Atlantic States Marine Fisheries Commission

Shad and River Herring Management Board

August 7, 2024
4:15 p.m. – 5:30 p.m.

Draft Agenda

The times listed are approximate; the order in which these items will be taken is subject to change; other items may be added as necessary.

1. Welcome/Call to Order (*L. Fegley*) 4:15 p.m.

2. Board Consent 4:15 p.m.
   - Approval of Agenda
   - Approval of Proceedings from October 2023

3. Public Comment 4:20 p.m.

4. Consider 2024 River Herring Benchmark Stock Assessment **Action** 4:30 p.m.
   - Presentation of Stock Assessment Report *(K. Drew; M. Conroy)*
   - Presentation of Peer Review Panel Report *(A. Jordaan)*
   - Consider acceptance of benchmark stock assessment and peer review report for management use
   - Consider management response, if necessary

5. Other Business/Adjourn 5:30 p.m.

The meeting will be held at The Westin Crystal City (1800 Richmond Highway, Arlington, VA; 703.486.1111) and via webinar; click here for details

MEETING OVERVIEW

Shad and River Herring Management Board Meeting
August 7, 2024
4:15 p.m. – 5:30 p.m.

Chair: Lynn Fegley (MD) Assumed Chairmanship: 2/23	Technical Committee Chair: Wes Eakin (NY)	Law Enforcement Committee Representative: Lt. Col. Jeffrey Sabo
Vice Chair: Phil Edwards (RI)	Advisory Panel Chair: Pam Lyons Gromen	Previous Board Meeting: October 16, 2023
Voting Members: ME, NH, MA, RI, CT, NY, NJ, PA, DE, MD, DC, PRFC, VA, NC, SC, GA, FL, NMFS, USFWS (19 votes)		

2. Board Consent

- Approval of Agenda
- Approval of Proceedings from October 2023

3. Public Comment – At the beginning of the meeting public comment will be taken on items not on the agenda. Individuals that wish to speak at this time must sign-in at the beginning of the meeting. For agenda items that have already gone out for public hearing and/or have had a public comment period that has closed, the Board Chair may determine that additional public comment will not provide additional information. In this circumstance the Chair will not allow additional public comment on an issue. For agenda items that the public has not had a chance to provide input, the Board Chair may allow limited opportunity for comment. The Board Chair has the discretion to limit the number of speakers and/or the length of each comment.

4. Consider 2024 River Herring Benchmark Stock Assessment (4:30-5:30 p.m.) Action
Background • The River Herring Benchmark Stock Assessment was initiated in April 2022. After delays in the proposed timeline, the scheduled completion date was moved to August 2024. • The final Assessment Workshop was held August 21-25, 2023. • The assessment evaluated the condition of Atlantic coast river herring stocks and habitat availability on a system-specific, regional, and coastwide metapopulation basis (**Briefing Materials)**. • The assessment was peer-reviewed by a panel of independent experts June 4-7, 2024. The Peer Review Report provides the panel's evaluation of the assessment findings (**Briefing Materials**).
Presentations • Overview of Benchmark Stock Assessment by K. Drew and Margaret Conroy • Presentation of Peer Review Report by A. Jordaan
Board actions for consideration at this meeting • Consider the stock assessment for management use • Consider management response to the assessment and peer review

5. Other Business/Adjourn

Shad and River Herring 2024 TC Tasks

Activity level: Medium

Committee Overlap Score: Medium (Multi-species committees for this Board)

Committee Task List
• Updates to state Shad SFMPs • Annual state compliance reports due July 1
TC Members: Wes Eakin (Chair, NY), Matthew Jargowsky (Vice-Chair, MD), Mike Brown (ME), Conor O'Donnell (NH), Brad Chase (MA), Patrick McGee (RI), Kevin Job (CT), Brian Neilan (NJ), Brian Niewinski (PA), Johnny Moore (DE), Ingrid Braun-Ricks (PRFC), Joseph Swann (DC), Patrick McGrath (VA), Holly White (NC), Jeremy McCargo (NC), Jim Page (GA), Reid Hyle (FL), Ken Sprankle (MA), Ruth Hass-Castro (NOAA), John Ellis (USFWS). Ted Castro-Santos (USGS), C. Michael Bailey (USFWS), Kyle Hoffman (SC), James Boyle (ASMFC), Katie Drew (ASMFC)

DRAFT PROCEEDINGS OF THE

ATLANTIC STATES MARINE FISHERIES COMMISSION

SHAD AND RIVER HERRING MANAGEMENT BOARD

Beaufort Hotel
Beaufort, North Carolina
Hybrid Meeting

October 16, 2023

These minutes are draft and subject to approval by the Shad and River Herring Management Board.
The Board will review the minutes during its next meeting.

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INDEX OF MOTIONS

1. **Approval of Agenda** by consent (Page 1).

2. **Approval of Proceedings of August 1, 2023** by consent (Page 1).

3. **Move to approve the Shad and River Herring Fishery Management Plan Review and state compliance reports, and de minimis requests for ME, NH, MA, and FL for American shad and NH, GA, and FL for river herring for the 2022 fishing year** (Page 3). Motion by Doug Grout; second by Spud Woodward. Motion approved by unanimous consent (Page 3).

4. **Move to adjourn** by consent (Page 3).

ATTENDANCE

Board Members

Pat Keliher, ME (AA)
Steve Strain, ME (GA)
Rep. Allison Hepler, ME (LA)
Renee Zobel, NH, proxy for C. Patterson (AA)
Doug Grout, NH (GA)
Dennis Abbott, NH, proxy for Sen. Watters (LA)
Melanie Griffin, MA, proxy for D. McKiernan (AA)
Raymond Kane, MA (GA)
Sarah Ferrara, MA, proxy for Rep. Peake (LA)
Conor McManus, RI, proxy for J. McNamee (AA)
David Borden, RI (GA)
Eric Reid, RI, proxy for Sen. Sosnowski (LA)
Justin Davis, CT (AA)
Bill Hyatt, CT (GA)
Craig Miner, CT, proxy for Rep. Gresko (LA)
Marty Gary, NY (AA)
Emerson Hasbrouck, NY (GA)
Joe Cimino, NJ (AA)
Jeff Kaelin, NJ (GA)
Allison Murphy, NOAA

(AA = Administrative Appointee; GA = Governor Appointee; LA = Legislative Appointee)

Ex-Officio Members

Delayne Brown, Law Enforcement Committee Rep.

Staff

Bob Beal
Toni Kerns
Tina Berger
Madeline Musante
Katie Drew
James Boyle
Caitlin Starks
Chelsea Tuohy
Tracey Bauer
Jeff Kipp
Jainita Patel
Kristen Anstead

Guests

Pat Augustine
Jason Avila
Alan Bianchi, NC DMF
Emily Bodell, NEFMC
Jason Boucher, NOAA
Colleen Bouffard, CT DEEP
Allen Burgenson, Lonza
Benson Chiles
Margaret Conroy, DE DNREC
Jamie Cournane, NEFMC
Caitlin Craig, NYS DEC
Renee St. Amand, CT DEEP
Kevin Sullivan, NH FGD
John Sweka, US FWS
Julie Evans
Emily Farr, Manomet
Maria Fenton
Tony Friedrich, ASGA
Marty Gary, NY (AA)
Pat Geer, VMRC
Allie Hayser, Manomet
Derrek Hughes, NYS DEC
Jon Hurdle, NJ Spotlight
Chip Lynch, NOAA
John Maniscalco, NYS DEC
Mike Thalhauser, Maine Center for Coastal Fisheries
Verewe Wang, ECU
Craig Weedon, MD DNR
Steve Meyers
Allison Murphy, NOAA
Josh Newhard, US FWS
Conor ODonnell, NH FGD
Jeffrey Pierce, Alewife Harvesters of Maine
Michael Pierdinock
Paul Risi
Jeffrey Sabo, PA FBC
Christopher Scott, NYS DEC
Melissa Smith, MA DMR
Chris Wright, NOAA
Darrell Young, Alewife Harvesters of Maine
Renee Zobel, NH FGD

The Shad and River Herring Management Board of the Atlantic States Marine Fisheries Commission convened in the Rachel Carson Ballroom via hybrid meeting, in-person and webinar; Monday, October 16, 2023, and was called to order at 4:50 p.m. by Chair Lynn Fegley.

CALL TO ORDER

CHAIR LYNN FEGLEY: It looks like we are in order. My name is Lynn Fegley; I'm the Administrative Commissioner for the state of Maryland, happy to serve as your Chair. I have had enough Swedish fish at this point to talk very fast. I think we're going to roll right through this. The first order, well, first let me just remind everybody that we have James Boyle here to my right, Dr. Katie Drew to my left, to help with today's presentations.

We have just one action item, which is FMP Review, so I'll be looking for a motion for that towards the end of the meeting.

APPROVAL OF AGENDA

CHAIR FEGLEY: The first order of business is Board consent on the agenda. Does anybody have any suggested changes or modifications to the agenda? Okay, seeing none; we'll consider that approved by consent.

APPROVAL OF PROCEEDINGS

CHAIR FEGLEY: You have the proceedings from the May, 2023 meeting in your materials. Are there any edits, modifications, changes? Okay, seeing none; I'll consider that approved by consent. Next on the agenda is Public Comment. I know we have in our materials one letter from a Jeffrey Pierce. I would encourage everybody to read that.

PUBLIC COMMENT

CHAIR FEGLEY: Is there any other public comment in the room? Okay, is there anybody online who would like to make public comment? All right, and again, I would just encourage everybody to read the letter from the Alewife Harvesters of Maine, there is some really interesting information in there.

PROGRESS UPDATE ON RIVER HERRING BENCHMARK STOCK ASSESSMENT

CHAIR FEGLEY: Moving on from that, we're going to move right over to, Katie Drew is going to give us a progress update on the river herring benchmark.

DR. KATIE DREW: If you recall from our August meeting, we were at the August Board meeting about to go into our August assessment workshop for the river herring assessment. After the conclusion of that workshop at the end of August, the SAS felt that we needed additional time to complete this assessment, that our original schedule was to have the assessment peer reviewed at the end of this year, and then presented to the Board in February.

But based on we were at the end of August, we felt that was not a reasonable timeline to produce the best product. We are pushing the assessment deadline back one meeting cycle, so that now the assessment will be peer reviewed in February or March, so that it can be presented to the Board at the May meeting, instead of at the February meeting of next year. That's the major progress update for that. We continue to work forward on that, and that seems like I think right now we're going to make that deadline, but I'm happy to answer any questions about that schedule change, or anything else about the assessment if you still have questions.

CHAIR FEGLEY: Are there any questions for Dr. Drew on the assessment timeline shift? Okay, nice work. With that, we're going to move on.

CONSIDER FISHERY MANAGEMENT PLAN REVIEW AND STATE COMPLIANCE FOR THE 2022 FISHING YEAR

CHAIR FEGLEY: James is going to give us the FMP Review and State Compliance, and again, I'll be looking for a motion at the end of this.

MR. JAMES BOYLE IV: I'm going to try to go through this relatively quickly, I know the time crunch. Here is an outline for the presentation. I'm going to start with a short reminder of historical landings over time, and then cover the 2022 fishing year specifically. I'll move on to some of the monitoring efforts in the Compliance Reports, including fish passage, stocking efforts and sturgeon bycatch interactions.

Finally, I'll end with the de minimis requests and recommendations from the Plan Review Team. First a very quick reminder of the historical context. This figure shows the trajectories of commercial landings for river herring and American shad since 1950. Starting in the 1970s, river herring landings fell drastically, and then steadily decreased over time.

For shad there has also been a steady decrease in landings over time, which is of course due in part to the moratorium implemented through Amendments 2 and 3. For this next slide we're just going to zoom in since the 1990s for a better view. If you look at the landings since 1990, there is more variations from river herring, and for shad you can see a general downward trend in landings since the '90s.

I will note that the river herring number needs to be updated, which I'll get into a little bit shortly. Moving on to 2022. Again, the river herring number needs to be corrected, but this table shows state landings and coastwide totals for shad and river herring, excluding confidential data. The river herring coastwide commercial landings, including bycatch, totaled about 2.8 million pounds, so we'll correct that.

The Maine number is about 2.6 million pounds that should be in that table, so that updates the numbers accordingly. The nonconfidential bycatch data values increased by 761 percent from 2021 to 3,865 pounds, although bearing in mind as we talked about the last FMP review, that only 451 pounds were reported last year.

Additionally, Massachusetts reported 27,558 pounds of combined shad and river herring bycatch data from NEFOP. For American shad, the total 2022 commercial landings, directed and bycatch included, reported in compliance reports was 110,027 pounds, which is a 44 percent decrease from landings of 2021.

Bycatch landings of shad also decreased 75 percent, and represent 8 percent of total landings. Reported hickory shad commercial landings were 98,962 pounds, which is a 0.5 percent decrease from 2021. Although bycatch landings increased by 40 percent, but they still represent only 3 percent of total landings. As part of the requirements in Amendments 2 and 3 for river herring and shad, respectively, passage counts are required on select rivers in Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, Pennsylvania, Maryland and South Carolina, 4.55 million river herring were counted, which represents a 2.4 percent increase compared to 2021, and 483,587 shad is a 27 percent increase compared to 2021. Though I will note that this is still excluding Pennsylvania's passage numbers, as I'll get into shortly.

In 2022, 14.64 million hatchery reared American shad fry were stocked in the Pawcatuck, Nanticoke stock tank, for Casco, Potomac, Edisto, and the Santee Rivers, which is a 10 percent decrease from 2021. Maine also continues to participate in trap and transfer stocking of adult pre-spawning alewife of wild origin on the Androscoggin River, although it's not included in the table in the document.

For sturgeon interactions in 2022, there were 49 reported interactions with three fatalities. However, New Jersey gillnetters report the weight of the sturgeon rather than the number of individuals, so they reported 653 pounds. Of those 49 interactions, 36 were identified as Atlantic sturgeon, and 13 as short nosed.

Rhode Island also reports NOAA NEFOP data and at-sea monitoring data, which is available after the compliance report deadline, so their data lagged by one year. In this compliance report for the 2022 fishing year, they reported 23 actions in 2021, and we will see the 2022 interactions in next year's compliance report in July.

For the upcoming fishing year, Maine, New Hampshire, Massachusetts and Florida have requested de minimis status to their American shad fisheries, and New Hampshire, Georgia and Florida request de minimis status for river herring. They all continue to meet the requirements and qualify for de minimis status, based on their commercial landings.

In evaluating the state compliance reports, the PRT noted some inconsistencies with the requirements in Amendments 2 and 3. First, the PRT did not receive a compliance report from Pennsylvania. Also, similarly last year, there are just a few longstanding issues that are related to funding, staffing choices primarily.

If a state either cannot complete a survey or can take samples and not process them, for example, and there were some other small inconsistencies within compliance report template, such as not including a copy of the state's fishing regulations or a link to the regulations, or a sex on hickory shad, which the PRT requests, even if that section is not applicable to that particular state.

With those minor issues, the PRT recommended approval for the compliance report for 2022. Also, in this year's compliance reports, the PRT requested more detailed information on the sources of bycatch data, in response to the last FMP review. The results showed quite a wide variety of sources, included some states reporting that they had no information available. Therefore, the PRT is recommending the Board consider the inconsistency of bycatch reporting sources coastwide, and was impacted on evaluating bycatch annually.

With that information, the action before the Board is to consider approval of the 2022 shad and river herring FMP Review, State Compliance Reports and de minimis status for Maine, New Hampshire, Massachusetts, Georgia and Florida. With that I am happy to take any questions.

CHAIR FEGLEY: Excellent, thank you, James. Any questions on James' presentation? Questions from the Board. Okay, seeing none; does anybody have a motion around this? Anybody? Doug Grout.

MR. DOUGLAS E. GROUT: I **move to approve the shad and river herring Fishery Management Plan Review and State Compliance report for 2022,** and if you'll put up the list of states that requested de minimis, I'll be glad to list those.

CHAIR FEGLEY: I was waiting to see if you were going to be able to remember all that. While they're getting the motion up, is there a second? All right, Spud, Spud Woodward, thank you very much. Okay, we'll wait for the motion to come up.

MR. GROUT: **And de minimis requests for Maine, New Hampshire, Massachusetts, and Florida for shad and New Hampshire, Georgia and Florida for river herring for the 2022 fishing year**.

CHAIR FEGLEY: Okay, I think that looks about right. We have a motion on the Board, is there any discussion about this? Okay, I'm going to read it into the record really quick. **Move to approve the shad and river herring Fishery Management Plan Review and State Compliance Reports and De Minimis requests from Maine, New Hampshire, Massachusetts and Florida for American shad, and New Hampshire, Georgia and Florida for river herring for the 2022 fishing year**.

Motion by Mr. Grout, second by Mr. Woodward. **Is there any objection to this motion? All right, seeing none; this motion is approved by consent, thank you very much.**

ADJOURNMENT

CHAIR FEGLEY: With that we're going to go right on to Other Business. Does anybody have any other business to bring before the Board? Okay, seeing none; unless there is an objection, I would move to adjourn this meeting. It's been a long day, thank you, everyone.

(Whereupon the meeting adjourned at 5:01 p.m. on October 16, 2023)

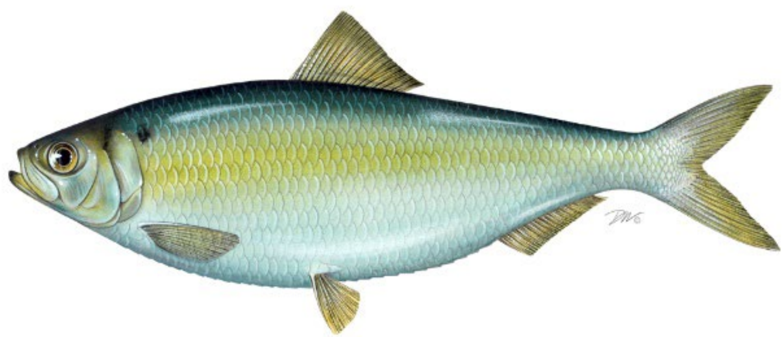
Following is the River Herring Benchmark Stock Assessment Peer Review Report and the Terms of Reference Section from the River Herring Benchmark Stock Assessment Report. Due to very large file sizes, copies of the full Benchmark Stock Assessment and its appendices can be found at:

https://asmfc.sharefile.com/public/share/web-sca695e61b99f4f5a95abd08d87890fa2

DRAFT FOR MANAGEMENT BOARD REVIEW

Atlantic States Marine Fisheries Commission

River Herring Benchmark Stock Assessment Peer Review



June 2024

Sustainable and Cooperative Management of Atlantic Coastal Fisheries

DRAFT FOR MANAGEMENT BOARD REVIEW

Atlantic States Marine Fisheries Commission

River Herring Benchmark Stock Assessment Peer Review

Conducted on
June 4-7, 2024
Arlington, Virginia

Prepared by the
ASMFC River Herring Stock Assessment Review Panel

Dr. Adrian Jordaan (Chair), University of Massachusetts-Amherst
Dr. Heather Bowlby, Fisheries and Ocean Canada, Dartmouth, Nova Scotia
Dr. John Wiedenmann, Rutgers University, New Brunswick, New Jersey

ACKNOWLEDGEMENTS

The Review Panel gratefully recognized the work conducted by the River Herring Stock Assessment Subcommittee and Technical Committee in preparing the 2024 Benchmark Assessment. The Panel also appreciated the professional, open, and constructive spirit of discussion during the review workshop. The Review Panel thanks the Science staff of the Atlantic States Marine Fisheries Commission for organizing the workshop, and providing review materials in a timely fashion.

EXECUTIVE SUMMARY

River herring stocks remain depleted from a coastwide perspective, with a decade or more of effort in restoration and moratoria not leading to improved status. Trend analysis demonstrated there has been little improvement in populations; most trajectories were flat although high variability resulted in low power to detect trends. No official statement was made regarding current rates of mortality. The assessment employed a stochastic Spawner Per Recruit (SPR) modeling framework to estimate the total mortality (Z) that would reduce the population spawning biomass to 40% of the unfished level (Z40%). Based on this reference point, the terminal year mortality rate had a 50% chance of being above the reference point for 50% of blueback populations and 65% of alewife populations. Mortality rates were high across a number of harvested runs. In addition, a forward projecting statistical catch-at-age model for Monument River (MA) alewife that predicts numbers at age by sex and maturity stage from total in-river catches, escapement counts, and escapement age composition, suggested that at-sea mortality was high. With incidental catch now representing the largest source of fisheries mortality on the population, the high mortality rates create a need to improve the monitoring and modeling of bycatch and improve the efficacy of the current catch caps. The assessment explored data-based catch-cap setting tools and the panel encourages continued effort to improve the monitoring and modeling of bycatch towards improving outcomes.

Data standardization and survey methodology, as well as species identification, and bycatch accounting remain issues and are significant impediments to producing a more data-rich assessment. The panel strongly supports expanded monitoring and effort to better track sources of mortality to region, if not river, specificity.

Overall, the review panel supports the current methodology, analyses, and interpretation of results, and recommends the assessment as the most current and best available science.

TERMS OF REFERENCE

1. Evaluate the choice of stock structure

River herring challenge many of the conventional perspectives on stock structure, since there is weak river-to-river structure based on genetic studies, state-level rule making and regional oversight through the ASMFC, while most management actions are focused at the individual river level. The panel had questions about the use of the genetic data, based on limited years and many systems located close to the same river mouth, especially in southern data. Ultimately, the structure based on genetically-defined stock regions was helpful for organizing the assessment report, but each river functionally is its own stock.

The genetic analysis suffers from a couple of issues with respect to being used to define stock management units. First, the fish collections were composed of 137 collections taken from 99 locations (n=5678). Thus, temporal replicates were available for 28 locations. While temporal stability was present for most rivers capable of being evaluated, there were generally not multi-annual samples for most sites. Still, the panel is satisfied with the level of sampling for the conclusion of genetic regional groupings. Additionally, stocking influence and lack of complete coverage of all river herring populations means that precise geographic partitioning is difficult and confounded by human interventions.

Threats to river herring and restoration of populations are river specific in nature, and as a result the genetic groupings are practical for organizing regional runs, but are not an effective scale for management actions. How to lump rivers will remain a challenge until a more robust approach for regional groupings based on genetics is completed, with expanded sampling and repeated sampling of sites. The panel had discussions around the likelihood of straying within closed bays such as Albemarle Sound, Chesapeake Bay and other particularly southern sites that all grouped together genetically. Straying remains a question in the population structuring or river herring, and has important consequences for the ability of the species to respond with potential range shifts due to climate change (Poulet et al. 2023).

It will also be important to account for the influence of recovery actions on underlying stock structure for river herring, if regional groupings continue to be based on genetic analyses. The SAS was not able to quantify transfers among rivers or regions from historical stocking as detailed information on supplementation programs was not available for the assessment. Although trap and transfer as well as hatchery programs seem to be declining due to smaller run sizes in donor rivers, these types of restoration activities can affect the strength of genetic differentiation among rivers, both by increasing straying rates and through hybridization (Quinn 1993; Koch and Narum 2021). It will be important to have more detailed accounting on donor and recipient rivers to track genetic effects of any future supplementation to ensure regional distinctions and population structure among rivers are maintained.

Thus, we support use of regional groupings based on genetic clusters but believe individual or perhaps adjacent rivers are the primary stock unit. This is consistent with how the status update tables summarize river specific trends in the assessment report.

2. **Evaluate the thoroughness of data collection and the presentation and treatment of fishery-dependent and fishery-independent data in the assessment.**
    a. Presentation of data source variance (e.g., standard errors).
    b. Justification for inclusion or exclusion of available data sources.
    c. Consideration of data strengths and weaknesses (e.g., temporal and spatial scale, gear selectivity, aging accuracy, sample size).
    d. Calculation and/or standardization of abundance indices.
    e. Estimation of bycatch.

General Statements

There were panel questions about the reporting of coefficients of variation (CVs) from the different indices, and whether they could be compared between GLMs and GAM model-based standardization or nominal indices, such as the stratified arithmetic and delta mean. Indices used for trend analysis were chosen using consistent criteria, with each survey needing consistent data collection methods over the time series, or a way to calibrate between gear, vessel, or other changes, 10 consecutive years of data, and 10% of tows/hauls/sampling events were positive for alewife or blueback herring. Overall, the SAS did well to characterize uncertainty from so many different indices with different underlying methodologies and data structures. More clarity on which standardization approach was used for each data series would be helpful. The power analysis was perhaps more informative than the prevalence-based approach. For example, zeros were common in daytime sets of a purse seine and resulted in higher variability for daytime compared to nighttime density estimates (Devine et al. 2018).

Otherwise, there is also a question of the appropriateness of the Z error calculation with both over and underdispersion found in the data. Unfortunately, species identification issues remain a problem in surveys and the various indices, while useful, have low power to detect trends. Thus, it was not surprising that trends were not evident in many datasets. Sample sizes by age were not initially provided and the panel was concerned there were likely small numbers of fish age 5 and greater for estimating Z. Small differences in a low sample size for 6- and 7-year olds would introduce substantial variability. Sample sizes were provided during the peer review workshop and should be made available for future assessments. The detailed information supported concerns about low sample sizes in select systems at the annual scale.

Gear selectivity has not been considered, and may be important particularly in the Northeast Fishery Observer Program (NEFOP) data. Because of the deep body of river herring, they are likely retained at different sizes than Atlantic herring. Understanding selectivity would provide improved understanding of survey indices and observer data from otter trawl and midwater trawl fisheries. The panel had questions about whether ratio-based expansions to the fleet would be appropriate as bycatch estimators for pelagic schooling fish with strong seasonal patterns in availability (see more detail below).

The panel feels the SAS did as good a job as possible in accumulating all the data on river herring from both fisheries dependent and independent sources. Significant data limitations remain an issue for these stocks, particularly with the lack of standardized methods for ageing and abundance indices. There are essentially only a handful of river herring focused surveys. Species identification in reported landings, and in most historical data sources, as well as current harvested runs in Maine, remains problematic for allocating catch to each of the two species. The lack of genetic assignments of bycatch over time is also an issue with current discards.

Fishery-dependent Data

Commercial Landings

Commercial landings data for years prior to 1950 came from the US Fish Commission reports, and for 1950-2022 came from the Atlantic Coastal Cooperative Statistics Program (ACCSP). States had a variety of reporting strategies associated with river herring commercial fisheries that were initiated in different years. It was not always clear whether all data were from ACCSP, or whether they were maintained independently. The majority of States have enacted moratoria on harvest, except Maine, New York (Hudson River only) and South Carolina.

Recreational fisheries data are collected through surveys, online and intercept, through the Marine Recreational Information Program (MRIP). As a result, river and freshwater recreational catch is unmonitored, including during spawning when use of river herring as bait is most likely. While recreational harvest needs better accounting, it is not likely to be at an equivalent scale relative to marine discards or the limited directed fisheries. Riverine monitoring should be the focus of any future recreational harvest research.

Port-side sampling

Probably the most important aspect of incidental catch is that it has become the highest individual source of fishing mortality on river herring. Thus, understanding total mortality into the future will be contingent on better sampling of the fisheries with incidental bycatch of river herring. A short-term multi-year study from Massachusetts is mentioned here as recognition that, since the primary pelagic fisheries that catch river herring are full retention fisheries, there would be great value in maintaining some level of monitoring that can identify fish to species level. Genetic assignment would be an extremely valuable addition to port sampling to understand the impacts of bycatch on the regional stock groupings.

Incidental catch

Incidental catch is collected as part of the Northeast Fishery Observer Program, although sampling effort is mostly directed to the northeast multispecies groundfish complex. The lack of spatial coverage in the midwater trawl fishery, and pelagic fisheries in general, as well the resulting estimation method for bycatch (see below) were identified by the review panel and in the public comment period as a source of uncertainty. As the northeast multispecies groundfish fishery has high levels of observer coverage, more uncertainty is found in the midwater trawl pelagic fisheries. It is important to note that bottom trawl catch was a substantial source of incidental catch over the time series, with large catches in some years (Fig. 13-Fig. 14).

The SAS quantified incidental catches (retained and discarded) of alewife and blueback herring from fleets sampled by the Northeast Fishery Observer Program, considering numerous gear types and multiple mesh sizes for trawls and gillnets. There was a recent switch in data systems, with information coming from GARFO with bycatch estimated through SBRM from 1989-2019 and then using CAMS in 2020-2022. The SAS went to considerable effort to standardize the fleet definitions among the two data sources to ensure annual values were comparable. Bycatch from each fleet was estimated using the combined ratio method of Wigley et al. (2007), stratified by region, year, quarter, gear group, and mesh size, while CAMS uses the separate ratio method. In general, the ratio represented the total catch of alewife or blueback herring divided by the kept weight of all species (t/k ratio), where data were imputed from the next closest time period for each gear-region combination if there were no observed catches of river herring in a specific quarter. Total landed weight from dealer slips was used as the raising factor to expand the t/k ratios to total incidental catch, except for mid-water trawl, where the captain's hail estimate from VTR data was used. Compared to landings and recreational catches, bycatch makes up a substantial proportion of total fisheries removals in recent years.

The ratio method has a long history of application in stock assessments, so the SAS did not evaluate the appropriateness of the underlying assumptions for river herring. Specifically, whether alewife or blueback herring catches were proportional and linearly related to total kept catch for each fleet and strata (region, year, quarter, gear group, mesh size). The appendices showing validation plots from various bycatch estimators from Wigley et al. (2006) were provided to the review panel to demonstrate that the assumption of linearity tended to hold. However, the predictive ability of catch ratios for river herring was not assessed.

Since the development of the combined ratio method, there has been substantial progress applying spatial modeling or machine learning tools to observer data to estimate bycatch (Stock et al., 2019, 2020; Yan et al., 2022). Unlike ratio estimators, the more complex methods can account for non-linearity, excess zeros, as well as any underlying correlation structure in catches arising from environmental, ecological, and biological factors. Different bycatch estimators could be compared relative to predictive ability, where the preferred approach would have the lowest root-mean-square-error in cross-validation (e.g., Stock et al. 2020). For river herring, appropriate implementation of the bycatch cap as well as quantifying total fishing mortality critically depend on the precision of bycatch estimates. Therefore, we recommend the ratio estimator be validated with respect to river herring in the shorter term, and further investigation of alternative bycatch estimation approaches in the longer term. Uncertainty in the impacts of bycatch on river herring stocks remains a key issue in the assessment. Given its importance for developing catch caps, the bycatch estimation techniques should receive additional attention and review.

Fishery-independent Data

Run-counts are conducted in numerous states using either electronic fish counters or at fishways. In all but one instance (Monument River, MA), the run-count data do not represent escapement estimates given removals upstream of the enumeration site. Associated biological data collection is required to separate counts to species as well as to monitor length and weight, to take scale or otolith samples for ageing and to characterize maturity and previous spawning history from scales. The review panel appreciated the diversity of sampling programs and urged the SAS to keep working towards better standardization of sampling methods among agencies. In the current assessment, it was challenging to understand precisely how observations were scaled up to daily abundance estimates and how biological sampling was distributed over the run (e.g., proportional to daily counts?). The review panel could not comment on whether sampling was likely to be representative of run characteristics, which influences all subsequent analyses in the assessment. Continued emphasis on biological sampling in association with run counts should be prioritized, and initiating biological data collection on rivers with only counts would be beneficial to future assessment efforts.

Fishery-independent Surveys

The assessment team identified a wide variety of surveys that intercepted one or more life stages of river herring. These included ocean, estuarine, and in-river surveys using trawls, seines, and trapnets. The SAS considered overall interception rates for alewife and blueback herring when including specific surveys in the assessment, discarding ones with extremely low catches of river herring, and/or retaining a subset of the available data (e.g., strata with > 10% positive tows).

Unfortunately, the majority of fishery-independent surveys represented sampling programs that were not specifically designed for river herring. Thus, there are very likely to be undetected issues in the sampling design that do not meet analytical assumptions when calculating abundance indices. For example, the stratification scheme used in the larger oceanic surveys may not result in lower in-stratum vs. among stratum variance (Smith and Gavaris, 1993). In other instances, repeated observations from the same site were treated as independent rather than autocorrelated samples. As with the run count data, whether or not sampling was truly representative and random was not possible to determine from the information presented in the assessment, where the temporal structure of river herring runs (Gibson et al. 2016) makes true random sampling very challenging. The panel considered it likely that undetected autocorrelation, sampling biases, and undetected heterogeneity in river herring observations were prevalent in the data used to calculate abundance indices.

The SAS compared multiple analytical approaches for developing fishery-independent indices from the available data, including design-based and model-based estimators. A key criterion used to select among options was the relative magnitude of the series CV, with approaches resulting in lower CVs considered optimal. However, we consider it inappropriate in this application to base model selection on a comparison of CVs. Design-based approaches rely on a specific sampling scheme to select units of observation from the underlying population. Their implementation does not require inherent knowledge of the factors causing variability in the population (Cotter and Pilling, 2007). Model-based estimators do not make assumptions about the sampling process generating the data, but inference relies on identifying and incorporating all relevant variables that describe the population response. Models thus seek to balance an explicit trade-off between capturing the maximum amount of variability, while minimizing model complexity (i.e., the bias-variance trade-off; Dumelle et al. 2022).

In fisheries applications such as this one, knowledge and availability of important explanatory variables may be limited, and practical constraints will exert influence over any sampling design. Because the derivation of variance metrics does not encompass statistical prediction uncertainties from model mis-specifications (Hordyk et al., 2019), they are not comparable among different analytical approaches. In other words, we do not know how strongly specific assumptions are violated in the calculation of each fishery-independent index, so it becomes inappropriate to use the relative magnitude of the CV for model selection. Design-based estimators typically have lower variance as compared to model-based, which was confirmed with the SAS and demonstrated by the relative frequency that design-based indices were selected for inclusion in the assessment report.

We recommend that the magnitude of the CV should not be used for selection when both design-based and model-based approaches are compared. Instead, the SAS should attempt to evaluate the characteristics of the data arising from a specific sampling scheme to determine if design-based estimators are appropriate. Alternatively, they should consider the availability of appropriate covariates if pursuing model-based approaches. As it stands, the report inadvertently suggests that specific indices are much less variable than others, even though that impression directly depends on which analytical approach was selected.

Standardizing Techniques

There remain a number of areas in the assessment where methods lack standard protocols across the range that make comparisons difficult. There were two specific issues regarding standardized techniques. The first is species identification. A number of river herring runs still need better species assignment. The panel was concerned over the lack of individual species monitoring. We suggested more biological sampling or the use of scales for ID of species, for proper accounting as part of any sustainable harvest plan, and for State monitoring efforts. Scale collections from runs were not associated with a specific protocol. There was concern across all sites that improper sampling of the run, for example missing the first fish or few samples from mid-run, could result in a bias to smaller and younger individuals. Few details were available for the sample distribution over the spawning run.

The report states “Although used extensively, these protocols have not been validated with known-age river herring. A 2014 aging workshop for river herring found CVs greater than 5% across labs, and systematic bias across readings from paired scales and otoliths.” This admission of issues with diverse ageing processes taken in every state, and the lack of agreement in ages, is of concern to the panel. It was not clear how consistent the agers were, even for each dataset.

3. **Evaluate the methods and models used to estimate population parameters (e.g., Z, biomass, abundance), biological reference points, and bycatch caps/limits, including but not limited to:**
    a. Evaluate the choice and justification of the preferred model(s). Was the most appropriate model (or model averaging approach) chosen given available data and life history of the species?
    b. If multiple models were considered, evaluate the analysts' explanation of differences in results.
    c. Evaluate model parameterization and specification (e.g., choice of CVs, effective sample sizes, likelihood weighting schemes, calculation/specification of M, stock-recruitment relationship, choice of time-varying parameters, plus group treatment).
    d. Evaluate the diagnostic analyses performed, including but not limited to:
        - Sensitivity analyses to determine model stability and potential consequences of major model assumptions.
    e. Evaluate the methods used to characterize uncertainty in estimated parameters. Ensure the implications of uncertainty in technical conclusions are clearly stated.

The SAS conducted a range of analyses to evaluate population trends and statuses. Estimation of total mortality (Z) reference points from SPR analysis (see also TOR 5) by stock region required estimates of length-, weight-, maturity-, natural mortality-, and selectivity-at-age. The SAS also conducted trend analysis on a variety of estimates, including survey CPUE and run sizes, mean length, and mean length-at-age at the river level. Trends were evaluated using two methods: the non-parametric Mann-Kendall test for monotonic trends, and auto-regressive, integrated moving average (ARIMA) models. Mann-Kendall tests were applied for the whole time series, and since 2009 or later if the time series started after 2009. ARIMA models were also applied to the catch per unit effort (CPUE) and run size estimates using the entire time series. Previously-developed statistical catch at age assessment models were updated for three rivers.

Analyses for the Estimation of Total Mortality Reference Points

Growth

The SAS developed a hierarchical Bayesian von-Bertalanffy growth model (VBGF) to estimate length-at-age at different spatial scales, including coastwide, stock region, and individual rivers, accounting for the impacts of aging method (scales or otoliths) and sex. Uncertainty in parameter estimates were derived from the posterior distributions for each parameter.

Results from the analysis indicated females were consistently larger than males at a given age, and that scales resulted in a lower maximum size (L_∞) compared to otoliths. While there were differences across rivers in growth estimates, there were no consistent patterns across rivers spatially.

The panel noted this was a thorough and well-done modeling effort, but suggested future exploration of changes in growth over time was warranted. Due to the current runtime of the model, the Panel recommended preliminary explorations that looked at time blocks as opposed to years, and estimating parameters initially at broader spatial scales (coastwide or stock region) to see if there is a temporal influence. It was noted that priors were based on a subset of the data, in order to improve model runtime. Specifically, in the assessment report (page 112) it reads "variances for all hyper-parameters were specified using half student-t priors with 3 degrees of freedom, a mean of zero, and a scale parameter (v) derived from the data for each species." The Panel questioned this approach, and worried that differences among rivers were largely an artifact of variability arising from low river-specific sample size and the effect of the assumed priors, rather than capturing real life history differences among populations. The Panel feels discussion of the potential impacts of the approach versus other priors is warranted. Sensitivity analyses could be conducted to discern the impact of this assumption.

Natural Mortality (M)

Estimates of weight-at-age were used to estimate M-at-age using the Lorenzen (1996) method. The panel noted Lorenzen was a widely-used and reasonable approach to estimate M. Uncertainty in M was based on uncertainty in weight-at-age, as well as the uncertainty in the parameters relating weight- and M-at-age estimated by Lorenzen (1996). Age-based estimators of M were also discussed by the panel. However, reliance on a maximum age estimate may be problematic based on the sampling design, the portion of the run sampled, and the magnitude of uncertainty in age assignments. The panel felt overall this was a useful approach to calculate M with uncertainty. However, the panel also noted the details were limited in the assessment report on the estimation of the length-weight relationship and uncertainty in the parameters.

Maturity

Proportion mature-at-age was estimated following the approach of Maki et al. (2001) that is based on spawning marks in scales. The approach requires assumptions about ages of full maturity and immaturity, and the SAS assumed all fish younger than 3 were immature, and all fish older than 5 were mature. Thus, the proportion mature at ages 3-5 was estimated for each species by sex at the area grouping level. The SAS noted the method assumes equal survival between mature and immature fish. However, the assumption is likely violated given the different sources of mortality faced by mature fish that return to freshwater to spawn. Uncertainty in maturity ogives by region were derived by bootstrapping of the Maki et al. (2001) approach, which produced standard errors for the proportion mature for ages 3-5. Overall, the panel felt this was a suitable approach for deriving sexual maturity ogives for alewife and blueback herring.

Selectivity

Estimation of selectivity-at-age by region was not possible at the river or stock region level due to limited information on in-river removals, as well as uncertainties in how the coastwide catch is distributed across individual stocks and ages within stock. As a result, selectivity-at-age was derived from the maturity-at-age estimates. The SAS assumed fully mature fish were fully selected in the fishery, and partially mature ages (3-5) had a selectivity proportion that was ≥ the maturity proportion for a given age. The SAS generated random selectivities by first drawing random maturities at age, then adding a uniform random variable to this proportion that was bounded to keep selectivity between the random maturity proportion and 1 for a given age. Then, they fit a logistic curve to approximate selectivity, and associated variability, for immature fish. While unconventional, the panel felt this was a reasonable attempt to characterize mortality for immature fish.

Z SPR-based Reference Points

The SAS developed stochastic SPR models to estimate the total mortality (Z) that would reduce the population spawning biomass to 40% of the unfished level (Z40%). The SAS discussed the possibility of other percentages, and based their selection of 40% on previous studies evaluating the question in a simulation framework. For each species and area grouping, 5,000 sets of parameters were drawn for M-, maturity-, selectivity-, and weight-at-age, and Z40% was calculated for each set. The parameter draws were independent and did not account for potential covariation among parameters. The panel noted that accounting for covariation might reduce the extreme right-skew in the distribution of the reference points and give a more representative estimate for the upper confidence interval. Parameter draws were based on joint distributions from individual rivers within the regional groupings, which resulted in some unusual distributions for some inputs (e.g., bimodal L_∞ for an area), and also provided even weight to rivers within the regional groupings. Although the panel had concerns about these issues, overall they concluded it was a reasonable approach to calculate Z reference points with uncertainty.

Z Estimates

The SAS calculated total mortality (Z) over time across rivers with sufficient age information for comparison with the Z40% reference points. They explored using the Chapman Robson method for estimating Z, but ultimately used a Poisson GLM model based on the analysis of Nelson (2019) who showed it was one of the least biased methods under multi-stage cluster sampling. They assumed the first age at full selection was five, corresponding to the age of full maturity, and included rivers that had at least 3 ages with a minimum of 30 fish total. Uncertainty in Z estimates were based on the standard error estimated from the Poisson model.

The panel felt this was a useful approach overall, but there were some concerns identified. First, the Poisson model included a correction for overdispersion that occasionally resulted in infinite standard errors, when data were actually underdispersed rather than overdispersed. The SAS attempted to address the issue and ultimately utilized an approach that ignored the correction factor when underdispersion occurred. The net result of the change was that standard errors were lower for both alewife and blueback, on average. The panel also noted the method of using catch-at-age in a given year is sensitive to cohort effects, which could result in estimates of Z biased either high or low. Also, due to run sampling timing, later sampling of younger spawners could produce Z estimates that were positively biased. The panel suggested exploration of the Sinclair (2001) method, to estimate Z across cohorts by aggregating data across three to five years and calculating a common slope and different intercepts for each cohort. Being able to use all of the age data rather than having to exclude information below the age of full selectivity could also be beneficial, particularly because sample sizes were low in some rivers. This was particularly important in the terminal year where small changes in numbers would have greater influence. The GLMM method developed by Billard (2020) that fits a catch curve using the number of previous spawnings, rather than age class, as the predictor variable in the regressions, and factoring the data by age at maturity. Applicability of the method would require non-negligible numbers of fish spawning three or four times to reliably fit the curve, similar to how the original catch curve method used at least three fully-selected age classes.

Last, by using data based on age 5+ fish, the analysis becomes restricted to only fully mature fish when natural mortality is expected to be at its lowest (Fig. 91-98). Mortality during younger age classes that contributed most to the observed run count is not able to be estimated, as the proportion of the adult spawning population is composed mostly of first-time spawners (Fig. 113-115, Fig. 132, Fig. 144, Fig. 174, Fig. 178, Fig. 191, Fig. 197, Fig. 215). Thus, the mortality rate represents only the oldest ages, and not the peak abundance exposed to bycatch.

Trend Analyses

The SAS conducted trend analyses on different sources of information using the Mann-Kendall non-parametric test for monotonic trends, and the auto-regressive integrated moving average (ARIMA) model. Both methods were applied to indices of abundance from surveys and run count data, and the Mann-Kendall method was also applied to mean length and length-at-age trends, and proportion of repeat spawners. For a given data set the Mann-Kendall test was applied for the full time series, and from 2009 onwards, to look at overall versus recent trends. Uncertainty was incorporated in the ARIMA model via bootstrapping to calculate the percentage of times the terminal year smoothed value was above the 2009 value, as well as the 25th percentile for the entire time period (reference points are discussed in more detail in ToR 5). Overall, the Panel felt the Mann Kendall and ARIMA methods were suitable for looking at trends over time.

Index Standardization

Survey indices-of-abundance were included in the trend analysis for surveys with consistent methodology over time, at least 10 years of consecutive data, and ≥ 10% positive tows for river herring in suitable strata, months, and stations. For stratified random design surveys, the stratified arithmetic mean was calculated for each year. For other surveys, the SAS explored the use of GLMs and GAMs with different covariates, as well as the delta and geometric mean. The SAS selected the delta mean over the geometric mean due to lower bootstrapped means overall, and only considered the model-based estimates if they reduced the interannual variability in the estimates. The Panel had some concerns about comparing CVs as a model selection tool, detailed under TOR 2.

Correlation Analysis

With indices of abundance, the SAS conducted pairwise Spearman's correlations by species and rivers within the regional grouping areas to look for consistent trends over time in indices used for trend analysis. Overall, there were few correlations within regions. The panel felt this was an interesting and useful analysis. There was some discussion that comparisons across all rivers and different indices might be interesting. One might expect rivers that are far apart, yet have similar remediation efforts, to be correlated in time.

MARSS Model

In addition to the pairwise correlation analysis, the SAS conducted a multivariate auto-regressive state space model (MARSS) to explore common trends in indices by region. Limited detail was provided regarding the model development and fitting. It was noted the MARSS approach was not pursued in great detail due to model fitting issues, including inconsistent trends within regions. The panel agreed that trying to identify patterns in rivers within regions was of great interest. However, an analysis that looked for trends across the entire region is also of interest, in part due to adjacent rivers being split between regions. Also, other factors may play a role at broader spatial scales (e.g., restoration efforts or development trends across rivers).

Power Analysis

The SAS conducted a power analysis following the method of Gerrodette (1987) to calculate the probability of detecting trends in abundance indices from the surveys. Specifically, they looked at the probability of detecting a ≥ 50% change over a 10 year period for both linear and exponential trends. The SAS noted this is not a retrospective power analysis often done after testing for a trend. Rather, it is a measure of the possibility of identifying a trend if one were to occur. The panel felt this was a very useful analysis, as it revealed a very low probability to detect significant trends if they were to occur over 10 years.

Trends in Maximum Age, Mean Length, Length-at-age, and Proportion of Repeat Spawning

The SAS explored trends in age, length, and repeat spawning over time where possible. The panel felt the analyses were interesting and useful. However, care was needed when using trends in the data to make inferences about stock status, as other dynamics including the sampling design and changes in personnel may be influencing the observed data.

Trends in maximum age by species and sex were explored across rivers where age information was available. Trend analyses were not conducted on maximum age, and trends were evaluated visually. Rivers where changes in ageing method changed over time were split. Maximum ages ranged between 4-9 across rivers with ages 6-7 most common. Over time values fluctuated. In general, there was no discernible trend across the majority of rivers. The panel noted that observed maximum age for a given river may be influenced by the timing of the sampling relative to the run timing, and therefore may not be reflective of the true maximum age returning to a river.

Length data from fishery-independent and -dependent sources were collected to calculate trends in overall mean length and length at age for individual spawning populations. Time series with at least 10 years of data and with at least five years of continuous data were used in Mann-Kendall tests for a monotonic trend. The SAS noted that year-class effects can influence trends in mean length (but not mean length-at-age), particularly for shorter time series. The panel also suggested looking at changes in mean length in the NMFS offshore trawl survey to get a more coastwide look at changes in size, as there are some length-based data limited methods that could be explored for adjusting the bycatch cap.

The percentage of repeat spawners was calculated as the percent of fish sampled with one or more spawning marks divided by the total sampled in a given year. The Mann Kendall test was applied for rivers for 10+ years of data, with at least five continuous years. A few rivers stood out as they had large increases towards the end of the time series, with very high percent repeat spawners. Although this seemed to be a positive result at first glance, the panel noted it could also be the result of successive year class failures. In response, the SAS conducted a simulation of the data and demonstrated that indeed year class failure could be responsible for such changes. It might be useful in the future to structure the data so that figures showing each river or regional grouping could allow for visual evaluation of the various indices and facilitate attempts to make inferences about biological processes. The aging of scales and detection of repeat spawning events using them remains a source of variability that is hard to quantify. Last, the panel was concerned with the very low number of repeat spawners in some years (eg. 2018 in CAN-NNE, Fig. 174).

Statistical Catch-at-Age Models

Statistical catch-at-age (SCAA) models were updated for stocks in three rivers. Catch-at-age models are discussed in detail below in response to ToR 4.

Bycatch Cap Limit

The SAS explored the use of data-limited methods to estimate a bycatch cap based on trends in abundance. The SAS clearly indicated this was a proof-of-concept analysis and not being recommended for management purposes. Five methods were explored: the iSmooth method, used to adjust the ABC for a number of stocks in New England, and four variations of the iSlope method. Both the iSmooth and iSlope methods were selected because they performed well in simulation testing conducted by an Index-Based Methods Working Group (NEFSC 2020). Both iSmooth and iSlope adjust recent average catches based on trends in abundance. The SAS used recent bycatch estimates, and explored adjusting the catch using two indices of abundance: the NMFS trawl survey (ME-NC), and summed run counts from the SNE stock region for alewife and from the MAT region. The SAS also conducted a retrospective analysis to quantify the interannual change in bycatch cap that would have resulted if each method had been applied previously.

The panel felt this was a useful exploration and worthy of further consideration. There was some concern about the interannual variability in cap estimates, particularly for the iSmooth method. The iSlope variations were less variable than iSmooth, although there was considerable variation for blueback herring in some years. The variability was largely due to spikes in bycatch in certain years. There was discussion that using bycatch magnitude as the catch cap could be problematic. If this approach were to be used, the current bycatch cap should be adjusted up or down (and not the recent average bycatch) based on trends in the index. The panel was also unsure how the approach could be operationalized to set a bycatch cap that includes four species (also American and hickory shad), and feels that further consideration of how to do so is needed.

Spatial Distribution Models

The SAS also presented the potential use of habitat models to predict species distribution in the marine environment and identify bycatch hotspots. The models would inform future development of time-area closures and could be explored as an alternative to management using a bycatch cap. The panel agreed the methods held promise and supported continued exploration, while cautioning that a fully spatial approach would not inherently track the magnitude of bycatch. Thus, there is the potential that some type of bycatch cap would need to be implemented concurrently with spatial management. The panel also noted there are numerous steps to developing and validating various options for time area closures, and these require clear management objectives to be defined *a priori* (Bowlby et al. 2024).

4. **For each stock, identify best estimates of biomass, abundance, and exploitation from the assessment for use in management, if possible, or specify alternative estimation methods.**

Despite the diversity of data available, it was difficult for the SAS to use conventional fish population modeling to estimate biomass or abundance of river herring, either by river system or by region. For the majority of river systems, only one type of monitoring data existed that could be used as an abundance index. And, the available catch data were difficult to partition to species level due to challenges in biological sampling. There were only three rivers where a statistical catch-at-age model could be developed to estimate biomass/abundance and fishing mortality.

Monument River Statistical Catch-at-Age Model

The statistical catch-at-age (SCA) model for the Monument River (MA) alewife was a forward projecting population model that predicts numbers at age by sex and maturity stage from total in-river catches, escapement counts, and escapement age composition. The SCA incorporated the updated estimates of natural mortality (M) by age derived from weight at age (Lorenzen 1996) and used the age and repeat-spawner frequency to derive annual proportions of fish mature at each age and sex following Maki et al. (2001). The structural difference from the last assessment was to incorporate a multiplier on M, to give a coefficient for two time periods: 1980-1999 and 2000-2022. Fishing mortality is currently extremely low and known (only research catches), making it possible to evaluate changes in M over time because escapement was monitored.

Model diagnostics were adequate, yet there were retrospective patterns in several parameters, notably total population abundance and female SSB. The river system is currently under moratorium, so there is limited management application for the results other than determining a relative current mortality rate. The biomass predictions in the terminal year for female SSB are below both the $F_{40\%}$ and $F_{20\%}$ reference points, suggesting recent abundance is low. The panel noted the increase in the M multiplier (1.67 to 2.68) was interesting, as it suggests other sources of anthropogenic mortality (not F) have substantially increased in this population in recent years.

Nanticoke River and Chowan River Statistical Catch-at-Age Model

Age-structured SCA models for alewife and blueback herring were developed for both rivers. Models were fit to total in-river catches, observed proportions at age and repeat spawner data, and fishery-independent indices. Unlike the Monument River model, additional anthropogenic mortality (e.g., multipliers on M) could not be estimated concurrently with fishing mortality due to the lack of information on escapement. Both rivers are currently under moratorium and recent estimates of F were minimal. Sensitivity runs indicated that biomass predictions were sensitive to the scale of removals, limiting the management utility of both models now that there are no directed fisheries. The influence of bycatch, other sources of anthropogenic mortality, or environmental effects due to climate change could not be evaluated from the available data. Any assumptions made as to their magnitude would rescale abundance estimates from the models.

Overall

Predicting biomass or abundance for alewife and blueback herring depends on having substantial extant monitoring effort in a single river. Given the sheer number of river systems, it is unlikely that future monitoring will ever be increased across systems to enable the development of additional SCA models. Furthermore, age-structured SCA approaches are not applicable at the regional level, given the diversity in population dynamics among river systems, coupled with separability issues for aggregated species data such as bycatch information. The review panel sees limited value in future model development and validation of the SCA models for management advice.

In future, the SAS could explore using population dynamics models within a Population Viability Analysis (e.g., Reid et al. 2002, Legault 2005), particularly for the Monument River. This type of an approach would shift the focus from stock status towards conservation questions and recovery planning. For example, the predominance of in-river as opposed to at-sea mortality affecting the population trajectory (e.g., Gibson et al. 2009), the potential utility of stocking (e.g., Bowlby and Gibson 2011), or the probabilities of recovery and/or extinction under various mortality scenarios (e.g., Gibson et al. 2015) could be explored. However, the assessment team noted this suggestion is effectively a simpler version of the habitat model discussed below, albeit implemented at a river-specific level.

Habitat Model

The habitat model presented for river herring was an extension of the one previously developed for American shad (Zydlewski et al. 2021) and is available via open source software. It is an age and sex structured projection model that uses current biological parameters (here regional, not river-specific values) to predict survival, maturity and productivity through time (here 50 years), conditional on the distribution and accessibility of freshwater habitat. Density dependence via a Beverton-Holt recruitment function relates the number of spawners to subsequent larval recruitment. Upstream passage and downstream mortality rates govern the probabilities of reaching suitable habitat (i.e., in freshwater for adult spawners and in ocean environments for larval recruits).

The model was initialized at a large starting population size, with the number of individuals in an age class determined by age-specific natural mortality rates and a random probability of being female drawn from a beta distribution. The amount of freshwater habitat in a river system was calculated for each reach segment using stream discharge-width relationships and summed with lake area to get the total. The position of dams in combination with modeled upstream passage and downstream survival rates affected the accessibility of freshwater habitats. The model was run for alewife and blueback herring in each region identified by the genetic analyses (see TOR 1), comparing a no-dam (1.0 upstream passage and downstream survival), a current (0.5 passage and survival), and a no-passage (0 passage and survival) scenarios.

The habitat model conclusively demonstrated the impact of accessibility on the expected productivity of different regions for river herring, with the magnitude of habitat reduction within a region reflected by decreases in predicted spawner abundance (in millions of fish). For alewife, all of the regions had 65% or more of the habitat located above first dams. For blueback herring, the proportions of habitat above dams tended to be slightly lower by region; however, for both species there was a gradient in habitat accessibility from South to North, with Northern rivers being more impacted by dams. The current model is sensitive to the amount of habitat that would remain after dam removals, and assumes all habitat to be of equal quality. These assumptions currently limit the applicability of the model, as it is known that all habitat is not equal (Monteiro Pierce et al. 2020, Devine et al. 2021), and choices between fish passage and dam removal will have significant impacts on habitat availability and quality.

For the habitat model to be used to develop explicit management advice, it would be necessary to account for the influence of fisheries, both in-river as well as ocean bycatch, as well as to compare abundance predictions to observed data to ensure sources of mortality and life history dynamics are adequately represented. Ideally, landings and bycatch would be ascribed to individual river systems to understand the combined influence of freshwater habitat loss and fishing mortality on underlying population productivity. By capturing the main sources of freshwater and at-sea mortality, the abundance predictions (estimates of numbers) could then be assessed relative to run count and escapement data to see if the modeling approach is able to approximate observed patterns. This would help validate the predictions, particularly if there is the intention to explore other sources of anthropogenic mortality (e.g., the influence of climate change) using the modeling approach. Overall, we encourage the SAS to continue development of the habitat modeling approach.

5. **Evaluate the choice of reference points and the methods used to determine or estimate reference points. Determine stock status from the assessment, or, if appropriate, specify alternative methods/measures for management advice.**

The SAS developed reference points for total mortality (Z) and for the ARIMA-smoothed time series. The reference points were then used to compare terminal estimates of Z and smoothed abundance to quantify the probability of a stock being above or below the reference point. Uncertainty was accounted for in both the terminal estimate and the reference point.

For the Z reference point, the SAS used the SPR target of 40%. Their justification for using 40% was based on a number of simulation studies that showed 40% was a robust proxy for MSY. The Panel discussed the possibility of other target SPR percentages, but also noted 40% is widely used across stocks in the U.S., and that it was reasonable for river herring.

Regarding status relative to Z, results varied by river. For blueback herring, 4 of 11 rivers had a greater than 50% chance of Z being above the reference point. For alewife, 28 of 43 rivers had a greater than 50% chance of Z being above the reference point. Although the Panel felt this approach was suitable, there was discussion over using only the terminal year estimate of Z to compare with the reference point. There is considerable interannual variation in Z, and averaging multiple years (e.g., the most recent three) may be more appropriate. Also, as noted earlier the mortality being estimated for each river is based on fully recruited 5+ year fish and thus does not represent the mortality rate of younger age classes. Ages 3 and 4 are the predominant contributors to annual variability in the run count, as most populations consist of a majority of first-time spawners. Although mortality affecting the older age groups is an accumulated metric over multiple factors (harvest, incidental catch, and fish passage), mortality is generally expected to be higher in younger and small ages. This is made slightly more complicated by a lack of mortality as a result of river use such as through fish passage during younger ages. However, length data collected in the observer program (Fig. 17-Fig. 18) demonstrate there is significant catch of young (immature) river herring as judged by the growth curves (Fig. 91-98). In fact, there are very few fish in bycatch at lengths that are consistent with age 5+ fish (approximately 275-300mm, Fig. 91-98). Thus, the calculated mortality rates are not truly indicative of all sources of mortality river herring are exposed to throughout ontogeny. Using the catch curve analysis method based on previous spawning history (Billard 2020) would better characterize mortality in earlier years as data from age 3 and 4 fish would be included in the estimation. Even though mortality is likely underestimated, the mortality rate had a 50% chance of being above the reference point for 50% of blueback populations and 65% of alewife populations. What is clear is that mortality remains high, and given the level of historical depletion throughout their respective ranges, does not bode well for recovery of either alewife or blueback herring. It is important to note the mortality rates were over the reference point in many harvested runs as well.

For the ARIMA trend analysis the SAS used two reference points – the 25th percentile from the entire smoothed time series, and the 2009 smoothed value. The 25th percentile was selected based on the work of Helser and Hayes (1995). The 2009 value was based on changes in management related to FMP Amendment 2. The Panel felt the focus should be more on the 2009 index value, in part because the 25th percentile can change over time and the 2009 value tended to be higher than the 25th percentile value. The 2009 smoothed index is fixed in time. It has relevance to known changes in management and should be considered a limit reference point. Therefore, comparisons of the current year to 2009 provide evidence if interventions are having a positive impact. With regard to status relative to reference points, the majority of rivers for both species had a greater than 50% chance of the index terminal year being above the 25th percentile and the 2009 value.

6. **Review the research, data collection, and assessment methodology recommendations provided by the TC. Make additional recommendations as necessary. Clearly prioritize the research needed to inform and maintain the current assessment, and provide recommendations to improve future assessments.**

The panel suggested de-prioritizing research questions that would not lead to information used to assess status. The panel categorized research priorities as short-term high priority that are possible now without additional data collection, and medium priority that would require additional planning, new data collection, or additional time to implement.

High Priority

The panel recognizes the need for improved estimation of bycatch and discard mortality. Exploring different estimation methods among fisheries is a high priority as it can be done now with no new data. Different analytical techniques could be compared in a sensitivity analysis to assess their relative predictive ability for estimating total bycatch. The manner in which iSlope or other methods could be implemented as catch caps should be explored. Since incidental catch seems to comprise the largest source of ongoing fishing mortality, and mortality remains high for many populations, the focus on bycatch is urgent.

Another high priority research need is to improve the habitat model by incorporating all major sources of mortality, and then to use observed data to ground truth the outputs. This does not imply a fit to data, but rather the results should be tethered to reality in that predicted run sizes are of a realistic magnitude relative to what has been observed. There were a number of unrealistic outputs in the current implementation. Future iterations should work to include fishing mortality, including bycatch, and measures of habitat quality in freshwater.

Of equal priority, but with implementation over a longer time period, is improved monitoring via port sampling to collect morphological and species data from bycatch. This would require portside monitoring to be reinstated and expanded for full-retention fisheries. However, it would appear to be a relatively low-cost solution compared to increasing at-sea observer coverage. The variability in bycatch estimate CVs relative to a target of 30% suggests increases in at-sea observer coverage would have to be substantial. During subsampling of catch, samples should be taken for genetic analysis of bycatch, even if the samples are stored for analysis at a later date. A better accounting of incidental catch is critical to improving the status of coastwide stocks.

The panel also sees a high priority in continued improvement of enumeration techniques, including hydroacoustics, eDNA, and run count video image processing with machine learning. Current fish counting technologies are phasing out. The advance of many alternatives offers the opportunity to calibrate methods and continue long-term monitoring datasets.

Medium Priority

The panel recognized the need to implement sampling programs where data are collected over the whole life stage on a single river. Such data can be input into models to allow the partitioning of mortality into different components of life history, increasing understanding of the impacts of different sources (in-river, downstream passage, incidental catch).

A detailed river history and inventory that captures current population numbers, details of restoration, and documents data collection methods would be very informative when trying to interpret current status. This could include a landscape database of threats, documenting their location, type, and magnitude along the river network. Such a baseline would help evaluate whether the environment of the river has changed. The status of current environmental monitoring, prior or subsequent run monitoring, as well as other information could help in prioritizing the collection of new data. It would also provide a platform for research and engagement.

River herring specific surveys would be of great benefit to the assessment, and the panel suggests interspecies and interstate collaboration on survey design. The low power of surveys in the assessment can, in part, be linked to the dependence on a variety of surveys not developed for river herring. At the very least, new workshops to standardize data collection and explore expanding the designs to better sample river herring in current surveys, or implementing additional methods to complement existing efforts, would be extremely useful. Angler surveys in freshwater or in spawning reaches, currently not the focus of MRIP, would fill some data holes. However, recreational harvest is probably not resulting in significant mortality.

The panel considered most of the other medium and high priority research objectives identified by the SAS (short and long term) to be less important, primarily because they would have a lower likelihood of leading to information useful for status assessment or management.

7. **Recommend timing of the next benchmark assessment and assessment updates, if necessary, relative to the life history and current management of the species.**

The review panel took into consideration the life history of river herring, the available assessment methods, and current management when recommending the timing of the next benchmark and update assessments. The review panel agreed with the SAS that an assessment update in 5 years and a benchmark assessment in 10 years would be appropriate.

Relative to life history, 5 years represents approximately 1 generation for river herring, based on the average age of spawners. There would be sufficient time for recruits in 2024 to contribute to the spawning population prior to the next benchmark. However, the current assessment demonstrates the power to detect trends in monitoring data can be quite low given the variability characteristic of river herring, particularly with shorter time series. Thus, continued improvement of the habitat model and linking of the results to ground-truthing data would be logical steps.

In the assessment, 10 years was used as a cut-off when identifying the time series data appropriate for trends analyses. Holding the next benchmark assessment in 10 years should allow for measurable population response to management actions, particularly from those implemented following the previous benchmark in 2012.

The complexity of river herring assessment largely stems from the diversity of organizations involved in monitoring, data collection, and management, as well as the numerous anthropogenic activities affecting each population. More frequent assessments would take substantial effort on behalf of numerous agencies with little expectation of measurable population response. An update or a benchmark on a shorter time-scale is likely to lead to the same biological conclusions and management advice as the current assessment. The panel also suggests additional inter-assessment coordination amongst states to develop as many standardized approaches (ageing, spawning checks, indices) as possible.

8. **Prepare a Review Panel terms of reference and advisory report summarizing the panel's evaluation of the stock assessment and addressing each peer review term of reference. Develop a list of tasks to be completed following the workshop. Complete and submit the report within 4 weeks of workshop conclusion.**

The panel was generally content with the current assessment report. However, documentation of sample sizes for catch curve estimation should be included. In future assessments, the SAS should also work to explore time blocks in simplified growth models, and evaluate the assumptions underlying the catch ratio estimator for bycatch. We thank the SAS for recalculating mortality estimates, and providing additional figures and spreadsheets describing sample sizes, at the request of the panel during the peer review workshop.

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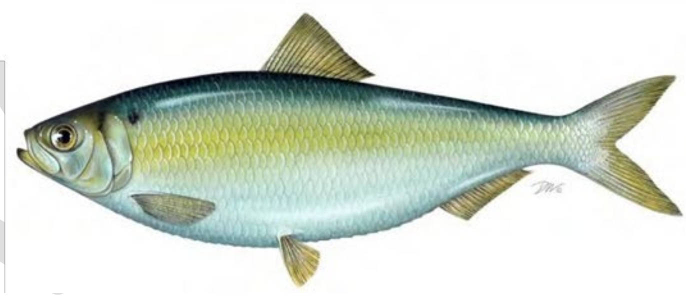
Atlantic States Marine Fisheries Commission

River Herring Benchmark Stock Assessment: Terms of Reference Report



Draft for Board Review

Vision: Sustainable and Cooperative Management of Atlantic Coastal Fisheries

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TERMS OF REFERENCE

For the 2024 ASMFC River Herring Benchmark Stock Assessment

Board Approved November 2022

1. Define and justify stock structure.

2. Characterize precision and accuracy of fishery-dependent and fishery-independent data used in the assessment, including life history data (e.g., age and repeat spawner data) and nontraditional data (e.g., entrainment, impingement, passage). Characterization should include the following but is not limited to:
    a. Provide descriptions of each data source (e.g., time series, geographic location, sampling methodology and changes, potential explanation for outlying or anomalous data).
    b. Describe calculation and potential standardization of abundance indices.
    c. Discuss trends and associated estimates of uncertainty (e.g., standard errors).
    d. Where possible, explore reader consistency, potential bias, and agreement statistics for age and repeat spawner data.
    e. Justify inclusion or elimination of available data sources.

3. Estimate bycatch where and when possible.

4. Summarize data availability and trends by stock.

5. If possible, develop models used to estimate population parameters (e.g., Z, biomass, abundance) and biological reference points, and analyze model performance.
    a. Briefly describe history of model usage, its theory and framework, and document associated peer-reviewed literature. If using a new model, test using simulated data.
    b. Clearly and thoroughly explain model strengths and limitations.
    c. Discuss the effects of data strengths and weaknesses (e.g., temporal and spatial scale, gear selectivity, ageing accuracy, sample size) on model inputs and outputs.
    d. State assumptions made for all models and explain the likely effects of assumption violations on synthesis of input data and model outputs. Examples of assumptions may include (but are not limited to):
    - Choice of stock-recruitment function.
    - Calculation of M. Choice to use (or estimate) constant or time-varying M and catchability.
    - Choice of equilibrium reference points or proxies for MSY-based reference points.
    - Choice of a plus group for age-structured species.
    - Constant ecosystem (abiotic and trophic) conditions.

    e. Justify choice of coefficients of variation (CVs), effective sample sizes, or likelihood weighting schemes.
    f. Describe stability of model (e.g., ability to find a stable solution, invert Hessian).

g. Perform sensitivity analyses for starting parameter values, priors, etc. and conduct other model diagnostics as necessary.
h. Characterize uncertainty of model estimates and biological or empirical reference points.
i. If multiple models were considered, justify the choice of preferred model and the explanation of any differences in results among models.

6. If possible, develop methods to calculate a biologically-based cap or limit on bycatch of river herring in ocean fisheries.

7. Recommend stock status as related to reference points, if available.

8. Other potential scientific issues:
    a. Compare trends in population parameters and reference points with current and proposed modeling approaches. If outcomes differ, discuss potential causes of observed discrepancies.
    b. Compare reference points derived in this assessment with what is known about the general life history of the exploited stock. Explain any inconsistencies.
    c. Explore climate change impacts on the species.
    d. Explore predation impacts on the species.
    e. Discuss all known anthropogenic sources of mortality and productivity (i.e., stocking, passage mortality) by stock.

9. If a minority report has been filed, explain majority reasoning against adopting approach suggested in that report. The minority report should explain reasoning against adopting approach suggested by the majority.

10. Develop detailed short and long-term prioritized lists of recommendations for future research, data collection, and assessment methodology. Highlight improvements to be made by initiation of next benchmark stock assessment. Note research recommendations from the previous assessment that have not been addressed and those that have been partially or fully addressed.

11. Recommend timing of next benchmark assessment and intermediate updates, if necessary relative to biology and current management of the species.

For the 2024 ASMFC River Herring Benchmark Stock Assessment

1. Evaluate choice of stock structure.

2. Evaluate the thoroughness of data collection and the presentation and treatment of fishery-dependent and fishery-independent data in the assessment, including the following but not limited to:
   a. Presentation of data source variance (e.g., standard errors).
   b. Justification for inclusion or elimination of available data sources.
   c. Consideration of data strengths and weaknesses (e.g., temporal and spatial scale, gear selectivities, ageing accuracy, sample size).
   d. Calculation and/or standardization of abundance indices.
   e. Estimation of bycatch.

3. Evaluate the methods and models used to estimate population parameters (e.g., Z, biomass, abundance), biological reference points, and bycatch caps/limits including but not limited to:
   a. Evaluate the choice and justification of the preferred model(s). Was the most appropriate model (or model averaging approach) chosen given available data and life history of the species?
   b. If multiple models were considered, evaluate the analysts' explanation of any differences in results.
   c. Evaluate model parameterization and specification (e.g., choice of CVs, effective sample sizes, likelihood weighting schemes, calculation/specification of M, stock-recruitment relationship, choice of time-varying parameters, plus group treatment).
   d. Evaluate the diagnostic analyses performed, including but not limited to:
      - Sensitivity analyses to determine model stability and potential consequences of major model assumptions.
   e. Evaluate the methods used to characterize uncertainty in estimated parameters. Ensure that the implications of uncertainty in technical conclusions are clearly stated.

4. If a minority report has been filed, review minority opinion and any associated analyses. If possible, make recommendation on current or future use of alternative assessment approach presented in minority report.

5. Recommend best estimates of stock biomass, abundance, and exploitation from the assessment by stock for use in management, if possible, or specify alternative estimation methods.

6. Evaluate the choice of reference points and the methods used to determine or estimate them. Recommend stock status determination from the assessment, or, if appropriate, specify alternative methods/measures for management advice.

7. Review the research, data collection, and assessment methodology recommendations provided by the TC and make any additional recommendations warranted. Clearly prioritize the activities needed to inform and maintain the current assessment, and provide recommendations to improve the reliability of future assessments.

8. Recommend timing of the next benchmark assessment and updates, if necessary, relative to the life history and current management of the species.

9. Prepare a peer review panel terms of reference and advisory report summarizing the panel's evaluation of the stock assessment and addressing each peer review term of reference. Develop a list of tasks to be completed following the workshop. Complete and submit the report within 4 weeks of workshop conclusion.

TERMS OF REFERENCE SUMMARY REPORT

1. **Define and justify stock structure**

River herring stock structure was identified genetically by Palkovacs et al. (2014) and later refined by Reid et al. (2018). A robust baseline collection that covered the range of both species indicated four regional genetic groups of alewife (one in Canada (CAN), and three in the US, Northern New England (NNE), Southern New England (SNE), and Mid-Atlantic (MAT)) and five of blueback herring (Canada-Northern New England (CAN-NNE), Mid-New England (MNE), Southern New England (SNE), Mid-Atlantic (MAT), and South Atlantic (SAT)). Within regional genetic groups there was much weaker genetic differentiation between rivers; there were indications that genetic isolation by distance was highly affected by stocking. The stock assessment conducted analyses at the individual river level where possible, and used the genetic stock-regions of Reid et al. (2018) to pool data and summarize results across rivers.

2. **Characterize precision and accuracy of fishery-dependent and fishery-independent data used in the assessment, including life history data (e.g., age and repeat spawner data) and nontraditional data (e.g., entrainment, impingement, passage)**

Commercial landings data for 1881-1949 came from the US Fish Commission reports. Data for 1950-2022 came from the Atlantic Coastal Cooperative Statistics Program (ACCSP), which compiles fisheries data from state and federal databases along the Atlantic coast. The ACCSP database was queried for landings records of alewife, blueback herring, and river herring, and ACCSP staff validated the data with the states. Reported commercial landings averaged 1,016 mt (2.24 million lbs) from 2013-2022, compared to 27,923 mt (61.6 million lbs) from 1950-1969, the height of the directed fishery.

The earliest historical data is likely an underestimate of coastwide landings, as it relies on opportunistic canvassing of the fisheries, concentrating on the mid-Atlantic states. Although reporting has become more standardized and mandatory in recent years, identification to the species level remains unreliable. The vast majority of river herring landings are reported as alewife, even for states or rivers where blueback herring dominate the runs.

Estimates of incidental catch of river herring (both retained and discarded) in non-directed ocean fisheries were developed from the Northeast Fishery Observer Program (NEFOP) data, which observes catches on federally-permitted vessels in the Mid-Atlantic and New England region. Observer data for the gillnet and bottom trawl fleets goes back to 1989, but incidental catch estimates for the midwater trawl (MWT) fleets are only provided for 2005-2022 because marked improvements to NEFOP sampling methodologies occurred in the high-volume MWT fisheries beginning in 2005.

Estimates of river herring bycatch are frequently imprecise, with CVs ranging from 0.2 to over 1.0 at the annual level. This is due to the overall low observer coverage, which has declined in recent years due to budget issues; coverage in nearshore/state waters is even lower due to the federal nature of the observer program. In addition, in high volume fisheries, it is difficult to identify river herring to the species-level.

Estimates of recreational harvest and live releases for river herring on the Atlantic coast come from the NOAA Fisheries Marine Recreational Information Program (MRIP), which uses a combination of effort surveys and angler-intercept surveys to develop those estimates. MRIP estimates of river herring recreational catch are highly variable from year to year, ranging from a minimum of less than 1,000 fish for alewife and zero for blueback herring in several years to maximums of 1.3 million alewife and 3.4 million blueback herring. The percent standard error (PSE) of the estimates are also high, with most years having a PSE of greater than 50%, and several years having a PSE of greater than 100%, even at the coastwide level. The MRIP angler-intercept survey that estimates catch per trip of each species does not occur above the head-of-tide, so in-river catches, where the directed fishery is most commonly prosecuted, are not captured by MRIP, contributing to the low precision of the estimates.

From 2013-2022, estimates of total river herring removals on the US Atlantic coast from all sources averaged 1,213 mt (2.67 million lbs) or approximately 4% of the average reported landings at the peak of the directed fishery (Figure 1). This represented an average of 6.83 million fish per year.

Fishery-independent data sets that caught river herring were evaluated and accepted or rejected for assessment use based on established criteria, including the length of the time series (at least ten consecutive years of data; surveys with 7-9 years of data were accepted for use in future updates but not included in the trend analysis results for this assessment) and the proportion of sampling events that were positive for alewife or blueback herring, when subset to the most representative strata, stations, months, etc. (at least 10% positive tows/hauls). A total of 43 fishery-independent surveys met the criteria for one or both species. Surveys ranged from Maine to Florida and included young-of-year surveys and age-1+ surveys (Figure 2). Young-of-year or spawning stock surveys that occurred in the nursery grounds or rivers were assigned to the stock-region that the river or estuary was in; surveys that occurred in the ocean were assigned to the coastwide mixed stock for each species. Gears included trawls, seines, gillnets, and electrofishing. The SAS explored using GLMs and GAMs to incorporate environmental information into the calculation of the abundance indices. If the model-based standardization reduced interannual variability or the CVs of a dataset or could account for changes in sampling methods that would otherwise require dropping years of data, the standardized index was used. Otherwise, the nominal index was used.

The major sources of uncertainty in the surveys were (1) the lack of a targeted design, with majority of the surveys being multispecies monitoring projects that did not target river herring, resulting in a high proportion of zero tows in the datasets, and (2) time-series length, with virtually all surveys starting in the 1980s or later, after the significant decline in the directed fishery.

Two fishery-dependent CPUE datasets were also included; the length of the time-series and consistent methods of sampling provided useful contrast in the trends in abundance, but the ability to define effort in a detailed, consistent way over the time-series did increase uncertainty for those indices.

In addition to fishery-independent surveys, run counts were used as indices of abundance for river herring. Run counts were available from Maine through South Carolina for both species, although the majority of counts were from the northern end of the range. The major source of uncertainty for the run counts was the potential for changes in passage efficiency over time, due to factors like deliberate passage improvements or improvements in counting methodology, degradation of passage, or interannual variability in flow or other environmental factors. In addition, for a number of run counts, river herring were not identified to the species level for part or all of the time series. While the SAS attempted to restrict the years in the analysis to years of consistent methodology, it was not possible to account for all sources of variability. The SAS considered run counts to be indices of relative abundance rather than estimates of absolute abundance.

Biological data including lengths, weights, ages, and repeat spawner marks were available from fishery-dependent and fishery-independent sources. River herring have historically been aged using scales, using protocols first developed by Cating (1953) for American shad and Marcy (1969) for river herring. Although used extensively, these protocols have not been validated with known-age river herring. A 2014 ageing workshop for river herring found CVs greater than 5% across labs, and systematic bias across readings from paired scales and otoliths. Collection of otoliths has increased since the last benchmark, and several thousand otolith ages were available across multiple stock-regions for both species.

3. Estimate bycatch where and when possible

Estimates of incidental catch of river herring (both retained and discarded) in non-directed ocean fisheries were developed from the NEFOP data, at both the annual level and stratified by gear and region. From 2005-2022, the total annual incidental catch of alewife ranged from 22.7-537.8 mt in New England and 6.5-295 mt in the Mid-Atlantic. The dominant gear varied across years between paired midwater trawls and bottom trawls. Corresponding estimates of precision (coefficients of variation, CVs) exhibited substantial interannual variation and ranged from 0.01-10.61 across gears and regions. Total annual blueback herring incidental catch from 2005-2022 ranged from 8.2–186.6 mt in New England and 1.4-388.3 mt in the Mid-Atlantic. Across years bottom trawl, paired and single midwater trawls exhibited the greatest blueback herring catches. Corresponding CVs ranged from 0.01 – 3.56.

Total incidental catch estimates from 2020-2022 were among the lowest in the time series (2005-2022) for both alewife and blueback herring. From 2005-2019, incidental catch made up 27% of total removals in weight and 35% of total removals in numbers, but from 2020-2022, incidental catch was 7.5% of total removals in weight and 10% of total removals in numbers. These lower estimates of bycatch are related to the lower effort in the Atlantic herring and mackerel fleet in recent years, but are also affected by the lower levels of observer coverage and port sampling in those years.

4. Summarize data availability and trends by stock

Information on abundance and/or total mortality were available from 75 rivers or river systems, as well as the Atlantic Ocean, for one or both species, across all stock-regions.

Indices and run counts were analyzed with the non-parametric Mann-Kendall trend analysis (Mann 1945, Kendall 1975) to determine if a monotonic trend was present in each series. The autoregressive integrated moving average (ARIMA) approach (Box and Jenkins 1976) was used to minimize measurement error in the survey estimates and to infer population status relative to an index-based reference point for both abundance indices and run counts. The reference points used were the 25th percentile of the time series, and the index value in 2009, the year when Amendment 2 to the Shad and River Herring Fishery Management Plan was implemented.

There was no clear trend signal for either species across the coast. Even within the genetic stock-regions, individual rivers often differed in recent and long-term trends for both abundance and mortality. Overall, the northern most stock regions (NNE for alewife, CAN-NNE for blueback herring) had more rivers with significant positive trends than the other stock-regions.

For alewife, in the NNE stock-region, there were eight species-level time series: six run counts and two young-of-year surveys. ARIMA results indicated five of the six run counts and both young-of-year indices had a greater than 50% chance of being higher than they were in 2009. Four of the eight time-series showed an increasing trend over the full time series, while two of eight showed an increasing trend since 2009. The rest of the trends were non-significant. In the SNE region, there were eight species-level time series: seven run counts and one young-of-year survey. ARIMA results indicated four of the seven run counts had a greater than 50% chance of being higher than they were in 2009; the young-of-year index only had a 6% probability of being higher than it was in 2009. None of the time-series had a significant trend in recent years; four runs had had a long-term decreasing trend and one run had a long-term increasing trend. In the MAT stock-region, there were 21 species-level time series: eleven age-1+ indices and ten recruitment (young-of-year or age-1) indices. ARIMA results indicated five of the eleven age-1+ indices and six of ten recruitment indices had a greater than 50% probability of being higher than they were in 2009. None of the time-series showed a significant trend in recent years. One age-1+ index and three recruitment indices showed a decreasing trend over the full time series. Three age-1+ indices, all in North Carolina, and one recruitment index showed an increasing trend over the full time series.

For blueback herring, in the CAN-NNE stock-region, there was one species-level time series, a young-of-year index. ARIMA results indicated it had a very high probability of being above the 2009 index value, and showed an increasing trend in both recent years and over the full time series. In the MNE stock-region, there were five species-level time-series: four run counts and a young-of-year index. ARIMA results indicated that three of the four run counts had a greater than 50% probability of being higher than they were in 2009. None of the time-series showed a significant trend in recent years. The Oyster River run count had a decreasing trend over the full time series, and only a 16% probability of being above the 2009 value. The young-of-year index also had a significant decreasing trend over the full time series, but had a high probability of being above the 2009 value in the most recent year. There were no species-level time-series for the SNE stock-region (all run counts for this region were reported as mixed river herring). For the MAT stock-region, there were 27 species-level time series: 16 age-1+ surveys and 11 recruitment indices. ARIMA results indicated that seven of sixteen age-1+ indices and nine of the eleven recruitment indices had a greater than 50% probability of being higher than they were in 2009. Only one time series, the NC Albemarle Sound Gillnet Survey of age-1+ abundance had an increasing trend in recent years; the rest were non-significant. Over the full time series, four recruitment indices and two age-1+ indices showed decreasing trends, while one recruitment index and three age-1+ indices showed increasing trends. For the SAT stock region, there were three species-level time series: one run count, one age-1+ survey, and a young-of-year index. ARIMA results indicated that the age-1+ surveys and the young-of-year survey had a greater than 50% probability of being higher than they were in 2009, while the Santee-Cooper River run count had only a 3% probability of being above the 2009 value. The Santee-Cooper River run count showed a decreasing trend over the full time series and in recent years. The young-of-year index showed an increasing trend over the full time series, but the age-1+ index had no significant trend over either time period.

5. **If possible, develop models used to estimate population parameters (e.g., Z, biomass, abundance) and biological reference points, and analyze model performance.**

This assessment updated and refined the trend analyses, total mortality (Z) estimates, and Z reference points from the 2012 benchmark assessment. New analyses included the exploration of a MARSS model in an attempt to identify underlying trends within stock-regions, and the development of a habitat model to understand the importance of habitat loss and restoration on river herring population trends at the watershed level.

Indices of abundance were developed and correlation of the indices within region was measured with Spearman's Rank Correlation. Power analysis was used to calculate the probability of detecting trends in the abundance indices developed from fishery-independent data using the methods of Gerrodette (1987). Indices and run counts were analyzed with the non-parametric Mann-Kendall trend analysis (Mann 1945, Kendall 1975) to determine if a monotonic trend was present in each series. The autoregressive integrated moving average (ARIMA) approach (Box and Jenkins 1976) was used to minimize measurement error in the survey estimates and to infer population status relative to an index-based reference point (25th percentile and fitted 2009 value respectively) for both abundance indices and run counts.

Trends in maximum age, mean age-at-length, mean length, and repeat spawner percentage were tested for by species and sex where the data existed.

A Poisson log-linear model was used to estimate total instantaneous mortality (Z) rates (Millar, 2015) for each species and year combination for two different spatial scales: at the river level and at the regional level. A stochastic spawning stock biomass per recruit model (SPR) was developed to estimate a total mortality threshold of $Z_{40\%SPR}$ for each stock-region to evaluate the estimates of Z against; the stochastic approach allowed a more comprehensive inclusion of uncertainty for the key life history and fishery parameters in the model.

A Multivariate Auto-Regressive State-Space (MARSS) model was explored for each stock-region which analyzed river-level surveys and run counts in an attempt to identify underlying trends across rivers within each stock-region. However, the overall performance of this model was poor, indicating an inability to isolate a single consistent trend in abundance across rivers within stock-regions.

Statistical catch-at-age (SCA) models developed during the last benchmark were updated and refined for the Monument (alewife), Nanticoke (alewife and blueback herring), and Chowan (blueback herring) rivers.

A habitat model was developed which modeled population abundance of anadromous river herring as a function of freshwater habitat availability throughout their native ranges (habitat model). This model relies on a combination of biological parameters and habitat distribution in freshwater spawning and rearing environments to project populations through time similar to the American shad model (ASMFC 2020).

6. **If possible, develop methods to calculate a biologically-based cap or limit on bycatch of river herring in ocean fisheries.**

The SAS developed a proof-of-concept example for a bycatch cap based on the data-limited index-based methods simulation-tested as part of the 2020 SAW/SARC Research Track "Topics" Assessment, specifically the iSmooth (aka Plan B Smooth) and iSlope approaches (NEFSC 2020). In the simulations, these approaches were able to rebuild stocks above SSB_{MSY} on average in the long term, and also had the highest median catch among the methods that achieved rebuilding more than 50% of the time (NEFSC 2020). The NEFSC and NEAMAP surveys were used as ocean/mixed-stock indices, and an index from run counts from stock-regions identified as significant contributors to bycatch in the midwater trawl fishery by Reid et al. (2022) was used as a sensitivity run (SNE for alewife, MAT for blueback herring).

The estimated catch caps were lower than both the estimated bycatch and the current bycatch cap across species and fisheries. The total cap for all river herring and shad across the mackerel and Atlantic herring fleets was 490 mt per year over the last three years. The estimates of the alewife catch cap for the coast ranged from a high of 85.2mt for the iSmooth approach with the mixed stock index to a low of 34.4mt for the iSlope approach with the run count index (Table 31). Coastwide bycatch of alewife has averaged 91.7 mt over the last three years. The blueback herring catch cap for the coast ranged from a high of 41.4mt for the iSmooth approach with the mixed stock index to a low of 20.9mt for the iSlope approach with the run count index (Table 31). Coastwide bycatch of blueback herring has averaged 42.5 mt over the last three years.

The iSmooth and iSlope approaches utilize available information on river herring abundance to adjust the bycatch caps instead of using a fixed, historical level. This allows the caps to decrease when river herring abundance is decreasing and increase as river herring abundance increases, making them more responsive to trends in the river herring population. However, there is no mechanistic population model underlying these methods to provide an estimate of what a sustainable level of removals for these populations are. In addition, declines in river herring are only partially driven by ocean bycatch, so reducing incidental catch may not lead to increases in abundance and the TAC would continue to be reduced if the population continued to decline.

Furthermore, the bycatch fishery is operating on the mixed stock population, and the proportion of each run or genetic stock-region that is present in the bycatch is a function of the abundance of each run as well as the time and area where the fishery is operating. The genetic composition of the bycatch is not currently monitored, so even if population-level estimates of bycatch limits could be developed from population models, the current sampling framework could not accurately monitor removals against those caps.

The SAS recommended developing a species-distribution model to determine time-area closures as an alternative or complement to the catch cap approach to reduce river bycatch, which would require less intensive observer sampling to implement. However, the development of that kind of model was beyond the scope of this assessment.

7. Recommend stock status as related to reference points, if available

The coastwide populations of both alewife and blueback herring were still depleted relative to historic levels. The habitat model indicated that overall productivity of all stock-regions for both species is lower than would be expected under virgin habitat conditions. In terms of recent trends, there is no clear signal for either species across the coast. Even within the genetic stock-regions, individual rivers often differed in recent and longer-term trends for both abundance and mortality, with some rivers showing increasing trends and low mortality rates, and others showing flat or declining trends and total mortality rates above the $Z_{40\%SPR}$ reference point.

While the NNE and CAN-NNE stock-regions showed the highest proportion of rivers with positive abundance trends, there were rivers in these stock-regions with high Z rates and/or no sign of increases since 2009. Meanwhile, some rivers in other stock-regions did show positive trends, and the MAT stock-region for both species had the highest proportion of rivers with a low probability of being above the $Z_{40\%SPR}$ reference point. See Table 28 and Table 39 for a river-by-river summary of stock status.

8. Other potential scientific issues

Where available, the SAS compared trends in *Z* estimates to trends in abundance, and found that in most cases, the trends were inversely related, as would be expected if *Z* is affecting abundance. I.e., most rivers with an increasing *Z* trend showed a decreasing abundance trend, and rivers with increasing abundance trends showed a decreasing trend in *Z*. A few rivers showed declines in abundance even though *Z* was stable. However, the majority of rivers with data did not have both a *Z* estimate and an abundance trend.

The habitat model indicated that habitat loss was greatest for the CAN-NNE and NNE stock-regions, but those regions had the highest number of increasing trends along the coast. The northern states have done extensive work to restore access to habitat in multiple stock-regions, but not all rivers have responded. Habitat restoration may be part of the reason the northern stock-regions are showing positive trends, but other factors may be hindering rebuilding in other stock-regions. Reid et al. (2022) noted that bycatch in ocean fisheries is comprised mainly of alewife from the SNE stock-region and blueback herring from the MAT stock-region, areas that have undergone habitat restoration but do not show the same positive trends as the more northern stock-regions.

The literature on the effects of climate change on river herring is not extensive, even less so for blueback herring than for alewife. Alewife and blueback herring have been ranked as “Very High Risk” to climate change by Hare et al. (2016) and as “Vulnerable” by Galbraith and Morelli (2017). This is due to their exposure to multiple factors of climate change impacts and their life history (i.e., temperature-driven spawning runs to their natal freshwater spawning grounds) that make it more difficult for them to adapt to these changes. The direct effects of climate change are difficult to measure. The Gulf of Maine is one of the fastest warming areas in the ocean, but the trends in that region are more positive than in other locations on the coast. Staudinger et al. (2024) found that evidence of changes in the timing (initiation and peak) of spawning runs was mixed, with some populations shifting earlier in recent years, some shifting later, and some not changing. Alewife’s center of biomass has been shifting further north in the NEFSC trawl survey. However, without genetic composition data, it is difficult to determine whether the biomass of the total coastwide population is shifting north, or whether the change in the center of biomass is driven by different patterns in abundance trends in northern vs. southern populations of alewife.

9. **If a minority report has been filed, explain majority reasoning against adopting approach suggested in that report. The minority report should explain reasoning against adopting approach suggested by the majority.**

No minority report has been filed.

10. **Develop detailed short and long-term prioritized lists of recommendations for future research, data collection, and assessment methodology**

High priority short-term recommendations for research and data collection included develop consistent ageing protocols across all states; establishing a database of existing data sources with comprehensive metadata and recommendations for use; expand observer and port sampling coverage including genetic sampling to better quantify incidental catch of river herring; studies to quantify, improve, and implement standard practices for fish passage efficiency; and evaluating and validating hydroacoustic methods to quantify river herring spawning run numbers in major river systems. Continued development of the habitat model or similar models to predict the potential impacts of climate change on river herring distribution and stock persistence and develop targets for rivers undergoing restoration (dam removals, fishways, supplemental stocking, etc.) was a high-priority short term research recommendation for assessment methodology.

High priority long-term recommendations were to conduct regular exchanges or workshops to monitor the precision of ageing across states and maintain or implement river herring-specific surveys, particularly in rivers without run counts or rivers where restoration efforts (e.g., dam removal) will break or end the time series of run counts.

11. Recommend timing of next benchmark assessment and intermediate updates, if necessary relative to biology and current management of the species

The SAS recommends that an assessment update be conducted in five years and a benchmark assessment in ten years. Due to the high variability of fisheries independent surveys, an assessment update at a shorter timeframe will likely not show any significant changes in indices of abundance. New datasets which would warrant a benchmark would require a time-series of at least seven years. If significant improvements to the habitat or other models are achieved before ten years, the benchmark could be accelerated.

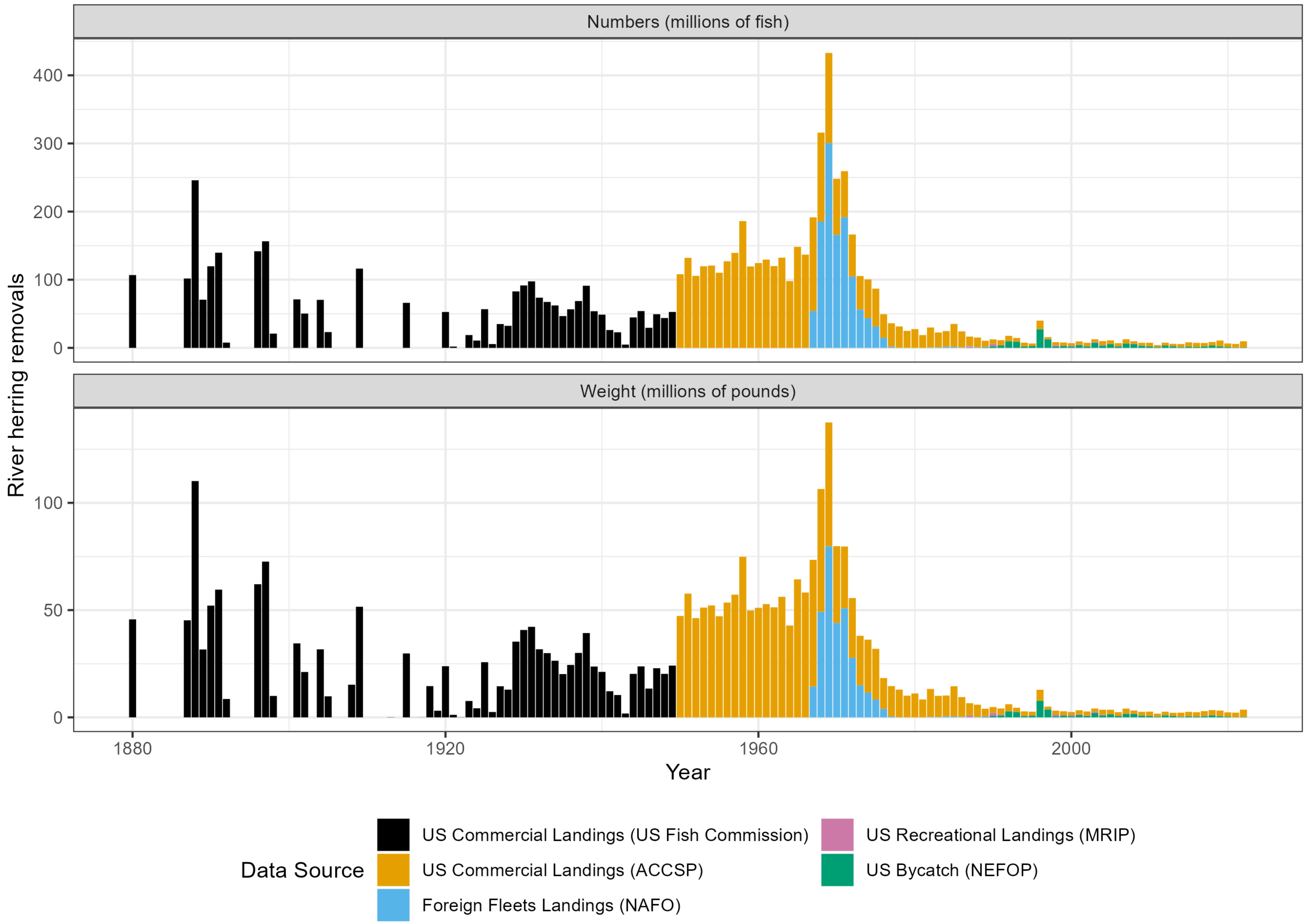

Figure 1. Total removals of river herring by data source, 1880-2022.

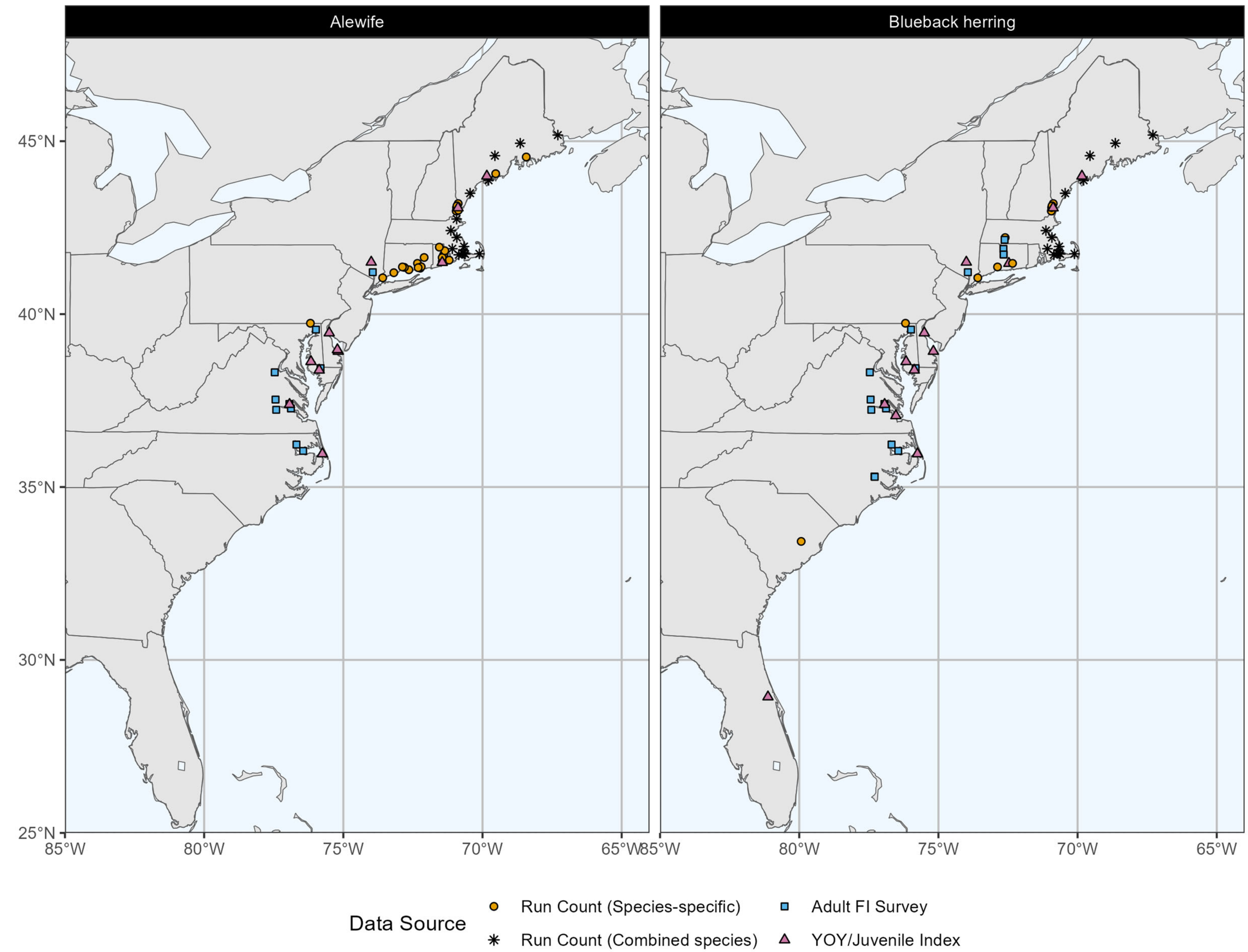

Figure 2. Map of river herring data sources by river and data type.

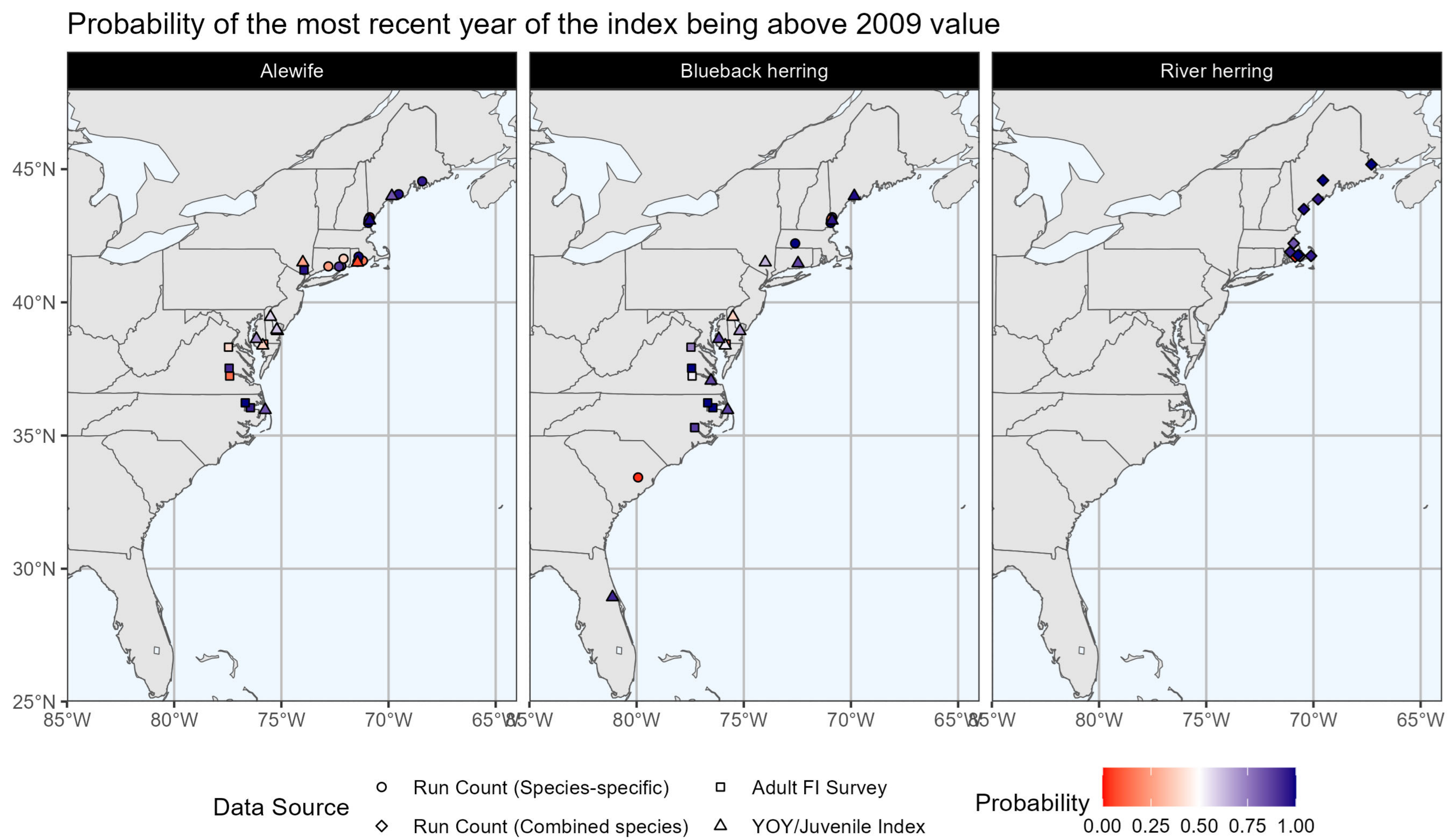

Figure 3. Map of the results of the ARIMA analysis showing the probability that the terminal year of the index is greater than the 2009 value. "River herring" indicates run counts that are not differentiated by species.

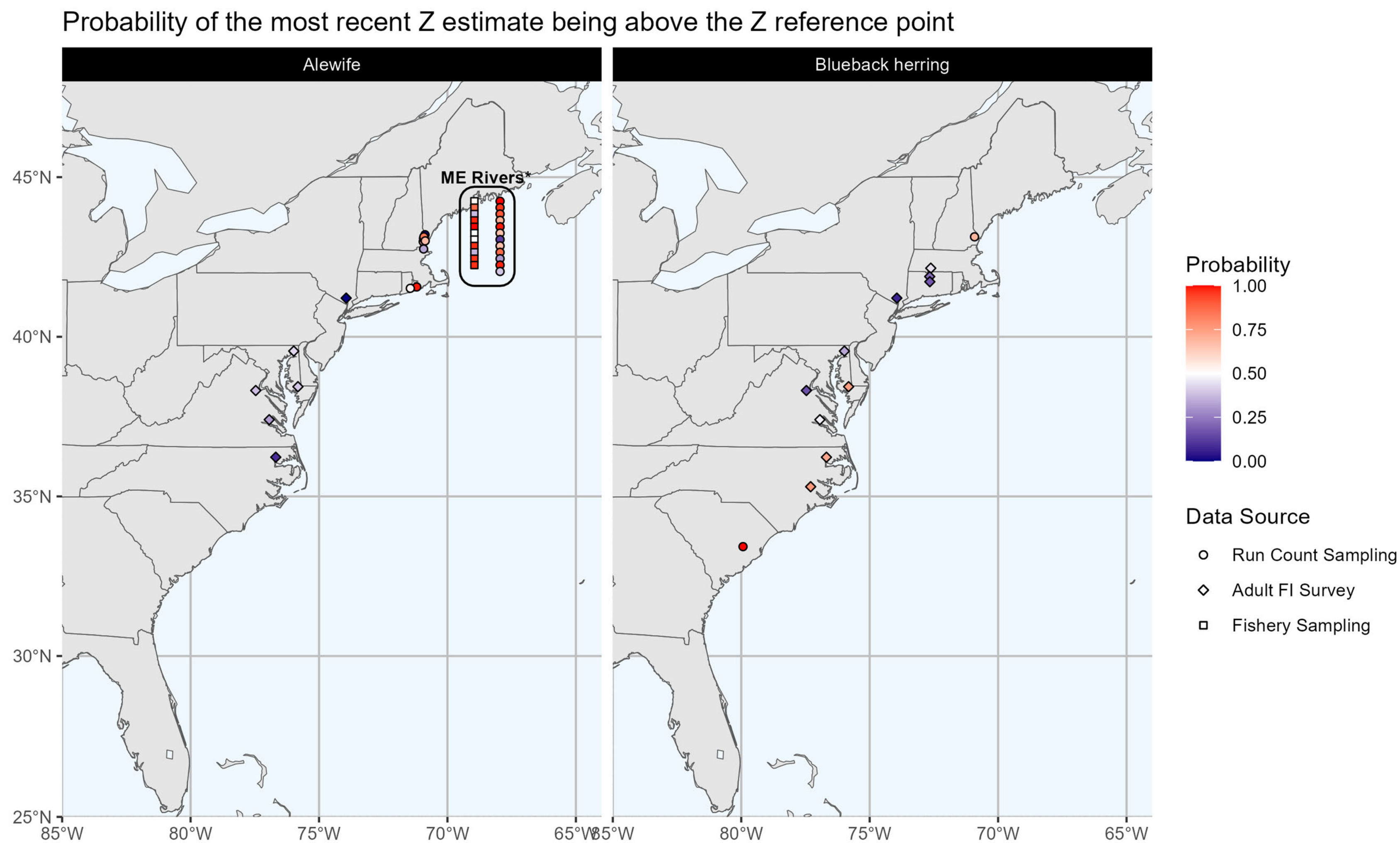

Figure 4. Map of the probability that the most recent Z estimate is above the $Z_{40\%SPR}$ reference point. *ME Rivers: Maine rivers are not plotted geographically to preserve confidentiality.

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Jeff Pierce
Director, Alewife Harvesters of Maine

July 15, 2024

Dear Chairwoman Fegley,

This letter is in response to the ongoing ASMFC stock assessment process for river herring.

The Alewife Harvesters of Maine support this process and would like to express our appreciation to the ASMFC and River Herring Stock Assessment Sub-Committee for their commitment to determine current stock status and develop management recommendations. However, we are concerned by what is **not** addressed in this report and would like to request that the ASMFC include and consider (in their assessment of river herring stocks) the current effects of local, harvest centered, stewardship efforts that positively affect river herring populations.

Stock assessments look at population trends, biological data, and consider pressures and stressors on populations that affect populations in either a positive or negative way. We are concerned that while stock assessments do a comprehensive job of looking at traditional fisheries metrics, they miss the mark in looking at the effects of harvester-based stewardship and how incentivizing these practices will benefit river herring populations in Maine and other states.

Through previous river herring assessments and Management Board actions, the ASMFC and TC developed specific recommendations for metrics that should be met for a directed commercial fishery to occur. These metrics apply standard fisheries management practices and techniques to avoid applying too much pressure to one stock.

There is one problem. These metrics follow a traditional assumption that a fishery (and therein, the fisherman) has only one effect on populations, and that is to catch and remove fish from the population. The end results are recommendations on how not to catch too many fish, or how to avoid disproportionately and adversely affecting certain age classes or sub populations that might have a larger significance for a biological or other reason (like protecting more fecund individuals in a population.) What this traditional thinking leaves out is the potential that fishermen and fisheries (in some cases) may have a net positive effect on populations, and if conducted in the right way, is something that should be incentivized and supported rather than curtailed and prevented.

The AHOM recognizes this argument sounds typical of a fishing advocacy organization that just wants to catch more fish. But we are not arguing for any specific new fishery openings and we are not asking for higher harvest levels. We are looking for an analysis of the effects of single stock, single fisherman, freshwater fisheries, conducted by fishermen that are catching fish from the same stock. One where fishing effects (positive or negative), will be felt by the same individual fisherman in the future.

This unique scenario is the tradition in Maine river herring fisheries and we believe that it is one of the most significant reasons why Maine is the last stronghold for river herring populations coastwide. In 2024 Maine had several river herring runs returning more than 1-million fish, with some runs topping 5-million adult returns. There is effective individual and community-based ownership in these fisheries that supports the collection of individual population level data through the harvesters or potential harvesters that are collecting the 10 years of data currently required to open a

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fishery. These harvest based stewardship activities give managers data required to effectively manage and restore additional river herring populations.

Harvester-based activities also support downstream passage by keeping migration corridors open to post spawn and juvenile river herring. These effects might not reflect any significant importance in models and forecasts, but that is because they have not been studied in the manner that fishing practices are addressed. There is simply no recognition of post spawn and juvenile emigration success in many of the existing models.

One question to consider is "What effects would there be on future river herring populations if existing local harvest activities were stopped?" The first thing that would happen is that ASMFC would no longer receive fishery biological (fisheries dependent or fisheries independent, in the case of a municipality trying to start a harvest) data associated with individual river herring populations. If harvesting is prohibited, managers lose a significant source of biological data for assessment and management actions. Maine's commercial river herring harvesters don't just count fish and collect scales for aging. Maine's river herring harvesters are knowledgeable professionals that oversee the annual river herring runs during their daily presence at the harvest location and during the critical periods of downstream migration for post spawn adults and juvenile river herring. Harvesters clear debris from streams, including beaver dams that can individually shut off hundreds of thousands (millions in some cases) of fish that are heading to their spawning grounds. These harvesters give tours of streams, river herring runs, and create the outreach and education opportunities that engage future stewards to become involved. This will be the reason these fisheries still exist in 100 years. The list of potential benefits goes on but we sincerely believe these dedicated individuals are important to the continued success the state of Maine is seeing in increasing river herring populations.

To be clear, we are not asking for some kind of blanket opening of all fisheries. Clearly, there is still an important place for safeguards and restrictions to mitigate potential risks of fishing. But without considering benefits of harvest, we believe the ASMFC is missing a large piece of the picture that has made Maine the leader in river herring recovery. It is also clear from losses of other fisheries that institutional knowledge and ownership can be lost in an instant if it is not recognized and used to best manage the fishery.

We ask that, before this stock assessment is approved, that the River Herring & American Shad Management Board make certain that this important part of the picture is included in how we manage river herring fisheries into the future.

Thank you for your time and consideration and please don't hesitate to reach out with any questions.

Sincerely,

Jeff Pierce

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