-term thinking in managing fisheries sustainably.

The PFMC's Coastal Pelagic Species FMP (2011) also addresses incidental catch, and has been amended to set Incidental Catch Allowances for overfished stocks at 0 to 20% of the assessed stock, as recommended by the council. To insure that incidental catch species are not overfished but also that directed fisheries are not economically damaged, total incidental catch estimates are considered along with harvest guidelines for the targeted species. The plan does not implement further restrictions on incidental catch, but does recognize that future seasonal or area restrictions may be needed in the future to effectively manage bycatch or incidental catch.

Collaboration amongst agencies and councils in the Pacific fisheries has been instrumental to sustainably managing target and non-target stocks, as it similarly has been amongst the states, councils, and agencies of the Atlantic fisheries. For example, The Alaska Department of Fish and Game collaborates on FMP limits by issuing fish tickets to help manage the economically important Salmon fisheries in the Exclusive Economic Zone (EEZ). The tickets are issued to document commercial fishing activity, and must be submitted within a week of the harvest. In doing so, the current status of landings can be tracked and fisheries or management areas can be closed when the ACL is met. As a long-time aid in the tracking of commercial fishery landings, the 1989 Amendment 13 to NPFMC's BSAI groundfish FMP established the "Observer Plan" (NOAA Fisheries 2013).

The PFMC and NPFMC have both faced the predicament of managing multiple non-target stocks that occur throughout multiple management areas and for which little abundance data exist. Using a precautionary approach, the councils are effectively managing these species to insure that directed fisheries are ecologically and therefore economically sustained. By using available data, existing guidelines and regulations, the councils minimize fish mortality, both retained and discards by setting science based catch limits, up to and including complete prohibition, to protect stocks in need of conservation and management, similar to approaches already undertaken by the Atlantic states.

Benefits

Several categories of benefits result from restored stocks of RH/S, some of which are described below. These benefits will be distributed along the entire US East Coast because the RH/S are coast-wide species and are depleted throughout their range.

Commercial/Recreational

Primarily, the commercial and recreational RH/S catch has been as a bait species. However, RH are also a commercially important species and are even used in pet foods and fertilizers (Nedeau 2003). Also, counter to popular thought, establishing a healthy population of RH/S will not interfere with the population numbers of freshwater fish. Adult RH do not compete with freshwater fish for food as they essentially stop feeding during the migration and spawning period in those bodies of freshwater. They will only resume feeding on their trek back through brackish waters toward the sea (Nedeau 2003). A side benefit to their planktonic feeding habits may benefit the eutrophic estuaries the RH move through on their way back to the open ocean. Even at sea, fish comprise a very small proportion of their diet (Nedeau 2003).

Secondarily, a healthy RH/S population supports healthy populations of other commercially and recreationally caught target fish species. RH has been found to play an important role as forage fish for other species along the Atlantic coast. The herring runs in the spring provide much needed food for those animals preying on herring or scavengers after the winter. Those RH that survive the spawning run create a second wave of protein moving downstream when the young-of-the year migrate to sea (Kenney 2007). Young-of-the-year live in freshwater for three to seven months and grow to two to five inches before making their way to the ocean (Nedeau 2003). Studying the diets of predators has confirmed that RH are a primary food source for many fish, birds, and mammals (Kenney 2007).

Especially affected is the diet of striped bass, a recently restored fishery, as well as northern pike, pickerel and lake trout. Striped bass will follow migrating RH for many miles up estuaries and rivers, providing a recreational fishery in May and June (Nedeau 2003). A study of the striped bass diet along the northeast coast from Maine to New Jersey indicates their diet consists of 33% RH during the spring migration (Walter et al. 2003). In the Chesapeake Bay, the striped bass diet can consist of nearly 80% RH (Walter and Austin 2003). The diet of North Carolina striped bass can consist of up to 33% RH during the winter and 50% during the spring migration (Walter et al. 2003).

Additionally, bluefish found in the Hudson River estuary have been found to have a diet of up to 40% RH during the summer months (Buckel et al. 1999). The white perch's diet in Maine in late summer and early fall consists entirely of young-of-the-year RH (Moring and Mink 2002). Young-of-the-year RH are eaten by many important game fish such as perch, bass, salmon, and trout. In studying RH in coastal Massachusetts lakes, it was found that they are the most important prey for largemouth bass and provide a high growth potential for "trophy" largemouth bass. The RH also provide a large forage base for the valuable game fish Atlantic cod whose population decline along the Gulf of Maine has been linked to the loss of the nutritious and predictable food source that the RH provide (Hall et al. 2011). Restoration of pelagic and groundfish stocks in the Gulf of Maine would also likely benefit from restoration of RH populations (Nedeau 2003).

However, taking these predatory effects on RH into account is no small part of the RH restoration efforts. There have been many river restoration programs that have targeted increasing the RH populations, including the Connecticut River. Increasing the RH runs from 200 fish in the early 1970s to 630,000 by 1985 was an impressive collaboration between state and federal agencies that created better habitat and opened up waterways for the RH. However, despite these efforts, the same river once again has low levels (Gephard and McMenemy 2004).

<u>Ecosystem benefits</u>

Many other organisms rely on RH, including ospreys, loons, herons, bald eagles, egrets, kingfishers, harbor seals, and river otters (Kenney 2007). Based on a study of osprey by the Connecticut Department of Environmental Protection, ospreys consistently rely on RH runs to feed their chicks (CT DEP 2007). Another benefit to a large run of anadromous RH is that they are less contaminated than the resident freshwater fish that frequently carry a higher body burden of toxic chemicals such as PCBs and dioxins. The oceanic herring (and shad) provide a food source with lower contaminant levels for growing chicks during their most vulnerable developmental stages (Nedeau 2003). Also, harbor seals in Saint John Harbor, New Brunswick, are five times more abundant during the peak of the alewife run as compared to their yearly average (Brown and Terhune 2003).

Additionally, spawning RH provide nutrients to freshwater ecosystems by way of their eggs, sperm, and decaying bodies. Because the RH continue to come back to their same spawning grounds up to eight times in a lifetime, and a female can produce 60,000 to 467,000 eggs annually, the smallest of aquatic organisms benefit from these byproducts. Zooplankton, bryozoans, clams, and insect larvae feed on these important proteins, and may come back to these same areas because of the RH. Even the decaying bodies of RH are food for scavengers such as crayfish, turtles, eels, raccoons, gulls, and bald eagles (Nedeau 2003).

RH also play an important and unique role in the survival of freshwater mussels, specifically the "alewife floater". The larvae of this mussel must attach to a host fish to survive and have been found to only attach to RH/S. These freshwater mussels are important to filtering freshwater bodies along coastal rivers and lakes, and are able to remove harmful amounts of algae, bacteria, and sediments that can impede the health of these water bodies and the fish and animals that live there (Nedeau 2003).

Efficacy of federal management to protect and restore the RH/S stocks

Multiple factors may affect the stocks in the coastal and inshore waters, including fishing pressure of several categories, habitat degradation, and other factors. Past fishery management experience (given below) and abundant literature on the topic of cumulative risk demonstrates that federal management action is both appropriate and timely, even in the absence of perfect knowledge of how these multiple factors are structured. The Council can act to mitigate those factors under their control. This situation is known as cumulative risk in which the aggregate influence of multiple stresses combine to cause harmful impacts on a species, population or community. The staff memo suggests that because it is not known how multiple factors are combined, that action on part of the suite of factors – the fishing pressures- may not be timely. Actually, the converse is true and there are examples of how such cumulative risk situations are managed by taking action, not by inaction.

The MAFMC White Paper on the topic in the October 2013 Briefing book, at Tab 2 states: "The “depleted” determination was used instead of “overfished” because of the many factors that have contributed to the declining abundance of river herring, which include not just directed and incidental fishing, but likely also habitat issues (including dam passage and water quality), predation, and climate change." But the fact that multiple factors may be involved in the current population declines does not prevent action on the part of the MAFMC.

In cases of cumulative risk or impacts, the answer is to address the identified and identifiable factors. In this case, controlling all the factors that Council staff raise – and others. This topic is addressed in EPA documents (EPA Cumulative Risk Framework and deFur and Menzie 2012).

<u>Two examples of restoration in the face of uncertainty and multiple causes:</u>

The Council action to designate RH/S as management unit stocks in a federal FMP status species would not be the first effort to restore an anadromous East Coast species despite uncertainty and controversy over the causes of severe population declines. In the mid 1970s, the ASMFC took the bold step of instituting a moratorium on striped bass fishing in the Chesapeake Bay region because the population was so depleted. The arguments against this management action included the one that the exact cause(s) of the decline were uncertain and might include: fishing mortality, predation on young, habitat degradation, poor water quality, and other factors. Despite the uncertainties, and the concerns over short term impacts to the commercial and recreational fisheries, the ASMFC acted to control fishing mortality in order to accomplish long-term management goals of restoration. The same factors and arguments are applied here in the Council white paper. The ASMFC acted, instituted a moratorium, and the stocks recovered (deFur and Kaszuba 2002).

Oyster harvests in the 19th and early 20th century reached over a million bushel annually, and concerns of overharvesting fell on deaf ears. But by the mid-twentieth century when two parasitic infections plagued the Bay, it was clear that the industry was in trouble. Efforts to control everything from water quality to habitat to harvest and even the disease seemed doomed to failure as the harvests continued into a downward spiral. Sometime in the 1990's Virginia modified regulations covering oyster growing practices to increase off-bottom culture, and embarked on a habitat restoration effort with the Army Corps of Engineers. In the face of multiple threats from fishing mortality, disease mortality, habitat degradation, poor water quality, Virginia pursued restoration. In 2012, Virginia recorded an annual harvest more than 10x the harvest of a decade before (Minutes of the July 2013 VMRC posted at: http://www.mrc.virginia.gov/Commission_Summaries/cs0713.shtm item #11).

Council obligations and Council actions needed for success

First, as demonstrated in reports by the ASMFC and MAFMC, USFWS and independent analyses, the RH/S stocks of the East Coast are seriously depleted and at all-time low levels from population measurements over the past few decades (see ASMFC stock assessment 2012 and MAFMC AM 15 Scoping Document Oct 2012).

Second, the RH/S species do occur in federal waters and are caught in fisheries managed by NMFS and the MAFMC.

Third, MSA clearly indicates that NMFS has both the authority and duty to act, indicating “within each Council’s geographical area of authority” NMFS shall “identify those fisheries that are overfished or are approaching a condition of being overfished.”[16 USC 1854 (e)1]. And in cases for which a species is overfished or approaching an overfished condition, NMFS must develop a fishery management plan, plan amendment, or proposed regulations [16 USC 1854 (e)3]. Notwithstanding the overfishing status determination, councils clearly have the obligation to conserve and manage fish species populations that are important for fisheries and ecosystems (as indicated in MSA 302(h)(1). One example of such action is that taken under Amendment 16 to protect deep sea coral.

Fourth, once a fish stock is included as a managed stock in the fishery, then the council must develop management measures as required under Section 303 of the MSA. As specified in the MSA, these “measures in the plan to conserve target and non-target species and habitats, considering the variety of ecological factors affecting fishery populations.”

The question becomes how can and shall the Mid Atlantic Council conserve and manage the RH/S stocks.

The Council now takes up AM 15 that directly addresses the matter of including RH/S as federally managed stocks under Magnuson-Stevens. The Council considers that RH/S occur in federal waters as well as state waters, RH/S are caught in federal fisheries as incidental catch (and by-catch) and substantial benefits potentially accrue from replenishment/restoration of the RH/S stocks. A Council generated Draft Environmental Impact Statement (DEIS) will examine the biological, management, and economic issues in great detail. The DEIS will also afford Council members and the public the opportunity to consider a range of options that might be applied to the problem of severely depleted RH/S stocks. The options in a DEIS will range from the no action alternative, to managing the species as a unit under an FMP as required by the MSA.

The Council admittedly faces the challenge of uncertainty in any action or inaction to restore RH/S stocks. The most certain course of action is that the stocks will continue the declines of recent decades under the management scheme that has led to the present situation. Basically, unless something is done fairly soon, the RH/S stocks will remain at a small fraction of historical levels. Fortunately, the ASMFC has taken management action for state waters, inside the three mile federal limit and the Atlantic states are complying with Commission requirements. The success of Commission actions alone, without supporting federal action, in restoring RH/S is uncertain.

The MAFMC has weighed in on the management of RH/S after several years of considering action and has taken final action on Amendment 14 (AM14) to the Mackerel-Squid-Butterfish Fishery Management Plan, and on an annual specifications package for the fishery that includes an interim cap on river herring and shad. AM 14 seeks to increase observer coverage, make other monitoring improvements, and provide the RMP with the authority to adopt a cap on the incidental catch of RH/S in the fisheries for MSB. But AM 14 is not in place now, the action is in the rule-making phase, and out for public comments (due Oct 11 2013). And the catch cap action, in addition to being entirely dependent on NMFS approval of the authority under AM 14, awaits the start of NMFS rulemaking. The fate and success of the catch cap and increased observer coverage are both uncertain; rule-making is not finalized, the rule is opposed by commercial fishing entities, and the implementation remains in the future.

Thus, current management efforts and plans remain uncertain as to the likelihood of success. This uncertainty is set against the uncertainty of other management options, specifically that of using MSA to place RH/S under federal management by including these species as managed stocks in the Mackerel-Squid-Butterfish FMP. The uncertainty in the case of directly managing MSB fisheries as a component of RH/S restoration rests in the categories of management uncertainty and in whether reducing fishing mortality will result in increasing RH/S stocks.

Uncertainty exists in the efficacy of the set of actions found in both Amendments 14 and 15. This uncertainty is inherent in any set of measures to increase RH/S because the factors contributing to their decline are numerous and varied, and some are wholly unstudied or possibly unknown at present (i.e. global warming). In this case, with such a steep and obvious decline threatening their existence as a potentially fishable species in the future, as well as their importance to the trophic structure of other organisms now, complementary measures that target both state and federal jurisdictions are prudent. RH/S rely on, and are relied upon, in both jurisdictional areas throughout their life cycle; a concerted effort is necessary across these state and federal actions to stem the uncertainty that any measures will, in fact, increase RH/S. A wait-and-see attitude on Amendment 15 may further degrade the chance to increase RH/S before other factors decrease these species' ability to buffer themselves from complete collapse. With both state and federal actions in place, further data gathering and stock assessments can best clearly delineate which best management practices to continue and which are less effective. It is possible that these measures and amendments can be reversed and modified, but a complete reversal of the commercial and recreational extinction of these fish species is not.

The Council faces competing uncertainties: taking little action with uncertain prospects of greater positive impact VS taking more direct action with uncertainty of how effective the positive impacts will be.

Resource requirements in time and budget

Council staff worked with appropriate federal and partners in an FMAT to develop materials in preparation for AM 15, including a scoping document and subsequent decision documents. The stock assessments have been completed by the Commission, with input and data from the states, NMFS and USFWS. Thus, a data collection effort does not need to start at the beginning, but rather build on existing information.

The basic work to develop AM 15 has been completed and the final steps of drafting the DEIS, accompanying documents, and the FEIS remain. Staff time (but not necessarily additional financial resources) will be needed to complete the AM 15 process.

Once in place, MAFMC will need to assign staff as coordinator for RH/S, as noted above. Ideally, NEFMC and SAFMC may be sharing this responsibility, spreading out the duties and the budget impact in terms of staff time.

FMP status would add RH/S coordinators at the level of NMFS Northeast Regional Office (NERO) and the Councils (NEFMC and MAFMC). None of these has RH/S coordinators at present, leaving the analysis work as an ad hoc effort and taking a secondary status to FMP managed species for which the Councils and NERO have statutory obligations and requirements. The cost to Councils and NERO is staff time in each case.

There are several areas in which Council efforts involve either members or staff or both in activities not directly part of an FMP but that complement FMP actions and benefit the goals in the FMP. One area where coordination among various entities is exemplified is in the Ecosystems and Ocean Planning Committee, including EBFM and regional planning efforts.

Coordination with state programs to restore RH/S

The MAFMC has a long and successful record of coordinating with other management partners to achieve notable successes in restoring the species under Council jurisdiction. The coordination efforts with ASMFC at the state level and NEFMC at the federal level include the fisheries for surfclams; scallops; seabass, flounder and scup; bluefish and others. The most recent success in this regard is AM 16 for MSB in which under Mid Atlantic lead, the three east coast councils signed an agreement and will be implementing management programs, to secure the protection of deep sea corals at the shelf edge and in deep sea canyons.

MAFMC has the opportunity in the case of AM 15 to initiate a coast-wide, multi-agency management effort in the form of a cooperative effort with ASMFC, NEFMC and SAFMC to address coast-wide issues in the range of RH/S. All Atlantic coast states face this problem, as recognized by ASMFC and the solution needs to be coast-wide in near-shore as well as federal waters.

Summary

This report provides information and analysis concerning Amendment 15 (AM 15) to the Mackerel-Squid-Butterfish Fishery Management Plan, an amendment to provide federal management of river herrings and shads (RH/S) under MSA. This amendment considers including the four fish species (RH/S) as a group as managed stocks in the MSB Fishery Management Plan. RH/S stocks are severely depleted throughout their east coast range and ASMFC actions address fishing mortality in state waters but not federal waters/federal fisheries where fishing mortality continues. The MSA section 302(h)(1) directs the council to take action for each fishery under its authority that requires conservation and management. The action by MAFMC in amendment 14 may limit incidental and by-catch of RH/S, but that action is not completed, may not occur and remains uncertain in effectiveness.

The economic and ecosystem benefits of restored RH/S stocks include millions of dollars from fishery-related outcomes such as harvest and recreational activities. Ecological benefits are likely to include enhancing stocks of prey species and game fish, as well as numerous water-dependent species throughout the range of RH/S.

Management actions by the Pacific and North Pacific councils for more than a decade have included non-target stocks in their fisheries as FMP amendments for the purpose of restoring stocks. Indeed, the west coast councils have been successful in improving stocks of the managed non-target species.

On the east coast, uncertainty over precise causes for stock declines has not hampered management actions, with highly successful restoration efforts.

The MAFMC can work cooperatively with NEFMS, SAFMC, ASMFC and NMFS and the fishing communities in this management effort, as the Council has so successfully cooperated with their partners for many years on a range of actions.

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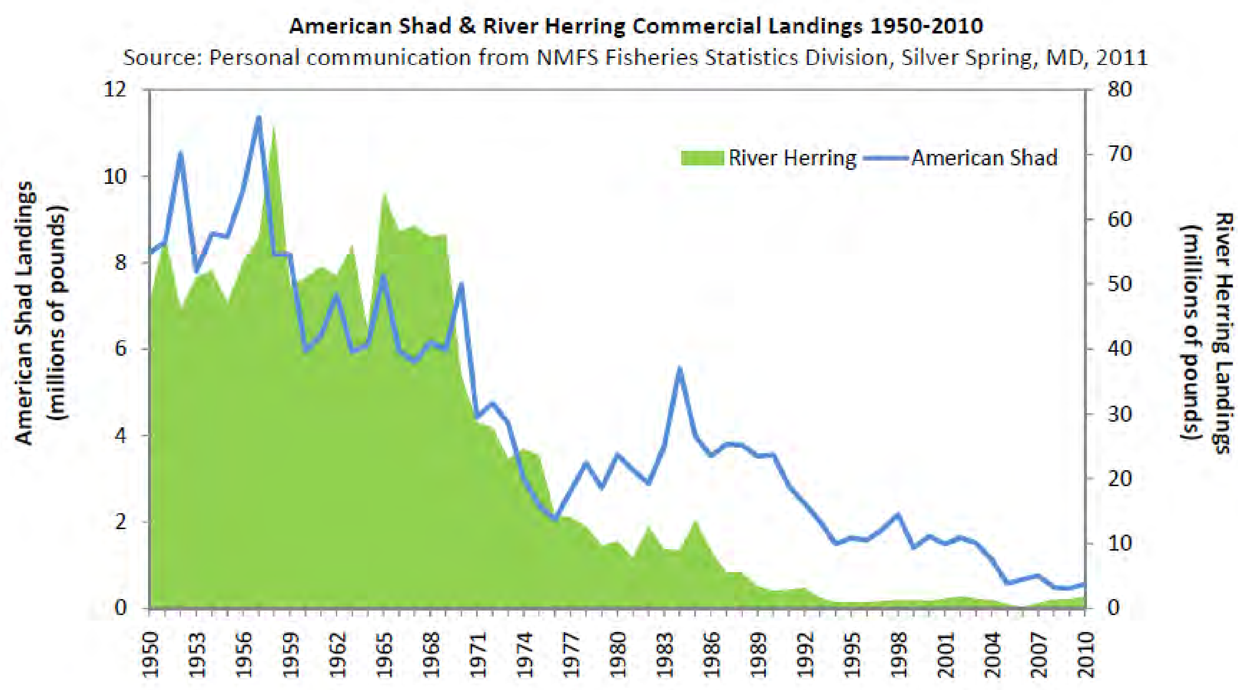
Overview of Stock Status
Shad & River Herring



Timeline of Management Actions: FMP ('85); Amendment 1 ('99); Addendum I ('00); Amendment 2 - River Herring ('09); Amendment 3 – American shad ('10)

Figure 1. American shad and river herring commercial landings, 1950-2010