Atlantic States Marine Fisheries Commission

Executive Committee

October 23, 2024
8:00 – 10:00 a.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.

A portion of this meeting may be a closed for Committee members and Commissioners only.

1. Welcome/Call to Order *(J. Cimino)*

2. Board Consent
   - Approval of Agenda
   - Approval of Meeting Summary from August 2024

3. Public Comment

4. Review and Consider Approval of FY24 Audit (*L. Leach*)

5. Legislative Update (*A. Law*)

6. New ASMFC Website Demo, if time allows (*T. Berger/K. Cunningham*)

7. Future Annual Meetings Update

8. Other Business/Adjourn

The meeting will be held at The Westin Annapolis (100 Westgate Circle, Annapolis, Maryland; 88.627.8994) and via webinar; click here for details.

DRAFT MEETING SUMMARY OF THE

ATLANTIC STATES MARINE FISHERIES COMMISSION

EXECUTIVE COMMITTEE

Westin Crystal City
Arlington, VA

August 7, 2024

For Review and Action by the Executive Committee October 23, 2024

INDEX OF MOTIONS

ATTENDANCE

Committee Members

Pat Keliher, ME
Cheri Patterson, NH
Dennis Abbott, NH (LA Chair)
Dan McKiernan, MA, Vice Chair
Jason McNamee, RI
Justin Davis, CT
Marty Gary, NY
Joe Cimino, NJ, Chair
Kris Kuhn, PA
Roy Miller, DE (GA Chair)
John Clark, DE
Lynn Fegley, MD
Jamie Green, VA
Chris Batsavage, proxy for Kathy Rawls, NC
Ben Dyar, SC
Doug Haymans, GA
Erika Burgess, FL

Other Commissioners/Proxies

Pat Geer, VMRC AA proxy
Jim Gilmore, NY
Allison Hepler, ME LA
Gary Jennings, FL GA
Ray Kane, MA GA
Robert LaFrance, CT GA Proxy
John Maniscalco, NY DEC
Nichola Meserve, MA DMF
Eric Reid, RI LA proxy
Dave Sikorski, MD LA proxy
Megan Ware, ME DMR
Renee Zobel, NH F&G

Staff

Bob Beal
Alexander Law
Laura Leach
Madeline Musante

Guests

Margaret Conroy, DEDNREC
Chip Lynch, NOAA
Brian McManus, FFWC
Allison Murphy, NMFS
Ronald Owens, PRFC
Will Poston, ASGA

CALL TO ORDER
The Executive Committee of the Atlantic States Marine Fisheries Commission convened August 7, 2024 in the Jefferson Ballroom at The Westin Crystal City in Arlington, Virginia. The meeting was called to order at 8:05 a.m. by Chair Joe Cimino.

APPROVAL OF AGENDA
The agenda was approved as presented.

APPROVAL OF SUMMARY MINUTES
The summary minutes from the May 1, 2024 meeting were approved as presented.

PUBLIC COMMENT
There was no public comment.

LEGISLATIVE COMMITTEE UPDATE
Legislative Program Coordinator Alexander Law provided an update to the Executive Committee on the strengths of the FY25 Senate CJS bill, and plans to garner support for provisions which are of benefit to ASMFC. William Hyatt presented on Senator Shaheen's (NH) State Boating Act, and urged the Executive Committee to support the bill. Next, there was a Q&A session with Anderson Tran of Congressman Graves's office on the Fisheries Data Modernization and Accuracy Act of 2024. Mr. Tran committed to continuing to work with the Commission to develop bill language that considers the priorities of the Atlantic coast. Updated draft language will be circulated in the fall for discussion.

FUTURE ANNUAL MEETING LOCATIONS

Mrs. Leach provided an update on future Annual Meeting locations. In October 2024 the Annual Meeting will be in Annapolis, Maryland; in 2025 Delaware; in 2026 Rhode Island; in 2027 South Carolina; in 2028 Massachusetts; in 2029 Pennsylvania and in 2030 Georgia.

ADJOURN
The Executive Committee adjourned at 9:20 a.m.

Atlantic States Marine Fisheries Commission

Business Session of the Commission

October 23, 2024; 10:15 - 11:15 a.m.
October 24, 2024;11:15 – 11:30 a.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.

October 23

1. Welcome/Call to Order *(J. Cimino)*

2. Board Consent
   - Approval of Agenda
   - Approval of Proceedings from January 2024

3. Consider Approval of 2025 Action Plan **Final Action**

4. Consider Noncompliance Recommendations, if necessary **Final Action**

5. Elect Commission Chair and Vice-Chair **Final Action**

6. Other Business

October 24

7. Reconvene *(J. Cimino)*

8. Consider Noncompliance Recommendations, if necessary **Final Action**

9. Other Business/Adjourn

The meeting will be held at The Westin Annapolis (100 Westgate Circle, Annapolis, Maryland; 88.627.8994) and via webinar; click here for details.

DRAFT PROCEEDINGS OF THE

ATLANTIC STATES MARINE FISHERIES COMMISSION

BUSINESS SESSION

The Westin Crystal City
Arlington, Virginia
Hybrid Meeting

January 25, 2024

These minutes are draft and subject to approval by the Business Session.
The Board will review the minutes during its next meeting.

TABLE OF CONTENTS

INDEX OF MOTIONS

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

2. **Approval of Proceedings of October 18, 2023** by consent (Page 1).

3. **On Behalf of the Lobster Board move the Commission send a letter to NOAA Fisheries to withdraw the Commission's recommendation to implement the measures of Sections 3 and 4, except Sections 3.1.1 and 3.2.1 transfers of multi-LCMA Trap Allocation of Addendum XXI and all of Addendum XXII** (Page 2). Motion by Jason McNamee; second by Cheri Patterson. Motion passes by consent (Page 2).

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

ATTENDANCE TO BE FILLED ON A LATER DATE

The Commission Business Session of the Atlantic States Marine Fisheries Commission convened in the Jefferson Ballroom of the Westin Crystal City Hotel, Arlington, Virginia, via hybrid meeting, in-person and webinar; Thursday, January 25, 2024, and was called to order at 10:45 a.m. by Chair Joe Cimino.

CALL TO ORDER

CHAIR JOE CIMINO: I'm calling to order the Commission's Business Session. We do have a couple agenda items that we need to cover here.

APPROVAL OF AGENDA

CHAIR CIMINO: I'm going to ask if there are any, excuse me, are there any additions to the agenda? Toni, do you want to do this formally as an addition?

MS. TONI KERNS: Yes.

CHAIR CIMINO: We have one from, Toni, go ahead.

MS. KERNS: During Policy Board we forgot about a letter that the American Lobster Board asked us to send to NOAA Fisheries on rulemaking, pertaining to Addendum XXI and XXII, so the Board Chair will bring that up.

CHAIR CIMINO: Yes, we'll cover that. Unless there are any other additions or concerns, I'm going to assume that we can approve the agenda with that addition. I don't see any hands up.

APPROVAL OF PROCEEDINGS

CHAIR CIMINO: We'll move on to approval of the proceedings from the annual meeting of October, '23. I see a hand, Doug.

MR. DOUGLAS E. GROUT: Just briefly. It indicates on the time page that we met there in 2022 instead of 2023.

CHAIR CIMINO: Well, thank you, that's a great catch. That was one of those Easter eggs that we just put out there every once in a while, make sure somebody is looking. You win the prize there, thank you. I appreciate that. We'll make that edit. If there are no other edits.

MR. GROUT: I'm glad to offer my services.

CHAIR CIMINO: I love it, I love it. The proceedings approved width that edit. It's a very important edit, I may add.

PUBLIC COMMENT

CHAIR CIMINO: Are there any public comments for the Business Session here? We do have some folks from the public, but I don't see any hands, and no online. Okay, great.

CONSIDER APPROVAL OF REVISION TO 2024 ACTION PLAN

CHAIR CIMINO: We'll move on. Toni will cover the Action Plan.

MS. KERNS: Thank you, Mr. Chairman, and I just have one slide and I'll talk while that slide gets put up. But the Commission Summer Flounder, Scup, and Black Sea Bass Management Board met with the Mid-Atlantic Council in December, to set recreational specifications.

ADDITION TO GOAL 1 TO DEVELOP AN ACTION WITH THE MID-ATLANTIC FISHERY MANAGEMENT COUNCIL FOR SUMMER FLOUNDER COMMERCIAL MEASURES

MS. KERNS: Also, during that time there was a discussion on the summer flounder flynet definition, and boundaries of the small mesh exemption area.

Both bodies agreed to take up this issue, or their intent to take up these issues immediately in 2024, in order to address changes in time for NOAA to promulgate regulations by November of this year. This issue was not included in the Commission's Action Plan, so we wanted to see if the Commission would consider adding it to the Action Plan, so we can have similar regulations if changes are made.

The reason why we would put these regulations in the Commission's FMP is because states have these regulations in their definitions, in particular for the flynet definition, as well as some states reference the exemption areas, while the measures are pertaining to mostly federal water fisheries, it is important to have cohesiveness between the two FMPs.

The one thing to note for this, and this is something that we did not discuss at the Council meetings, because we weren't sure how it would impact the timeline of work that these two management bodies are doing, as well is that there is an amendment on sector separation and recreational accountability that the Policy Board is working on with the Mid-Atlantic Council.

Because of this work on the summer flounder commercial measures, that work would be pushed back, and would be addressed at the earliest in the fall of this year. That would be presenting a scoping document for recreational accountability and the sector separation, and I can take any questions.

CHAIR CIMINO: Questions for Toni. I realize not every member state is paying close attention to this, but you know although this is a longstanding issue, we feel like it is something that needs to be addressed. I was glad to see the Mid take action, and most likely doing the heavy lifting on this. I'll just ask if there is any objection to adding this to our Plan for 2024.

I don't see any objections. I personally really appreciate that. I would like to get this straightened out. With no objections we'll move forward on that. Well, let's cover the lobster letter that we have as an added agenda item. We have a motion on the board, so Jason, if you don't mind.

DR. JASON McNAMEE: **On behalf of the Lobster Board, move the Commission to send a letter to NOAA Fisheries to withdraw the Commission's recommendation to implement the measures of Section 3 and 4, except Sections 3.1.1 and 3.2.1; transfers of multi-LCMA trap allocation of Addendum XXI, and all of Addendum XXII.**

CHAIR CIMINO: Great, thank you, do we have a second for that motion? Cheri Patterson from New Hampshire, thank you. Any discussion on this motion? Yes, go ahead, Toni, sorry.

MS. KERNS: Just to add to the record that the Board, as Pat talked about at the Policy Board, did note the intention of us expressing to NOAA Fisheries how we intend the Mitchell Provision to apply to the minimum size. Oh, that is for a different letter, and I'm so sorry. Never mind.

CHAIR CIMINO: No problem. We're still going to have that on the record. We'll have that on the record as much as possible. However, yes, that does not necessarily apply to this motion. Any further discussion on this motion? **Any objection to this motion? Not seeing any. We'll consider that passed by unanimous consent**.

REVIEW AND CONSIDER APPROVAL OF 2024-2028 STRATEGIC PLAN

CHAIR CIMINO: With that I'm going to turn it over to Bob to go over the 2024 to 2028 Strategic Plan.

EXECUTIVE DIRECTOR ROBERT E. BEAL: Great, thank you, Mr. Chair. In the interest of time, and recognition of the fact that most folk around the table were here at the Executive Committee yesterday when I went over this in fairly high detail. I'm just going to go over some of the changes that were agreed to at the Executive Committee yesterday, then I'm happy to answer any questions.

But the idea is that we are seeking approval of this document at this point. It's been a couple iterations have gone past the Executive Committee; you know it was brought up at the Policy Board at the annual meeting. The suggested staff edits were included in briefing materials for the Executive Committee, and for this Business Session.

With that, there are a couple of highlights worth noting that were not reflected in the edits that are included here. At the top of Page 2 we're going to insert recognition that we also partnership and work with U.S. Fish and Wildlife Service and USGS. Then moving down along the majority of this was approved, or recommended for approval as edited yesterday.

Then getting down into goals themselves. Goal 1, there were no recommended changes yesterday, and Goal 2, Jason McNamee brought up the notion that a lot of pieces of Goal 2 kind of look like MSE. But we're going to put a specific reference to Management Strategy Evaluations included as one of the bullets in Goal 2.

Then moving along, actually, I missed one item, two items. Okay, so on Page 8 there is a notion about, well the bullet reads, promote sustainable harvest and access to rebuild fisheries. There is a side note there about, this might take some further discussion. The Executive Committee felt that it was okay as written, so we're going to maintain that in Goal Number 1, as it's written.

Then in Goal 2, there is a note, same idea that this may warrant some more discussion for the bullet that reads, balance request from fishery management with finite assessment workload capacity. There was some good discussion on that yesterday, but ultimately, the Executive Committee recommended that we keep that the same.

Then no changes to Goals 3, 4, and 5. When we went down to Goal 6, there was a conversation about some of the sort of new approaches and strategies that some of our stakeholders have, as far as commenting and generating a lot of press and a lot of e-mail activity and social media activity that really isn't accurate, based on some of the science that the Commission has. There is a suggestion that we include a bullet there that really goes at, directly and proactively, engaging and commenting on some of the Commission management decisions and scientific information to prevent, or at least reduce some of the misinformation that is out there for some of these topics. Throughout the document there is also references to offshore wind/renewable energy. We're going to balance that out.

The offshore wind does take a lot of the bandwidth for a lot of the states, and some of the Commission activities, but there are also other renewable energy activities that are out there that may be emerging and may become an issue for the fish. We'll balance that out a little bit better throughout the document.

Other than the staff suggested edits, those few that I just mentioned really are all the other changes that we will weave into this document. The idea is, if the Commission is comfortable approving this today, you can do that. Staff will update the document and publish it on the website, and share it with all the Commissioners. Happy to answer any questions, but those are the highlights of the suggested changes.

CHAIR CIMINO: Thank you, Bob, any questions or comments for Bob? Not seeing any; as noted previously in our Policy Board discussions, we don't have any noncompliance findings.

ADJOURNMENT

Is there anything else to come before us today? Not seeing anything, any hands online? Well, it's great with that, I'll entertain a motion to adjourn. John Clark, second by Lynn Fegley. That is Delaware and Maryland. The folks closest to home are ready to go. Good for you, safe travels everyone.

(Whereupon the meeting adjourned at10:57 a.m. on Thursday, January 25, 2024)

Atlantic States Marine Fisheries Commission

Shad and River Herring Management Board

October 23, 2024
11:30 a.m. – 12:15 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*)	11:30 a.m.
2.	Board Consent • Approval of Agenda • Approval of Proceedings from August 2024	11:30 a.m.
3.	Public Comment	11:35 a.m.
4.	Consider Updates to Shad and River Herring Sustainable Fishery Management Plans (SFMPs) *(W. Eakin)* **Action** • New Hampshire River Herring SFMP and Proposal to Reopen Fishery • Maine River Herring SFMP • Massachusetts American Shad SFMP • Connecticut American Shad SFMP	11:45 a.m.
5.	Review Advisory Panel Report on 2024 River Herring Benchmark Assessment *(P. Lyons Gromen)*	12:05 p.m.
6.	Other Business/Adjourn	12:15 p.m.

The meeting will be held at The Westin Annapolis (100 Westgate Circle, Annapolis, Maryland; 888.627.8994) and via webinar; click here for details

MEETING OVERVIEW

Shad and River Herring Management Board Meeting
October 23, 2024
11:30 a.m. – 12:15 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: August 7, 2024
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 August 2024

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 Updates to Shad and River Herring Sustainable Fishery Management Plans (11:45 a.m.-12:05 p.m.) Action
Background • Amendments 2 and 3 to the Shad and River Herring FMP require all states and jurisdictions that have a commercial fishery to submit a sustainable fishing management plan (SFMP) for river herring and American shad, respectively. Plans are updated and reviewed by the Technical Committee (TC) every five years. • Massachusetts and Connecticut submitted updated SFMPs for American shad (**Briefing Materials**). • Maine and New Hampshire submitted updated SFMPs for river herring (**Briefing Materials**). • New Hampshire also submitted a proposal to reopen the river herring fishery, which has been closed since 2021 due to a failure to reach its fishery-independent sustainability metric in 2019 (**Briefing Materials**).
Presentations • Shad and River Herring SFMP Updates for Board Consideration by W. Eakin
Board actions for consideration at this meeting • Consider approval of updated SFMPs for Maine, New Hampshire, Massachusetts, and Connecticut, as well as approval of New Hampshire's proposal to reopen the river herring fishery.

5. Review Advisory Panel Report on 2024 River Herring Benchmark Assessment (12:05-12:15 p.m.)
Background • The Advisory Panel met to review the 2024 River Herring Benchmark Assessment and provide additional input for Board consideration (**Supplemental Materials**).
Presentations • Advisory Panel Report by P. Lyons Gromen

6. 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 and River Herring 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

The Westin Crystal City
Arlington, Virginia
Hybrid Meeting

August 6, 2024

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.

TABLE OF CONTENTS

INDEX OF MOTIONS

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

2. **Approval of Proceedings of October 16, 2023** by consent (Page 1).

3. **Move to accept the 2024 River Herring Benchmark Stock Assessment and Peer Review Report for management use.** (Page 21) Motion by John Clark; second Cheri Patterson. Motion passes by unanimous consent (Page 21).

4. **Move to adjourn** by consent (Page 22).

ATTENDANCE

Board Members

Pat Keliher, ME (AA)
Rep. Allison Hepler, ME (LA)
Cheri Patterson, NH, (AA)
Doug Grout, NH (GA)
Dan McKiernan, MA (AA)
Sarah Ferrara, MA, proxy for Rep. Peake (LA)
Ray Kane, MA (GA)
Phil Edwards, RI, proxy for J. McNamee (AA)
Eric Reid, RI, proxy for Sen. Sosnowski (LA)
Dr. Justin Davis, CT (AA)
Bill Hyatt, CT (GA)
John Mansicalco, NY, proxy for M. Gary (AA)
Jim Gilmore, NY, proxy for Sen. Thiele (LA)
Emerson Hasbrouck, NY (GA)
Heather Corbett, NJ, proxy for J. Cimino (AA)
Adam Nowalsky, NJ, proxy for Sen. Gopal (LA)
Kris Kuhn, PA, proxy for T. Schaeffer (AA)
Loren Lustig, PA (GA)
John Clark, DE (AA)
Craig Pugh, DE, proxy for Rep. Carson (LA)
Roy Miller, DE (GA)
Lynn Fegley, MD
Allison Colden, MD, proxy for Del. Stein (LA)
Pat Geer, VA, proxy for Jamie Green (AA)
Chris Batsavage, NC, proxy for K. Rawls (AA)
Chad Thomas, NC, proxy for Rep. Wray (LA)
Mel Bell, SC, proxy for Sen. Cromer (LA)
Malcolm Rhodes, SC (GA)
Spud Woodward, GA (GA)
Erika Burgess, FL, proxy for J. McCawley (AA)
Gary Jennings, FL (GA)
Ron Owens (PRFC)
Daniel Ryan (DC Fisheries) proxy for R. Cloyd
Rick Jacobson (USFWS), proxy for Wendi Weber

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

Staff

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

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.

The Shad and River Herring Management Board of the Atlantic States Marine Fisheries Commission convened in the Jefferson Ballroom of the Westin Crystal City Hotel, Arlington, Virginia, via hybrid meeting, in-person, and webinar; Wednesday, August 7, 2024, and was called to order at 4:15 p.m. by Chair Lynn Fegley.

CALL TO ORDER

CHAIR LYNN FEGLEY: Welcome, everyone, to the Shad and River Herring Board meeting. I am Lynn Fegley, from the state of Maryland, and I am happy to serve as your Chair today. I have up with me, James Boyle, Dr. Katie Drew, Dr. Margaret Conroy, and also Dr. Adrian Jordaan is online, who is going to deliver our Peer Review.

I also want to point out that we have members of the Council online, and we're going to offer them an opportunity to ask questions after the Board discusses the Stock Assessment Report. We're going to be looking for one action today will require a motion, so please, be ready for that. I'll start with Board Consent.

APPROVAL OF AGENDA

The first thing is Approval of the Agenda. Does anybody have any changes or adjustments to the agenda they would like to propose? Okay, seeing none; is there any opposition to the agenda as it stands? Okay, we consider the agenda approved by consent.

APPROVAL OF PROCEEDINGS

CHAIR FEGLEY: The next one is approval of proceedings from October, 2023.

I was told to note that there are some inaccuracies, there are some people missing from the attendance list. Staff is working on correcting that. Is there any other changes or edits needed to the October proceedings? Okay, is there any opposition to the proceedings? All right, we'll consider that approved by consent.

PUBLIC COMMENT

CHAIR FEGLEY: Next on the agenda is public comment. Is there anybody in the room or online who would like to make comment on things that are not on the agenda? Okay, seeing no public comment, we are going to roll right into our agenda.

CONSIDER 2024 RIVER HERRING BENCHMARK STOCK ASSESSMENT

CHAIR FEGLEY: The first thing we're going to get is a Presentation of the Stock Assessment Report, and we're going to have that from Dr. Drew and Dr. Conroy, so take it away.

2024 RIVER HERRING BENCHMARK STOCK ASSESSMENT

DR. MARGARET CONROY: I am going to be presenting to you the 2024 River Herring Benchmark Stock Assessment. This Stock Assessment is a product of the ASMFC River Herring SAS and the Shad and River Herring TC. River herring is still a data poor species complex that is challenging to assess but we've made some progress since the 2012 Benchmark. We have an improved understanding of the stock structure. We've added some new datasets. We have abundance trends and/or mortality estimates for 84 rivers representing 105 stocks of river herring. We have refined the methods for trend analysis and Z estimates, and we have some new modeling approaches, including hierarchical growth model for each species, as stochastic SPR reference point model, a habitat model and have done some work on data-limited bycatch cap options.

In this presentation I will go through stock structure, then data, methods, stock status followed by bycatch caps and research recommendations. For stock structure, for the last benchmark we assessed river herring at the river level, and then pooled up to states to summarize the trends, and we developed Z reference points as a coastwide level.

But the SAS felt that using stock regions to pool data and summarize trends was more biologically meaningful than using states. In this assessment we assessed alewife and blueback herring at the river level wherever possible. Then used genetic stock regions to pool data where necessary for reference points and to summarize trends.

Our stock regions are based on genetic work by Reid et al. (2018). Here you see our stock regions, on the left are alewife, on the right are blueback herring. The points are the points that were used by Reid et al to determine these. For alewife we used three stock regions, the Northern New England, Southern New England and Mid-Atlantic.

For blueback herring we used five regions, Canada, Northern New England, of course we used only the U.S. portion of this region, Mid-New England, Southern New England, Mid-Atlantic and South Atlantic. Moving on to data. We're going to talk about landings and bycatch, and then indices and run counts.

Our total removals are going to be presented as river herring removals, because it is difficult to separate by species, especially for the historical landings. We present in weight and numbers, which means some translation there, so commercial landings and bycatch and weight are converted to numbers.

Recreational total catch in numbers is converted to weight. Our conversions are based on the average size of river herring for each sector, where sampling was available. Here are our total removals in weight. Note that the historical ones may be incomplete. The yellow is the U.S. commercial landings from ACCSP, the blue is the foreign fleet landings, the pink is the U.S. recreational landings, and the green is bycatch.

We see here that the total removals have declined significantly since the 1950s and '60s, and in the last 10 years total removals averaged about 2.67 million pounds per year, with just about 4 percent of the reported landings at the height of the directed fishery. The overall pattern is similar for removals in numbers of fish, which are shown here.

In the last 10 years the total removals average 6.83 million fish per year, which is approximately 4 percent of the average reported landings as at the peak of the directed fishery. If we zoom in on the more recent years, we can see that there hasn't been much of a trend in total removals since the mid-1990s. Note that the estimates of recreational catch start in 1982, again those are in the pink, and the estimates of bycatch start in 1989 in the green. Recreational removals have generally been small and have high PSEs, and bycatch estimates make up a significant component of the current removals. Here you see the proportion of river herring removals for those recent years, and again we see the commercial landings in yellow, foreign fleet landings in blue, recreational landings in pink, and bycatch in green.

Note that bycatch has been about 30 to 75 percent of removals since 1989. It was much lower than average in 2020 to 2022. Let's look at that recent change. On the left here are some numbers from 2005 to 20019, and we'll call that the older period, and 2020 to 2022 we will call that the recent period. You note that the estimates of bycatch for 2022 were lower than in previous years, and they made up a smaller percentage of the overall removals.

The bycatch averaged about 757,000 pounds per year in that older period, whereas it was only about 200,000 pounds per year in the recent period. That translates to about 281 million fish per year in the older period versus 0.75 million fish per year in the recent period. In the older period it was about 20 percent, the bycatch was about 27 percent of total removals in weight, and 35 percent have showed a removal in numbers, whereas in those recent three years was about only 7.5 percent of total removals in weight, or 10 percent of total removals in numbers.

This is due in part to lower effort in Atlantic herring and mackerel fleets in recent years, but there was also lower observer coverage and port sampling in those years, especially in the Mid-Atlantic midwater trawls. Bycatch makes up a higher proportion of total removals by numbers, because the average size of the river herring in the bycatch is smaller than the river herring in the in-river fisheries. Here we see the bycatch length composition, with alewife on the left and blueback herring on the right.

The top row is the in-river directed fishery sampling, the middle row is the in-river fishery independent sampling, and the bottom is the NEFOP bycatch sampling. Length information collected by observers shows that the ocean bycatch, that bottom panel, contains small river herring, defined here as less than 200 millimeters that are not seen in in-river monitoring, indicating that the ocean fisheries are catching juvenile and immature river herring, as well as mature adults.

Moving on to data, so our run counts and indices. The TC reviewed a wide range of state, federal and academic datasets, and in deciding what to use in a trend analysis, a run count or survey was used if it had 10 or more years of data, had consistent methodology or changes in methods were accounted for, and it encountered river herring in at least 10 percent of the trials over the time period.

Some surveys or run counts with less than 10 years of data were accepted for use in the next assessment update. For alewife we used 52 datasets for trend analysis, 23 of those are run counts, 10 are adult in-river surveys, 11 are recruitment surveys and 8 are ocean mixed-stock surveys.

For blueback herring, we used 42 datasets for the trend analysis, that is 10 run counts, 13 adult in-river surveys, 12 recruitment surveys and 7 ocean mixed-stock surveys. In addition, we had 14 run counts that are not separated to species. Now the SAS assumes that run counts are more like indices than true population counts. They represent trends in abundance, but other factors like passage rate, amount of spawning habitat below the page level counts, environmental factors, et cetera. I mean we don't know how much of the spawning population is actually being counted each year.

The different types of datasets are not distributed equally across the coast. These maps show alewife on the left, blueback herring on the right, and the data sources by shape. Run counts, if they are species specific, are shown by yellow circles here. If they are combined species they are shown by an asterisk.

The adult fishery independent surveys are shown by a blue square, and the pink triangle denotes young of year or juvenile indices. You will note that most of the run counts are in the northern region, and most of the surveys are in the Mid-Atlantic Region. The South Atlantic Region for blueback herring is particularly data poor.

That was our data, now we're going to move on to methods. For methods we will first seek a trend analysis, then on mortality comparisons to reference points, and then the habitat model. For trend analysis we looked at Mann-Kendall trends, which detect an increasing or decreasing trend over the time series.

We also looked at auto aggressive integrated moving average. We used that to minimize measurement area and decreased variants, and then we looked at the probability that the terminal year of that ARIMA index is greater than either the reference year of 2009, or greater than the 25th percentile of the time series.

We used 2009, which was the year Amendment 2 was adopted for river herring as the reference year, to try to address the question of whether river herring abundance has changed since management action was taken. This trend analysis was applied to run counts, indices, and life history characteristics.

We found very few significant trends in our life history trends analysis, so that would include maximum age, mean length, mean length at age, and percent repeat spawners. There are also some difficulties interpreting those trends. For example, does declining recruit spawner percentage indicate decreased survival in elder fish, or does it indicate that there is higher recruitment and more first-time spawners?

It was hard to determine that without a lot of additional data on recruitment or abundance. Because of this, the TC/SAS did not rely on these results for status information, but you can look at the assessment report for detailed results. After the trend analysis, we looked at total mortality compared to reference points.

We estimated Z from age data from in-river monitoring using the Poisson GML method. We used the age of full maturity as the age of full selectivity, which was Age 5 for most of the stock region. We applied this for years with at least 30 samples of at least 3 fully selected ages. Then we calculated a stochastic Z 40 percent SPR reference point. To do this, instead of using point estimates for the input, like mortality, maturity, et cetera, we drew from distribution of parameters, and created a distribution of Z 40 percent SPR estimates. We developed these reference points for each stock region. The probability of Z being above the Z 40 percent SPR reference point incorporates uncertainty from both the Z estimates and the reference point.

Note that our total mortality was based on adult mortality only, with no influence of juvenile mortality. Another way that we tried to assess the data was by using a habitat model. This model is a simulation model to look at the affects of habitat loss on the productivity of alewife and blueback herring in each stock region.

It is similar to the model that would be used for American shad during the 2020 benchmark, but the life history information and habitat data were updated to reflect alewife and blueback herring stock regions. All of our results are in the Assessment Report in detail. If you look at Table 20 and Table 39, it gives you a river-by-river summary.

In this presentation, I'm going to summarize the results coastwide and by stock region. The tables that I will show you, the Mann-Kendall Trend over the entire time series, the Mann-Kendall Trend since 2009, the probability of the latest year of the ARIMA being above the 25th percentile, and also of it being above the index of the 2009, and the probability of Z being above the Z 40 percent SPR reference point in the most recent year..

On to stock status. We're first going to discuss what we learned from the habitat model, then the Mann-Kendall Trends, then the ARIMA comparison to reference and then the total mortality comparison to reference. There are a lot of stock status challenges for river herring. River herring abundance is affected by a number of factors.

Affected by directed fishing, bycatch, habitat loss and degradation, passage mortality, and environmental factors including predation and climate change. Also, each river system has its own challenges, and for almost all stocks we have only one data source. To add even more challenges, all of our datasets on abundance and mortality start well after the peak of the directed fishery in the 1960s and the collapse of landings during the 1970s.

The habitat model tells us that a significant amount of river herring spawning habitat has been lost or made difficult to access, due to dams. In these maps here, blueback herring is on the left, alewife is on the right. It shows how many dams are in each part of the river. The darker, redder colors indicate river herring have more barriers to accessing the habitat.

For instance, that darkest red area, the river herring would have to cross upward of a dozen dams to get to those areas. The loss of access to spawning habitat results in a lower potential abundance. Here I will show you alewife. The Y value here is the coastwide alewife abundance in millions of fish, and across the bottom there are three scenarios.

There is a no passage scenario on the left, a no dams scenario on the right, and the current scenario in the middle. Historical abundance of spawning alewife was predicted to be 352 million fish under the no dam scenario. Abundance under the no passage scenario was 87 million spawning fish, which is a reduction of about 75 percent. Current levels of passage don't provide much improvement over the no passage scenario. Analogously for blueback herring, we see the same figure, the mean historical abundance of blueback herring was predicted to be 63 million spawning fish under the no dam scenario. Abundance under the no passage scenario was 41 million spawning fish, which is a reduction of about 35 percent.

Again, current levels of passage do not provide much improvement over the no passage scenario. What is our habitat model telling us? Well, alewife and blueback herring are depleted, relative to historic level. The habitat model indicates that the overall productivity of the stock is lower now than it was for an unexploited population in an unaltered landscape.

But this doesn't incorporate fishing mortality, so it doesn't provide an estimate of true current abundance. Moving on to our abundance trends, this is a figure showing abundance trends over the full time series. On the left is alewife, in the middle is blueback herring, and on the right is river herring unspecified.

The abundance trends are denoted by a red downward pointing triangle if they are decreasing, a green upward pointing triangle if they are increasing, and if there is no significant trend it is denoted by a black square. As you see, there is no clear coastwide trends. More of the northern regions seemed to have more positive trends, but even within the regions there are differences from river to river.

Then if we look at the trends since 2009, since our reference year, you see even fewer significant trends. You see one decreasing significant trend in blueback, which is the Santee Cooper River. You see two increasing trends for alewife, two for blueback and two for river herring. The alewife increasing trends are the Damariscotta River run counts and the Merry Meeting Bay young of year index.

Both of those are in northern New England, and the blueback increasing trends are again, Merry Meeting Bay young of year index, and that is in the Canada/Northern New England Region, and Albemarle Sound adult index in the Mid-Atlantic. The ARIMA results compared to the 2009 reference year shown here. It's the probability of the most recent year of the index being above the 2009 value. The shape indicates the type of data, either survey or run count.

The run count species-specific are circles, run count combined species are diamonds, square is your adult fishery independent surveys and then triangle is young of year or juvenile. As for color, the darker blue indicates a higher probability. The darker red indicates a lower probability, and lighter colors indicate around a 50 percent probability of being above the 2009 value.

You can see that the northern points tend to be darker, and there are more light-colored and redder symbols on the map in Southern New England and Mid-Atlantic areas, indicating lower probabilities of being above the reference period. Here you see the probability of the most recent Z estimate being above the Z reference point.

In this case, shape again indicates the type of data and for color, darker red indicates a higher probability. Darker blue indicates a lower probability, and the lighter colors more of a 50 percent probability of being above the Z 40 percent SPR reference points. Most rivers had a higher than 50 percent chance of total mortality being above the Z reference point, with the more northern regions having a higher probability than the Mid-Atlantic. You think that is a little counter intuitive from what we just told you about the abundance trend, but out of 105 stocks for which we have data, we only had 26 that had both Z and adult abundance trends. That was a little bit hard to draw conclusions.

To summarize, our stock status here on the left we look at the time series trends since 2009. The left-hand column is a significant negative trend, the middle is no significant trend, and the right is increasing significant trend. Now the middle column there is the number of datasets with a greater than 50 percent probability of the terminal year being greater than a 2009 value based on that ARIMA.

On the right we see the number of rivers with a greater than 50 percent probability that the mortality in the latest year is greater than the reference point. You see here for alewife that there is no clear coastwide trend since Amendment 2. There are very few significant trends, but those that are significant are positive.

Note that high values are better for the middle column, and high values are worse in the right-hand column. You see there is one significant positive trend in Northern New England and three in the mixed stock ocean, and all the others are nonsignificant. As for the latest year of the ARIMA being higher than the 2009 value, 92 percent of the Northern New England rivers for which we have values were greater, 67 in Southern New England, 65 percent in Mid-Atlantic and 67 percent in the mixed stock ocean, so that's good.

But then on the right the number of rivers where the mortality is higher than the reference point is pretty high in Northern New England at 72 percent of them, 78 percent of them in Southern New England and you know, Mid-Atlantic none, so that's great. The more northern regions seem to have more positive trends, but also higher Z estimates.

But even within the regions there are differences from river to river, in terms of trends and a Z estimate. This is the analogous information for blueback herring. Similar to alewife there is no clear coastwide trends, while the northern region seemed to have more positive trends, they also have higher Z estimates.

Again, even within regions, there are differences from river to river, in terms of the trends and the Z estimate. There were no species-specific run counts for indices for the Southern New England Region for blueback herring, so as you see here, we only show the mixed species run counts. In summary, there are no clear coastwide trends since Amendment 2.

Some systems are showing positive trends, some negative, and many know the technical trends. The Northern Region seemed to have more positive trends, but a lot of variability even within regions. Run counts increasing trends may be influenced by increased passage efficiency, as well. The Northern Regions have put a lot of effort into habitat restoration and dam removal, but still have states further south, and they have not seen the same positive trend in run counts and indices. In Northern New England stock region also accounts for the majority of the directed catch in recent years, while states in Middle New England, Southern New England and Mid-Atlantic stock regions have closed their fisheries. What other factors are affecting river herring abundance? One of them may be the bycatch influence. Reid et al in 2022 looked at the genetic composition of ocean bycatch from Cape Cod, Long Island Sound, New Jersey area, which has historically had a high fishing effort and high estimates of river herring bycatch.

In this area the majority of alewife bycatch was from the Southern New England stock region, and the majority of the blueback herring bycatch was from the Mid-Atlantic stock region. These are two stock regions that have more negative trends in recent years, despite habitat restoration efforts and directed fishery closures.

Let's move on to talking about possible bycatch cap measures. Concerns about the impacts of ocean bycatch led the Board to include a TOR to develop methods to calculate biologically based caps for a limit on bycatch of river herring in ocean fisheries. A proof-of-concept approach was developed, using data limited methods, so that if that bycatch cap based on trends in alewife and blueback herring abundance.

We used the iSmooth and the iSlope methods, these were peer reviewed in the 2020 index-based methods and Control Rules Research Track Assessment. These methods have the highest medium catch among the methods that achieve rebuilding more than 50 percent of the time. The iSmooth and iSlope are conceptually very similar. Slope have been the index in recent years we've used to develop a multiplier that is applied to the recent catch, with or without additional buffers.

Basically, if the index is decreasing the bycatch cap would decrease. Then if the index was increasing, the cap would increase. The data required for this is catch data and index data. The catch data we looked at was the Northeast Fisheries Science Center species specific coastwide bycatch estimates.

The index data for the ocean mix stock indices was the Northeast Fisheries Science Center Bottom Trawl and NEAMAP. For run counts for alewife, you look at the sum of the Southern New England run count, and for blueback herring we looked at the sum of the Mid-Atlantic run count and these were the stock regions, remember that comprise most of the bycatch being studied by Reid et al in 2022.

The final numbers would depend on the method, choice of index, and what kind of buffers are in place. We ran through some seemingly reasonable numbers, and found that our estimates had lower, they were lower than the current bycatch count, lower than the coastwide bycatch estimates, but higher than recent estimates of catch against the current cap, because remember, not all the coastwide bycatch of river herring counts against the current cap.

There were pros and cons to using an index-based bycatch cap. The pros it is more biologically based than the current historical average approach. As your indices decline caps will decline. If indices increase the caps can go up. The cons are that it is based on index data only, it's not a population model, and it assumes a relationship between a bycatch and the population abundance, although we know that bycatch is only one factor that is protecting river herring abundance. In order to finalize anything, it would need more work in consultation with managers on the scope and implementation. What we did was species-specific, and the current caps are shad and river herring combined. The caps we came up with are coastwide, but the current caps are based on specific fisheries and gear area combinations.

Data limited methods need more management input on risk and buffer levels, and monitoring at a biologically meaningful scale is difficult. Not all bycatch affects all rivers or stock regions equally, and the current monitoring doesn't include genetics. The TC/SAS strongly supported the species distribution modeling approach as an alternative or a complement to the catch cap.

Model river herring distributions and identify potential "hot spots," where the risk of bycatch is increasing, and use time/area closures to minimize bycatch, instead of an in-season catch cap approach. This avoids some of the issues with intensive monitoring needs with the catch cap approach, but the models need to be developed further. On to research recommendations. The research recommendations are shown in full in the assessment report, along with the updates on what we have accomplished thus far.

Last year we highlighted some of the selected recommendations. A high priority short term research recommendation for assessment methodology is to continue development of the habitat model or similar models to predict the potential impacts of climate change on the river herring distribution and stock persistence and develop targets for rivers undergoing restoration. Some high priority short-term recommendations for research and data collection are to develop consistent aging protocols across all states.

To establish a database of existing data sources with comprehensive meta data and recommendations for use. To expand observer and port sampling coverage including genetic sampling, to better quantify incidental catch of river herring. Studies to quantify and prove and implement standard practices for fish passage efficiency, and to evaluate and validate hydroacoustic methods to quantify river herring spawning run numbers in major river systems. Any questions?

PEER REVIEW PANEL REPORT

CHAIR FEGLEY: Thank you, Dr. Conway, that is just an impressive amount of work. I think what I would like to do, unless there is loud objection and protest, is move right on to the Peer Review Report, and then take questions together. Dr. Jordaan, I apologize if I'm mispronouncing your name. If you're ready, let's go ahead with the Peer Review, and then we'll discuss.

DR. ADRIAN JORDAAN: According to my data, I've been mispronouncing our last name. We'll be okay, thank you so much. First of all, I would like to thank the River Herring Technical Committee and Stock Assessment Subcommittee, and I'm going to just call that the SAS, because I'm not going to say all those words every time.

But I would like to comment on them for their efforts around this stock assessment, and we're really happy to be a part of the group that got to review it. The Review Workshop was June 4-7 in Arlington, Virginia, and our scientific review focused on the data inputs, analytical methods, results, and overall quality of the stock assessment. Obviously, you have all had access to the materials, so we can go to the next slide. The Scientific Review Panel was a Chair and two additional technical reviewers with expertise in anadromous fish ecology and population dynamics, stock assessment modeling, data limited methods, fish passage, and bycatch estimation.

I fulfill some of those, so I was very fortunate to have Dr. Heather Bowlby from the Fisheries and Oceans Canada, who has had experience working on river herring, although virtual estimate ranks currently, but a rich experience in stock assessment and Dr. John Weiderman, who also spends time on the Science Statistical Committee with me on the New England Fisheries Management Council, and has a lot f experience working with stock assessments, so a really great group of people, and think hopefully we did the assessment justice in our review.

While not mentioned here, I'll probably mention this a couple times. This remains a data limited complex of stocks, as Dr. Conroy mentioned, and they remain depleted from a coastwide perspective. This follows a decade or more of restoration efforts and moratoria in numbers of states., simply haven't improved status beyond some marginal improvements.

However, most of the population trends themselves are flat. I try not to get in the weeds here too much, but when I say population trends, I really do mean the run counts, the indices, and all the life history indices as well. But for right now just talking mostly about the population trends, where there was high variability in many of those surveys, and there just was a lack of ability to detect trends.

While no official statement was made regarding the current rates of mortality, total mortality was quite high in many of the individual stocks, as pointed out by Dr. Conroy's presentation. It was sort of spread throughout the assessment, but within one of the statistical catch-at-age models on the Monument River. There was certainly an indication that there was high mortality occurring during the ocean period of their life history of river herring.

Many members of the public and managers brought up concerns over the potential high levels of discard mortality, or at least about the lack of current monitoring of that mortality. The new habitat-based model shows a lot of promise, and indicates a lower productivity overall, due to damage and habitat loss.

We certainly as a group encouraged the continued development of that to bring in more information about how the habitat varied in quality, as well as trying to use information that sort of tied it, grounded the habitat model to some of the other aspects of their life history. One of the big, honestly one of the biggest positive things of the habitat model, parts of the model itself was also the growth modeling and other sort of synthesis of information that occurred as part of that.

Those were really encouraging and a monumental amount of effort, primarily by Dan Stitch, so I'll give him a call out at this point. Based on the current methodology analyses and interpretation of results, we believe that the assessment provides the best available science. But again, I think that there are just in general with river herring a way to go to bring these stocks to a more data rich scenario would allow us to say more about the sources of mortality and provide better recommendations for management action. I'm going to step through each of the TORs that we had, as a part of the review. The first was to evaluate the choice of stock structure. We really, as a group, thought that the use of the genetic information to aggregate the information into these broader regions that were not defined, necessarily by state as a positive move forward. However, since most of the mortality is very much river specific, and certainly runs in better stability by experiencing harvest, as our harvest is at the specific river or run.

We recognize that the unit, the river is still the stock unit that is most important. From a recommendation standpoint, we recommended that there be further data collection from populations and fisheries for apportionment of discard mortality at sea, but also just to try to continue to better understand the spatial aspects of river herring during their complex life history.

I'll also say at this point that the lack of data along some parts of the coast, in terms of the genetics, led to there being sort of not quite enough information to really nail down perfect stock unit. I think there is just an overall more work to be done in both genetic analyses, as well as collecting information for future analyses of genetics in those discards.

Again, we were very happy with the amount of data that was collected on river herring from both fisheries dependent and independent sources. I think it is important to acknowledge that there are significant limitations, data limitations that remain a significant issue for these stocks, particularly with the lack of standardized methods for aging, and for developing abundance indices.

I'm actually going to do the second recommendation first, because it feels like it leads from the second comment better, and that is that one of the things that I think it comes out really nicely, and what Dr. Conroy just presented, was the fact that many rivers only had one index or one life history index, or a run count or a juvenile index, or an adult survey of some kind.

One of the problems is that it was, as again noted by Dr. Conroy, that it is difficult to assign mortality or understand where there are issues, when you have such disparate data. We really think that one of the things that might be helpful is to continue to develop the surveys and standardized methods, but focus on a few rivers across the region that allow there to be these sort of sentinel populations that allow a better understanding of what is occurring within that river, sort of like what we saw in the Monument River.

Then of course there is just an overall missing data across the board from supplementing other surveys that are currently collecting parts of the information that are useful, so either a run count, but not really collecting enough information for some other aspect, but also just in general the discard monitoring is an area that is certainly needed.

TOR 3 was to evaluate the assessment methods and models. As I noted this has remained a data-poor assessment. The majority of river systems there was only just this one type of monitoring data that would exist that could be used as some kind of index, whether it be abundance, run count or so forth, and that is certainly a limitation.

The catch-curve estimation of total mortality (Z) compared to the reference points developed by the spawner stock recruitment biomass to recruit model seemed appropriate. I have a feeling I called Z F later, and I apologize ahead of time, unless someone fixed it. Certainly, we feel like this was a big step in the right direction for the assessment of these populations, although there are certainly some issues that were identified, I think a little bit in the weeds, but certainly worth continued exploration around how to best estimate mortality and make comparisons to the biological reference points.

The trend analysis of Mann-Kendall and ARIMA on the survey and other data sources provided a little additional information, but I think you got the general sense that trends have been generally flat since the last assessment, and so there really hasn't been a lot of either improvement within this, or enough power to detect those trends, which frankly is our problem across a lot of surveyed anyway.

Then of course the statistical catch-at-age models were updated for three rivers and suggested high at-sea mortality, although only one of those models was really, I think at the level that was capable of making that kind of inference. For the conclusions of the assessment methods. We believe that there needs to be a continued development of these bycatch caps.

Based on the abundance we thought that that was certainly a step forward from the more historical sort of what has been caught. However, there were a number of issues identified, particularly interannual variability in cap estimates. We just think that there needs to be a little bit of additional thought on this process.

But it seems like a very, in general, a positive way forward. We were as a group and individually, we were concerned about the use of a fully spatial bycatch avoidance approach, because it wouldn't inherently track the magnitude of bycatch or just things as part of that. We really felt that there would have to be some kind of cap implemented currently with spatial management, to avoid the potentially negative outcomes that could follow through from that.

Of course there are ways around that, which leads to one of the comments, which is that we think in developing these ideas, especially for the time/area closures, you really need some clear management objectives that are going to be complicated by the fact that they're going to be multi-species driven, and that these clear management objectives need to be defined a priori, and there is a reference provided in the document to help tease that out more.

In TOR 4 we were asked to identify the best estimates of stock abundance, total mortality, and exploitation for management use. Some of this is going to be a little bit redundant. The first one is just a reemphasis that the idea that for a majority of river systems there was only one type of monitoring data that was able to be used, and this really limits interpretation, and I think Dr. Conroy gave some good examples.

The trend analysis on survey CPUE and run size as mean length and mean length at age data, really gave mixed results, and in general had a low power. There were some, I would say weak positive outcomes from that. But in general, I think that the group took it as a whole that the trends were generally pretty flat and unchanged. There is the F40 in the next slide. There was I think across the board higher mortality. I think there was high mortality across all of the runs, or across many runs, and there seemed to be high mortality occurring within the runs up in the north. One point I am just going to make here that I think is worth everybody being aware of, and that is that the use of Age 5 and further, you know an older fish in terms of developing the mortality estimates, certainly is a bit of a limiting factor, in terms of understanding the full dynamics of what is going on over the life history. Obviously, a positive way forward, but just to recognize that there is bycatch mortality occurring as well as in-river mortality during the return after for spawning.

I think that while initially I was surprised that those mortality rates were high, I think that there are some potentially confounding factors in there a little bit as well. The statistical catch-at-age modeling suggested high at-sea mortality and the habitat model suggested continuing need for improvement of habitat access or said another way that we're still very much below the baseline of undammed systems based on the habitat model.

We just suggested the continued development of data limited methods for developing a bycatch cap, based on trends in abundance, and really felt that that type of method moving forward was likely to balance the need for some flexibility in the approach, but also recognizing that it's not just the historical catch that drives the potential for bycatch.

There are some recommendations, and some of these are redundant, but to have these sentinel sites that are tracking more data on more indices to allow for better interpretation of results. Move the statistical catch-at-age model to more of a population viability analysis, which is really just a tweak, and hoping that more of those sentinel sites will bend themselves to becoming statistical catch-at-age models in the future, so we really have a better tracking of the process of what is going on coastwide.

Continue the development, we really encourage the continued development of that habitat modeling approach. We really think there is a lot of promise in that. Then of course the work with the New England Fisheries Management Council's Plan Development Teams in both the herring and mackerel, to work on approaches to limiting bycatch, and also to continue to better monitor those fisheries.

We overall, we agree with the assessment that the river herring stocks remain depleted. Although there is a low power to detect trends, there is an increased monitoring need and a better standardization of techniques, and hopefully movement toward some of these sentinel sites, a little help, I think, to understand better how our populations are trending.

Mortality exceeded the biological reference points in many rivers, and at-sea mortality appears to be high. While the river herring stocks remain data poor, and status determinations were impossible, we do find that the lack of recovery, given the last decade of restoration and effort is troubling. A quick note here though that many areas are still improving access and improving.

Many of those populations may not have entered into the assessment. We hope that in the future these sorts of improving areas might get more call-out. But we do believe that the lack of discard mortality monitoring remains a really important missing element for the assessment, and leaves us in a little bit of a difficult position, in terms of assigning or apportioning where the issues are, in terms of what is limiting the recovery of these populations. This is really on the research recommendations. The Panel really recognized the importance of an improved estimation of bycatch and discard mortality, and so this is essentially really working on comparing the current analytical techniques in a sensitivity analysis to understand and assess their relative predictability in estimating total bycatch.

This is particularly important, because river herring are a schooling fish, and those numbers, they are just not a typical fish population in many ways, and I think they need a little bit of work on the analytical side, and it was really a strong recommendation by the Peer Review Panel. Certainly, continuing explore these, iSlope was probably the preferred version between the two, but to continue to explore these.

Since incidental catch seems to comprise the largest source of ongoing fishing mortality, and it remains high for many populations. The focus on bycatch at this point is fairly urgent. Continued improvement of the habitat model, they are incorporating major sources of mortality, and then to use observed data to ground truth the outputs.

We're really excited about some of the advances in that habitat model, and actually the assessment overall. These are still high priority for us, but we recognize that some high priority things you can pick up at the computer and do. Those were the things we just sort of just discussed. These things involve a little bit more on-the-ground work, and sort of more collaboration beyond the Atlantic States Marine Fisheries Commission.

Equal priority, although with implementation over a longer time period and improved monitoring via port sampling or dockside monitoring, to collect more information about a species in bycatch. Because most of these species are full retention, or many of them are, we really don't have to require observer coverage.

We really hope that this can be a step forward over the next numbers of years towards the next assessment. The Panel also saw a high priority and continued improvement of enumeration techniques, including hydroacoustic, eDNA, other run counts, sort of video imaging processing with machine learning, all these ideas to increase the amount of information that we have, increased its reliability.

Then hopefully do so in such a way that dovetails with those other types of data being collected about the life history, so that we can continue to have more sites that we have better interpretation of the overall data. Then for a medium priority, we had sort of a need to implement sampling programs. This is actually sort of going back to what I just said, which is sort of having these sentinel sites, where we sort of would be collecting more information about the overall life history of the species in a single river.

This was something that Dr. Bowlby brought up a number of times, and I think is actually something that would be well worth some effort, would be a detailed river history and inventory that captures current population numbers, details about restoration, and documents data that is collected, and what those methods are. In order to really help interpret current status, but also to allow people to use as a resource moving forward. I know there is a little bit of work out of Maine that sort of trying to get up at, so something to think about in the future. River herring specific surveys would be of great benefit to the assessment. Some of the best surveys, in terms of how they provided, in terms of how the operated with the power to detect trends, were actually surveys developed for river herring. I guess there is not surprise there. But the dependence on a lot of surveys that were not either timed or developed to collect information on river herring, no doubt increases the amount of variability in those surveys, and then makes them less powerful to detect the trends.

Either tweaks or changes or new surveys to increase variability to understand what is going on with the population would be of great value. The Panel considered most of the other medium and high priority research objectives that were identified in the SAS to be a little bit less important, only because they had a lower likelihood of actually leading to information that would directly inform the management in the next assessment.

That is not to say that they are not important, but this just feels like these, the ones I just presented were the critical issues where we really need additional work to move the assessment and management of river herring forward over the next decade. TOR 7 was, recommend the timing of future stock assessments.

We simply agreed with the SAS that the update in five years and a benchmark assessment in ten years would be appropriate, given sort of the life history of the species, sort of talking about a couple of generations that would go through by the next benchmark. Hopefully, we've seen some improvement, and things have continued to gather steam, both in terms of restoration, but also in terms of our overall data collection to inform how things are moving, and in which direction.

I just wanted to, as a closing comment. You know one of the things that I had talked about in my fisheries class are the time lags between when things occur and when decisions get made. In the meantime, since we did the review, I've also sat at NE-SSC, and there were just pretty significant cuts to the Atlantic herring fishery that occurred, and I also know that the Atlantic mackerel fishery is facing some challenges.

It's sort of an interesting moment here, in terms of what's going to happen with bycatch. I don't rejoice in any of these things, I think that they are all complicated and challenging. But certainly, working with the relevant PDTs seems like we're right at this moment where these bycatch caps of spatial management could be really rethought, hopefully as we see a return in Atlantic herring in the future.

Then just to point out sort of a concern of mine, and that is that we don't have a lot of forage fish in the Gulf of Maine area, and one of the things that my research, one of my graduate students working on an ecosystem model pointed out, was that sometimes the consumption can actually be a really big source of mortality, and can sort of overwhelm any fisheries-based changes in management.

Just as a concern here that with herring lower, river herring are going to be a more important forage items to many predators. I think we have some challenges coming up over the next decade, and I look forward as a researcher to be involved in those, and hopefully I can be involved in this type of a process moving forward as well. I think that might be it, but next slide. Yes, and I'll pass it back to you. Thank you.

CHAIR FEGLEY: Thank you very much for that presentation. It's a tough one, it's a big one to wrangle, and you guys have done an excellent job. At this point what I'll do is turn to the Board for questions on either the Assessment or the Peer Review, so if you have a question. All right, we'll start with Bill Hyatt.

MR. WILLIAM HYATT: Thank you for a very, very excellent presentation. My question has to do with a statement that was made in what I believe is the Peer Review Report. I might be wrong on that, but I believe it was. It was a statement that the calculated mortality rates don't include all sources of mortality, and that was actually an underestimate.

You know I believe the statement was made because the mortality estimate was based upon assuming Age 5 plus spawners. I would just like you to mention that if you would, go over it a little bit, and if you could, speculate on how big of a potential underestimate that might be, based on what knowledge or information you have. I'm kind of asking this question from the perspective of having some information for southern New England stocks that only about 19 percent of the spawning stock is made up of 5 plus individuals.

DR. CONROY: I'm going to start and then you can jump in. The reason that we looked at only the 5 plus, in terms of calculating mortality is that was the data that we had, because most of our data is from spawning runs. I don't now exactly how we would get the data to include younger years. Go ahead, Katie.

DR. KATIE DREW: Yes, I think the challenge obviously with the catch curve approach is that you need all of your ages to be fully selected when you are sort of trying to figure out how they are disappearing over time. If you have a lot of river herring start maturing at Age 3, Age 4, but the ones that come out back to the river, that is only part of the Age 3s that are actually out there. And only part of the Age 4s that are actually out there.

We can't really include them in the catch curve approach, which is a limitation of this approach, and it's a limitation of our data that we don't have information on those fish when they are out at sea, either as immature or mature fish. It is difficult to track them back to their river systems, but even looking at them, the data sources that we have on the ocean, such as the bycatch and the fishery independent surveys don't age those fish.

We just have length information on them. In addition, you know there is definitely going to be a selectivity effect on that as well. I think that is a limitation on the available data that we have. Moving towards more of a model-based approach that can pull in additional information the way we do with all of our other species, to get an estimate of total mortality would be great.

I don't think we have a way of knowing what the affect of that additional mortality on the stock is, because from river to river it's going to be different. I think the bycatch is not happening equally across all rivers. The stress of returning to that river to spawn, or the predation level in the river, or the environmental affect, or the passage efficiency is different from river to river, and so it is really difficult to say how much additional mortality they are experiencing as young fish compared to kind of what we're measuring on these oldest fish. I think the reference points take into account some mortality on those younger fish, so we don't completely disregard that in the reference points. When we compare these total estimates, we are comparing it to a reference point that assumes some mortality has happened on those younger fish. But that is just a real black box in our understanding of this population,

MR. HYATT: Safe to say there is confidence that it is an underestimate, but no idea whether it is a small underestimate or a large underestimate.

DR. DREW: Right, yes. Again, this is like mortality on those older fish from year to year was, what are the younger fish experiencing? We have no measure of that at all. Are they experiencing, probably they are experiencing more mortality than the older fish, but even just the stress of returning to spawn is probably also a significant source of mortality for the older ones as well, so yes.

CHAIR FEGLEY: I see you, Justin Davis, but I'm going to go to Emerson Hasbrouck online first.

MR. EMERSON C. HASBROUCK: Thank you, Dr, Conroy, and Dr. Jordaan for your presentations, very informative. I have a question, and I'm not sure whether you can answer it, but I'm going to ask it anyhow and see where it goes. How long would it take for a river population of either alewife or blueback, or just combining river herring, to fully respond to habitat improvement, especially dam removal. Maybe the period that it takes the population to respond is just longer than what our recent data is showing.

DR. DREW: I think the issue is that I don't think we know. I mean we could tell you; you know that is what the habitat model would get at if we had like this perfect scenario where there is no fishing mortality, there is no other sources of mortality, you take out a dam, habitat spawning increases, you know recruitment, blah, blah, blah.

You could run those projections and see. But I think we don't understand sort of how much of what is limiting each stock is fishing mortality or bycatch mortality or other factors, predation, climate change, poor recruitment versus how much of it is a lack of access to the habitat? If the majority of what is holding the stock back is lack of access to spawning habitat.

Then they are going to respond faster than a population that is also being held back by bycatch mortality or some other factor. I think the short answer is, it's going to vary from system to system, depending on how much habitat is available to them now, and all of the other factors that are influencing their current abundance.

DR. CONROY: It is also the influence of change in predation when those dams are taken out.

DR. JORDAAN: Can I add one thing?

CHAIR FEGLEY: Go ahead.

DR. JORDAAN: One thing I just want to comment on, because it came up both during the Peer Review and it just comes up a little bit every now and then is, it's this idea that there is an immediate response by river herring to dam removals, for example. One of the things that I think everyone needs to realize is that very frequently there is not great monitoring of that change.

There is sometimes good monitoring of a passage improvement, but not always. Sometimes there is monitoring of a dam removal in some way. But it's very difficult to get at that question that was just asked in, I think a really quantitative way. I think there is some work that is going to come out over the next few years that will help answer those kinds of timeline responses.

But I think that Dr. Drew's answer was almost spot on that it is going to depend, but that this expectation that it is immediate, that to me is all to suggest that there were river herring that were below the dam that couldn't use the habitat before that are now being granted access. I worry sometimes that those numbers that get sort of given, in terms of the numbers improved of fish that came back immediately after a dam are actually composed a lot of fish that were just never counted before. That is my perspective on that.

CHAIR FEGLEY: Thank you for that. Justin Davis.

DR. JUSTIN DAVIS: This is a question that might drift in the comment territory, but I'll try to keep it as a question. This has to do with the analysis of the habitat model and dams. I think the takeaway there is that on a timescale of centuries, dams are persuasive explanation for why we have lower river herring productivity now than we did, say 300 years ago, before we built all the dams.

But not that over the timescale of say the last 40 years that dams are a persuasive explanation for why we've seen the dramatic declines in river herring runs from say, the 1980s or '90s until now, because we haven't been building new dams. We've been out of the dam building business for a long time. In fact, you know I had my staff pull this information together before the meeting.

Just in Connecticut alone in the last 30 years we've built 66 fish ways and removed 30 dams, so that is just in one state. We've sort of been going the other way, with taking dams out of the picture. I just wanted to clarify that that analysis is taking like a big picture look at what the productivity of our rivers could be, in terms of river herring, but it is not suggesting that dams are really a factor in what we've seen over the last four years with these declines.

DR. CONROY: One thing is that some of the newer information on fishways is showing that the downward travel is very, very important, and if we improve the upward travel then that whole area just becomes a sync. It is possible that some of the older fishways, like before that was well known, may have actually been exacerbating the problems of the dams. But yes, I agree with most of what you said.

CHAIR FEGLEY: Dan McKiernan.

DR. JORDAAN: Can I just jump in really quickly in response to Justin's comment?

CHAIR FEGLEY: One hundred percent.

DR. JORDAAN: I think one of the advantages to the habitat model is not telling us something that we already knew, which I think you just nailed really well. But in fact, the idea that it can be a tool to understand how things are progressing. I think Dr. Conroy just pointed out one of those issues, which would be the downstream passage.

But also, as information that that is able to be brought in, for example that provides for different water quality, accessed for different habitat qualities, and then allows you to really build a model that is actually much more like the system. Then you get to a place where you start out being able to ask questions about what will provide positive outcome. Is it downstream passage? Is it reduced at-sea mortality? I think it's a tool that has a lot of validity moving forward, notwithstanding I think your comment was spot on.

CHAIR FEGLEY: Okay, to Dan McKiernan

MR. DANIEL McKIERNAN: I am curious to know if the elevated total mortality, the Z scores, have gotten worse in recent years, and whether that could be related to predation, and not necessarily attributable to commercial fisheries bycatch. That is an interesting question I think we all would like to know. But given what we are all expecting over the next five years or so, which is s vastly diminished sea herring and mackerel fishery, I guess I don't know where we go.

I mean some of the recommendations about extra sea sampling. I'm not sure the fleet is going to be there. As I was listening to the presentation, I heard there was a lot of implications of commercial fisheries bycatch, and then Adrian, the last thing you said was, there are not many forage species left. I guess what I'm hearing is you are sort of implying that this could elevate total mortality on river herring at sea. Can you comment on that?

DR. JORDAAN: In some ways I think I should have not included that last slide, but I thought it was important for context, because here we are. I think you've identified exactly what is going to happen, the future, in the next couple of years here with, I think both mackerel and Atlantic herring. I think those are going to be much diminished fisheries, especially Atlantic herring.

Our work on this, and this is the ideas of this paper on the contrasting fisheries, reduction and habitat improvement. I probably did not quite get in the title properly, but it essentially showed that if you do fisheries regulations that reduce fish catch, you actually also reduce the catch of some of the predators, and the result is that essentially you don't see any change in the river herring population. Now, it's a model. It's an ecosystem model with huge assumptions around consumption and productivity.

But I think that that paper pointed out the fact that habitat improvement is the sole way, or increasing the amount of habitat is the sole way to really improve these runs of herring, when compared to these sorts of fisheries management of passageway because of this predation pressure. I feel like it is an important thing to bring up now, so we don't get five years down the road, and everybody is wondering why bycatch reductions haven't reduced at-sea morality. I would worry much more about the overall populations of these species that we have currently available, and worry about there not going to be sufficient moving forward to be partitioned around everyone who needs them. I always called them the hot dogs of the sea. I know a lot of people don't like hot dogs, but I mean they just are eaten by almost everything, and I think that is one of the challenges, it's their role, and I think it's a big challenge for their management. I don't envy making management decisions around a stock that also remains fairly data poor.

DR. CONROY: Just one addition. We did show the estimates by river in the assessment if you want to look it up. If they varied a lot, like whether the mortality is getting worse or better, it varies a lot by river. If there is a particular river that you want to see, you can look that up.

CHAIR FEGLEY: Okay, Jeff Kaelin.

MR. JEFF KAELIN: Thanks for the presentations, I've kind of been bouncing back and forth between the slides that were shown earlier by Dr. Conroy and some of the language in the Peer Review Report. In the Peer Review Report, on Page 4, and also repeated in the Terms of Reference 6 slide that we just saw.

It says probably the most important aspect of incidental catch is that it has become the highest individual source of fishing mortality on river herring. But if we look at the Figure 1, the total removals in your slides, which is on Page 10 of the written document, it doesn't look that way, and in fact I think you had another slide that blew up the scale, so you could really see the comparison between bycatch and mortality of river herring that followed, which we don't have in the written document.

My question, so I don't think it's accurate to say that most of the mortality is bycatch mortality, because my understanding is that there are several rivers that are under sustainable fisheries plan, certainly in Maine that's the case. I think Maine's directed mortality is a couple million pounds of fish coming out of sustainable. Yes, there you go. Out of sustainable runs.

You know what is missing, I think, in the way this data is being displayed is, we don't have any idea. We can't identify, I can't identify anyway, which river systems are under management through the sustainable fisheries plan approach that we've taken at the Commission, the other approach being the black box approach, and New Jersey is guilty of that.

We don't have any rivers that we're looking at. But I think it would be really important to try, so this shows me right here that in fact incidental catch is not the majority of the mortality of river herring, that directed landings are greater. What I can't determine is how much of those directed landings are coming from river systems that are under sustainable fishery's plans? We don't know that and I hope it's a big number, so that is my first question.

DR. DREW: Yes, all the directed landings, so what's in yellow on these pages are coming from states that have sustainable fishery management plans. A lot of this data we can't actually show river by river, especially from Maine, because it is confidential. But I would say, I think maybe the issue, and I don't want to speak for the Review Panel, but speaking for the Stock Assessment. I think the issue is more that in some rivers the bycatch is maybe more than. We have rivers that are closed, but we know that those rivers are still vulnerable to bycatch from some of the snapshots of genetic data that we have. Meanwhile, we have other rivers that continue to have a fishery, and are contributing, are influenced less by the bycatch, again, based on the genetic snapshots that we have. We could go through maybe and show, in the giant table of results we could maybe try to compare rivers that are flagged, which rivers are under sustainable fishery management plans and which are not.

How does that relate to the trends that we're seeing? But it's difficult to then, we can't parse bycatch back to specific rivers, we have some snapshots in time of where the majority of the bycatch was coming from at kind of a regional level. While we can definitely partition the commercial directed data back to specific states and rivers, that is more difficult to show because of confidentiality.

MR. KAELIN: There you go. It looks like the sustainable fishery plan program is working then, and it should be maybe an incentive for other states to go down that road, if we really want to bring some of these stocks back. On the forage concern issue, yes, we just saw yesterday, 86 percent caught in the herring quota in one year, but 2500 metric tons of herring available to the entire U.S. fleet to take, so no, there is no herring fishing and mackerel is rebuilding.

But according to our projections on Atlantic menhaden, there are 4.5 million metric tons of Atlantic menhaden out there. I don't know if river herring eats menhaden, they probably eat menhaden possibly when they're inshore, so I just wanted to point out that there is certainly a lot of menhaden out there, there is a lot of butterfish out there.

Again, I don't know what is in the river herring diet, but it's an interesting concept to say that because herring and mackerel are going to go down, we can expect greater mortality on river herring. It's an interesting concept. These legacy rivers that with the research recommendations suggest that we identify.

Wouldn't those be the rivers that are under the Sustainable Fisheries Plans? Couldn't we identify them more specifically that we're able to? You mentioned the issue of confidentiality, I'm looking at the table that shows, it's the one that has the little box with Maine, with all the red confidentiality. I don't know which one of these documents that's in.

My question about that is, there are a lot of fish that are being managed up there. What is it about those river systems that just show a little box with a whole lot of red in it, which doesn't allow us to really unpack the value of these SSP rivers that are under management. What is it, Katie that requires confidentiality? I mean a lot of them are managed by towns. Some of them are owned by individuals because that is really unfortunate. If we can't really see what the value of the legacy river is, if the data coming out of there is confidential.

That's my last question, I'm going to stop there. But there are a lot of pieces that don't really fit here. To incentivize states to develop those plans and put the resources in them, it would be nice to be able to see how well they are working, you know, get some kind of feedback. But apparently the confidentiality requirements will never allow that to happen, possibly. I'll stop there, that is my question, thank you.

DR. DREW: For Maine, I'll defer to Maine. I think in a lot of these cases the issue is that there is only one harvester on these rivers, and so if we go down to the river levels, then those landings and the biological information associated with those landings is considered confidential, and so we can't display that publicly.

MR. KAELIN: Yes, I get that. I was looking for my last point. You know a lot more about this, Pat, than I do. But why couldn't we have NDAs developed, so that those harvesters could agree to allow that information to be made publicly available, because it demonstrates the value of setting aside those rivers and managing them? This was Jeff Pierce's comment in his letter to us. Otherwise, we're just stuck in this situation. Maybe NDAs could be used, we're using them in the squid fishery and so forth, so just a suggestion. That might be one way to get around it.

DR. DREW: I mean obviously, ASMFC defers to the states. We follow the states rules about confidentiality in that respect. You know, if Maine wanted to pursue that we would certainly be wiling to be bound by whatever you would like on that front. But that is really a state issue.

MR. KAELIN: Kind of suggestion to Pat, I don't know if that is reasonable or not.

CHAIR FEGLEY: Okay, so Pat, do you want to follow up on that, and then Doug, I'll go over to you.

MR. PATRICK C. KELIHER: Just very quickly, Madam Chair. I think it's important to point out that while the information may not be public, right, we're still utilizing that information. We understand what the Zs are within all of these systems, and the benefit of the runs, how they're growing. I just want to correct one thing. They are not owned by any individual. These are municipal fisheries that still fall under the state of Maine's management prerogative.

They still have to have their harvest plans approved by DMR before they can proceed with fishing. As you know, Jeff, we've got very strict, well we all have the same, basically with confidentiality laws the rule of three applies. Whether we've got an NDA, a Non-Disclosure Agreement or allow them to disclose it. We couldn't force them to do that. I think at the end of the day, and I was going to say this earlier, Madam Chair, as far as these.

We're seeing very different responses up and down the coast. Look at Dr. Davis's comment earlier about how much work is happening in Connecticut and what you're seeing for responses versus what we're seeing for responses in northern New England and Maine. We've got high Zs, we had 7 million fish in Benton.

Right and to Mike Brown's comment to me as we were preparing for this meeting goes, Z that, baby, right, 7 million fish. It's made up of, it's a young run. Anyway, I'll stop there, but I think I'm comfortable with the approach that we're taking, only because the information is going into the assessments. Yes, it is protected by confidentiality, but it is a key bit of information that is used to assess the runs.

CHAIR FEGLEY: Great, thank you. Doug Grout.

DR. JORDAAN: Can I follow up with one small comment?

CHAIR FEGLEY: Sure, quickly.

DR. JORDAAN: Thank you, Madam Chair. This is really about the comment about the majority of bycatch or majority of mortality coming from bycatch of that its fishing mortality, and that is because the orange bars currently are really only from Maine, and so it's really a geographic outlook, and not as specific in terms of actual numbers.

Acknowledging however, that those bycatch numbers that are being offered there are certain to be underestimates. I think that we recognize that Maine is a bit of its own story here, living with a high Z and very productive, whereas other places don't have that directed harvest that are still subject to the discard mortality.

CHAIR FEGLEY: Okay, Doug Grout.

MR. DOUGLAS E. GROUT: Just a question. When did the NEFOP program begin? Was it the late eighties early nineties? Really, we just have no idea prior to that what any bycatch was. I know we had a lot more small mesh fisheries back then, so it potentially could have been even higher back in some of the earlier years. Is that correct?

DR. DREW: Yes. The NEFOP Program, the estimates start in 1989 for the gillnets and the otter trawls, but the small mesh midwater trawls are not really considered reliable until 2005, where they make the changes to how they do high volume fishery samples. Yes, the coverage was much lower, and the CDs under the estimates are much higher, and did not exist prior to really 1989, so for sure.

CHAIR FEGLEY: I hate to do it, but I had one question, and maybe it's a spot question for later, or maybe if it is worthwhile we can hear about it at our next meeting. But I am intrigued by the idea of the Sentinel River, and I'm trying to understand if you could help us understand, how to best pick those rivers. What do they do? Which ones would be worth throwing our research into. If you could answer it really quickly that's great. Otherwise, maybe we can table that until later.

DR. DREW: I think that was specifically a Peer Review Panel recommendation, so the TC and SAS have not really fully thought about it. We were just like, increase monitoring everywhere. But they had the more targeted idea, so maybe I would defer to Adrian on that question.

DR. JORDAAN: That is such a good question, Madam Chair. You know I would probably defer to the states who have the best knowledge. I mean I could pick my like five favorite runs from the northern part of the range. But I think that it would be really much more probably effective to work through the state agencies responsible for managing those populations.

I think that going back to some comments earlier, it would be really nice if some of those were also harvested runs with whatever agreements needed to be put in place, and then really geographic spread. I think that is one of the things if you look at the maps earlier on, are really lacking some of that, especially in the southern part of the range. It would be nice to have, I mean I don't know what the magic number is, two per state, three per state, that had a little bit of dedicated effort. I would really want the states, I think, to weigh in on which ones of their runs are most likely to be able to be worked in that kind of way. It's not every system and it is certainly not every location. I think it would need some local knowledge.

CHAIR FEGLEY: Okay, Justin.

DR. DAVIS: I appreciate the second bite at the apple, given the late hour. I just wanted to put the idea out there that from my perspective, I'm a little concerned with the idea that I think has sort of been floated around in various discussions around this, that because of what is happening in the Atlantic herring and mackerel fisheries, for the unfortunate reality there that bycatch is sort of something we don't have to worry about anymore, and those fisheries are generally for river herring.

Certainly, there is going to be less directed effort in those fisheries, but those are not the only fisheries that river herring bycatch occurs in. For instance, I think there is a fair amount of bycatch in the small mesh bottom trawl fishery. Even if in recent years levels of bycatch in aggregate have been something like 750,000 fish annually, I think was the number I saw.

There is good reason to believe from genetic evidence for just how the fishery is performing that that bycatch is disproportionately concentrated in space and time in such a way that it is impacting southern New England runs. Our runs in Connecticut, most of them now are not even measured in the thousands of fish, it's hundreds of fish.

Even a couple hundred thousand fish being removed that are from Connecticut origin runs is not an insignificant impact. I think we just need to continue to pay attention to the bycatch issue. I appreciated the sort of mentions throughout the stock assessment in the presentation today about the importance of needing to continue to work on that issue.

CHAIR FEGLEY: Eric Reid.

MR. ERIC REID: There was a lot of discussion about at-sea mortality and a lack of monitoring. Do any of you know why there is a lack of monitoring?

DR. DREW: Part of it is COVID, part of it is budget restrictions, part of it is, these are fisheries that there is not a lot of effort directed towards them anymore, and so the total amount of effort, of trips available to be sampled is lower in the herring and mackerel fleet going forward.

MR. REID: Okay, I agree with that. But the other part of that is, the way some of these bycatch caps are measured is from X amount of trips over X amount of time. The fleet itself that prosecutes the directed fishery wants observer coverage. Nobody is trying to avoid observer coverage, because in some cases we are working on X amount of trips, I think it's 5. Is it 5 or it's 3? I think it's 5, some odd number. They go back in time more than a year because we can't get observers to observe current trips, to analyze what is happening now as opposed to what has happened. You know that effect will linger, even though now. There has been really no directed fishery in southern New England for herring in a few years. We're still working on very old data, and if we went out and never caught a herring, we would still be under the rule of 5 trips over X amount of time to calculate what that is. That is a real concern to us, because we want to carry observers. There are certain areas in the directed herring fishery, I can't remember if it's

Area 3 or 1B, that you cannot go fishing unless you have an observer onboard, and those areas are pretty lightly fished, because they won't give us observers.

I just want to be very clear that the industry itself that is in this fishery really wants to have observer coverage to do the right thing, do the right calculations. But we can't get them, so don't think we're avoiding observers in any way, shape or form. I agree with your answer, but the other answer is, I don't know why we can't get them. That's another question I can't answer. My 50 percent probability of having a question I can't answer. Anyway, thank you.

CHAIR FEGLEY: Thank you for that, Eric Reid, and Jeff Kaelin, can you make it quick?

MR. KAELIN: Yes, just quickly. I appreciate Eric bringing this up, because we've actually asked the Science Center to allocate the small number of days in the midwater trawl fleet, for example, and it's a small number of days, because there is not a lot of discards, right that's what drives it. But the flexibility has been removed from the SPRM program by the Oceana law suit, and we're being told by the Science Center, well, they don't have the flexibility to put the days where we need them, basically, you know the spring time for example.

That is a problem we just haven't been able to resolve. Cheri knows, as the Chair of the Herring Committee that we brought this up. We talked to the Science Center, but there just doesn't seem to be a lot of flexibility left to allocate those days in that way, which is really a conundrum. Because if we had those observed days, we would be able to observe clean trips.

There are clean trips, and balance out the factors that lead to closures, and there have been closures in herring and mackerel as a result. We have trouble allocating the days for time and areas where they should be on the boats. As Eric said, we haven't caught any herring in southern New England for a long time.

CHAIR FEGLEY: Thank you, Jeff, I really appreciate that conversation. Okay, so I know we have one member of the public online, and I think what I would like to ask Ms. Evans, and it's because of the late hour, if you wouldn't mind reaching out to staff with your question on e-mail. I think that would really help us. We still have a couple things we need to take care of here, and it's getting late.

CONSIDER THE ACCEPTANCE OF THE BENCHMARK STOCK ASSESSMENT AND PEER REVIEW REPORT FOR MANAGEMENT USE

CHAIR FEGLEY: Moving on, our next agenda item is to Consider the Acceptance of the Benchmark Stock Assessment and Peer Review Report for Management Use. For this I would need a motion. I think John Clark.

MR. JOHN CLARK: I would be glad to make a motion, Madam Chair, oh there we go. **Move to accept the 2024 River Herring Benchmark Stock Assessment and Peer Review Report for management use.**

CHAIR FEGLEY: I have a second from Cheri Patterson. Is there any discussion on the motion? All right, any public comment on the motion? **Is there any objection to the motion? Excellent, so thank you all very much for your great work that has been accepted**, and we'll move on to the last bullet, which is to Consider Management Response if Necessary. I will defer that to the Board, I am not under the impression that there is a desire to take management action based on this, but if somebody wants to say otherwise, please do.

Okay, we have a new stock assessment, we are not currently taking management, and a lot to think about, I will say.

OTHER BUSINESS

CHAIR FEGLEY: Okay, finally, we are at Other Business. Any other business to come before the Board?

ADJOURNMENT

CHAIR FEGLEY: I'm going to have to beg for this one, a motion to adjourn. All right, meeting adjourned, thank you, everyone.

(Whereupon the meeting adjourned at 5:53 p.m. on Wednesday, August 7, 2024)

Atlantic States Marine Fisheries Commission

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Shad & River Herring Technical Committee
Meeting Summary

September 23, 2024

Technical Committee Members: Wes Eakin (Chair, NY), Matthew Jargowsky (Vice-Chair, MD), Michael Brown (ME), Ken Sprankle (USFWS), Patrick McGee (RI), Ruth Haas-Castro (NOAA), Patrick McGrath (VA), Conor O'Donnell (NH), Reid Hyle (FL), Kevin Job (CT), Brian Neilan (NJ), Holly White (NC), Brad Chase (MA), Jeremy McCargo (NC), Kyle Hoffman (SC),

ASMFC Staff: James Boyle and Katie Drew

The TC met via webinar on September 23, 2024, to review updates to the Sustainable Fishery Management Plans (SFMPs) for river herring from New Hampshire and Maine, as well as updates to the SFMPs for American shad from Massachusetts and Connecticut. The Maine and New Hampshire updates also included proposals to change and reopen their fisheries, respectively.

1. **New Hampshire River Herring SFMP Update and Proposal to Reopen Fishery**

Conor O'Donnell presented an updated New Hampshire SFMP for river herring, as well as a proposal to reopen the fishery. The new SFMP includes updated instantaneous mortality rates, standard error calculations for Visual Time Counts, and an added figure of a juvenile abundance index from the state's juvenile seine survey. The TC did make a request for New Hampshire to add some of the river specific results from the 2024 River Herring Benchmark Stock Assessment to the SFMP. **The TC recommended the updated plan for approval by consensus.**

Along with the updated SFMP, New Hampshire submitted a proposal to reopen the river herring fishery, which was closed in 2021 due to low spawning run counts in 2019 and 2020. With new passage estimates in the Exeter River, the Great Bay indicator Stock in New Hampshire has been above the fishery-independent target escapement level of 94,598 fish for the past four years. However, the Technical Guidance on the Implementation of Amendments 2 and 3 to the Shad and River Herring Fishery Management Plan contains a TC recommendation that states:

"If a state has implemented a management restriction in response to the stock falling below the sustainability target(s), the management restriction must stay in place until the sustainability target(s) have been met for at least 5 consecutive years of sufficient data collection" (pg. 8).

With the exception of the Cocheco River, the proposal requested to open the state fishery for the upcoming 2025 fishing season, which is one year earlier than the recommended five-year closure. The proposal states that the reasons for the low spawning run counts in 2019 and 2020 were primarily driven by errors in counting, rather than true declines in river herring abundance. Specifically, New Hampshire notes that there were issues with quantifying river herring in both the Cocheco and Exeter Rivers. In the Cocheco River, equipment failure and fishway modifications led to a loss of efficiency and inaccurate electronic fish counting. In the Exeter River, the majority of river herring are utilizing restored spawning habitat between the former Great Dam and Pickpocket Dam and not accessing the habitat above Pickpocket Dam fishway, where the new electronic counting station was installed after the Great Dam removal.

The TC was unable to reach a consensus on whether to recommend for or against New Hampshire opening their fishery a year earlier than recommended. The TC is hesitant to go against previously established technical guidance, but the they also acknowledge that it is unclear whether the decreases in spawning run counts in 2019 and 2020 were true reflections of abundance or due to methodology.

2. **Maine River Herring SFMP Update and Proposal for Additional Fisheries**

Michael Brown presented an updated Maine SFMP for river herring, which included the addition of five additional commercial fisheries: Sewall Pond, Wights Pond, Chemo Pond, Pennamaquan Lake, and Pushaw Lake. The plan includes updated fishery independent surveys; a recalculated 25th percentile metric; updated *Z* estimates from the 2024 River Herring Benchmark Stock Assessment; and an added age range requirement, all of which are to be used as management triggers. Of the five new commercial fisheries that were requested to be opened, Sewall and Wights Pond were provisional fisheries approved from 2019-2024, Chemo Pond and Pushaw Lake were added due to significant improvements as a result of restoration efforts, and Pennamaquan Lake previously supported a fishery prior to the moratorium in 2012. **The TC recommended the updated plan for approval by consensus.**

3. **Massachusetts American Shad SFMP Update**

Brad Chase presented an update to the Massachusetts SFMP for American shad. There were no significant changes to the previous SFMP other than the addition of a description of stocking efforts in the Taunton River. Over 5 million shad larvae have been stocked each year from 2022-2024 in collaborative effort with USFWS. This fishery is solely a recreational fishery. **The TC recommended the updated plan for approval by consensus.**

4. **Connecticut American Shad SFMP Update**

Kevin Job presented an update to the Connecticut SFMP for American shad. No significant changes were made from the previous SFMP. Connecticut has a recreational fishery and small commercial fishery. The fishery is managed using a stop light approach. Harvest from both fishing sectors has declined over time, with most anglers now targeting striped bass. **The TC recommended the updated plan for approval by consensus.**

5. **Review of Technical Guidance on Incorporation of Stock Assessment Information into SFMPs**

The TC revisited their previous recommendation (pg. 9) not to recommend requiring jurisdictions to use the stock assessment information to develop sustainability metrics for SFMPs (e.g. benchmarks based on total adult mortality). While they did not express interest in recommending changes to state requirements to maintain flexibility for states to account for regional differences, the TC will amend the Technical Guidance document to include specific recommendations on how states should include stock assessment metrics in future SFMP updates.

6. **Other Business**

Matthew Jargowsky informed the TC of Maryland's plan to change their age sampling. Since 2016, Maryland has been taking a subset of both otoliths and scales for river herring, with plans to eventually transition to otoliths. The only active spawning stock survey in Maryland is the North East River spawning stock survey that started in 2012; however, Maryland is in the process of developing an additional spawning stock survey for river herring and is planning to start that survey collecting the preferred aging structure. Currently, for the North East River, Maryland has been aging up to 300 scales per species per year and collecting up to 100 otoliths per species per year (~80 and ~50 per year for alewife and blueback, respectively). Starting in 2025, for each survey, Maryland would sample up to 200 otoliths per species per year. Sampling collection would be based on length bins to facilitate the use of ALKs. Maryland will also begin aging all previously collected otoliths, so that age and mortality estimates from 2016–2024 can be compared. This will be completed by the next river herring stock assessment update.

Additionally, Maryland has been taking both fork and total length measurements for river herring, but will be switching to just taking total lengths since that was the preferred measurement in the most recent stock assessment. Maryland will continue to only collect/age scales for American shad due to sampling constraints.

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Scott R. Mason
Executive Director

September 1, 2024

James Boyle
FMP Coordinator
Atlantic States Marine Fisheries Commission
1050 N. Highland St., Suite 200 A-N
Arlington, VA 22201

Ref: Reopening New Hampshire's River Herring Fishery

Dear Mr. Boyle,

The Atlantic States Marine Fisheries Commission's (ASMFC) Amendment 2 to the Interstate Fishery Management Plan for Shad and River Herring calls for states to close recreational and commercial river herring fisheries with an exception for coastal riverine/estuary management systems with a sustainable fishery and an ASMFC approved plan. New Hampshire's (NH) Sustainable Fishery Management Plan (SFMP) for river herring was initially approved by the ASMFC in 2011 and updated and approved in 2020. The proposed SFMP has two separate targets, one fishery-dependent (Figure 1) and one fishery-independent (Figure 2). The fishery-independent target is a 3-year average return to NH's Great Bay Indicator Stock (Cocheco, Lamprey, Oyster, and Exeter rivers) of 94,589 spawning river herring (Table 1). Upon analyzing NH's 2019 anadromous fish passage data it was determined NH was currently out of compliance of the fishery-independent target in NH's River Herring SFMP, resulting in a closure of the river herring fishery in 2021.

There were three reasons for NH's low river herring spawning run counts in 2019 and 2020:

1) Environmental: Low water temperatures during the early part of spawning season. Once water temperatures reached favorable levels river flows were significantly decreased.
2) Cocheco River Fishway: Equipment failure and fishway modifications at the Cocheco River fishway led to loss of efficiency and decreased river herring passage. Many river herring were observed in the fishway but could not be accurately counted due to poor flow within the modified fishway resulting in inaccurate electronic fish counting.

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3) Exeter River fish passage: Fish passage counts at the Pickpocket Dam fishway on the Exeter River were low despite thousands of ascending river herring observed in the vicinity of the former head-of-tide Great Dam and associated fishway, which was removed in 2016. The Pickpocket Dam is located 13.4 km upstream of the former Great Dam location. The reasoning for such low counts at the next upstream fishway is that the majority of river herring are utilizing restored spawning habitat between the former Great Dam and Pickpocket Dam and not accessing the habitat above Pickpocket Dam fishway where the electronic counting station was installed.

In response to challenges accounting for spawning river herring in the Exeter River after the Great Dam removal, and the low river herring returns in the Cocheco River after fishway modifications were made, the NH Fish and Game Department (NHFGD) began using a different monitoring method in 2021. Visual time counts at the former Great Dam site were initiated to more accurately estimate the spawning river herring ascending the Exeter River near the head-of-tide and converted the Cocheco River fishway back to the more successful previous operational processes.

Through improved fish passage counting estimates in the Exeter River, the Great Bay Indicator Stock has exceeded the proposed fishery-independent target of 94,589 river herring, for the last four years. NHFGD will propose to keep the Cocheco River closed to recreational/personal use and commercial river herring harvest (harvest levels in Tables 2 and 3) while improvements to fishway passage continue and returns increase. The remaining rivers of the Great Bay Indicator Stock will support harvest opportunities while meeting NH's fishery-independent sustainability target as outlined in the River Herring SFMP. River herring harvest on the Cocheco River has historically been minimal, less than 20 pounds between 2013 and 2020, and likely will not increase fishing pressure on other rivers in the Great Bay Estuary.

With the exception of the Cocheco River, NHFGD is requesting to open its river herring fishery for the 2025 season as the returning river herring in the Great Bay Indicator Stock have surpassed the fisheries-independent target for four consecutive years and can support the traditional commercial and recreational fisheries without diminishing potential future stock reproduction and recruitment.

If you have any questions regarding this proposal to reopen NH's river herring fishery feel free to contact Conor O'Donnell at (603) 868-1095 or Conor.ODonnell@wildlife.nh.gov.

Sincerely,

Cheri Patterson

Cheri Patterson
Chief of Marine Fisheries

cc: Renee Zobel, Marine Program Supervisor
Conor O'Donnell, Marine Biologist

Table 1. Numbers of river herring returning to fishways on coastal rivers of New Hampshire, 1972–2023, and preliminary returns of 2024.

Year	Cocheco River	Exeter River	Oyster River	Lamprey River	Taylor River	Winnicut River	Annual Total
1978	1,925	205	419	20,461	168,256	3,229++	194,495
1979	586	186	496	23,747	375,302	3,410++	403,727
1980	7,713	2,516	2,921	26,512	205,420	4,393++	249,475
1981	6,559	15,626	5,099	50,226	94,060	2,316++	173,886
1982	4,129	542	6,563	66,189	126,182	2,500++	206,105
1983	968	1	8,866	54,546	151,100	+	215,481
1984	477		5,179	40,213	45,600	+	91,469
1985	974		4,116	54,365	108,201	+	167,656
1986	2,612	1,125	93,024	46,623	117,000	1,000++	261,384
1987	3,557	220	57,745	45,895	63,514	+	170,931
1988	3,915		73,866	31,897	30,297	+	139,975
1989	18,455		38,925	26,149	41,395	+	124,924
1990	31,697		154,588	25,457	27,210	+	238,952
1991	25,753	313	151,975	29,871	46,392	+	254,304
1992	72,491	537	157,024	16,511	49,108	+	295,671
1993	40,372	278	73,788	25,289	84,859	+	224,586
1994	33,140	*	91,974	14,119	42,164	+	181,397
1995	79,385	592	82,895	15,904	14,757	+	193,533
1996	32,767	248	82,362	11,200	10,113	+	136,690
1997	31,182	1,302	57,920	22,236	20,420	+	133,060
1998	25,277	392	85,116	15,947	11,979	219	138,930
1999	16,679	2,821	88,063	20,067	25,197	305	153,132
2000	30,938	533	70,873	25,678	44,010	528	172,560
2001	46,590	6,703	66,989	39,330	7,065	1,118	167,795
2002	62,472	3,341	58,179	58,065	5,829	7,041	194,927
2003	71,199	71	51,536	64,486	1,397	5,427	194,116
2004	47,934	83	52,934	66,333	1,055	8,044	176,383
2005	16,446	66	12,882	40,026	233	2,703	72,356
2006	4,318	16	6,035	23,471	147	822	34,809
2007	15,815	40	17,421	55,225	217**	7,543	96,261
2008	30,686	168	20,780	36,247	976	8,359	97,214
2009	36,165	513	11,661	42,425	*	4,974	95,737
2010	32,654	69	19,006	33,327	675	576+++	86,307
2011	43,090	256	4,755	50,447	59	72+++	99,338
2012	27,608	378	2,573	86,862	92	5+++	117,518
2013	18,337	588	7,149	79,408	128	0	105,610
2014	29,968	789	4,227	84,868	57	0	119,909
2015	64,456	5,562	1,803	69,843	*	0	141,664
2016	99,241	6,622	863	92,364	*	0	199,090
2017	28,926	--	4,492	35,920	*	0	69,338
2018	24,743	32	5,716	50,884	*	53	81,428
2019	1,682	28	4,969	34,684	*	0	41,363
2020	3,832	17	4,655	56,632	*	0	65,136
2021	2,117	167,400	9,976	80,567	*	5	260,065
2022	4,452	273,228	11,272	77,285	*	0	366,237
2023	6,143	234,948	8,936	59,793	*	0	309,820
2024	77,597	115,236	10,797	101,830	*	0	305,460

* Swim through operation.
** Due to fish counter malfunction there was up to two weeks where passing fish were not enumerated.
*** Sea lamprey inundation caused fish counter to false count.
+ Fishway unable to pass fish until modifications in 1997.
++ Fish netted below and hand passed over Winnicut River Dam.
+++ Minimum estimate based on time counts, fishway/dam removed in fall 2009.
2024 data is preliminary as of 7/2024.

Table 2. New Hampshire's reported coastal harvest landings (pounds) of river herring (alewife and blueback herring) from 1991 to 2024.

Year	Harvest (lbs)
1990	15,513
1991	8,402
1992	9,772
1993	2,131
1994	1,940
1995	5,138
1996	4,003
1997	9,168
1998	25,993
1999	19,049
2000	22,141
2001	14,129
2002	13,617
2003	16,516[b]
2004	9,093[b]
2005	1,514
2006	1,716
2007	1,408
2008	7,669
2009	9,439
2010	7,466
2011	4,094[b]
2012	2,681
2013	4,481[a]
2014	5,737[c]
2015	7,566[c]
2016	4,354[c]
2017	4,016[c]
2018	4,398[c]
2019	11,326[c]
2020	7,964[c]
2021	0
2022	0
2023	0
2024	0

[a]- River herring harvested by New Hampshire coastal harvesters for personnel use and for sale.

[b]- River herring harvested by New Hampshire coastal harvesters for personnel use and for sale plus NMFS reported landings from federal waters.

[c]- River herring harvested by New Hampshire coastal harvesters for personnel use.

Table 3. Reported commercial harvest (metric tons and pounds) of river herring landed in New Hampshire from the NOAA Fisheries, 1957-2023.

Year	Metric Tons	Pounds
1957	34	75,000
1958	27.2	60,000
1959	36.3	80,000
1960	43.1	95,000
1961	45.4	100,000
1962	56.7	125,000
1963	68	150,000
1964	34	75,000
1965	56.7	125,000
1966	34	75,000
1967	29.5	65,000
1968	18.4	40,600
1969	17	37,500
1970	14.1	31,000
1971	11.3	25,000
1972	10.9	24,000
1973	9.8	21,500
1977	95.3	210,000
1978	74.8	165,000
1982	51.9	114,500
1983	52.3	115,216
1984	40.8	90,000
1985	27.8	61,300
1986	12.2	26,990
1987	8.9	19,550
1988	5.5	12,087
1989	5.1	11,200
1992	4.4	9,802
1993	1.2	2,676
1998	11.8	25,994
2007	0.6	1,408
2008	3.7	8,132
2009	4.3	9,439
2010	3.4	7,466
2011	1.9	4,113
2012	1.2	2,681
2013	2	4,420
2014	0	0
2015	0	0
2016	0	0
2017	0	0
2018	0	0
2019	0	0
2020	2.7	5,850
2021	0	0
2022	0	0
2023	0	0
Grand Total	958.2	2,112,405

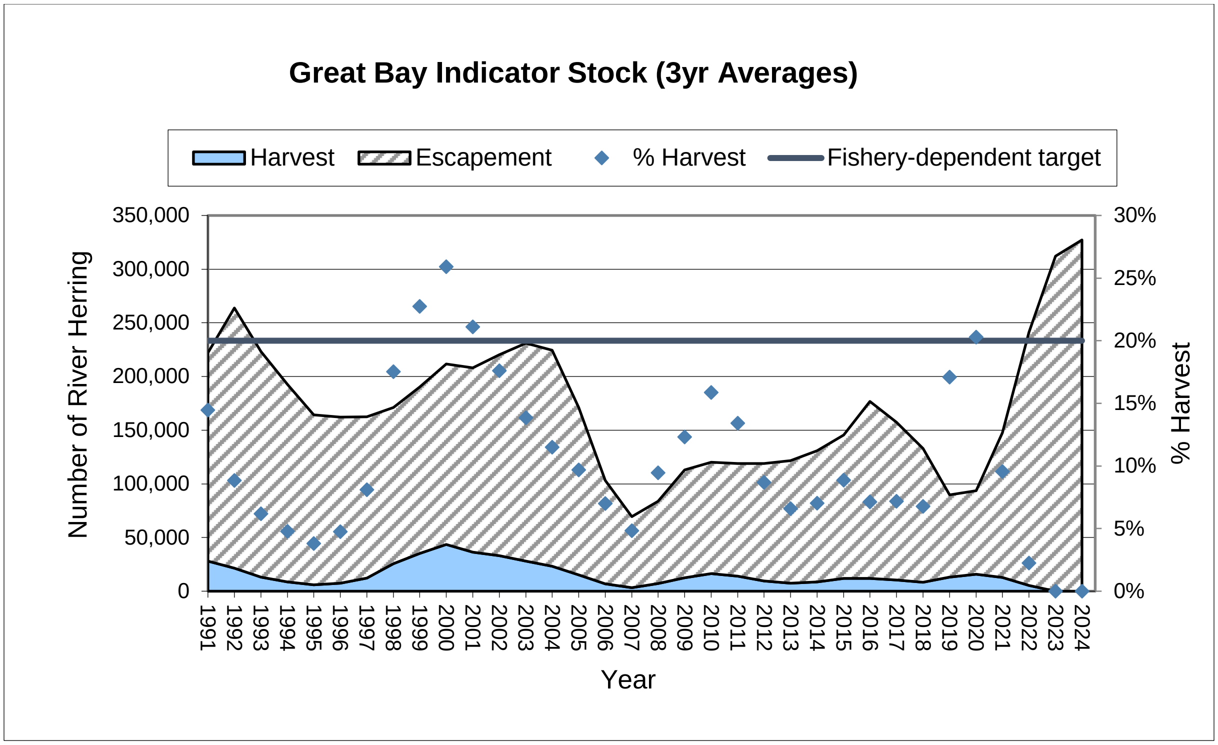


Figure 1. Fishery-dependent target. Harvest level (3yr averages) that results in an exploitation rate that does not exceed 20% of the Great Bay Indicator stock, providing 80% escapement. [2024 data is preliminary as of 7/2024]

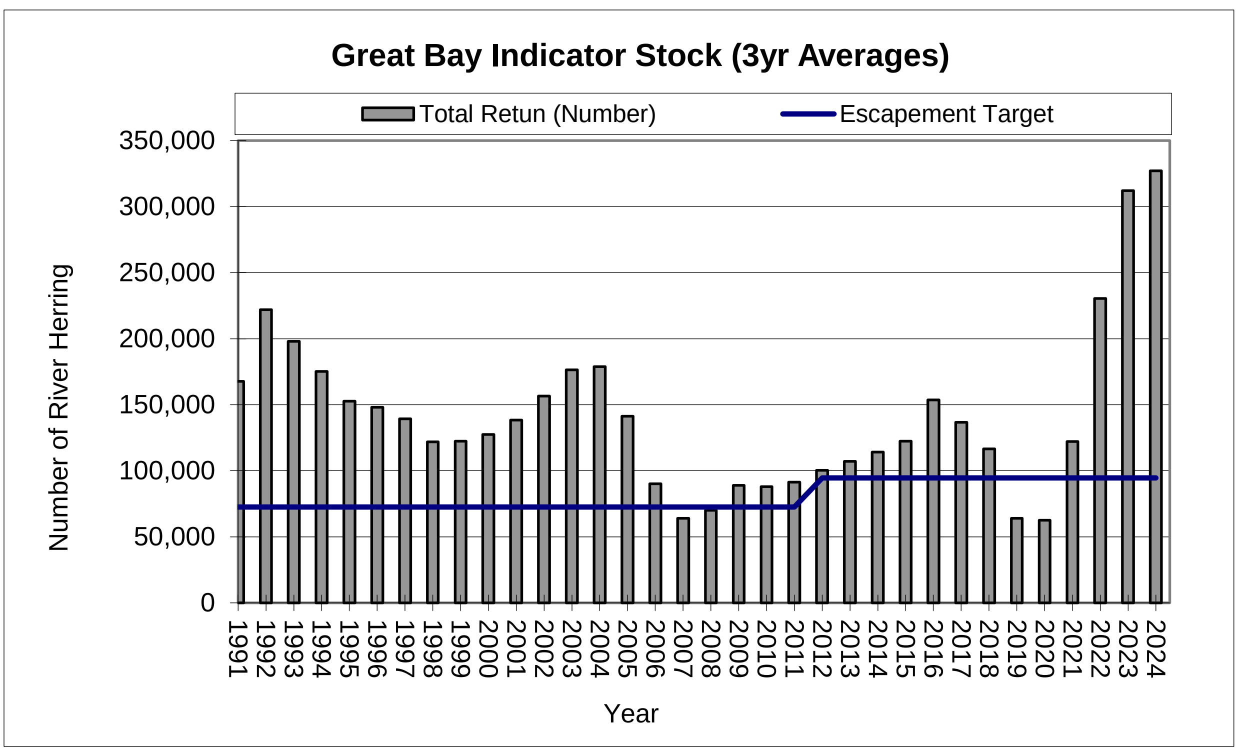


Figure 2. Proposed fishery-independent target. Three-year average returns to NH coastal rivers, with an escapement level of 216 fish per surface acre of available spawning habitat (94,589 fish). [2024 data is preliminary as of 7/2024]

New Hampshire ASMFC River Herring Sustainable Fishery Management Plan

New Hampshire Fish and Game Department

Updated October, 2024

Contents

Executive Summary

Introduction

The Atlantic States Marine Fisheries Commission's (ASMFC) Amendment 2 to the Interstate Fishery Management Plan for Shad and River Herring (FMP) calls for states to close recreational and commercial river herring (Alewife *Alosa pseudoharengus* and Blueback Herring *A. aestivalis*) fisheries with an exception for systems with a sustainable fishery. The FMP defines a sustainable fishery as one "that demonstrates their alewife or blueback herring stock could support a commercial and/or recreational fishery that will not diminish potential future stock reproduction and recruitment." States and jurisdictions are required to develop sustainability targets with substantiated data, which "may include, but is not limited to, repeat spawning ratio, spawning stock biomass, juvenile abundance levels, fish passage counts, hatchery contribution to stocks and bycatch rates."

The unique ecosystem interactions found within a state or jurisdiction allow targets to be "applied state-wide or can be river and species specific." New Hampshire is proposing to use the extensive monitoring data from New Hampshire's largest estuary, the Great Bay Estuary System, to evaluate whether river herring stocks can continue to support a commercial and/or recreational fishery that will not diminish potential future stock reproduction and recruitment. River herring harvest in the Great Bay Estuary (Estuary) accounts for 95-100% of the statewide harvest. In addition, New Hampshire Fish and Game (NHFGD) monitors river herring spawning stock returns at fish ladders on four of the seven major rivers in the Estuary and monitors juvenile abundance on an estuary-wide basis via a seine survey. Finally, the Estuary's unique geographical characteristics lend itself to monitoring the systems resource as a whole rather than on a river-specific basis. The Estuary includes seven small to moderate size rivers with most flowing into a large embayment (Great Bay and Little Bay) before draining into a narrow, 15 km long opening to the sea via the Piscataqua River.

Current Regulations

The first law protecting river herring in New Hampshire state waters was enacted in 1967. This law required that any resident wishing to harvest river herring using a seine, net, or weir to obtain a license through the NHFGD. Furthermore, in 1987 regulations prohibiting the taking of river herring on Wednesdays was established to provide a day of escapement from the fishery. In 2005, prior to adoption of Amendment 2, NHFGD took significant management action to reduce river herring harvest in the state. First, in the Exeter River, allowable harvest days were reduced from six to two days per week and a one fish tote per day possession limit was implemented. This action was taken following seven years of substantial increases in the river herring harvest in this river that accounts for the vast majority of the statewide river herring harvest. Second, a large portion of the Taylor River in the Hampton-Seabrook Estuary System was completely closed to the taking of river herring following long term and persistent declines in the river herring run. In 2012, the Oyster River was closed to the taking of river herring by any method from the head-of-tide dam at Mill Pond to the mouth of the river at Little Bay. This was in response to diminishing returns of river herring to the Oyster River fishway. These actions resulted in a significant reduction in statewide river herring harvest. Table 1 shows a summary of river herring regulations, prior to 2021 closure, including special river restrictions.

Current Status of Stocks

River herring stocks are managed on a statewide level within New Hampshire state waters by monitoring annual spawning runs and harvest from fisheries. Annual spawning runs (returns) of river herring have been monitored on six of the major coastal rivers, which demonstrate inter-annual variability in return numbers (Table 2). With the exception of return estimates produced in 1979, there was a period of high abundance in the 1990's with nearly 300,000 fish returning to spawn, before gradually declining to levels between 100,000 and 200,000. In recent years, river herring spawning returns have been trending upwards of 300,000 fish, likely in response to newly restored spawning habitat, fishway modifications, and better accounting of spawning run in the Exeter River. Estimates of the total instantaneous mortality rate (Z) have shown an overall stable or slightly decreasing trend (Table 3) and the percentages of repeat spawning fish in the rivers monitored in the Great Bay Estuary have ranged from 32% to 52% for all rivers combined since 2000 (Tables 4 and 5).

Changes in return numbers are most pronounced in the Oyster River where the number of returning fish increased steeply between 1986 and 1992 from less than 9,000 fish per year to more than 150,000 fish, followed by a steady, long term decline to less than 1,000 fish in 2016 (Table 2). The declines in recent years may be related to poor water quality with low dissolved oxygen levels that have been measured during the summer months in the impoundment behind the fish ladder.

In the Exeter River, returns of spawning river herring past the head-of-tide dam (Great Dam) had been constrained by the inefficiency of the fish ladder. Significant spawning activity had been observed below the fish ladder and reported harvest below this spawning area (Tables 6 and 7) has consistently exceeded the ladder counts by large amounts indicating a much larger spawning stock in this river than indicated by only ladder counts. The number of fish which reach and spawn below the head-of-tide ledges were not quantified and therefore not included in the annual return values, making return or escapement numbers a minimum estimate. The Great Dam and associated fish ladder was removed in the fall of 2016. Over the next few years, fish passage counts at the next barrier, Pickpocket Dam and associated fishway (located 13.4 km upstream of the former Great Dam location), were low despite thousands of ascending river herring observed at the restored river section near the former Great Dam. The reasoning behind such low counts is that the majority of river herring are utilizing restored spawning habitat between the former Great Dam and Pickpocket Dam and not accessing the habitat above Pickpocket Dam. Currently, quantitative monitoring of river herring occurs at the former Great Dam location by conducting daily visual time counts to provide an estimate of annual returns to the Exeter River.

In the Lamprey and Cocheco rivers, river herring returns numbers have varied greatly over the years; building to a high time-series level exceeding 90,000 fish in 2016 (Table 2). Spawning activity has also been observed occurring in significant numbers below the Lamprey River fish ladder. At present, the number of fish that reach and spawn below both the Lamprey and Cocheco river's fish ladders are not quantified and therefore not included in the annual return values, making return or escapement numbers a minimum estimate.

High flows existed in all coastal rivers during April or May in the years 2005–2007, reaching "100-year flood" levels in 2006 and 2007. These high flows prevented river herring from finding and ascending coastal fish ladders for significant periods during the spawning run leading to the lowest return numbers through the fish ladders in three decades. During those years, data obtained from the Great Bay Estuary juvenile abundance index seine survey exhibited increases in the geometric mean occurrence of both river herring species (Table 8). This data further suggests that return numbers determined by fish ascending fish ladders are a minimum value and that non-quantified numbers of river herring are successfully spawning below head-of-tide dams.

Sustainability Targets

River herring in New Hampshire are currently managed as a statewide management unit, but two sustainability targets, one fishery-dependent and one fishery-independent, will be established using exploitation rates and numbers of returning river herring per surface acre of available spawning habitat in the Great Bay Estuary. This method was chosen because at least 95% of the river herring harvest in New Hampshire occurs in this estuary and there are currently fish ladders on five of the seven rivers in the Great Bay Estuary, each of which are monitored by the NHFG annually (Tables 6 and 7). Historical monitoring of river herring runs within New Hampshire have shown that the numbers of returning river herring to four rivers (Cocheco, Lamprey, Oyster, and Exeter rivers) have accounted for greater than 80% of the returning fish enumerated annually at fish passage structures on New Hampshire coastal rivers (Table 9). The Atlantic States Marine Fisheries Commission Shad and River Herring FMP states that “Definitions of sustainable fisheries and restoration goals can be index-based or model-based” and that “Member states or jurisdictions could potentially develop different sustainability target(s) for river herring based on the unique ecosystem interactions and…Targets can be applied statewide or can be river and species specific.” Therefore, New Hampshire will be using the stocks of river herring returning to the Cocheco, Lamprey, Oyster, and Exeter rivers in the Great Bay Estuary as an indicator of statewide river herring abundance and refer to them as the ‘Great Bay Indicator Stock’. Using an estuary-wide versus river-specific approach is the best suitable method due to the physical/geographical characteristics of the Great Bay Estuary.

New Hampshire’s River Herring Sustainable Fisheries Management Plan (SFMP) will include two separate targets, fishery-dependent and fishery-independent. The fishery-dependent target will be a harvest level that results in a harvest percentage (exploitation rate) that does not exceed 20% in the ‘Great Bay Indicator Stock’, providing an 80% escapement level. Specifically, a three-year running average of the total annual river herring harvest from throughout Great Bay Estuary will be compared to a three-year running average of minimum annual counts of spawning river herring returns documented via fish passage counts on the Great Bay Indicator Stock rivers plus the annual harvest of river herring throughout the estuary system. This is a very conservative target since the harvest from throughout the Great Bay Estuary (including seven rivers, Great Bay, Little Bay, and Portsmouth Harbor) is being compared to river herring return numbers counted at fish ladders on only four of the seven major rivers in Great Bay Estuary which represents some fraction of the total spawning river herring in the Estuary each year.

For development of the fishery-independent target, New Hampshire initially used historical studies as a basis for the target used in Maine’s River Herring Sustainable Fishery Management Plan that was previously approved by the Shad and River Herring Management Board. New Hampshire has never conducted studies to determine ideal densities of fish per acre of available spawning habitat, but the target was established based on studies conducted in the state of Maine during the 1970's and 1980's along with other historical information of annual river herring spawning runs in New Hampshire. Maine studies have indicated that an average return of 235 fish per surface acre and escapement rate of 35 fish per surface acre allows for adequate harvest, escapement to maintain the run, and available broodstock to increase the run if desired. Using that analysis-based minimum annual escapement of 35 river herring per surface acre, a target value was calculated for the 207 acres of currently accessible spawning habitat in New Hampshire. This escapement level would only provide a minimum of 7,245 river herring returning to the Great Bay Estuary annually. New Hampshire believes that number would be insufficient to maintain current population levels, thus a second approach of calculating half of the mean annual return of river herring in the past 20 years was used to establish a proposed fishery-independent target escapement level of 350 fish per surface acre of available spawning habitat (72,450 fish).

Upon review of the New Hampshire's 2011 River Herring SFMP, it was determined that the available spawning habitat in New Hampshire was originally miscalculated using New Hampshire's Department of Environmental Services (NHDES) dam impounded water data that was available at the time. The recent use of Geographic Information Systems (GIS) software provided a more accurate value, increasing the available spawning habitat from 207 acres to 336 acres. A new escapement target of value of 216 fish per surface acre was calculated by using half of the mean annual return of river herring (72,450 fish) divided by the corrected available spawning habitat (336 acres).

Access to spawning habitat increased further with the construction of a new fish passage structure in 2012 on the Lamprey River in the town of Durham, NH, bringing the total available spawning habitat in New Hampshire up to 438 acres. Using an annual escapement value of 216 river herring per surface acre, a target value was calculated for the 438 acres of current accessible spawning habitat in New Hampshire. The fishery-independent target escapement level would require a minimum annual return of 94,589 river herring. This target remains slightly above 50% of the mean annual river herring returns to the Great Bay Estuary since 1990.

Proposed Regulation Modification to Support Target

In response to low river herring spawning returns over the last few years in the Cocheco River after fishway modifications in 2016, NHFGD is proposing to keep the Cocheco River closed to recreational/personal use and commercial river herring harvest while improvements to fishway passage continue and returns increase. The remaining rivers of the Great Bay Indicator Stock will support harvest opportunities while meeting NH's fishery-independent sustainability target. River herring harvest on the Cocheco River has historically been minimal, less than 20 pounds in recent years, and likely will not increase fishing pressure on other rivers in the Great Bay Estuary.

Adaptive Management

The Department annually monitors, evaluates, and quantifies fish passage on five major coastal rivers in New Hampshire (Cocheco, Oyster, Lamprey, Winnicut, and Exeter rivers); fishery-independent information. The harvest of river herring is determined through mandatory reporting of all fish taken by state permitted harvesters and through conduct of the federal

Access Point Angler Intercept Survey (fishery-dependent data). Both will be reviewed annually to ensure that both sustainability targets are met within the Great Bay Indicator Stock. If the fishery-dependent target is not met, then the state will use one or more of the following management measures: 1) Add additional days or areas of prohibited harvest of river herring; 2) Implement or lower a daily harvest limit for state-permitted harvesters; and/or 3) Implement a daily catch limit for recreational anglers. If the fishery-independent target is not met, then the state will implement a prohibition on harvest of river herring to all fisheries operating in state waters. As a requirement of Amendment 2, the NH River Herring SFMP will be reviewed and updated as necessary or every seven years.

1 Introduction

The purpose of this River Herring Sustainable Fishery Management Plan is to ensure river herring populations in New Hampshire remain stable and fishing opportunities continue to exist.

New Hampshire's coastal rivers once supported abundant runs of river herring. They have been denied access to historical freshwater spawning habitat since the construction of milldams as early as the 1600s but more dramatically during the nineteenth century textile boom in many New Hampshire coastal rivers. Barriers eliminated American shad and Atlantic salmon populations, but river herring only declined in numbers because they utilized the small area of freshwater at the base of dams during spring runoff for spawning.

Restoration of river herring populations in New Hampshire began with construction of fishways in the late 1950s and continued through the early 1970s by the NHFGD in the Cocheco, Exeter, Oyster, Lamprey, and Winnicut rivers in the Great Bay Estuary, and the Taylor River in the Hampton-Seabrook Estuary. These fishways re-opened acres of freshwater spawning and nursery habitat for American shad, river herring, and other diadromous fish.

2 'Great Bay Indicator Stock' Management Area

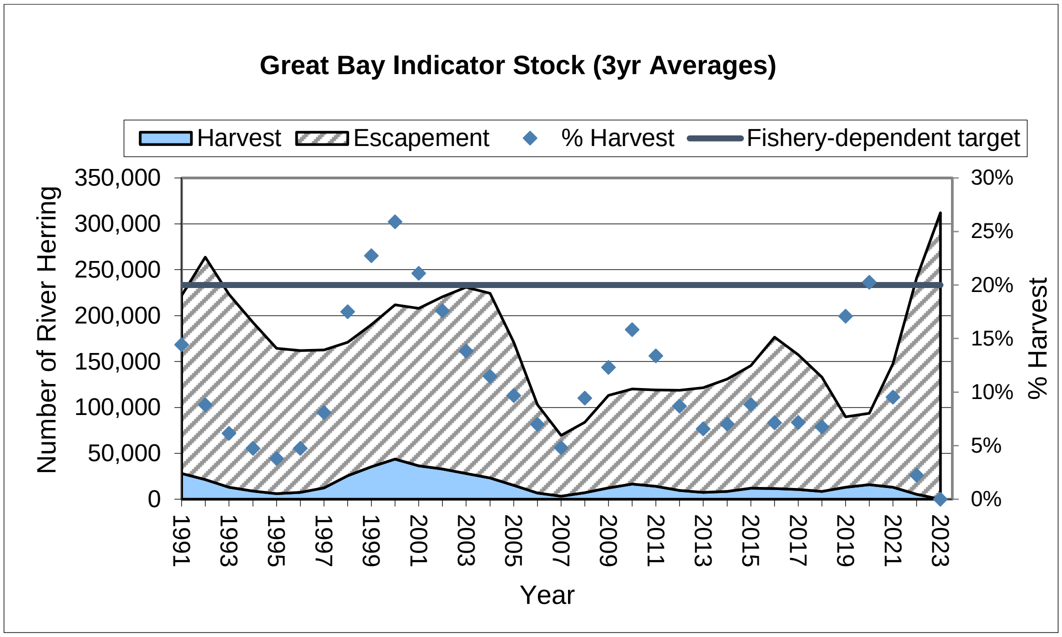
Physical Description:

Amendment 2 to the Interstate Fishery Management Plan for Shad and River Herring states that the unique ecosystem interactions found within a state or jurisdiction allow for targets to be applied state-wide or can be river and species specific (ASMFC 2009). New Hampshire is proposing to use the extensive monitoring data from New Hampshire's largest estuary, the Great Bay Estuary, to evaluate whether river herring stocks can continue to support a fishery that will not diminish potential future stock reproduction and recruitment.

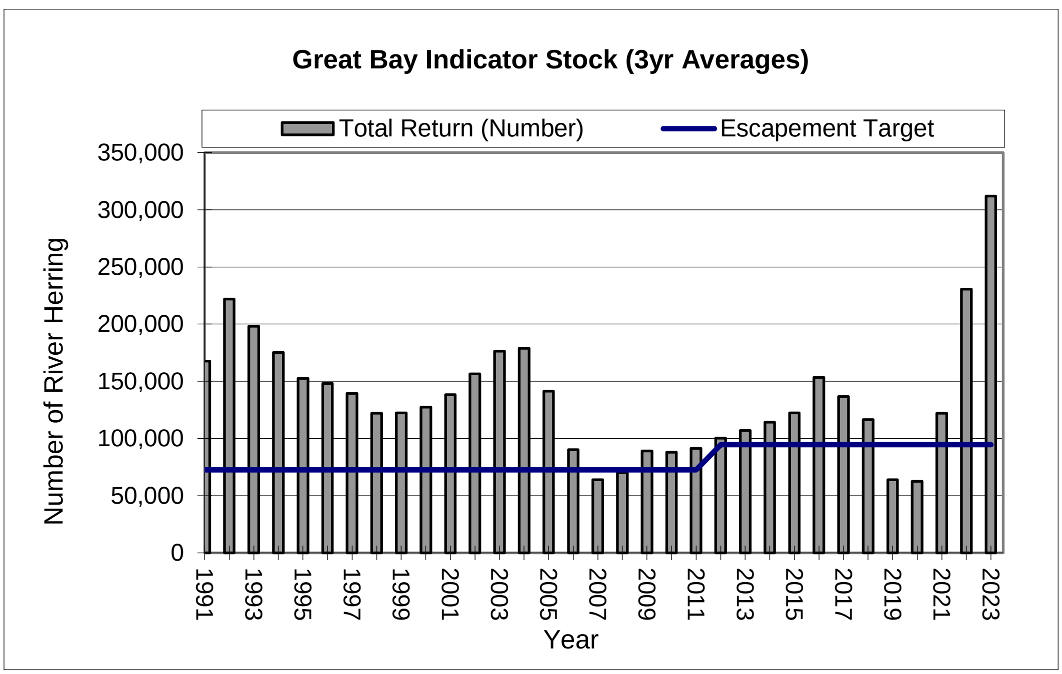
The estuary includes seven small to moderate size rivers with most flowing into a large embayment (Great Bay and Little Bay) before draining into a narrow, 15 km long opening to the sea via the Piscataqua River (Figure 1). NHFGD monitors river herring spawning stock returns on four of the seven major rivers in the estuary and monitors juvenile abundance on an estuary-wide basis via a seine survey. Analysis of juvenile river herring catch rates from the seine survey (Table 8 and Figure 2) do not produce any significant correlations with annual ladder returns, river herring harvest levels, or exploitation rates, likely due to the estuary-wide design and the limited sampling rate in close proximity to river mouths during times of juvenile emigration in the late summer/fall. Fish passage structures on the four monitored rivers allow river herring access to approximately 438 surface acres of available spawning habitat. The Estuary's unique geographical characteristics lend itself to monitoring the river herring resource as a whole rather than on a river-specific basis.

Description of Fishery:

River herring harvest in the Estuary accounts for 95-100% of the statewide harvest. The primary harvest of river herring in New Hampshire is for personal use as bait by anglers and lobster harvesters. The intensity of fishing effort and resulting harvest varies greatly between individual rivers, although the methods for harvest are almost primarily cast nets, dip nets, and gill nets in all locations. The annual river herring harvest numbers from the Great Bay Indicator Stock have ranged from approximately 3,200 fish to 43,600 fish (Figure below and Table 6).



The exploitation rate is currently 0%, which is below the fishery-dependent target of 20% (Table 7) and the run is currently above the fishery-independent target of 216 fish per acre (Figure below and Table 9).



In addition, both the three-year repeat spawning percentage of 35% (65% R-0, 22% R-1, 10% R-2, 3% R-3, 1% R-4; Tables 4 and 5) and the instantaneous mortality rates calculated from age data using the Chapman-Robson method appear steady or slightly decreasing (Figure below and Table 3).

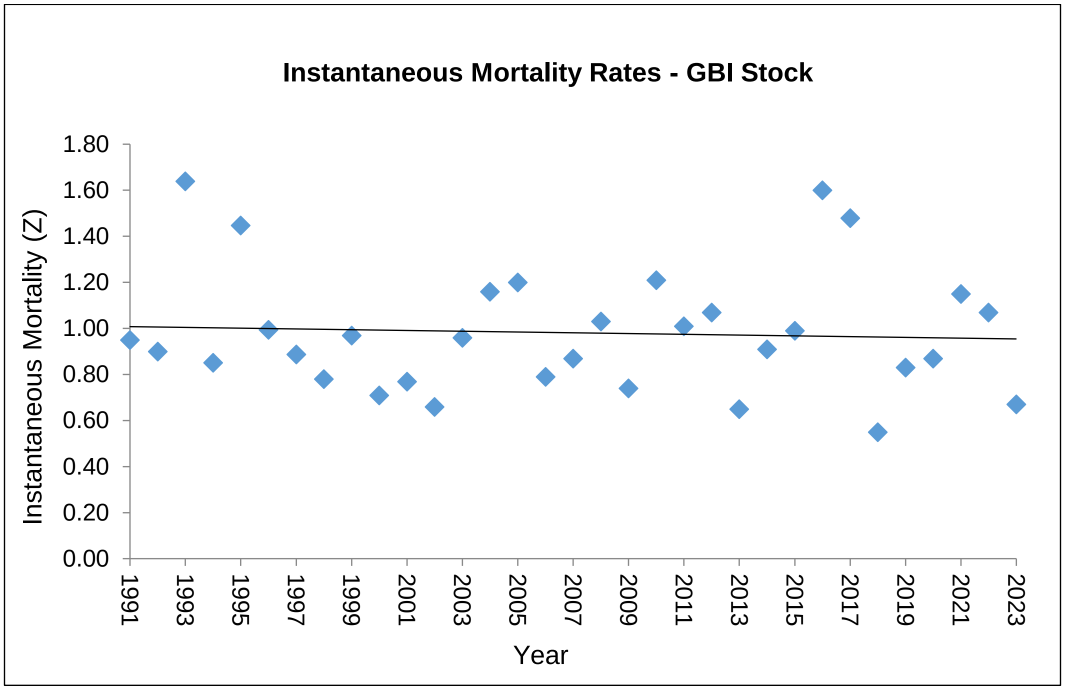
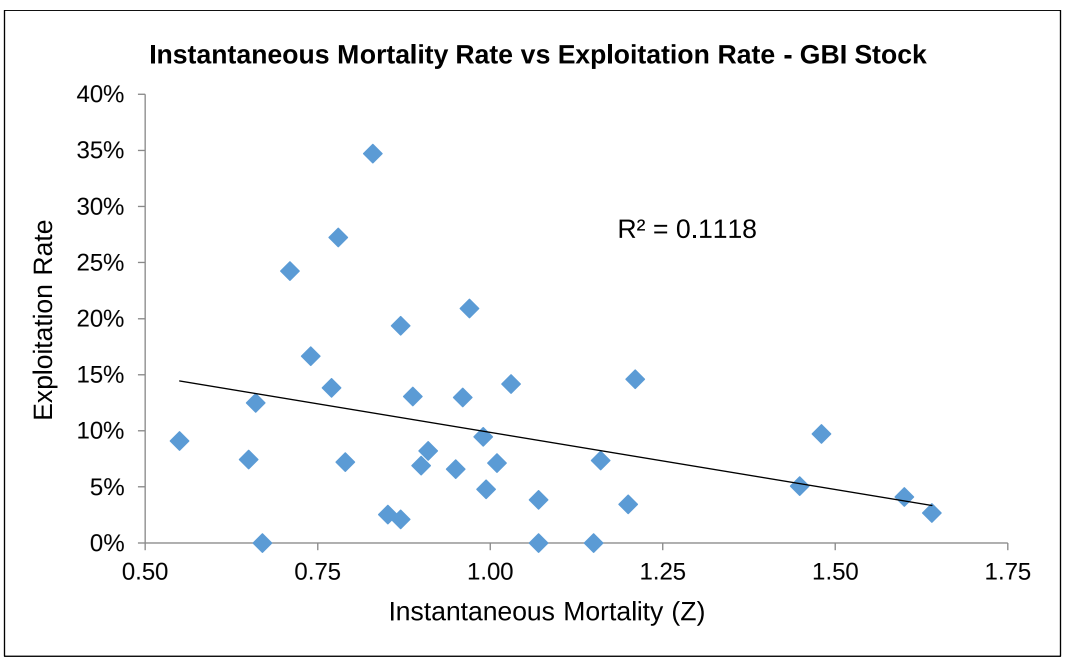


Table 10 and the Figure below shows a significant correlation (P=0.001) between mortality rates and exploitation rates. Although there is a correlation between changes in the calculated instantaneous mortality rate and the exploitation rate, the plot indicates that years of high exploitation coincide with years of low mortality rate suggesting that the exploitation rate is likely more dependent on the mortality rate than the mortality rate being dependent on the exploitation rate.



2.1 River Descriptions

New Hampshire's coastal area contains two major estuaries with the Great Bay Estuary being the largest. The following is a description of each river in the Estuary, a description of the river herring fishery, and other factors related to river herring management.

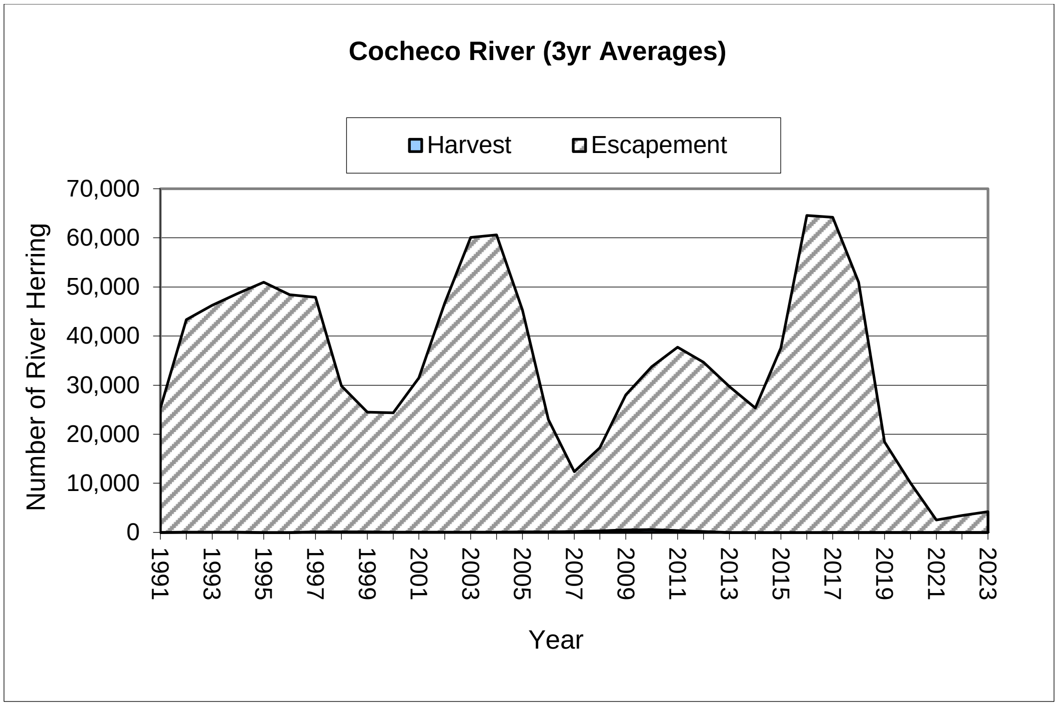
2.1.1 Cocheco River

Physical Description of River, Watershed, and Impoundment:

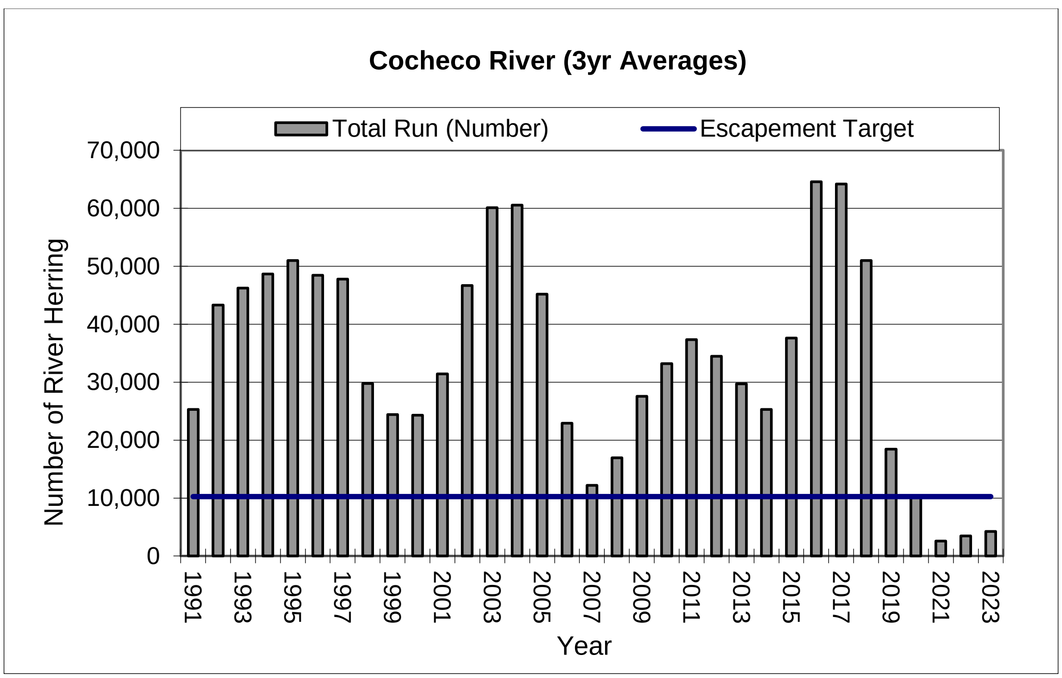
The Cocheco River flows 48 km southeast through southern New Hampshire to Dover where it confluences with the Salmon Falls River to form the Piscataqua River (Figure 1). The Piscataqua River flows approximately 15 km to the sea. The Cocheco River drains a watershed of 479 square km. The lowermost dam (4.6m high, built on a natural ledge for a total height of 8-10 m) on the Cocheco River is within the City of Dover, at rkm 6.1. This dam impounds an area of 20 acres. A Denil fish ladder, which provides access for anadromous fish to approximately 47 acres of potential spawning habitat, was constructed at the dam between 1969 and 1970 by NHFGD. The dam owner maintains a downstream migration structure, which was replaced for increased efficiency in 2010 and modified again in 2017. The downstream passage system is a PVC tube emptying in a plunge pool below the dam, which successfully passes emigrating diadromous species when operating efficiently. The next barrier is a set of natural falls located at rkm 10.6. It has never been studied to determine if river herring can ascend this natural falls and continue migrating upriver a distance of 1.3 km to the Watson Dam in Dover, NH, during normal flow conditions. However, there is no fish ladder at this dam and no fish have been observed during occasional observations, but a downstream migration pipe is provided by the hydroelectric facility to accommodate emigration of enhancement stocking in upper river reaches.

Description of fishery:

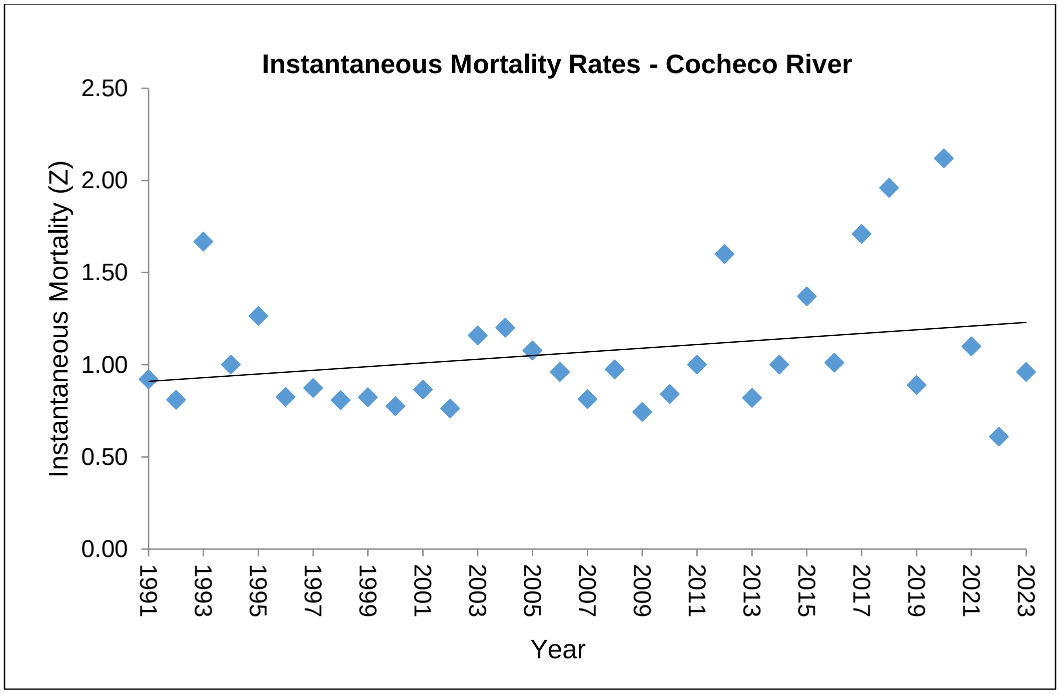
The river herring fishery in the Cocheco River is very sporadic with very few fish harvested over the course of the last several years (Figure below and Table 6). Total annual in-river harvest has ranged from zero fish to approximately 600 fish (Table 7). Harvesters typically fish with cast nets, dip nets, or gill nets. The Cocheco River is closed to fishing from the fish ladder at the lowermost dam to the Washington Street Bridge, approximately 200 m downstream. Most of the river herring harvest in the Cocheco River occurs from the Washington Street Bridge to approximately 0.50 km downriver. In addition, there is a popular striped bass fishery that occurs along this stretch of river where recreational anglers "snag" river herring to be used as live bait.



The run is currently below the fishery-independent target of 216 fish per acre (Figure below and Table 9); has a three year repeat spawning percentage of 36% (65% R-0, 18% R-1, 10% R-2, 5% R-3, 1% R-4; Tables 4 and 5).



The instantaneous mortality rates calculated from age data using the Chapman-Robson method are trending slightly upward (Figure below and Table 3), and there is a significant correlation (P=0.018) between mortality rates and exploitation rates (Table 10 and Figure 3).



Ladder Efficiency, Spawning Area, and Water Quality:

Modifications made to the Cocheco River fishway trap conducted in the summer of 2015 allowed for the use of an electronic fish counter for the first time in 2016. This eliminated the laborious task of netting and passing the entire anadromous fish run by hand. However, following low returns in 2019 and 2020, NHFG consulted with US Fish and Wildlife Service fish passage engineers regarding potential changes in operation. These changes consisted of removing the two uppermost baffles within the fish trap to lower trap levels, provide more resilience to varying impoundment levels, and provide more flow and attraction water down the fishway. Finally, after low returns again in 2021 it was decided to remove all the structure within the fish trap allowing for fish counter use. In 2022, the fishway was operated as it was prior to the modifications in 2016. Currently there are no concerns with the upstream passage efficiency of the existing fish ladder or the water quality throughout the spawning and emigration season in the Cocheco River. Some spawning activity has been observed below the dam in recent years.

2.1.2 Lamprey River

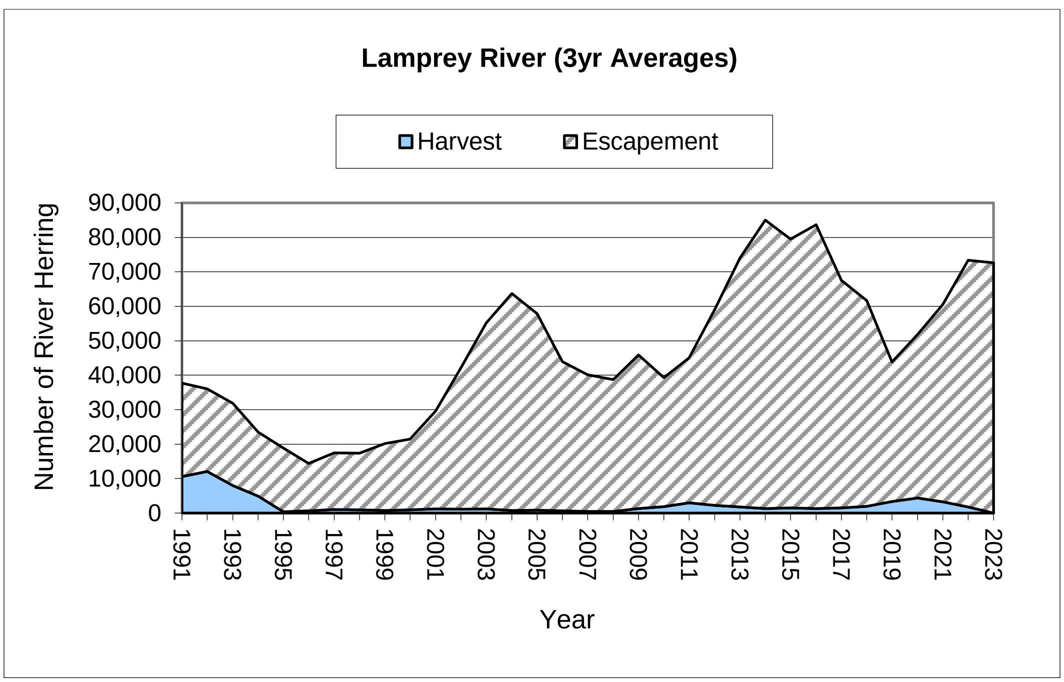
Physical Description of River, Watershed, and Impoundment:

The Lamprey River flows 97 km through southern New Hampshire to the Town of Newmarket where it becomes tidal and enters the Estuary just north of the mouth of the Exeter River (Figure 1). The mouth of the Lamprey River in Great Bay is approximately 27 km inland from the Atlantic coast. The Lamprey River watershed drains an area of 549 square km. It is the largest watershed that empties directly into The Great Bay. The Macallen Dam, located at rkm 3.8 in Newmarket, is the lowermost head-of-tide dam (8.2 m high) on the Lamprey River. A Denil fish ladder constructed between 1969 and 1970 for anadromous fish by NHFGD allowed access to

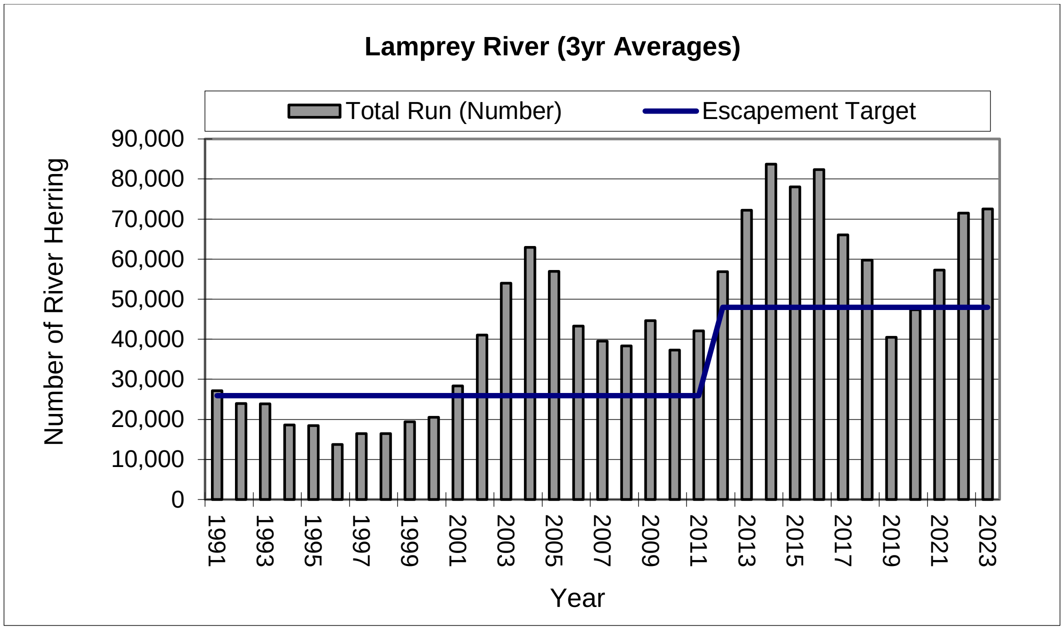
120 acres of potential spawning habitat. The 3.4 m high Wiswall Dam is located 4.8 km upstream of the Macallen Dam and has a Denil fish ladder that was completed in January of 2012, which further increased the total available spawning habitat to 222 acres. The fish ladder at Wiswall Dam is owned and operated by the Town of Durham, NH, with technical advice and monitoring provided by NHFGD. This fishway provides access to another 5.8 km of river habitat up to the next barrier to fish passage, a partially breached dam at Wadleigh Falls in Lee, NH. There are no downstream passage facilities at the Macallen Dam and emigrating juveniles and adults must pass over the spillway. Fish kills have not been observed below this dam suggesting that adults emigrate with limited mortality.

Description of fishery:

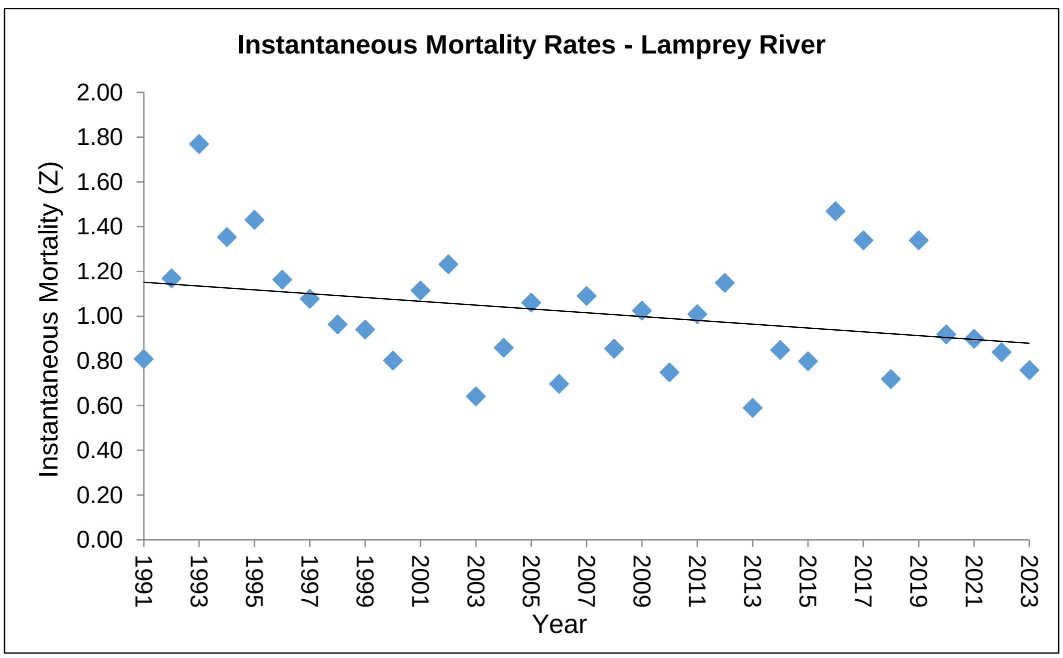
River herring fishing activity is very sporadic and harvest at the Lamprey River in recent years has been very low, usually less than 2,000 fish per year (Figure below and Table 6). Harvest is reported using a variety of methods including: cast net, gill net, dip net, and weir. Primarily the harvest occurs between approximately 70–500 m downstream of Macallen Dam. It is worth noting that each spring there is a very popular striped bass fishery that occurs within 350 m downstream of Macallen Dam and anglers "snag" river herring to use as live bait.



The run is currently above the fishery-independent target of 216 fish per acre (Figure below and Table 9), has a three year repeat spawning percentage of 46% (54% R-0, 29% R-1, 14% R-2, 3% R-3, 1% R-4; Tables 4 and 5).



The instantaneous mortality rates calculated from age data using the Chapman-Robson method are trending downward (Figure below and Table 3), and there is no significant correlation between mortality rates and exploitation rates (Table 10 and Figure 3).



Ladder Efficiency, Spawning Area, and Water Quality:

The run of river herring through the fishway each year tends to be mostly alewives. However, each spring towards the end of the annual migration a large number of blueback herring congregate just below the Macallen Dam. A small number of these blueback herring ascend the fishway, but the vast majority spawn below the dam. The spawning area is approximately 0.40 acre in size. Above the Macallen Dam, there is a variety of spawning habitat available for both alewives and blueback herring with no observed water quality issues, so it is unclear why most blueback herring spawn below the fishway/dam.

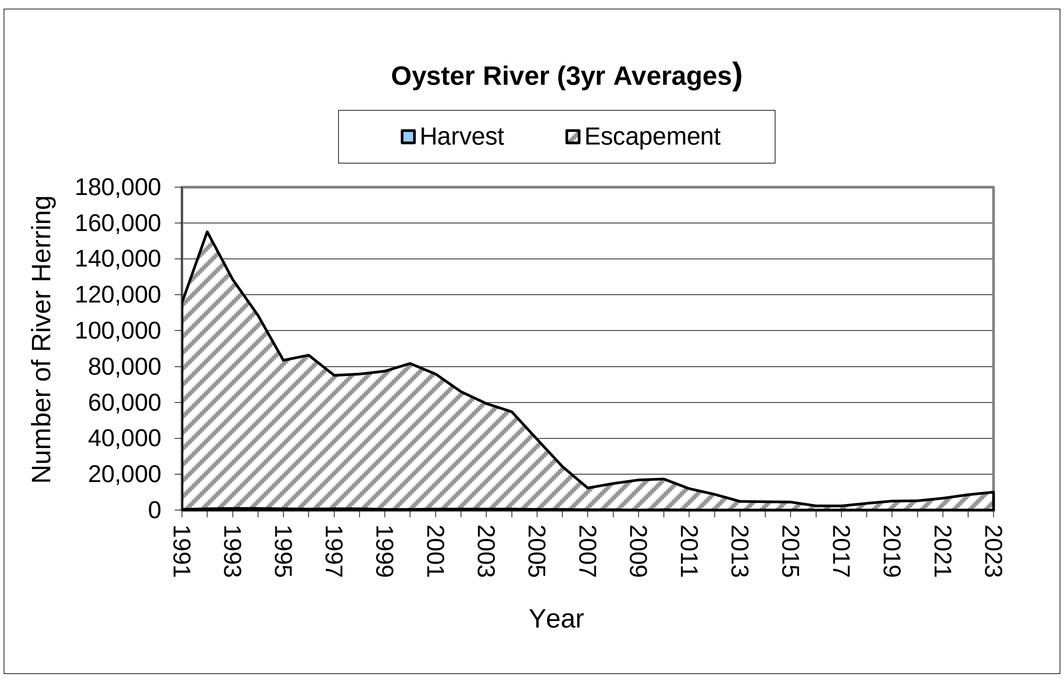
2.1.3 Oyster River

Physical Description of River, Watershed, and Impoundment:

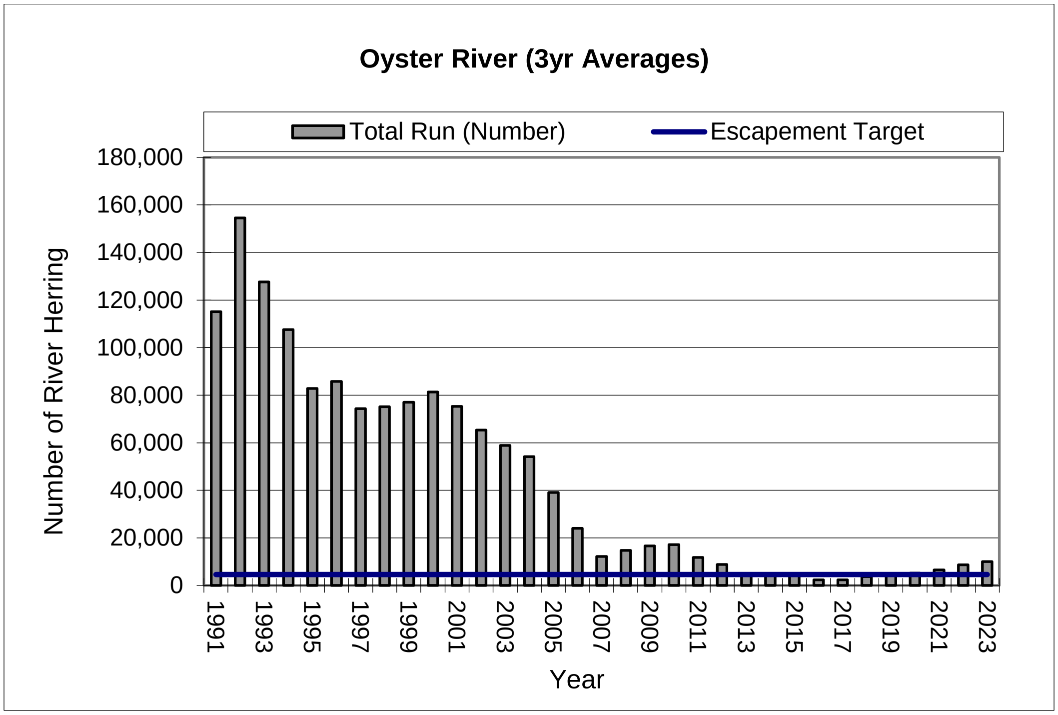
The Oyster River begins in the town of Barrington, NH. The size of the Oyster River watershed is approximately 67 square km. The Oyster River flows southeasterly approximately 27.5 km through the towns of Lee and Durham and empties in Little Bay in the Great Bay Estuary (Figure 1). The mouth of the Oyster River lies approximately 19 km from the Atlantic Ocean. The head-of-tide dam occurs at rkm 4.8 in Durham, NH. There is a Denil fish ladder at this dam that was constructed in 1975. This fish ladder provides access to approximately 21 acres of potential spawning habitat. The next dam on the Oyster River occurs at rkm 8.0 and is a barrier to river herring passage.

Description of fishery:

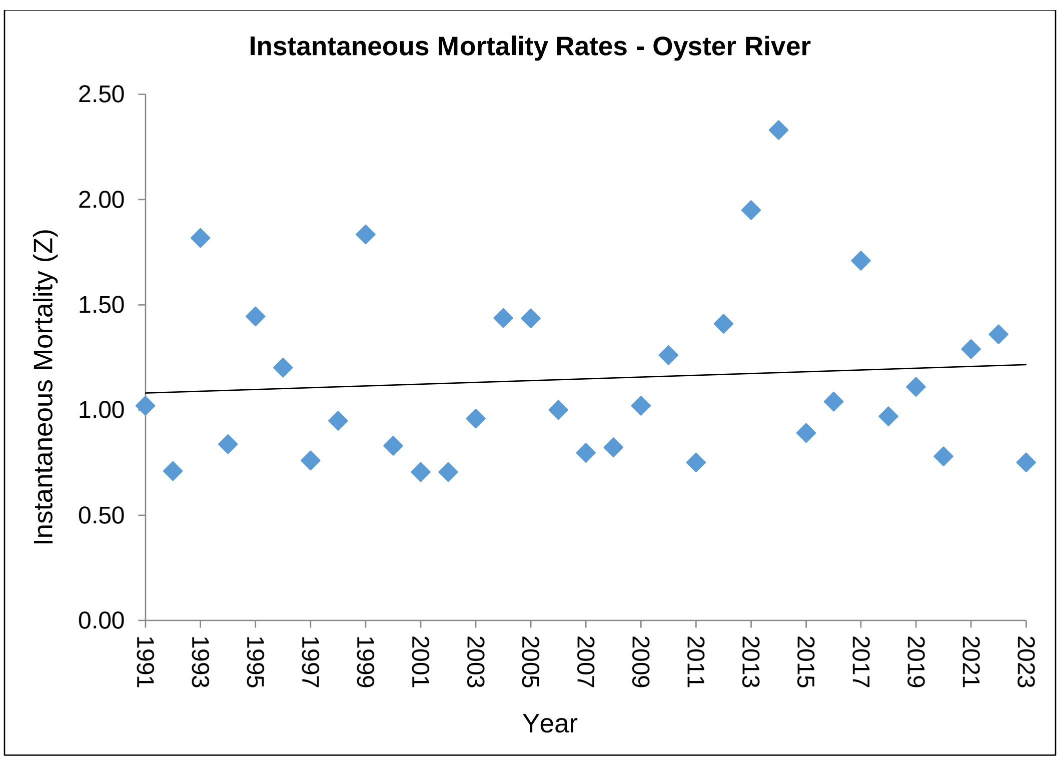
Prior to the harvest closure in 2012, typically very little river herring harvest occurred in the Oyster River, usually less than 800 fish per year (Figure below and Table 6). The limited harvest that occurred was via dip net, cast net, or gill net.



The run is currently above the fishery-independent target of 216 fish per acre (Figure below and Table 9), has a three year repeat spawning percentage of 29% (72% R-0, 20% R-1, 6% R-2, 1% R-3, 0% R-4; Tables 4 and 5).



The instantaneous mortality rates calculated from age data using the Chapman-Robson method appear steady or slightly increasing (Figure below and Table 3), and there is no significant correlation between mortality rates and exploitation rates (Table 10 and Figure 3).



Ladder Efficiency, Spawning Area, and Water Quality:

The numbers of river herring returning to the Oyster River fishway have been decreasing since the mid 1990's. One possible explanation for the decline is diminishing water quality in the Mill Pond impoundment above the head-of-tide dam. Increasing eutrophication has been observed by NHFGD staff over the past several years. Due to this eutrophication, oxygen levels could be critically low while juvenile river herring are utilizing the impoundment as nursery habitat. In addition, the Oyster River is used as a municipal water supply. In years when river flows are lower than average very little water is observed flowing over the head-of-tide dam spillway. River herring can only emigrate from this impoundment using the spillway and thus become "trapped" in water with poor water quality in years with low flows.

2.1.4 Squamscott/Exeter River

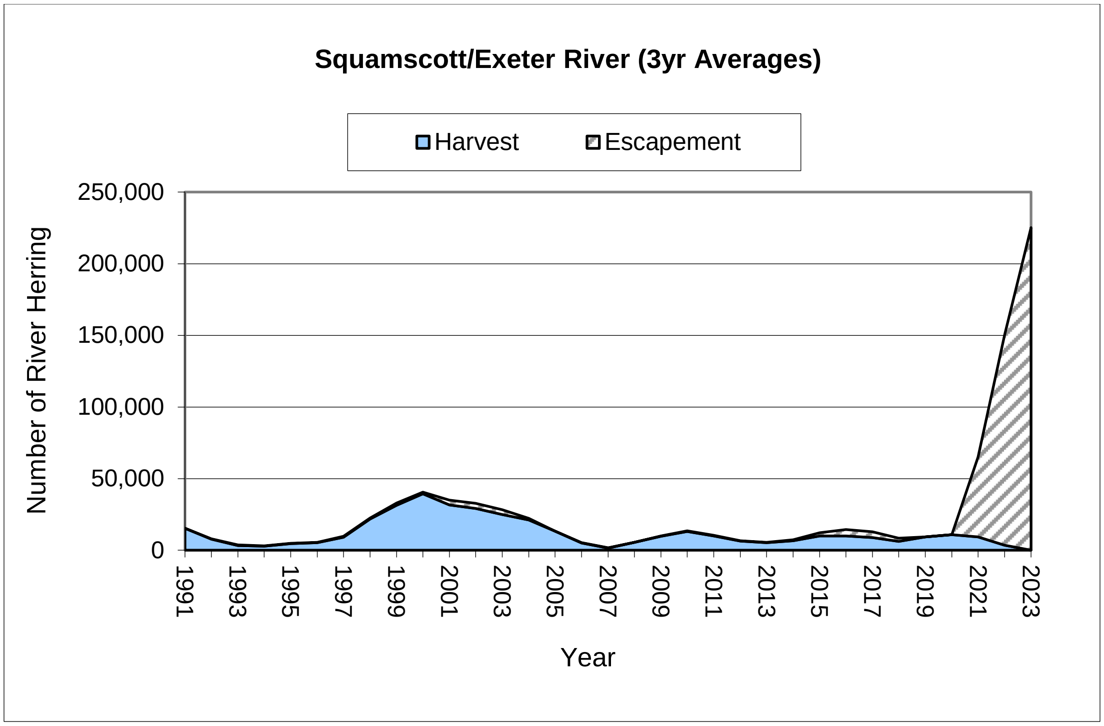
Physical Description of River, Watershed, and Impoundment:

The Exeter River drains an area of 326 square km in southern New Hampshire. The river flows east and north from the Town of Chester to the Town of Exeter and empties into the Estuary northeast of Exeter (Figure 1). The head-of-tide occurs at the Town of Exeter and the saltwater portion of this river is named the Squamscott River. The two lowermost dams (Great Dam) on the mainstem Exeter River in Exeter at river kilometer (rkm) 13.5 were removed in the fall of 2016. The next barrier is the Pickpocket Dam at rkm 26.9 (4.6 km high). Removal of the Great Dam and a Denil fish ladder at the Pickpocket Dam provide access to approximately 147 acres of potential spawning habitat. The next barrier above Pickpocket Dam is a set of natural falls at rkm 38.1. The mouth of the Squamscott River in Great Bay lies approximately 27.4 km inland from the sea.

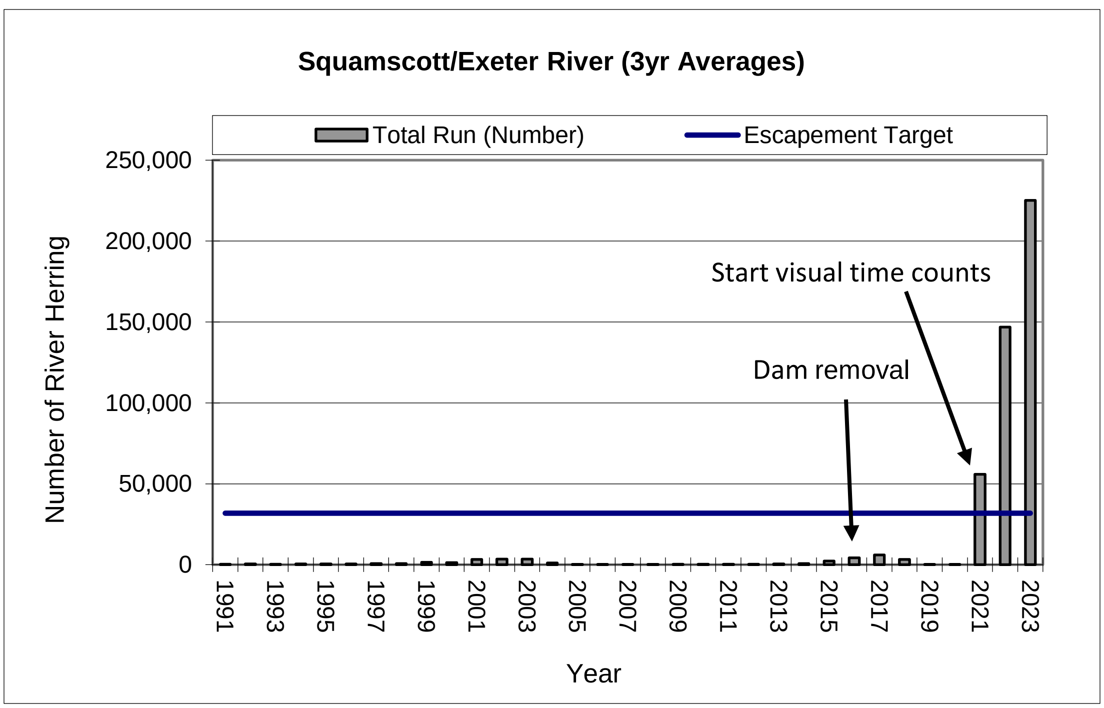
Description of fishery:

The river herring fishery that occurs in the Squamscott River is for personal use as bait for lobster and striped bass. The majority of the fishing occurs approximately 125 m downstream of the former Great Dam, northwest of the String Bridge. There is an elevated ledge constriction point under the String Bridge where migrating river herring gather below in numbers to ascend the ledge. This is the area harvesters focus fishing efforts. The gear types utilized by harvesters include; cast nets, gill nets, dip nets, and wire baskets. Despite being legally limited to a two-day fishery and a one-tote per day per angler limit, the Exeter River can still account for as much as 90% of the total New Hampshire harvest for river herring (Table 6).

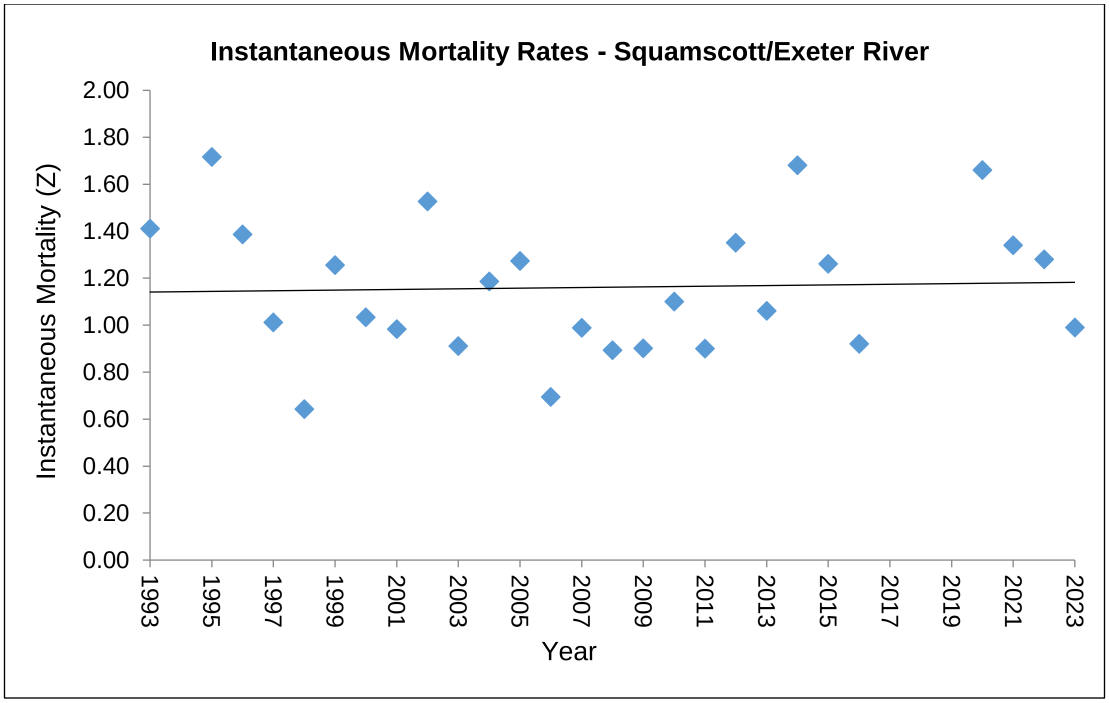
In 2005, following a number of years of increased harvest in the Squamscott River, NHFGD implemented changes to rules for river herring and shad in this river in order to reduce harvest levels. These changes included implementing a one-tote harvest limit per day and increasing the escapement days from one day per week to five days per week. Harvest levels since 2005 have been reduced by roughly 50% of the levels observed between 1998 and 2003 (Figure below and Table 6).



The run is currently above the fishery-independent target of 216 fish per acre (Figure below and Table 9) and has a three year repeat spawning percentage of 35% (66% R-0, 20% R-1, 10% R-2, 4% R-3, 0% R-4; Tables 4 and 5).



The instantaneous mortality rates calculated from age data using the Chapman-Robson method appear stable (Figure below and Table 3), and there is a significant correlation (P=0.001) between mortality rates and exploitation rates (Table 10 and Figure 3).



Ladder Efficiency, Spawning Area, and Water Quality:

The Exeter River was the only river monitored by the NHFGD that had available fresh water spawning habitat located below the fishway. NHFGD constructed upstream fish passage facilities (Denil fishways) on both dams from 1969 to 1971 for anadromous fish. Fish ladder improvements occurred in 1994 and 1999 at the Great Dam fishway and a fish trap was constructed at the exit of the fish ladder. In addition, improvements were made in the vicinity of the ladder entrance to enhance attraction flow during normal river flow conditions. Despite work to improve fish passage efficiency of the fish ladder at the Great Dam, the vast majority of river herring spawned below the dam in an approximately 0.50-acre area of fresh water that occurs between head-of-tide and the former Great Dam caused by an elevated ledge that prevents saltwater incursion. River herring gathered in large numbers below the former Great Dam and spawning was observed. These observations combined with relatively high levels of documented harvest occurring each year below the former dam and the inefficiency of the fish ladder in passing river herring indicated that escapement to spawn in this river was much higher than measured by the number of river herring passing up river through the fish ladder. The former Great Dam and associated fish ladder were removed in the fall of 2016 and fish were observed freely passing the location in the spring of 2017. Work completed in the fall of 2017 allowed for comparable monitoring of the river herring reaching the Pickpocket Dam beginning in 2018.

Over the following few years, fish passage counts at the Pickpocket Dam fishway on the Exeter River were low despite thousands of ascending river herring observed near the former head-of-tide Great Dam and fishway. Pickpocket Dam is located 13.4 km upstream of the former Great Dam location. The reasoning behind such low counts is that the majority of river herring are spawning in newly restored habitat between the former Great Dam and Pickpocket Dam and not accessing the habitat above Pickpocket Dam fishway where the electronic counting station was installed. Therefore, new monitoring methods were adopted to estimate fish passage at the former dam site. Beginning in 2021, quantitative monitoring of river herring occurs at the former Great Dam site, by conducting daily 10-minute visual time counts during the fish migration period using a random stratified sampling design as described by Nelson (2006). The daily time counts are expanded over the course of a twelve-hour migration period, taking into account passage over the ledges generally only occurs during a high tide. Daily totals are summed to provide an estimate of annual river herring passage and associated standard error (Table 11).

There is no downstream fish passage facility at the Pickpocket Dam so emigrating adults and juveniles pass over the spillway when river flows allow. Poor water quality had been documented in the critical nursery habitat above the former Great Dam prior to removal in 2016. Periodic water quality monitoring had recorded low levels of dissolved oxygen (DO) between the two dam locations in some years since 1995 (Smith et al. 2005; Langan 2004).

2.1.5 Other Rivers of Interest

Physical Description of Rivers, Watersheds, and Impoundments:

There are four other major rivers of interest in coastal New Hampshire that are not monitored regularly by NHFGD. They are the Winnicut, Taylor, Bellamy and Salmon Falls rivers. The rivers range in length from 14.6 km for the Winnicut to 61 km for the Salmon Falls. Watershed sizes range from approximately 855 square km for the Salmon Falls to 28.6 square km for the Taylor River.

The Winnicut River flows directly into the Estuary in Greenland, NH. The NHFGD operated a Canada step-weir fishway from approximately 1957 until 2009 on the Winnicut River. During the summer of 2009, the fish ladder and associated NHFGD owned dam were removed to restore the Winnicut River. While the dam removal drained a 34-acre impoundment, a run-of-river fishway was built just above the head-of-tide under a bridge constriction that is currently ineffective at passing most fish species.

The Bellamy River enters the Estuary in Little Bay in Dover, NH. A partially breached timber crib dam at the head-of-tide at rkm 6.9 was removed to restore diadromous fish habitat in 2004. Since the removal, NHFGD staff had observed large numbers of river herring below the next dam complex (two consecutive dams) approximately 0.6 km upstream. These two dams were removed between 2018 and 2020. The first investigation of effective fish passage past these former dams occurred in the spring of 2020.

The Salmon Falls River confluences with the Cocheco River at the head of the Piscataqua River within the Estuary. The head-of-tide dam is located at approximately rkm 6.7. A Denil fish ladder has been operated at this dam since 2002. The Salmon Falls River is a border river between the states of Maine and New Hampshire and the fish ladder and associated hydroelectric facility are on the Maine side, in the town of South Berwick. The hydroelectric operator is responsible for operation and maintenance of the fish ladder with technical guidance by both NHFGD and Maine Division of Marine Resources. The Denil fish ladder at the head-of-tide dam provides river herring access to a 58-acre impoundment. New Hampshire harvest estimates from the Salmon Falls River are minimal, with no reported harvest since 2014. The minimal harvest and location of the fish ladder on the Maine side of the river in South Berwick, ME, were considered justification for continuing to allow harvest in this river without direct annual monitoring by NHFGD.

The Taylor River is located in southeastern New Hampshire and is about 17.1 km long. The river begins on the border between Hampton Falls and Kensington, NH. It flows north, east, then southeast through Hampton Falls where it meets tidal water at Interstate 95. The lowermost 6.4 km of the river forms the boundary between Hampton and Hampton Falls. The first dam is located at rkm 3.2. There is a Denil fish ladder at this head-of-tide dam that was constructed in 1976. The next dam is a barrier to further fish passage and is located at rkm 5.1.

In December of 2014, the NHFGD submitted a proposal to the Atlantic States Marine Fisheries Commission (ASMFC) to withdraw its monitoring requirement of the Taylor River under Amendment 2 for the State of New Hampshire. The ASMFC Shad and River Herring Management Board approved the proposal in February 2015. Since spring 2015, the Taylor River fishway has been operated as a swim through with no regular monitoring or biological sampling performed by NHFGD. The fishway will be opened each spring in late April and closed in late June. Weekly visits by NHFGD staff to check for proper fishway operation will still occur.

River herring runs on the Taylor River have declined considerably from over 100,000 fish in 1986 (Table 2). The major cause of the decline is likely eutrophication of the Taylor River impoundment. The Taylor River fish run was estimated using a Smith-Root Model 1101 electronic fish counter. NHFGD staff made daily visits to the fishway during the migration to perform calibration counts and collect biological samples of river herring, if possible. The last time river herring were observed at the fishway was in 2008 when a total of seven fish were sampled. In addition to declining river herring returns, the Denil fishway at the Taylor River dam was constructed without a trap at the exit, which makes confirmation of fish passage difficult.

Description of fishery:

The Bellamy, Winnicut, and Salmon Falls Rivers have a very sporadic harvest ranging from 0 fish to as many as 2,548 fish at the Salmon Falls in 1999 (Table 12). Like many other New Hampshire coastal rivers, it is very difficult to capture river herring efficiently at these locations so harvest can occur anywhere along the tidal portion. Typically, gill nets, cast nets, and dip nets are used to harvest river herring at these locations.

After river herring returns diminished from around 100,000 fish in 1986 to 1,397 fish in 2003 and 1,055 fish in 2004, the Taylor River was closed to the taking of river herring by any method of netting in 2005. The closed section of river extends upriver from the railroad trestle bridge near Hampton Harbor to the head-of-tide dam. No harvest of river herring was reported from the Taylor River from 1999-2004 and only 32 fish were harvested in 1998.

3 Current Regulations

The first law protecting river herring in New Hampshire state waters (inland and 0-3 miles) was enacted in 1967. This established that any resident or nonresident had to obtain a license to use a seine, net, or weir for the taking of river herring. In an effort to provide a day of escapement, the taking of river herring in state waters on Wednesdays by any method was prohibited in 1987 (Table 1).

The harvest of river herring by netting of any kind has been prohibited in the Taylor River from the section of the river upstream of the railroad trestle bridge to the head-of-tide dam since 2005 due to declines in return numbers. Also, in response to a decline of river herring returns to the Exeter River, new regulations were put in place in 2005 for the Exeter/Squamscott River in Exeter. The new regulations restricted netting to only Saturdays and Mondays. In addition, there is a one-tote limit per day. This location has consistently accounted for the vast majority of river herring harvest in New Hampshire (Tables 6 and 12). In response to diminishing returns of river herring to the Oyster River fishway, the Oyster River was closed to the taking of river herring by any method from the head-of-tide dam at Mill Pond to the mouth of the river at Little Bay in 2012 (Tables 2 and 9).

Currently there are no regulations establishing a length limit or daily bag limit for recreational anglers on either alewives or blueback herring within any tidal water body of the state. Additionally, there are no closed seasons to the taking of river herring by recreational anglers, except being prohibited from harvesting river herring on Wednesdays.

4 Brief Description - Current Status of Stocks

The NHFGD manages river herring as a single statewide stock, although annual return numbers are monitored on a river-specific level through fish passage structures along five of the major coastal rivers. The exception being the Exeter River where fish passage is monitored through visual time counts at the former head-of-tide dam site.

Each of the monitored rivers (Cocheco, Lamprey, Oyster, Exeter, and Winnicut rivers) demonstrate inter-annual variability in the number of returning fish due to various factors which are specific to each river (Table 2). Major factors affecting return values include uncontrollable variables related to environmental conditions (e.g., river flow levels, temperatures) and controllable variables such as passage efficiency and harvest levels. Data collection efforts of the NHFGD have also indicated that numbers of returning fish are likely underestimates of actual stock size due to likely successful spawning activity occurring within rivers downstream of the monitored fish passage structures as well as non-monitored river systems that support additional small numbers of river herring returns within the state.

The most recent peer reviewed River Herring Benchmark Stock Assessment found that coastwide populations of both alewife and blueback herring were depleted relative to historic levels (ASMFC 2024). While there are no clear coastwide trends for either species, trends in abundance and mortality differed between genetic stock-region as well as from river to river.

In the Northern New England (NNE) stock-region, an ARIMA trend analysis indicated many of NH's alewife population stocks were categorized as stable or increasing. Additionally, three out of the four run counts in NH had a greater than 50% chance of being higher than the 2009 reference point. Blueback herring in the Mid-New England (MNE) stock-region were categorized as stable or decreasing. However, ARIMA results indicated that three out of the four run counts are likely to be higher now than when Amendment 2 was adopted in 2009.

A young-of-year index from the New Hampshire Juvenile Finfish Survey for the Hampton-Seabrook and Great Bay estuaries was available for 1997-2021. According to the Mann-Kendall test there was no significant trend over the time series for alewife. Blueback herring on the other hand exhibited a significant decreasing trend over the time series. The indices for both species in 2021 had a very high probability of being above the 25th percentile of the time series, and of being above the 2009 index value (ASMFC 2024).

While many of the population stocks in NH indicated stable or increasing trends in river herring abundance, some of those populations had a greater than 50% probability of exceeding the Z40%SPR reference point, indicating total mortality on adult fish was too high. Mortality estimates for alewives were available from scale data for the NNE region. There was a decreasing trend from the early 1990s until the mid-2000s, then increasing until around 2015, followed by a decrease in the final years of the time series. For the entire time series, average Z was 1.1/yr and ranged from 0.56/yr to 1.7/yr. Blueback herring mortality estimates for the MNE region varied during 1992 to 2021 but overall, there was a decreasing trend. During this time period, average Z was 1.1/yr and ranged from 0.54/yr to 1.9/yr (ASMFC 2024).

A new habitat model was developed for the most recent stock assessment to look at river herring abundance as a function of freshwater habitat availability in each stock-region. About 37% of alewife habitat occurs in the NNE region, while only about 4% blueback herring habitat is in the MNE region. In the NNE and the MNE regions, the greatest proportional reduction of habitat is due to dams (ASMFC 2024). Recent restoration efforts, including multiple dam removals, have opened and increased historic spawning habitat on many of NH's coastal rivers.

4.1 Landings

Commercial landings of river herring (fish that are sold via dealers) within the state are monitored through mandatory landings reports submitted annually to the National Marine Fisheries Service or the NHFGD. Commercial landings of river herring from federal waters are generally incidental catch and are not sampled by the NHFGD (Table 13).

The recreational and small commercial landings of river herring from state waters are primarily through netting activities of state-permitted coastal harvesters (Tables 6 and 12). All individuals participating in netting of river herring within the state are required to submit trip-level reports of both fishing effort and harvest weight or numbers of river herring taken. The estimates of harvest by recreational anglers using hook and line are determined through the cooperative state/federal Marine Recreational Survey (Table 13).

4.2 Fisheries Independent / Fisheries Dependent

The NHFGD collects both fishery-dependent and fishery-independent data on an annual basis. Fishery-dependent data is submitted by all state-permitted coastal harvesters as well as through reported annual harvest estimates produced by the cooperative state/federal Marine Recreational

Survey. The data obtained on netting activities is area specific, but recreational angler data is only attributable to state or federal waters.

The majority of fishery-independent data is collected annually through monitoring of the six major coastal rivers in which the primary runs of river herring occur. The data collected provides river-specific enumeration of fish successfully passing the fishway or former head-of-tide dam sites as well as population structure analysis from scale and length samples taken periodically throughout the runs. The biological sample analysis allows the Department to track age structure, species and sex ratios, length distributions, and repeat spawning success of river herring within each river. A beach seine survey is also conducted at 15 fixed stations along New Hampshire's coastal waters each month between June and November. Mean catch rates of juvenile river herring within the beach seine survey are used as relative indicators of occurrence of spawning activity from year to year. Although, the information was not used in formulation of the fishery-independent target due to estuary-wide design and limited sampling rate in close proximity to monitored rivers during times of peak juvenile river herring emigration in the late summer/fall months.

Analysis of fishery-independent and fishery-dependent data indicate that New Hampshire's river herring stock is relatively stable, and currently above the minimum target level of 216 fish per surface acre of available spawning habitat. Values of return numbers to the Great Bay Indicator Stock have generally increased since 2007, but declined in 2019 and 2020 (Table 9). Estimates of Z appear steady or slightly declining (Table 3), the percentage of repeat spawners have remained between 32% and 52% (Table 4), spawning escapement has consistently exceeded 80% and exploitation rates since 2001 have remained at or below 20% (Table 7).

4.3 Other

(None)

5 Fisheries to be Closed

5.1 Commercial

No commercial fisheries directed at harvest of river herring within New Hampshire state waters will be closed.

5.2 Recreational

No recreational fisheries directed at harvest of river herring within New Hampshire state waters will be closed.

6 Fisheries Requested to be Open

6.1 Commercial

Most river herring harvested in New Hampshire state waters are for personal use as bait in a variety of fisheries and not sold. There are very few commercial fisheries occurring within New Hampshire state waters directed towards the harvest of river herring. The National Marine Fisheries Service federal landings database that is inclusive of fishing harvest outside of New Hampshire indicates the recent annual river herring landings are negligible (Table 13). All commercial fisheries of river herring will remain open and the existing regulations will continue until such time that either the fisheries-independent or dependent targets have been met.

6.2 Recreational

Harvest of river herring occurring in New Hampshire is primarily through state-permitted coastal harvesters that fish for personal use, such as bait, and not sold. As a result, this fishery is classified as recreational in New Hampshire. Upon all tidal water bodies in New Hampshire (with the exception of the Exeter River) harvest of river herring is prohibited on Wednesdays and no daily limit exists. Netting in the Exeter/Squamscott River is limited to Saturdays and Mondays only between April 1 and June 30, and harvest is limited to one tote per day.

Similarly, hook and line anglers target river herring to be used as bait in a few relatively isolated locations, which are surveyed through the cooperative state/federal Marine Recreational Survey with low frequency of harvest and poor associated precision values associated with those landings. There is currently no size or bag limit on river herring taken by angling in New Hampshire, but a closure to all river herring harvest on Wednesdays is in place.

All recreational fisheries will remain open in New Hampshire and the regulations stated above will continue until such time that either the fisheries-independent or -dependent targets have been met.

6.3 Incidental

(None)

7 Sustainability Target(s)

7.1 Definition

The sustainability target will be established as a reference point and defined as a point below which sufficient escapement of spawning populations of river herring occurs to maintain annual runs at sustainable levels in New Hampshire.

River herring in New Hampshire are currently managed as a statewide management unit, but two sustainability targets, one fishery-dependent and one fishery-independent, will be established using exploitation rates and numbers of returning river herring per surface acre of available spawning habitat in the Estuary. This method was chosen because 1) river herring harvest in the Estuary accounts for 95-100% of the statewide harvest, 2) the NHFGD monitors river herring spawning stock returns on four of the seven major rivers in the Estuary, and 3) monitors juvenile abundance on an estuary-wide basis via a seine survey. Historical monitoring of river herring runs within New Hampshire have shown that the numbers of returning river herring to these four rivers have accounted for greater than 80% of the returning fish enumerated annually at fish passage structures on New Hampshire coastal rivers (Tables 3 and 9). The Atlantic States Marine Fisheries Commission's Shad and River Herring FMP states that "Definitions of sustainable fisheries and restoration goals can be index-based or model-based" and that "Member states or jurisdictions could potentially develop different sustainability target(s) for river herring based on the unique ecosystem interactions and…Targets can be applied state-wide or can be river and species specific." Therefore, New Hampshire will be using the stocks of river herring returning to the Estuary system as an indicator of statewide river herring abundance and refer to them as the 'Great Bay Indicator Stock'.

The fishery-dependent sustainability target will be set at a harvest level that results in a harvest percentage (exploitation) rate that does not exceed 20% in the 'Great Bay Indicator Stock', providing an 80% escapement level. Specifically, a three-year running average of the total annual river herring harvest from throughout Great Bay Estuary will be compared to a three-year running average of minimum annual counts of spawning river herring returns documented via fish ladder or visual time counts on four rivers in Great Bay Estuary plus annual harvest of river herring throughout the Estuary. This is a conservative target, since the harvest from throughout the Estuary (including seven rivers, Great Bay, Little Bay, and Portsmouth Harbor) is being compared to river herring returns counted at only four of the seven major rivers in the Estuary, which represents some fraction of the total spawning river herring in the estuary each year.

Table 7 shows the calculated harvest percentages for each year in New Hampshire since 1991, based on rolling three-year averages. New Hampshire has remained below the sustainability target level of 20% harvest within the 'Great Bay Indicator Stock' for all but three years (Table 6) and in subsequent years following the high harvest percentages, the annual returns of river herring continued to increase for three consecutive years. This sustainability target allows for limited harvest of river herring within New Hampshire while still maintaining healthy populations of river herring.

For the fishery-independent target, New Hampshire is proposing to use a target similar to that used in Maine's River Herring SFMP, which was previously approved by the Shad and River Herring Management Board. New Hampshire has never conducted studies to determine ideal densities of fish per acre of available spawning habitat. Therefore, the target was created based on studies conducted in the state of Maine during the 1970's and 1980's, which have indicated that an average escapement rate of 35 fish per surface acre, allows for adequate harvest, escapement to maintain the run, and available broodstock to increase the run if desired. Using that analysis-based minimum annual escapement of 35 river herring per surface acre, a target value was calculated for the 207 acres of currently accessible spawning habitat in New Hampshire. This escapement level would only require a minimum of 7,245 river herring returning to the Estuary annually. New Hampshire believes that number would be insufficient to maintain current population levels. Therefore, a second approach of calculating half of the mean annual return of river herring in the past 20 years was used to establish the proposed fishery-independent target escapement level of 350 fish per surface acre of available spawning habitat (72,450 fish).

Upon review of New Hampshire's River Herring SFMP in 2023, it was determined that the available spawning habitat in New Hampshire was originally miscalculated using New Hampshire's Department of Environmental Services (NHDES) dam impounded water data that was available at the time. The use of Geographic Information Systems (GIS) software has provided a more accurate value, increasing the available spawning habitat at time of the SFMP's creation in 2011 from 207 acres to 336 acres. A new escapement target value of 216 fish per surface acre was calculated by using the half of the mean annual return of river herring (72,450 fish) divided by the corrected available spawning habitat (336 acres).

Available spawning habitat increased further with the construction of a new fish passage structure in 2012 on the Lamprey River in the town of Durham, NH, bringing the total available spawning habitat in New Hampshire up to 438 acres. Using an annual escapement value of 216 river herring per surface acre, a target value was calculated for the 438 acres of currently accessible spawning habitat in New Hampshire. The fishery-independent target escapement level would require a minimum annual return of 94,589 river herring. This target remains slightly above 50% of the mean annual river herring returns to the Estuary since 1991 (Tables 2 and 9).

7.2 Methods Used to Develop Target(s)

River herring runs in New Hampshire have been monitored by the Department at fish ladders since initiation of restoration programs in the early 1970's. Seven fish ladders had been operated and maintained along six coastal rivers, although the lowermost dams and associated fish passage structures on the Winnicut River and Exeter River were removed in the fall of 2009 and 2016, respectively. At five of the locations (Cocheco, Oyster, Lamprey, Winnicut, and Exeter), river herring runs are enumerated and sampled for biological information such as age, sex, species, and repeat spawning occurrence when possible.

The number of returning river herring in the Great Bay Indicator Stock have remained variable throughout the years (Tables 2 and 9). Using a three-year running average, a period of high abundance was observed in the 1990's followed by six years of successive decline in number of river herring before increasing to another period of high abundance in the 2010's. The inter-annual variability of return numbers can be great, but many factors including weather, river levels, water temperature, and inefficiencies of fish passage structures play a large role in the variation.

An example of strong control by environmental conditions occurred in 2005, 2006, and 2007 when New Hampshire's coastal rivers experienced flood conditions that reached "100-year flood" levels in 2006 and 2007. During years where persistent high river velocity exists in all coastal rivers in the state, many river herring are unable to reach or successfully ascend the fish ladders monitored by the NHFGD. As a result, the passage inefficiency of fish ladders created by unusually high river flow levels in turn reduces the annual return enumerations in those years.

Although annual river herring return values for 2005–2007 declined significantly from 2004, the previously mentioned flooding conditions were a large reason for potential underestimation during those years. Reviews of supplemental data such as young-of-the-year indices (Table 8) and percentage of repeat spawners within each river (Table 4) provide evidence of the population's health and relative stability despite reduced fish passage numbers. The supplemental data from the Estuary juvenile finfish seine survey conducted by the Department showed increases in young-of-the-year indices for the two species of river herring in both 2006 and 2007 (Table 8), when the number of fish able to ascend the ladder were low. Since return numbers to the fish ladders were down those two years, large numbers of river herring may have still successfully spawned downriver from the fish ladders. Additionally, Table 4 shows that the percentage of repeat spawning fish that have been observed in the four rivers being monitored for the Great Bay Indicator Stock has been consistently high, ranging from 32% of returning fish in 2009 to 52% in 2006.

The majority of fishing effort and resulting harvest directed towards river herring in New Hampshire is conducted through state-permitted coastal harvesters using gear such as cast nets, gill nets, and dip nets. The harvest levels reported by harvesters also fluctuates between years, but is much more stable than return numbers (Table 6). All reported landings are associated with an area of fishing activity, which indicates that the large majority of river herring harvest comes from a single location, the Squamscott River (Tables 6 & 7). Collection of the harvest data also has indicated that the enumeration of returning fish in the Exeter River fish passage structure was greatly underestimating the actual number of fish within that river system. This is particularly noticeable when the harvest percentages in the tidal portion is several times higher than the number of fish ascending the ladder, which would suggest that even though few ascend the fishway, many river herring in that location continued to spawn below the dam. Since the removal of the Great Dam in 2016, thousands of river herring have been observed ascending the Exeter River near the former dam site.

Harvest estimates of river herring by recreational finfish anglers are also available through the cooperative state/federal Marine Recreational Survey, but infrequency of occurrence and poor levels of precision associated with the estimates make the data to unreliable for inclusion at this time (Table 13).

The Department reviewed the harvest percentages (exploitation rates) of river herring within the ‘Great Bay Indicator Stock’ locations between 1991 and 2023. To limit the variation between years, three-year rolling averages were used to establish both the annual return and the harvest portions of the harvest percentage. The resulting harvest percentages have ranged from as high as 26% in 2000 to 0% in 2023 (Table 7). Exploitation rate data was plotted against instantaneous mortality rates calculated from age data using the Chapman-Robson method (Figure 3). When a linear regression correlation was applied to the Great Bay Indicator Stock, there was a significant correlation between the two factors. The Cocheco and Squamscott/Exeter Rivers showed a similar significant correlation between the two factors, however there is no significant correlation within each of the remaining rivers. Although there is a correlation between changes in the calculated instantaneous mortality rate and the exploitation rate, the plot indicates that years of high exploitation coincide with years of low mortality rate, and conversely years of low exploitation coincide with years of a high instantaneous mortality rate. This suggests that the exploitation rate is likely more dependent on the mortality rate than the mortality rate being dependent on the exploitation rate. Specifically, in years of low calculated instantaneous mortality rates, there are more fish returning and available for individuals to harvest, whereas in years of high calculated instantaneous mortality rates, there are fewer fish for state-permitted netters to harvest. Great Bay Indicator Stock exploitation rates have remained relatively low, near or below 15%, since 1991 but did increase briefly to near or above 20% from 1998 to 2002. This was driven by an increased effort and resulting harvest in the Squamscott River for unknown reasons, but prompted NHFGD to enact new regulations to limit the harvesting at that location to only two days per week as opposed to the previous six days, as well as implementing

a daily harvest limit of one tote per person. A brief increase in exploitation again occurred between 2019 and 2020, but never exceeded the 20% target (Table 7).
NHFGD does not currently have available data sufficient for analysis to determine an escapement target below which the river herring stock would be negatively affected. Therefore, the 20% fishery-dependent and 216 fish per surface acre fishery-independent sustainability targets from the 'Great Bay Indicator Stock' were set based on the downward trend of calculated instantaneous mortality rates, the correlation of exploitation rate and mortality rate that does not indicate that increased harvest corresponds to increased mortality, and the historical observations of fishing effort and exploitation rates. NHFGD feels that these two targets will provide a large enough resource of spawning river herring to maintain current population levels.

7.3. Monitoring to be Conducted to Support Target(s)

The NHFGD staff will monitor the return of river herring on the Cocheco, Lamprey, Oyster, and Exeter rivers, collectively referred to as the 'Great Bay Indicator Stock', on an annual basis. With the exception of the Exeter River, monitoring of these river specific returns will include enumeration of fish successfully ascending the fish passage structure, maintenance of fishways to increase passage efficiency, and periodic biological sampling of river herring at each location throughout the run. Biological samples will be used to determine age, sex, repeat spawning percentage, and species distributions of the returning populations within each river in an effort to track relative health and stability of herring within each of the rivers. Monitoring river herring at the Exeter River will be conducted at the former head-of-tide dam site following the removal of the dam and fish passage structure. The enumeration from these four rivers of New Hampshire's primary river herring run will be used to calculate the return portion of the 3-year average harvest percentage of the 'Great Bay Indicator Stock.'

As supplemental information, a beach seine sampling study will be used to determine a mean catch per seine haul index of juvenile river herring within the Great Bay System. This relative annual index can be used to determine successful occurrence of river herring spawning activity between years, although the information was not used in formulation of the fishery-independent target due to estuary-wide design and limited sampling rate in close proximity to monitored rivers during times of peak juvenile river herring emigration in the late summer/fall months.

Mandatory reporting of harvested quantities and directed effort toward river herring is required by the ASMFC's FMP. The reported information must provide harvest data specific to a location or river system within the state. The harvest portion of the 'Great Bay Indicator Stock' will be calculated annually by totaling the number of river herring reported to be harvested from the Estuary. This will include the Great Bay, Little Bay, and Cocheco, Lamprey, Exeter, Bellamy, Salmon Falls, and Piscataqua rivers. The harvest and return portions of the 'Great Bay Indicator Stock' will then be used to ensure that the annual harvest percentage (exploitation rate) does not exceed the fishery-dependent sustainability target level of 20%.

The ladder counts, visual time counts, and harvest information at each location will be used to ensure that the number of returning fish to the Great Bay Indicator Stock will remain above the fishery-independent target of 216 fish per acre of spawning habitat within the Great Bay Estuary (approximate 438 acre area), resulting in a target return of 94,589 river herring.

8 Proposed Regulation Modification to Support Target(s)

In response to low river herring spawning returns over the last few years in the Cocheco River after fishway modifications in 2016, NHFGD is proposing to keep the Cocheco River closed to recreational/personal use and commercial river herring harvest while improvements to fishway passage continue and returns increase. The remaining rivers of the Great Bay Indicator Stock will support harvest opportunities while meeting NH's fishery-independent sustainability target. River herring harvest on the Cocheco River has historically been minimal, less than 20 pounds between 2013 and 2020 (Table 6), and likely will not unduly increase fishing pressure on other rivers in the Great Bay Estuary.

9 Adaptive Management

9.1 Evaluation Schedule

The NHFGD annually monitors, evaluates, and quantifies fish passage levels along five major coastal rivers in New Hampshire (Cocheco, Oyster, Lamprey, Winnicut, and Exeter rivers). Returning fish are enumerated and sampled for biological information, including species, sex, age, and levels of repeat spawning. Monitoring of specified rivers will continue on an annual basis with the exception of the Winnicut River due to removal of the dam and associated fishway in the fall of 2009.

The harvest of river herring is determined through mandatory reporting of all landings by harvesters in New Hampshire state waters. Additional estimates of angling harvest are provided by the cooperative state/federal Marine Recreational Survey on an annual basis, but precision of those estimates is often very poor and are not reliable enough to be included in the annual harvest calculation. The harvest percentage (exploitation rate) will be determined annually and used to calculate a 3-year average value to compare to the sustainability target level of 20%.

9.2 Consequences or Control Rules

If the statewide harvest of river herring, determined by combining reported landings by state-permitted coastal harvesters from the 'Great Bay Indicator Stock' results in an exploitation rate that exceeds the fishery-dependent 20% sustainability target, the NHFGD will take the following action:

i) Use landings and return data to identify the problem area(s) to determine whether over harvest of river herring is river or fishery specific.

ii) Once a problem area is identified, one or more of the following measures may be used:

1) Add additional days of prohibited harvest of river herring. This could be statewide or in identified problem areas.

2) Implement or lower a daily harvest limit for state-permitted coastal netters at all areas or identified problem areas.

3) Implement a daily catch limit for recreational anglers statewide or in identified problem areas.

If the fishery-dependent target of 216 river herring per surface acre of available spawning habitat, 94,589 river herring, is not met, the NHFGD will take the following action:

i) Implement a prohibition on harvest of river herring to all fisheries operating within state waters.

10 References

ASMFC. 2024. River Herring benchmark Stock Assessment and Peer Review Report. Arlington, VA. 499 p.

ASMFC. 2009. Amendment 2 to the Interstate Fishery Management Plan for Shad and River Herring. Atlantic States Marine Fisheries Commission. Washington, D.C. 166 p.

Langan, R. 2004. Cooperative Institute for Coastal and Estuarine Environmental Technology. Unpublished data.

Nelson, Gary A. 2006. A Guide to Statistical Sampling for the Estimation of River Herring Run Size Using Visual Counts. Massachusetts Division of Marine Fisheries. TR-25.

Smith, B., K. Weaver, and D. Berlinsky. 2005. The Effects of Passage Impediments and Environmental Conditions on Out-Migrating Juvenile American Shad. Final Report for NMFS Federal Aid Project no. NA03NMF4050199. 20 p.

Table 1. Summary of river herring regulations and special river restrictions in New Hampshire tidal waters*.

Species	Restriction(s)		
	Length	Limit	Season
River Herring (Alewife / Blueback Herring	No minimum length	No limit	May not be taken Wednesdays by any method.

Area	Restriction(s)
Cocheco River	Closed from the upstream side of Central Avenue Bridge to downstream side of Washington Street Bridge in Dover
Exeter River (downtown)	Closed from the upstream side of High Street (Great) Bridge to downstream side of Chestnut Street (String) Bridge (on Squamscott River) in Exeter
Lamprey River	No person shall use any type of net or weir for the taking of finfish from the downstream side of the Macallen Dam to a line perpendicular with the two riverbanks from the north side of the Newmarket boat launch ramp. Closed from the upstream side of Rte 108 Bridge to 275 feet below the downstream side of Macallen Dam (tidal water) in Newmarket In the Lamprey River, use of nets, except weirs, shall be restricted to the period of sunrise to sunset
Oyster River	Closed from the upstream side of dam and fishway, including a 50-foot radius in front of the fishway; closed to the taking of river herring from Mill Pond Dam, Durham, downstream to the river mouth in Little Bay
Piscataqua River	Including Great Bay estuary and tributaries inland of Memorial Bridge, close to the use of gill nets with mesh larger than 3 inches
Salmon Falls River	Closed from the upstream side of the Route 4 Bridge to 150 feet downstream of South Berwick Dam
Squamscott River	River herring harvest: Open Mondays and Saturdays only from April 1-June 30. Daily Limit of 1 tote per person Tote container measures 31.5 inches x 18 inches x 11.5 inches.
Taylor River	Closed from the Railroad bridge to the head of tide dam in Hampton to the taking of river herring by netting of any method Closed from the upstream side of fishway and dams, including a 50-foot radius in front of the fishway on upstream side, to a line perpendicular to south end of south overflow culvert at Route 95 to opposite side of river (east)
Winnicut River	Closed to all fishing within a 25-foot radius of the downstream portion of the fishway and a 6-foot radius of the upstream portion of the fishway Closed to the taking of all fish, except by angling, from the south side of the Boston and Maine Railroad bridge to the Route 33 Bridge

* Rules prior to 2021 fishery closure.

Table 2. Number of river herring successfully ascending fish passage structures in New Hampshire by river between 1978 and 2023.

Year	Cocheco River	Exeter River	Oyster River	Lamprey River	Taylor River	Winnicut River	Annual Total
1978	1,925	205	419	20,461	168,256	3,229++	194,495
1979	586	186	496	23,747	375,302	3,410++	403,727
1980	7,713	2,516	2,921	26,512	205,420	4,393++	249,475
1981	6,559	15,626	5,099	50,226	94,060	2,316++	173,886
1982	4,129	542	6,563	66,189	126,182	2,500++	206,105
1983	968	1	8,866	54,546	151,100	+	215,481
1984	477		5,179	40,213	45,600	+	91,469
1985	974		4,116	54,365	108,201	+	167,656
1986	2,612	1,125	93,024	46,623	117,000	1,000++	261,384
1987	3,557	220	57,745	45,895	63,514	+	170,931
1988	3,915		73,866	31,897	30,297	+	139,975
1989	18,455		38,925	26,149	41,395	+	124,924
1990	31,697		154,588	25,457	27,210	+	238,952
1991	25,753	313	151,975	29,871	46,392	+	254,304
1992	72,491	537	157,024	16,511	49,108	+	295,671
1993	40,372	278	73,788	25,289	84,859	+	224,586
1994	33,140	*	91,974	14,119	42,164	+	181,397
1995	79,385	592	82,895	15,904	14,757	+	193,533
1996	32,767	248	82,362	11,200	10,113	+	136,690
1997	31,182	1,302	57,920	22,236	20,420	+	133,060
1998	25,277	392	85,116	15,947	11,979	219	138,930
1999	16,679	2,821	88,063	20,067	25,197	305	153,132
2000	30,938	533	70,873	25,678	44,010	528	172,560
2001	46,590	6,703	66,989	39,330	7,065	1,118	167,795
2002	62,472	3,341	58,179	58,065	5,829	7,041	194,927
2003	71,199	71	51,536	64,486	1,397	5,427	194,116
2004	47,934	83	52,934	66,333	1,055	8,044	176,383
2005	16,446	66	12,882	40,026	233	2,703	72,356
2006	4,318	16	6,035	23,471	147	822	34,809
2007	15,815	40	17,421	55,225	217**	7,543	96,261
2008	30,686	168	20,780	36,247	976	8,359	97,214
2009	36,165	513	11,661	42,425	*	4,974	95,737
2010	32,654	69	19,006	33,327	675	576+++	86,307
2011	43,090	256	4,755	50,447	59	72+++	99,338
2012	27,608	378	2,573	86,862	92	5+++	117,518
2013	18,337	588	7,149	79,408	128	0	105,610
2014	29,968	789	4,227	84,868	57	0	119,909
2015	64,456	5,562	1,803	69,843	*	0	141,664
2016	99,241	6,622	863	92,364	*	0	199,090
2017	28,926	--	4,492	35,920	*	0	69,338
2018	24,743	32	5,716	50,884	*	53	81,428
2019	1,682	28	4,969	34,684	*	0	41,363
2020	3,832	17	4,655	56,632	*	0	65,136
2021	2,117	167,400	9,976	80,567	*	5	260,065
2022	4,452	273,228	11,272	77,285	*	0	366,237
2023	6,143	234,948	8,936	59,793	*	0	309,820

** - Due to damage to the fish trap, fishway became a swim through operation.*
*** - Due to fish counter malfunction there was up to two weeks where passing fish were not enumerated.*
**** - Fishway operated but not monitored due to staffing constraints.*
+ - Fishway unable to pass fish until modifications in 1997.
++ - Fish netted below and hand passed over Winnicut River Dam.

Table 3. Instantaneous mortality rates (Z) estimates calculated using Chapman-Robson method from 'Great Bay Indicator Stock' locations between 1991 and 2023.

	Cocheco River		Exeter River		Oyster River		Lamprey River		GBI	
Year	Z	SE	Z	SE	Z	SE	Z	SE	Z	SE
1991	0.92	0.093	1.02	0.113	1.02	0.103	0.81	0.091	0.95	0.050
1992	0.81	0.077	1.01	0.091	0.71	0.071	1.17	0.126	0.90	0.044
1993	1.67	0.156	1.41	0.170	1.82	0.209	1.77	0.189	1.64	0.083
1994	1.00	0.088	--	--	0.84	0.073	1.35	0.151	0.85	0.043
1995	1.27	0.124	1.72	0.180	1.44	0.161	1.43	0.151	1.45	0.076
1996	0.82	0.063	1.39	0.375	1.20	0.127	1.16	0.123	0.99	0.052
1997	0.87	0.090	1.01	0.077	0.76	0.064	1.08	0.142	0.89	0.043
1998	0.81	0.070	0.64	0.050	0.95	0.092	0.96	0.107	0.78	0.033
1999	0.82	0.073	1.26	0.117	1.83	0.209	0.94	0.097	0.97	0.040
2000	0.78	0.069	1.03	0.110	0.83	0.072	0.80	0.068	0.71	0.025
2001	0.86	0.081	0.98	0.109	0.71	0.066	1.11	0.127	0.77	0.032
2002	0.76	0.069	1.53	0.276	0.70	0.063	1.23	0.158	0.66	0.027
2003	1.16	0.107	0.91	0.129	0.96	0.092	0.64	0.056	0.96	0.043
2004	1.20	0.125	1.19	0.176	1.44	0.161	0.86	0.078	1.16	0.056
2005	1.08	0.117	1.27	0.224	1.44	0.194	1.06	0.110	1.20	0.068
2006	0.96	0.096	0.69	0.183	1.00	0.112	0.70	0.069	0.79	0.044
2007	0.81	0.073	0.99	0.195	0.80	0.063	1.09	0.124	0.87	0.040
2008	0.97	0.095	0.89	0.083	0.82	0.083	0.85	0.084	1.03	0.050
2009	0.74	0.058	0.90	0.053	1.02	0.105	1.02	0.087	0.74	0.024
2010	0.84	0.013	1.10	0.156	1.26	0.014	0.75	0.019	1.21	0.012
2011	1.00	0.006	0.90	0.062	0.75	0.011	1.01	0.005	1.01	0.004
2012	1.60	0.016	1.35	0.083	1.41	0.042	1.15	0.005	1.07	0.004
2013	0.82	0.006	1.06	0.047	1.95	0.028	0.59	0.002	0.65	0.002
2014	1.00	0.007	1.68	0.082	2.33	0.056	0.85	0.004	0.91	0.003
2015	1.37	0.007	1.26	0.018	0.89	0.022	0.80	0.004	0.99	0.003
2016	1.01	0.004	0.92	0.012	1.04	0.044	1.47	0.006	1.60	0.006
2017	1.71	0.013	--	--	1.71	0.030	1.34	0.009	1.48	0.007
2018	1.96	0.019	--	--	0.97	0.014	0.72	0.003	0.55	0.002
2019	0.89	0.028	--	--	1.11	0.019	1.34	0.011	0.83	0.005
2020	2.12	0.053	1.66	0.437	0.78	0.013	0.92	0.004	0.87	0.004
2021	1.10	0.033	1.34	0.004	1.29	0.016	0.90	0.004	1.15	0.003
2022	0.61	0.009	1.28	0.004	1.36	0.017	0.84	0.003	1.07	0.002
2023	0.96	0.013	0.99	0.004	0.75	0.008	0.76	0.003	0.67	0.002

Table 4. Three-year running average values* of river herring scale samples analyzed, number of repeat spawning fish, and associated repeat spawning percentage during annual river herring runs occurring in New Hampshire at 'Great Bay Indicator Stock' locations between 2000 and 2023.

	Cocheco River			Lamprey River			Oyster River			Exeter River			'Great Bay Indicator Stock'		
Year	Scale Samples	Repeat Spawners	Repeat Spawning Percentage	Scale Samples	Repeat Spawners	Repeat Spawning Percentage	Scale Samples	Repeat Spawners	Repeat Spawning Percentage	Scale Samples	Repeat Spawners	Repeat Spawning Percentage	Scale Samples	Repeat Spawners	Repeat Spawning Percentage
2000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2001	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2002	140	53	38%	160	88	55%	144	65	45%	97	31	32%	541	238	44%
2003	141	52	37%	142	83	58%	146	74	51%	83	35	42%	513	243	47%
2004	134	57	43%	148	84	57%	141	72	51%	55	19	34%	478	232	49%
2005	127	61	48%	144	77	53%	135	76	56%	59	20	34%	465	234	50%
2006	110	61	56%	138	76	55%	133	71	53%	46	15	32%	426	223	52%
2007	123	52	42%	134	75	56%	149	64	43%	40	9	23%	446	200	45%
2008	130	46	35%	139	69	49%	156	57	36%	67	9	14%	493	180	37%
2009	164	51	31%	165	78	47%	154	55	36%	167	20	12%	650	205	32%
2010	135	50	37%	145	69	48%	128	48	38%	166	21	13%	574	189	33%
2011	111	45	41%	126	67	53%	120	51	43%	139	18	13%	495	182	37%
2012	70	39	55%	85	45	53%	112	50	45%	54	12	22%	321	146	45%
2013	76	37	48%	81	40	49%	120	42	35%	64	16	24%	342	135	39%
2014	87	47	53%	87	46	53%	117	50	43%	77	26	33%	369	169	46%
2015	93	44	48%	88	50	57%	117	53	45%	92	31	33%	391	178	45%
2016	89	44	50%	86	55	64%	121	64	53%	103	37	35%	398	200	50%
2017	76	39	51%	77	53	69%	119	45	38%	84	28	34%	356	165	46%
2018	79	44	55%	78	52	66%	108	34	32%	58	18	32%	315	147	47%
2019	94	46	49%	80	48	60%	99	28	28%	31	8	26%	288	126	44%
2020	105	47	45%	80	42	53%	106	39	37%	22	7	30%	291	129	44%
2021	116	51	44%	76	38	50%	116	36	31%	33	8	25%	309	125	40%
2022	106	47	44%	76	34	45%	118	33	28%	47	19	39%	299	114	38%
2023	104	37	36%	74	34	46%	118	34	29%	59	20	35%	295	105	35%

** All numbers shown are 3-year running average values of number of river herring scale samples.*

Table 5. Distribution of repeat spawning frequency* of river herring in New Hampshire at 'Great Bay Indicator Stock' locations, from scale samples aged between 2000 and 2023.

	Cocheco River					Lamprey River					Oyster River					Exeter River					'Great Bay Indicator Stock'				
Year	% of r0	% of r1	% of r2	% of r3	% of r4	% of r0	% of r1	% of r2	% of r3	% of r4	% of r0	% of r1	% of r2	% of r3	% of r4	% of r0	% of r1	% of r2	% of r3	% of r4	% of r0	% of r1	% of r2	% of r3	% of r4
2000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2001	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2002	62%	25%	12%	1%	0%	44%	33%	19%	4%	0%	55%	28%	13%	4%	0%	73%	18%	8%	1%	0%	56%	27%	14%	3%	0%
2003	64%	25%	9%	2%	0%	42%	34%	20%	5%	0%	49%	30%	16%	4%	0%	63%	24%	12%	1%	0%	53%	29%	15%	3%	0%
2004	56%	29%	13%	2%	0%	43%	28%	23%	6%	0%	48%	25%	22%	5%	0%	66%	22%	11%	1%	0%	51%	26%	18%	4%	0%
2005	51%	30%	15%	4%	0%	47%	30%	18%	5%	0%	44%	31%	21%	4%	0%	66%	22%	10%	2%	0%	50%	29%	17%	4%	0%
2006	45%	32%	16%	6%	1%	45%	32%	18%	5%	0%	47%	28%	20%	5%	0%	66%	24%	8%	2%	0%	48%	30%	17%	5%	0%
2007	56%	23%	13%	6%	1%	44%	32%	18%	4%	1%	56%	29%	11%	3%	0%	74%	21%	4%	1%	0%	55%	27%	13%	4%	0%
2008	63%	22%	9%	4%	1%	50%	27%	17%	5%	1%	64%	23%	9%	4%	0%	78%	18%	4%	0%	0%	62%	23%	11%	4%	0%
2009	71%	21%	6%	1%	0%	53%	29%	13%	3%	1%	64%	27%	7%	2%	0%	87%	11%	2%	0%	0%	69%	21%	7%	2%	0%
2010	60%	27%	12%	0%	0%	51%	33%	12%	3%	0%	61%	25%	10%	3%	0%	85%	13%	1%	1%	0%	65%	24%	9%	2%	0%
2011	57%	26%	14%	4%	0%	46%	34%	15%	6%	0%	57%	30%	10%	3%	0%	84%	14%	0%	1%	0%	61%	25%	10%	3%	0%
2012	44%	32%	19%	4%	1%	48%	31%	15%	6%	0%	55%	27%	13%	4%	0%	77%	19%	3%	1%	0%	54%	28%	14%	4%	0%
2013	51%	28%	14%	6%	1%	51%	28%	15%	6%	0%	65%	23%	10%	2%	0%	76%	19%	6%	0%	0%	60%	25%	11%	4%	0%
2014	46%	30%	17%	7%	1%	48%	34%	14%	4%	0%	56%	33%	9%	1%	0%	67%	25%	7%	0%	0%	55%	30%	12%	3%	0%
2015	53%	23%	14%	10%	0%	43%	32%	18%	7%	0%	54%	34%	10%	2%	0%	67%	25%	7%	1%	0%	55%	28%	12%	4%	0%
2016	51%	27%	13%	8%	0%	35%	34%	22%	10%	1%	46%	37%	12%	5%	0%	65%	26%	8%	1%	0%	50%	31%	13%	6%	0%
2017	49%	28%	17%	6%	1%	31%	27%	32%	9%	0%	63%	21%	11%	5%	0%	67%	21%	11%	1%	0%	54%	24%	17%	5%	0%
2018	44%	26%	26%	3%	0%	33%	21%	35%	10%	0%	73%	18%	6%	4%	0%	72%	19%	8%	0%	0%	56%	20%	19%	5%	0%
2019	49%	18%	28%	4%	1%	39%	21%	29%	10%	0%	75%	19%	5%	1%	0%	74%	18%	8%	0%	0%	59%	19%	18%	4%	0%
2020	54%	17%	22%	6%	1%	47%	24%	20%	9%	0%	67%	22%	9%	2%	0%	73%	19%	8%	0%	0%	59%	21%	15%	5%	0%
2021	56%	19%	14%	9%	2%	50%	31%	14%	5%	0%	70%	18%	10%	2%	0%	74%	15%	10%	1%	0%	61%	21%	12%	5%	1%
2022	56%	21%	12%	9%	2%	55%	27%	15%	2%	1%	73%	17%	8%	2%	0%	65%	22%	11%	2%	0%	62%	22%	11%	4%	1%
2023	65%	18%	10%	5%	1%	54%	29%	14%	3%	1%	72%	20%	6%	1%	0%	66%	20%	10%	4%	0%	65%	22%	10%	3%	1%

** All frequencies shown are 3-year running average values of number of river herring scale samples.*

Table 6. Three-year running average values* of river herring harvested by state-permitted coastal netters in New Hampshire by location between 1991 and 2023; Areas used to calculate the harvest portion of the annual 'Great Bay Indicator Stock' used to set the sustainability target are shown.

Year	Cocheco River+	Lamprey River+	Oyster River+	Exeter River+	Winnicut River+	Bellamy River+	Salmon Falls River+	Great Bay+	Little Bay+	Portsmouth+	Piscataqua River+	All Other Locations	Statewide Total River Herring Harvested (# Fish)	Great Bay Estuary River Herring Harvested (# Fish)	% of Statewide Total
1991	0	10,565	385	15,224	297	1,163	61	13	0	0	326	1,467	29,502	28,035	95%
1992	19	12,058	620	7,618	74	946	68	4	0	0	20	1,023	22,451	21,428	95%
1993	34	7,952	927	3,315	80	551	112	4	3	0	20	532	13,530	12,998	96%
1994	34	4,900	855	2,767	44	47	98	13	3	0	0	468	9,229	8,761	95%
1995	16	410	621	4,606	27	164	180	13	3	0	1	98	6,139	6,041	98%
1996	2	703	522	5,274	366	238	223	14	0	0	7	44	7,393	7,349	99%
1997	105	1,053	715	9,068	375	237	594	5	0	0	17	42	12,211	12,170	100%
1998	116	917	752	21,792	368	445	1,045	1	63	0	25	634	26,158	25,524	98%
1999	140	730	384	31,432	23	543	1,807	3	63	83	43	930	36,182	35,253	97%
2000	70	897	386	39,347	24	770	1,871	3	72	83	65	1,243	44,831	43,588	97%
2001	57	1,228	504	31,631	24	820	1,762	3	62	83	76	628	36,879	36,251	98%
2002	47	1,135	574	29,097	24	1,007	997	0	62	0	52	317	33,312	32,995	99%
2003	25	1,214	444	24,808	0	844	650	15	53	0	20	3	28,077	28,074	100%
2004	82	770	475	21,051	0	518	232	15	0	0	0	127	23,270	23,143	99%
2005	85	873	363	13,215	19	369	158	15	0	0	0	127	15,224	15,097	99%
2006	114	614	305	5,084	163	435	32	2	0	0	0	127	6,875	6,748	98%
2007	171	505	103	1,552	243	610	15	2	0	0	0	0	3,202	3,202	100%
2008	334	438	86	5,488	282	569	18	3	0	0	10	0	7,228	7,228	100%
2009	482	1,279	74	9,685	137	694	31	1	0	0	10	0	12,394	12,394	100%
2010	579	1,912	96	13,152	58	569	55	1	0	0	10	0	16,432	16,432	100%
2011	399	2,940	69	10,015	0	580	59	0	0	0	0	0	14,062	14,062	100%
2012	211	2,230	39	6,459	4	505	48	10	0	0	0	0	9,506	9,506	100%
2013	7	1,730	2	5,169	4	575	20	10	0	0	0	0	7,516	7,516	100%
2014	8	1,298	0	6,645	4	604	3	16	20	0	0	0	8,599	8,599	100%
2015	8	1,473	0	9,844	0	505	0	6	20	0	0	0	11,856	11,856	100%
2016	1	1,328	0	10,020	1	394	0	6	20	0	0	0	11,771	11,771	100%
2017	0	1,482	0	8,787	1	288	0	0	0	0	0	0	10,558	10,558	100%
2018	0	1,927	0	6,116	1	402	0	0	0	0	0	0	8,447	8,447	100%
2019	0	3,380	0	9,149	0	565	0	0	0	0	0	0	13,094	13,094	100%
2020	0	4,380	0	10,875	0	537	0	0	0	0	0	0	15,792	15,792	100%
2021	0	3,293	0	9,249	0	317	0	0	0	0	0	0	12,860	12,860	100%
2022	0	1,800	0	3,412	0	97	0	0	0	0	0	0	5,309	5,309	100%
2023	0	0	0	0	0	0	0	0	0	0	0	0	0	0	--

** All numbers shown are 3-year running average values of number of river herring reported harvested; landings reported by weight in pounds were calculated using conversion factor (1 lb = 2 river herring).*

+ These reported locations are within the Great Bay Estuary and used to calculate the 'Harvest Portion' of the 'Great Bay Indicator Stock' sustainability target.

Table 7. Number* of river herring harvested, number of river herring returning, and percentage of river herring harvested by state-permitted coastal netters in New Hampshire at 'Great Bay Indicator Stock' locations between 1991 and 2023.

	Cocheco River				Lamprey River				Oyster River				Exeter River				'Great Bay Indicator Stock' Harvest to Return Percentage			
Year	Harvest (# Fish)	Ladder Return (# Fish)	Minimum Spawning Run Estimate (# Fish)	Percent Harvest	Harvest (# Fish)	Ladder Return (# Fish)	Minimum Spawning Run Estimate (# Fish)	Percent Harvest	Harvest (# Fish)	Ladder Return (# Fish)	Minimum Spawning Run Estimate (# Fish)	Percent Harvest	Harvest (# Fish)	Ladder Return (# Fish)	Minimum Spawning Run Estimate (# Fish)	Percent Harvest	Harvest Portion+ (# Fish)	Return Portion (# Fish)	Percent Harvest	Sustainability Target Status
	H	*L*	*R=H+L*	*H/R * 100*	*H*	*L*	*R=H+L*	*H/R * 100*	*H*	*L*	*R=H+L*	*H/R * 100*	*H*	*L*	*R=H+L*	*H/R * 100*	*∑H*	*∑R*	*(∑H / ∑R)* 100*	
1991	0	25,302	25,302	0%	10,565	27,159	37,724	28%	385	115,163	115,548	0%	15,224	104	15,329	99%	28,035	193,902	14%	Below Target
1992	19	43,314	43,333	0%	12,058	23,946	36,005	33%	620	154,529	155,149	0%	7,618	283	7,902	96%	21,428	242,388	9%	Below Target
1993	34	46,205	46,239	0%	7,952	23,890	31,842	25%	927	127,596	128,523	1%	3,315	376	3,691	90%	12,998	210,295	6%	Below Target
1994	34	48,668	48,702	0%	4,900	18,640	23,540	21%	855	107,595	108,450	1%	2,767	272	3,039	91%	8,761	183,731	5%	Below Target
1995	16	50,966	50,982	0%	410	18,437	18,847	2%	621	82,886	83,507	1%	4,606	290	4,896	94%	6,041	158,232	4%	Below Target
1996	2	48,431	48,433	0%	703	13,741	14,444	5%	522	85,744	86,266	1%	5,274	280	5,554	95%	7,349	154,696	5%	Below Target
1997	105	47,778	47,883	0%	1,053	16,447	17,500	6%	715	74,392	75,108	1%	9,068	714	9,782	93%	12,170	150,273	8%	Below Target
1998	116	29,742	29,858	0%	917	16,461	17,378	5%	752	75,133	75,884	1%	21,792	647	22,440	97%	25,524	145,560	18%	Below Target
1999	140	24,379	24,519	1%	730	19,417	20,147	4%	384	77,033	77,417	0%	31,432	1,505	32,937	95%	35,253	155,019	**23%**	**Above Target**
2000	70	24,298	24,368	0%	897	20,564	21,461	4%	386	81,351	81,737	0%	39,347	1,249	40,596	97%	43,588	168,161	**26%**	**Above Target**
2001	57	31,402	31,460	0%	1,228	28,358	29,586	4%	504	75,308	75,813	1%	31,631	3,352	34,983	90%	36,251	171,842	**21%**	**Above Target**
2002	47	46,667	46,713	0%	1,135	41,024	42,160	3%	574	65,347	65,921	1%	29,097	3,526	32,623	89%	32,995	187,416	18%	Below Target
2003	25	60,087	60,112	0%	1,214	53,960	55,174	2%	444	58,901	59,346	1%	24,808	3,372	28,180	88%	28,074	202,812	14%	Below Target
2004	82	60,535	60,617	0%	770	62,961	63,731	1%	475	54,216	54,691	1%	21,051	1,165	22,216	95%	23,143	201,256	11%	Below Target
2005	85	45,193	45,278	0%	873	56,948	57,822	2%	363	39,117	39,481	1%	13,215	73	13,288	99%	15,097	155,869	10%	Below Target
2006	114	22,899	23,013	0%	614	43,277	43,891	1%	305	23,950	24,255	1%	5,084	55	5,139	99%	6,748	96,298	7%	Below Target
2007	171	12,193	12,364	1%	505	39,574	40,079	1%	103	12,113	12,216	1%	1,552	41	1,593	97%	3,202	66,252	5%	Below Target
2008	334	16,940	17,273	2%	438	38,314	38,753	1%	86	14,745	14,832	1%	5,488	75	5,563	99%	7,228	76,420	9%	Below Target
2009	482	27,555	28,038	2%	1,279	44,632	45,912	3%	74	16,621	16,695	0%	9,685	240	9,925	98%	12,394	100,570	12%	Below Target
2010	579	33,168	33,747	2%	1,912	37,333	39,245	5%	96	17,149	17,245	1%	13,152	250	13,402	98%	16,432	103,639	16%	Below Target
2011	399	37,303	37,702	1%	2,940	42,066	45,007	7%	69	11,807	11,876	1%	10,015	279	10,294	97%	14,062	104,879	13%	Below Target
2012	211	34,451	34,662	1%	2,230	56,879	59,108	4%	39	8,778	8,817	0%	6,459	234	6,693	96%	9,506	109,280	9%	Below Target
2013	7	29,678	29,685	0%	1,730	72,239	73,969	2%	2	4,826	4,828	0%	5,169	407	5,576	93%	7,516	114,058	7%	Below Target
2014	8	25,304	25,312	0%	1,298	83,713	85,010	2%	0	4,650	4,650	0%	6,645	585	7,230	92%	8,599	122,203	7%	Below Target
2015	8	37,587	37,595	0%	1,473	78,040	79,512	2%	0	4,393	4,393	0%	9,844	2,313	12,157	81%	11,856	133,657	9%	Below Target
2016	1	64,555	64,556	0%	1,328	82,358	83,687	2%	0	2,298	2,298	0%	10,020	4,324	14,344	70%	11,771	164,885	7%	Below Target
2017	0	64,208	64,208	0%	1,482	66,042	67,524	2%	0	2,386	2,386	0%	8,787	4,061	12,848	68%	10,558	146,966	7%	Below Target
2018	0	50,970	50,970	0%	1,927	59,723	61,649	3%	0	3,690	3,690	0%	6,116	2,218	8,334	73%	8,447	124,644	7%	Below Target
2019	0	18,450	18,450	0%	3,380	40,496	43,876	8%	0	5,059	5,059	0%	9,149	20	9,169	100%	13,094	76,555	17%	Below Target
2020	0	10,086	10,086	0%	4,380	47,400	51,780	8%	0	5,113	5,113	0%	10,875	26	10,900	100%	15,792	77,879	20%	Below Target
2021	0	2,544	2,544	0%	3,293	57,294	60,588	5%	0	6,533	6,533	0%	9,249	55,815	65,064	14%	12,860	134,729	10%	Below Target
2022	0	3,467	3,467	0%	1,800	71,524	73,324	2%	0	8,634	8,634	0%	3,412	146,882	150,294	2%	5,309	235,719	2%	Below Target
2023	0	4,237	4,237	0%	0	72,578	72,578	0%	0	10,061	10,061	0%	0	225,192	225,192	0%	0	312,069	0%	Below Target

** All numbers shown are 3-year running average values of number of river herring reported harvested or returning; landings reported by weight in pounds were calculated using conversion factor (1 lb = 2 river herring).*

+ 'Harvest Portion' of the Great Bay Indicator Stock uses reported harvest from all areas within the Great Bay Estuary (see Table 12); therefore, it will exceed the sum of the harvest from the four rivers monitored for the 'Return Portion'.

Table 8. Geometric mean catch per seine haul of alewife, blueback herring, and both species combined from a juvenile finfish seine survey conducted in the Great Bay Estuary between 1997 and 2023.

	Alewife		Blueback Herring		Combined	
Year	Annual Geometric Mean	3-yr Average	Annual Geometric Mean	3-yr Average	Annual Geometric Mean	3-yr Average
1997	0.07	--	0.43	--	0.51	--
1998	0.04	--	0.66	--	0.67	--
1999	0.27	0.13	0.97	0.69	1.09	0.76
2000	0.26	0.19	0.74	0.79	0.89	0.89
2001	0.14	0.22	0.89	0.87	0.98	0.99
2002	0.34	0.25	0.26	0.63	0.56	0.81
2003	0.32	0.27	0.71	0.62	1.17	0.90
2004	0.14	0.27	0.22	0.40	0.32	0.68
2005	0.11	0.19	0.35	0.43	0.47	0.65
2006	0.32	0.19	0.42	0.33	0.63	0.47
2007	0.21	0.21	0.5	0.42	0.77	0.62
2008	0.15	0.23	0.13	0.35	0.28	0.56
2009	0.10	0.15	0.20	0.28	0.26	0.44
2010	0.08	0.11	0.17	0.17	0.22	0.25
2011	0.08	0.09	0.05	0.14	0.12	0.20
2012	0.02	0.06	0.08	0.10	0.09	0.14
2013	0.22	0.11	0.04	0.06	0.27	0.16
2014	0.05	0.10	0.14	0.09	0.20	0.18
2015	0.31	0.19	0.06	0.08	0.34	0.27
2016	0.14	0.17	0.21	0.14	0.24	0.26
2017	0.21	0.22	0.30	0.19	0.50	0.36
2018	0.23	0.19	0.34	0.28	0.48	0.41
2019	0.07	0.17	0.17	0.27	0.22	0.40
2020	0.33	0.21	0.33	0.28	0.67	0.46
2021	0.31	0.24	0.30	0.27	0.54	0.48
2022	0.25	0.30	0.08	0.24	0.33	0.51
2023	0.21	0.26	0.04	0.14	0.26	0.38

Table 9. Three-year running average of the number* of river herring successfully ascending fish passage structures in New Hampshire by river between 1991 and 2023. The Great Bay Indicator Stock rivers set the sustainability target.

	'Great Bay Indicator Stock'								
Year	Cocheco River	Lamprey River	Oyster River	Exeter River	Winnicut River+	Taylor River	Annual River Herring Return (# Fish)	'Great Bay Indicator Stock' Return (# Fish)	Percentage of Annual Return
1991	25,302	27,159	115,163	313	--	38,332	206,269	167,728	81%
1992	43,314	23,946	154,529	425	--	40,903	263,117	222,072	84%
1993	46,205	23,890	127,596	376	--	60,120	258,187	198,067	77%
1994	48,668	18,640	107,595	408	--	58,710	234,021	175,174	75%
1995	50,966	18,437	82,886	435	--	47,260	199,984	152,579	76%
1996	48,431	13,741	85,744	420	--	22,345	170,680	148,195	87%
1997	47,778	16,447	74,392	714	--	15,097	154,428	139,331	90%
1998	29,742	16,461	75,133	647	--	14,171	136,154	121,983	90%
1999	24,379	19,417	77,033	1,505	--	19,199	141,533	122,334	86%
2000	24,298	20,564	81,351	1,249	350	27,062	154,873	127,461	82%
2001	31,402	28,358	75,308	3,352	649	25,424	164,495	138,421	84%
2002	46,667	41,024	65,347	3,526	2,895	18,968	178,426	156,564	88%
2003	60,087	53,960	58,901	3,372	4,529	4,764	185,613	176,320	95%
2004	60,535	62,961	54,216	1,165	6,837	2,760	188,475	178,878	95%
2005	45,193	56,948	39,117	73	5,391	895	147,618	141,332	96%
2006	22,899	43,277	23,950	55	3,856	478	94,516	90,181	95%
2007	12,193	39,574	12,113	41	3,689	199	67,809	63,920	94%
2008	16,940	38,314	14,745	75	5,575	447	76,095	70,076	92%
2009	27,555	44,632	16,621	240	6,959	597	96,604	89,051	92%
2010	33,168	37,333	17,149	250	4,636	825	93,362	87,902	94%
2011	37,303	42,066	11,807	279	1,874	367	93,697	91,456	98%
2012	34,451	56,879	8,778	234	218	275	100,835	100,342	100%
2013	29,678	72,239	4,826	407	26	93	107,269	107,150	100%
2014	25,304	83,713	4,650	585	2	92	114,346	114,252	100%
2015	37,587	78,040	4,393	2,313	0	93	122,425	122,333	100%
2016	64,555	82,358	2,298	4,324	0	57	153,592	153,535	100%
2017	64,208	66,042	2,386	6,092	0	--	138,728	136,697	99%
2018	50,970	59,723	3,690	3,327	18	--	117,728	116,601	99%
2019	18,450	40,496	5,059	30	18	--	64,053	64,025	100%
2020	10,086	47,400	5,113	26	18	--	62,642	62,625	100%
2021	2,544	57,294	6,533	55,815	2	--	122,188	122,186	100%
2022	3,467	71,495	8,634	146,882	2	--	230,479	230,478	100%
2023	4,237	72,548	10,061	225,192	2	--	312,041	312,039	100%

** All numbers shown are 3-yr running average values of number of river herring returning.*

+ Winnicut River return numbers have been excluded from the return portion of the 'Great Bay Indicator Stock' because the dam and associated fish passage structure were removed in fall of 2009.

Table 10. Correlation tests between instantaneous mortality rates (Z) and annual exploitation rates of river herring from 'Great Bay Indicator Stock' locations between 1991 and 2023 (*Plots in Figure 3*).

	Cocheco River	
Year	Z	Exploitation Rate (single years)
1991	0.92	0.0%
1992	0.81	0.1%
1993	1.67	0.1%
1994	1.00	0.0%
1995	1.27	0.0%
1996	0.82	0.0%
1997	0.87	1.0%
1998	0.81	0.2%
1999	0.82	0.4%
2000	0.78	0.3%
2001	0.86	0.0%
2002	0.76	0.1%
2003	1.16	0.0%
2004	1.20	0.4%
2005	1.08	0.3%
2006	0.96	2.7%
2007	0.81	2.1%
2008	0.97	1.7%
2009	0.74	1.5%
2010	0.84	1.9%
2011	1.00	0.0%
2012	1.60	0.0%
2013	0.82	0.1%
2014	1.00	0.0%
2015	1.37	0.0%
2016	1.01	0.0%
2017	1.71	0.0%
2018	1.96	0.0%
2019	0.89	0.0%
2020	2.12	0.0%
2021	1.10	0.0%
2022	0.61	0.0%
2023	0.96	0.0%
r^2 = 0.0748		P = 0.018
Significant		

	Lamprey River	
Year	Z	Exploitation Rate (single years)
1991	0.81	23.5%
1992	1.17	47.1%
1993	1.77	0.0%
1994	1.35	0.0%
1995	1.43	7.2%
1996	1.16	7.3%
1997	1.08	4.5%
1998	0.96	4.9%
1999	0.94	1.6%
2000	0.80	5.7%
2001	1.11	4.4%
2002	1.23	0.1%
2003	0.64	2.7%
2004	0.86	0.7%
2005	1.06	0.9%
2006	0.70	4.1%
2007	1.09	0.3%
2008	0.85	0.4%
2009	1.02	7.7%
2010	0.75	5.8%
2011	1.01	6.0%
2012	1.15	1.6%
2013	0.59	0.7%
2014	0.85	2.2%
2015	0.80	2.7%
2016	1.47	0.1%
2017	1.34	6.3%
2018	0.72	6.0%
2019	1.34	11.4%
2020	0.92	8.7%
2021	0.90	0.0%
2022	0.84	0.0%
2023	0.76	0.0%
r^2 = 0.0027		P > 0.05
Not Significant		

	Oyster River	
Year	Z	Exploitation Rate (single years)
1991	1.02	0.2%
1992	0.71	0.5%
1993	1.82	2.2%
1994	0.84	0.1%
1995	1.44	0.1%
1996	1.20	1.6%
1997	0.76	1.2%
1998	0.95	0.2%
1999	1.83	0.3%
2000	0.83	1.0%
2001	0.71	0.8%
2002	0.70	0.8%
2003	0.96	0.6%
2004	1.44	1.2%
2005	1.44	1.1%
2006	1.00	2.0%
2007	0.80	0.3%
2008	0.82	0.4%
2009	1.02	0.8%
2010	1.26	0.6%
2011	0.75	0.1%
2012	1.41	0.0%
2013	1.95	0.0%
2014	2.33	0.0%
2015	0.89	0.0%
2016	1.04	0.0%
2017	1.71	0.0%
2018	0.97	0.0%
2019	1.11	0.0%
2020	0.78	0.0%
2021	1.29	0.0%
2022	1.36	0.0%
2023	0.75	0.0%
r^2 = 0.0001		P > 0.05
Not Significant		

	Squamscott/Exeter River	
Year	Z	Exploitation Rate (single years)
1991	1.02	94.3%
1992	1.01	83.3%
1993	1.41	88.4%
1994	--	100.0%
1995	1.72	93.3%
1996	1.39	94.3%
1997	1.01	92.0%
1998	0.64	99.2%
1999	1.26	92.1%
2000	1.03	98.6%
2001	0.98	77.6%
2002	1.53	88.4%
2003	0.91	99.7%
2004	1.19	99.3%
2005	1.27	96.7%
2006	0.69	98.8%
2007	0.99	97.1%
2008	0.89	98.8%
2009	0.90	96.5%
2010	1.10	99.4%
2011	0.90	94.4%
2012	1.35	89.7%
2013	1.06	93.1%
2014	1.68	91.7%
2015	1.26	69.9%
2016	0.92	56.0%
2017	--	100.0%
2018	--	99.3%
2019	--	99.8%
2020	1.66	99.8%
2021	1.34	0.0%
2022	1.28	0.0%
2023	0.99	0.0%
r^2 = 0.0047		P = 0.001
Significant		

	Great Bay Indicator Stock	
Year	Z	Exploitation Rate (single years)
1991	0.95	6.6%
1992	0.90	6.9%
1993	1.64	2.7%
1994	0.85	2.5%
1995	1.45	5.1%
1996	0.99	4.8%
1997	0.89	13.1%
1998	0.78	27.2%
1999	0.97	20.9%
2000	0.71	24.2%
2001	0.77	13.8%
2002	0.66	12.5%
2003	0.96	13.0%
2004	1.16	7.3%
2005	1.20	3.4%
2006	0.79	7.2%
2007	0.87	2.1%
2008	1.03	14.2%
2009	0.74	16.7%
2010	1.21	14.6%
2011	1.01	7.1%
2012	1.07	3.8%
2013	0.65	7.4%
2014	0.91	8.2%
2015	0.99	9.5%
2016	1.60	4.1%
2017	1.48	9.7%
2018	0.55	9.1%
2019	0.83	34.7%
2020	0.87	19.4%
2021	1.15	0.0%
2022	1.07	0.0%
2023	0.67	0.0%
r^2 = 0.1118		P = 0.001
Significant		

Table 11. Annual river herring returns estimates in the Exeter River between 2021 and 2023 derived from Visual Time Counts, with associated standard error values.

Year	Total Return (Number)	SE
2021	167,400	49,852.04
2022	273,228	33,273.73
2023	234,948	30,334.74

Table 12. Annual number of river herring harvested by state-permitted coastal harvesters in New Hampshire by location between 1991 and 2023; Areas used to calculate the harvest portion of the annual 'Great Bay Indicator Stock' used to set the sustainability target are shown.

Year	Cocheco River+	Lamprey River+	Oyster River+	Exeter River+	Winnicut River+	Bellamy River+	Salmon Falls River+	Great Bay+	Little Bay+	Portsmouth+	Piscataqua River+	All Other Locations	Statewide Total River Herring Harvested (# Fish)	Great Bay Estuary River Herring Harvested (# Fish)	% of Statewide Total
1991	0	9,155	320	5,139	152	1,594	163	0	0	0	61	200	16,784	16,584	99%
1992	58	14,700	796	2,681	70	0	41	12	0	0	0	1,186	19,544	18,358	94%
1993	43	0	1,666	2,124	18	60	132	0	10	0	0	210	4,263	4,053	95%
1994	2	0	103	3,497	43	81	120	26	0	0	0	8	3,880	3,872	100%
1995	4	1,230	94	8,197	20	351	288	13	0	0	2	77	10,276	10,199	99%
1996	0	880	1,369	4,127	1,034	283	262	2	0	0	18	48	8,023	7,975	99%
1997	310	1,050	683	14,882	70	77	1,232	0	0	0	32	0	18,336	18,336	100%
1998	38	820	203	46,368	0	974	1,642	0	190	0	25	1,854	52,115	50,261	96%
1999	72	320	265	33,045	0	579	2,548	10	0	250	73	935	38,097	37,162	98%
2000	100	1,550	690	38,628	73	757	1,423	0	25	0	96	940	44,282	43,342	98%
2001	0	1,814	558	23,219	0	1,123	1,314	0	160	0	60	10	28,258	28,248	100%
2002	40	42	473	25,443	0	1,142	255	0	0	0	0	0	27,395	27,395	100%
2003	34	1,786	302	25,763	0	267	382	45	0	0	0	0	28,579	28,579	100%
2004	171	481	650	11,948	0	145	60	0	0	0	0	380	13,835	13,455	97%
2005	50	353	138	1,934	56	694	32	1	0	0	0	0	3,258	3,258	100%
2006	120	1,009	126	1,369	433	465	4	5	0	0	0	0	3,531	3,531	100%
2007	343	154	45	1,354	239	672	10	0	0	0	0	0	2,817	2,817	100%
2008	538	152	88	13,741	173	571	40	4	0	0	30	0	15,337	15,337	100%
2009	566	3,532	90	13,960	0	838	43	0	0	0	0	0	19,029	19,029	100%
2010	632	2,053	111	11,754	0	298	83	0	0	0	0	0	14,931	14,931	100%
2011	0	3,236	6	4,330	0	603	51	0	0	0	0	0	8,226	8,226	100%
2012	1	1,400	0	3,293	12	615	10	30	0	0	0	0	5,361	5,361	100%
2013	20	553	0	7,883	0	506	0	0	0	0	0	0	8,962	8,962	100%
2014	3	1,940	0	8,760	0	692	0	19	60	0	0	0	11,474	11,474	100%
2015	0	1,925	0	12,889	0	317	0	0	0	0	0	0	15,131	15,131	100%
2016	0	120	0	8,411	4	173	0	0	0	0	1	0	8,709	8,709	100%
2017	0	2,400	0	5,060	0	375	0	0	0	0	0	0	7,835	7,835	100%
2018	0	3,260	0	4,877	0	659	0	0	0	0	0	0	8,796	8,796	100%
2019	0	4,480	0	17,511	0	661	0	0	0	0	0	0	22,652	22,652	100%
2020	0	5,400	0	10,236	0	291	0	0	0	0	0	0	15,927	15,927	100%
2021	0	0	0	0	0	0	0	0	0	0	0	0	0	0	--
2022	0	0	0	0	0	0	0	0	0	0	0	0	0	0	--
2023	0	0	0	0	0	0	0	0	0	0	0	0	0	0	--

+ These reported locations are within the Great Bay Estuary and are used to calculate the 'Return Portion' of the 'Great Bay Indicator Stock' sustainability target.

Table 13. Estimates of annual river herring harvest occurring in New Hampshire waters, derived from the cooperative state/federal Marine Recreational Fisheries Statistics Survey, with associated proportional standard error (PSE) values, and reported commercial landings⁺ from the federal landings database between 1991 and 2023.

	State/MRIP				Federal Landings Database	
	Blueback Herring		Alewife		Blueback Herring	Alewife
Year	Estimated Harvest (# Fish)	PSE	Estimated Harvest (# Fish)	PSE	Reported Landings (# Fish)	Reported Landings (# Fish)
1991	0	--	0	--	0	0
1992	0	--	0	--	0	19,604
1993	0	--	0	--	0	5,352
1994	0	--	0	--	0	0
1995	0	--	408	77.7	0	0
1996	0	--	0	--	0	0
1997	0	--	0	--	0	0
1998	0	--	0	--	0	51,988
1999	0	--	0	--	0	0
2000	0	--	0	--	0	0
2001	267	102.8	15,073	98.6	0	0
2002	0	--	0	--	0	0
2003	5,121	103.3	0	--	0	0
2004	0	--	0	--	0	0
2005	78	72.7	0	--	0	0
2006	0	--	0	--	0	0
2007	0	--	63,323	51.5	0	2,816
2008	0	--	154,208	71.6	0	16,264
2009	278	76.7	8,045	88.8	0	1,880
2010	0	--	14,681	89.0	0	14,932
2011	0	--	0	--	0	8,226
2012	42	102.6	34,991	84.2	0	5,362
2013	64	104.0	22,074	57.2	0	8,840
2014	5,246	98.4	61,271	54.0	0	0
2015	0	--	0	--	0	0
2016	0	--	0	--	0	0
2017	86	108.4	691	85.9	0	0
2018	0	--	13,581	85.4	0	0
2019	10,331	97.6	2,340	96.7	0	0
2020	6,720	106.9	4,239	61.5	0	11,700
2021	0	--	0	--	0	0
2022	0	--	0	--	0	0
2023	0	--	0	--	0	0

⁺ *Landings values are in numbers of fish landed by commercial harvesters within New Hampshire waters, but the location of harvest is exclusively from the EEZ*

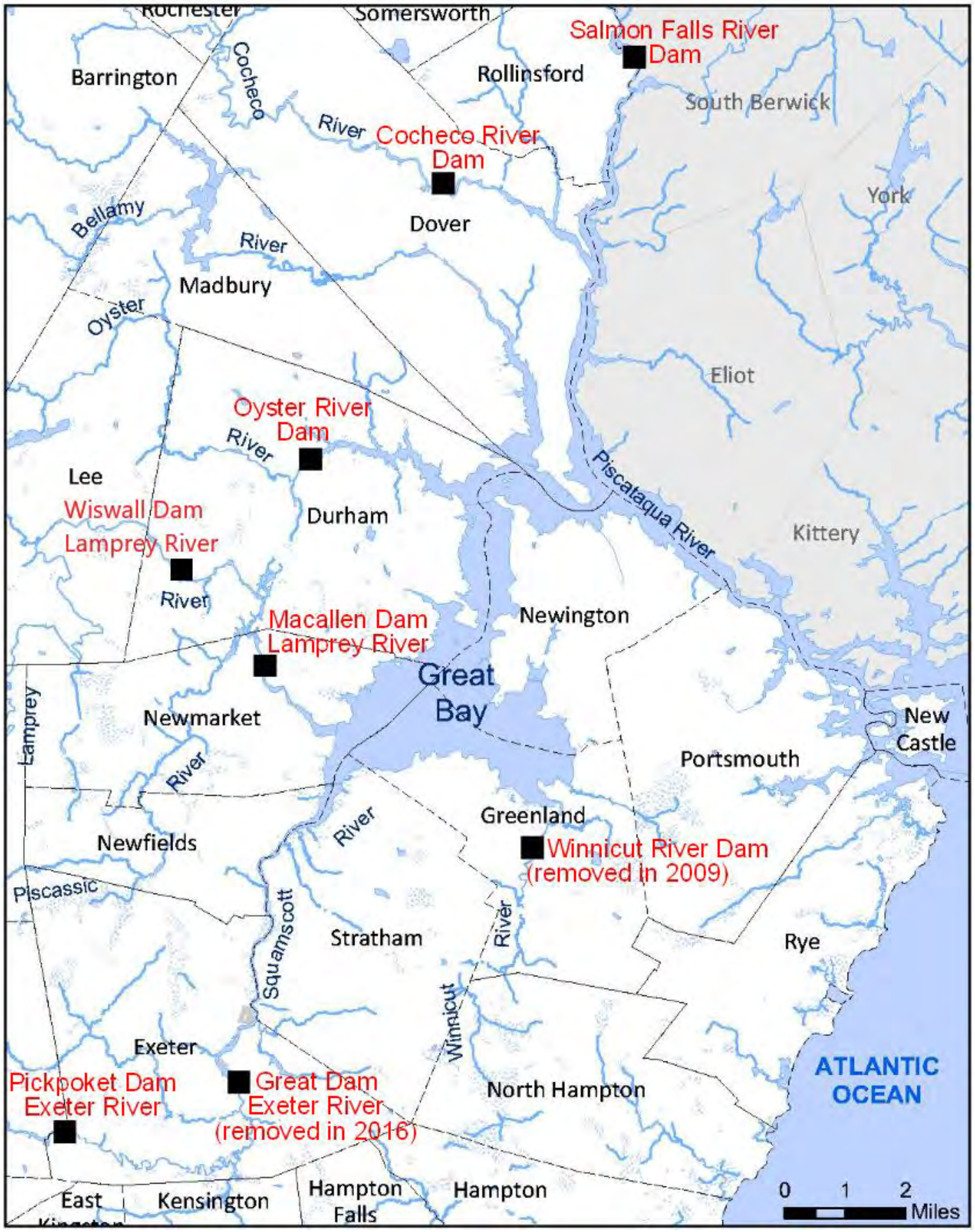


Figure 1. **Map of the Great Bay Estuary showing major coastal rivers, and dam locations.**

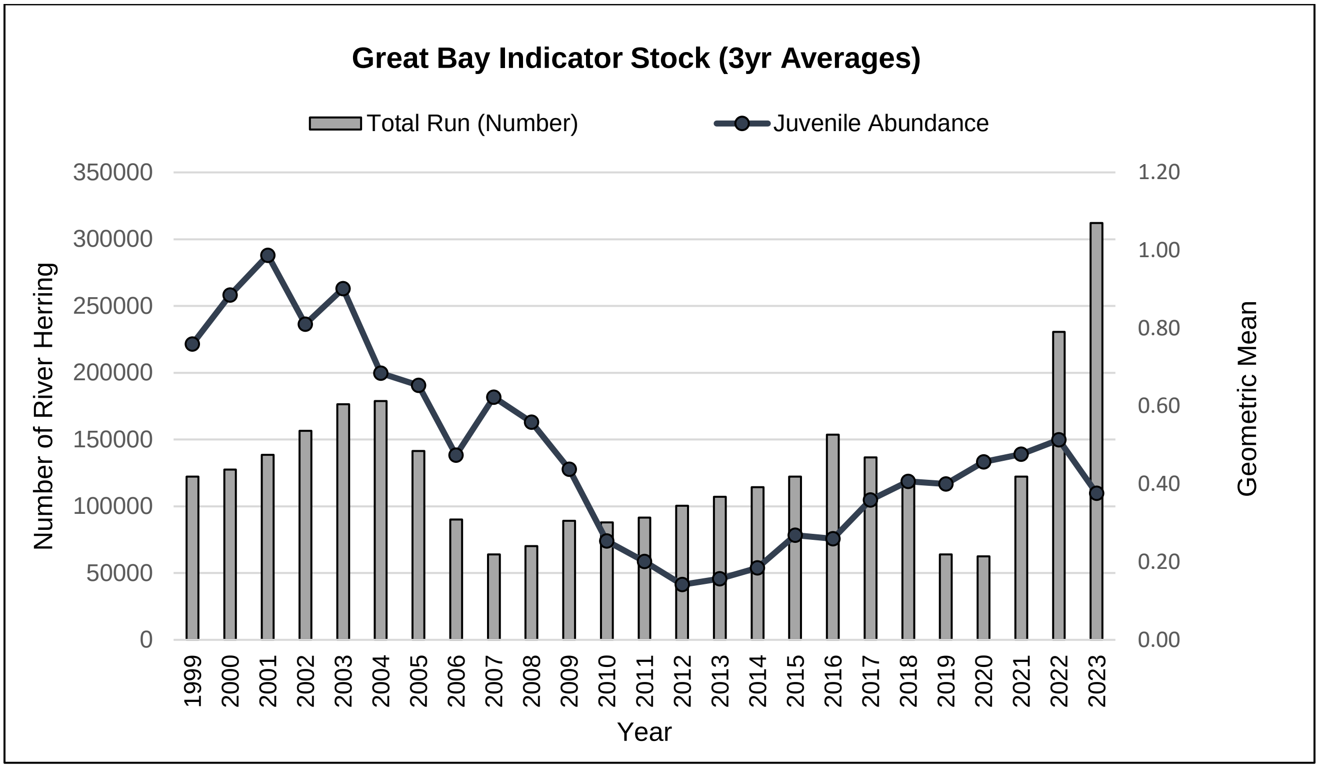


Figure 2. **Three-year running averages of the number of river herring returning in New Hampshire at 'Great Bay Indicator Stock' locations compared to the geometric mean catch per haul from the juvenile finfish seine survey conducted in the Great Bay Estuary between 1999 and 2023.**

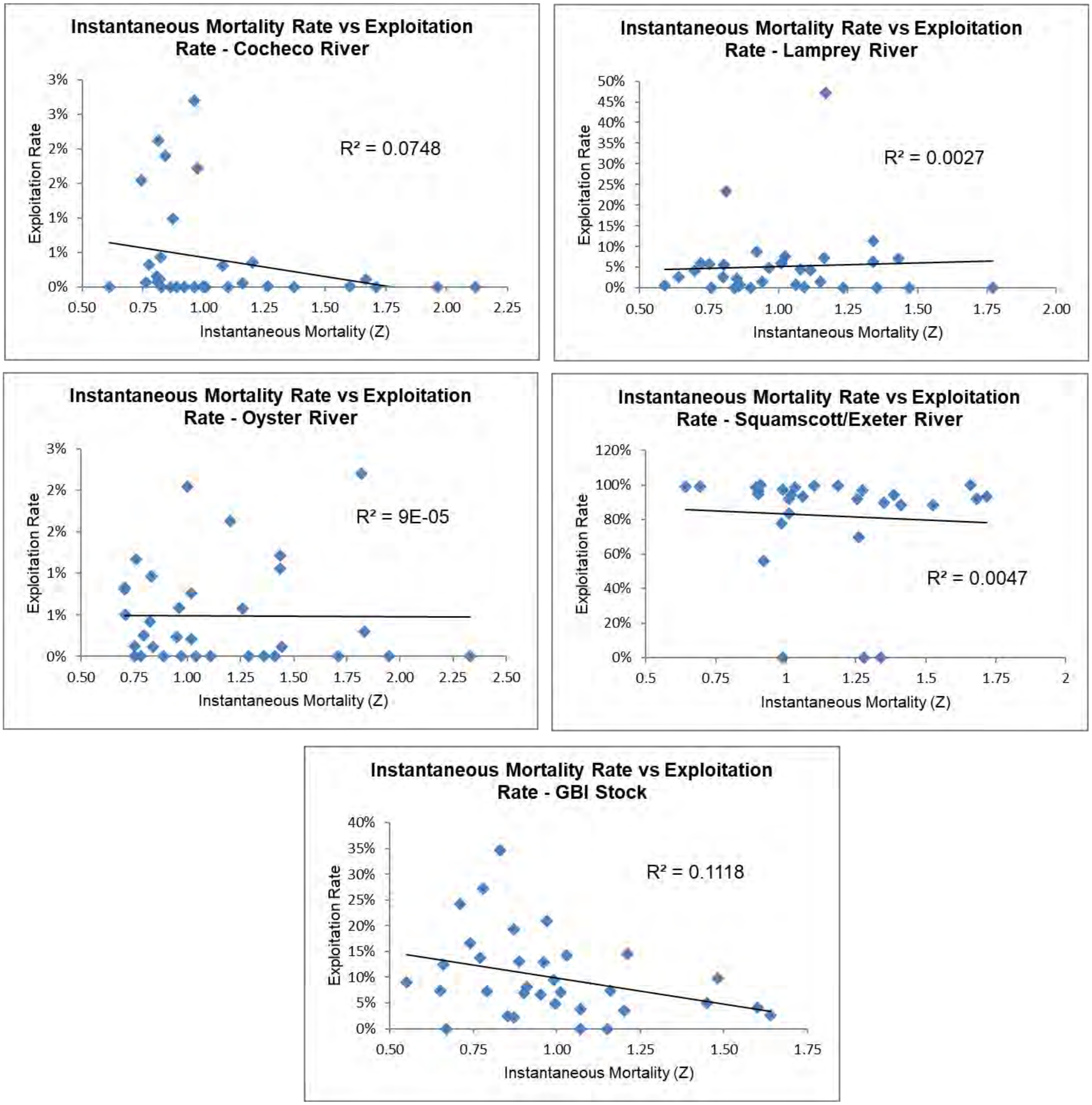


Figure 3. **Plots of instantaneous mortality rate against river herring exploitation rates for individual years, 1991-2023, with associated linear regression and coefficient of determination (R^2) values, for Great Bay Indicator Stock and individual location.**

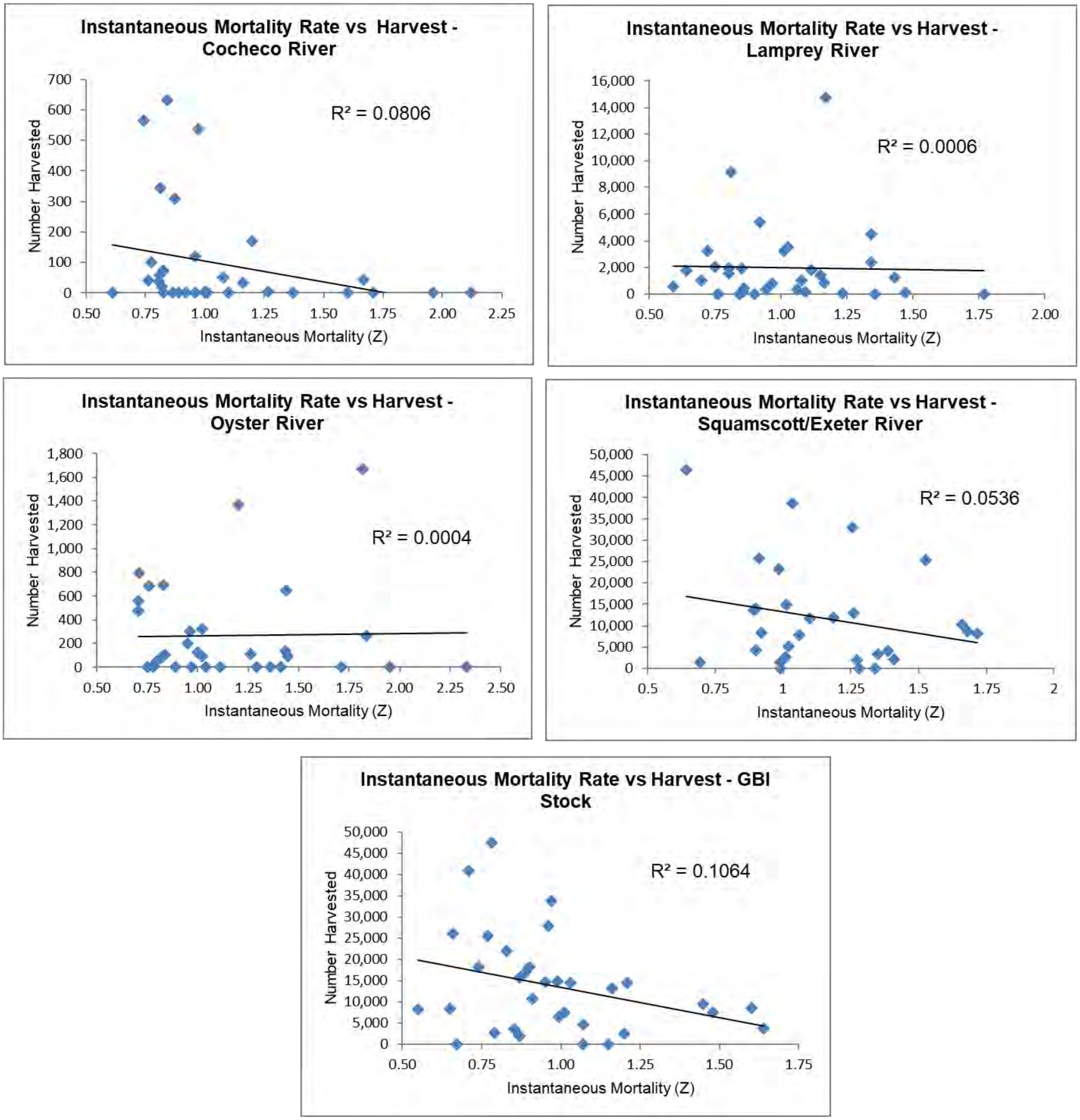


Figure 4. **Plots of instantaneous mortality rate against river herring harvest for individual years, 1991-2023, with associated linear regression and coefficient of determination (R^2) values, for Great Bay Indicator Stock and individual location.**

Maine River Herring Sustainable Fishery Management Plan

Draft Maine SFMP Update for ASMFC Review

Note: All confidential data has been removed from this SFMP update. There are no graphs provided that indicate landings or escapement for the existing commercial fisheries. As a result, sections of Appendix A will appear incomplete to protect individual harvesters' information. Because there is only one harvester per run in Maine's commercial river herring fisheries all graphs and tables have been removed. A full copy of the Maine SFMP update was provided to ASMFC to share with individuals who are approved to access Maine's confidential fisheries data.

Update Submitted by the Maine Department of Marine Resources to the Atlantic States Marine Fisheries Commission September 1, 2024

The draft 2024 Maine River Herring Sustainable Fisheries Management Plan update provided below contains information that by Maine state law needs to remain confidential. This information may only be used by the ASMFC River Herring and Shad Technical Committee members while evaluating the updated river herring management plan. This information may not be shared with any individual or group outside of this committee. The expectation that this information will remain confidential facilitates the State of Maine's ability to collect the best quality data available from individual fishermen for use in managing Maine's commercial river herring fisheries.

§6173. Confidentiality of statistics

1. Collection and reporting of statistics. The commissioner may, with the advice and consent of the advisory council, adopt rules to collect pertinent data with respect to the fisheries, including, but not limited to, information regarding the type and quantity of fishing gear used, catch by species in numbers of fish or weight, areas in which fishing was conducted, time of fishing, number of hauls and the estimated processing capacity of, and the actual processing capacity utilized by United States fish processors. The commissioner may collect statistics from any source and may require reporting of these statistics. The information collected by or reported to the commissioner is confidential and may not be disclosed in a manner or form that permits identification of any person or vessel, except when required by court order or when specifically permitted under this section. The commissioner may share data collected under this section with the National Marine Fisheries Service or successor organization for research or fisheries management purposes, provided that federal laws and regulations protect the confidentiality of the shared data. The commissioner shall adopt rules to carry out the purposes of this section. Rules adopted under this section are routine technical rules pursuant to Title 5, chapter 375, subchapter2-A.

Maine ASMFC River Herring Sustainable Fishing Plan Update 2024

1. Introduction

The purpose of the Maine Sustainable Fisheries Management Plan (SFMP) is to establish river herring management goals, objectives, and develop management actions that continue to support and expand existing river herring resources that provide forage for Maine's fish and wildlife and offer commercial fishing opportunities in Maine's coastal communities. The Maine Sustainable Fisheries Management Plan establishes population metrics to track and assess the health of Maine's commercial and noncommercial river herring populations. Population trend data from fishery dependent and fishery independent surveys provide information to develop a framework for the management actions used to make sound management decisions and ensure that Maine meets the goal and objectives of Amendment 2 to the Shad and River Herring Management Pan.

The State of Maine Department of Marine Resources (DMR) and municipalities that harvest alewife and blueback herring (Alosa aestivalis, Alosa pseudoharengus**)** collectively known as river herring, operate under state and federal site-specific management plans that guide the conservation and harvest of river herring resources. These plans promote and manage commercial and recreational river herring resources where they occur within the state. Maine formalized river herring management plan formats in 1950, though management plans and harvest agreements existed prior to this date.

Maine has 39 municipalities that are granted the exclusive right to commercially harvest river herring. In 2024, twenty-three municipalities actively harvest river herring (Table 1). Joint municipal fisheries, where one or more municipalities harvest the same resource, operate through cooperative agreements between municipalities bordering a shared waterbody. One example is Winnegance Lake in mid-coast Maine. Three municipalities, Bath, West Bath, and Phippsburg, which border the spawning habitat along Winnegance Lake share and coordinate harvest, reporting, and collect biological data from the single commercial harvest location.

The State of Maine, in accordance with state and ASMFC river herring management plans, conducts a review of all municipal river herring harvest requests on an annual basis. An annual review of municipal harvest requests includes analysis of existing commercial harvest practices, escapement, species composition, age structure, repeat spawning, and mortality estimates. Analysis of biological and run count data determines the level of commercial harvest or need for management action for populations that do not achieve SFMP metrics. The most common management actions are additional closed days for the fishery, additional pre-escapement before harvest can occur, gear modifications, or closing the fishery.

Directed commercial harvest of alewife or blueback herring does not occur in the mainstem of nine of Maine's largest rivers (Penobscot, Kennebec, Androscoggin, Saco, St. Croix, Presumpscot, Machias, Salmon Falls, and East Machias). Commercial fisheries do exist on the tributaries of larger rivers, for example, harvest is permitted on the Sebasticook River six miles above its confluence with the

Kennebec. These traditional conservation strategies provide alewife and blueback herring unrestricted access through large migratory corridors and allows access to spawning habitats upstream. To further conserve existing river herring populations in coastal waters this plan prohibits the use of all gear types for directed commercial fisheries for blueback herring or alewife in Maine's territorial waters (inside three miles) except for the permitted municipal fisheries **(Appendix B)**.

There are ongoing efforts to improve commercial and noncommercial runs that occur throughout historic spawning habitats within the state. Dam construction during the last two centuries isolated river herring from many of the inland waters DMR is trying to restore through alewife and blueback herring reintroductions. Due to dams without fish passage, the historical significance of anadromous fish to inland waters was eventually lost and freshwater fish communities, especially recreational game fish, began dominating these habitats.

In the 1980s, DMR began actively restoring access to historic spawning habitats for anadromous fish. To initiate restoration activities DMR must receive a permit from the Maine Department of Inland Fisheries and Wildlife (IFW) before stocking any state water with river herring. The reintroduction of river herring is not permitted into some historic spawning habitats based on perceived conflicts with rainbow smelt and recreational sport fish species including landlocked salmon. Establishing a baseline for reintroduction was important to inland fisheries managers that manage fishing opportunities for salmon, trout, and bass.

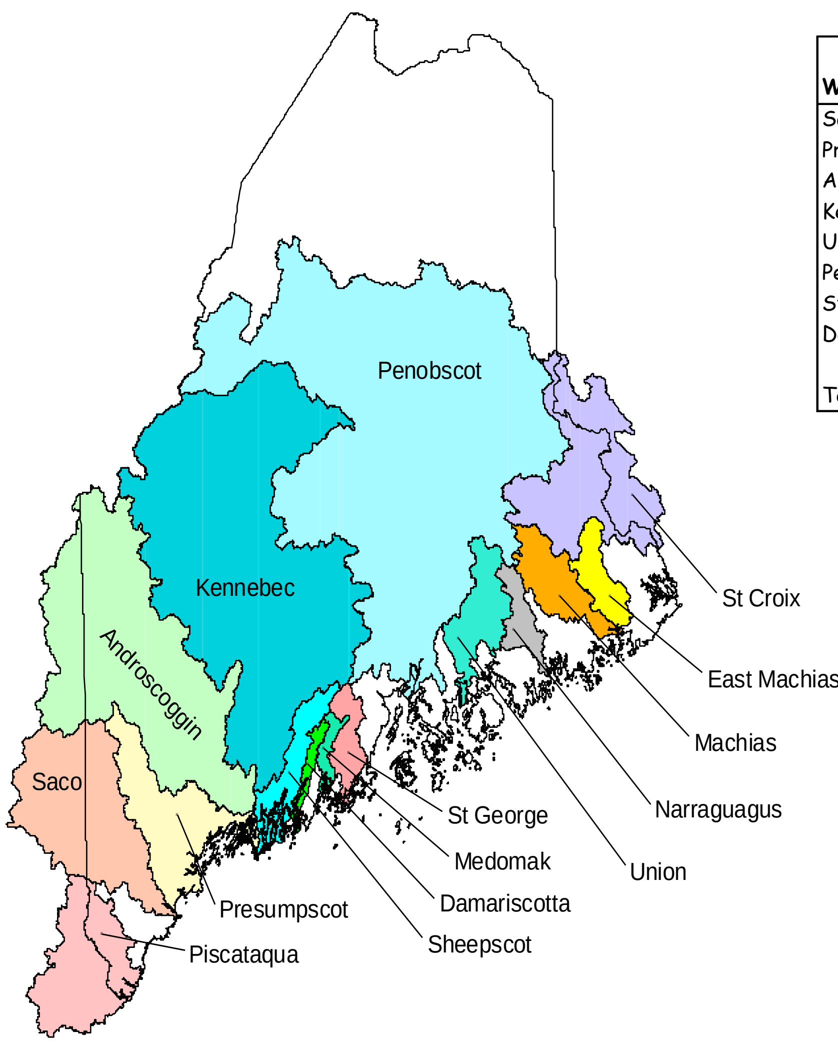
The State of Maine developed an interim restoration stocking target of six fish per surface acre for alewife stocked by truck into Maine's inland lake and pond habitats. State resources agencies established this stocking rate based on the results of a 10-year study (Lake George Report) conducted by DMR, Maine Department of Environmental Protection (DEP), and Maine Inland Fisheries and Wildlife (IFW) (Kircheis 2002). The goal of the study was to quantify the effects of a spawning population of alewife on the resident fish species and zooplankton communities within inland waters.

A stocking rate of six fish per surface acre of lake or pond habitat exhibited no negative effects on growth rates of resident freshwater fish species. Based on this study, and through an agreement reached between IFW and DMR, a stocking rate of six fish per acre is used for all truck-stocked restoration sites. River herring returns at the conclusion of restoration efforts are passed at a rate higher than six fish per acre. Returns post-restoration are passed at the rate that river herring return to the fishway and may be as high as several hundred fish per acre.

It is important to note that the experimental stocking rate for this study was arbitrary and the initial stocking density could be higher and still not demonstrate significant impacts to resident fish species, in fact it may show significant benefits. The potential alewife population based on historically available habitat and estimates of current production would exceed 54.5 million fish (Figure 1).

State legislation prohibits stocking river herring or providing passage into several waters within the state. Most often this is to address concerns regarding spread of non-native fish species, though in some cases it is targeted at preventing the expansion of river herring populations. Most commercial runs could expand if they were not constrained by permitting or fish passage restrictions unrelated to the commercial harvest. One example is the Androscoggin River, Maine's third largest River where only 1/3 of the historic spawning area is open to river herring restoration. A similar issue occurred on the St. Croix River when the Maine Legislature ordered modifications to the existing fishways to prevent river herring from ascending the river. In the 1980s', soon after the state closed these fishways, the St. Croix River river herring run declined from a population of 2.8 million returns to approximately 5,000. In 2013, the Maine Legislature reversed its decision and river herring were allowed to pass into a larger portion of the watershed beginning in 2014. The DMR continues to work with state, federal, and tribal resource agencies and NGOs to increase access to historic spawning habitats on the St. Croix River and other rivers statewide.

Figure 1. Estimates of potential alewife returns from historic alewife habitat by watershed (@235/fish/acre).



Watershed	Alewife Potential
Saco River	720,630
Presumpscot River	147,700
Androscoggin River	2,300,000
Kennebec River	11,143,086
Union River	2,000,000
Penobscot River	14,561,305
St Croix River	22,660,000
Damariscotta	1,034,000
Total	54,566,721

Commercial harvesters and supporters of river herring restoration efforts continue to advocate for increased passage for river herring. All municipalities that exercise commercial river herring fishing rights maintain and monitor up and downstream passage during the spring and fall. In 2008, commercial harvesters began collecting scale samples and biological data from their respective commercial catches to meet the data collection objectives and anticipated management actions resulting from Amendment 2. In municipalities which do not exercise their right to fish, river herring returns typically remain below expectations. In most cases, there is no local interest in providing/improving passage or monitoring these runs at the municipal level. However, this has changed in recent years with increased funding for fish passage and renewed local interest in restoring many locations with native sea-run fish species.

Table 1. Maine municipalities with directed commercial river herring fishing rights

Municipality	Fishery	Municipality	Fishery
Alna*	Long Pond	Meddybemphs	Meddybemphs Lake
Arrowsic*	Sewall Pond	Mount Desert	Somes Pond
Bath* Phippsburg* West Bath*	Winnegance Pond	Newcastle* Nobleboro*	Damariscotta Lake
Benton*	Sebasticook River	Orland*	Orland River
Boothbay Harbor	West Harbor Pond	Pembroke	Pennamaquan Lake
Breman	Webber Pond	Perry*	Boyden Lake
Bristol	Pemaquid Pond	Penobscot	Peirce Pond
Cherryfield*	Narraguagus River	Penobscot*	Wights Pond
Columbia Falls	Pleasant River	Phippsburg	Center Pond
Dresden*	Mill Pond	South Berwick	Salmon Falls River
East Machias*	Gardiner Lake	Steuben*	Tunk Lake
Ellsworth*	Union River	Sullivan*	Flanders Pond
Franklin*	Great Pond	Surry	Patten Pond
Gouldsboro*	West Bay Pond	Tremont	Sea Cove Pond
Hampden	Souadabscook Pond	Vassalboro*	Webber Pond
Jefferson*	Dyer-Long Pond	Waldoboro	Medomak River
Kennebunk	Alewife Pond	Warren*	St. George River
Lincolnville Northport	Pitcher Pond	West Bath	New Meadows Pond
		Woolwich*	Nequasset Lake

* Towns that currently harvest river herring

2. Current regulations

Commercial Fisheries

In Maine, the directed commercial fisheries for river herring occur through the state's municipal governments. State law permits the Commissioner of the Department of Marine Resources to grant exclusive river herring harvest rights to a municipality entitled to those rights prior to 1974. The State of

Maine requires municipalities with exclusive river herring harvest rights to file an annual notification that they wish to maintain exclusive fishing rights. Notification usually occurs through an annual town meeting or through a town ordnance giving town officials the authority to renew harvest rights on the behalf of the town. An annual harvest plan, provided by the municipality, is submitted to the Department of Marine Resources for review and approval for each municipal fishery prior to the fishing season. Most commercial harvest plans follow the model harvest plan provided below, while some plans have additional management requirements specific to an individual run. Each municipality restricts the number of harvesters to one individual who is responsible for harvesting fish under the municipality's harvest plan. All commercial fisheries have a 72-hour closed period or conservation equivalency to insure proper escapement into spawning habitat. Municipal fisheries that operate under conservation equivalencies are required to pass the minimum number of spawning river herring upstream based on habitat availability at the rate of 35 fish per surface acre of spawning and nursery habitat and/or provide additional escapement periods during the season.

Coastal intercept fisheries that historically harvested alewife and blueback herring using stop seines, gill nets and purse seines closed when the river herring moratorium began in January 2012. These fisheries harvested large numbers of spent and sub-adult alewife and blueback herring along the coast during the summer and fall seasons. Large quantities of fish, especially blueback herring, were harvested in numbers that indicate that these fish were likely not produced in Maine rivers.

Commercial Season

The annual river herring harvest begins when fish arrive at the harvest site, typically the last week of April, though many runs do not commence until the first week of May. The run timing of commercial catches is progressively later as you move eastward along the coast. The river herring season ends June 5th unless the municipality submits a request for a 10-day extension until June 15th. The DMR will award an extension if environmental conditions delay run timing during the season and river herring are not available to the commercial harvester during the regular fishing season. Weekly closed periods still apply, which effectively reduces the extension period to no more than seven and as few as five additional fishing days for the season. Most years the June 5th end date coincides with the start of the blueback herring run in Maine rivers, though in recent years blueback herring have arrived earlier in the season. At some locations commercial harvesters do capture blueback herring toward the end of the alewife season (Orland, Benton, Warren). Most commercial alewife harvest locations do not support blueback herring populations. In general, Maine rivers with blueback herring runs see spawning into the first week of July. Most commercial quantities of blueback herring are found in the mainstems of our large rivers and larger tributaries and are protected by time/area closures and gear restrictions.

Model Harvest Ordinance for the Harvest of River Herring

Towns are provided with a model harvest plan that may be used as a template for developing a harvest plan that is specific to their run and harvest location. Most municipalities conduct commercial harvest with a variation of a weir and trap which allows the harvester the ability to capture the entire run during a harvest day. The largest threat to harvest gear is high river/stream flows that can make it difficult to maintain a weir site under high flows and debris loads. During periods of high flow fishing gear may be removed from the stream or modified to prevent damage. River herring benefit under these conditions and may pass the harvest location without being captured. The model ordinance provided to the town contains the following requirements:

1) A minimum unobstructed opening of two feet (2') shall be maintained at all times between the riverbank and the downstream end of the weir.

2) The maximum mesh size of wire, twine, or other material used in the weir shall not exceed one inch by one inch (1" x 1").

3) There shall be a 72-hour weekly closed season on alewives from 6:00 a.m. Thursday morning until 6:00 a.m. the following Sunday morning. During the closed period, a minimum size unobstructed opening of three feet by three feet (3' x 3') shall be maintained in the upstream and downstream end of the trap to allow escapement of spawning river herring and other migratory fish.

4) Migratory fish such as salmon, shad, or other species except river herring that enter the trap shall be removed and allowed to pass upstream.

5) Fishing operations shall cease and all fishing gear obstructing the passage of fish shall be removed from the fishing waters not later than June 5. If late-run river herring enter the river, the town must seek written approval from the Department of Marine Resources to extend the season up to, but no later than, June 15.

6) The total landings in pounds or bushels and value of the catch shall be made available to the Maine Department of Marine Resources and/or National Marine Fisheries Service. Annual harvest reports are required by the State and must be submitted by August 1.

Additional Regulations for Streams with Atlantic Salmon Runs

1) The entrance to the dipping pen or trap shall be covered by bars, slats, or spacers with a maximum width of two inches (2") between said bars, slats or spacers.

2) Dipping of river herring shall be confined to the dipping pen or trap.

The U.S Fish and Wildlife Service lists Atlantic salmon as endangered in all Maine watersheds. There are no known conflicts with commercial river herring fisheries in the rivers where these fisheries currently exist. Siting locations of commercial river herring fisheries takes the presence of Atlantic salmon into consideration, with a goal of keeping migratory routes open for Atlantic salmon migration upstream. River herring may provide benefits to the Atlantic salmon smolts during emigration by increasing the numbers of forage fish within the system during smolt migration. The U.S. Fish and

Wildlife Service is currently testing the hypothesis that river herring provide a cover for migrating Atlantic salmon smolts, lessening predation on smolts during downstream migration to the sea.

Newly Enacted Legislation

The 124th Maine Legislature passed a law that creates a "Commercial Pelagic and Anadromous Fishing License and Establishes the Pelagic Fisheries Fund." The law requires mandatory reporting of all catch data within 60 days, tracks bycatch for river herring, and provides funding to conduct limited research **(Appendix B)**. This legislation tracks river herring bycatch statewide and helps identify fishing locations and gear types that have high incidence of river herring bycatch in coastal waters.

The 126th Maine Legislature passed a law opening up the St. Croix River to the passage of river herring. "*By May 1, 2013, the commissioner and the Commissioner of Inland Fisheries and Wildlife shall ensure that the fishways on the Woodland Dam and the Grand Falls Dam located on the St. Croix River are configured or operated in a manner that allows the unconstrained passage of river herring.*"

Recreational Fisheries

In Maine, limited opportunities exist for recreational river herring harvest in tidal and inland waters. Exclusive harvest rights to the most productive river herring waters are granted to the municipalities. Municipalities may choose to allow a recreational harvest, though most do not permit this activity. Current state law allows recreational anglers to take 25 fish per day for personal use during the open fishing days. A 72-hour weekly closed period prohibits recreational river herring harvest from 6:00 a.m. Thursday morning until 6:00 a.m. Sunday. The closed period allows a weekly migration window for river herring to access spawning habitat. Recreational anglers are restricted to using hook-and-line and dip nets to harvest river herring. Few locations in Maine permit recreational anglers to regularly catch 25 fish per day. Recreational harvest activities and gear types are permitted only in areas outside of a watershed and downstream of the municipal harvest location where exclusive rights are granted by the State. These restrictions are in place to prevent any harvest of fish allowed to escape the commercial fishery.

3. Brief Description - Current Status of the Stocks

The State of Maine manages individual river herring runs as separate stocks. These stocks have separate, well-defined spawning habitats, migration routes, and run timing that make them unique compared to similar runs throughout the state. Information on individual river herring runs is maintained by the State and collected through fishery independent and fishery dependent data collection. All commercial river herring fisheries are monitored through trends in commercial harvest, run counts, biological sampling, and analysis of scale data collected from the commercial catch. Noncommercial sites are monitored using run count data, biological sampling, and scale data where these data are collected.

River herring restoration activities continue to produce increasing numbers of adult returns to many Maine rivers. Restoration activities since 1999 have opened historic river herring habitats that were inaccessible for the last 150 years on two of the state's largest rivers. Multiple fishway construction and fishway replacement projects continue to support access to spawning habitat throughout the state. River herring returns to the Union, Penobscot, Damariscotta, Dennys, East Machias, Sebasticook, and Orland rivers and Pushaw and China lakes have all surpassed 1 million adult returns at least once since 2022, with three of these waters each returning 3-7 million adults.

The most recent peer reviewed coastwide analysis of river herring populations in the Northern New England (NNE) stock-region are provided in the approved 2024 ASMFC River Herring Benchmark Stock Assessment (ASMFC 2024). Analysis of these data were presented in the to the American Shad and River Herring Management Board on August 7, 2024, which accepted and endorsed the assessment. A summary of the results for the NNE stock-region is provided below:

For many of Maine's river herring populations stocks were categorized as stable or increasing. The ASMFC River Herring Stock Assessment Subcommittee (SASC) reviewed eight species-level time series in the NNE stock-region. ARIMA results indicated five of the six run counts had a greater than 50% chance of being higher than they were in 2009, indicating an improvement in these run counts compared to run counts prior to Amendment 2. These findings are supported by run count data collected at fishways in Maine where passage count data are recorded annually. In most cases, significant increases in returns have occurred over the past 15 years. (Appendix C). For the remaining species-specific run counts that the SASC investigated trends were classified as non-significant.

There were 11 rivers in the NNE region where run counts did not separate river herring species. Four of these run counts have continued through 2021 or 2022 while others terminated in early years. Of those with data through 2021 or 2022 (Androscoggin River, Kennebec River, Saco River, and St. Croix River), river herring abundance has increased over the last two decades with high probabilities in the terminal year of being greater than the 2009 reference point. (ASMFC 2024).

Analysis of Maine and New Hampshire fishery independent survey data from the Maine-New Hampshire Trawl Survey, Merrymeeting JAI Survey and New Hampshire Juvenile Finfish Seine Survey are trending upward. NNE alewife abundance indices included two juvenile abundance indices. The assessment indicated that the two NNE fishery independent JAI surveys are significantly positively correlated with a Rho > 0.5. Trends in ARIMA fits generally indicated increases in abundance for both adults and juveniles with a high probability of being greater than the Q25 and 2009 index based reference points. (ASMFC 2024).

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.

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. Mortality estimates for mature fish were only available from scale data for the NNE region.

There was a decreasing trend from the early 1990s until the mid-2000s, then there was an increase until around 2015 followed by a decrease in the final years of the time series. For the entire time series, average Z was 1.1/yr and ranged from 0.56/yr to 1.7/yr. For the 33 rivers that had Z estimates since the last assessment, 19 (or 57.6%) of them had a greater than 50% probability of exceeding the Z40%SPR reference point (ASMFC 2024).

Maine runs can reflect wide annual variation of Z estimates based on several factors related to the year-class strength, upstream and downstream passage, annual harvest, escapement, and bycatch in other fisheries. When assessing Maine's commercial fisheries, mortality estimates are considered in conjunction with annual and 3-year average run counts, age structure, species composition, repeat spawning ratios, and environmental conditions to achieve harvest rates that support Maine SFMP metrics and create a basis for implementing sound management actions.

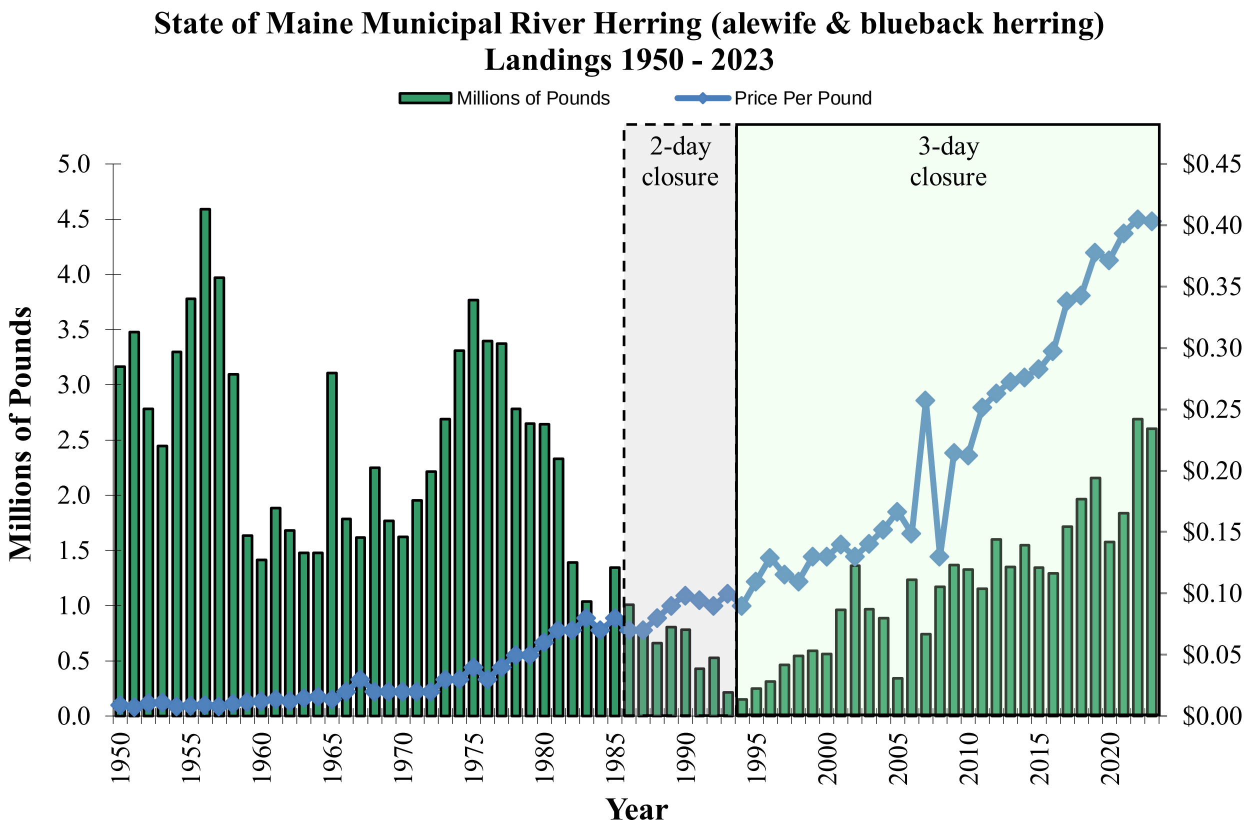
Most noncommercial runs are stable at low levels, except where active restoration efforts are improving run size. Many noncommercial runs are small by nature and experience passage issues that limit reproduction and run size. Despite commercial closure, many of these runs maintain comparatively small populations to some larger runs in Maine. Improving upstream and downstream passage and stocking efforts to rebuild these runs could enable these habitats to produce excess fish for commercial harvest in the future. At locations where significant restoration projects have occurred during the past 10 years river herring numbers have increased significantly, resulting in river herring runs of more than 1-million fish in several rivers.

a. Landings

The State of Maine requires mandatory reporting of municipal landings by August 1st of each year. Trend analysis indicates an increasing trend in state landings for the period 1981 to 2023 (Figure 2). The Department of Marine Resources also tracks annual landings through time to observe trends by stock. Total and stock specific annual landings data is becoming less dependable as a metric to assess the health of commercial runs due to changes in harvest activity. An increasing number of municipal harvesters are choosing to harvest for personal use or limited retail sale and not fully exploiting the available population as has occurred historically. Exact escapement numbers are unknown in most Maine river herring fisheries and are estimated using a ratio of closed days and reported commercial landings. Population level estimates of escapement and total run size using commercial landings are the best estimators of population size for most of Maine's commercial runs. However, reduced commercial harvest may result in a substantially lower estimate of escapement and total run size when runs are not actively harvested. To address this issue the Maine DMR is conducting total escapement counts on some runs where limited harvest is known to exist.

Estimates of annual commercial escapement calculated using fishery independent data as a proxy for commercial runs can range from 15 – 80 percent. To ground truth estimates of escapement to actual escapement, runs where daily counts were conducted were used as a proxy for commercial fisheries. The ratio of the number fish passed on closed days, when commercial fisheries were not allowed, was compared to open days when commercial fisheries were allowed. These data indicate that consecutive closed days during the week can achieve a mean escapement rate approximating 42.8 percent of the annual run. The daily counts at the Sebasticook River fishway indicate escapement similar to those observed at Brunswick. The escapement rate at the Sebasticook River fishway was 45 percent based on the numbers of fish passed upstream on fishing days vs non-fishing days. Counts were also collected at the Weber Pond fishway where an active harvest exists and the numbers of fish that pass into the pond are counted daily. These data indicate that escapement may exceed the target escapement of 42.8 percent of the run. Fisheries staff bases these estimates on upstream passage at fishery independent and fishery dependent locations where actual counts provide total escapement numbers by day.

Figure 2. State of Maine river landings 1950 – 2023.

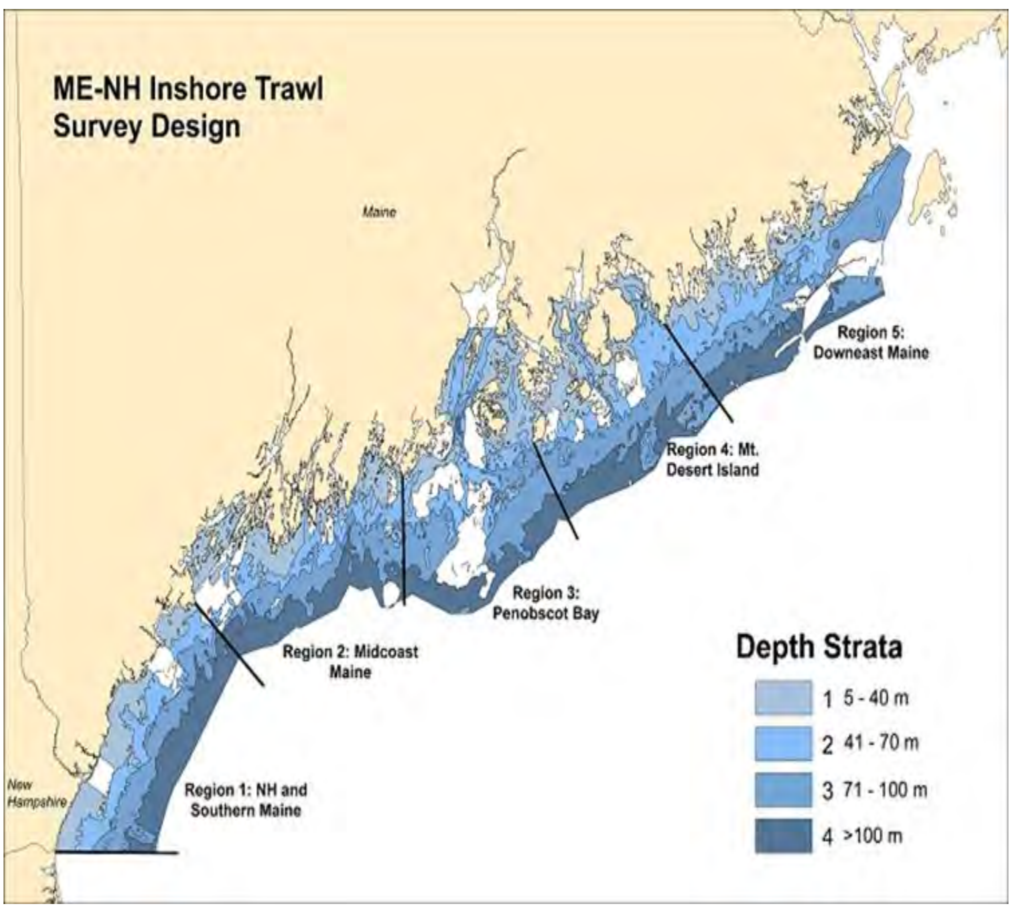


b. Fishery Independent and Fishery Dependent Indices

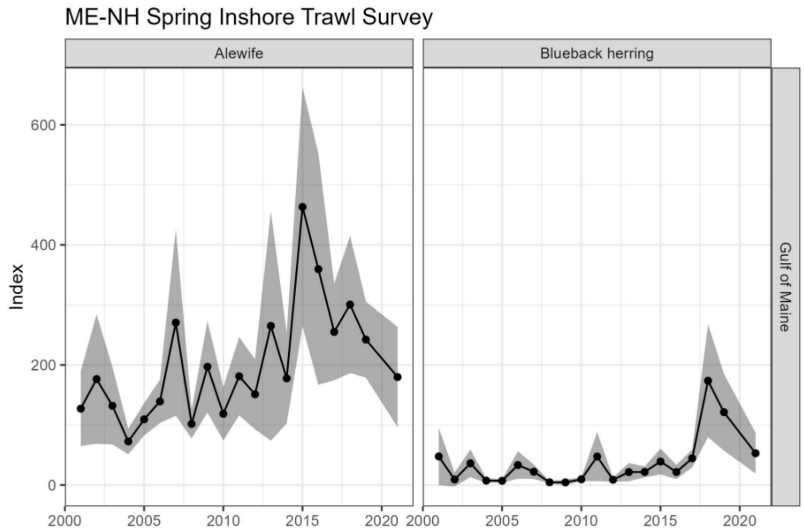
Both fishery independent and fishery dependent data are available to provide relative measures of river herring run health and condition. Most fishery independent data come from the Maine-New Hampshire Trawl Survey, River Herring JAI Beach Seine Survey, fishway counts, or volunteer fish counts on rivers without commercial fisheries. Fishery dependent data originate from the commercial catches and run counts on commercial rivers. Analysis of harvest data alone may not be the best way to determine the health of all stock specific runs throughout the state due to recent changes in how some commercial harvesters conduct individual fisheries. Fewer harvesters are electing to fully exploit existing harvest days and gear types to maximize harvest for commercial sale. Increasing numbers of harvesters are harvesting for personal use to meet their existing need for bait in the lobster fishery. This allows an individual harvester a guaranteed source of bait without the need to be present at the harvest site through the duration of the harvest season. Harvesters simply elect to open the trap or remove the gear and allow fish to pass upstream even though they are legally permitted to harvest fish.

Maine-NH Trawl Survey:

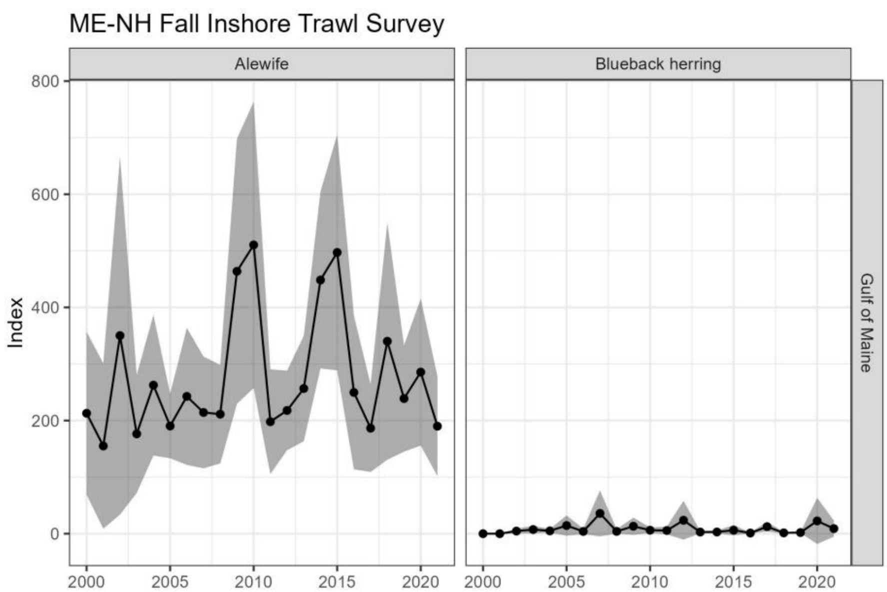
The Maine-New Hampshire inshore trawl survey takes place during spring and fall in five regions and four depth strata along the coast of Maine and New Hampshire. The survey was initiated in the fall of 2000, with the fourth depth strata added in 2003. Regions are based on geologic, oceanographic, geographic and biologic factors and divided into four depth strata: 5–20, 21–35, 36–55, and 55+ fathoms. Stations are selected randomly to reflect representative conditions within each of the strata, with a target level of 120 stations per season. Sample gear consists of a modified shrimp net with 2-inch mesh in the wings and a 1-inch mesh liner in the cod end. Foot rope and head ropes are 57' and 70' respectively, with 6-inch rubber cookies. Indices were developed separately for each season for each species.



Indices of abundance from the ME-NH Inshore Trawl Survey for the spring.



Indices of abundance from the ME-NH Inshore Trawl Survey for the fall.

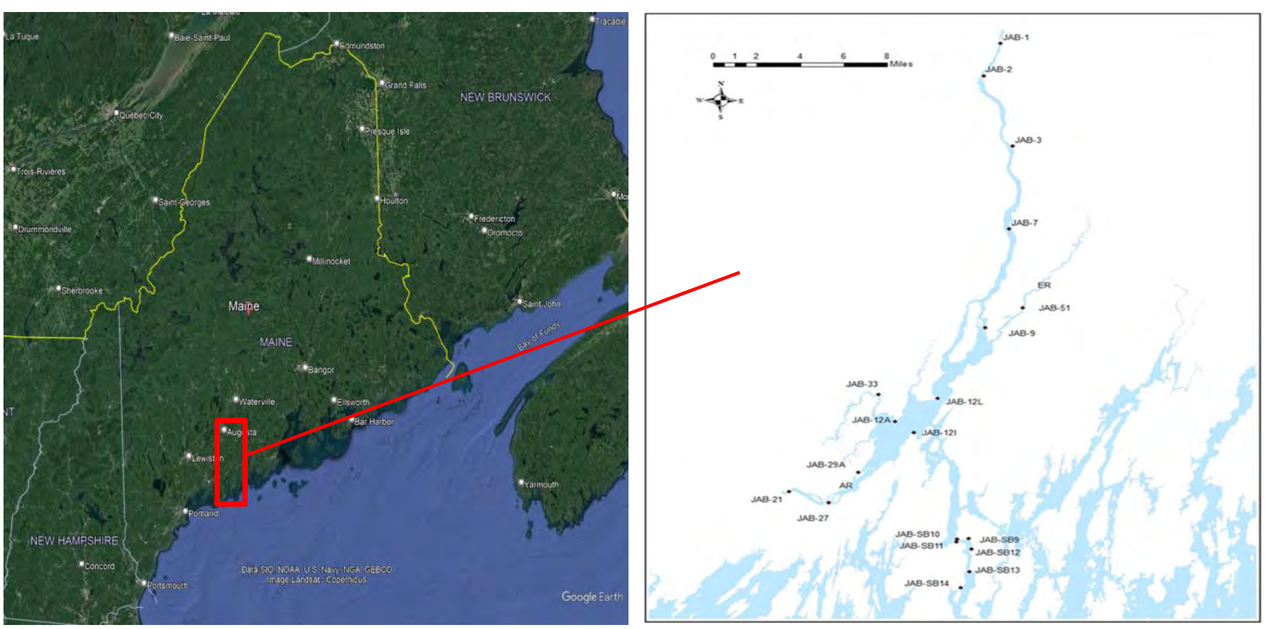


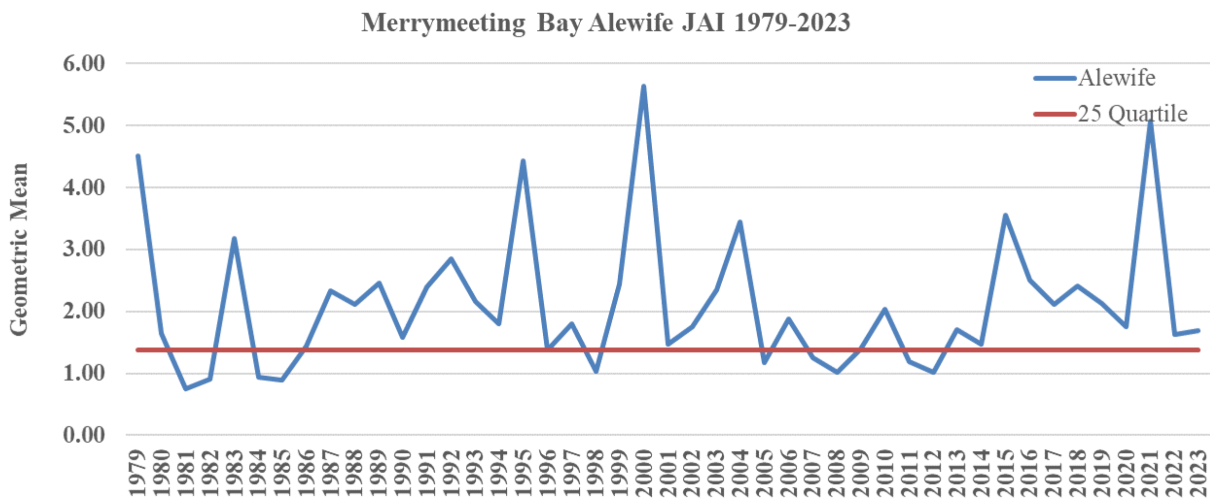
Results from the analysis of the Maine-New Hampshire Trawl Survey data were included in the 2024 ASMFC River Assessment along with additional regional indices of juvenile abundance. The assessment report presented to the Management Board indicated the following results: For alewife, in the NNE stock-region, both young-of-year indices had a greater than 50% chance of being higher than they were in 2009. 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.

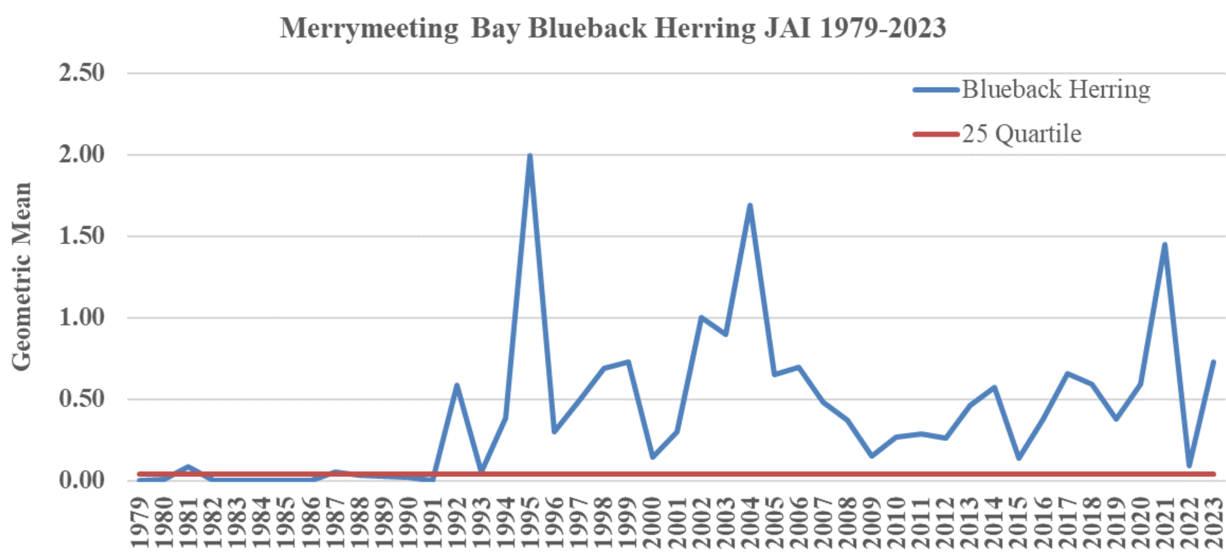
Juvenile Abundance Index:

The JAI survey monitors the abundance of juvenile river herring and American shad in the Merrymeeting Bay river complex in mid-coast Maine. The survey began in 1979, covering 17 fixed stations as well as data from a separate juvenile striped bass survey designed to assess the numbers of juvenile striped bass in the lower Kennebec River. The juvenile abundance survey for the Kennebec/Androscoggin estuary monitors the abundance of juvenile alosines at 14 permanent sampling sites. Four sites are on the upper Kennebec River, three on the Androscoggin River, four on Merrymeeting Bay, one each on the Cathance, Abadagasset, and Eastern Rivers. These sites are in the tidal freshwater portion of the estuary. Since 1994, DMR added six additional sites in the lower salinity-stratified portion of the Kennebec River. A total of 120 samples are collected during the sample season. The sample data is used to calculate the geometric and arithmetic means, SE and confidence intervals for alewife, blueback herring, and American shad.

The sampling protocol for all stations is similar to that used in the juvenile shad-sampling program on the Connecticut River. Field staff sample each site once every other week from July to the end of September. The goal is to sample each site six times during the season. Field staff collects samples with a beach seine within three hours of high slack water. The seine is made of 6.35 mm stretch mesh nylon, measures 17 m long and 1.8 m deep with a 1.8 m x 1.8 m bag at its center. One person holds an end of the seine stationary at the land/water interface, and the boat operator tows the opposite end perpendicular to shore. After the net fully extends, the boat operator tows the seine in an upriver arc and pulls the net ashore. The net samples an area of approximately 220 m^2.







The 2024 River Herring Assessment used the Merrymeeting Bay beach seine survey data as an index of juvenile abundance for alewife and blueback herring in NNE Stock-Region. The draft assessment included the following results.

A young-of-year index from the Maine Merrymeeting Bay Juvenile Alosine survey was available for 1982-2021. Although the index was variable from year to year, there was an increasing trend in the alewife YOY index over the time series and over the 2009-2021 time period, according to the Mann-Kendall test. The alewife YOY index in 2021 had a 97% probability of being above the 25th percentile of the time series, and an 83% probability of being above the 2009 value.

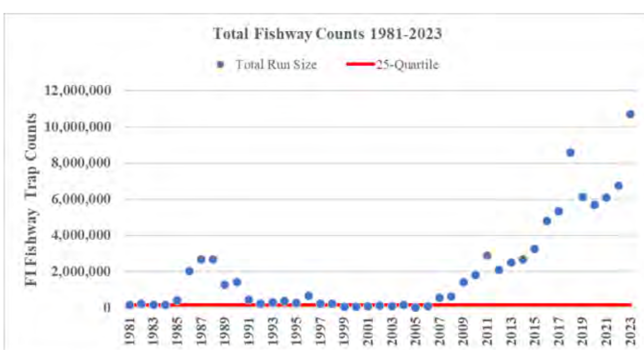
An ARIMA model was fit to only one juvenile blueback herring survey in the CAN-NNE region (ME Merrymeeting Bay Juvenile Alosine Survey). This survey showed a general increasing trend in abundance from the 1980s through mid-2000s, followed by a decrease to 2010, but another increase back to levels observed in the mid-2000s (ASMFC 2024).

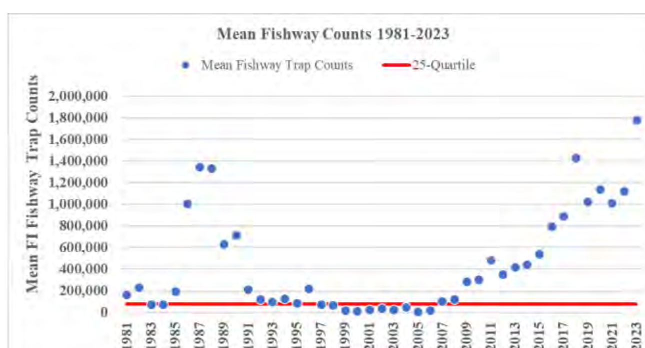
Fishway/Run Counts:

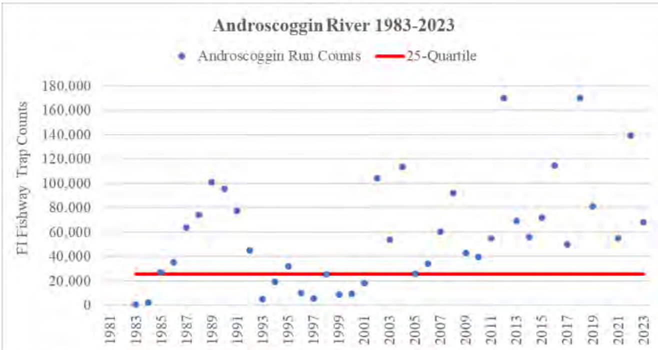
At locations with fishways, annual run data are collected to monitor upstream passage and determine spawning escapement at locations that provide passage into spawning habitats. The Saco, Androscoggin, Damariscotta, Union, Penobscot, Sebasticook and St. Croix rivers provide the most consistent sources of count data, though many other locations conduct passage counts at various levels depending on location, staffing, and environmental conditions. The time series length and counting methods vary by site. The counts of river herring runs in Maine fall under two categories: total counts and subsampled counts. Total counts occur at locations where the state maintains electronic tube counters or trapping facilities that make electronic or hand counting the total population possible. Most volunteer or community counts use the VisuCount software and count protocol to determine total run counts and associated confidence intervals. The VisuCount system works well for volunteer groups and is adaptable to staffing and funding constraints. Some locations use standardized 10-minute counts at the beginning of each hour from 7:00 a.m. to 7:00 p.m. throughout the duration of the river herring run. The methods used to collect volunteer run count data have not changed since 2010. However, there is an effort to standardize all volunteer counting methods using the VisuCount program identified by ASMFC as the best existing counting platform for organized volunteer groups that count river herring.

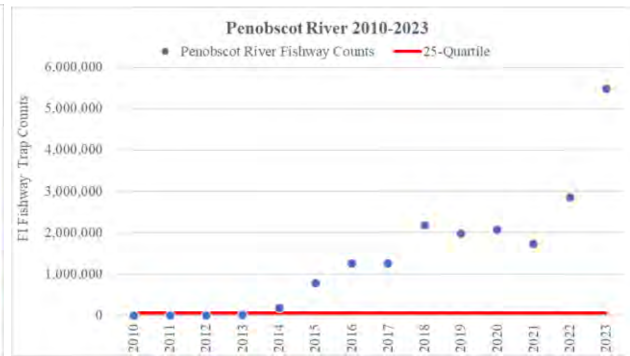
Fishery Independent Management Triggers for Recreational River Herring Harvest

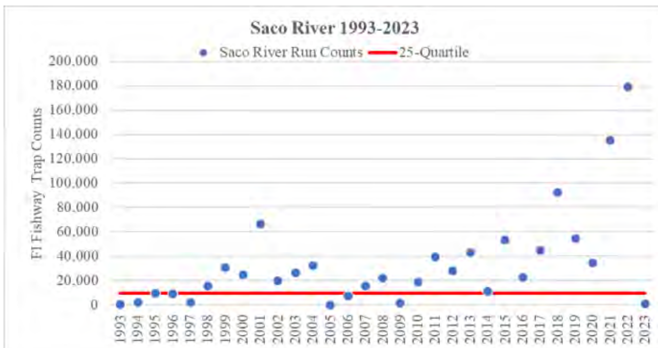
Fishway	25-Percentile
Saco River	9,491
Androscoggin River	25,682
Kennebec River	68,744
Penobscot River	56,390
St. Croix River	20,900
Fishway Totals	169,620
Fishway Mean	76,636

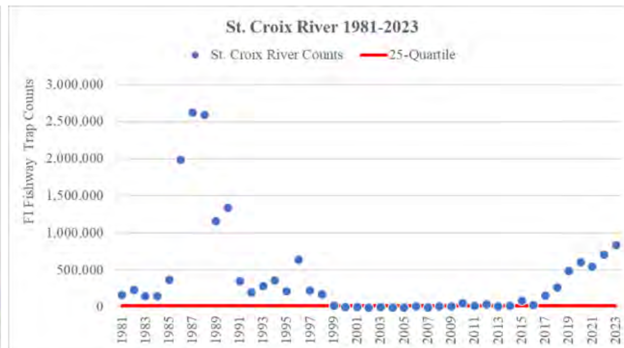


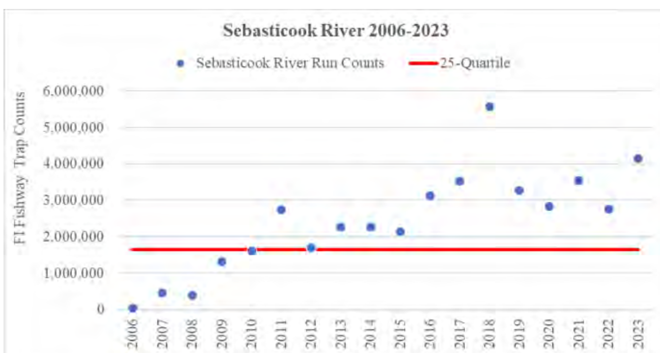






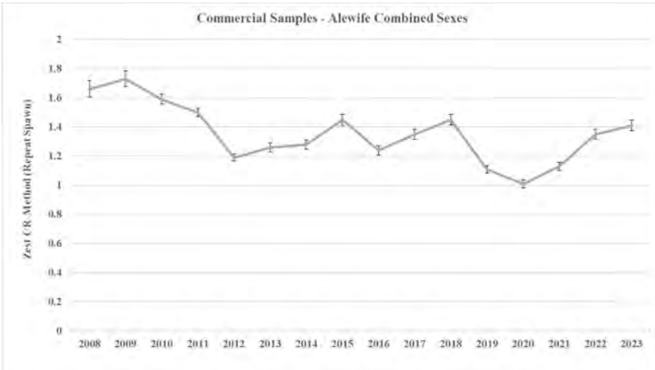


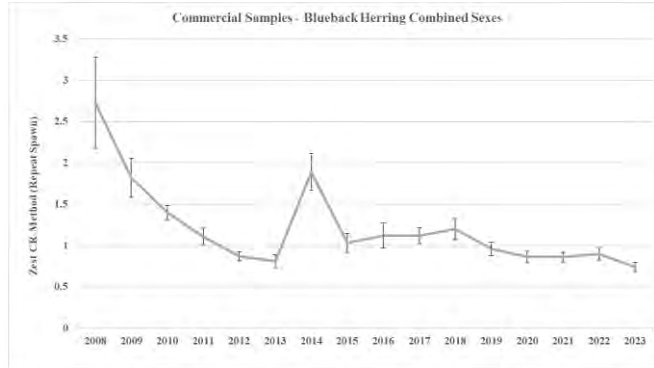


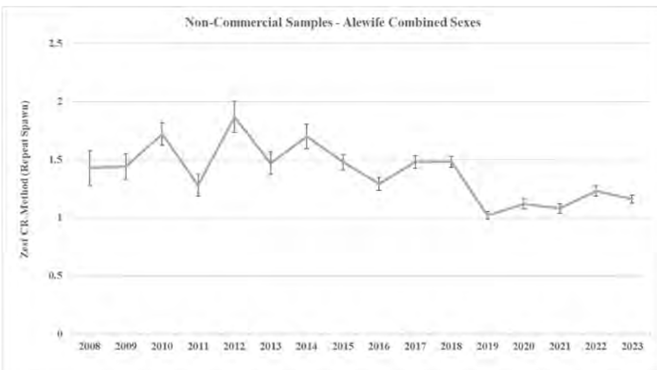


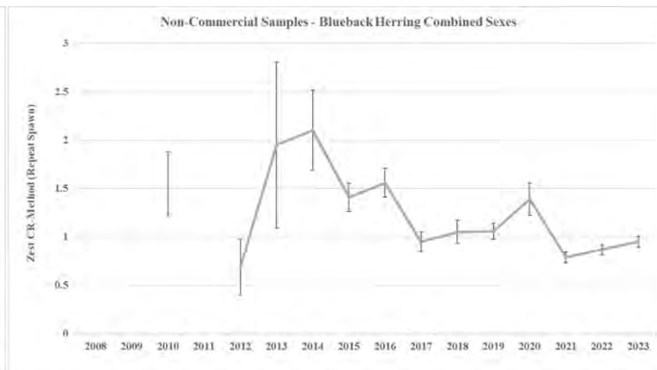
Harvester Data:

Commercial harvesters collect fishery dependent river herring data as part of their permitted harvesting activities. Harvesters collect scale samples weekly from their commercial catches and DMR analyzes the scales to determine species, age, mortality, and repeat spawning history. Scales are used to calculate mortality estimates based on age and repeat spawning marks. Scale samples are also collected from several fishery independent locations during the annual river herring run. The total number of samples collected varies annually, but ranges between 4,200 and 5,500 samples a year. Scale data time series vary, with the most consistent sampling occurring since 2008.









c. Current Habitat Restoration Efforts

Coordinated restoration of historical river herring habitat throughout Maine has been the focus of the Bureau of Sea-Run fisheries since the early 1970s', though this has been an ongoing process since the first dams were built in the mid-18th century. Historical archives demonstrate the importance of diadromous fish and fisheries as a food source and regional/global commodity. Early inhabitants petitioned the governor and state legislature to require mill dam owners to install fish passage for migratory fish. Early attempts to provide passage were met with limited success and were a precursor to a suite of significant environmental and industrial processes that reduced diadromous fish populations along the Maine coast for decades.

The Clean Water Act, passed in 1972, helped address water quality issues in Maine's large industrial rivers. Though still impacted by water quality issues, rivers were becoming less polluted and improvements in fish passage technology helped pass those few fish that were returning to Maine rivers. One of the biggest impacts on recovery of river herring in Maine was the removal of the Edwards Dam on the Kennebec River at the head-of -tide in Augusta. The removal of Edwards Dam is notable on a national level because it was the first time FERC refused to relicense an operating hydro-electric dam. This decision set in place the ultimate removal of the dam and reopened over 100-miles of habitat for diadromous fish.

Similar success was achieved on the Penobscot River with the removal of two mainstem dams and construction of a bypass around the Howland Dam. The benefits of the Penobscot River restoration projects significantly increased the number of American shad, alewife and blueback herring in the watershed. These projects demonstrated the ability to successfully restore diadromous fish to the landscape when restoration projects are properly planned and supported. The success of the Kennebec and Penobscot river restoration projects have helped to increase the number of restoration sites that were proposed and are now moving forward.

In 2023, Maine submitted $150 million in requests for 80 projects to restore 1,000 miles of sea-run fish habitat. Between 2021 and 2023, the Federal Highway Administration awarded $35M for 27 culvert upgrades to open over 100 miles of stream/river and 7,500 pond/lake acres of sea-run fish habitats. NOAA, USFWS, and NFWF awarded the Maine Department of Marine Resources (DMR) $22 million to build new fishways on the St. Croix River to improve passage to 680 miles of sea-run fish habitat and 68,000 pond/lake acres of sea-run fish habitat. The National Fish and Wildlife Foundation and USFWS awarded DMR $5.3 million to remove dams and build new fishways on the Sabattus River to open 75 miles and 2,400 pond/lake acres of sea-run fish habitat. These projects will have a significant impact on future returns and help support continued recovery of diadromous fish in Maine.

4. Fisheries to Remain Open

Municipality	Fishery	Municipality	Fishery
Alna	Long Pond	Jefferson	Dyer-Long Pond
Bath Phippsburg West Bath	Winnegance Lake*	Newcastle Nobleboro	Damariscotta Lake*
		Orland	Orland River
Benton	Sebasticook River	Perry	Boyden Lake
Cherryfield	Narraguagus River	Sullivan	Flanders Pond
Dresden	Mill Pond	Steuben	Tunk Lake
East Machias	Gardner Lake	Mount Desert	Somes, Long ponds
Ellsworth	Union River	Vassalboro	Webber Pond
Franklin	Great Pond, Card Mill	Warren	St. George River
Gouldsboro	West Bay Pond	Woolwich	Nequasset Lake

* Shared fishery among the municipalities listed

Proposed fisheries for addition in 2024

Proposed Fisheries for Addition in 2024

Arrowsic	Sewall Pond
Bradley	Chemo Pond
Glenburn	Pushaw Lake
Pembroke	Pennamaquan River
Penobscot	Wights Pond

Commercial Justifications for the Municipal Fisheries Listed Above:
In the commercial landings graphs provided below, years with extremely low landings or zero landings for one or more years indicate that fishing during that year did not occur or occurred at very low levels. Two main reasons for zero landings are 1) the municipality decided to close the fishery for conservation or other purposes or 2) the harvester fished for a limited number of days due to weather, gear, price, or other factors that created unfavorable market conditions. In 2005, extreme high water prevented many commercial fishermen from conducting normal fishing operations during the season. The result was a major decline in reported statewide landings for 2005. Biological data by river for most river systems, other than commercial harvest data, are generally unavailable for years prior to 2008 except for locations where specific short-term scientific studies occurred. The State of Maine and commercial harvesters began collecting run specific data in 2008 to address concerns presented in ASMFC Amendment 2 to the Shad and River Herring Management Plan.

The sustainability threshold established in 1984 for most Maine commercial fisheries is 35 fish per surface acre of spawning habitat. Since 1984, MDMR has used 235 fish/acre to estimate commercial alewife production in Maine's lakes and ponds. The Department established this unit production value from the commercial harvest in six Maine watersheds for the years 1971-1983. Based on these data, commercial yield was assumed to be 100 pounds/surface acre of ponded habitat. This value is slightly less than the average of the lowest yield/acre for all six rivers and within the range of yields experienced in other watersheds. Assuming a weight of 0.5 pounds per adult, the commercial yield equals 200 adults/surface acre. The commercial harvest was assumed to represent an exploitation rate of 85%, because most alewife runs were harvested six days per week. Exploitation rates on the Damariscotta River, for example, ranged from 85-97% for the years 1979-1982. When commercial yield is adjusted for the 15% escapement rate, the total production is 235 adult alewives/acre. This is a conservative estimate of the numbers of returns based on an average individual weight value of .5 pounds per return, including blueback herring.

The Maine Department of Marine Resources estimates escapement for commercial runs where actual counts are not conducted. The estimate is calculated by dividing the number of fishing days allowed by the potential number of fishing days in a week then multiplying by the reported landings for the year. For most fisheries this will be 0.43 * number of fish reported landed for the season.

Fishery Specific Information

a. Commercial

See Appendix A

b. Recreational

Municipalities which maintain historic harvest rights control access to most of the river herring resources within the state. Municipalities maintain this control through exclusive harvest rights granted by the Commissioner of the Maine Department of Marine Resources. All locations inhabited by river herring and managed by a state/municipal harvest plan, are open to recreational harvest if the municipal harvest plan permits recreational harvest. All recreational harvest must occur below the commercial fishing location and within the municipality that maintains their river herring harvest rights. The number of river herring allowed for personal use is 25 river herring per person per day with associated gear restrictions (hook and line, dip net) down from 120 fish per day allowed prior to 2012.

Most municipalities choose to keep recreational river herring fisheries closed. Municipalities that choose to keep the recreational fishing closed can do so through the municipal harvest plan. Closing the recreational harvest prevents recreational harvest at any location within the municipal boundaries or in the watershed above the municipality that maintains harvest rights.

All locations statewide, outside and below locations controlled by the state's municipal fisheries, will remain open to recreational fishing. A limited recreational catch/possession limit of 25 fish per person per day and gear restrictions will apply along with a statewide closed period to allow escapement of spawning fish. The statewide closed period for recreational fisheries runs from 6:00 a.m. Thursday to 6:00 a.m. Sunday each week.

Recreational catches of river herring are typically used as bait to catch striped bass, halibut or smoked and used as food. The State of Maine relies on the MRIP program to collect catch statistics for the recreational catches of blueback herring and alewife.

5. Fisheries Requested to be Closed (if more specific than statewide)

a. Commercial

The state will close, or keep closed, one or more waters in the towns listed below to the harvest of river herring until these runs can meet minimum state sustainability requirements and are approved by the

ASMFC River Herring Management Board. Prior to Amendment 2 commercial fisheries occurred in all the municipalities listed below. Some of these runs are currently under restoration (*), while others return viable numbers of fish without supplemental stocking and may support a small harvest in the future. Most of these runs have passage problems that prevent the current population from increasing to commercially viable harvest numbers. Returns to these rivers range from 15,500 to 1,139,000 individuals based on actual counts in Surry and Meddybemphs in 2024. All waters in the state of Maine that are not expressly approved by ASMFC will remain closed to the directed harvest of river herring.

Municipality	Municipality	Municipality
*Breman	Cape Elizabeth	Boothbay Harbor
Kennebunk	*Phippsburg (Center Pond)	Lincolnville
*Bristol	Northport	South Berwick
*Surry	*Waldoboro	West Bath (New Medows)
Bath (Weskeag)	Hampden	*Penobscot (Pierce Pond)
Meddybemphs	Tremont	

b. Recreational

All locations controlled by municipal fisheries will remain closed to recreational fishing unless expressly opened within the municipal harvest plan. Any recreational harvest must occur below the commercial fishing location if there is an active commercial fishery. This requirement is in effect to protect any river herring escaping the commercial fishery from being harvested upstream. This includes the watershed or sub-watersheds within the drainage above the municipality. A limited recreational catch/possession limit of 25 fish per person per day, gear restrictions, and closed days will apply.

All locations statewide outside and below locations controlled by municipal fisheries will remain open to recreational fishing. A limited recreational catch/possession limit of 25 fish per person per day, gear restrictions, and closed days will apply.

c. Incidental

Incidental catch of river herring may occur in small mesh trawl fisheries, weir, bait gill net, and seine fisheries for other species. There is mandatory catch/bycatch reporting for all of these fisheries. Based on Vessel Trip Reports (VTR) and Dealer Reports (DR), bycatch in state waters appears to be low. An existing law requires all commercial fishermen who fish for pelagic or anadromous species to purchase the "Pelagic and Anadromous Commercial Fishing License" and requires mandatory reporting of river herring landings. **(Appendix B)**

6. Sustainability Targets/Threshold

Sustainability Definition – The number of alewife broodstock needed per surface area of spawning habitat in Maine to provide alewife populations capable of sustaining annual alewife runs at current levels while providing surplus broodstock for harvest or increasing run size in the future.

The Maine sustainability threshold established an escapement number equal to 35-fish per surface acre of spawning habitat which commercial fisheries must meet to retain commercial fisheries status or close until populations rebuild to meet sustainability metrics. This number is used as the minimum or threshold value that commercial river herring fisheries may not fall below and continue to fish. This metric represents the minimum escapement number used historically to provide commercial quantities of river herring for sustainable harvest and provides a basis from which managers feel the stock can recover if populations decline. However, the State of Maine requires three consecutive closed fishing days, or a conservation equivalent, which was developed to ensure that populations do not approach this minimum threshold value. This plan will achieve escapement numbers through passage counts above commercial fisheries, closed fishing days, season length, gear restrictions or continuous escapement.

An escapement level of six fish per surface acre is used by the Department to provide broodstock for initial introductions of anadromous alewife in Maine lakes and ponds under restoration. This number was developed as the result of a 10-year study researching the effects of alewife introductions into freshwater habitats. Initial introductory, or restoration stocking, can produce runs that may far exceed six fish per acre depending on passage and habitat. The six fish per acre escapement number has demonstrated that it can grow to provide significant run response in a relatively short amount of time given passage and habitat requirements are supportive of alewife and blueback life history. River herring restoration projects started on both the Penobscot and Sebasticook rivers using the six-fish-per-acre each return more than 5-million fish annually as of 2024. Commercial and recreational fisheries are not permitted at locations where the six fish per acre restoration value is actively used to restore river herring populations.

Method Used to Develop Spawning Threshold

The minimum sustainability threshold of 35-fish per acre of spawning habitat is the result of a combination of studies, observations, and documented commercial catches over several years. Maine uses this minimum sustainability threshold for commercial fisheries that are required to provide escapement of river herring broodstock from river/lake/pond specific populations.

Since 1984, DMR has used 235 fish/acre to estimate commercial alewife production in Maine's lakes and ponds. The Department established this production value from the commercial harvest in six Maine watersheds for the years 1971-1983. Based on these data, commercial yield was calculated to be 100 pounds/surface acre of ponded habitat. This value is slightly less than the average of the lowest yield/acre for all six rivers and within the range of yields experienced in other watersheds. Assuming a weight of 0.5 pounds per adult, the commercial yield equals 200 adults/surface acre. The commercial harvest was estimated to represent an exploitation rate of 85%, because most alewife runs were harvested six days per week. Exploitation rates on the Damariscotta River, for example, ranged from 85-97% for the years 1979-1982. When commercial yield is adjusted for the 15% escapement rate, the total production is 235 adult alewives/acre.

Results from studies conducted at Damariscotta Lake located in mid-coast Maine in the 1970s -1980s indicate that increasing the escapement of spawning alewives ranging from 40 to 60 fish per acre caused the parent progeny relationship to trend downward (Walton, C.J. 1987. Parent-Progeny relationship for an Established Population of Anadromous Alewives in a Maine Lake. American Fisheries Society Symposium 1:451 – 454, 1987). The relationship between increased numbers of spawning individuals and returns 4-5 years later does not support increased escapement rates for many Maine runs. Analysis of escapement numbers and commercial catches in fisheries with a sustained level of escapement over several years does indicate a large variation in run size unassociated with the number of spawning fish.

The State of Maine uses an alternative 6-fish per acre target when establishing new river herring runs. The 6-fish per acre target was established through fisheries work designed to examine the effect of anadromous alewives on existing sportfish and zooplankton populations in lakes without anadromous alewives (Lake George Study). The 10-year study conducted by the Maine Department of Inland Fisheries and Wildlife, Department of Environmental Protection, and the Department of Marine Resources, determined that stocking six prespawn fish per surface acre does not negatively affect growth of inland sportfish species including trout, landlocked salmon, or rainbow smelts, but increased numbers of alewives did change the zooplankton structure in the nursery habitat. Based on the study results, the Lake George Study remains the basis for the multispecies fisheries management plans in habitats that receive new introductions of river herring.

7. Monitoring to be Conducted to Support Target(s)

Commercial

Fisheries staff will continue to use annual landings data, escapement counts, escapement estimates, mortality estimates, and scale sample data to track relative health of river specific alewife and blueback herring stocks. Data from the JAI survey will be used to determine changes in juvenile river herring abundance in the tidal portions of the Kennebec River, Merrymeeting Bay and associated tidal rivers. The Maine-New Hampshire Inshore Trawl Survey will provide a broader coastwide perspective on abundance of the mixed stocks of river herring that are found off the Maine coast during the spring and fall seasons. Both fishery independent indices were used in the 2024 ASMFC Benchmark River Herring Assessment. Monitoring efforts will continue for all existing commercial fisheries and will occur for all locations where directed commercial fisheries may open in the future.

Recreational
For locations where commercial fisheries are permitted, monitoring of the commercial catches and existing controls will remain in place to assess and support the development of population metrics for the recreational fishery. For locations where there is no existing commercial fishery, or existing municipal harvest rights, fishway counts will be used to monitor run size where recreational fisheries are permitted **(Appendix C)**.

Fisheries staff will continue to use annual run count data, escapement counts, mortality estimates, and scale data to track relative health of river specific stocks where these data are collected at noncommercial monitoring sites. Additional data from the JAI survey will be used to determine changes in juvenile river herring abundance in the tidal portions of the Kennebec River, Merrymeeting Bay and associated tidal rivers.

8. Proposed Rulemaking to Support Target(s)

Commercial fisheries that cannot support commercial harvest levels above the minimum spawning threshold or maintain other plan metrics will remain closed for conservation. In addition, this plan eliminates the directed harvest, possession, and sale of any river herring within state waters other than the approved directed fisheries contained within this plan. The State has also created a Pelagic Fisheries license which requires annual harvester reports for all river herring harvest activities **(Appendix B)**.

The Department passed a rulemaking proposal prohibiting the opening of new river herring fisheries as required by the Atlantic State Marine Fisheries Commission Management Board.

30.02 Limits on River Herring
Beginning January 1, 2012, it shall be unlawful for any person to take, possess, harvest or sell river herring in the State of Maine or in waters under the jurisdiction of the State of Maine.

> **Exceptions:**
> A. River Herring fishing rights. A municipality or an individual with existing river herring harvest rights granted by the Commissioner in accordance with 12 M.R.S. §6131 are not subject to Chapter 30. The Commissioner may authorize a future river herring fishery, authorized pursuant to 12 M.R.S. §6131, after submission of a sustainable fisheries management plan for that fishery by the Department, which is approved by the Atlantic States Marine Fisheries Commission (ASMFC) Management Board.

Since January of 2012 there has been no additional rule making or statute chances that affect river herring harvest.

9. Adaptive Management

a. Evaluation schedule

The Maine Department of Marine Resources will conduct an annual review of all municipal fisheries harvest plans. Many plans carry over year to year because they demonstrate adequate protection for the river herring resource. Plan reviews incorporate landings data, escapement counts or estimates, broodstock needs, effort controls, and compliance with SFMP metrics. There is no plan to change the review schedule for individual river herring management plans at this time.

b. Consequences or control rules

All Maine directed commercial river herring fisheries operate under a 72-hour closed period or conservation equivalent. The Maine Department of Marine Resources will extend closed periods, modify conservation equivalencies, or close fisheries that cannot sustain existing commercial fisheries and meet SFMP standards. Management actions for fisheries not meeting specific SFMP metrics are provided below.

Commercial

1) Additional management review and/or individual river specific management plan changes will occur based on decreasing trends in running three-year averages of annual landings, increasing time series trends in total mortality (z), trends in repeat spawning rates for fishery dependent and fishery independent sites, and age structure.

   A) **Decreasing trends in running three-year averages of annual run counts**

   If the run demonstrates a declining trend in the running three-year average of annual run counts the fishery will close for the following year or additional closed days per week will be added to the season.

   B) **Increasing time series trends in total instantaneous mortality (Z) for repeat spawning fish**

   If the fishery does not achieve a Z-estimate of 1.67 or less for repeat spawners for the 3-year running average the fishery (number of fishing days) will be reduced or fishery closed until the Z-estimate falls below 1.67.

   C) **Decreasing time series trends in repeat spawning rates**

   If the number of repeat spawning fish for the sample year does not achieve 20 percent, the fishery (number of fishing days) will be reduced until the annual repeat spawning rate exceeds 20 percent.

   D) **Decreasing time series trends in age structure**

   River herring populations that do not demonstrate the presence of fish ranging in age from 3 to 7 during a three-year period will result in a reduction of fishing days.

2) Fisheries staff will review harvest and age data collected from annual returns to assess the need to increase the number of closed days in the fishery. Due to the variability of river herring runs in Maine under stable escapement rates, run size, and species composition, runs may exhibit wide swings in annual assessment values. However, there may be other unforeseen factors that may require a reduction in allowed fishing days/season (mortality events, disease, extreme environmental conditions).

3) The management objective for all commercial fisheries is to ensure that river herring populations maintain a minimum (35 fish/acre) spawning stock threshold into the future. A commercial fishery that does not meet the minimum spawning stock escapement established for that system will be required to close the following season until fishery achieves the escapement goal for that year.

Recreational

All Maine recreational river herring fisheries operate under a 72-hour closed period (Tuesday 6:00 a.m. to Sunday 6:00 a.m.). The Maine Department of Marine Resources will extend closed periods, modify conservation equivalencies, or close fishing on populations that cannot meet the 25^{th} percentile for fishery independent run counts.

1) Additional management review and/or changes will occur based on decreasing trends in running three-year averages of annual landings, increasing time series trends in total mortality (z), and trends in repeat spawning rates for fishery dependent and fishery independent sites where these data are collected.

2) All recreational river herring fisheries not associated with a commercial run will close if the mean statewide fishway count falls below the 25-percentile for three consecutive years.

3) Recreational fisheries not associated with a commercial fishery will close regionally if one of the fishery independent fishway counts fails to achieve the 25-percentile for three consecutive years. The management objective is to ensure that regional recreational fisheries do not impact spawning stock on rivers without river specific monitoring. The rivers in table <u>Fishery Independent Management Triggers for Recreational River Herring Harvest</u> will represent regions of the state equidistance between fishway locations listed below. The 25-percentile values are fixed but will be updated once every five years when state River Herring SFMP's are reviewed and updated.

Fishery Independent Management Triggers for Recreational River Herring Harvest

Fishway	25-Percentile
Saco River	9,491
Androscoggin River	25,682
Kennebec River	68,744
Penobscot River	56,390
St. Croix River	20,900
Fishway Totals	169,620
Fishway Mean	76,636

References:

ASMFC. 2024. Draft Stock Assessment Report. Atlantic States Marine Fisheries Commission River Herring Benchmark Assessment. Arlington, VA. USA. 475p.

Kircheis, F.W., J.G Trial, D.P Boucher, B. Mower, Tom Squiers, Nate Gray, Matt O'Donnell, and J.S. Stahlnecker. 2002. Analysis of Impacts Related to the introduction of Anadromous Alewife into a Small Freshwater Lake in Central Maine, USA. Maine Inland Fisheries & Wildlife, Maine Department of Marine Resources, Maine Department of Environmental Protection. 53 pp.

Rounsefell,G.A.,L.D, Stringer. 1943. Restoration and Management of the New England Alewife Fisheries with Special Reference to Maine. United States Department of the Interior Fish and Wildlife Service Fishery Leaflet 42.

Walton, C. J. 1987. Parent-progeny relationship for an established population of anadromous alewife in a Maine lake. American Fisheries Society Symposium 1: 451-454.

Appendix A

Note: All confidential data has been removed from this SFMP update. There are no graphs provided that indicate landings or escapement for the existing commercial fisheries. As a result, sections of Appendix A will appear incomplete to protect individual harvesters' information. Because there is only one harvester per run in Maine's commercial river herring fisheries all graphs and tables have been removed.

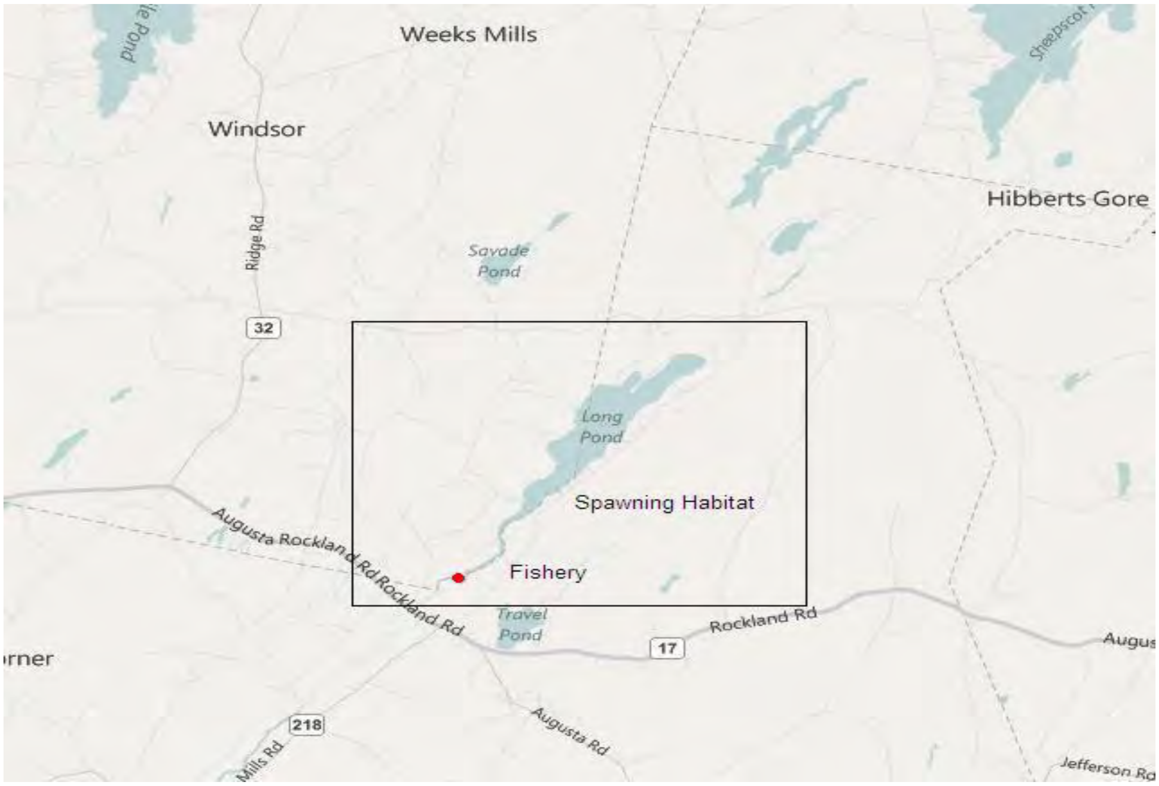
Alna Commercial Fishery:
The Maine Department of Marine Resources manages eastern branch of the Sheepscot River drainage for a commercial escapement of 38.2 fish per acre through a conservation equivalent of 20,000 river herring passed upstream by the harvester throughout the season. The management plan has always achieved returns to meet the target escapement developed for this system or passed the entire run upstream. Long Pond was not commercially harvested during the years 2020 – 2023 and only partially harvested in 2019. The harvester holding the harvest contract through the town of Alna elected not to harvest during several years of the contract due to access issues at the approved harvest location. Total run count and biological data are not available for the years 2020 – 2023 but have resumed in 2024. Commercial harvest occurs in the river just downstream of Long Pond, which is the only accessible alewife spawning habitat on the east branch of the Sheepscot River. The Department of Inland Fisheries and Wildlife will not permit alewives access to historical spawning habitat in Sheepscot Pond, or the watershed above, because of concerns with disease that may affect sport fish raised at a state own fish hatchery downstream of Sheepscot Pond.

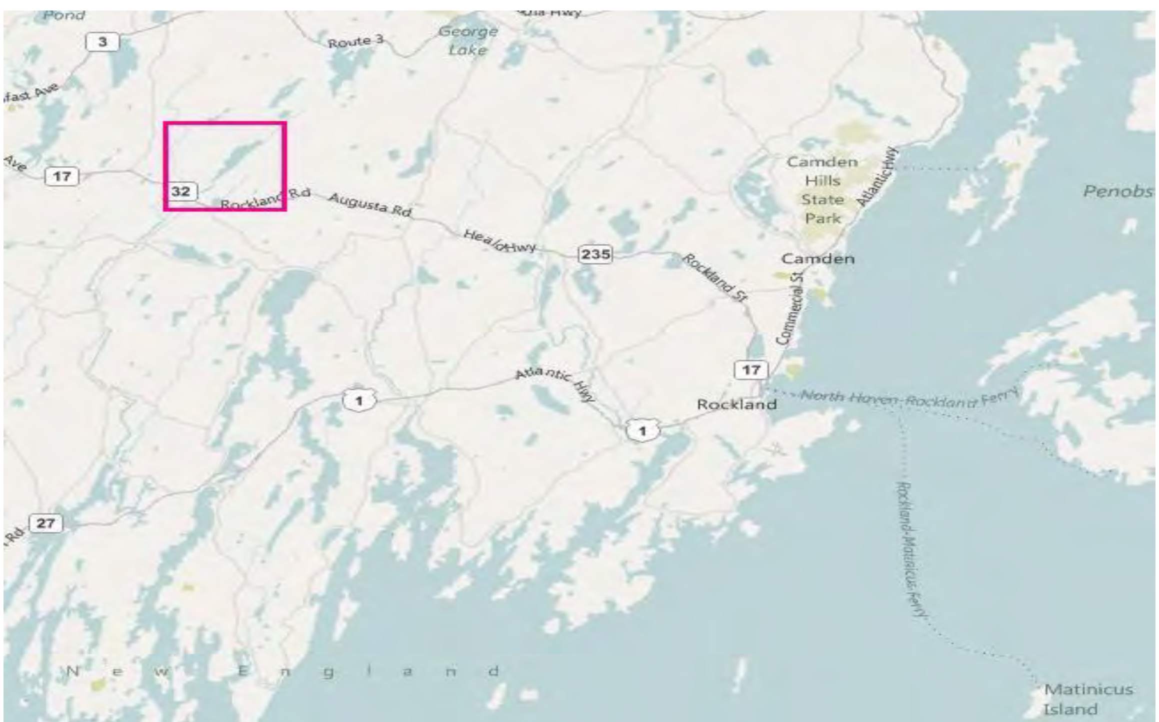
The west branch of the Sheepscot River leading to Branch Pond currently contains very few river herring due to the lack of a fishway prior to 2024. However, in 2023 the construction of a fishway leading to Branch Pond now allows access to spawning habitat. The DMR stocked Branch Pond for a four-year period 2021-2024 to establish a river herring population that is expected to increase as a result of the new fishway. River herring are not harvested commercially on the west branch of the Sheepscot River. The town of Alna does retain the right to harvest these fish if populations reach a level of sustainability in the future and a fishery is approved by ASMFC.

Spawning habitat is available for blueback herring in the river below the newly constructed fishway and on in the east branch of the Sheepscot River. Incidences of blueback herring in the commercial catches or biological samples below the fishway are rare. There is no available spawning habitat for alewives in the Sheepscot River below the commercial fishery and there are no reports of juvenile blueback herring emigrating from this system in appreciable numbers currently.

The Sheepscot River alewife run would be considerably larger if all historic river herring spawning habitats were accessible to river herring. Access restrictions to Sheepscot Pond by the Maine Department of Inland Fisheries and Wildlife prevent river herring from the largest single spawning habitat within the system. Restrictions at Sheepscot Pond are unlikely to change soon due to disease concerns related to the IFW sport fish hatchery. Progress on increasing passage efficiency within the mainstem occurred in 2017 with the removal of the dam at Coopers Mill. The Coopers Mill dam removal facilitates upstream and downstream passage but is unlikely to increase production significantly unless blueback herring populations expand.

Town	River	Lake size (acres)	Threshold (N/acre)
Alna	Sheepscot	532	35





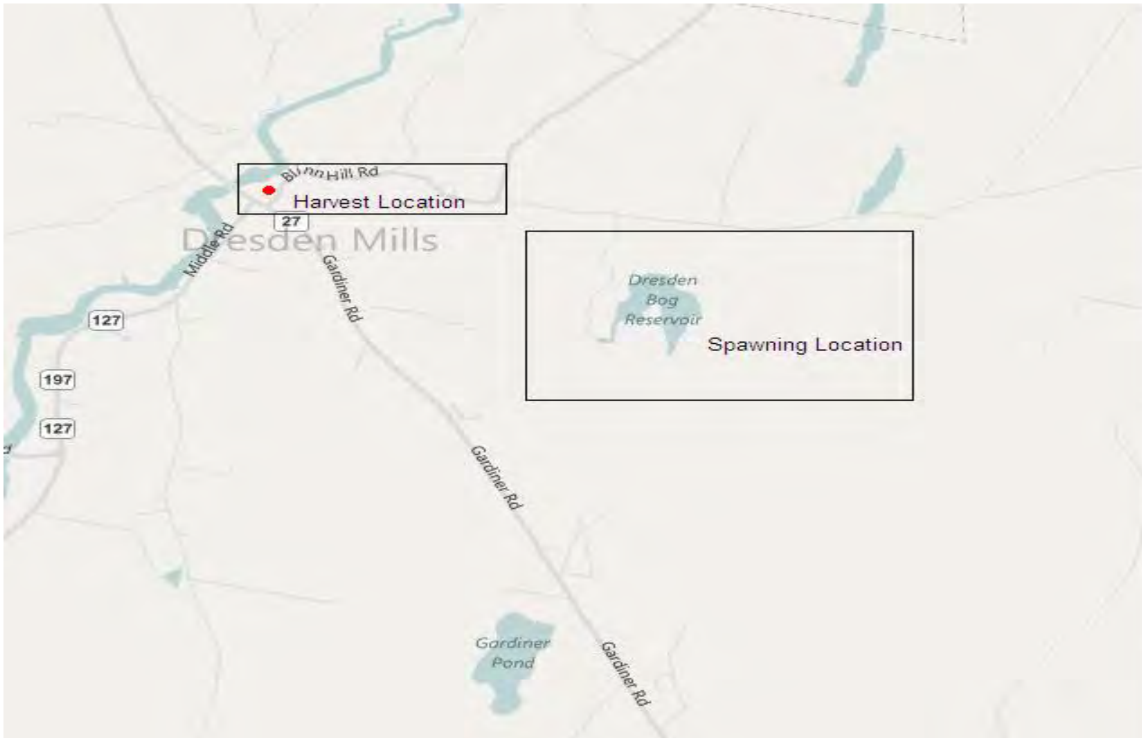
Year	Municipality	River	% repeat spawners by year and frequency	R-0	R-1	R-2	R-3	R-4
2023	Coopers Mills	Sheepscot	No Commercial Fishery					
2022	Coopers Mills	Sheepscot	No Commercial Fishery					
2021	Coopers Mills	Sheepscot	No Commercial Fishery					
2020	Coopers Mills	Sheepscot	No Commercial Fishery					
2019	Coopers Mills	Sheepscot	53.0	47.00	42.00	11.00		
2018	Coopers Mills	Sheepscot	30.0	70.00	26.00	4.00		
2017	Coopers Mills	Sheepscot	14.0	86.00	14.00			
2016	Coopers Mills	Sheepscot	11.5	88.50	10.30	1.10		
2015	Coopers Mills	Sheepscot	9.1	91.00	8.00	0.00	1.00	
2014	Coopers Mills	Sheepscot	41.0	59.00	36.00	5.00		
2013	Coopers Mills	Sheepscot	33.8	66.20	32.30	1.00	0.50	
2012	Coopers Mills	Sheepscot	7.2	92.76	6.58	0.66		
2011	Coopers Mills	Sheepscot	22.0	78.00	22.00			
2010	Coopers Mills	Sheepscot	4.9	95.15	3.88	0.97		
2009	Coopers Mills	Sheepscot	19.0	81.00	17.00	2.00		
2008	Coopers Mills	Sheepscot	10.0	90.00	10.00			

Dresden Commercial Fishery:

The Maine Department of Marine Resources manages Mill Stream and Dresden Bog for a minimum commercial escapement of 35 fish per acre. The spawning escapement need for this system is 5,950 river herring passed upstream through three consecutive closed days per week during the fishery. The management plan has always achieved returns to meet the escapement threshold developed for this system or passed the entire run for the season. The DMR does not permit a river herring fishery in the mainstem of the Eastern River. The Eastern River provides available spawning and rearing habitat for blueback herring, American shad, shortnose sturgeon and striped bass. The commercial fishery for river herring occurs upstream of the confluence of the Eastern River at Mill Stream, which leads to spawning habitat in Mill Stream and Dresden Bog.

The Eastern River is one of several rivers in Maine that protect spawning populations of anadromous fish through gear restrictions, seasons, and time/area closures. The Eastern River is a free-flowing tidal river without any upstream barriers to delay upstream passage. There are no estimates of numbers of blueback herring spawning in the Eastern River, though numbers may be as high as several hundred thousand based on the available habitat. It is unknown, but unlikely that alewives spawn in the mainstem of the Eastern River. Biological sample data indicate that blueback herring and alewife may interbreed in the mainstem of the Eastern River.

Town	River	Lake size (acres)	Threshold (N/acre)
Dresden	Eastern	170	35



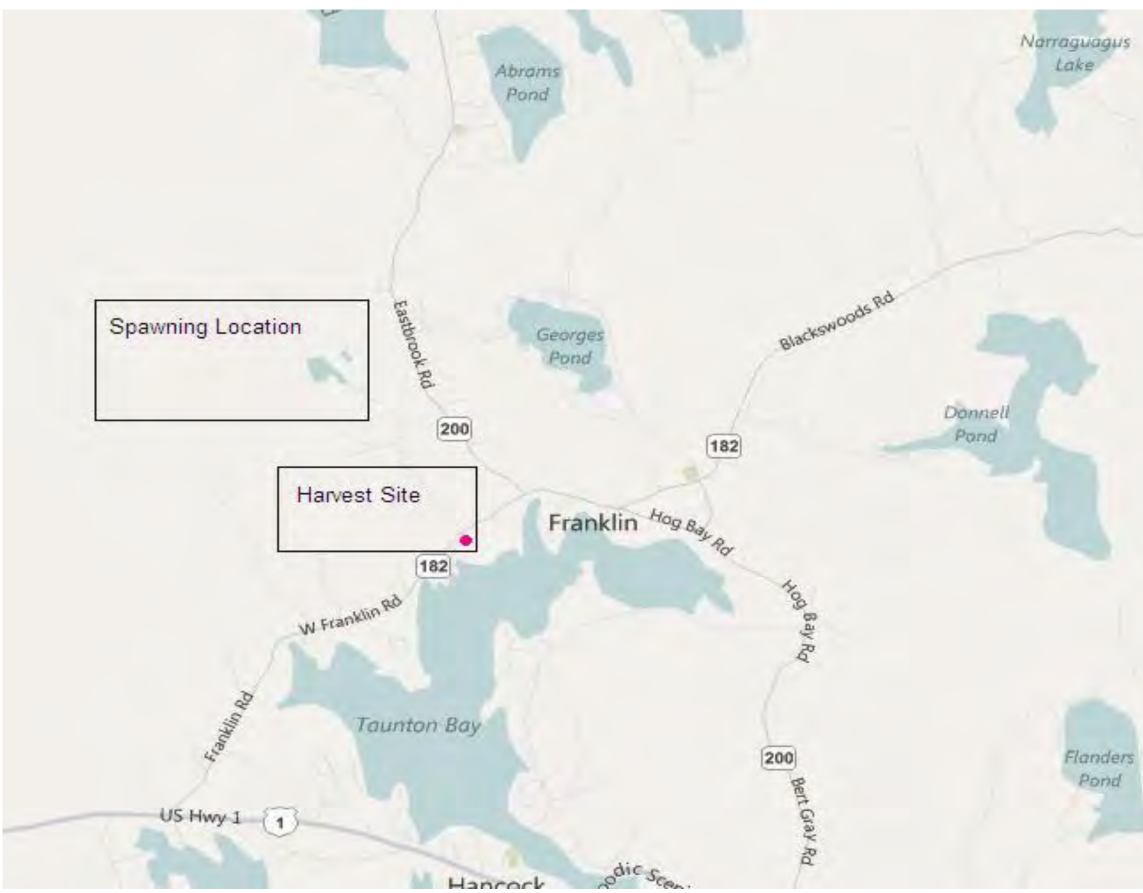
Year	Municipality	River	% repeat spawners by year and frequency	R-0	R-1	R-2	R-3	R-4
2023	Dresden	Eastern River	53.6	43.70	30.10	15.50	9.70	1.00
2022	Dresden	Eastern River	69.6	28.00	34.70	25.30	9.30	2.70
2021	Dresden	Eastern River	64.0	36.00	38.00	21.00	2.00	3.00
2020	Dresden	Eastern River	48.0	52.04	32.65	10.20	4.08	1.02
2019	Dresden	Eastern River	50.0	50.00	34.21	10.53	5.26	
2018	Dresden	Eastern River	30.0	70.00	26.00	4.00		
2017	Dresden	Eastern River	69.3	30.66	30.67	26.67	12.00	
2016	Dresden	Eastern River	74.3	25.70	44.60	25.70	3.98	
2015	Dresden	Eastern River	45.5	54.55	41.41	4.04		
2014	Dresden	Eastern River	29.0	71.00	19.00	8.00	2.00	
2013	Dresden	Eastern River	50.5	49.45	24.17	9.89	16.48	
2012	Dresden	Eastern River	24.5	75.52	18.56	3.37	2.53	
2011	Dresden	Eastern River	22.1	77.87	13.27	8.25	0.59	
2010	Dresden	Eastern River	52.5	47.51	40.33	8.83	3.31	
2009	Dresden	Eastern River	38.4	61.60	29.30	5.10	4.00	
2008	Dresden	Eastern River	29.7	70.30	18.80	6.90	4.00	

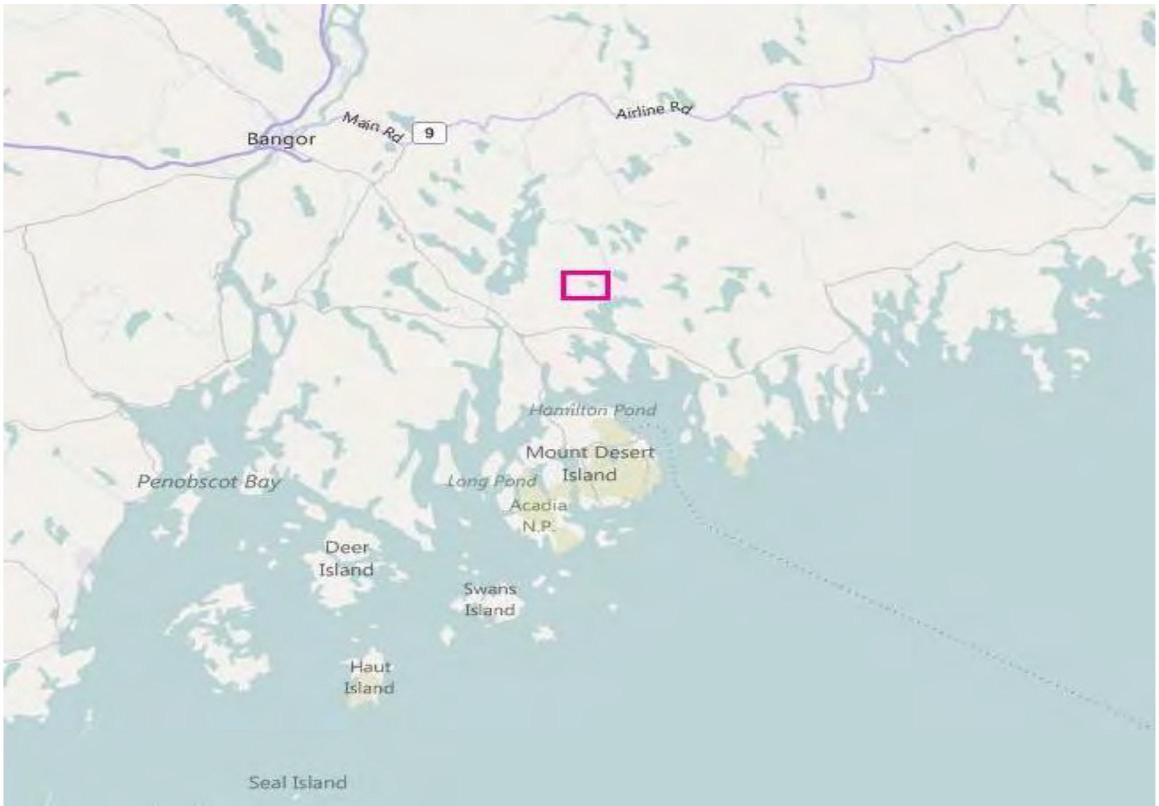
Franklin Commercial Fishery:

The Maine Department of Marine Resources manages Great Pond (Grist Mill Stream) for a minimum commercial escapement of 35 fish per acre. The spawning escapement need for this system is 9,170 river herring passed upstream through three closed days per week during the fishery. The management plan has always achieved returns that meet the target escapement developed for this system or passed the total run upstream. There is no spawning below the pond. Beaver dams are a perennial problem at this location, affecting upstream and downstream migration during periods of low flow. As with many small coastal runs, access to spawning habitat is influenced by spring and fall water levels necessary to permit upstream and downstream migration. Spawning does not occur in the stream below or above the commercial fishery for alewife. Blueback herring are not observed in this system and there are no historical records to indicate that blueback herring inhabited the stream.

The Franklin fishery at one time only harvested post spawn runback river herring. This practice is not permitted currently but likely had a significant effect on spawning stock, exploitation rates, and number of repeat spawning fish within the system historically.

Town	River	Lake size (acres)	Threshold (N/acre)
Franklin	n/a	262	35





Harvest location for Great Pond in Franklin, Maine.

Year	Municipality	River	% repeat spawners by year and frequency	R-0	R-1	R-2	R-3	R-4
2023	Franklin	Grist Mill	47.0	53.00	46.00	1.00		
2022	Franklin	Grist Mill	22.0	78.00	9.00	13.00		
2021	Franklin	Grist Mill	51.0	49.00	44.00	5.00	2.00	
2020	Franklin	Grist Mill	28.0	72.00	24.00	4.00		
2019	Franklin	Grist Mill	53.0	47.00	31.00	19.00	3.00	
2018	Franklin	Grist Mill	38.1	61.90	29.52	8.57		
2017	Franklin	Grist Mill	65.1	34.91	53.77	10.38	0.94	
2016	Franklin	Grist Mill	20.8	79.20	16.00	4.80		
2015	Franklin	Grist Mill	18.2	81.19	16.83	1.98		
2014	Franklin	Grist Mill	49.5	50.50	41.58	5.94	1.98	
2013	Franklin	Grist Mill	43.8	56.17	37.65	6.17		
2012	Franklin	Grist Mill	13.8	86.17	11.47	2.35		
2011	Franklin	Grist Mill	28.4	71.63	26.54	1.45	0.36	
2010	Franklin	Grist Mill	18.8	81.17	16.31	2.50		
2009	Franklin	Grist Mill	9.7	90.30	8.90	0.80		
2008	Franklin	Grist Mill	27.6	72.40	19.40	7.10		

Nobleboro and Newcastle Commercial Fishery:
The Maine Department of Marine Resources manages Damariscotta Lake for a minimum commercial escapement of 35 fish per acre. The spawning escapement need for this system is 153,335 river herring counted upstream by the hydropower company which owns the fishway. The age and design of the previous fishway limited the numbers of river herring entering spawning habitat. In 2007 a one million-dollar fishway renovation significantly improved escapement into spawning habitat in Damariscotta Lake.

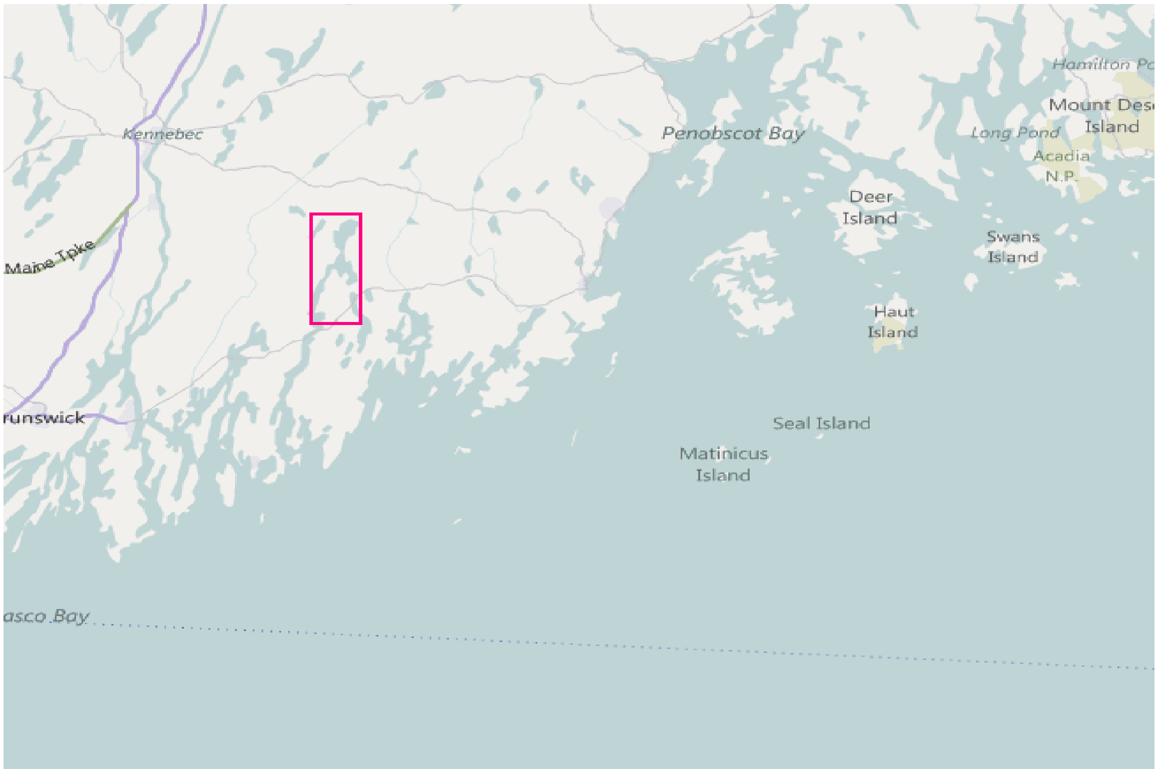
The Nobleboro and Newcastle fishery is a joint fishery conducted by two municipalities at one fishing location. The current municipal management plan for this fishery permits all river herring arriving at the fishway during the first week of the season free passage upstream. This fishery is one of two fisheries in Maine that currently allows continuous escapement of spawning fish throughout the season in addition to closed days, though traditionally they harvested seven days a week. Historically, Damariscotta Lake never had a river herring run. The run began in 1806 with the construction of a 42-foot-high fieldstone fishway and an initial introduction of broodstock from the Sheepscot River. After residents established the run, fishing rights were granted by the State of Massachusetts in 1810 permitting the fishery to occur seven days per week. Continuous escapement up the fishway, and into to the lake, occurred throughout the fishing season. Estimated annual exploitation rates for this run ranged from 85-95 percent from the early 1800s through 1984.

A tidal stream leads from the Damariscotta River to the base of the fishway. Alewives arrive and depart the area downstream of the fishway based on the tidal stage in the river. During high tide river herring enter the tidal stream and attempt to ascend the fishway into Damariscotta Lake. The run is entirely alewife with no blueback herring present in the commercial catches. There is no spawning habitat for either species below the fishway due to high salinities, but American shad, shortnose sturgeon, and sea-run brown trout are observed below the fishway.

A hydropower turbine is located at one of the lakes' two outlets and produces a limited amount of hydropower during early spring and winter. The hydropower station does not operate during the downstream migration period for alewife or American eel (July – November). Operation schedules during the 1960s and 1970s are unknown as are any associated adult or juvenile mortality events.

Damariscotta Lake is an oligotrophic lake that produces small juvenile river herring compared to other lakes in the area. These juveniles start to emigrate from the lake in early July at total lengths as small as 42mm. Work conducted at Damariscotta indicates that increased escapement levels negatively affect the numbers of juveniles produced within the lake. Increased stocking rates appear to lead to diminished yield per adult spawner (Walton 1987). The towns that operate the harvest choose to allow significantly more adult river herring into the system than recommended by Walton's research. Escapement into the lake regularly exceeds 500,000 adults per year and exceeded 900,000 during eight years since 2012 with five years being more than 1-million adult spawners during the same period.

Town	River	Lake size (acres)	Threshold (N/acre)
Nobleboro	n/a	4,381	35



Year	Municipality	River	% repeat spawners by year and frequency	R-0	R-1	R-2	R-3	R-4
2023	Nobleboro	Damariscotta	39.0	61.00	29.00	8.00	1.00	1.00
2022	Nobleboro	Damariscotta	44.8	55.20	30.50	13.30	1.00	
2021	Nobleboro	Damariscotta	45.0	55.00	37.00	8.00		
2020	Nobleboro	Damariscotta	39.0	61.00	31.00	6.00	2.00	
2019	Nobleboro	Damariscotta	40.0	60.00	32.00	8.00		
2018	Nobleboro	Damariscotta	34.2	65.79	29.82	4.39		
2017	Nobleboro	Damariscotta	11.5	88.46	9.62	1.92		
2016	Nobleboro	Damariscotta	28.0	72.00	13.00	13.00	2.00	
2015	Nobleboro	Damariscotta	25.6	70.41	23.47	5.10	1.02	
2014	Nobleboro	Damariscotta	30.4	69.60	14.70	14.70	1.00	
2013	Nobleboro	Damariscotta	23.8	76.20	22.80	1.00		
2012	Nobleboro	Damariscotta	16.3	83.70	10.80	4.80	0.80	
2011	Nobleboro	Damariscotta	33.2	66.80	27.70	5.50		
2010	Nobleboro	Damariscotta	17.9	82.00	14.40	2.60	1.00	
2009	Nobleboro	Damariscotta	44.7	55.30	42.60	2.10		
2008	Nobleboro	Damariscotta	29.7					

Commercial harvest of river herring at Damariscotta Lake in the 1980s

Entrance to the Damariscotta fishway.

Upper section of the Damariscotta fishway prior to restoration.

Upper section of the fishway after restoration.

Bath-West Bath-Phippsburg Commercial Fishery:
The Maine Department of Marine Resources manages Winnegance Lake for a minimum commercial escapement of 35 fish per acre. The fishery is jointly harvested by three municipalities through coordination of a single harvest location and contracting with a single harvester. The annual spawning escapement need for this system is 4,795 river herring passed upstream through the fishway during the three-day closed period. The management plan has always achieved returns that meet the target escapement developed for this system or passed the total run upstream. The fishway leads from the tidal zone directly into the 137-acre spawning habitat provided by Winnegance Lake. This fishery is typically the earliest of all Maine river herring runs, with river herring arriving as early as March 15. There is no spawning below the tidal fishway.

The commercial harvester catches blueback herring at this location toward the end of the commercial fishing season. It is unknown how successful blueback spawning or survival is in the lake. Blueback herring may drop out of the lake prior to spawning to look for suitable spawning habitat which is not available in the lake. Field staff have not observed any juvenile blueback herring in biological samples collected as juveniles emigrate from the lake in the fall.

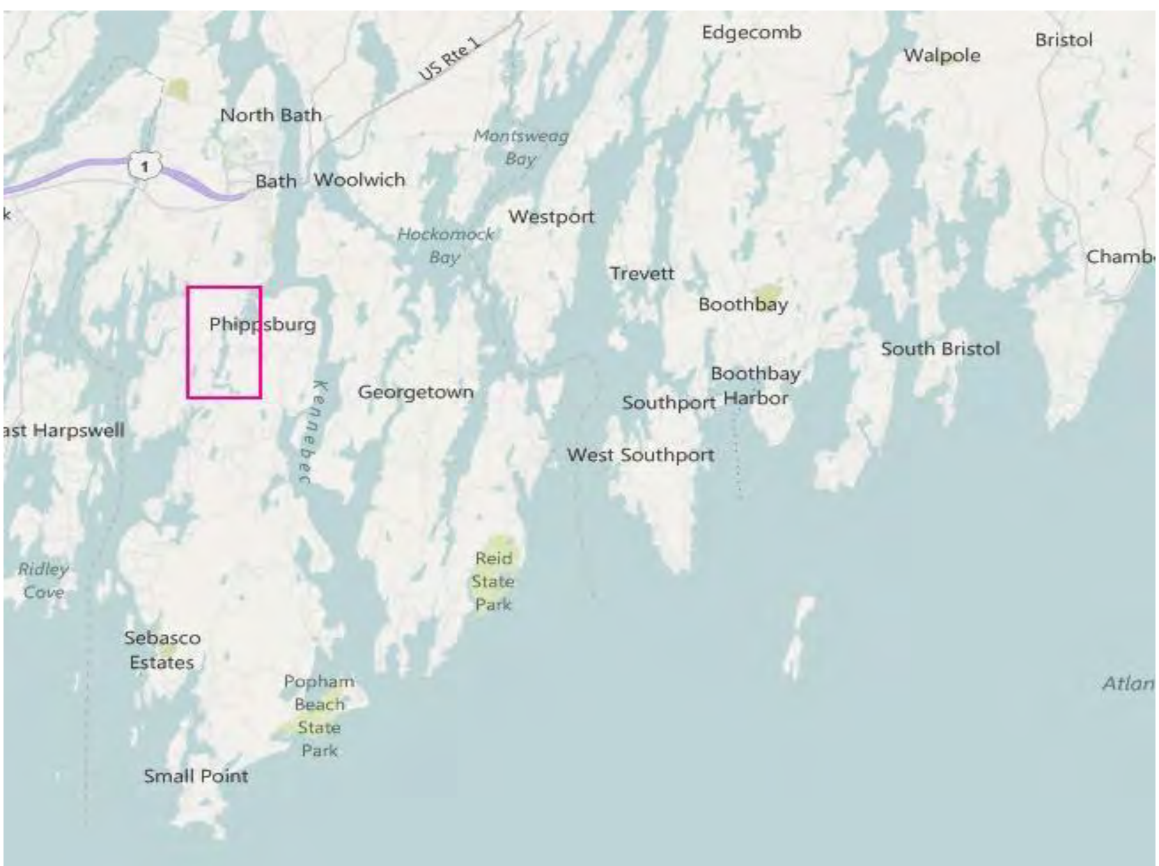
The fishery at Winnegance Lake is currently on the watch list. Though the fishery currently meets the minimum escapement levels in the plan, the annual run is below expectations. The cause for the decline in the annual run is not clear. There are several factors that may be impacting annual returns. In the early 2000’s the dam at the outlet of the lake was reconstructed to make repairs and improve the harvest area. The existing Denil fishway is sufficient to pass fish into the lake but the existing configuration may make it difficult for fish to find the downstream passage. There are periods of time when downstream passage appears to be nonexistent due to low flow during the summer and fall.

Winnegance Lake is one of several river herring spawning habitats effected by sea level rise. The dam is low enough that the Kennebec River regularly flows back into the lake during above average high tides. The salinity of the river water flowing into the lake can be as high as 15ppm. Once this water enters the lake there is no way for the denser seawater to exit the lake. Prior to the 2017 season the Department deployed a sonde into the lake soon after ice out to collect water quality data. Data indicates that the salinity within the deeper parts of the lake can exceed 7ppt during the summer.

In recent years, northern pike and black crappie were illegally introduced into the lake and predation on adult and juvenile river herring has likely increased. Both species are known to prey heavily on alewives in Maine’s freshwater ecosystems.

Town	River	Lake size (acres)	Threshold (N/acre)
Phippsburg	n/a	137	35

Fishing Location
Phippsburg
Spawning Location
Arrowsic
Georgetown
East Harpswell
Halls Bay
Knubble Bay
Robinhood Cove
Ridley Cove
Reid State Park
Sebasco Estates
Sagadahoc Bay
Atkins
Gurnet Rd
Harpswell Islands Rd
24



Edgecomb
Walpole
Bristol
US Rte 1
North Bath
Montsweag Bay
Bath
Woolwich
Westport
Hockomock Bay
Trevett
Boothbay
Phippsburg
South Bristol
Georgetown
Kennebec
Boothbay Harbor
Southport
ast Harpswell
West Southport
Ridley Cove
Reid State Park
Sebasco Estates
Popham Beach State Park
Small Point

The Winnegance Lake fish trap is located in the lake above the fishway exit.

Year	Municipality	River	% repeat spawners by year and frequency	R-0	R-1	R-2	R-3	R-4
2023	Bath	Kennebec	58.9	41.10	45.20	13.10	0.60	
2022	Bath	Kennebec	21.0	79.00	14.00	6.00	1.00	
2021	Bath	Kennebec	14.0	86.00	7.00	5.00	2.00	
2020	Bath	Kennebec	36.0	64.00	32.00	4.00		
2019	Bath	Kennebec	10.0	90.00	8.00	2.00		
2018	Bath	Kennebec	5.3	94.74	5.26			
2017	Bath	Kennebec	4.0	96.00	2.00	2.00		
2016	Bath	Kennebec	28.3	74.50	19.60	3.90	2.00	
2015	Bath	Kennebec	39.0	62.00	34.00	4.00		
2014	Bath	Kennebec	16.1	83.90	12.90	2.20	1.10	
2013	Bath	Kennebec	8.8	91.20	7.30	1.50		
2012	Bath	Kennebec	8.0	92.00	5.00	2.00	1.00	
2011	Bath	Kennebec	6.5	93.46	4.52	2.01		
2010	Bath	Kennebec	25.5	74.49	17.35	8.16		
2009	Bath	Kennebec	9.0	91.00	7.00	2.00		
2008	Bath	Kennebec						

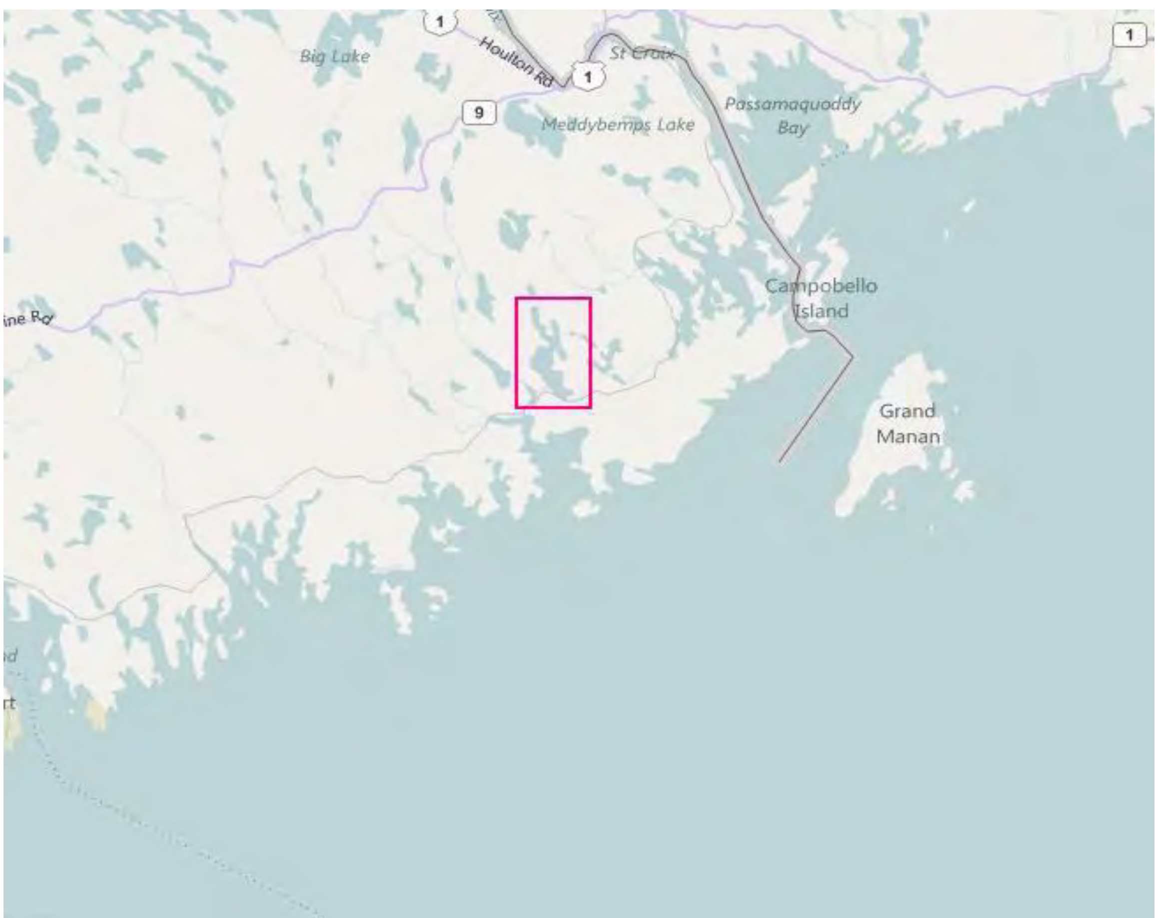
East Machias Commercial Fishery:
The Maine Department of Marine Resources manages Gardner Lake for a commercial escapement of 35 fish per acre. The spawning escapement need for this system is 176,225 river herring passed upstream through three closed days per week for the fishery. The management plan had not achieved returns to meet the 35 fish per acre target escapement developed for other systems for several years prior to 2013. Recent returns meet escapement objectives and the number of older fish in the population are increasing. Commercial harvest did not occur in 2020 due to COVID-19 and concerns by the town regarding gathering at the harvest location.

The mainstem East Machias River system has a large run of river herring that is unexploited. The mainstem river remains closed as a conservation measure while allowing a larger harvest at the first tributary on the river at the outlet of Gardiner Lake. An estimated run of 2.1 – 4.5 million river herring ascend the East Machias' 9,000 acres of accessible habitat. An unknown number of blueback herring ascend the river to spawn in the mainstem. These fish are not harvested and are allowed free access up and down the river. The DMR may allow a higher exploitation rate for Gardiner Lake to keep the mainstem of the East Machias open to free passage for all anadromous fish, including Atlantic salmon. The East Machias River has no dams in the mainstem and provides spawning and juvenile habitat for endangered Atlantic salmon.

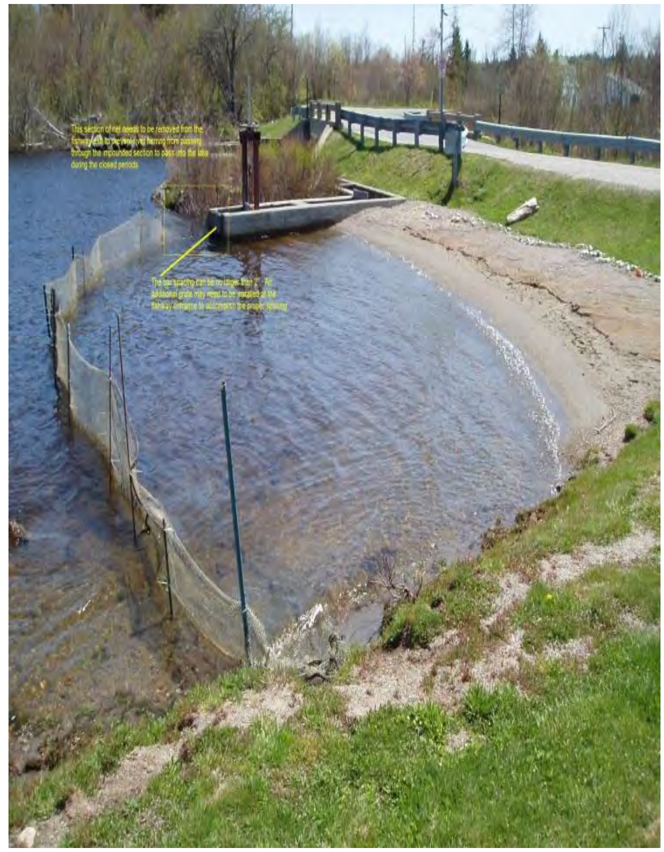
For several years prior to 2010 the harvest data from the Gardiner fishery was severely underreported. Historical landings data that are the basis for calculating escapement indicate escapement into the lake was far below expectations compared to runs in general. Under new management, and with accurate landings data, the run is closer to meeting expectations. Additional data collected from this system and analysis of the 2022 and 2023 scale samples indicate the population is trending in a positive direction. If indications are that escapement from the commercial fishery is not increasing DMR will impose additional closed days in 2024.

Town	River	Lake size (acres)	Threshold (N/acre)
East Machias	Chase Mill Stream	5,035	35


Second Lake
Spawning Habitat
Hadley Lake
Gardner Lake
Fishing Location
East Machias
Jacksonville Rd
arshfield
Main St
Machias
Dublin St
Machiasport


Big Lake
Houlton Rd
St Croix
Meddybemps Lake
Passamaquoddy Bay
Campobello Island
Grand Manan

Chase Mill Stream is a tributary to the East Machias River. Fishing gear is deployed at the top of the fishway to capture returns to Gardiner Lake.

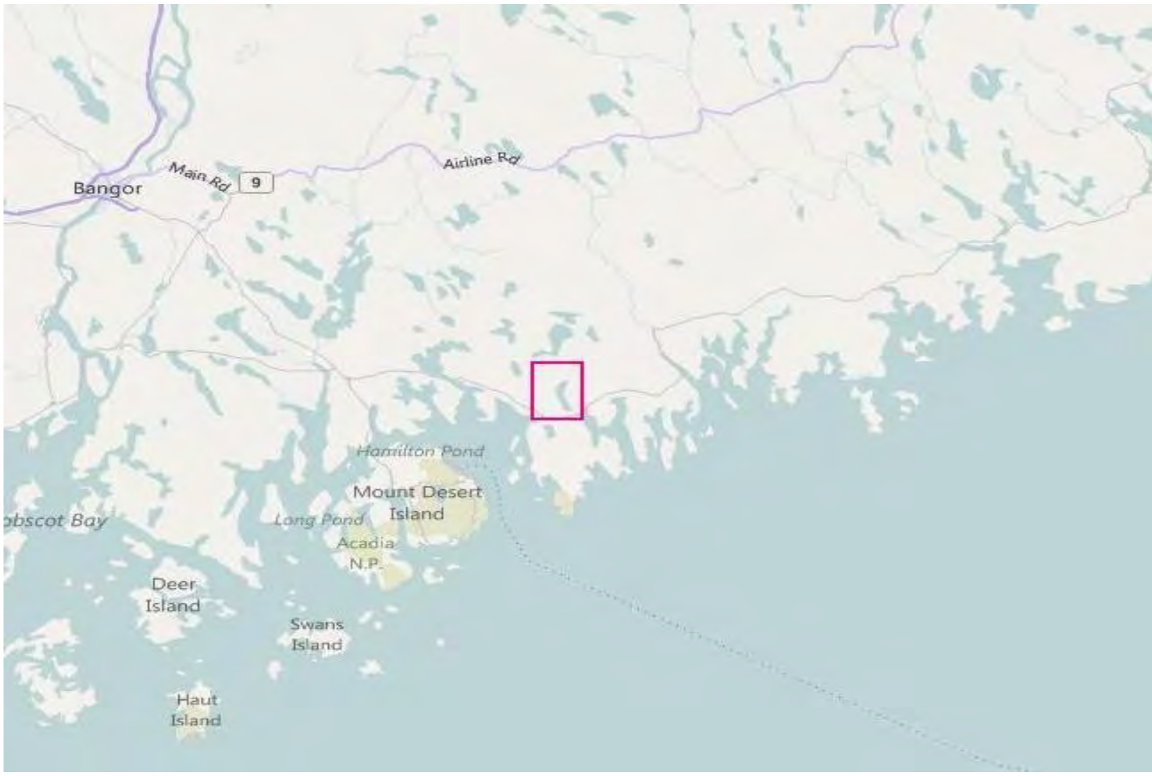


Year	Municipality	River	% repeat spawners by year and frequency	R-0	R-1	R-2	R-3	R-4
2023	East Machias	East Machias	10.2	89.80	1.70	5.10	2.50	0.80
2022	East Machias	East Machias	34.3	65.70	22.90	8.60	1.90	1.00
2021	East Machias	East Machias	35.0	65.00	20.00	12.00	1.00	2.00
2020	East Machias	East Machias	No Fishery					
2019	East Machias	East Machias	47.5	52.90	35.30	11.80		
2018	East Machias	East Machias	27.6	72.38	20.00	5.71	1.90	
2017	East Machias	East Machias	19.0	81.00	15.00	4.00		
2016	East Machias	East Machias	17.0	83.00	12.00	4.00	1.00	
2015	East Machias	East Machias						
2014	East Machias	East Machias						
2013	East Machias	East Machias	31.6	68.40	28.00	2.60	1.00	
2012	East Machias	East Machias	20.5	79.53	14.42	4.69	1.34	
2011	East Machias	East Machias	50.9	49.05	41.50	9.43		
2010	East Machias	East Machias	23.2	76.76	22.22	0.00	1.01	
2009	East Machias	East Machias	17.7	82.30	17.70			
2008	East Machias	East Machias	6.0	94.30	5.70			

Gouldsboro Commercial Fishery:

The Maine Department of Marine Resources manages West Bay Pond for a minimum commercial escapement of 35 fish per acre. The spawning escapement need for this system is 3,500 river herring passed upstream through three closed days per week during the season. The management plan has achieved returns to meet the target escapement developed for this system 95% of the years during the past 20-year period or passed the entire run upstream. The fishery failed to meet the escapement threshold in 2017, and the run was closed for 2018 and resumed in 2019. The run is comprised of all alewife and spawning does not occur below the fishery for either alewife or blueback herring.

Town	River	Lake size (acres)	Threshold (N/acre)
Gouldsboro	n/a	100	35



Fishway, fishing location, and trap deployed in the Gouldsboro alewife fishery.

Year	Municipality	River	% repeat spawners by year and frequency	R-0	R-1	R-2	R-3	R-4
2023	Gouldsboro	N/A	38.0	62.00	31.00	6.00		1.00
2022	Gouldsboro	N/A	19.0	81.00	18.00	1.00		
2021	Gouldsboro	N/A	10.0	90.00	9.00	1.00		
2020	Gouldsboro	N/A	39.0	61.00	32.00	6.00	1.00	
2019	Gouldsboro	N/A	8.0	92.00	8.00			
2018	Gouldsboro	N/A	17.1	82.86	13.33	2.86	0.95	
2017	Gouldsboro	N/A	2.8	97.22	2.78			
2016	Gouldsboro	N/A	7.8	92.20	5.60	2.20		
2015	Gouldsboro	N/A	26.6	73.42	22.15	3.17	1.27	
2014	Gouldsboro	N/A	17.6	82.40	13.60	4.00		
2013	Gouldsboro	N/A	33.3	66.70	30.10	2.70	0.50	
2012	Gouldsboro	N/A	22.2	77.80	22.20			
2011	Gouldsboro	N/A	33.8	66.15	30.76	3.07		
2010	Gouldsboro	N/A	17.5	82.50	15.00	2.50		
2009	Gouldsboro	N/A	17.9	82.10	3.60	14.30	4.00	
2008	Gouldsboro	N/A	29.7	52.40	47.60			

Orland Commercial Fishery:

The Maine Department of Marine Resources manages the Orland River system for a minimum commercial escapement of 35 fish per acre. The spawning escapement need for this system is 39,655 river herring passed upstream through three closed days per week during the fishery. The management plan has achieved returns to meet the target escapement developed for this system for 95% of the years during the past 20-year period or passed the entire run upstream. In 2005 floodwaters limited the commercial catch and the numbers of fish that migrated upstream could not be accurately estimated. It is assumed that most of the run passed upstream after floodwaters receded. Only a portion of historic spawning habitat in the Orland River watershed is accessible to river herring. Access to many of the historic spawning habitats is excluded due to conflicts with sport fish species. There is no expectation that additional habitat will reopen in the near future.

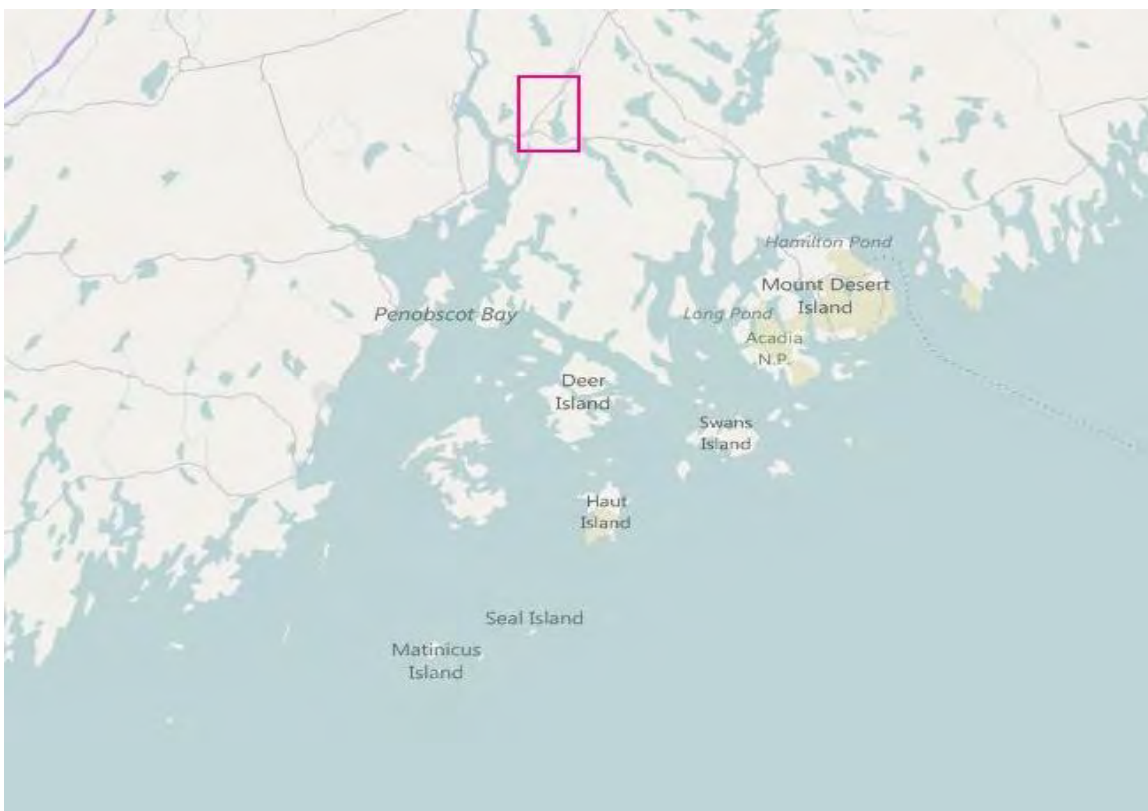
In addition to the closed fishing days the fishery is required to release 200 bushels of alewives upstream to support alewife spawning in Toddy Pond further up in the drainage. This management action was enacted in response to a shift in species composition in the commercial samples which indicated an increase in blueback herring presence without an increase in total river herring landings. Historically blueback herring accounted for 2-5% of the annual river herring catch. In recent years the proportion of blueback herring had increased above 50%. Data suggested that the alewife component of the run was declining, and these data were supported by independent fishway counts of alewives into Toddy Pond. Recent fishway count data and biological samples show an increase in the alewife proportion of the run during the past three years.

The State of Massachusetts granted the municipality of Orland exclusive harvest rights in 1805. Orland is one of two fisheries that DMR permits to use tidal weirs to fish for river herring due to the size of the river at the fishing location. Like the smaller box traps, tidal weirs can capture the entire run entering the river during the open fishing days. Once river herring pass the fishery, they are prevented from falling back below the weir because the weir spans the entire river at low tide, preventing them from reentering the fishery. Fish remain in the river below the dam while they locate the fishways that provide passage upstream. The Orland River, before it was dammed, likely contained runs of American shad and Atlantic salmon. There have been no observations of either species at this location by field staff or the harvester during the past 20 years.

There is no spawning below the tidal fishways on the Orland River for either species of river herring. The first dam on the Orland River has two Alaska Steep Pass fishways which provide upstream passage and at above average high tides the fish can swim over the dam. Neither of the Alaska Steep Passes are available during two hours on either side of low tide.

Town	River	Lake size (acres)	Threshold (N/acre)
Orland	Orland	1,133	35

Buck Pond
Silver Lake
Wights Ln
46
Spawning Location
Duck Cove Rd
Craig Pond
Bucksport
15
Orland
Fishing Location
Acadia Hwy
East Orland
3
Acadia Hwy
1
Verona
Upper Patten Pond
Front Ridge Rd
Spawning location
Castine Rd
175



Hamilton Pond
Mount Desert Island
Penobscot Bay
Long Pond
Acadia N.P.
Deer Island
Swans Island
Haut Island
Seal Island
Matinicus Island

Tidal weir located in Orland, Maine

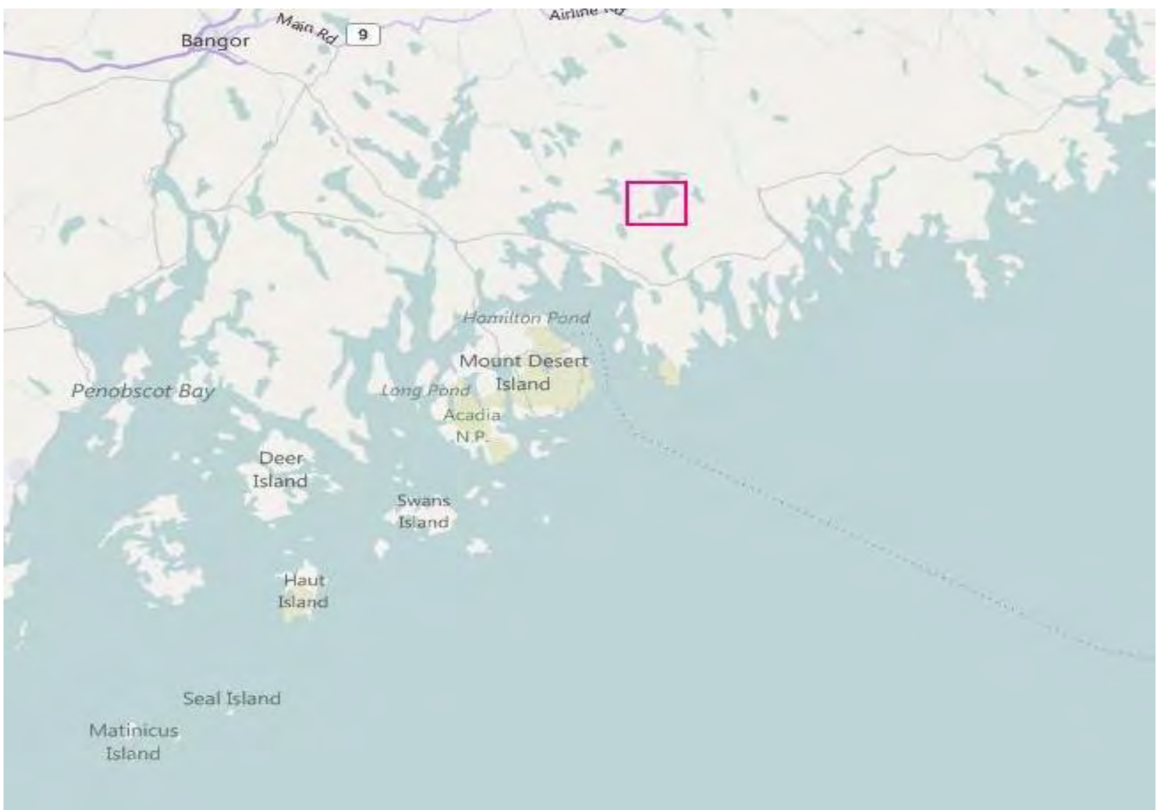
Commercial catches of river herring in May 2010 (left) and May,1970 (right).

Year	Municipality	River	% repeat spawners by year and frequency	R-0	R-1	R-2	R-3	R-4
2023	Orland	Orland River	28.8	66.00	22.00	9.00	2.00	1.00
2022	Orland	Orland River	22.0	78.00	17.00	4.00	1.00	
2021	Orland	Orland River	38.0	62.00	30.00	6.00	2.00	
2020	Orland	Orland River	47.0	53.00	30.00	16.00	1.00	
2019	Orland	Orland River	17.0	69.64	26.78	3.57		
2018	Orland	Orland River	28.3	71.71	23.23	5.05		
2017	Orland	Orland River	28.0	72.00	22.00	6.00		
2016	Orland	Orland River	23.1	76.90	19.25	1.92	1.92	
2015	Orland	Orland River	20.4	79.61	13.59	6.80		
2014	Orland	Orland River	16.7	83.33	15.33	1.33		
2013	Orland	Orland River	14.1	85.90	11.10	1.50	1.50	
2012	Orland	Orland River	15.0	85.00	10.00	5.00		
2011	Orland	Orland River	60.0	39.89	58.08	2.02		
2010	Orland	Orland River	25.0	75.00	21.00	4.00		
2009	Orland	Orland River	22.2	77.80	20.20	2.00		
2008	Orland	Orland River	17.2	82.80	17.20			

Steuben Commercial Fishery:
The Maine Department of Marine Resources manages this system for a minimum commercial escapement of three fish per acre. The spawning escapement need for this system is 6,213 river herring passed upstream by closing the harvest three days per week. The management plan has achieved returns to meet the target escapement developed for this system or passed the entire run upstream. The Steuben system is located several miles inland and is severely limited by beaver activity along the 15-mile-long brook leading to spawning habitat at Tunk Lake. Alewife production at this site depends on high water during both the spring and fall seasons. As a result, production from this system varies widely. This is one of several systems with landlocked salmon, lake trout, and rainbow smelt that the Maine Department of Inland Fisheries and Wildlife manages for sport fish. Commercial samples indicate the fishery is comprised solely of alewife. There is no known spawning for either river herring species within the mainstem river or streams leading to the spawning habitats.

Due to water quality issues associated with its oligotrophic characteristics, Tunk Lake produces very small juvenile alewives that emigrate to sea from July – October. The lake is nutrient poor and is not as productive as other lakes in the region. It is unlikely that increased escapement beyond the 3 fish per acre would produce consistently higher annual returns. The Steuben commercial fishery was closed during the period 2018 – 2020 for failing to meet SFMP sampling and repeat spawning metrics. The commercial harvest resumed in 2021.

Town	River	Lake size (acres)	Threshold (N/acre)
Steuben	Tunk Stream	2,071	3



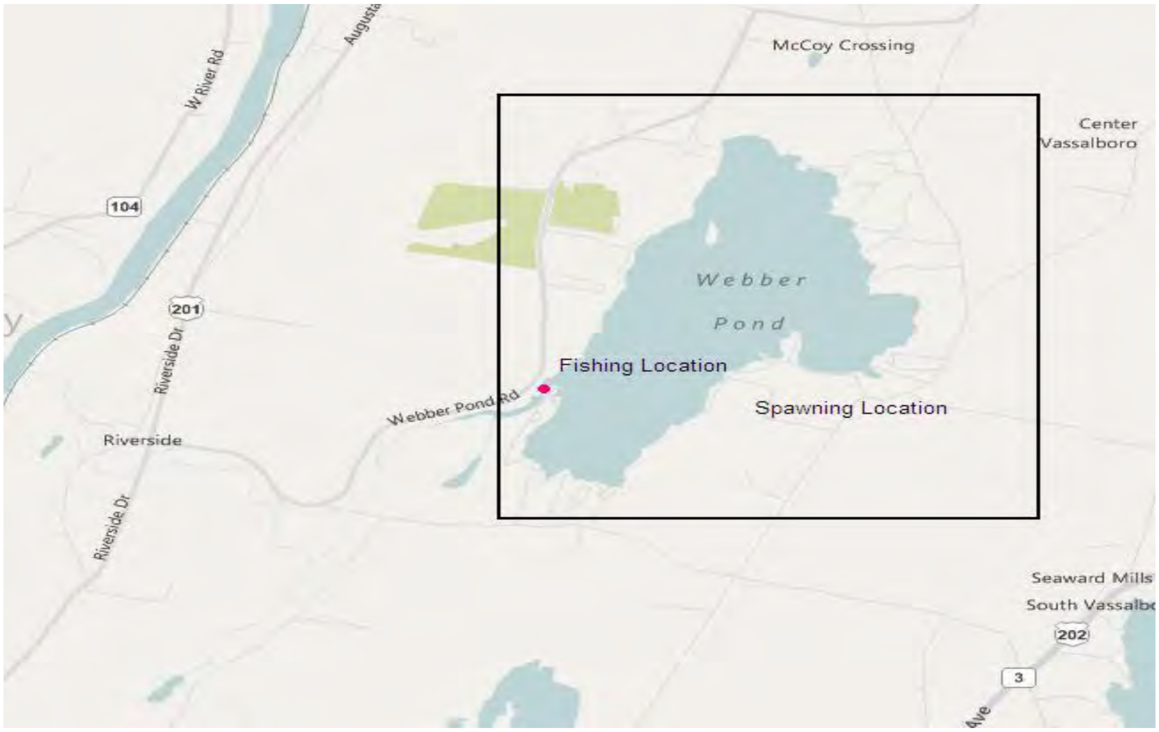
Year	Municipality	River	% repeat spawners by year and frequency	R-0	R-1	R-2	R-3	R-4
2023	Steuben	Tunk River	59.0	41.00	47.00	7.00	5.00	
2022	Steuben	Tunk River	41.6	58.40	23.80	8.90	7.90	1.00
2021	Steuben	Tunk River	47.6	52.38	22.86	15.24	7.62	1.90
2020	Steuben	Tunk River	50.0	50.00	32.00	13.00	4.00	1.00
2019	Steuben	Tunk River	53.0	46.46	34.34	17.17	0.00	2.02
2018	Steuben	Tunk River	27.0	73.00	23.00	2.00	2.00	
2017	No Samples	No Samples						
2016	Steuben	Tunk River	16.7	83.30	10.40	4.20	2.10	
2015	Unreadable	Unreadable						
2014	Steuben	Tunk River	16.8	83.17	7.92	8.91		
2013	Steuben	Tunk River	48.0	52.00	48.00			
2012								
2011	Steuben	Tunk River	20.6	79.38	14.40	6.18		
2010	Steuben	Tunk River	19.6	80.40	15.70	2.00	2.00	
2009								
2008								

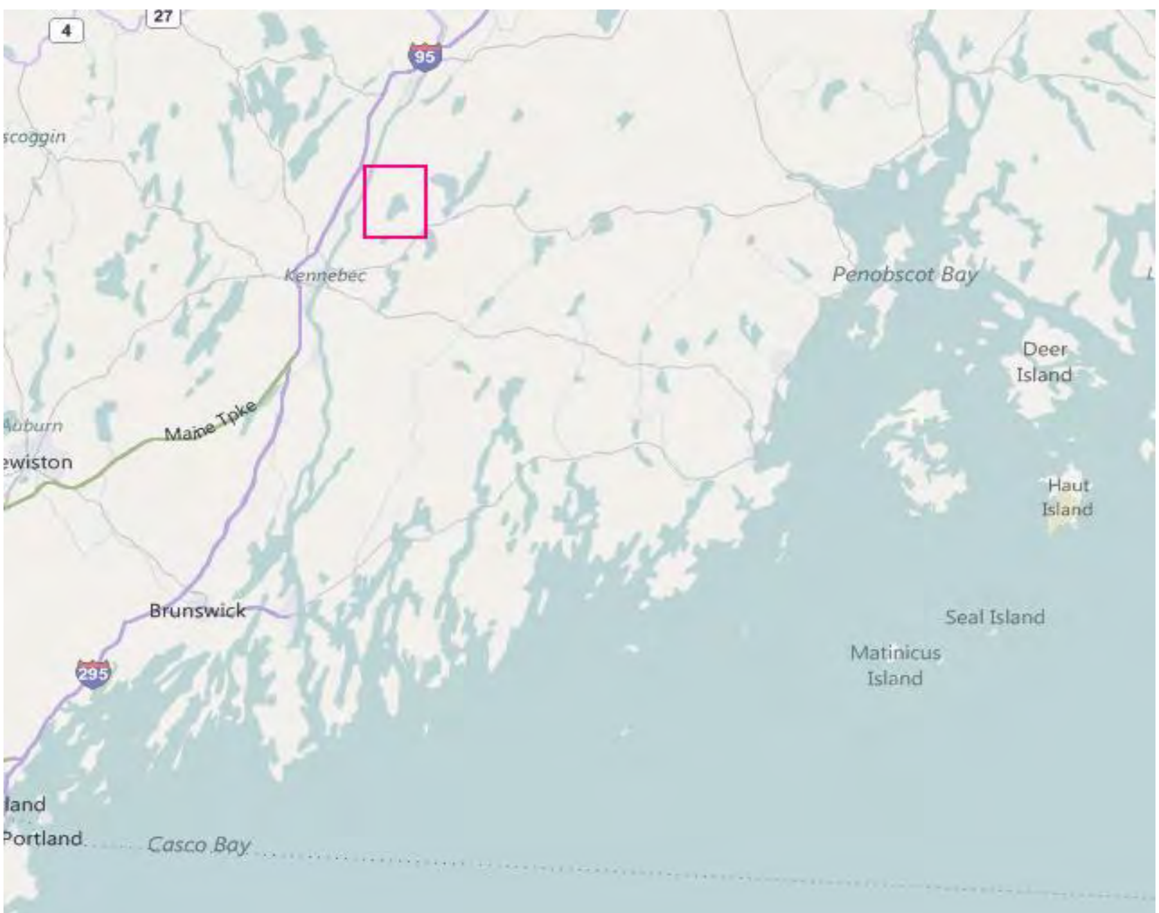
Webber Pond Commercial Fishery:

The commercial fishery at Webber Pond in Vassalboro began in 2009 as the result of a restoration project initiated by the Maine Department of Marine Resources in 2000. Until 2009 alewives were unable to reach spawning habitat in Webber Pond unless they were hand-dipped over the dam. Upstream passage now provides access to spawning habitat within this municipality. The Maine Department of Marine Resources manages this system for a minimum commercial escapement of 35 fish per acre. The municipality currently chooses to have the commercial harvester pass at least 18,000 alewives into spawning habitat before commercial harvest can commence. The minimum spawning escapement need for this system is 42,035 river herring passed upstream through three closed days per week during the season. The management plan has achieved the target escapement developed for this system during all years that the commercial harvest has occurred. Current returns to the commercial fishery are the result of trap and transfer operations that initially stocked the system with approximately 6 fish per acre though an agreement with the Maine Department of Inland Fisheries and Wildlife.

There is no spawning in the stream leading to Webber Pond. Like many of the small streams that lead to spawning habitat in lakes and ponds in Maine the stream is often plugged with beaver dams. The harvester must obtain a permit to remove these dams prior to downstream migration in the fall and the spawning run in the spring.

Town	River	Lake size (acres)	Threshold (N/acre)
Vassalboro	n/a	1,201	35


McCoy Crossing
Center Vassalboro
Webber Pond
Fishing Location
Spawning Location
Webber Pond Rd
Riverside
Riverside Dr
W River Rd
104
201
Seaward Mills
202
3


4
27
95
Kennebec
Penobscot Bay
Deer Island
Haut Island
Maine Tpke
Brunswick
295
Seal Island
Matinicus Island
Casco Bay

Outlet dam at Webber Pond. The commercial fishery occurs upstream and to the left of the dam.

Year	Municipality	River	% repeat spawners by year and frequency	R-0	R-1	R-2	R-3	R-4
2023	Vassalboro	Seven Mile	7.1	92.90	4.00	2.00	1.00	
2022	Vassalboro	Seven Mile	12.0	88.00	10.00	2.00		
2021	Vassalboro	Seven Mile	20.0	80.00	7.00	10.00	3.00	
2020	Vassalboro	Seven Mile	40.0	60.00	29.00	8.00	2.00	1.00
2019	Vassalboro	Seven Mile	43.8	56.19	36.19	4.76	1.90	0.95
2018	Vassalboro	Seven Mile	19.0	80.95	9.52	9.52		
2017	Vassalboro	Seven Mile	62.0	38.00	48.00	14.00		
2016	Vassalboro	Seven Mile	36.0	64.00	30.00	6.00		
2015	Vassalboro	Seven Mile	14.0	86.00	12.00	2.00		
2014	Vassalboro	Seven Mile	23.3	76.80	18.20	5.10		
2013	Vassalboro	Seven Mile	36.3	63.70	31.40	3.90	1.00	
2012	Vassalboro	Seven Mile	13.3	86.70	10.70	2.70		
2011	Vassalboro	Seven Mile	75.8	24.19	50.00	24.19	1.16	
2010	Vassalboro	Seven Mile	25.2	74.80	13.80	10.60	0.80	
2009	Vassalboro	Seven Mile	12.9	87.10	10.60	2.40		
2008								

Ellsworth Commercial Fishery:
There are two large dams on the Union River. The largest is the Ellsworth dam, approximately 66.7 feet high and has four turbine generators with a FERC-authorized capacity of 8.9MW. Graham Lake Dam is approximately 30 feet high and used only to release water from the Graham Lake impoundment. The water storage dam can expand the size of Graham Lake to over 9,000 surface acres. Since 1996, the hydropower owner has artificially propagated the alewife run through a long-term trap and truck program in lieu of permanent fish passage. Prior to the 1980s the state resource agencies transported fish above the hydropower facility to initiate a river herring run. These stockings resulted in returns as high as 1.8 million returning alewives in the mid-1980s. For the past several years the number of alewife stocked above the hydropower dam occurred as the result of the hydropower company owners trucking as many fish as possible during the closed fishing days.

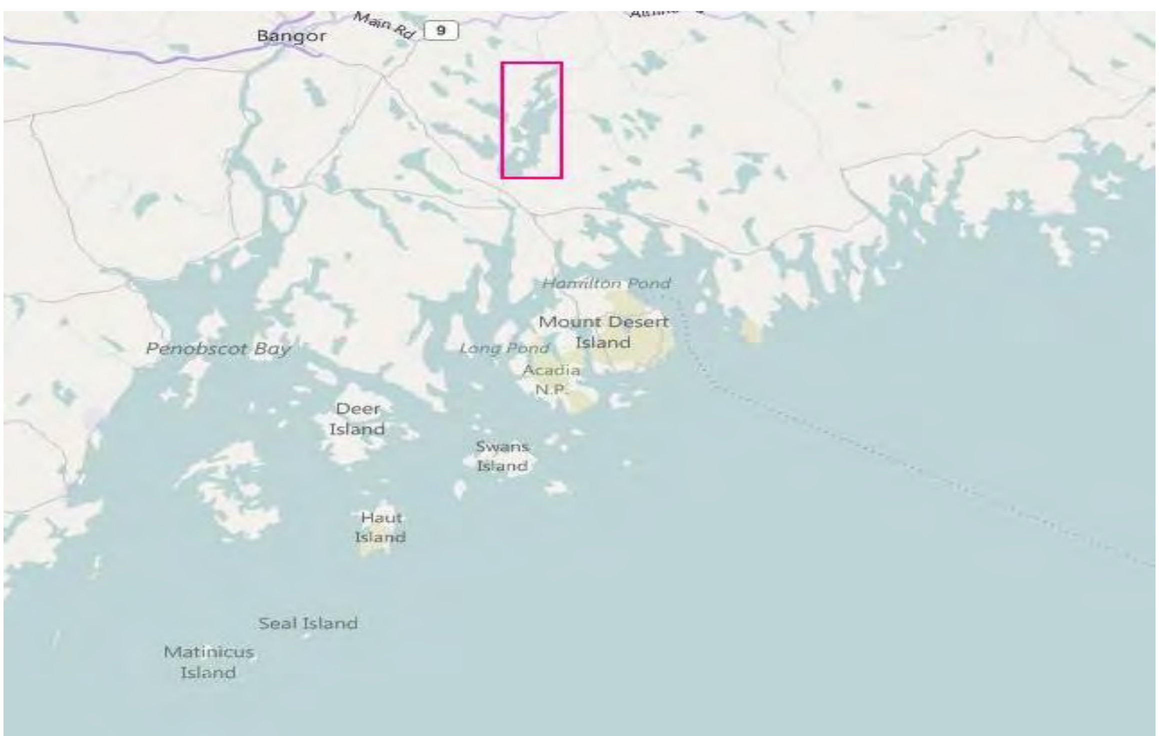
In accordance with the 2015-2017 Union River Fisheries Management Plan, the company currently stocks a minimum of 315,000 alewives annually upstream into Graham and Leonard lakes. Once 150,000 alewives are captured and stocked upstream, harvesting is allowed Monday through Friday each week. The additional 165,000 alewives are stocked on weekends through June 15 each year to represent the age structure and species composition of the run throughout the entire spawning period. Once the harvester attains the stocking goal, the management plan permits the municipality to harvest all remaining river herring coming up the fishway which ends in the hydropower station parking lot. A placeholder is in effect to transport blueback herring above the dams if they arrive at the trapping location. Biological samples indicated that the run is currently comprised entirely of alewife.

In addition to the dedicated downstream passage at the Graham Lake Dam, migrating fish are also known to pass through the turbines at Ellsworth dam. This can result in high mortality for both adult and juvenile river herring. The number of repeat spawning fish returning to the Union River is low compared to all other rivers in Maine. The lack of repeat spawning fish is likely the result of additional mortality from the turbines and high exploitation rate. As the numbers of fish stocked above the dam increased the number of repeat spawning fish also increased. The management plan has achieved the target escapement developed for this system each year during the past 20-year period solely through the efforts of Black Bear Hydro Partners and the contractors hired for the trap and truck program.

The hydropower facility is a peaking operation where water is stored during the night and passed though the turbines during the day when power demand is highest. Spill conditions exist for only three weeks during the early spring ice melt. During the remainder of the year there is no spill over the dam except during high water resulting from an extreme rain event or station shutdowns that provide spill.

There is no spawning below the dam for either species. The Union River is tidal to the base of the dam and provides little riverine habitat for any anadromous fish species. Atlantic salmon are present during some years and when caught in the trap are trucked upstream to spawning habitat. There are several ponds in the watershed that could support river herring, but alewife reintroductions are not permitted by the Department of Inland Fisheries and Wildlife because of perceived conflicts with sport fish species, rainbow smelt, or hatchery operations.

Town	River	Lake size (acres)	Threshold (N/acre)
Ellsworth	Union River	7,865	40



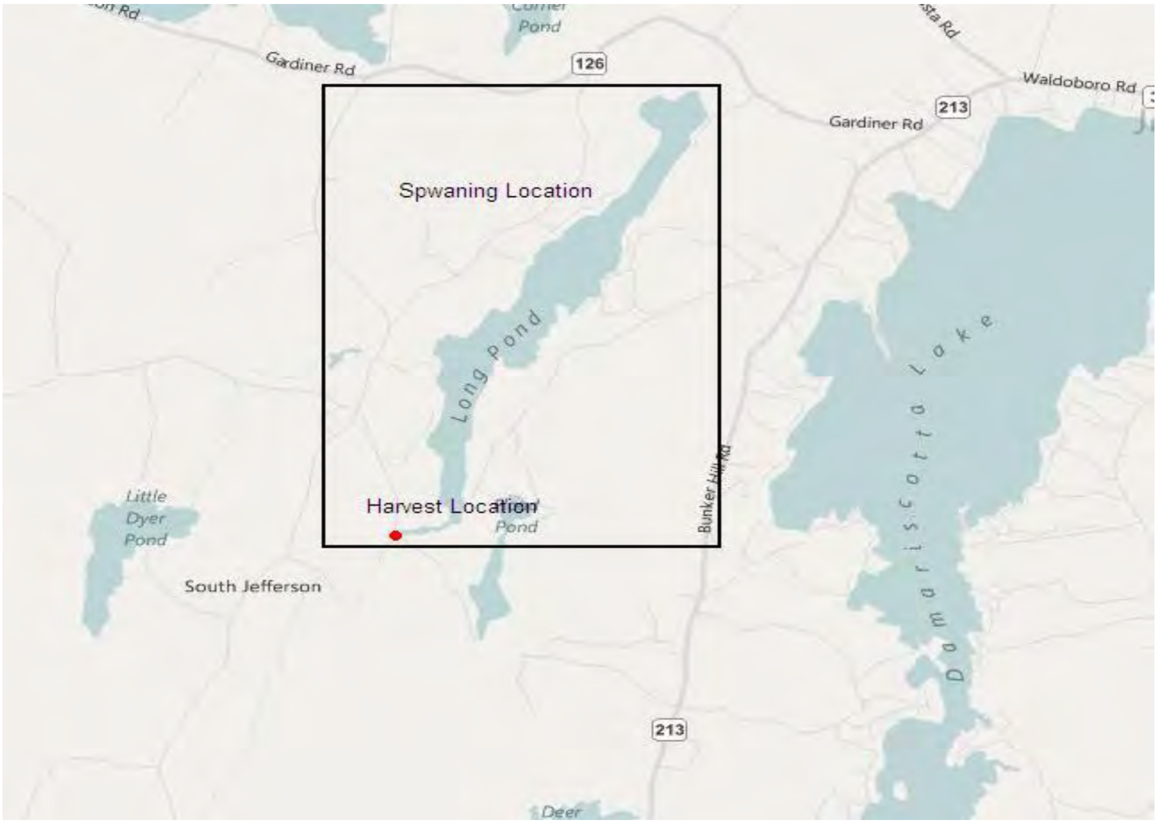
Year	Municipality	River	% repeat spawners by year and frequency	R-0	R-1	R-2	R-3	R-4
2023	Ellsworth	Union	32.0	68.00	29.00	3.00		
2022	Ellsworth	Union	10.6	89.40	6.70	3.80		
2021	Ellsworth	Union	11.0	89.00	9.00	2.00		
2020	Ellsworth	Union	45.0	55.00	41.00	4.00		
2019	Ellsworth	Union	1.1	98.95	1.05			
2018	Ellsworth	Union	3.9	96.08	3.92			
2017	Ellsworth	Union	23.8	76.19	20.95	2.86		
2016	Ellsworth	Union	29.2	70.80	29.20			
2015	Ellsworth	Union	7.8	92.22	7.78			
2014	Ellsworth	Union	17.0	83.00	12.00	5.00		
2013	Ellsworth	Union	12.0	88.00	12.00			
2012	Ellsworth	Union	10.9	89.10	7.90	3.00		
2011	Ellsworth	Union	7.9	92.10	7.23	0.65		
2010	Ellsworth	Union	8.0	92.00	7.00	1.00		
2009	Ellsworth	Union	7.0	92.30	2.80	4.90		
2008	Ellsworth	Union	2.0	98.00	2.00			

Jefferson Commercial Fishery:

The Maine Department of Marine Resources manages Dyer-Long Pond for a minimum commercial escapement of 35 fish per acre. The spawning escapement need for this system is 14,875 river herring passed upstream through a three-day closed period per week throughout the season. The management plan has achieved returns to meet the target escapement developed for this system or passed the entire run during each year for the past 20-year period. This fishery is typical of the smaller commercial river herring fisheries in Maine. The outlet stream from Dyer-Long Pond is a small coastal tributary to the lower Sheepscot River. This stream is heavily impacted by beaver activity in the fall that delay downstream passage and can obstruct upstream passage the following spring if the dams are not breached or spring flows do not overtop the dams.

The river herring run into Dyer-Long Pond is entirely alewife. Blueback herring are not present in the commercial catches or samples collected by field staff. There is no spawning habitat below the fishway for blueback herring or alewife. Poaching along the stream is a problem at times during the spring migration. The stream is easily accessible at several points along its course to the Sheepscot River.

Town	River	Lake size (acres)	Threshold (N/acre)
Jefferson	Dyer River	425	35


Gardiner Rd
Pond
126
Waldoboro Rd
213
Gardiner Rd
Spwaning Location
Long Pond
Damariscotta Lake
Little
Dyer
Pond
Harvest Location
Pond
Bunker Hill Rd
South Jefferson
213
Deer


Kennebec
Penobscot Bay
Long Pond
Mount De
Island
Acadia
N.P.
Deer
Island
Swans
Island
Maine Tpke
Haut
Island
Brunswick
Seal Island
Matinicus
Island
Casco Bay

Outlet stream from Dyer-Long Pond, fishway leading into the pond and alewife trap at the pond outlet.

Year	Municipality	River	% repeat spawners by year and frequency	R-0	R-1	R-2	R-3	R-4
2023	Jefferson	Dyer River	9.1	90.90	8.10	1.00		
2022	Jefferson	Dyer River	11.5	88.50	8.70	2.90		
2021	Jefferson	Dyer River	30.0	71.15	17.31	10.58	0.96	
2020	Jefferson	Dyer River	33.7	66.31	23.16	8.42	2.11	
2019	Jefferson	Dyer River	29.0	71.00	25.00	4.00		
2018	Jefferson	Dyer River	18.1	81.90	17.10	0.95		
2017	Jefferson	Dyer River	9.0	91.00	9.00			
2016	Jefferson	Dyer River	54.7	45.30	53.10	1.60		
2015	Jefferson	Dyer River	24.8	75.24	20.00	3.81	0.95	
2014	Jefferson	Dyer River	26.5	73.50	20.60	5.20	0.60	
2013	Jefferson	Dyer River	23.9	76.10	20.60	3.20		
2012	Jefferson	Dyer River	34.3	65.70	28.30	5.10	1.00	
2011	Jefferson	Dyer River	64.0	36.00	62.00	2.00		
2010	Jefferson	Dyer River	15.2	84.40	14.10	1.50		
2009	Jefferson	Dyer River	1.8	98.20	1.80			
2008	Jefferson	Dyer River	62.7	37.25	60.78	1.96		

Sullivan Commercial Fishery:

The Maine Department of Marine Resources manages Flanders Pond for a minimum commercial escapement of 35 fish per acre. The spawning escapement need for this system is 3,222 river herring passed upstream through a three-day closed period per week throughout the season. The management plan has achieved returns to meet the target escapement developed for this period system or passed the entire run upstream. The harvester monitors the stream during the spring and fall migration periods to ensure upstream and downstream passage is available. The condition of the outlet dam is poor and water levels can be difficult to maintain due to leaks which complicate fish passage. There is no spawning in the stream below or above the fishery other than the lake habitat. Blueback herring are not observed in biological samples or commercial catches. There are no dams located on the stream, but the previous fishway and culvert did impede upstream passage at certain flows. In 2012 a new bottomless arched culvert was installed, eliminating fish passage issues for anadromous fish in this system, though not at the dam. The commercial fishery was closed during 2021 for failure to meet SMFP metrics, no commercial fishery occurred in 2022, and a limited fishery occurred in 2023, harvesting only 60 bushels. The Sullivan fishery is one of the Maine fisheries that harvests primarily for personal use. Using commercial harvest to estimate escapement if not practical for this location.

Town	River	Lake size (acres)	Threshold (N/acre)
Sullivan	n/a	92	35


Spawning Location
Flanders Pond
Harvest Location
Hog Ba
200
Bert Gray Rd
Sullivan
1
Sullivan
Schoodic Scenic Byway
Sorrento
1
East Sullivan


New England
Taunton Bay
Tunk Lake
Ellsworth
US Hwy 1
Bar Harbor Rd
Route 1
3
102
Eden St
Eagle Lake Rd
Mount Desert Island
Acadia N.P.
Sound Dr
198
Schoodic Peninsula
Great Cranberry Island
Atlantic Ocean
Bar Harbor-Yarmouth Int'l Ferry
Swans Island
Long Island

Fishway leading to spawning habitat in Flanders Pond prior to fall of 2012 (left). Removal of the fish ladder and installation of a bottomless arch culvert ready for the 2013 alewife migration (right).

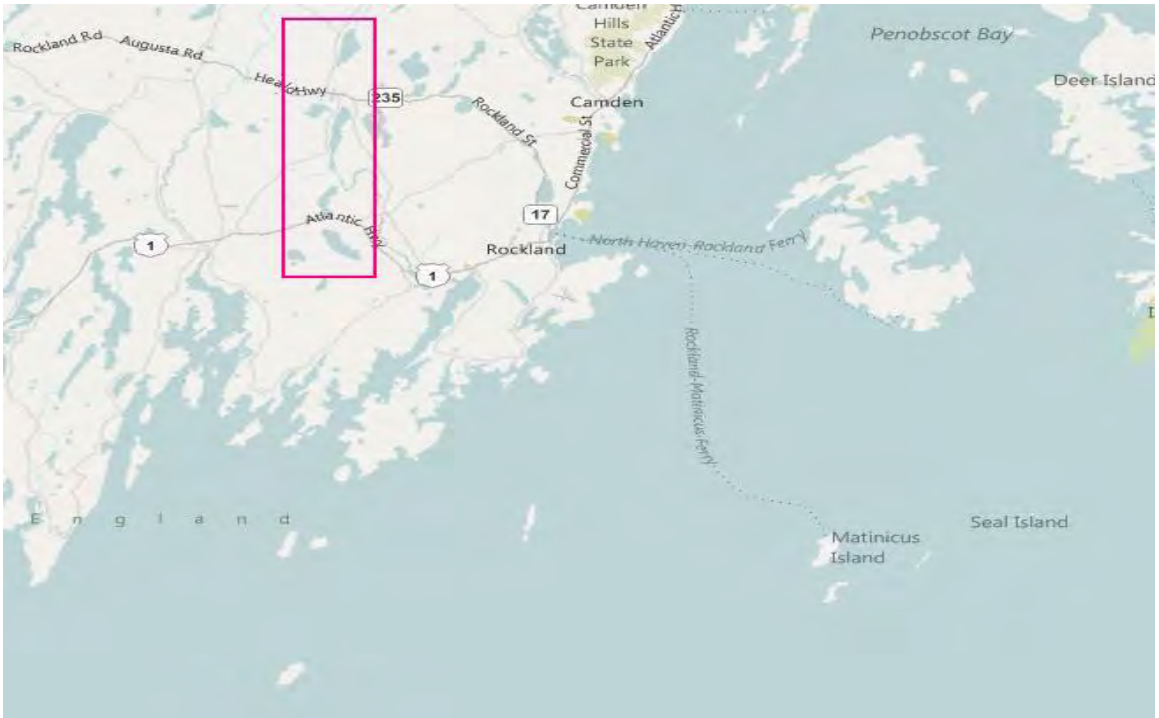
Year	Municipality	River	% repeat spawners by year and frequency	R-0	R-1	R-2	R-3	R-4
2023	Sullivan	N/A	25.2	74.70	24.20	1.00		
2022	No Fishery	N/A	11.0	89.00	11.00			
2021	No Fishery	N/A						
2020	Sullivan	N/A	68.7	31.31	48.48	15.15	5.05	
2019	Sullivan	N/A	28.0	72.00	20.00	8.00		
2018	Sullivan	N/A	36.0	64.00	25.00	10.00	1.00	
2017	Sullivan	N/A	26.0	74.00	24.00	2.00		
2016	Sullivan	N/A	28.0	72.00	23.00	5.00		
2015	Sullivan	N/A	48.5	51.52	33.33	8.08	7.07	
2014	Sullivan	N/A	43.0	57.00	21.00	22.00		
2013	No Sampling	N/A						
2012	Sullivan	N/A	8.5	91.50	8.50			
2011	No Sampling	N/A						
2010	Sullivan	N/A	11.8	88.20	10.50	1.30		
2009	Sullivan	N/A	26.3	73.70	23.70	2.60		
2008	Sullivan	N/A	33.3	66.70	22.20	11.10		

Warren Commercial Fishery:

The Maine Department of Marine Resources manages the St. George River Watershed for a minimum commercial escapement of 35 fish per acre. The management plan has achieved returns to meet the target escapement developed for this system. The spawning escapement need for this system is 66,115 river herring passed upstream by a two-day closure of the fishery each week and a delay in deploying the weir until sometime after May 1 of the fishing year. Due to the size of the weir and spring flows in the river, deploying the weir and active fishing at this location typically does not occur until the second week of May. During most years the delay in deploying the weir allows a larger proportion of the spawning stock to pass upstream compared to typical fisheries. There are several individual and varied spawning habitats within the watershed that act to support the large river herring run, which consists of both blueback herring and alewife.

Warren is one of the oldest and most productive commercial fisheries in Maine. The State of Massachusetts granted Warren exclusive harvest rights in 1802. By 1869 there were 16 dams on the mainstem of the St George River. The mainstem river is now clear of manmade obstructions and most spawning habitat is now accessible to river herring, however there are portions of historic habitat that are still inaccessible in the upper watershed. Dams at lake outlets without fish passage are the biggest obstacle to the full restoration of the watershed. There are blueback herring mixed in with the commercial alewife catches toward the end of the fishing season. Blueback herring continue to migrate upstream in large numbers after the June 5 commercial season closing date. The number of blueback herring in the system is estimated at 950,000 based on available spawning habitat. There is no spawning habitat located in the tidal river, below the town fishery, for either species.

Town	River	Lake size (acres)	Threshold (N/acre)
Warren	St. George	1,889	35



Year	Municipality	River	% repeat spawners by year and frequency	R-0	R-1	R-2	R-3	R-4
2023	Warren	St. George	25.2	74.80	13.50	7.10	3.90	0.60
2022	Warren	St. George	28.5	71.50	20.80	6.20	0.00	1.50
2021	Warren	St. George	37.2	62.76	22.07	11.03	3.45	0.69
2020	Warren	St. George	44.7	55.33	28.67	13.33	2.67	
2019	Warren	St. George	28.7	71.33	27.33	0.00	1.33	
2018	Warren	St .George	11.3	88.67	6.67	2.67	2.00	
2017	Warren	St .George	36.8	63.22	20.65	13.55	2.58	
2016	Warren	St .George	44.8	55.20	26.40	12.80	5.60	
2015	Warren	St .George	23.7	76.32	13.16	5.26	5.26	
2014	Warren	St .George	37.6	62.38	20.79	6.93	9.90	
2013	Warren	St .George	35.1	64.90	27.40	4.80	2.80	
2012	Warren	St .George	44.4	55.60	30.50	8.60	5.30	
2011	Warren	St .George	29.8	70.20	21.91	5.47	2.39	
2010	Warren	St .George	20.0	80.00	15.00	5.00		
2009	Warren	St. George	28.0	72.00	22.80	4.00	1.10	
2008	Warren	St. George	37.0	63.00	24.00	13.00		

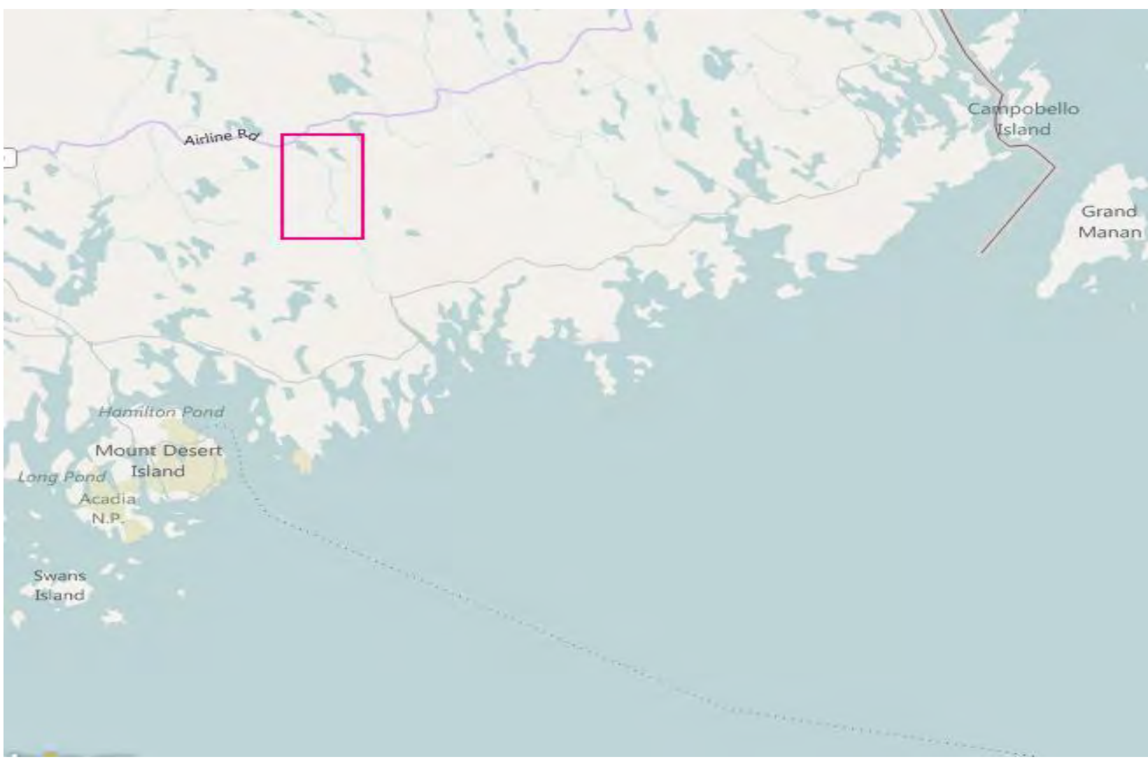
Fishing weir located at the head of tide on the St. George River in Warren, Maine.

Cherryfield Commercial Fishery:

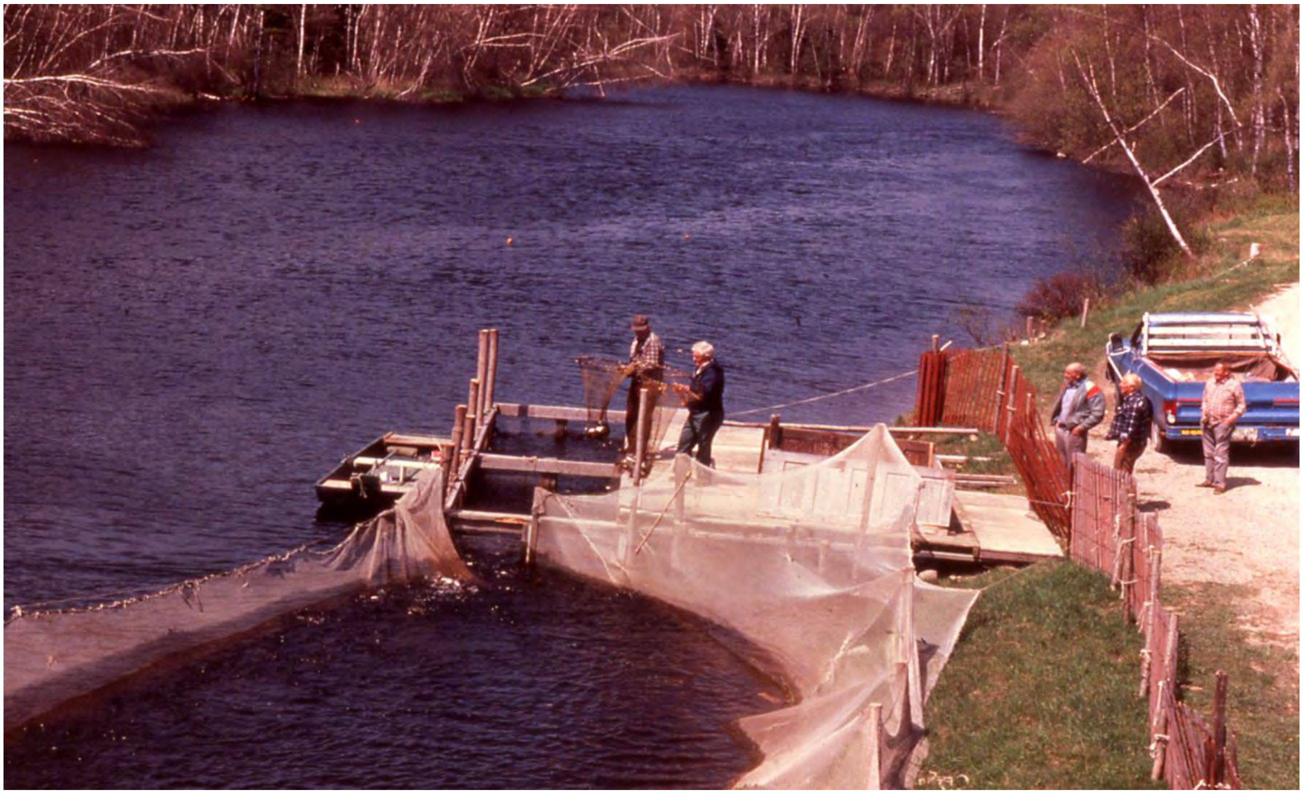
The Maine Department of Marine Resources the Narraguagus River for a minimum commercial escapement of 35 fish per acre. The spawning escapement need for this system is 29,050 river herring passed upstream through the three closed fishing days per week throughout the fishing season. The management plan has achieved the target escapement developed for this system or passed the entire run each year.

The Narraguagus River is an Atlantic salmon river with a significant number of alewives spawning in the lakes upstream of the dam located just above the head of tide. DMR fisheries biologists capture returning Atlantic salmon in a trap before salmon reach the alewife fishery released them into the river above the dam. A small run of American shad also spawn in the river above the dam and provide sport fishing opportunities for the region. There is no indication that blueback herring utilize this river based on commercial samples collected at the fishing location. There is only a short stretch of freshwater below the dam and there is no evidence that river herring spawn in this stretch of river.

Town	River	Lake size (acres)	Threshold (N/acre)
Cherryfield	Narraguagus	830	35



Commercial alewife fishery above the Cherryfield dam during the 1980s.



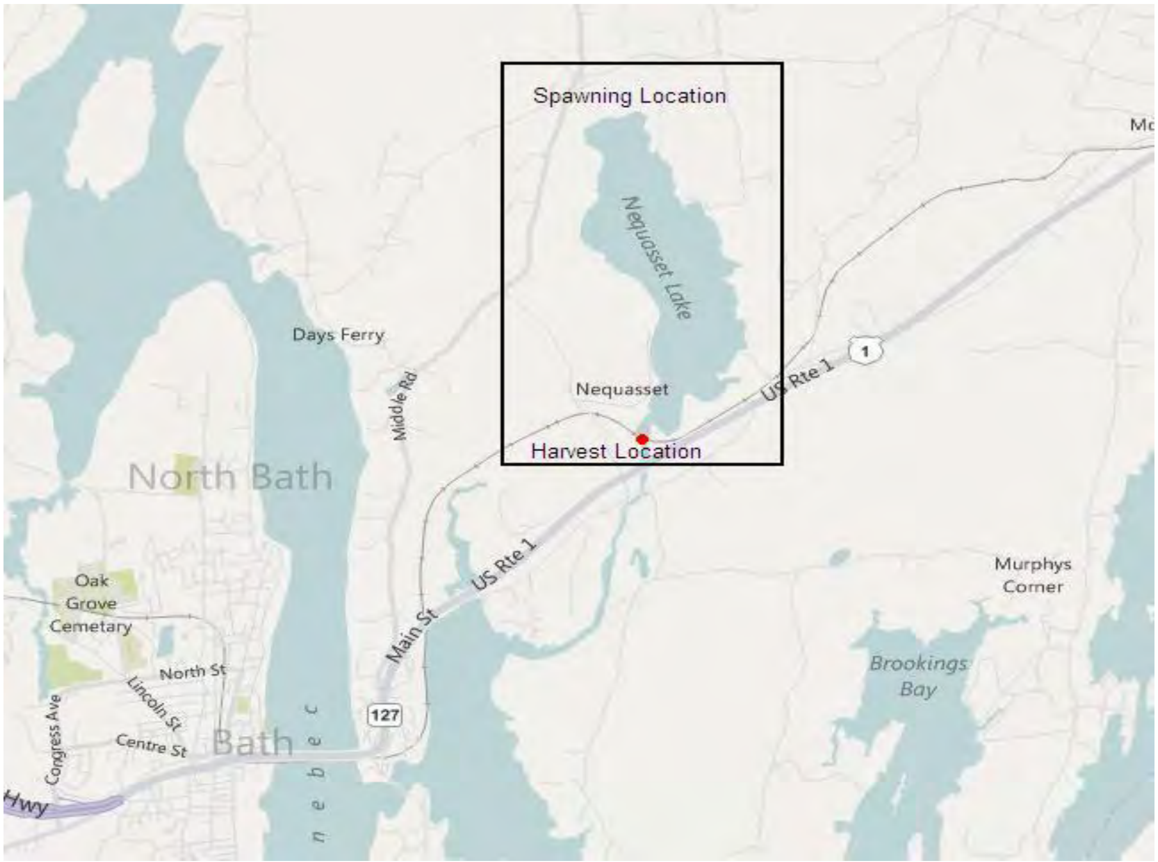
Year	Municipality	River	% repeat spawners by year and frequency	R-0	R-1	R-2	R-3	R-4
2023	Cherryfield	Narraguagus	52.5	47.50	40.60	8.90	3.00	
2022	Cherryfield	Narraguagus	16.0	84.00	10.00	6.00		
2021	Cherryfield	Narraguagus	50.9	49.12	41.23	8.77	0.88	
2020	Cherryfield	Narraguagus	44.0	56.00	32.00	9.00	3.00	
2019	Cherryfield	Narraguagus	66.0	34.00	36.00	23.00	7.00	
2018	Cherryfield	Narraguagus	32.0	68.00	31.00	1.00		
2017	Cherryfield	Narraguagus	27.0	73.00	17.00	9.00	2.00	
2016	Cherryfield	Narraguagus	26.0	74.00	19.00	6.00	1.00	
2015	No Sampling							
2014	Cherryfield	Narraguagus	23.3	76.77	12.12	11.00		
2013	Cherryfield	Narraguagus	26.7	73.30	22.00	4.00	0.70	
2012	Cherryfield	Narraguagus	29.0	70.94	20.94	6.10	2.00	
2011	Cherryfield	Narraguagus	37.0	63.20	32.18	4.60		
2010	Cherryfield	Narraguagus	20.0	80.00	18.00	1.00	1.00	
2009	No Sampling							
2008	Cherryfield	Narraguagus	29.3	82.80	15.20	2.00		

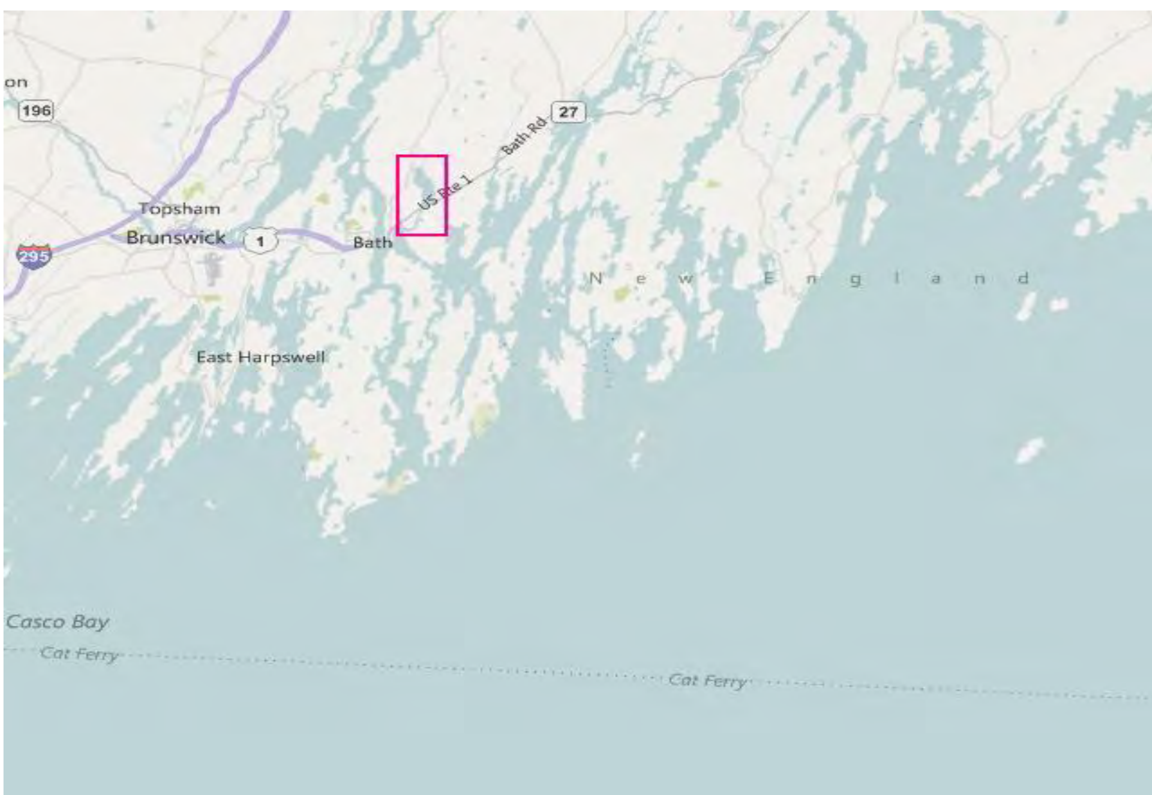
Woolwich Commercial Fishery:
The Maine Department of Marine Resources manages Nequasset Lake for a minimum commercial escapement of 35 fish per acre. The spawning escapement need for this system is 13,720 river herring passed upstream by the harvester. The management plan has achieved returns to meet the target escapement developed for this system or passed the entire run each year for the past 20-year period. This fishery is one of two commercial fisheries that allow constant spawning escapement throughout the run and is closed for an additional 72-hours during the week. To improve passage the fishway was rebuilt in 2014 and monitoring of the new passage structure is ongoing. Escapement counts into the lake are monitored using the VisuCount protocol and provide an alternative method of determining escapement at this location compared to estimates from commercial catches.

The fishery is located at the entrance to the tidal fishway that leads to Nequasset Lake. The Nequasset fishery is one of a handful of locations that harvest river herring for food. River herring are salted and smoked as a seasonal delicacy. Smoked alewives sell for $90.00 per/bushel compared to $35.00 per/bushel for lobster bait. Alewives sold as bait at Nequasset are rationed between the numbers of fishermen that arrive in the morning to pick up bait. Nequasset, like most fisheries, cap the number of alewives sold to any one fisherman per day. At Nequasset the daily limit per buyer is 2-4 bushel per day. The sale format allows the limited amount of bait caught on any one day to supply a larger number of individual fishermen.

Nequasset Lake is a municipal water supply for several towns in the surrounding area. Maintaining high water quality is important to the water district. Currently there are no limitations on the number of alewives permitted into the lake to spawn, though some municipal water districts prohibit alewife reintroduction. There is no evidence to this point that alewives are causing water quality concerns.

Town	River	Lake size (acres)	Threshold (N/acre)
Nequasett	Kennebec	392	35


Spawning Location
Nequasset Lake
Nequasset
Harvest Location
Days Ferry
Middle Rd
North Bath
US Rte 1
Main St
127
Oak
Grove
Cemetary
North St
Lincoln St
Congress Ave
Centre St
Bath
Hwy
Murphys
Corner
Brookings
Bay


196
27
Bath Rd
US Rte 1
Topsham
Brunswick
295
1
Bath
New England
East Harpswell
Casco Bay
Cat Ferry
Cat Ferry

Historic picture of the Nequasset Mill and fish passage to spawning habitat and the trapping facility prior to 2014 rebuild.

The Nequasset fishway and entrance to the trapping facility after repair in 2014.

Year	Municipality	River	% repeat spawners by year and frequency	R-0	R-1	R-2	R-3	R-4
2023	Woolwich	Kennebec	7.0	93.00	6.00	1.00		
2022	Woolwich	Kennebec	20.2	79.00	16.20	2.90	1.90	
2021	Woolwich	Kennebec	28.6	71.43	10.48	17.14	0.95	
2020	Woolwich	Kennebec	65.7	34.31	56.86	8.82		
2019	Woolwich	Kennebec	29.7	70.30	25.74	3.94		
2018	Woolwich	Kennebec	12.0	88.00	12.00			
2017	Woolwich	Kennebec	26.0	74.00	20.00	6.00		
2016	Woolwich	Kennebec	32.5	64.80	28.60	6.70		
2015	Woolwich	Kennebec	27.6	72.45	27.55			
2014	Woolwich	Kennebec	11.0	89.00	10.00	1.00		
2013	Woolwich	Kennebec	20.3	79.70	18.90	1.40		
2012	Woolwich	Kennebec	15.2	84.80	14.30	1.00		
2011	Woolwich	Kennebec	15.0	84.96	13.72	0.65	0.65	
2010	Woolwich	Kennebec	9.1	90.90	7.10	2.00		
2009	Woolwich	Kennebec	47.5	51.30	43.60	5.10		
2008	Woolwich	Kennebec	53.8	46.20	38.50	15.40		

Perry Commercial Fishery:

The Maine Department of Marine Resources manages Boyden Lake for a minimum commercial escapement of 35 fish per acre. The spawning escapement need for this system is 59,570 river herring passed upstream through a three day per week closure in the fishery. The management plan has achieved the target escapement developed for this system or passed the entire run each year.

This system has significant issues with beaver dams that restrict upstream and downstream migration throughout the season. Fish that escape the commercial fishery may, or may not, reach spawning habitat depending on water conditions. Boyden Lake is a municipal water supply operated by the Passamaquoddy Indian Tribe. Fluctuating water levels during upstream and downstream migrations influence the number of annual returns and survival of postspawn adults migrating downstream. The system is responsive when spawning fish can access the pond. There is no spawning habitat below the dam for either species of river herring. Beaver dams and low water flows that fail to attract fish to the stream or fishway entrance are the main obstacles to producing a larger run. Commercial harvest did not occur for several years prior to 2004.

The fishery in the town of Perry is operated by a commercial fisherman who chooses to harvest fish for personal use and not commercial retail sale. The harvester elects to pass fish upstream in addition to the required closed days. As a result, the harvest reported for this system is lower than expected and estimates of escapement based on harvest are low. The Maine Department of Marine Resources and Maine Sea Grant periodically install electronic fish counters at this location to assess escapement to ensure the fishery meets SFMP metrics.

Town	River	Lake size (acres)	Threshold (N/acre)
Perry	Little River	1,702	35

Dam and fishway under high flow conditions in 2006. Note harvest box and sluice pipe located at the corner pool of the fishway used to transport harvested fish into totes.

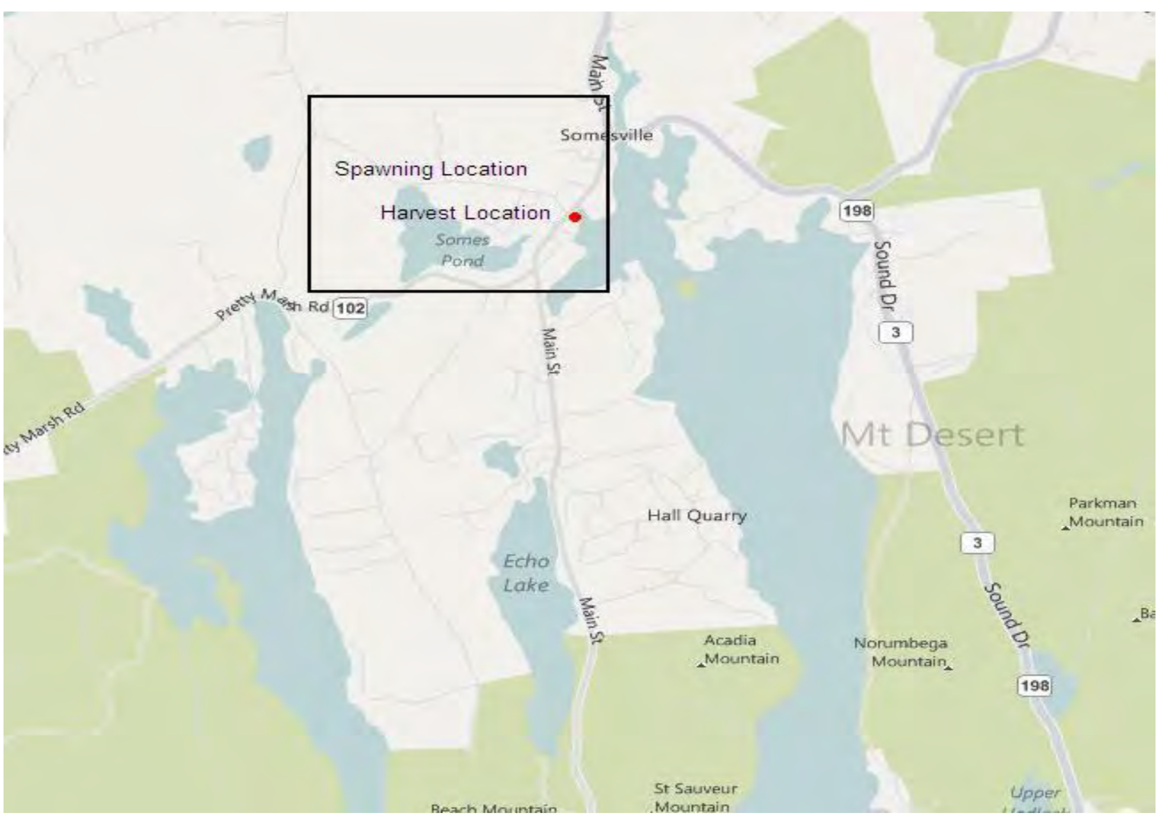
Year	Municipality	River	% repeat spawners by year and frequency	R-0	R-1	R-2	R-3	R-4
2023	Perry	Little River	14.0	86.00	13.00	1.00		
2022	Perry	Little River	17.0	83.00	15.00	2.00		
2021	Perry	Little River	9.0	91.00	6.00	1.00	2.00	
2020	Perry	Little River	52.0	48.00	16.00	33.00	3.00	
2019	Perry	Little River	79.0	21.00	54.00	23.00	0.00	2.00
2018	Perry	Little River	13.0	87.00	13.00			
2017	Perry	Little River	14.0	86.00	13.00	1.00		
2016	Perry	Little River	28.0	72.00	24.00	4.00		
2015	Perry	Little River	16.8	83.17	11.88	4.95		
2014	Perry	Little River	8.1	91.90	7.10	1.00		
2013	Perry	Little River	30.0	70.00	28.00	2.00		
2012	Perry	Little River	8.1	91.90	7.10	1.00		
2011	Perry	Little River	21.2	78.80	15.20	6.10		
2010	Perry	Little River	38.0	62.00	34.00	4.00		
2009	Perry	Little River	4.0	96.00	4.00			
2008	Perry	Little River	7.0	93.00	7.00			

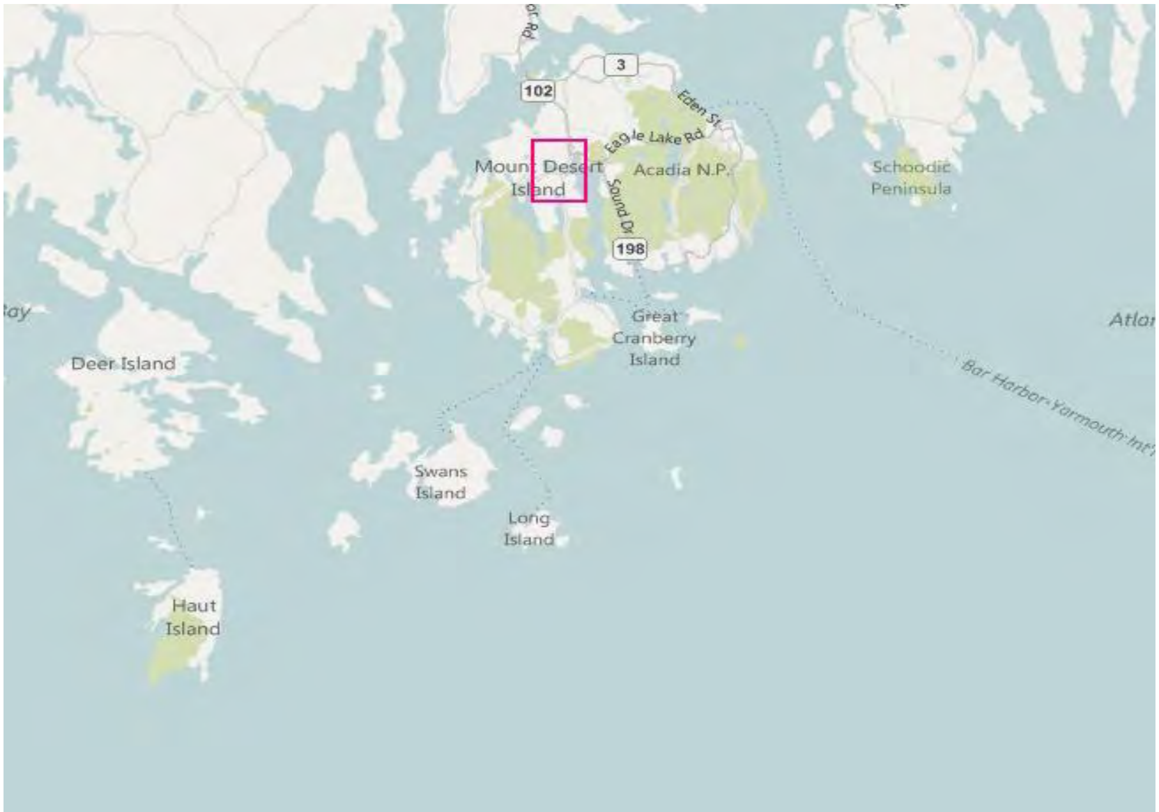
Mount Desert Commercial Fishery:

The Maine Department of Marine Resources Somes Pond for a minimum commercial escapement of 35 fish per acre. The spawning escapement need for this system is 3,640 river herring passed upstream. The municipality of Mount Desert selects to keep the run closed for conservation at this time, though recent counts indicate that a harvest is possible and has been approved by ASMFC. Fisheries staff began to collect age and repeat spawning data at this location in 2010. The spawning habitat at this location is limited and historically never produced large numbers of fish which could migrate to Somes Pond or Long Pond. Passage is difficult and several fishways are required to reach Long Pond spawning habitat. The run is entirely alewife based on analysis of the biological samples collected within the system.

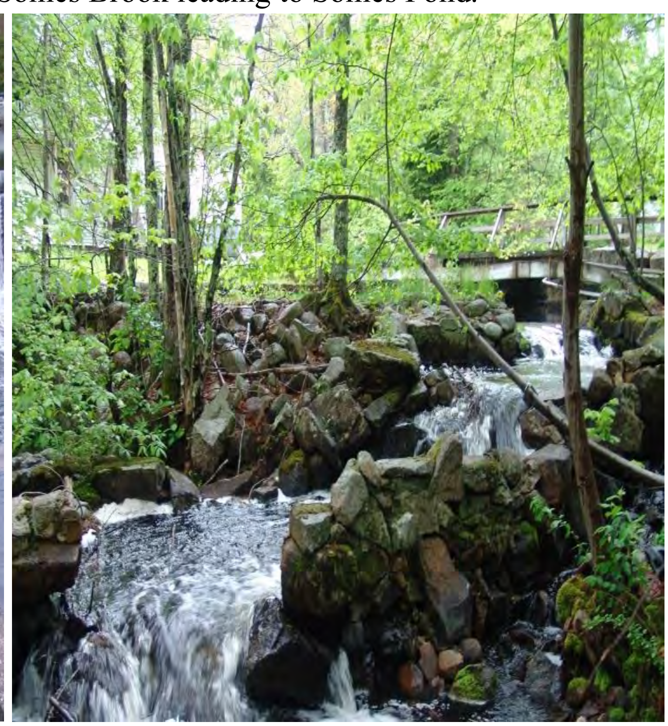
The fishway is a tidal fishway that is accessible only as the tide rises to meet the fishway entrance. This limits the time fish can access the fishway and migrate to spawning location upstream. This is common at several commercial harvest locations throughout the state. This emphasizes the need to maintain, clean, and monitor the tidal fish passages daily to ensure unobstructed upstream passage. The harvesters hired by the municipalities often fill this role, freeing state personnel to address other passage issues. At this location the local wildlife sanctuary monitors passage and maintains the fishways.

Town	River	Lake size (acres)	Threshold (N/acre)
Mount Desert	n/a	104	35





Tidal Denil fishway located in Somes Harbor and Somes Brook leading to Somes Pond.



Year	Municipality	River	% repeat spawners by year and frequency	R-0	R-1	R-2	R-3
2023	MDI	Somes/Long Pond	35.0	65.00	23.00	11.00	1.00
2022	MDI	Somes/Long Pond	51.2	48.80	46.40	4.80	
2021	MDI	Somes/Long Pond	12.1	87.90	11.10	1.00	
2020	MDI	Somes/Long Pond	10.1	89.90	8.10	2.02	
2019	MDI	Somes/Long Pond	21.2	78.72	19.15	2.13	
2018	MDI	Somes/Long Pond					
2017	MDI	Somes/Long Pond	6.1	93.94	6.06		
2016	MDI	Somes/Long Pond	5.0	95.00	5.00		

Benton Commercial Fishery:

In 2009, the Town of Benton resumed a commercial fishery for river herring for the first time in 198 years. The fishery is the result of the removal of the Edwards Dam in Augusta, Maine and a ten-year fisheries restoration program in the Kennebec River and Sebasticook River watersheds. The Maine Department of Marine Resources currently manages this system for a minimum commercial escapement of 35 fish per acre. The minimum spawning escapement need for this system is 379,890 river herring passed upstream into several spawning habitats in the Sebasticook River drainage.

Soon after the restoration project began, the Maine Department of Inland Fisheries and Wildlife and Maine Department of Marine Resources permitted a limited dip net fishery in the river below the first dam (2000-2006). DMR staff believes landings for this period were underreported based on the numbers of fishing permits issued and the number of landings reported at the end of the fishing season. The DMR closed the fishery in 2007 to allow the municipality of Benton to reacquire historical rights to the harvest. The Town of Benton conducted its first commercial dip net fishery in the Sebasticook in 2009 and the Town maintained this harvest method through 2024.

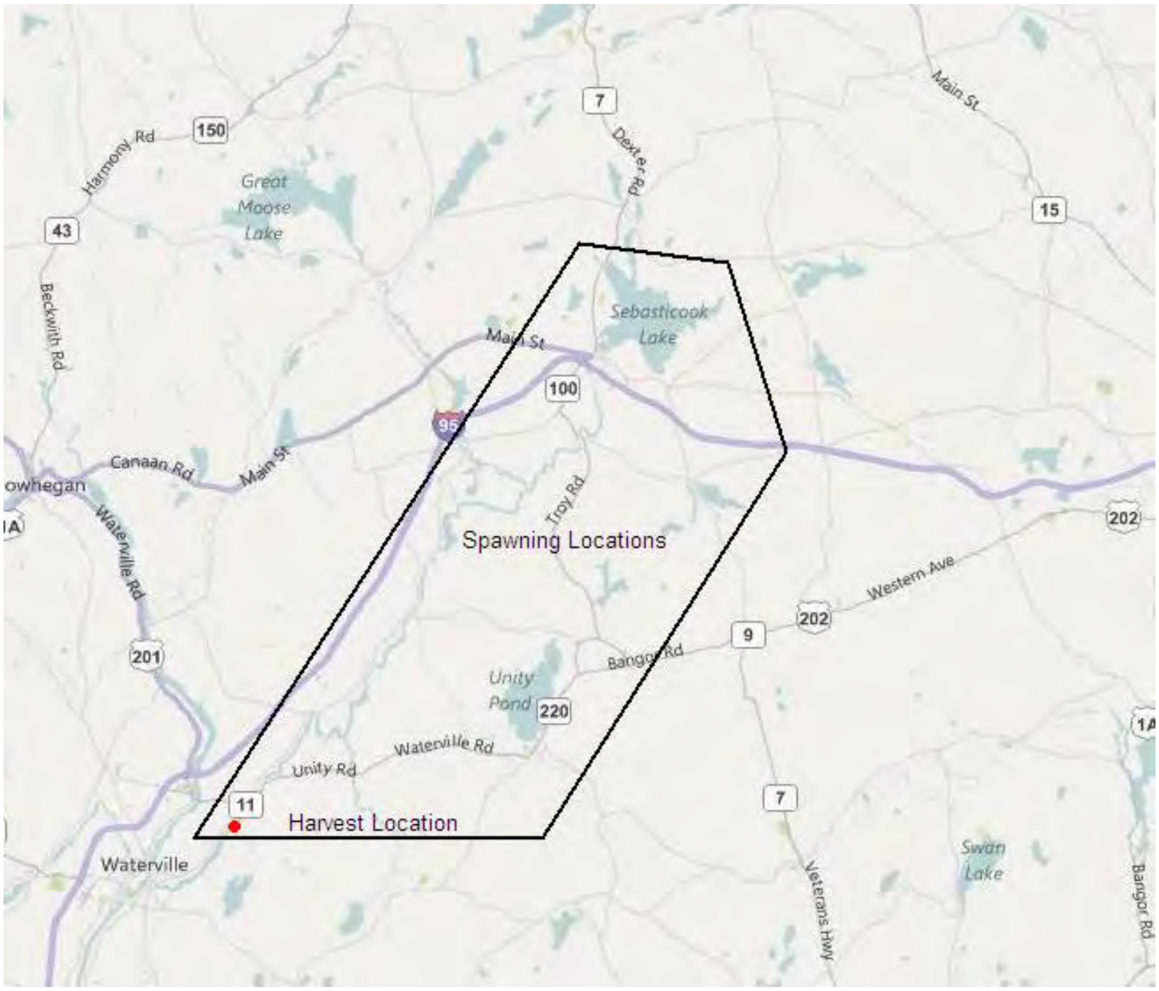
The Maine Department of Marine Resources began the Sebasticook River Restoration Project by stocking 6 fish/acre into available historic spawning habitat as permitted by the Maine Department of Inland Fisheries and Wildlife. The initial stocking, which placed 57,533 pre-spawn adults within the 10,854 acres of spawning habitat, created an estimated run on the Sebasticook River ranging between 1.5 and 3.5 million fish within six years. There was no permanent upstream passage available until the State of Maine and conservation groups removed the Fort Halifax Dam in 2008. Prior to 2007, an unlimited commercial dip net harvest below the first dam on the river captured returning adults. The fish escaping the fishery remained below the dam until they dropped out of the system during early summer. Estimates of the number of river herring remaining below the dam ranged from 1.25 - 3 million individuals.

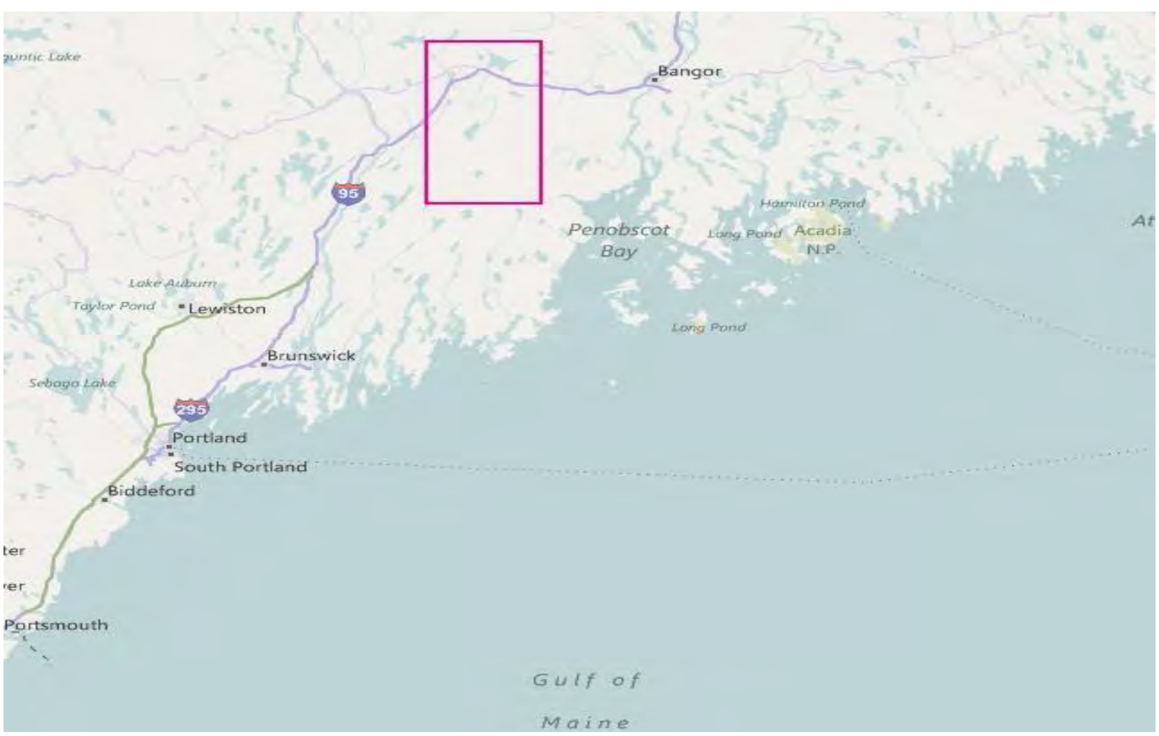
The mainstem river and several lakes and ponds within the Sebasticook River drainage provide excellent spawning and nursery habitat for river herring. These habitats currently support one of the largest monitored river herring runs in Maine. Restoration efforts in the watershed will continue to open additional historic spawning areas over the next several years. The Maine Department of Marine Resources, in conjunction with the hydropower company, operate and monitor upstream passage on the Sebasticook River. There are two hydropower dams that remain on the mainstem of the Sebasticook River. Both dams have dedicated upstream and downstream passages for anadromous fish. The passage efficiency for both sites is currently unknown, though the Benton Falls fishway does pass more than 2 million fish per year on a regular basis and passage counts have been as high as 6.5 million in recent years.

Upstream passage is a priority at this location with 200,000 fish required to pass upstream prior to commencing harvest activities. The municipal commercial harvest plan restricts harvest gear at the base of the hydropower dam to dip nets and cast nets. Discussions on how to improve harvest are occurring between the harvester and the Town. These gear types permitted severely limit the numbers of fish that the harvester can access during the fishing season.

Spawning habitat is available in the river above and below the dam for blueback herring and American shad but not alewife. There is a mix of blueback herring in the commercial alewife catch toward the end of the season. Most of the blueback herring escape the commercial alewife fishery due to the June 5 end date for the commercial season. If the species composition in the commercial catch exceeds 60% blueback herring the commercial fishery is closed for the season, prior to the June 5 closed date. This management effort is used to provide additional protection for blueback herring colonizing the river above the Benton Falls hydropower dam. Blueback passage numbers at the Benton fish lift often exceed 1 million during the season.

Town	River	Lake size (acres)	Threshold (N/acre)
Benton	Sebasticook River	10,854	35


Spawning Locations
Harvest Location
Great Moose Lake
Sebasticook Lake
Unity Pond
Swan Lake
Waterville
Harmony Rd
Beckwith Rd
Canaan Rd
Main St
Waterville Rd
Dexter Rd
Troy Rd
Western Ave
Bangor Rd
Waterville Rd
Unity Rd
Veterans Hwy
Bangor Rd
150
43
7
15
100
95
202
201
9
220
11


Bangor
Penobscot Bay
Acadia N.P.
Hamilton Pond
Long Pond
Lake Auburn
Taylor Pond
Lewiston
Brunswick
Sebago Lake
Portland
South Portland
Biddeford
Portsmouth
Gulf of Maine
95
295

Benton Falls Hydropower Station. The commercial fishery occurs below the dam.

Year	Municipality	River	% repeat spawners by year and frequency	R-0	R-1	R-2	R-3	R-4
2023	Benton	Sebasticook	19.0	81.00	14.30	2.90	1.00	1.00
2022	Benton	Sebasticook	33.3	66.70	18.20	11.10	4.00	
2021	Benton	Sebasticook	55.0	45.00	46.00	6.00	3.00	
2020	Benton	Sebasticook	31.0	69.00	21.00	7.00	3.00	
2019	Benton	Sebasticook	29.7	70.33	28.57	1.10		
2018	Benton	Sebasticook	26.0	74.00	22.00	4.00		
2017	Benton	Sebasticook	15.0	85.00	10.00	5.00		
2016	Benton	Sebasticook	31.0	69.00	24.00	7.00		
2015	Benton	Sebasticook	21.5	78.49	19.35	1.08	1.08	
2014	Benton	Sebasticook	16.0	84.00	13.00	2.00	1.00	
2013	Benton	Sebasticook	17.5	82.50	16.25	1.25		
2012	Benton	Sebasticook	15.0	85.00	11.00	4.00		
2011	Benton	Sebasticook	16.3	83.67	14.28	1.02	1.02	
2010	Benton	Sebasticook	60.0	40.00	52.00	6.00	2.00	

Arrowsic Commercial Fishery:

The Maine Department of Marine Resources manages Sewall Pond for a minimum commercial escapement of 35 fish per acre. The spawning escapement need for this system is 1,505 river herring. The management plan for Sewall Pond has achieved the target escapement developed for this system or passed the entire run for the past several years.

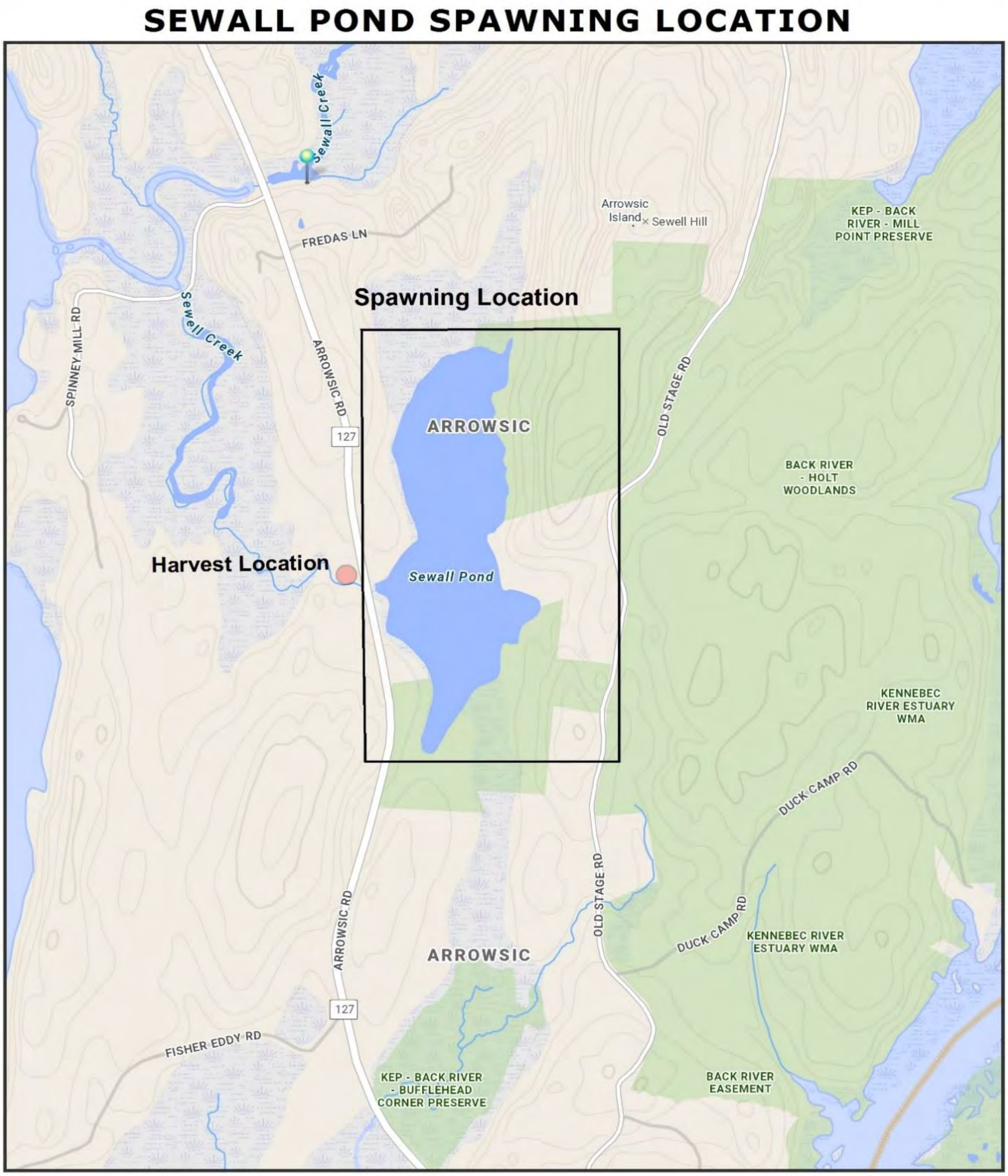
Sewall Pond is the smallest of the existing Maine systems with a current river herring fishery. For the past five years (2020-2024) the town had the option of operating a limited harvest under an ASMFC approved addendum to the Maine SFMP, though they elected to harvest during only two of those years 2023-2024. The approval to fish provided through the addendum ended at the conclusion of the 2024 fishing season and DMR is currently seeking ASMFC approval to continue the fishery. The town of Arrowsic historically fished for river herring and maintained their status regarding exclusive harvest rights to the river herring resource throughout the moratorium. Harvest was intermittent for several decades prior to implementation of Amendment 2 and harvest had not occurred for several years preceding 2012.

Through local efforts to improve passage and support river herring restoration activities, the river herring run into Sewall Pond has grown to several thousand fish. The largest improvement occurred in 2014 with the installation of a fishway under Route 127 which crosses the outlet of Sewall Pond. The culvert was failing and passage through the culvert leading to the pond was impossible under most flows. The culvert was replaced by a state-of-the-art passage corridor that contains a fishway that passes fish as well a subterranean pathway that passes other species (mammals, amphibians, reptiles).

Sampling conducted by the Arrowsic Conservation Commission documents run counts, run timing, and species composition of river herring returns. Scale samples collected by the Commission are analyzed by the Maine Department of Marine Resources to develop and track biological metrics regarding the Sewall Pond river herring population. The Commission also collects juvenile river herring samples as juveniles leave the pond and return to the ocean. Most biological data collected from recent returns originate from the coordinated sampling efforts of the Arrowsic Conservation Commission.

The population of river herring returning to Sewall Pond will likely never expand to reach population levels over 100,000 returns due to the size of the spawning habitat. The significance of the commercial fishery is also expected to be very modest. If a fishery is approved for this location beyond 2024 the Commission has expressed their interest in conducting an annual event or demonstration harvest that serves as a living history educational opportunity for those in the community and surrounding area. Fish captured at Sewall Pond in 2023 and 2024 were donated to a local fisherman and were not sold commercially. Sewall Pond is also experiencing the effects of sea level rise as water from the tidal Kennebec River enters the pond during extreme high tides.

Town	River	Lake size	Threshold (N/acre)
Arrowsic	Kennebec	43	35



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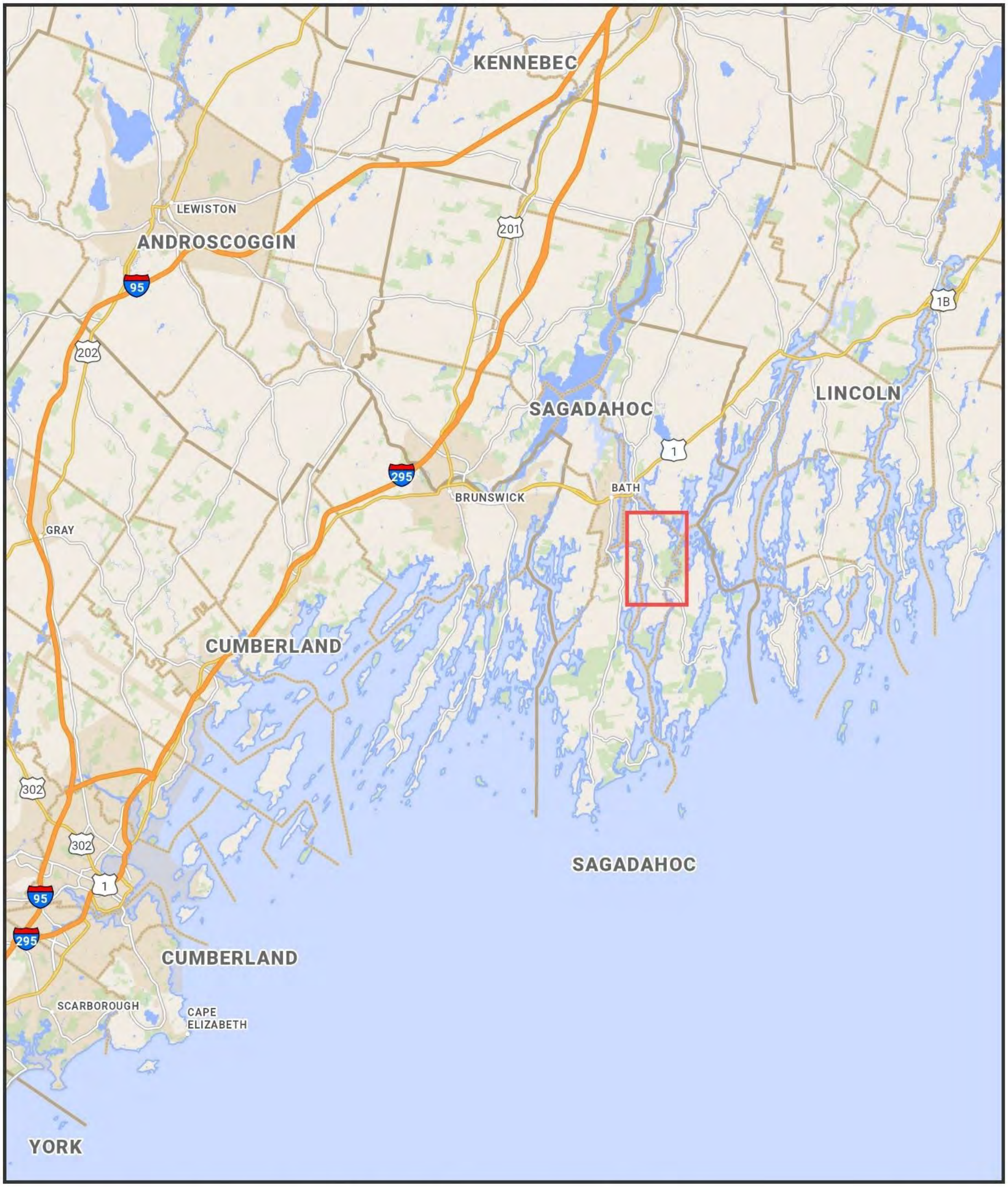
0.2 Miles
1 inch = 0.24 miles

Date: 8/5/2024
Time: 9:04:02 AM

SEWALL LOCATION



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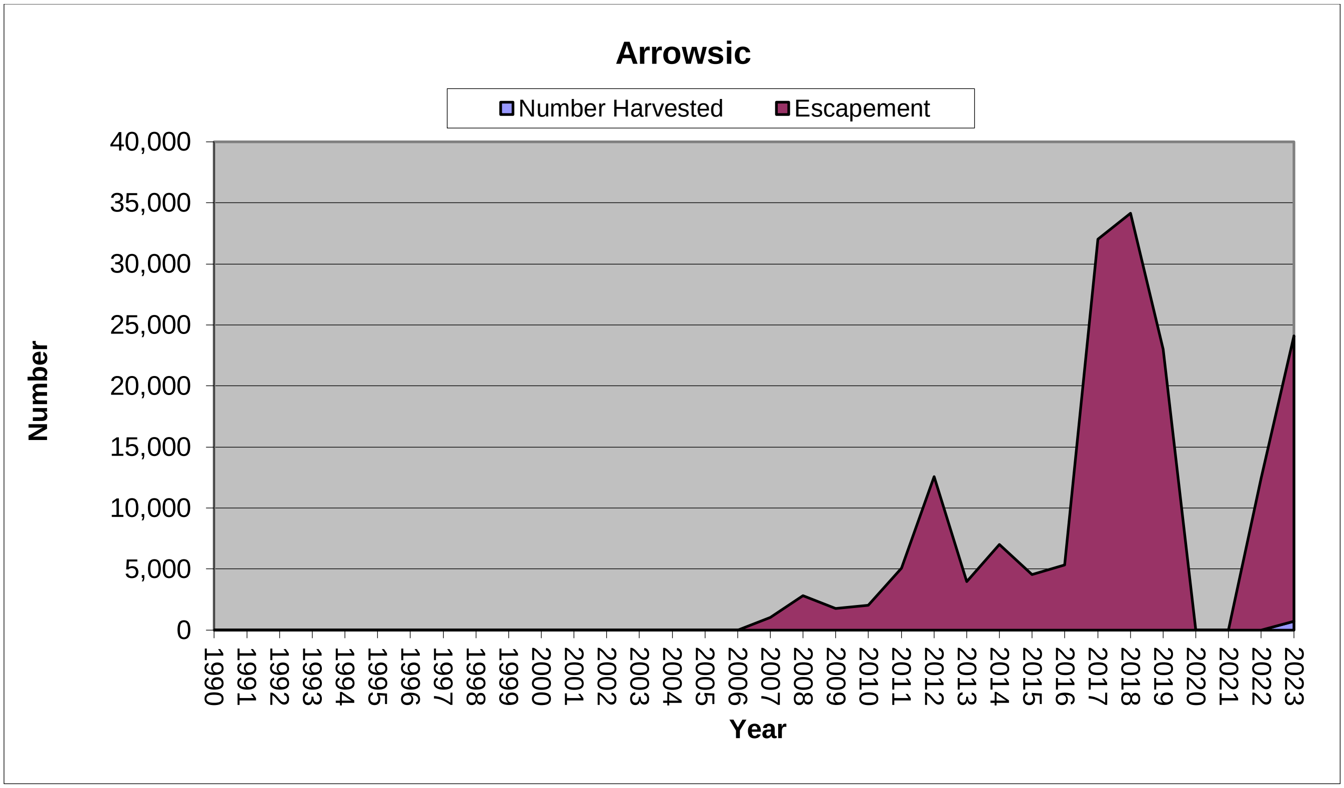
7 Miles
1 inch = 7.71 miles

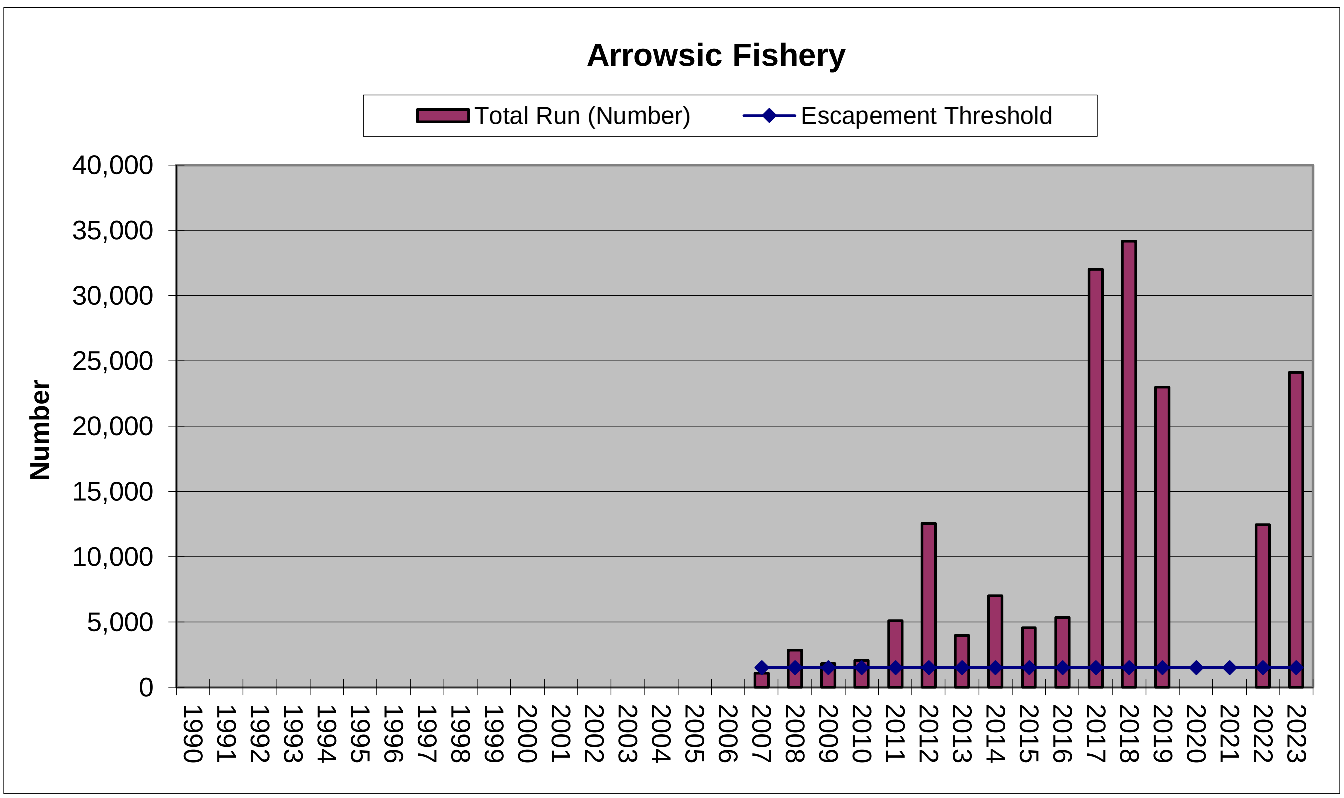
Date: 8/5/2024
Time: 9:20:54 AM

Installation of the new fish passage and removal of the existing outlet dam and fishway.

Intrusion of water from the Kenebec River into Sewall Pond during an extream high tide event



Arrowsic
Number Harvested
Escapement
Number
Year
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023



Arrowsic Fishery
Total Run (Number)
Escapement Threshold
Number
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023

Year	Municipality	River	% repeat spawners by year and frequency	R-0	R-1	R-2	R-3	R-4
2023	Arrowsic	Kennebec	20.1	79.90	18.30	1.80		
2022	Arrowsic	Kennebec	23.8	76.20	13.90	5.90	3.00	1.00
2021	Arrowsic	Kennebec	53.9	46.20	30.80	17.90	5.10	
2020	No Samples	No Samples						
2019	Arrowsic	Kennebec	46.2	53.76	34.41	10.75	1.08	
2018	Arrowsic	Kennebec	36.0	64.00	33.33	2.66		
2017	Arrowsic	Kennebec	21.3	78.67	16.67	4.67		
2016	Arrowsic	Kennebec	30.9	69.10	21.80	9.10		
2015	Arrowsic	Kennebec	36.5	63.46	26.92	3.84	5.77	
2014	Arrowsic	Kennebec	25.8	74.19	17.74	8.07		
2013	Arrowsic	Kennebec	50.9	92.59	3.70	3.70		
2012	Arrowsic	Kennebec	6.4	93.57	6.42			
2011	Arrowsic	Kennebec	22.0	77.96	19.49	2.54		
2010	Arrowsic	Kennebec	12.1	87.87	12.12			
2009	Arrowsic	Kennebec	10.7	89.30	9.20	1.50		
2008	Arrowsic	Kennebec	28.3	71.74	25.65	2.17	0.43	
2007	Arrowsic	Kennebec	16.2	83.09	14.07	1.47	1.47	

Pembroke Commercial Fishery:

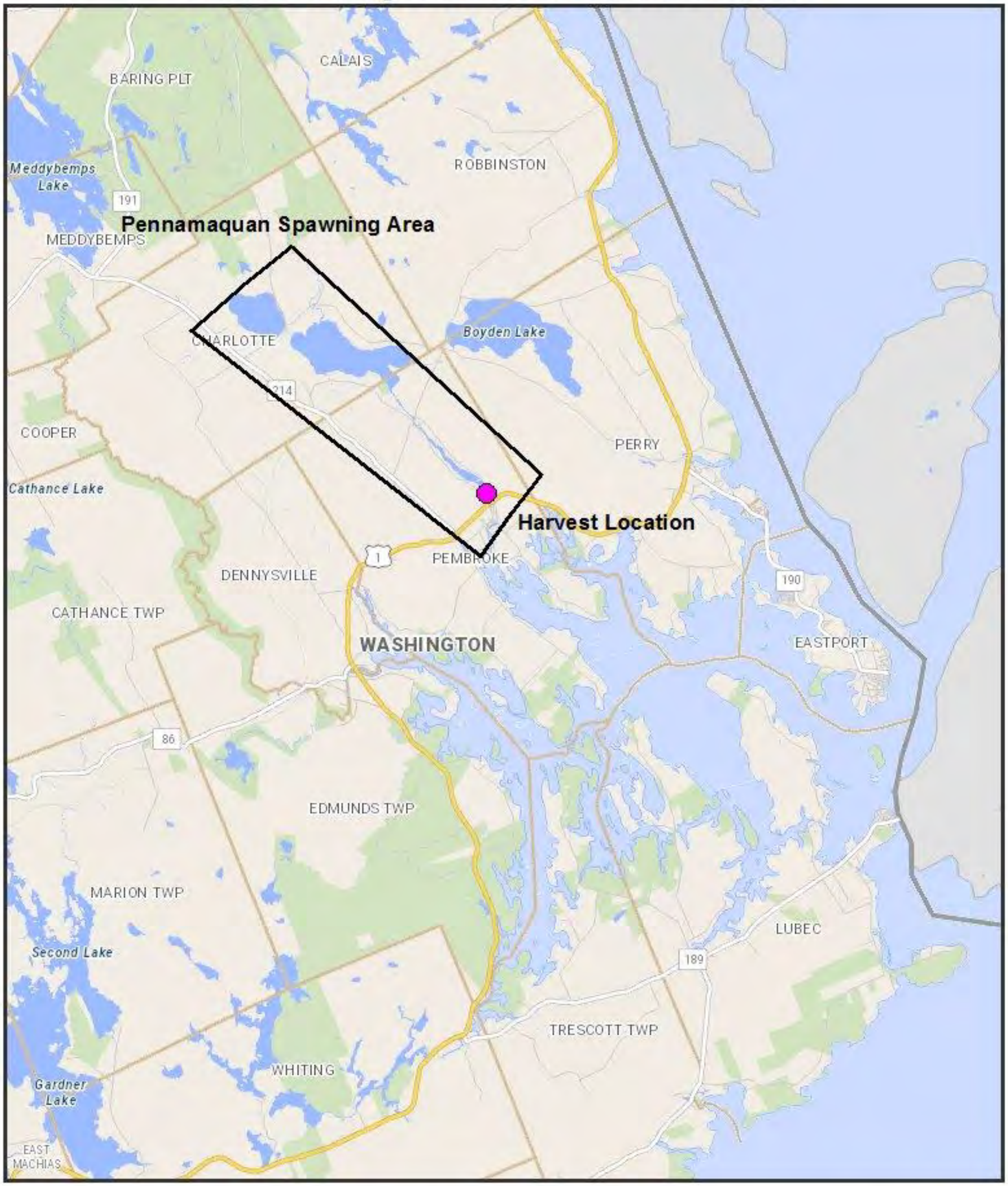
The Maine Department of Marine Resources manages the Pennamaquan system for a minimum commercial escapement of 35 fish per acre. The spawning escapement need for the Pennamaquan system is 42,315 river herring. The management plan for Pennamaquan has achieved the target escapement developed for this system and passed the entire run upstream since 2012.

The Pennamaquan River and lake system supports a run of both alewife and blueback herring. This system is one of seven systems that contain commercial quantities of both species. The historical fishery occurred below the fishways on the Pennamaquan River and was commercially active prior to the moratorium in 2012. A lack of interest by the Town of Pembroke in collecting or providing data to determine sustainability forced a closure to meet the objectives of Amendment 2. For the past 13 years the State of Maine, Maine Sea Grant, and Passamaquoddy Tribe have collected run count and biological data to assess sustainability and reopen the commercial fishery.

Fishway improvements were made to the Pennamaquan fishways in 2014 and have improved passage into spawning habitat for alewives. The river herring population has responded positively, and returns continue to increase. Biological sampling is conducted mainly by Maine Sea Grant with assistance by the Passamaquoddy Tribe and State of Maine. Scale samples collected by Sea Grant are analyzed by the Maine Department of Marine Resources to develop and track biological metrics regarding the Pennamaquan river herring population. Run count data were collected using an electronic tube counter and was deployed and maintained by Maine Sea Grant. As river herring runs increased, the large numbers of post-spawn downstream migrants were unable to pass downstream through the counting tubes. This required the removal of the counting device to allow downstream passage during the later part of the run. During the periods when the counting tubes were removed upstream migrants were not counted.

Town	River	Lake size (acres)	Threshold (N/acre)
Pembroke	Pennamaquan	1,2093	35

PENNAMAQUAN SPAWNING AREA



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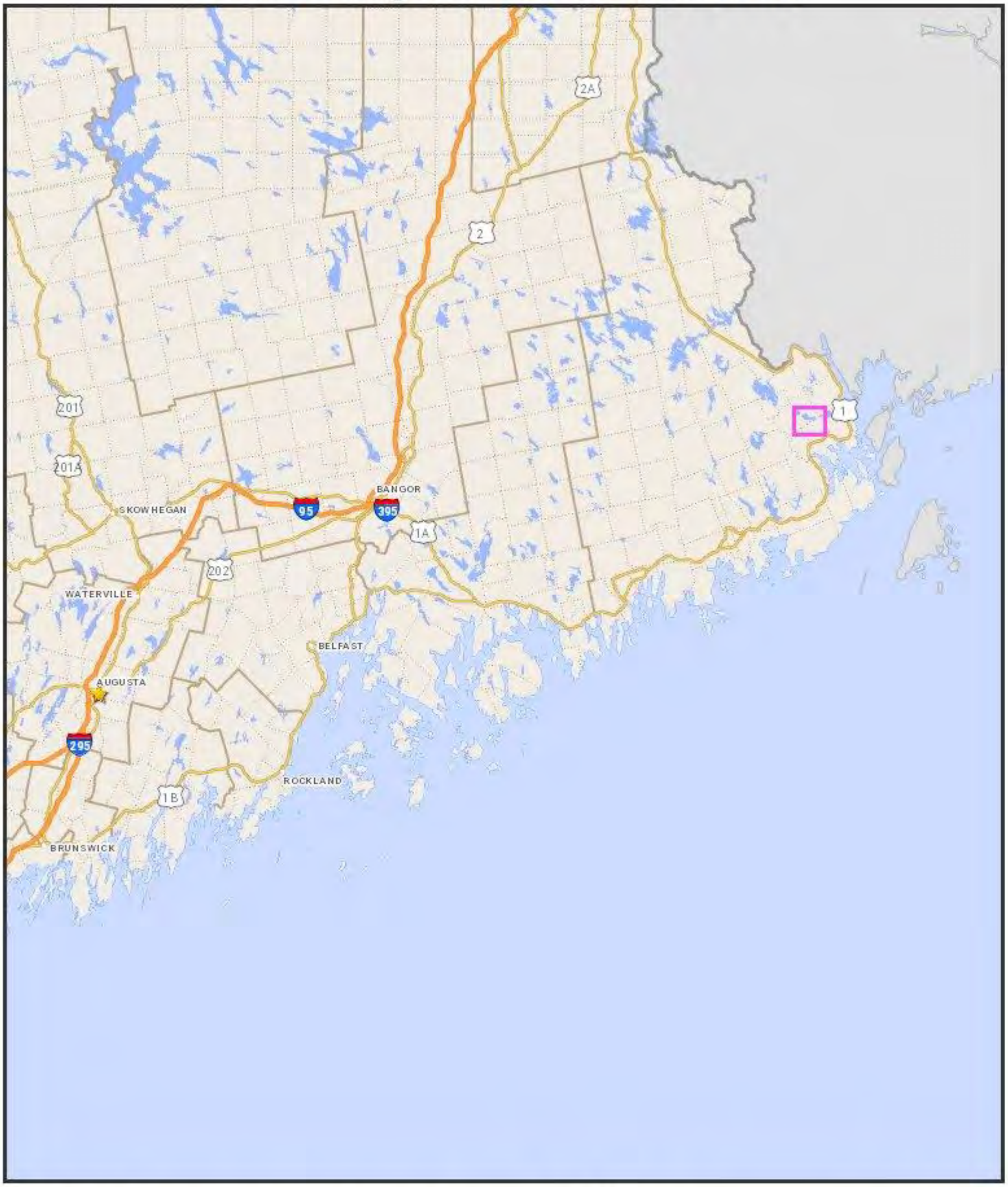
3.5 Miles
1 inch = 3.85 miles

Date: 8/5/2024
Time: 10:21:26 AM

PENNAMAQUAN LAKE LOCATION



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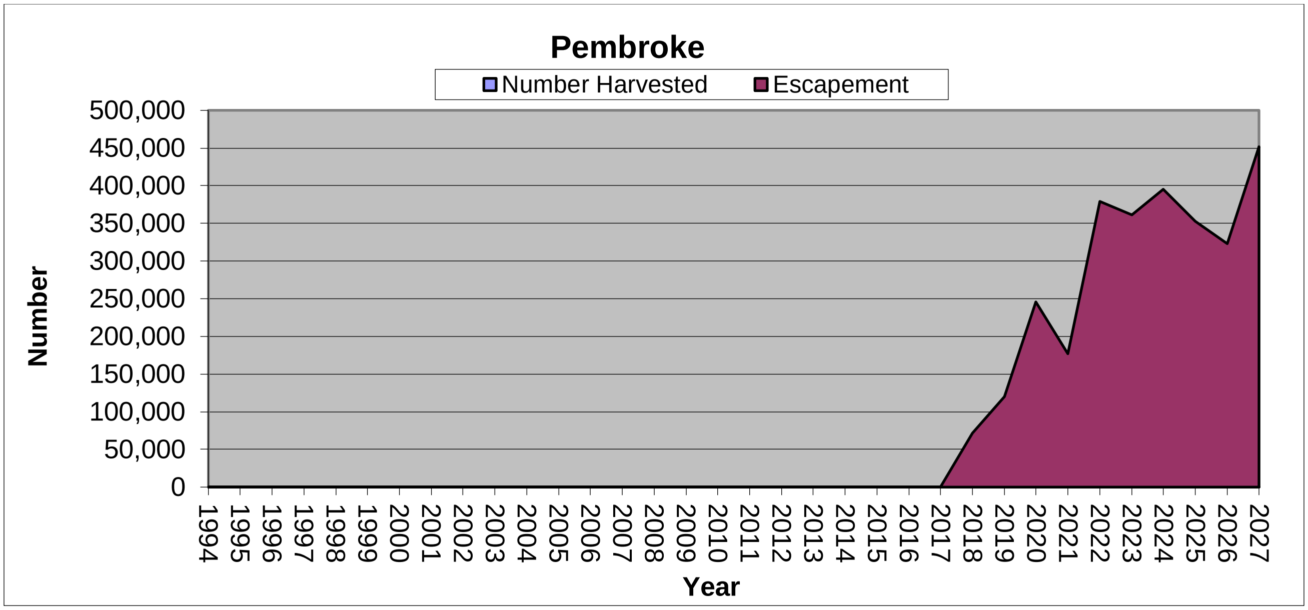
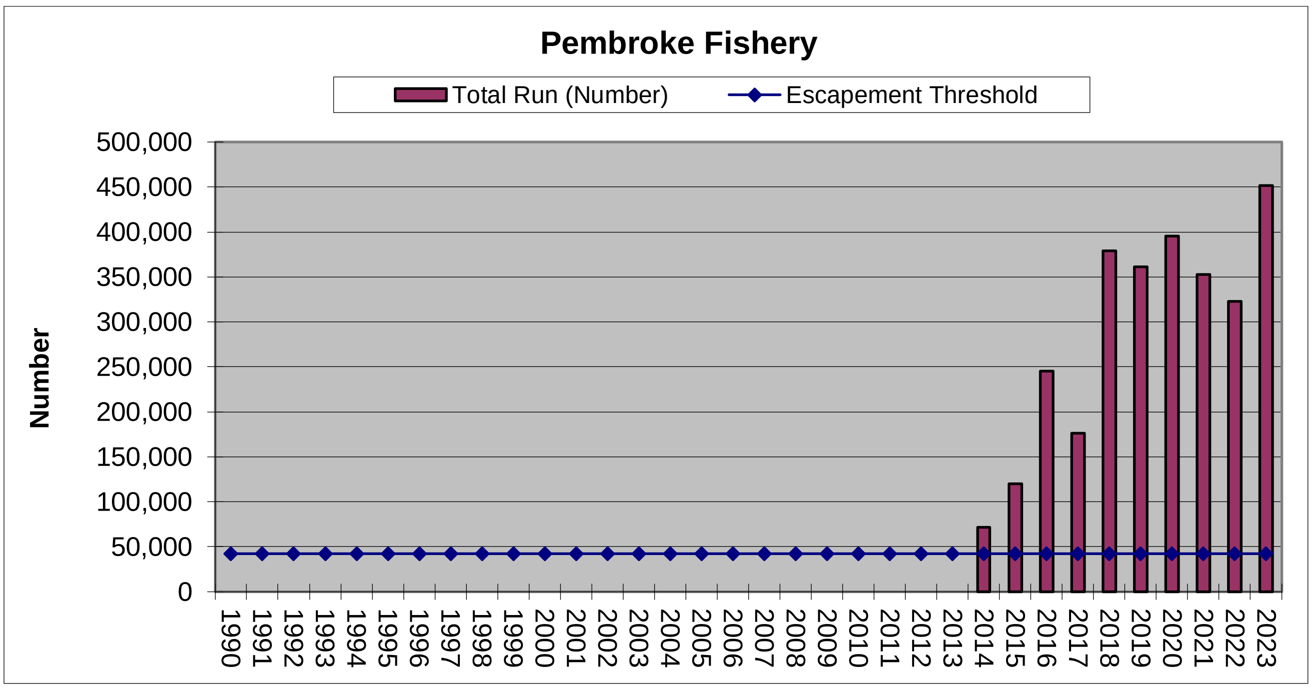
25 Miles
1 inch = 30.83 miles

Date: 8/5/2024
Time: 10:24:10 AM





Year	Municipality	River	% repeat spawners by year and frequency	R-0	R-1	R-2	R-3	R-4
2023	Pembroke	Pennamaquan	34.0	69.10	20.80	8.10	2.00	
2022	Pembroke	Pennamaquan	32.2	67.80	18.80	10.10	2.00	1.30
2021	Pembroke	Pennamaquan	52.0	48.00	37.33	12.67	2.00	
2020	Pembroke	Pennamaquan	58.0	42.00	35.00	21.00	2.00	
2019	Pembroke	Pennamaquan	69.0	31.00	54.00	11.00	4.00	
2018	Pembroke	Pennamaquan	20.0	80.00	14.00	4.00	2.00	
2017	Pembroke	Pennamaquan	33.7	66.33	31.63		2.04	
2016	Pembroke	Pennamaquan	25.5	74.50	19.60	3.90	2.00	

Penobscot Commercial Fishery:

The Maine Department of Marine Resources manages this system for a minimum commercial escapement of 35 fish per acre. The spawning escapement need for this system is 4,735 river herring. The management plan for Wight's Pond has exceeded the target escapement developed for this system for the past 10 years. The escapement for the 2023 season was 927 fish per acre.

For the past five years (2020-2024) the Town of Penobscot conducted a limited harvest under an ASMFC approved addendum to the Maine SFMP except for the 2023 season when no fish were harvested. The addendum ended at the conclusion of the 2024 fishing season and the town is currently seeking ASMFC approval to continue the fishery. The Maine Legislature granted the Town of Penobscot the right to manage, harvest, and sell alewives in 1828 and the town has maintained their status to the exclusive harvest rights to the river herring resource throughout the moratorium.

Working with multiple partners, the Town removed a low head dam with an Alaskan Steeppass fishway and replaced it with a nature-like, pool and weir fishway in 2017. This project improved passage for adult and juvenile alewife and other fish species. Significant improvements to passage within the system will continue to support the opportunity to increase run size. The annual alewife counts have more than doubled since the dam removal.

The town alewife committee is responsible for collecting biological data by recording the length, sex, and species of each sampled fish, documenting the number of fish entering the pond, run timing, and harvest amounts when applicable. The committee also collects emigrating juvenile alewives from the pond outlet as well as juveniles from the Bagaduce River estuary. The Maine Department of Marine Resources analyzes scale samples collected by the committee to track the biological metrics for the Wight's Pond alewife population.

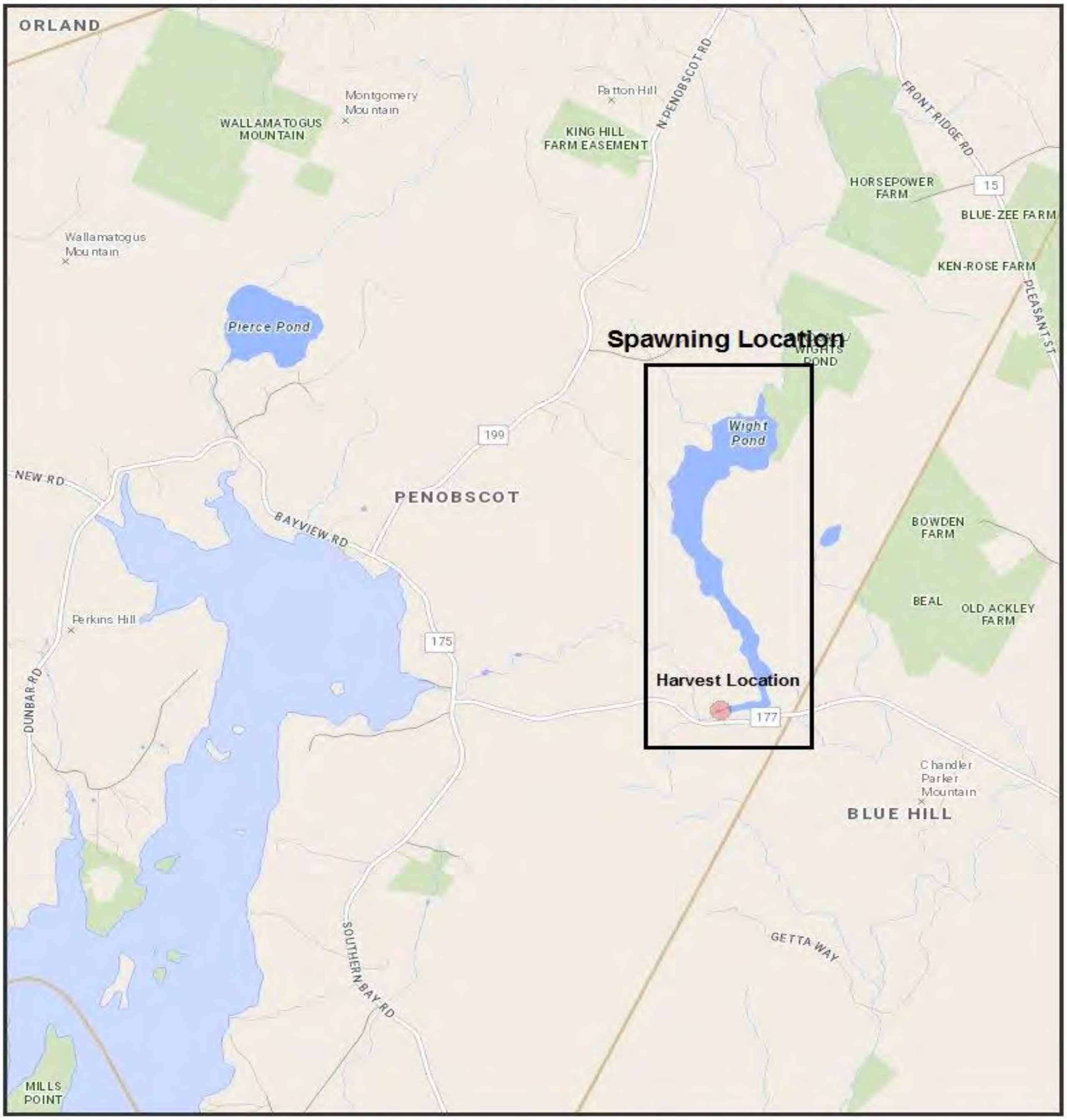
The committee created a public outreach and education program to explain the importance of river herring and their beneficial impacts on the environment. Partnering with land trusts, non-profits, and academia, committee members lead field trips for local elementary school children. In 2024, there were 198 students that participated in these trips. For context, many of these rural schools have a K-8 population of less than 60 students.

Due to a robust alewife population, dozens of bald eagles gather in Penobscot, drawing crowds of spectators. The abundance and diversity of wildlife has raised the environmental awareness of area residents, which is reflected by the attendance of the Bagaduce River Alewife Celebration which draws over 300 people to this three-hour event.

The commercial harvest provides the town and harvester with the incentive to be good stewards of the resource, which is essential to maintaining a sustainable fishery. Municipal revenue from the sale of alewives is placed in a reserve account that is used to fund fishway maintenance, boat landing improvements, public outreach, and educational expenses.

Town	River	Lake size (acres)	Threshold (N/acre)
Penobscot	Bagaduce	135	35

WIGHTS POND SPAWNING LOCATION



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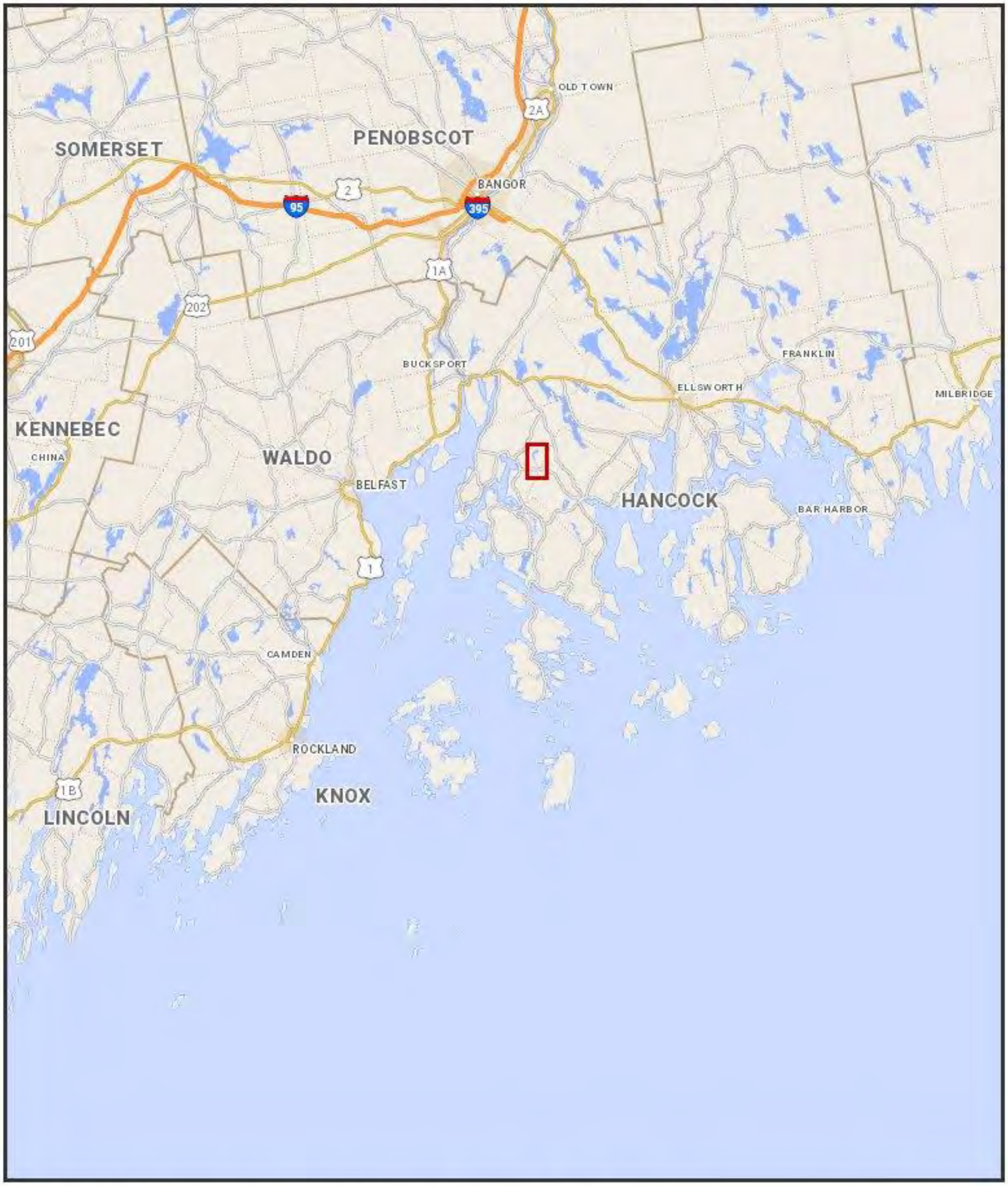
0.9 Miles
1 inch = 0.96 miles

Date: 8/5/2024
Time: 9:37:56 AM

WIGHTS POND LOCATION



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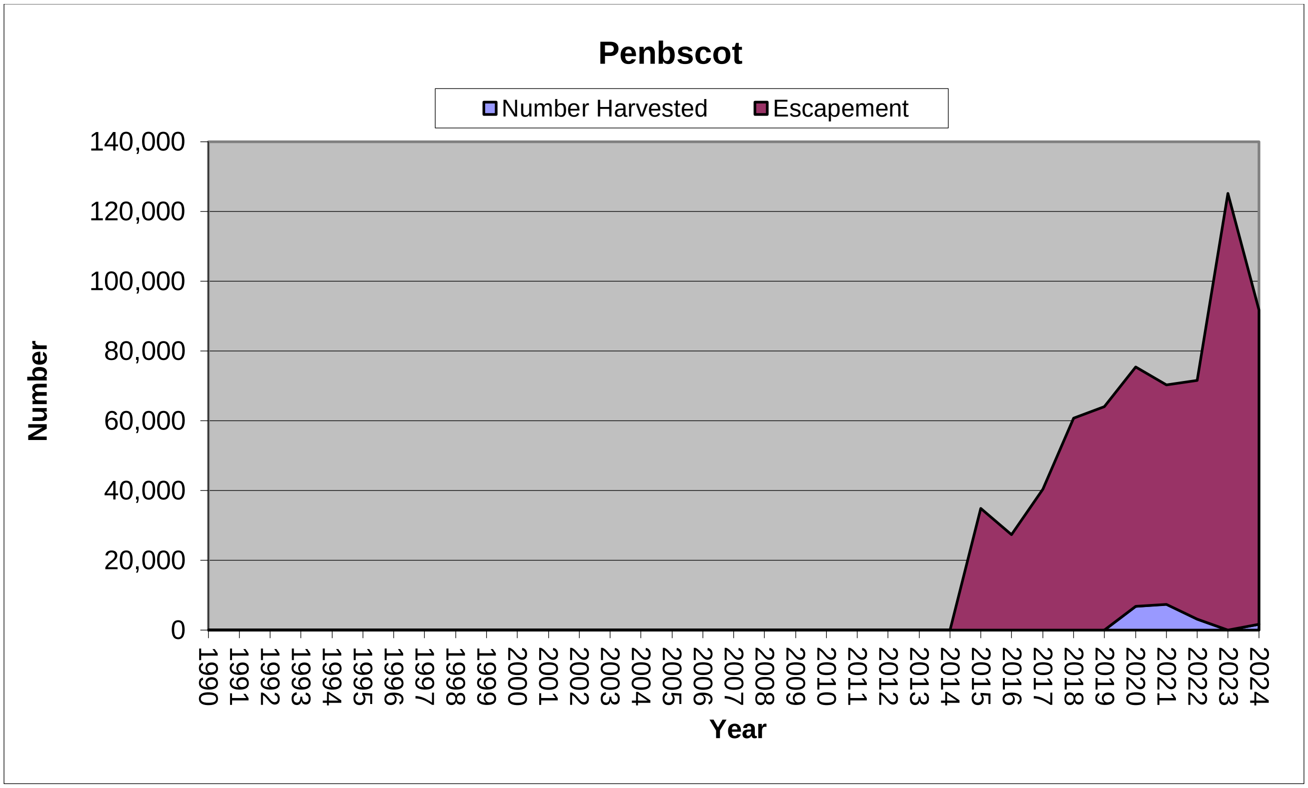
10 Miles
1 inch = 15.42 miles

Date: 8/5/2024
Time: 9:41:30 AM

Old dam and fishway located at Wights Pond prior to installation of a nature-like fishway

Nature-like fishway installed at Wights Pond


Penbscot
Number Harvested
Escapement
Number
Year
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
1990
1991
1992
1993
1994
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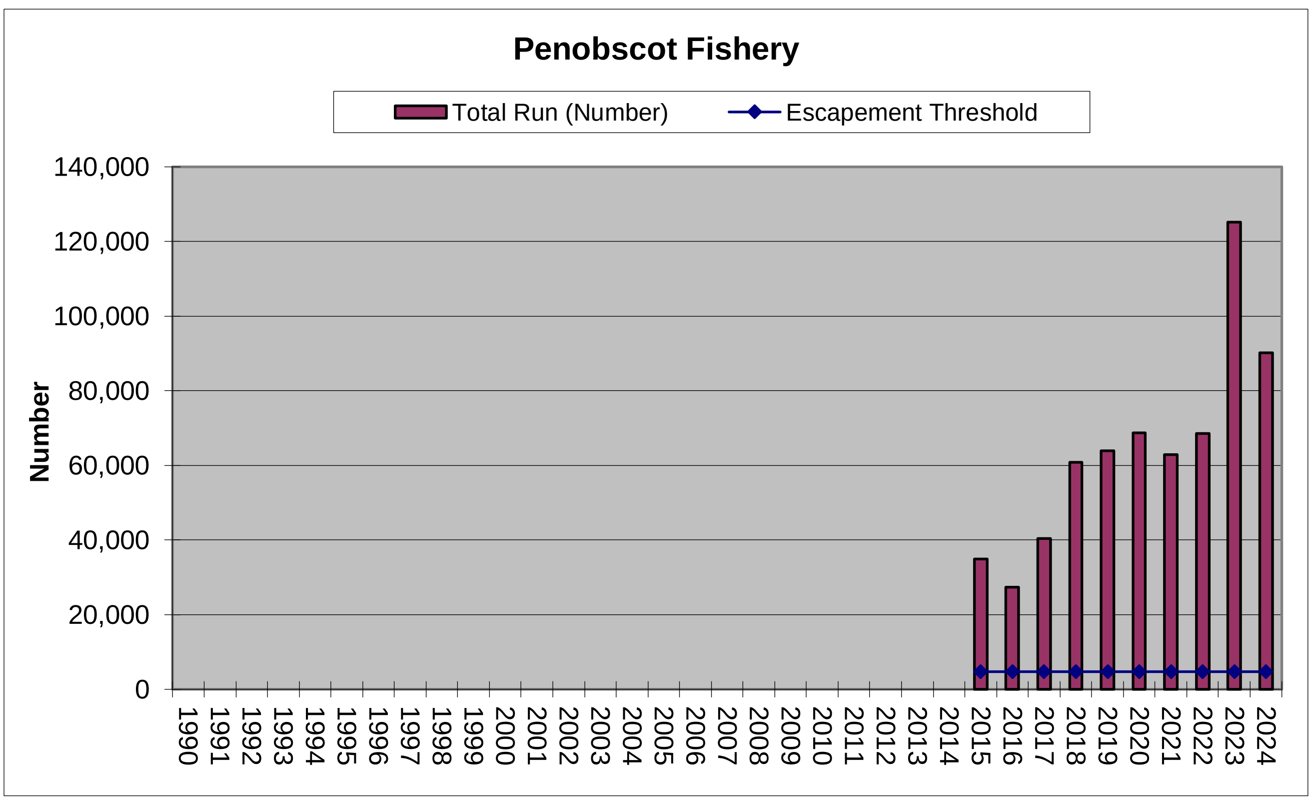
Penobscot Fishery
Total Run (Number)
Escapement Threshold
Number
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
1990
1991
1992
1993
1994
1995
1996
1997
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2020
2021
2022
2023
2024

Year	Municipality	River	% repeat spawners by year and frequency	R-0	R-1	R-2	R-3	R-4
2023	Penobscot	Wights Pond	36.0	64.00	32.80	2.40	0.80	
2022	Penobscot	Wights Pond	16.8	83.20	14.40	1.60	0.80	
2021	Penobscot	Wights Pond	54.0	46.00	43.00	10.00	1.00	
2020	Penobscot	Wights Pond	26.0	74.00	23.00	3.00		
2019	Penobscot	Wights Pond	32.0	68.00	28.00	4.00		
2018	Penobscot	Wights Pond	1.0	99.00	1.00			
2017	Penobscot	Wights Pond	8.0	92.00	5.00	3.00		
2016	Penobscot	Wights Pond	24.0	76.00	23.00	1.00		
2015	Penobscot	Wights Pond	38.0	97.37	2.63			
2014	Penobscot	Wights Pond	26.7	73.27	25.74	0.99		
2013	Penobscot	Wights Pond	4.0	96.00	4.00			
2012	Penobscot	Wights Pond	7.0	93.00	4.00	2.00	1.00	
2011	Penobscot	Wights Pond	30.6	69.38	24.48	6.12		

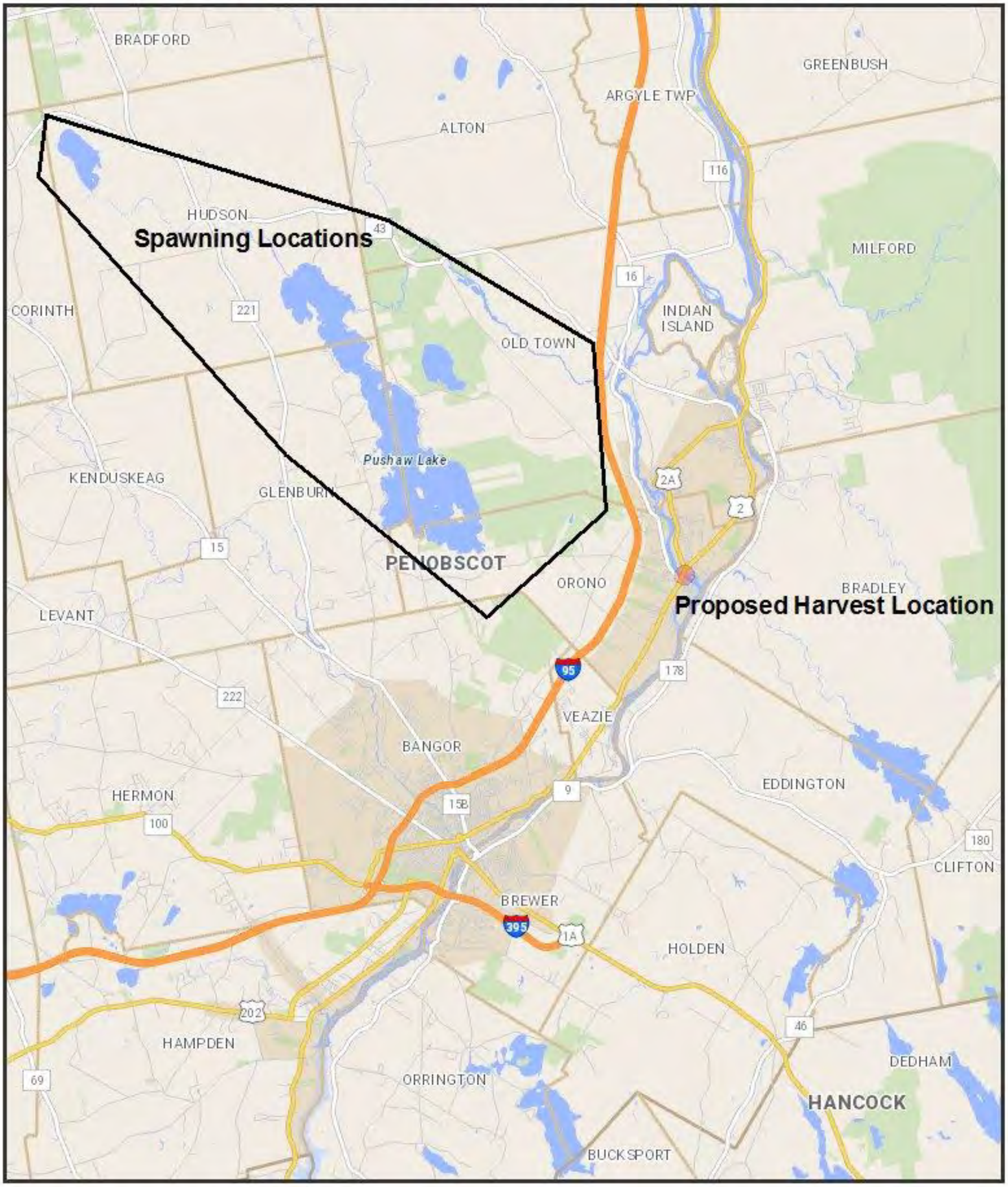
Glenburn Commercial Fishery:

The Maine Department of Marine Resources manages Pushaw Lake by allowing all returns to access the lake to spawn. Access to Pushaw Lake was provided through the dam removals on the mainstem Penobscot River in 2013 and a fishway installed at the outlet dam of Pushaw Lake in 2012. There is currently no commercial fishery at this location. Commercial fishing for river herring in the region declined with the construction of multiple dams on the mainstem Penobscot River coupled with heavy industrial pollution resulting from the logging and paper industries.

If a commercial fishery is approved for this location, it will be managed for a minimum commercial escapement of 35 fish per acre. The spawning escapement need for the Pushaw Lake system is 176,785 river herring. The management plan for Pushaw has achieved the target escapement developed for this system and passed the entire run upstream since 2016.

Town	River	Lake size (acres)	Threshold (N/acre)
Glenburn	Stillwater River	5,0513	35

PUSHAW LAKE SPAWNING LOCATIONS



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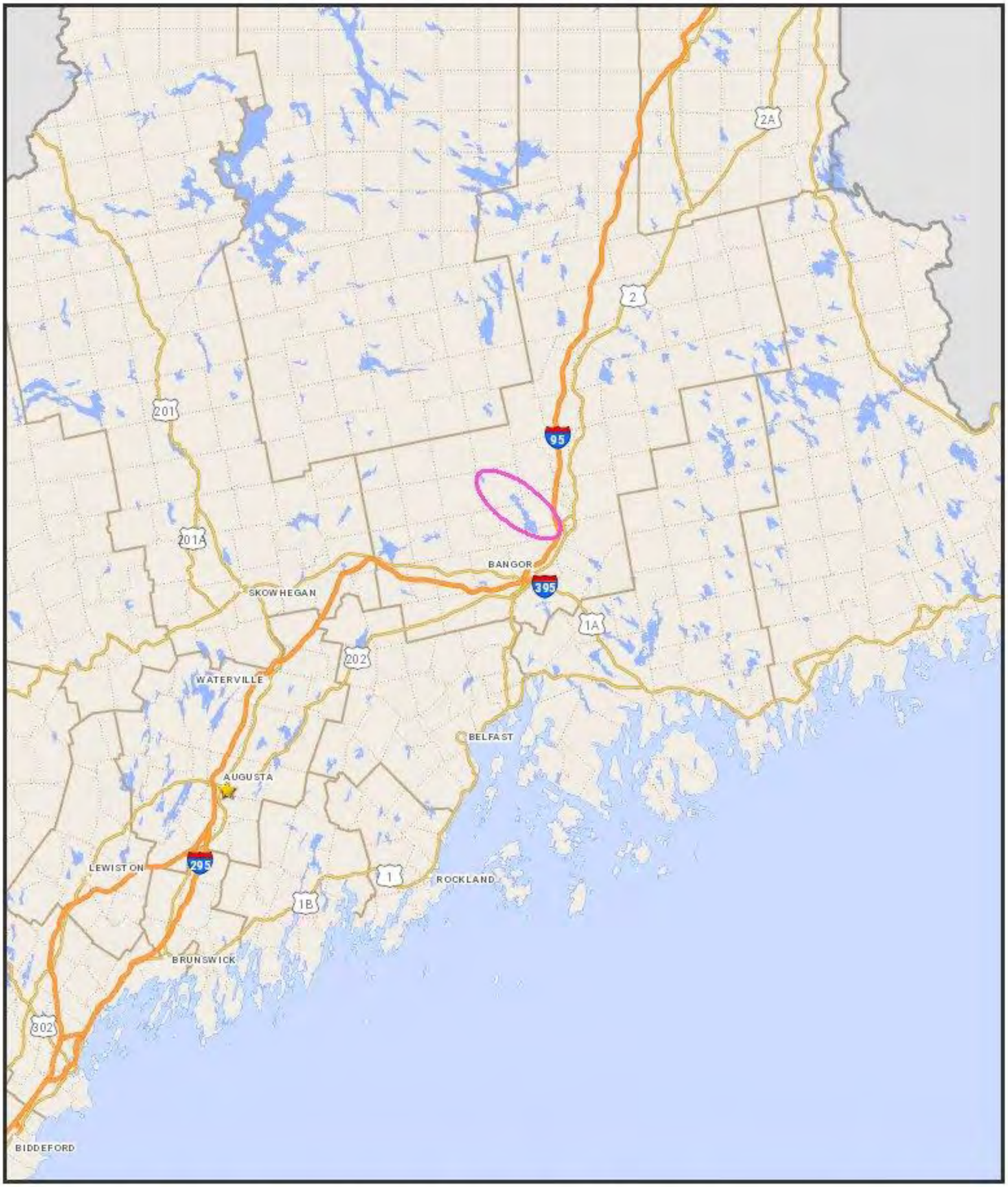
3.5 Miles
1 inch = 3.85 miles

Date: 8/5/2024
Time: 9:55:33 AM

PUSHAW LAKE LOCATION



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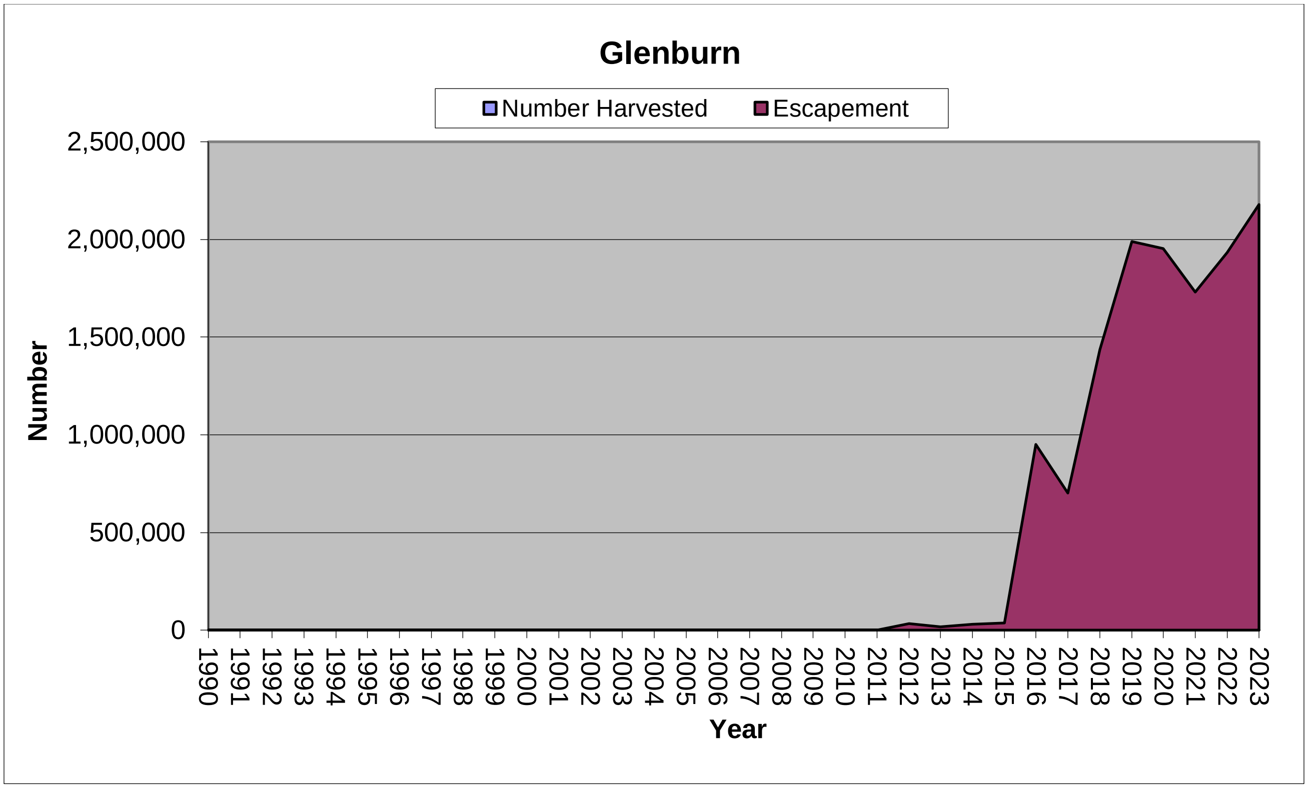
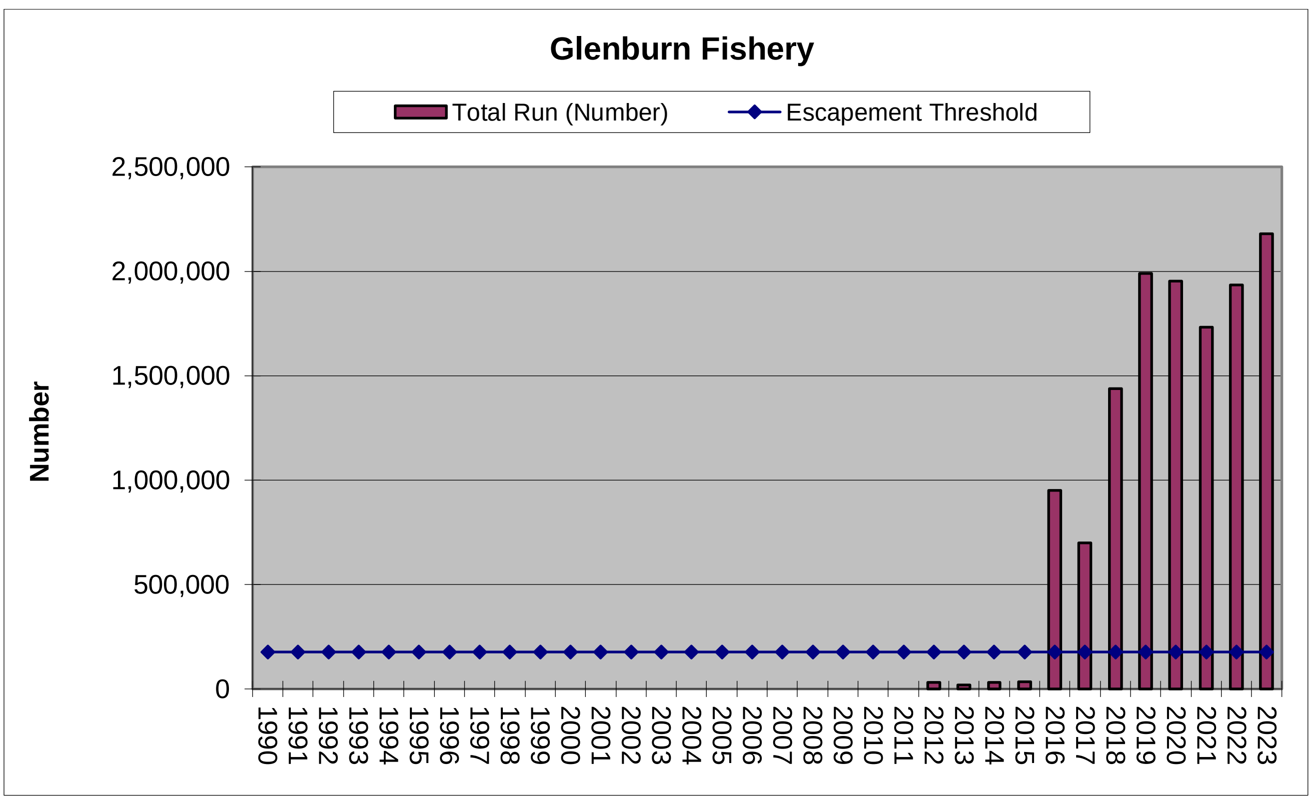
25 Miles
1 inch = 27.87 miles

Date: 8/5/2024
Time: 10:39:36 AM

Existing outlet dam at Pushaw Lake prior to fishway installation

Newly installed fishway and overtopping of the dam during the river herring run.


Glenburn
Number Harvested
Escapement
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
Number
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023
Year


Glenburn Fishery
Total Run (Number)
Escapement Threshold
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
Number
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023

Year	Municipality	River	% repeat spawners by year and frequency	R-0	R-1	R-2	R-3	R-4
2023	Glenburn	Pushaw Lake	34.1	65.90	22.70	9.00	2.40	
2022	Glenburn	Pushaw Lake	40.1	59.90	22.40	13.00	4.70	
2021	Glenburn	Pushaw Lake	42.4	57.60	17.60	18.80	6.00	
2020	Glenburn	Pushaw Lake	52.0	48.00	34.70	16.00	1.30	
2019	Glenburn	Pushaw Lake	35.0	65.00	27.70	6.00	1.30	
2018	Glenburn	Pushaw Lake	28.2	71.80	22.60	5.30	0.30	
2017	Glenburn	Pushaw Lake	26.4	73.60	22.50	3.90		
2016	Glenburn	Pushaw Lake	13.5	86.50	12.10	1.40		
2015	Glenburn	Pushaw Lake	7.4	92.30	7.40	0.40		
2014	Glenburn	Pushaw Lake	8.3	91.70	8.30			
2013	Glenburn	Pushaw Lake	7.0	93.00	4.50	2.50		

Bradley Commercial Fishery:

The Maine Department of Marine Resources manages Chemo Pond by allowing all returns to access the lake to spawn. Access to Chemo Pond was provided through the dam removals on the mainstem Penobscot River in 2013 and a fishway installed at the outlet dam at Chemo Pond in 2010. There is currently no commercial fishery at this location. Commercial fishing for river herring in the region declined with the construction of multiple dams on the mainstem Penobscot River coupled with heavy industrial pollution resulting from the logging and paper industries.

If a commercial fishery is approved for this location, it will be managed for a minimum commercial escapement of 35 fish per acre. The spawning escapement need for the Chemo Pond system is 40,110 river herring. The management plan for Chemo has achieved the target escapement developed for this system and passed the entire run upstream since 2014 when natural returns began entering the pond. The proposed harvest would follow the standard 4-fishing days and 3-nonfishing days per week throughout the fishing season.

Town	River	Lake size (acres)	Threshold (N/acre)
Bradley	Blackman Stream	5,0513	35

CHEMO POND SPAWNING LOCATION

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1.5 Miles
1 inch = 1.93 miles

Date: 8/5/2024
Time: 10:06:06 AM

CHEMO POND LOCATION

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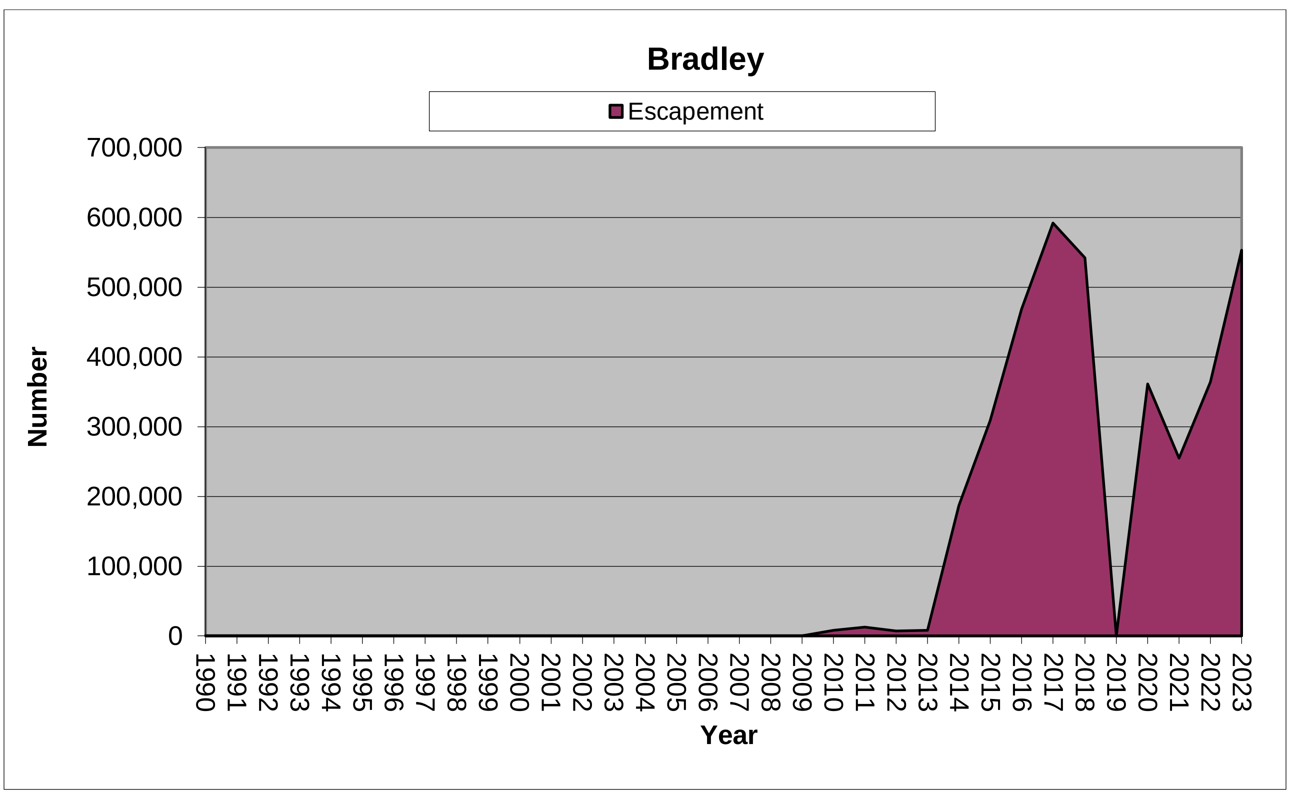
10 Miles
1 inch = 15.42 miles

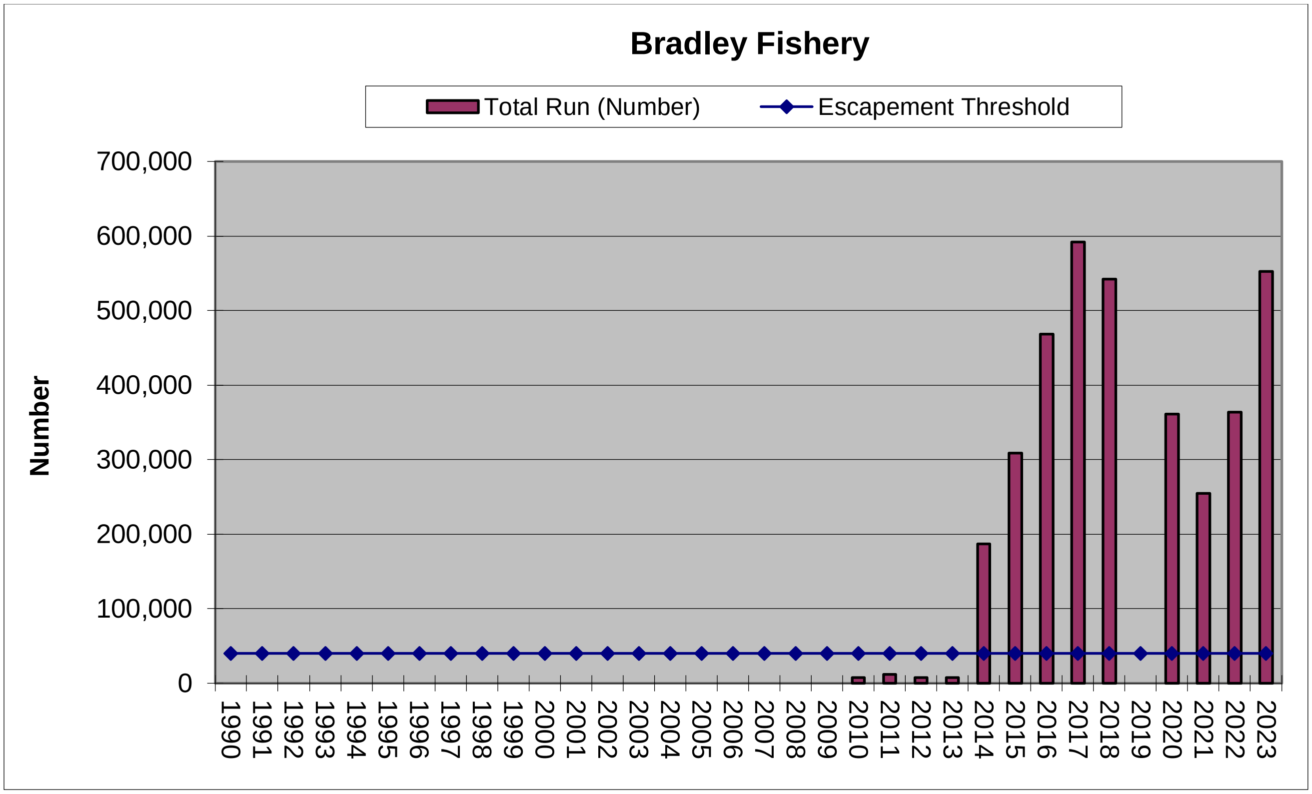
Date: 8/5/2024
Time: 10:11:47 AM

Newly constructed fishway through the outlet dam leading to Chemo Pond

Lower fishway constructed below the dam

Traditional method of smoking river herring at locations where this traditional activity occurs





Year	Municipality	River	% repeat spawners by year and frequency	R-0	R-1	R-2	R-3	R-4
2023	Bradley	Chemo Pond	46.0	54.00	33.00	11.00	1.00	1.06
2022	Bradley	Chemo Pond	44.0	56.00	22.00	18.00	4.00	
2021	Bradley	Chemo Pond	55.0	45.00	24.00	21.00	9.00	1.00
2020	Bradley	Chemo Pond	40.9	59.10	26.80	12.80	1.30	
2019	No	Sampling						
2018	Bradley	Chemo Pond	23.4	76.60	19.80	3.00	0.60	
2017	Bradley	Chemo Pond	17.3	82.90	13.60	3.00	0.60	

Appendix B

§6134. River herring passage; fishways on the St. Croix River

By May 1, 2013, the commissioner and the Commissioner of Inland Fisheries and Wildlife shall ensure that the fishways on the Woodland Dam and the Grand Falls Dam located on the St. Croix River are configured or operated in a manner that allows the unconstrained passage of river herring. [2013, c. 47, §1 (NEW).]

SECTION HISTORY
1995, c. 48, §1 (NEW). 2007, c. 587, §1 (RPR). 2011, c. 598, §12 (AMD). 2013, c. 47, §1 (RPR).

§6041. Pelagic and Anadromous Fisheries Fund

1. Uses of fund. The commissioner shall use the fund for research directly related to Pelagic or Anadromous fishery management and the processing of landings data information. The commissioner may authorize the expenditure of money in the fund for research and development programs that address the restoration, development, or conservation of Pelagic or Anadromous resources.

2. Sources of revenue. The fund is capitalized by surcharges assessed under **Section 2. 12 MRSA §6503**. In addition to those revenues, the commissioner may accept and deposit in the fund money from any other source, public or private.

Sec. 2. 12 MRSA §6503, is enacted to read:

§6503. Commercial Pelagic and Anadromous Fishing License

1. License required. A person may not engage in the activities authorized under this section without a current:

A. Pelagic and Anadromous fishing single license for a resident operator;

B. Pelagic and Anadromous fishing crew license for a resident operator and all crew members;

C. Nonresident Pelagic and Anadromous fishing license for a nonresident operator and all crew members.

2. Licensed activity. The holder of a Pelagic and Anadromous fishing license may fish for or take or possess, ship, transport or sell pelagic or anadromous fish that the holder has taken. The license authorizes crew members aboard the licensee's boat when it is engaged in Pelagic or Anadromous fishing to undertake these activities, if the license provides for crew members.

3. Exemptions. The licensing requirement under subsection 1 does not apply to activities described in this subsection.

A. A person may fish for, take, possess or transport any species of pelagic or anadromous fish if they have been taken by spear gun, harpoon, minnow trap, or hook and line and are only for personal use.

4. Eligibility. A Pelagic and Anadromous fishing license may be issued only to an individual.

5. Fees. Fees for Pelagic and Anadromous fishing licenses are:

A. Forty-one dollars for resident operator;

B. One hundred eleven dollars for resident operator and all crew members; and

C. Seven hundred and fifty-dollars for nonresident operator and all crew members.

6. Surcharges. The following surcharges are assessed on Commercial Pelagic and Anadromous fishing licenses issued by the department:

A. For a resident Pelagic and Anadromous fishing license, $150;

B. For a resident Pelagic and Anadromous fishing license with crew, $100; and

C. For a non-resident Pelagic and Anadromous fishing license with crew, $100.

7. Definition. For the purposes of this chapter, "pelagic fish or Anadromous fish" means Atlantic herring, Atlantic menhaden, whiting, spiny dogfish, alewife, Atlantic mackerel, blueback herring, and squid, butterfish, scup, black sea bass, smelt and shad.

8. Violation. A person who violates this section commits a civil violation for which a forfeiture of not less than $100 nor more than $500 may be adjudged.

Appendix C

Table 1. Fisheries independent monitoring locations to monitor recreational river herring fisheries in Maine.

	River Herring					
Year	Androscoggin	Saco	Kennebec	Sebasticook	Penobscot	St. Croix
1981						169,620
1982						233,102
1983	601					151,952
1984	2,530					152,900
1985	26,895					368,900
1986	35,471					1,984,720
1987	63,523					2,624,700
1988	74,341					2,590,750
1989	100,895					1,164,860
1990	95,574					1,339,050
1991	77,511					358,410
1992	45,050					203,750
1993	5,202	831				289,720
1994	19,190	2,240				362,930
1995	32,002	9,820				215,133
1996	10,198	9,162				645,978
1997	5,540	2,137				225,521
1998	25,189	16,078				177,317
1999	8,909	31,070				25,327
2000	9,551	25,136				8,569
2001	18,196	66,890				5,202
2002	104,520	20,198				900
2003	53,732	26,760				7,901
2004	113,686	32,801				1,299
2005	25,846	388				22
2006	34,239	7,994	4,094	45,960		11,829
2007	60,662	16,084	3,448	461,412		1,294
2008	92,359	22,563	93,775	401,331		12,261
2009	42,759	2,012	45,754	1,327,915		10,424
2010	39,689	19,258	76,947	1,626,872	222	58,776
2011	54,886	39,597	37,846	2,751,473	2,039	25,124
2012	170,191	28,058	179,357	1,703,520	54	36,168
2013	69,267	43,414	94,456	2,272,492	12,708	16,677
2014	55,953	11,576	108,432	2,282,454	187,438	26,893
2015	71,887	53,891	91,850	2,157,983	782,521	93,503
2016	114,874	22,644	224,990	3,128,753	1,259,307	33,016
2017	49,923	44,929	289,188	3,547,091	1,256,061	157,750
2018	170,040	92,836	307,035	5,579,903	2,174,745	270,659
2019	81,025	55,028	240,594	3,287,702	1,986,910	486,500
2020		34,571	143,240	2,847,095	2,074,324	611,907
2021	54,906	135,198	66,009	3,552,813	1,731,496	549,847
2022	139,326	179,366	83,978	2,779,209	2,852,037	712,670
2023	67,927	1,263	137,752	4,154,124	5,490,383	841,357

Figure 1. Locations of Recreational River Herring Monitoring Counts.

Figure 2. Total fishway counts for the six rivers used to monitor fish populations.

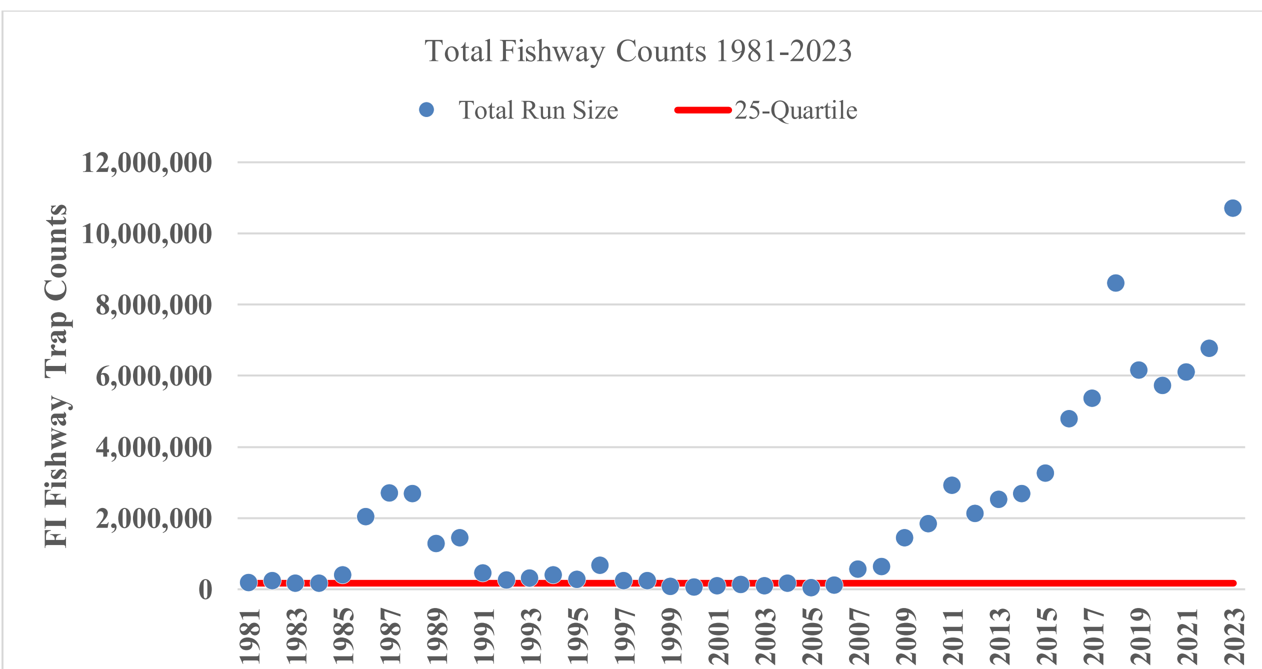


Figure 3. Mean fishway counts for the six rivers used to monitor fish populations.

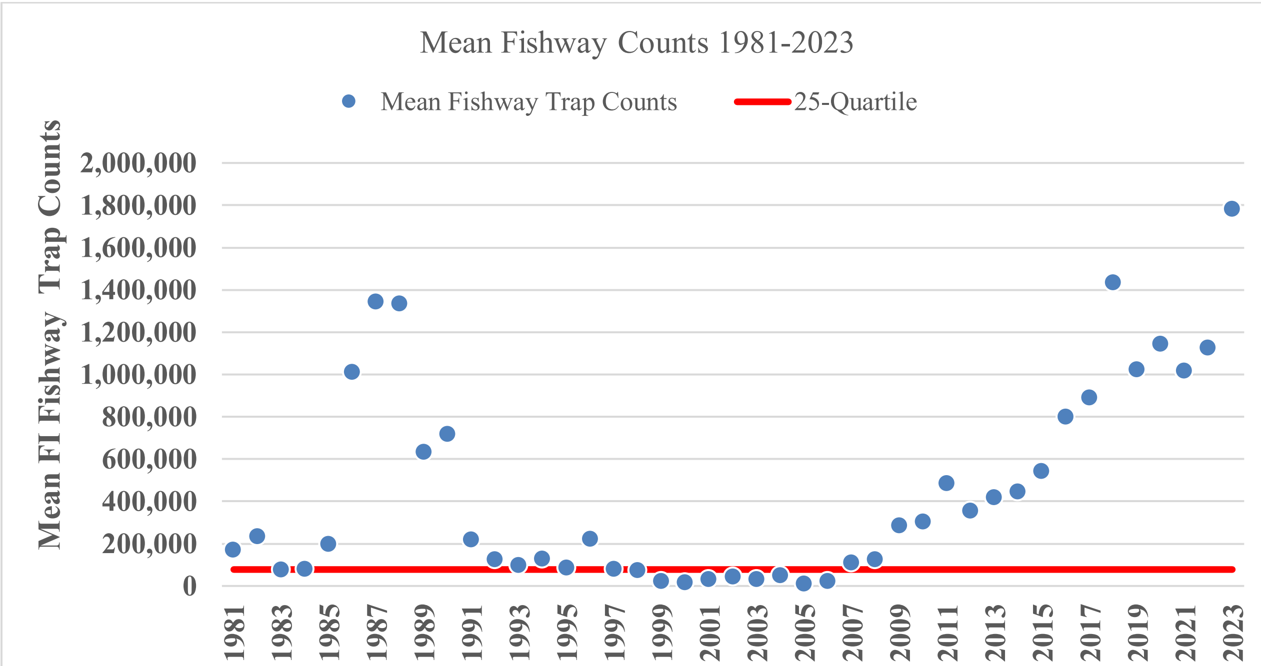


Figure 4. Fishway counts for the Saco River.

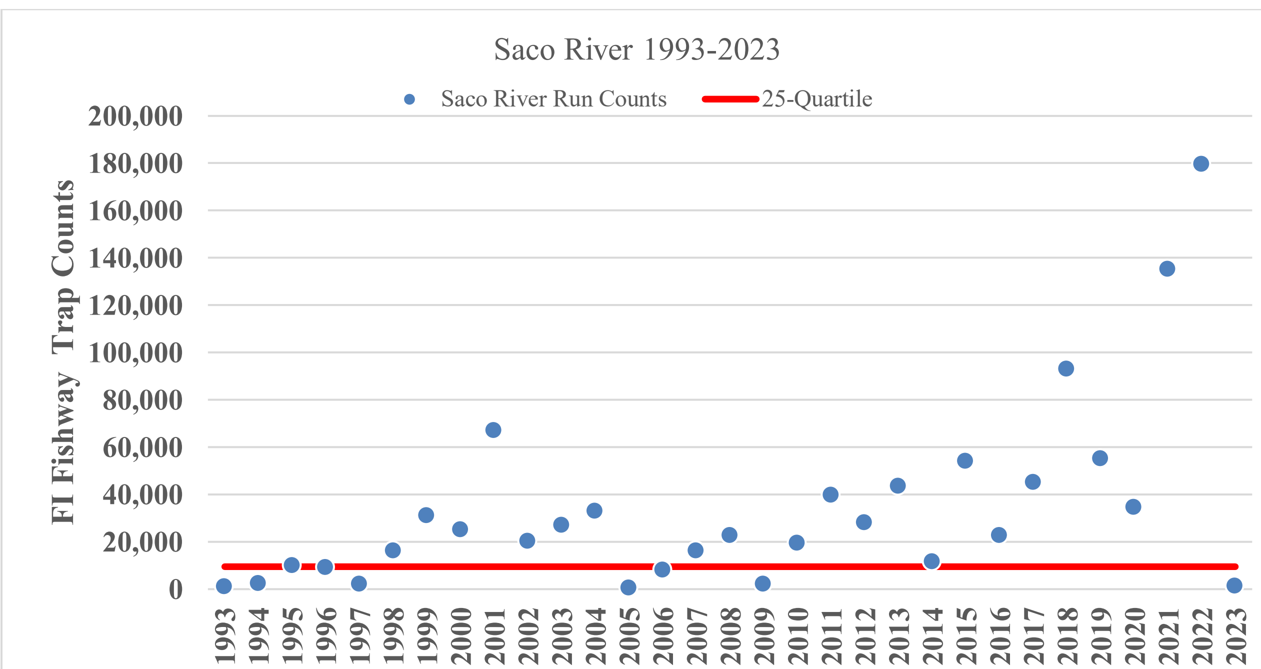


Figure 5. Fishway counts for the Androscoggin River.

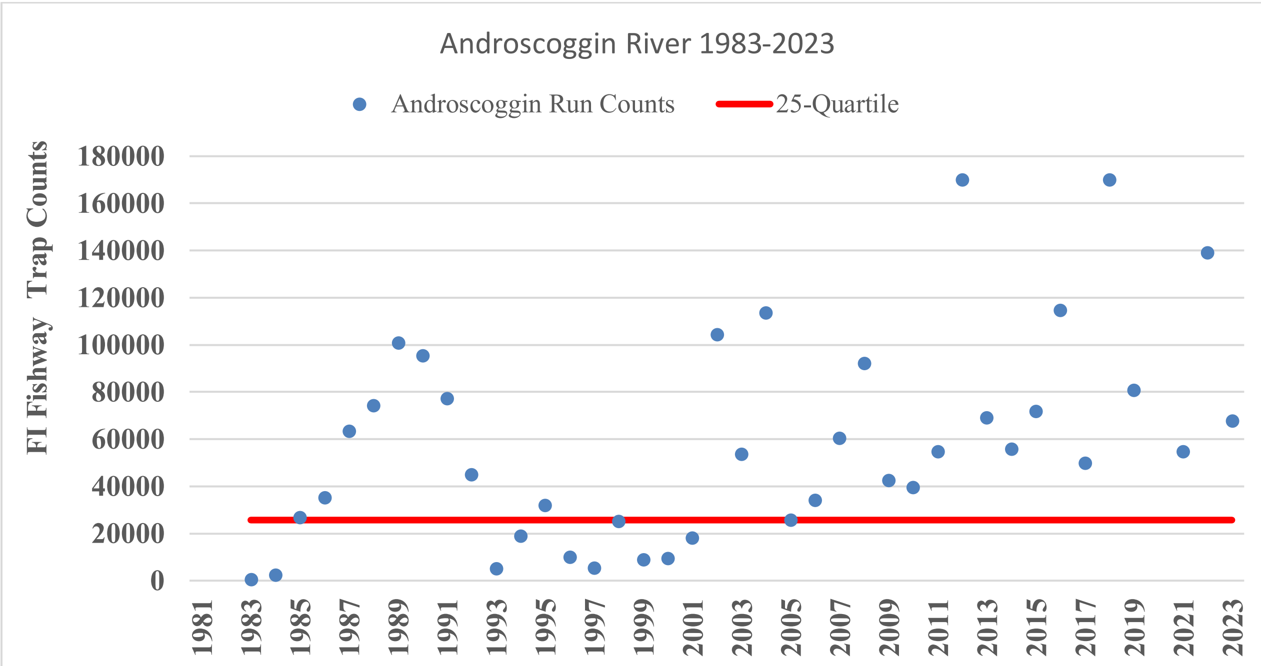


Figure 6. Fishway counts for the Kennebec River.

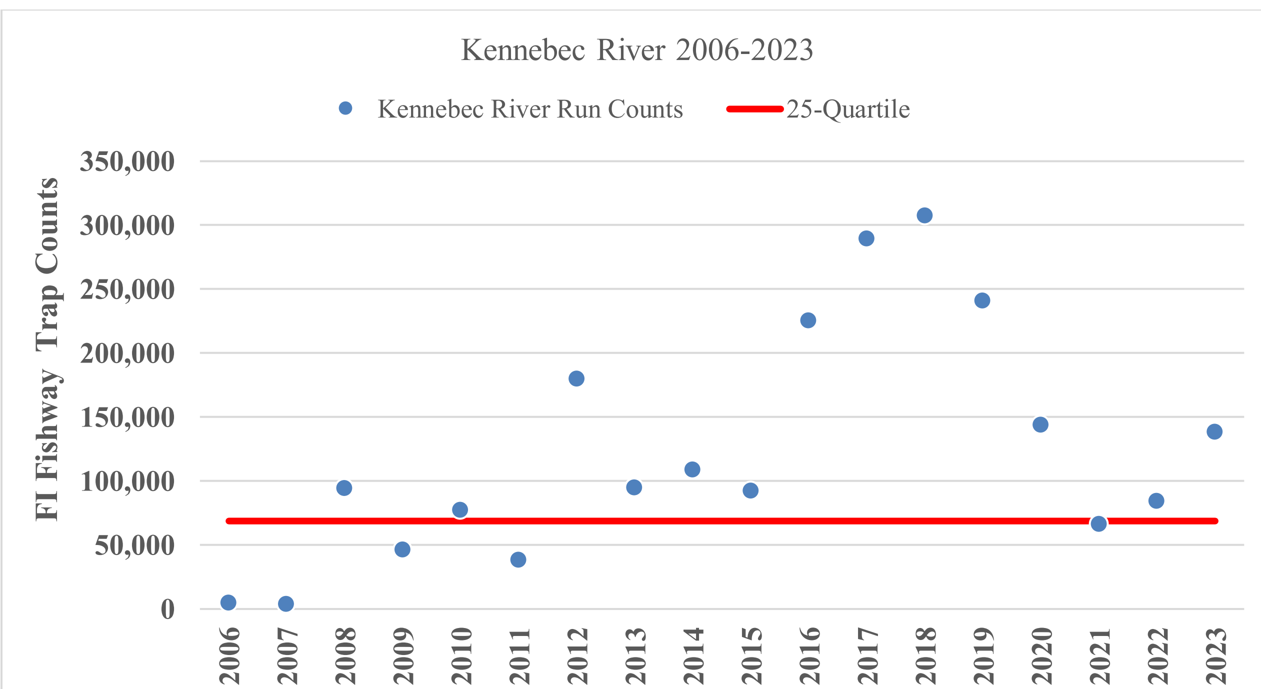


Figure 7. Fishway counts for the Sebasticook River.

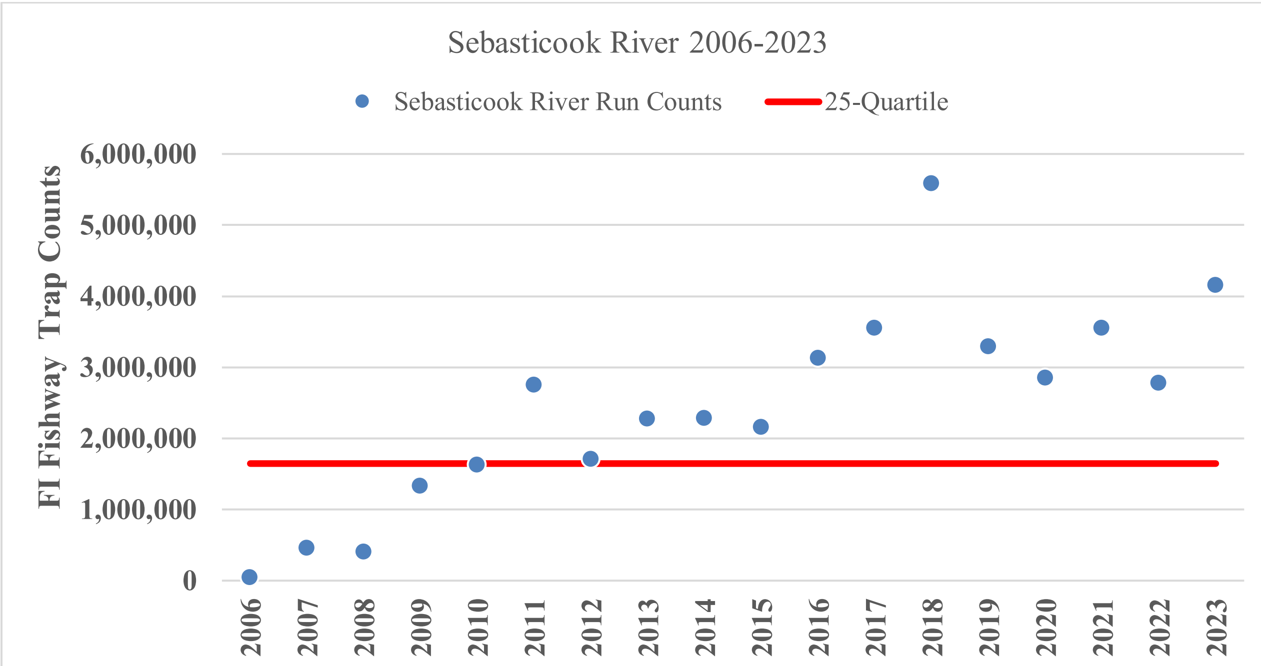


Figure 8. Fishway counts for the Penobscot River.

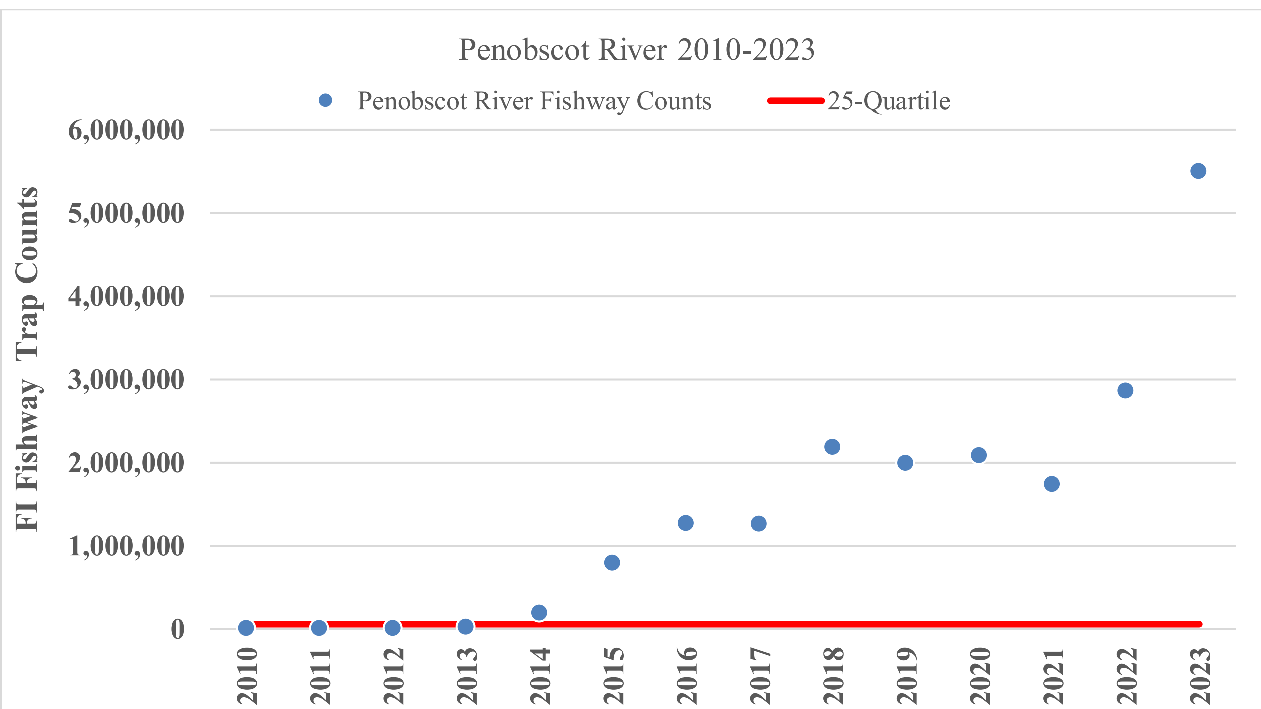
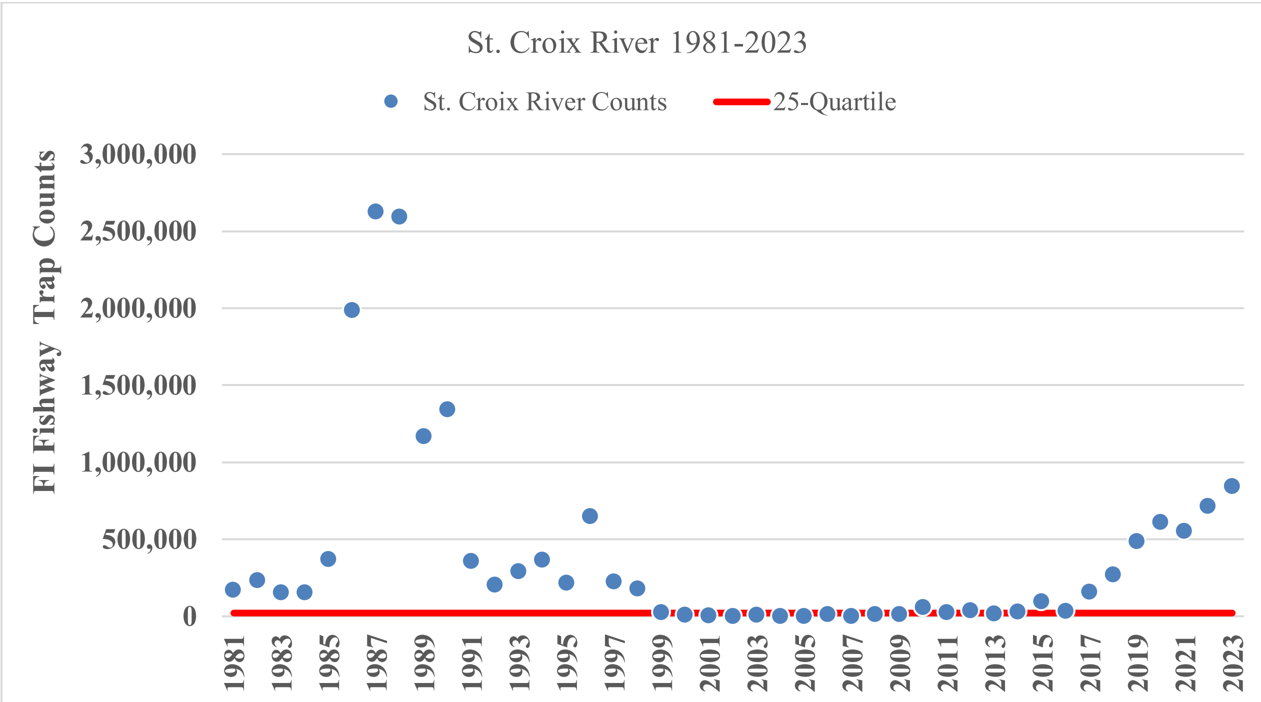


Figure 9. Fishway counts for the St. Croix River.



Massachusetts Sustainable Fisheries Plan for American Shad (*Alosa sapidissima*)

Submitted to:

Atlantic States Marine Fisheries Commission

Prepared by:

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1. Introduction

American shad *(Alosa sapidissima)* are presently managed under Amendment 3 to the Interstate Fishery Management Plan for Shad and River Herring. Amendment 3 contains the provision to close state fisheries for shad (except for catch and release only) for states without an approved sustainable fisheries management plan (SFMP) by January 2013. The purpose of this SFMP for Massachusetts is to allow the continuation of shad fishing in the Merrimack and Connecticut rivers while planning for population restoration in those rivers and others where populations are low and limited information is available.

2. Current Regulations

American shad are managed in Massachusetts jointly by the Division of Marine Fisheries (DMF) and the Division of Fisheries and Wildlife (*MassWildlife*). DMF manages shad passage and harvest in marine waters up the first dam or head of tide and *MassWildlife* manages shad passage and harvest in freshwater above the first dam or head of tide. Under current laws and regulations no commercial fishery for American shad presently operates within the Commonwealth of Massachusetts. Under Massachusetts General Laws (Chapter 130), American shad may be taken by hook and line only. The Code of Massachusetts Regulations (322 CMR 6.17) restricts the harvest of American shad to the Merrimack and Connecticut Rivers, with a three fish per angler possession limit. All other waters are catch and release only. Regulations at 322 CMR 4.12 prohibit the landing of net caught shad, even when taken outside of Massachusetts waters in the Exclusive Economic Zone or in the territorial seas of another state.

3. Current Status of Stocks

Four river systems in Massachusetts support recreational American shad fisheries that are predominantly catch and release. These are the Merrimack River, the North River and its tributaries of Pembroke and Marshfield, the Palmer River, and the Connecticut River. Three other rivers are considered to support shad runs due to recent observations of adult shad during spring (*see* Appendix, Table A1). Coastal runs of American shad in the Commonwealth are relatively small compared to the Mid-Atlantic and South Atlantic regions. The Connecticut and Merrimack rivers have the most potential to support large American shad runs, both have multi-jurisdictional anadromous fish management and restoration plans in effect. Following the section on state-wide reported landings, the plan will be divided into sections on the Merrimack River and Connecticut River. Finally, brief discussion will be included on the remaining small rivers that have limited information on existing shad runs or fisheries.

A. Statewide Landings

The prohibition of catching shad by net in 1987 essentially eliminated commercial harvest in Massachusetts. Since 1987, landings have been reported by the National Marine Fisheries Service (NMFS) (Table A2), with few shad landings in recent years. The origin of these harvested shad is uncertain but is expected to some degree to represent illegal landings made inadvertently within fisheries that were not targeting shad. Recreational catch estimates are made with high variability; showing higher catch in the late 1990s and low catch in recent years (Table A3). The recreational survey is also limited by incomplete statewide coverage of all areas where shad occur.

Merrimack River

Merrimack River. The Merrimack River flows for 204 km from tributaries in New Hampshire to the Atlantic Ocean. The lower 78 km of the river are in Massachusetts and the first dam is the Essex Dam, located at 42º 41' 57.942" N and 71º 09' 57.086" W at 48 rkm in Lawrence, Massachusetts. The drainage area of the Merrimack River is 12,970 km^2. A US Geological Survey streamflow gauge station has been maintained since 1923 in Lowell at drainage area 12,005 km^2 (#01100000) at approximately 66 rkm. Mean monthly discharge for the time series at this station during the spring are: 19,200 cfs – April; 11,600 cfs – May; 6,580 cfs – June; and 3,950 cfs – July (http://waterdata.usgs.gov/ma/nwis/).

Historically, the shad spawned in the Merrimack River as far in the watershed as Lake Winnipesaukee in central NH and its tributaries. Prior to dam construction, the shad run in the Merrimack River supported important fisheries that landed several hundred thousand shad annually (Stolte 1981). By the late 19th century, Goode (1884) considered the Merrimack River shad run to be insignificant due to passage barriers. Anadromous fish are managed by the Merrimack River Anadromous Fish Restoration Program that is comprised of US Fish and Wildlife Service (USFWS), NMFS, US Forest Service, DMF, *MassWildlife*, and NH Dept. of Fish and Game (NH DFG). Fishways are present on the first three dams in the Merrimack River. The lowermost dam, the Essex Dam, was first built in 1848 and presently has a spillway width of 920 ft and height of 31 ft. Several fish passage facilities have been operated at the dam since construction. Since 1983 passage has been provided by a fish lift. The fish lift is operated by the dam owner, Consolidated Hydro, Incorporated Energy (FERC Project No. 2800).

The next dam upstream is the Pawtucket Dam in Lowell MA at 70 rkm. The Pawtucket Dam was built in 1830, enlarged in 1876, and presently has a spillway width of 1086 ft and height of 15 feet. A vertical-slot fishway and fish lift at the Pawtucket Dam became operational in 1986. The fishways are operated by the Lowell Hydroelectric Project (FERC Project No. 2790). The third dam upstream is the Amoskeag Dam (1075 ft. width, 29 ft. height) in Manchester, NH, at 119 rkm, that has a pool-weir fishway where shad counts are monitored by the NH DFG. The next two dams in NH (Hooksett and Garvins) presently have no fish passage facilities.

Shad Spawning/Nursery Habitat. There is a large amount of existing and potential shad nursery habitat in the Merrimack River. Currently, upstream passage in the Merrimack River is blocked at the Hooksett Dam at 132 rkm. The Merrimack River Shad Restoration Plan (MRTC 2010) estimated that there was approximately 5,687 acres of potential mainstem nursery habitat downstream of the Hooksett Dam. The plan also identified 700 acres of potential nursery habitat available in tributaries to the Merrimack River downstream of the Hooksett Dam. Restoring upstream passage at Hooksett and Garvins would provide another 3,802 acres of habitat currently unavailable to spawning shad.

The Technical Committee for the Anadromous Fishery Management of the Merrimack River first introduced a strategic plan for restoration in the Merrimack River that contained an interim objective of annually passing 35,000 shad at the Essex Dam fish lift (USFWS 1997). The 1997 plan recognized that variable river discharge can alter both fish lift operations and attraction flows to the fish lift entrance which can influence the passage efficiency of shad present below the dam annually. The shad restoration plan for the Merrimack River was updated in 2010 (MRTC 2010) and contains shad restoration targets based on habitat units.

Coordination within the Merrimack River Watershed

The Massachusetts Division of Marine Fisheries accepts the restoration goals of the cooperative Merrimack River Anadromous Fish Restoration Program as specified in the updated shad restoration plan (MRTC 2010). Based on upstream habitat units and the assumed production metric of 100 shad per acre of habitat, the MRTC (2010) goal for passage is 744,083 shad at the Essex Dam and 651,173 shad at the Pawtucket Dam. The plan provides detailed recommendations for achieving shad restoration goals through fish passage improvements and stocking measures with long-term monitoring and program evaluation.

Additionally, the state of New Hampshire also accepts the restoration goals of the cooperative Merrimack River Anadromous Fish Restoration Program as documented in their American Shad Fishing/Recovery Plan submitted to the ASMFC Shad and River Herring Technical Committee in 2012 (NHFG 2011). New Hampshire presently has closed both the recreational and commercial shad fisheries to harvest while allowing catch and release for sportfishing in the Merrimack River. Discussions were held with NH Fish and Game staff at the time of the 2018 SFMP update over the need to coordinate further on this SFMP update; however, given that their fishery is closed to harvest, no further action was taken.

A. Landings

No Merrimack River-specific shad landings data are available. Harvest in MA has been restricted to hook and line since 1987. Communications with local fishing clubs and bait and tackle shops indicate a small sportfishery persists with relatively low participation and low retention of shad.

B. Fishery Independent and Dependent Indices

i. Juvenile Abundance Indices: There have been no historical or recent efforts to create a juvenile abundance index on the Merrimack River.

ii. Fish Lift Monitoring of Spawning Run

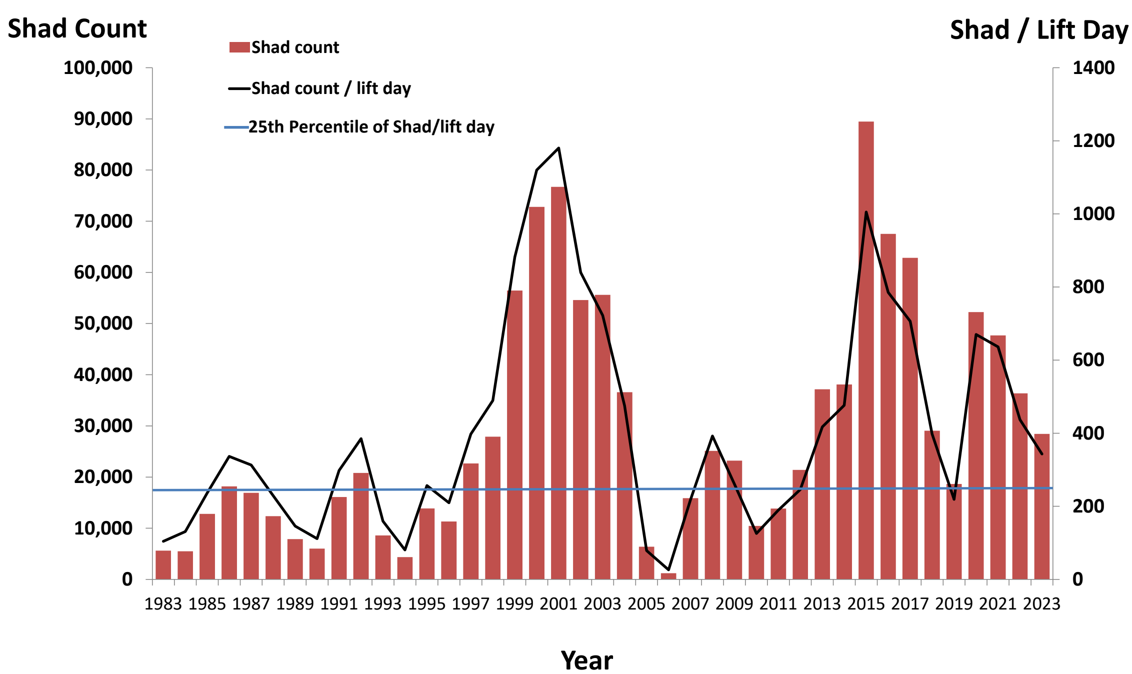
Long-term fishery independent indices for shad are available from fish lift data at large hydropower dams on the Merrimack River. Cooperative monitoring efforts have been ongoing in the Merrimack River since 1969 involving the USFWS, DMF and *MassWildlife*. The Merrimack River shad run is considered to be of sufficient size to support out-of-basin transfers for restoration efforts. The monitoring efforts include annual spawning stock surveys at the fish lifts, biological sampling, and determination of age structure and population mortality and survival estimates. *MassWildlife* is responsible for reporting shad monitoring at the two fish lifts in MA. The most recent performance report for the Essex Dam was prepared by Patriot Hydo (Patriot Hydro 2023).

From 2007 to 2017, approximately 700-1700 adult shad were collected annually at the Essex Dam for hatchery propagation and restoration efforts in the Merrimack River, Charles River and Maine rivers. American shad fish passage counts at the Essex Dam fish-lift from 1983–2023 are presented in Table A4 and Figure 1. High water levels in 2005 and 2006 caused the closure of the fish lifts which severely limited counts and collections. The series mean count, excluding 2005/2006, is 30,282 shad, the median is

22,661 and the 25th percentile is 13,314. The lift counts can be standardized by the number of days when the lift was operating each season (Table A5). The lift day index has a series mean of 426 shad/lift day, a median of 343 shad/lift day and 25th percentile of 218 shad/lift day. The 25th percentile of the shad/lift day data series was adopted as a threshold for lower run sizes in the 2012 SFMP.

Essex Dam Lift Operations. The Essex Dam fish lift begins operating each year between April 15th and May 1st depending on flow conditions. The lift is typically operated from 0800 to 1600 with lifts occurring each hour. The lift frequency and range of time can be extended if large numbers of shad are present. The lift operation ceases when the shad run is complete, usually in the latter half of July. The installation of flash boards on the dam crest is critical to attract shad to the fish lift entrance and prevent them from aggregating at the base of the dam. During 2005 and 2006, high flows prevented the installation of flash boards until June. In 2010 the flash boards were replaced with an inflatable flashboard system. Data on the number of lifts each year are not available for every year in the time series. When available the tally of lifts and count of days that the lift operated can be used to standardize shad counts relative to operations.

Figure 1. American shad counts at the Essex Dam fish lift in Lawrence, MA, Merrimack River, 1983–2023. Source: *MassWildlife*, and USFWS Central NE Fisheries Resource Office.
Note: 2005 and 2006 counts are not included in the 25th percentile calculation due to high flow.



iii. Passage Efficiency

Existing fish passage limitations, including passage efficiency, have been reviewed and summarized in the Merrimack River Shad Restoration Plan (MRTC 2010). Downstream passage assessments are recommended by the Plan (MRTC 2010), along with specific recommendations to improve fish passage efficiency throughout the watershed. Presently, downstream passage efficiency studies are underway at the five main stem dams. Upstream passage efficiency at the Essex Dam in Lawrence has not been assessed, although specific efforts to improve passage have been implemented recently through the Technical Committee that should increase passage efficiency.

Upstream passage efficiency at the Pawtucket Dam in Lowell is low. Data collected between 1989 and 2009 indicates that on average only 29% of fish that pass through the Essex Dam fish lift eventually ascend the lift at the Pawtucket Dam. Sprankle (2005) conducted telemetry studies to assess passage efficiency at the Lowell Dam. Sprankle (2005) found that 66% of the shad radio tagged at the Essex Dam arrived at the pool downstream of the Lowell Dam and 55% entered the dam tailrace. Only 4% of the shad entering the tailrace passed the Lowell Dam fish lift. No ripe shad have been caught below the Essex Dam during electrofishing monitoring, indicating that no spawning habitat occurs below the dam and all shad are seeking to move upstream.

4. Fisheries to be Closed

Commercial fisheries for shad are presently closed in Massachusetts with no change proposed. Recreational fisheries are presently open to catch and release only with the exception of harvest allowed in the Merrimack River and Connecticut River with a three fish per day bag limit.

5. Fisheries Requested to be Open

This plan proposes to maintain recreational shad catch and harvest in the Merrimack River and Connecticut River. Shad fishing in all other Massachusetts rivers was changed to catch and release only with the 2012 SFMP.

6. Sustainability Targets

A. Definition.

A sustainable American shad fishery will not diminish future stock reproduction and recruitment.

B. Methods for Monitoring Fishery and Stock.

No stock abundance indices are available for Merrimack River shad other than the ongoing fish lift monitoring at the Essex Dam. This long-term census data is proposed as the basis for establishing sustainable fishery benchmarks. The Essex Dam fish lift count series has 40 years of census and CPUE data of the annual spawning run. Biological data on shad size, age, and sex composition has also been collected since the 1990s. Over time, these data can be evaluated for stock thresholds related to size, age, total instantaneous mortality (Z) and repeat spawning ratio. Because the time series for age and mortality estimates and repeat spawning percentage is brief, the present plan will depend on the distribution of fish lift data. Mortality thresholds will be presented in the 2024 SFMP but will serve as a warning threshold until additional data can be collected.

SFMP Performance. The SFMP for the Merrimack River was prepared and approved in 2012 using fish lift count data from 1983-2011 as a basis for the benchmark. Shad counts at the fish lift increased substantially during the following SFMP update period of 2012-2017; averaging 17,694 shad/year in the last five years of the 2012 SFMP versus 59,019 shad/year in the most recent five years. For this update period of 2018-2023, the average count was 35,458 shad/year. This was a decline from the high annual counts during 2012-2017; however, counts were elevated relative to the time series, resulting in a modest increase in the average annual count and SFMP statistics.

Fish Lift Count Benchmark – Merrimack River. With the addition of 2018-2023 shad count data, the benchmark (25^{th} percentile of the 1983-2023 Essex Dam fish lift count data series) increases from 210 to 218 shad/lift day. This benchmark will serve as a spawning run threshold for management action. Three consecutive years below this benchmark will trigger consultation between *MassWildlife* and DMF to discuss reducing recreational harvest. This benchmark value will not vary annually but will be updated with the next SFMP review.

Repeat Spawning Ratio. Ongoing shad scale aging will provide data on the ratio of repeat spawners in the spawning run. Repeat spawning ratio data are available for the Merrimack River from 2004-2023 (Table 1). The time series is too brief to allow the setting of a repeat spawning ratio benchmark or to discern any trends. This data collection will continue and be reported in the River Herring and American Shad ASMFC Compliance Report annually and considered further with the next SFMP review.

Mortality Benchmark. Amendment 3 defined the shad mortality warning threshold as the level of total instantaneous mortality (Z) that resulted in a female spawning stock biomass that was 30% of the total female spawning stock biomass in a stock that experienced only natural mortality ($Z = M$). Amendment 3 provides benchmark values for New England shad runs of $Z_{30} =$ 0.98 and $A_{30} = 0.62$ (annualized mortality). The Z_{30} benchmark will be adopted by the 2024 SFMP as a warning threshold until a longer Merrimack River time series is recorded or further ASMFC recommendations are made.

The total instantaneous mortality rate (Z) was estimated using the Chapman-Robson method, regression-based estimates, and catch curves from repeat spawning age data. The Chapman-Robson method is a probability-based estimator that has been shown to be more accurate and less biased than the linear regression-based catch curves, especially when sample size is small. Shad ages 5 through 10 were used in the analysis. The suitability of the 2001-2023 Merrimack River mortality estimates may be limited by many factors including small sample sizes, a brief data series, combined genders in the estimate, and the assumption that all mortality is natural. The Chapman-Robson results were selected as most suitable and reported in Table 2.

The trend to date is that Merrimack River shad mortality was at or below the Z_{30} until 2013, when it increased above the threshold and has remained high since (Figure 2). No samples were collected in 2020 due to COVID-19 concerns which resulted in disruptions in lift operations. While Z has recently increased, fork length for both males and females has declined since 2005 and 2003, respectively. The mortality warning threshold was not exceeded under the 2012 SFMP but has been exceeded each year since 2013 with exceptions in 2019 and 2022. With the recent conditions of increasing spawning run stock, higher mortality estimates resulting from increased recruitment is not unexpected, although this dynamic should be reviewed and considered annually in the MA shad compliance report.

Table 1. Repeat spawning percentage (RSP) of sub-sampled American shad collected at the Essex Dam fish-lift, Merrimack River, 2004-2023 (Source: 2024 ASMFC River Herring and American Shad MA Compliance Report; Sheppard et al. 2024). The numbers in parentheses following RSP are the years of repeat spawning, with RSP (0) for virgin shad.

YEAR	*N*	*RSP (0)*	*RSP (1)*	*RSP (2)*	*RSP (3)*	*RSP (4)*	*RSP (5)*	*RSP (6)*
2004	243	53	23	13	6	4	1	0
2005	182	53	25	13	8	2	0	0
2006	175	66	22	8	4	0	0	0
2007	208	76	15	7	1	0	0	0
2008	211	84	7	5	3	0	0	0
2009	151	32	45	15	5	3	1	0
2010	181	38	43	15	3	1	1	0
2011	259	58	19	13	8	2	0	0
2012	178	69	21	7	3	1	0	0
2013	144	64	26	7	3	1	0	0
2014	254	61	31	6	1	0	0	0
2015	292	78	12	9	1	0	0	0
2016	225	63	22	12	3	0	0	0
2017	244	62	24	14	0	0	1	0
2018	211	91	76	30	14	3	0	0
2019	111	95	10	3	3	0	0	0
2020*								
2021	144	87	46	9	2	0	0	0
2022	204	126	50	25	3	0	0	0
2023	175	122	27	19	6	1	0	0

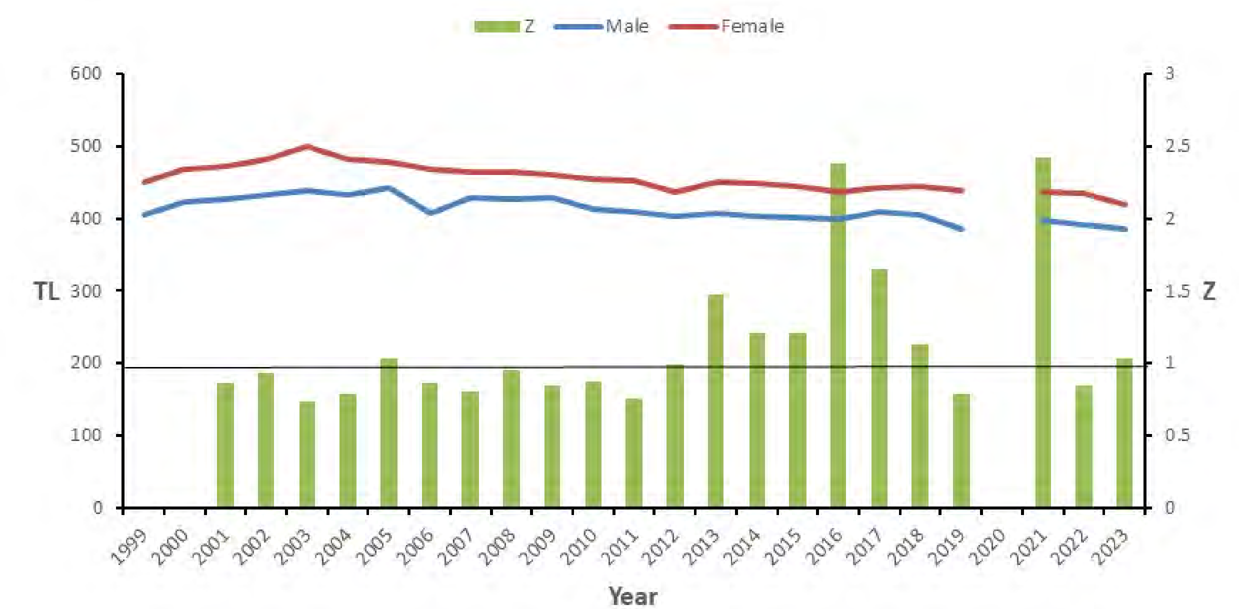
*No samples collected in 2020 due to disruptions in operations from COVID-19.

Table 2. American Shad age, growth, and sex statistics for adult returns at the Merrimack River (1991–2023). Source: 2024 ASMFC River Herring and American Shad MA Compliance Report (Sheppard et al. 2024).

Year	Sample N	N (male)	N (Female)	% Male	% Female	Ratio (M:F)	Mean Age Male	Mean Age Female	Mean FL (mm) Male	Mean FL (mm) Female	Mean Wgt (kg) Male	Mean Wgt (kg) Female	Mortality (Z) and Survivorship (S) - Chapman-Robson Z	SE	S	SE
1991	107	61	46	57.0	43.0	1.3:1.0	4.7	5.3	434	475	1.13	1.59	Unk	N/A	Unk	N/A
1992	48	23	25	46.0	54.0	0.9:1.0	4.4	5.2	Unk	Unk	Unk	Unk	Unk	N/A	Unk	N/A
1993	32	6	26	19.0	81.0	0.2:1.0	4.5	5.0	Unk	Unk	Unk	Unk	Unk	N/A	Unk	N/A
1995	160	101	59	63.0	37.0	1.7:1.0			404	465	0.91	1.50	Unk	N/A	Unk	N/A
1999	212	146	66	69.0	31.0	2.2:1.0	4.8	5.6	406	450	0.91	1.32	Unk	N/A	Unk	N/A
2000	217	103	114	47.5	52.5	0.9:1.0	4.7	5.6	422	467	1.00	1.50	Unk	N/A	Unk	N/A
2001	204	115	89	56.4	43.6	1.3:1.0	6.0	6.6	427	471	1.04	1.47	0.87	0.24	0.42	0.10
2002	199	79	120	39.7	60.3	0.8:1.0	5.7	6.3	432	482	1.10	1.69	0.94	0.20	0.39	0.08
2003	115	39	76	39.7	60.3	0.5:1.0	5.9	6.7	439	499	1.16	1.92	0.74	0.16	0.47	0.08
2004	257	152	119	45.5	54.5	1.3:1.0	5.8	6.5	433	482	1.08	1.59	0.79	0.11	0.45	0.05
2005	200	105	95	52.5	47.5	1.1:1.0	5.9	6.1	443	477	1.11	1.51	1.03	0.11	0.35	0.04
2006	178	79	99	44.4	55.6	0.8:1.0	4.9	5.7	407	468	0.96	1.49	0.87	0.06	0.42	0.03
2007	212	99	113	46.7	53.3	0.9:1.0	4.4	5.1	429	464	1.16	1.55	0.81	0.12	0.44	0.05
2008	227	113	114	49.8	50.2	1.0:1.0	5.4	5.6	427	464	1.10	1.43	0.96	0.25	0.38	0.10
2009	214	96	118	44.9	55.1	0.8:1.0	5.9	6.5	429	461	1.08	1.38	0.85	0.11	0.42	0.05
2010	181	65	116	36.0	64.0	0.6:1.0	5.1	5.6	412	455	1.04	1.53	0.88	0.17	0.41	0.07
2011	258	148	110	57.0	43.0	1.3:1.0	5.7	6.6	408	452	1.01	1.39	0.76	0.16	0.47	0.07
2012	243	155	88	63.8	36.2	1.8:1.0	5.1	5.5	404	436	0.95	1.28	0.99	0.15	0.37	0.06
2013	144	69	75	48.0	52.0	0.9:1.0	5.3	5.9	407	451	0.93	1.40	1.48	0.51	0.22	0.11
2014	302	158	144	52.0	48.0	1.1:1.0	5.1	5.8	403	449	0.92	1.36	1.21	0.21	0.29	0.06
2015	357	175	182	49.0	51.0	0.9:1.0	4.9	5.4	402	445	0.92	1.35	1.21	0.21	0.30	0.06
2016	225	91	134	40.0	60.0	0.7:1.0	5.3	5.7	400	437	0.90	1.31	2.38	0.58	0.10	0.05
2017	246	115	131	47.0	53.0	0.9:1.0	5.5	5.9	409	443	0.92	1.32	1.65	0.38	0.19	0.07
2018	214	92	122	43.0	57.0	0.8:1.0	5.4	6.0	405	444	0.88	1.29	1.13	0.24	0.32	0.08
2019	180	111	69	62.0	38.0	1.6:1.0	4.9	6.0	385	439	0.73	1.19	0.79	0.45	0.45	0.32
2020																
2021	145	59	86	40.7	59.3	0.7:1.0	5.3	5.7	398	437	0.87	1.30	2.42	0.01	0.08	0.15
2022	206	107	99	51.9	48.1	1.1:1.0	5.2	5.8	392	435	0.82	1.22	0.85	0.15	0.43	0.06
2023	175	95	80	54.3	45.7	1.2:1.0	5.3	5.4	385	418	0.77	1.10	1.03	0.11	0.35	0.04

* No biological samples collected in 2020 due to disruptions in operations from COVID-19.

Figure 2. Annual American shad average total length (TL) and mortality (Z) from spawning run samples at the Essex Dam fish lift in Lawrence, MA, Merrimack River, 1999-2023. Source: *MassWildlife*, and USFWS Central NE Fisheries Resource Office. The ASMFC Amendment 3 shad mortality warning threshold of Z_{30} = 0.98 is provided by the black line. The 2016 Z estimate may not be suitable because only two age classes were represented.



C. Timeframe.

These benchmarks and warning thresholds will be used starting October 1, 2024 and remain active until a plan review is conducted after five years.

7. Proposed Regulation Modification to Support Targets

A. Recreational Bag Limits

No changes are proposed to shad fishing regulations for the 2024 SFMP update. *MassWildlife* and DMF implemented the regulation changes in 2012 to lower the bag limit for American shad from 6 fish per angler per day to 3 fish per angler per day in the Merrimack River and Connecticut River. Secondly, the harvest of shad in all other rivers was closed with shad fishing allowed as catch and release only.

B. Enforcement

Massachusetts Environmental Police are charged with enforcing recreational shad bag limits on the Merrimack River and the no possession regulation on other rivers. *MassWildlife* and DMF will coordinate with regional enforcement staff each spring to exchange information on illegal harvest.

8. Adaptive Management.

A. Evaluation Schedule. Fish lift count data, age structure data, mortality estimates, and repeat spawner percentages will be reported annually in the MA River Herring and American Shad ASMFC Compliance Report. These ongoing data collections will contribute to a future revision of the SFMP.

B. Consequences or Control Rules

Three consecutive years below the fish lift count 25^{th} percentile benchmark at the Essex Dam on the Merrimack River will trigger consultation between *MassWildlife* and DMF to discuss reducing recreational harvest. These interim values will be revised when this plan is updated in the future. The Z_{30} shad mortality warning threshold has been exceeded each year since 2012. There is some concern related to the recent rise in shad mortality in the Merrimack River, although this is tempered by the expectation that recent improved recruitment is an influence on the estimates of higher mortality. This exceedance will receive annual attention and be documented in the annual compliance report and be used to supplement management decisions and actions if the fish lift benchmark is exceeded. A summary of SFMP metrics and thresholds is provided in Table A6.

C. Potential Future Benchmarks

Improved Essex Dam Lift Index. There is potential to modify the shad count index at the Essex Dam fish lift by standardizing the fish counts to environmental data such as discharge and water temperature, and operational data, and to model the results to improve the quality of this spawning run index of abundance. Discussions were held with the partners of the Merrimack River Anadromous Fish Restoration Program on this topic. For the 2024 SFMP it was agreed that much work was needed to bring environmental and operational data into the fish lift datafile to support an index modeling exercise. This investigation is recommended for a future SFMP update.

Connecticut River

The Connecticut River is the longest river in New England at 655 km and the largest in volume, with a mean freshwater discharge to Long Island Sound of 19,600 cfs. The Connecticut River defines the border between New Hampshire and Vermont and passes through the states of Massachusetts and Connecticut. The river is tidal to Windsor Locks, Connecticut at rkm 100. The lowermost fish passage facility is at the Holyoke Dam located at rkm 138 in the City of Holyoke and Town of South Hadley. The Holyoke Hydroelectric Project (FERC No. 2004) operates a 42.9 megawatt hydropower facility at the Holyoke Dam. The Holyoke Dam is 30 ft high and 985 ft in length, impounds a 2,290-acre reservoir, and includes six hydroelectric generating systems. The upstream fish passage facilities are two fish lifts, one at the Hadley Falls Station tailrace and the other at the bypass reach. Fish passage facilities for the Holyoke Dam are described in detail in the 2010 Annual report on upstream fish passage (HGE 2011).

Shad have been managed cooperatively on the Connecticut River since 1967 by the Connecticut River Atlantic Salmon Commission (CRASC). The states of Connecticut, Massachusetts, New Hampshire and Vermont, as well as the USFWS and NMFS are signatories of the Commission. The 1967 agreement stated restoration goals of a total Connecticut River population of two million shad, and passage of one million shad above the Holyoke Dam. The Commission approved a shad management plan in 1992 that retained these goals while seeking to restore shad to its historic range in the Connecticut River Basin (CRASC 1992). This management plan was updated in 2017 (CRASC 2017; CRASC 2020) with refined restoration objectives, including:

- Achieve and sustain a minimum river-wide population of 1.7 million American shad; that includes a run of over 1.0 million shad downstream of Holyoke Dam, and passage of greater than 687,000 shad at the Holyoke Dam.

- Achieve and sustain a target adult return rate of 203 shad per hectare in the main stem.

- Achieve an adult stock structure with a 5-year running repeat spawning average of 15%.

Shad Spawning/Nursery Habitat.

Reported in Connecticut plan

Coordination within the Connecticut River Watershed

The Connecticut River Atlantic Salmon Commission has coordinated extensive efforts to manage and restore shad in the watershed over the last 40 years. The Commonwealth of Massachusetts is a cooperator in the Commission's shad plan and benefits from this long-term commitment and experience. All Connecticut River shad restoration goals and population benchmarks will be directly adopted from the existing shad plan. Details on the management plan or fishway operations are available in other documents (CRASC 1992; HGE 2011).

Recreational rod and reel fisheries for shad occur in the states of Connecticut and Massachusetts in the Connecticut River and a traditionally important commercial gill net is conducted in Connecticut presently at low levels of harvest. The Connecticut Department of Energy and

Environmental Protection (CT DEEP) has been monitoring the gill-net fishery since the 1970s and has conducted an annual seine survey in the river since 1978 that produces a juvenile index for shad. Commercial shad landings in Connecticut have been less than 100,000 pounds annually since 2004 and the numbers of gill-net permits issued has declined to less than 12 in recent years. The recreational harvest of shad is only allowed in the Connecticut River in Connecticut with a 6 shad (combined American and Hickory shad) per angler bag limit. Connecticut was approved to maintain its existing commercial fishery and recreational fishery through their 2012 SFMP (CT DEEP 2012) that was updated in 2017 (CT DEEP 2017).

The Connecticut 2017 SFMP uses a "stop light" approach to monitoring and maintain a sustainable fishery for shad in the Connecticut River. This approach has two stock status (response) metrics and a fishing rate (stressor) metric that guide management responses. The PASSAGE response metric is based on the Holyoke Dam fish lift counts is a proxy for total run size. The PASSAGE response threshold of 140,000 shad passed at the fish lift is derived from Juvenile Abundance Index (JAI) values that vary independent of adult run size. It was found that lift counts in the range of 150,000 to 160,000 produced a wide range of year classes - suggesting sufficient stock reproductive capacity to support future reproduction and recruitment. The threshold of 140,000 was selected as a conservative target.

The RECRUITMENT response threshold is defined as three consecutive years below the 25th percentile of the JAI geometric mean time series. The ESCAPEMENT stressor threshold was selected as 90% of the total shad run "escaping" ((lift counts – total harvest)/lift counts) the fishery to spawn. This value was conservatively selected using the median escapement value of 96% for 1990 to 2016.

The details of the CT DEEP "stop light" approach for their shad SFMP are provided in CT DEEP (2017). All three thresholds will be adopted in the Massachusetts SFMP as warning metrics that will trigger consultations between *MassWildlife*, MA DMF and CT DEEP. The fish lift response metric for CT DEEP has a different basis, resulting in a lower threshold, than the MA DMF fish lift metric. For this reason the management trigger will occur with a single exceedance as to three years for other SFMP metrics.

A. Landings

No Connecticut River-specific shad landings data in MA are available. The fishery has been restricted to hook and line since 1987. Communication with local fishing clubs and bait and tackle shops indicate a small sportfishery persists and that is mainly catch and release.

B. Fishery Independent and Dependent Indices

i. Juvenile Abundance Indices (JAI)

The CT DEEP maintains a juvenile shad population index generated from a Connecticut River seine survey. The seining occurs weekly from mid-July to mid-October at seven fixed stations between Holyoke, MA, and Essex, CT. The survey has generated a JAI since 1978 using the geometric mean catch per seine haul. The JAI series was accepted in Amendment 3 of the ASMFC Shad and River Herring Fishery Management Plan using the 25th percentile of time series data as the threshold for management action. When three consecutive JAI values fall lower than the 25th percentile management action will be required to address juvenile recruitment failure (CT DEEP 2017). The Connecticut JAI is the only data source for juvenile shad indices that could be adopted for the MA SFMP.

ii. Fish Lift Monitoring of Spawning Run

American shad fish passage counts at the Holyoke Dam fish-lift from 1967 – 2023 are shown in Figure 3. A single fish lift operated from 1955 to 1975 and a second fish lift became operational in 1976. The 2012 SFMP used the entire count period for setting management benchmarks. The 2018 and the 2024 update used the period of 1976 to present when the two lifts were consistently operated. *MassWildlife* is responsible for reporting shad monitoring at the two fish lifts in MA. The most recent performance report for the Holyoke Dam (covering October 1, 2022 through September 30, 2023) was prepared by the USFWS (2023).

Holyoke Dam Fish List Operations. The Holyoke fish lift begins operations on April 1st each year or when flows fall below 40,000 cfs and continues until July 15th. Details on fish lift operations are provided in HGE (2024) and USFWS (2023).

iii. Passage Efficiency

The numbers of adult shad that pass the Holyoke Dam represent a variable proportion of the Connecticut River population. The percentage of Connecticut River shad passing upstream of the Holyoke Dam has increased since 1975 to approximately 40-60% annually (Leggett et al. 2004). A study in 1992 estimated average annual fish lift efficiency to be close to 50% (CRASC 1992). However, as a result of FERC relicensing in 2001 the lifts were rebuilt with larger hoppers and faster lift rate and these changes may have resulted in a change in passage efficiency. An ongoing cooperative tagging study involving CRASC participants is expected to provide additional data to address passage efficiency at the Holyoke Dam.

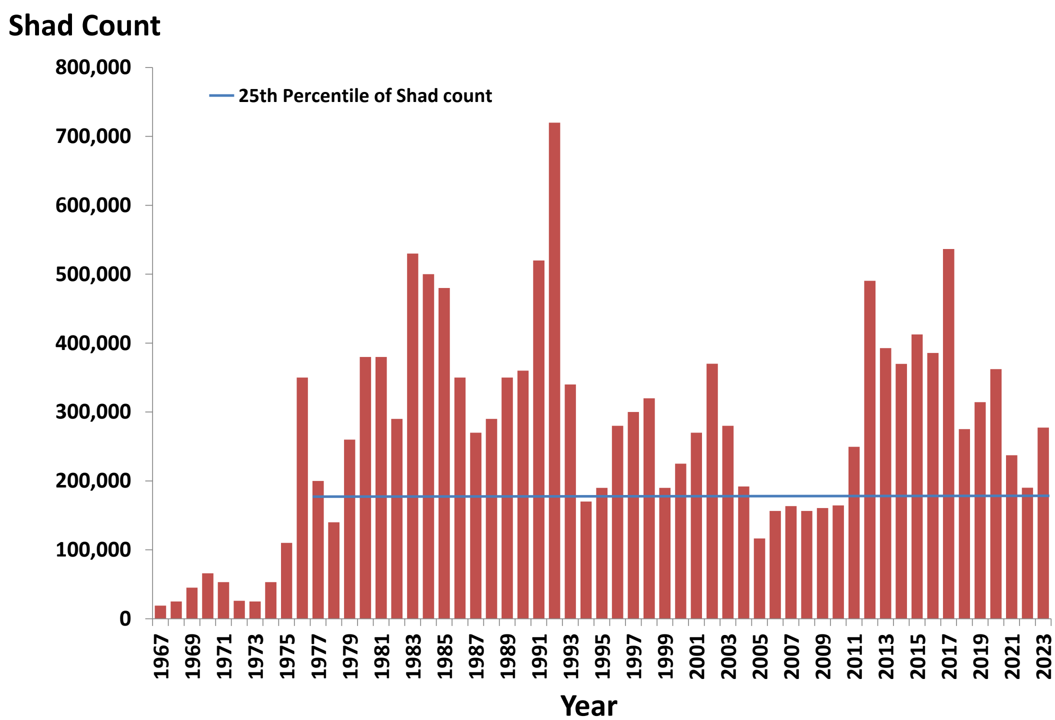
4. Fisheries to be Closed

Commercial fisheries for shad are presently closed in Massachusetts with no change proposed. Recreational fisheries for shad in Massachusetts are presently close to catch and release only at all rivers except the Merrimack River and Connecticut Rivers where a three fish daily bag limit is allowed.

5. Fisheries Requested to be Open

No changes are proposed to shad fishing regulations for the 2024 SFMP update. The 2024 SFMP update continues to allow recreational shad catch and harvest in the Merrimack River and Connecticut River, and catch and release fishing in all other Massachusetts rivers.

Figure 3. Monitoring counts of American shad recorded at the Holyoke Dam, Holyoke, MA, Connecticut River, 1967-2023. Source: USFWS Connecticut River Coordinator's Office. The 25th percentile benchmark is derived from 1976-2023 counts.



6. Sustainability Targets

A. Definition.

A sustainable American shad fishery will not diminish future stock reproduction and recruitment.

B. Methods for Monitoring Fishery and Stock.

Fish Lift Count Benchmark – Connecticut River. The 25th percentile of the 1976-2023 fish lift count data series of 190,800 shad at the Holyoke Dam is proposed as a spawning run benchmark for management action (Table A6). Three consecutive years below this benchmark will trigger consultation between *MassWildlife* and DMF to discuss reducing recreational harvest. This interim value will be updated and revised as necessary in future reviews of the plan.

The use of fish lift days of operation was considered to standardize the fish lift count data at Holyoke Dam. Records for the total number of days when the fish lift was in operation were available from 1980-2023. However, this period does not include the lower shad counts earlier in the time series, and there are operational changes that need to be considered and accounted for before using count data on fish per lift day. For the 2024 SFMP update, it is recommended to use the total lift counts for the entire data series (1976-2017) and to consider other metrics in future plans.

Connecticut DEEP SFMP Metrics. All three CT DEEP thresholds will be adopted in the Massachusetts SFMP as warning metrics. The exceedance of the PASSAGE, RECRUITMENT, or ESCAPEMENT thresholds described earlier in this section and outlined in Table A6 will trigger management consultations between *MassWildlife*, MA DMF and CT DEEP. We anticipate continued coordination with CT DEEP on the application of Connecticut River SFMP thresholds in future MA SFMP updates.

C. Timeframe.

These benchmarks and warning thresholds will start on October 1, 2024 and remain active until a plan review is conducted after five years.

7. Proposed Regulation Modification to Support Targets

A. Recreational Bag Limits

MassWildlife and DMF changed the harvest regulations in 2012 to lower the bag limit from 6 to 3 shad per angler per day in the Merrimack and Connecticut Rivers. Secondly, the fishing for shad in all other rivers were closed to harvest and allowed as catch and release only.

B. Enforcement

Massachusetts Environmental Police are charged with enforcing recreational shad bag limits in the Merrimack River and the upcoming no possession regulation in other rivers. *MassWildlife* and DMF will coordinate with regional enforcement staff each spring to exchange information on illegal harvest.

8. Adaptive Management.

A. Evaluation Schedule. Fish lift count data and biological thresholds will be reported annually in the MA River Herring and American Shad ASMFC Compliance Report. These ongoing data collections will contribute to a revision of the SFMP when requested by ASMFC.

B. Consequences or Control Rules

Three consecutive years below the fish lift count 25th percentile benchmark at the Holyoke Dam and/or exceedances of the CT DEEP SFMP metrics will trigger consultation between MA DMF, *MassWildlife* and CT DEEP to discuss management responses. These interim values will be revised when this plan is updated in the future. A summary of SFMP metrics and thresholds is provided in Table A6.

C. Potential Future Benchmarks

Improved Holyoke Dam Lift Index. There is potential to modify the shad count index at the Holyoke Dam fish lift by standardizing the fish counts to discharge and water temperature and operational data. For this to be attempted, daily records need to be summarized for all variables. Substantial work is needed to bring these data into the Holyoke lift datafile and conduct the necessary quality assurance and control review before attempting to standardize the lift data.

Connecticut River Mortality Threshold. Using shad mortality estimates has been considered as a potential threshold or benchmark for the Connecticut River. The low percentage of repeat spawners and older cohorts has been a limiting factor for generating mortality estimates. During the period of 2006-2015, a mean of 5% of the Connecticut River shad run were repeat spawners (CRASC 2017). Future SFMPs should revisit the available size/age data for shad in the Connecticut River to consider the utility of mortality estimates.

CATCH AND RELEASE RIVERS

In addition to the shad runs on the Merrimack and Connecticut rivers, shad have been recently documented in the Palmer River, Jones River, North River, Neponset River, and Charles River, with modest sportfishing know to occur in the North River tributaries and the Palmer River. Shad fishing in the five smaller river systems have been managed as catch and release fisheries since 2013. Both *MassWildlife* and DMF are interested in expanding monitoring to include the runs in these five river systems.

Taunton River Shad Stocking. The Taunton River shad habitat plan (Chase et al. 2022), monitoring plan (Mattocks et al. 2022), and interagency agreement with the Massachusetts Division of Fisheries and Wildlife (DFW) and the US Fish and Wildlife Service (USFWS) were finalized in 2022. Stocking of American shad by USFWS began in the spring of 2022. Approximately 350 adult shad were collected from the Connecticut River at the Holyoke Dam fish lift for use as broodstock. A total of 5,027,224 larval shad were stocked from May to June in four locations and 77,104 juvenile shad were stocked from July to September in three locations in the Taunton River. Monitoring for juvenile American shad was conducted in 2022 as part of the shad stocking project. A beach seine survey targeting juvenile American shad was conducted monthly at five locations along the Taunton River from June through October. Juvenile American shad were captured in two locations during the July survey (nine shad) and at one location during the October survey (seven shad). American shad were stocked by USFWS for a second year in 2023. A total of 5,699,205 larval shad were stocked from May to June in five locations in the Taunton River. Monitoring for American shad continued in 2023, however juvenile American shad were not caught during the 2023 seine survey, with low fish abundance and diversity observed throughout the season. In addition, efforts to collect genetic samples from native adult American shad began in spring 2023 with a rod and reel fishing trip and boat electrofishing surveys led by *MassWildlife*.

Charles River Hatchery Evaluation (% wild vs. hatchery). In 2004, the USFWS and DMF began an experimental hatchery operation using American shad from the Merrimack River system as a source for stocking in the Charles River. USFWS and DMF have released between 700,000 and eight million oxytetracycline (OTC) marked shad fry annually into the Charles River in Waltham from 2006 through 2016. Recaptures of OTC marked shad were first made in the Charles River in 2011. Future evaluations on the contribution of hatchery stocking to spawning runs may result in additional population targets in the Charles River. Additionally, an acoustic telemetry project was conducted in the Charles River from 2015-2017 to provide information on shad spawning run movements.

Spawning Run Electrofishing Study. An exploratory study was initiated by DMF in 2016 to monitor the presence and abundance of American shad in two coastal river systems in Massachusetts. The South River and Indianhead River historically supported viable recreational fisheries for shad, however no recent data on catch or harvest of shad exist for either of these systems. Between 12 and 21 electrofishing trips were made each spring during the shad spawning run to the two rivers between 2016 and 2023. Total length, sex and scales for aging were sampled from each shad. Fishing effort, mean total length, mean age for each sex as well as estimates of mortality and survivorship are summarized in Table 3.

Indices of abundance (catch-per-unit-effort, CPUE) for each river system were calculated to examine trends over the course of the spawning run. Annual geometric mean CPUE scores were calculated for each river and are listed in Table 3 and Figure 4. Additional analyses of gear efficiency including capture efficiency and capture probability as well as determining minimum sample sizes were conducted to assist the goals of developing standardized sampling protocols and long-term indices of population demographics.

Table 3. Effort and population demographic information of American Shad from the (A) South and (B) Indianhead Rivers (2016 – 2023).

A. SOUTH													
	N	GM CPUE		N	N	Mean TL		Mean Age		Mortality		Survivorship	
Year	Trips	(N/min)	SE	Male	Female	M	F	M	F	Z	SE	S	SE
2016	12	0.48	0.14	44	20	489	503	6.0	5.6	0.68	0.11	0.50	0.05
2017	14	0.30	0.16	56	17	483	524	5.6	6.1	1.42	0.25	0.23	0.06
2018	19	0.25	0.05	37	19	480	521	5.6	6.1	2.08	0.14	0.10	0.01
2019	19	0.39	0.09	48	32	465	497	5.6	5.3	0.71	0.10	0.49	0.05
2020	18	0.46	0.13	51	31	454	491	5.0	5.3	1.00	0.18	0.36	0.07
2021	14	0.34	0.15	28	24	485	516	5.8	6.1	0.97	0.07	0.37	0.03
2022*	17	0.09	0.12	12	5	478	516	6.3	6.2	N/A			
2023**	17	0.26	0.12	21	19	480	514	6.3	6.3	0.76	0.15	0.46	0.07

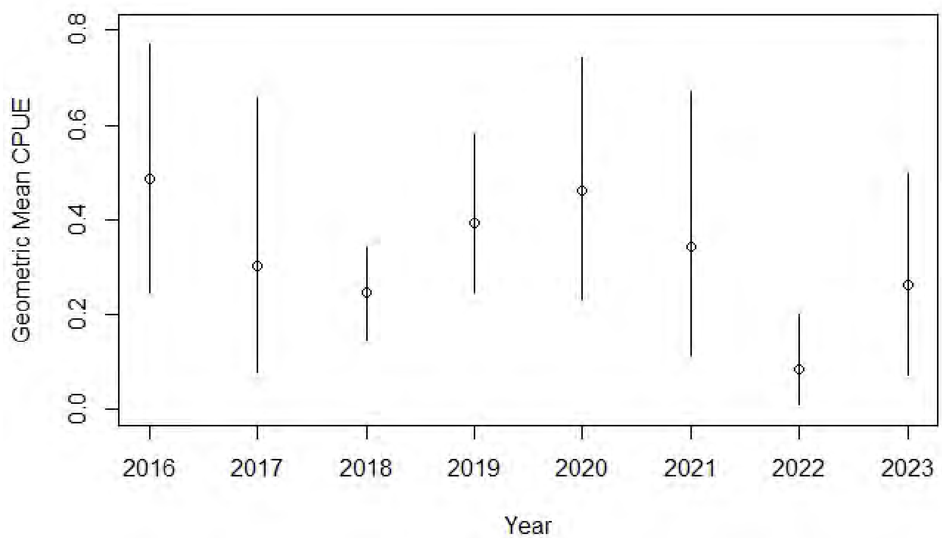
B. INDIAN HEAD													
	N	GM CPUE		N	N	Mean TL		Mean Age		Mortality		Survivorship	
Year	Trips	(N/min)	SE	Male	Female	M	F	M	F	Z	SE	S	SE
2016	12	0.32	0.09	61	46	488	512	5.9	6.0	1.40	0.39	0.24	0.09
2017	15	0.36	0.09	78	25	488	512	5.7	6.0	1.39	0.49	0.24	0.12
2018	21	0.43	0.08	125	53	464	512	5.2	6.1	0.49	0.09	0.61	0.06
2019	17	0.48	0.11	86	32	474	499	5.5	5.5	0.61	0.14	0.54	0.08
2020	18	0.51	0.11	77	54	473	511	5.6	5.8	0.73	0.11	0.48	0.05
2021	17	0.31	0.09	60	27	487	523	6.1	6.4	0.79	0.11	0.45	0.05
2022	19	0.21	0.05	49	8	485	512	6.1	5.9	1.21	0.34	0.29	0.10
2023	18	0.26	0.06	40	14	465	507	5.7	5.9	0.77	0.22	0.46	0.10

* Sample size too small to estimate mortality and survivorship

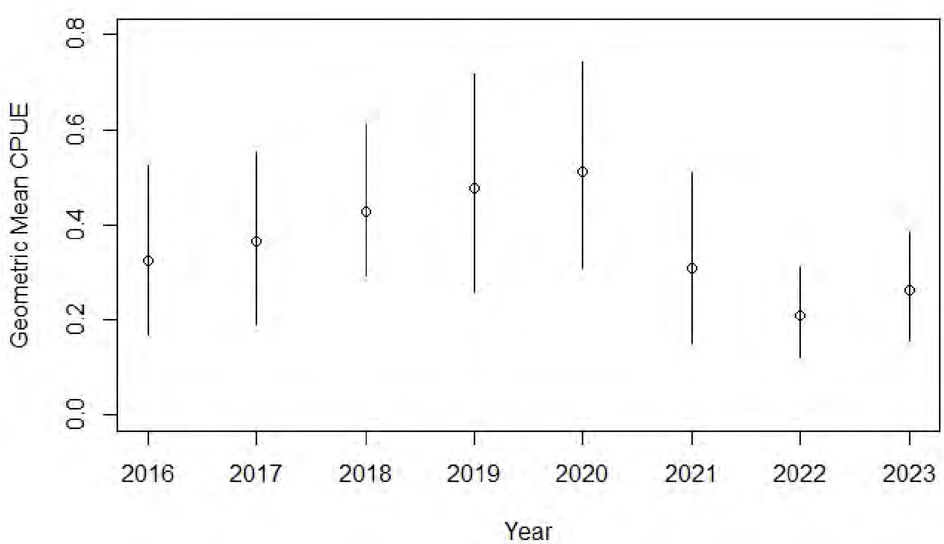
** Estimates of Z and S are based on low sample size and should be regarded with caution

Figure 3. Annual geometric mean CPUE scores (+/- 2 SE) of American shad captured during electrofishing operations in the (A) South River; and (B) Indian Head River.

(A) South



(B) Indian Head



REFERENCES

ASMFC, 2010. Amendment 3 of the Atlantic States Marine Fisheries Commission (ASMFC) American Shad Fishery Management Plan.

Chase, B.C., S. Mattocks, and K. Cheung. 2022. American Shad Habitat Plan for the Taunton River, Massachusetts. *Prepared by* Mass. Div. of Marine Fisheries, Mass. Div. of Fish and Wildlife, and U.S. Fish and Wildlife Service.

CRASC, 1992. A management plan for American shad in the Connecticut River Basin. Connecticut River Atlantic Salmon Commission. Feb. 4, 1992.

CRASC, 2017. Connecticut River American Shad Management Plan. Connecticut River Atlantic Salmon Commission, Sunderland, MA. June 9, 2017.

CRASC, 2020. Connecticut River American Shad Management Plan, Addendum to Fish Passage Performance. Connecticut River Atlantic Salmon Commission, Sunderland, MA. February 28, 2020.

CT DEEP, 2012. Connecticut River American Shad Sustainable Fishing Plan. *Submitted to* ASMFC, *Prepared by* Conn. Dept. Energy and Environ. Protection, Marine Fisheries Division, September 2012.

CT DEEP, 2017. Connecticut River American Shad Sustainable Fishing Plan. *Submitted to* ASMFC, *Prepared by* Conn. Dept. Energy and Environ. Protection, Marine Fisheries Division, August 2017.

Goode, G.B. 1884. The Fisheries and Fishery Industries of the United States. US. Commission of Fish and Fisheries, Washington DC.

HGE, 2024. Monitoring report: upstream fish passage at HG&E's Holyoke Dam fishway, spring and fall, 2010. Prepared by Normandeau Assoc., for City of Holyoke Gas & Electric Dept., Holyoke, MA.

Leggett, W.C., T. Savoy, and C. Tomichek. 2004. The impact of enhancement initiatives on the Connecticut River population of American shad. Pages 391-405. *In* P.M. Jacobson, D.A. Dixon, W.C. Leggett, B.C. Marcy, Jr., R.R. Massengill, *editors*. The Connecticut River Ecological Study (1965-1973) revisited: ecology of the lower Connecticut River 1973-2003. Am. Fish. Soc. Mon. 9. 545pp.

Mattocks, S., B.C. Chase, and K. Cheung, 2022. American Shad Monitoring Plan for the Taunton River, Massachusetts. *Prepared by* Mass. Div. of Fish and Wildlife, Mass. Div. of Marine Fisheries, and U.S. Fish and Wildlife Service.

MRTC, 2010. A Plan for the restoration of American shad Merrimack River Watershed. Prepared by, Tech. Comm. for Anadromous Fish. Mgt. of the Merrimack River Basin.

NFG, 2011. New Hampshire ASMFC American Shad Fishing/Recovery Plan. New Hampshire Fish and Game Department, *Draft Plan*, August 2011.

Normandeau Associates, Inc. 2024. Monitoring Report: Upstream Fish Passage at HG&E's Holyoke Dam, Spring 2023. Prepared for the City of Holyoke Gas and Electric Department, FERC No. P-2004, Holyoke, Massachusetts.

Patriot Hydo, 2023. Lower Merrimack River Fish Passage. Lawrence Hydro P-2800 Annual Report. Patriot Hydro, LLC, Manchester, NH.

Sheppard, J., B. Gahagan, S. Berkman, and B.C. Chase, 2024. Massachusetts 2023 Compliance Report: American shad (*Alosa sapidissima*), Hickory shad (*Alosa mediocris*), Alewife Herring (*Alosa pseudoharengus*), Blueback Herring (*Alosa aestivalis*). Submitted to the Atlantic States Marine Fisheries Commission, June 30, 2024, Massachusetts Division of Marine Fisheries.

Sprankle, K. 2005. Interdam movements and passage attraction of American shad in the lower Merrimack River main stem. NAJFM 25: 1456-1466.

Stolte, L. 1981. The forgotten salmon of the Merrimack. US Government Printing Office, Washington, D.C. 214 pp.

USFWS, 1997. Strategic Plan & Status Review Anadromous Fish Restoration Program Merrimack River. Tech. Comm. for Anadromous Fish. Mgt. of the Merrimack River Basin.

USFWS, 2023. Connecticut River Basin Diadromous Fish Restoration: Coordination and Technical Assistance. Annual Progress Report F-100-R-40, USFWS Connecticut River Fish and Wildlife Conservation Office, Sunderland, MA.

Appendix

Table A1. Rivers in Massachusetts with American shad runs present.

River	***Drainage***	***Drainage Area*** *(mi^2)*	***Q -- cfs*** *(mean May)*	***Fishery Status***
Connecticut	Connecticut River	8,332	21,400	Sportfishery – 3 fish bag
Palmer	Buzzards Bay	28	10*	minor sportfishery - 0 fish bag
Taunton	Narragansett Bay	261	551	minor sportfishery - 0 fish bag
Jones	South Shore	20	43	no known targeting of shad
North	South Shore	30	69	minor sportfishery - 0 fish bag
Neponset	Boston Harbor	101	392	no known targeting of shad
Charles	Boston Harbor	227	370	no known targeting of shad
Merrimack	Merrimack River	4,635	11,800	Sportfishery – 3 fish bag

* The stream flow gauge in the Palmer River was located far upstream of shad habitat.

Table A2. Massachusetts American shad landings, 1990-2017. The landings data were provided by the NMFS Fisheries Statistic and Economic Division, Northeast Regional Office.

Year	*MA Landings (lbs.)*	*Atlantic States (lbs.)*	*Shad Landings (% from MA)*
1990	5,605	3,553,473	0.16
1991	638	2,808,898	0.02
1992	308	2,435,127	0.01
1993	423	2,105,863	0.02
1994	286	1,493,906	0.02
1995	454	1,653,322	0.03
1996	134	1,583,079	0.01
1997	752	1,837,170	0.04
1998	1,765	2,174,226	0.08
1999	223	1,067,312	0.02
2000	268	890,624	0.03
2001	1,051	722,178	0.14
2002	424	1,471,850	0.03
2003	1,109	1,509,898	0.07
2004	530	1,136,527	0.05
2005	0	302,435	0.00
2006	102	193,855	0.05
2007	44	168,993	0.03
2008	31	100,901	0.03
2009	0	88,165	0.00
2010	0	105,477	0.00
2011	215	94,833	0.23
2012	10	118,189	0.01
2013	0	141,832	0.00
2014	0	40,256	0.00
2015	0	43,259	0.00
2016	0	14,075	0.00
2017	0	26,330	0.00
2018	0	18,433	0.00
2019	0	11,669	0.00
2020	9	62,125	0.00
2021	5	26,040	0.00
2022	0	4,133	0.00
2023	0	21,178	0.00

Table A3. Recreational estimates of total catch of American shad in Massachusetts (Source: MRFSS/MRIP, uncalibrated for FES and APAIS improvements).

Year	*TOTAL CATCH (TYPE A + B1 + B2)*	*PSE*
1981	3,545	100
1983	2,533	100
1989	6,628	43
1990	11,817	70.1
1991	737	100
1993	10,930	61.7
1994	2,053	100
1996	1,115	100
1997	45,548	50.5
1998	73,152	39.1
1999	69,206	28.8
2000	15,992	40.4
2001	3,405	52.7
2004	1,673	100
2006	55,232	52.3
2007	1,588	100
2008	4,452	71.2
2009	1,850	100
2010	0	
2011	0	
2012	-	
2013	0	
2014	-	
2015	0	
2016	-	
2017	2,042	59.5
2018	-	
2019	4,293	92.2
2020	159	101.5
2021	2,168	59.1
2022	52,093	69.4
2023	11,616	54.8

- No catch recorded

Table A4. American shad counts at the Merrimack River (Essex Dam Fish Lift, Lawrence), and the Connecticut River, (Holyoke Dam Fish Lift, Holyoke), Massachusetts, 1983–2017.
Note*: the Merrimack River series mean excludes 2005-2006 with high, disruptive spring flow.

Year	Merrimack River	Connecticut River
1983	5,629	528,185
1984	5,497	496,884
1985	12,793	487,158
1986	18,173	352,122
1987	16,909	276,835
1988	12,359	294,158
1989	7,875	354,180
1990	6,013	363,725
1991	16,098	523,153
1992	20,796	721,764
1993	8,599	340,431
1994	4,349	181,038
1995	13,861	190,295
1996	11,322	276,289
1997	22,661	299,448
1998	27,891	315,810
1999	56,461	193,780
2000	72,800	225,042
2001	76,717	273,206
2002	54,586	374,534
2003	55,620	286,814
2004	36,593	191,555
2005	6,382	116,511
2006	1,205	154,745
2007	15,876	158,807
2008	25,116	153,109
2009	23,199	160,649
2010	10,442	164,439
2011	13,835	244,177
2012	21,396	490,431
2013	37,149	392,967
2014	38,107	370,506
2015	89,467	412,656
2016	67,528	385,930
2017	62,846	537,249
2018	29,069	275,232
2019	18,653	314,361
2020	52,239	362,423
2021	47,678	208,858
2022	36,731	190,352
2023	28,438	277,367
Series Mean	30,292*	315,053

Table A5. American shad counts at the Essex Dam Lift on the Merrimack River, Lawrence, MA. The lift data source is the USFWS Central NE Fishery Office. The discharge data source is the USGS National Water Information System, Station No. 01100000.

Year	American Shad (No.)	Shad Count Index (No.)	Lift Days (No.)	Shad per Lift Day	Lifts (No.)	Lift Start Date	Lift End Date	Mean Q April	Mean Q May	Mean Q June	Mean Q July
1983	5,629	5,629	54	104.2		5/9/1983	7/9/1983	23,870	16,980	9,277	2,158
1984	5,497	5,497	42	130.9		5/9/1984	7/31/1984	27,650	16,240	23,660	7,606
1985	12,793	12,793	54	236.9		5/1/1985	7/22/1985	8,150	5,705	2,665	1,982
1986	18,173	18,173	54	336.5	506	5/2/1986	7/25/1986	14,070	5,842	7,782	4,368
1987	16,909	16,909	54	313.1	467	5/15/1987	7/23/1987	37,440	10,020	6,198	4,837
1988	12,359	12,359	54	228.9	485	5/9/1988	7/15/1988	12,480	14,080	4,061	3,563
1989	7,875	7,875	54	145.8		5/1/1989	7/28/1989	17,120	18,990	11,250	3,758
1990	6,013	6,013	54	111.4		5/1/1990	7/31/1990	16,750	14,840	7,128	3,187
1991	16,098	16,098	54	298.1		5/1/1991	7/14/1991	12,520	9,242	3,310	1,613
1992	20,796	20,796	54	385.1		5/4/1992	7/31/1992	12,350	8,774	7,046	3,850
1993	8,599	8,599	54	159.2		5/10/1993	7/15/1993	31,730	6,829	3,361	1,334
1994	4,349	4,349	54	80.5		5/2/1994	7/9/1994	23,330	13,020	3,951	2,324
1995	13,861	13,861	54	256.7		5/1/1995	7/9/1995	6,979	6,077	3,243	1,687
1996	11,322	11,322	54	209.7	325	5/20/1996	7/12/1996	24,300	21,270	5,834	8,611
1997	22,661	22,661	57	397.6	412	5/6/1997	7/7/1997	25,600	13,070	4,158	3,737
1998	27,891	27,891	57	489.3	443	5/4/1998	7/22/1998	15,790	10,900	20,940	8,730
1999	56,461	56,461	64	882.2	632	4/28/1999	7/2/1999	10,860	5,748	1,994	1,765
2000	72,800	72,800	65	1120.0	618	5/1/2000	7/7/2000	23,170	12,660	7,469	3,515
2001	76,717	76,717	65	1180.3	501	5/7/2001	7/20/2001	26,020	7,375	8,390	2,750
2002	54,586	54,586	65	839.8	558	4/29/2002	7/12/2002	12,310	11,920	8,273	2,173
2003	55,620	55,620	77	722.3		5/10/2003	7/3/2003	20,750	12,010	7,939	2,559
2004	36,593	36,593	77	475.2		4/29/2004	7/15/2004	22,730	11,930	5,850	3,397
2005	6,382		81			5/12/2005	7/19/2005	26,860	15,800	12,240	6,385
2006	1,205		46			4/17/2006	5/12/2006	7,554	27,810	22,410	9,813
2007	15,876	15,876	73	217.5		5/10/2007	7/16/2007	29,380	14,680	6,354	3,558
2008	25,116	25,116	64	392.4		5/13/2008	7/14/2008	26,640	11,910	3,638	6,668
2009	23,199	23,199	89	260.7		4/20/2009	7/17/2009	19,930	8,757	9,806	15,340
2010	10,442	10,442	83	125.8		4/24/2010	7/15/2010	23,600	5,670	3,497	1,895
2011	13,835	13,835	73	189.5		5/2/2011	7/15/2011	22,230	15,130	6,410	2,550
2012	21,396	21,396	87	245.9		4/16/2012	7/13/2012	6,298	10,730	10,060	1,968
2013	37,149	37,149	89	417.4		4/15/2013	7/12/2013	14,390	8,069	12,880	11,370
2014	38,107	38,107	80	476.3		4/22/2014	7/10/2014	25,700	11,580	5,401	6,099
2015	89,467	89,467	89	1005.2		4/20/2015	7/17/2015	17,850	5,128	5,751	5,034
2016	67,528	67,528	86	785.2		4/21/2016	7/15/2016	8,463	5,225	2,779	1,604
2017	62,846	62,846	89	706.1		4/17/2017	7/14/2017	22,160	16,880	11,030	5,458
Mean		29,350		422							
Median		20,796		313							
25th %		12,359		210							

Table A6. Summary of Massachusetts American Shad Sustainable Fishery Management Plan metrics and thresholds for 2018 plan update.

River	Index Site	Time Series	SFMP Metric	Threshold Level	Threshold Value	Threshold Status	Management Trigger
Merrimack River	Essex Dam Fish Lift	1983 - 2023	Benchmark	25th percentile	218 shad / lift day	Above	3 years below benchmark triggers mgt discussion on reducing rec. harvest
	Essex Dam Fish Lift	2001 - 2023	Warning	Z_{30} = 0.98	Z > 0.98	2018-2023: fail 3 of 6 yrs	Annual review of biological data and documentation in compliance report
Connecticut River	Holyoke Dam Fish Lift	1976 - 2023	Benchmark	25th percentile	190,800 annual count	Above	3 years below benchmark triggers mgt discussion on reducing rec. harvest
	CT DEEP Juvenile Shad Index	1978 - 2023	Warning	25th percentile	3.96 geometric mean	Above	3 years below benchmark triggers mgt discussion on reducing rec. harvest

Connecticut River American Shad Sustainable Fishing Plan Update

Submitted to the Atlantic States Marine Fisheries Commission

Prepared by

Connecticut Department of Energy and Environmental Protection

Fisheries Division

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Introduction

Annual spawning migrations of American Shad (*Alosa sapidissima*) in the Connecticut River have supported both recreational and commercial fisheries in the State of Connecticut, as well as recreational fisheries in upriver states, for generations. While American Shad once supported one of the largest commercial and recreational fisheries in the state, Connecticut shad fisheries are now mostly artisanal, although they still hold cultural and historical value. The Connecticut River now supports the state's only commercial shad fishery. There is currently a commercial drift gill net fishery that occurs south of River Kilometer (Rkm) 64, in the lower CT River. Landings in this gill net fishery have steadily declined in recent decades (Figure 1). The Connecticut River is also the only river in the state in which recreational harvest (via hook and line only) is currently permitted. The recreational fishery largely occurs in the range north of Hartford, Connecticut (Rkm 84) and south of the Holyoke Dam in Massachusetts (Rkm 139), with limited localized efforts occurring to the north and south of these areas.

The Connecticut Department of Energy and Environmental Protection (CT DEEP) has conducted annual research studies on American Shad in the Connecticut River since 1974 to monitor annual changes in stock composition. American Shad fishery data is collected from mandatory annual reporting of commercial landings while recreational fisheries are monitored periodically by a roving creel survey. The Massachusetts Division of Fish and Wildlife monitors fish passage which includes adult American Shad passage at the first mainstem dam (Rkm 139) on the Connecticut River in Holyoke, Massachusetts. Juvenile shad are monitored by CT DEEP through an annual seine survey conducted since 1978.

The number of commercial shad fishing licenses and associated effort has been steadily declining since peak levels during and after World War II. Recent commercial license sales continued to remain at low levels, typically 6 to 8 licenses have been sold annually since 2018. Commercial Shad license sales are expected to stay low or further decrease as fishermen retire and are not replaced. A high proportion of license holders exceed age 55 as few new participants have entered the fishery in the last decade.

The Connecticut River was once one of the most popular places to fish recreationally for American Shad and some think this was the birthplace of the sport. Numbers of fishermen, effort, catch, and harvest have all varied greatly over time, but similar to commercial fishing trends, recreational fishing for American Shad has exhibited a general decline in recent decades. Anecdotal and creel information gathered in the last ten years or so shows that fewer fishermen are targeting American Shad in the traditional shad fishing areas from Hartford to the CT/MA state line, and there is little reason to believe this trend will reverse. Anglers that traditionally fished for shad in this area have switched to pursue striped bass, which provides a quality fishery from Hartford up into Massachusetts. Access to traditional shad fishing sites along the Connecticut River has changed over the years with infrastructure changes, restricted shore access due to development, and the natural breaching of a low-head dam in Enfield. The overall decrease in fishing effort and harvest for shad is also a reflection of a decreasing demand for consumption with fewer people knowing how to debone American Shad.

The Connecticut River American Shad Sustainable Fishing Management Plan (SFMP) was developed by CT DEEP to fulfill the requirements of Amendment 3 to the Interstate Fishery Management Plan for American Shad and River Herring. This update provides information collected since the last SFMP update in 2017. CT DEEP proposes the continuation of both recreational and commercial shad fisheries in the Connecticut River, and continued monitoring of the three metrics currently used to gauge fishery sustainability: adult lift passage, juvenile abundance, and adult escapement. Commercial shad fishing will remain prohibited in all other rivers in the state**.** All river systems with recreational fisheries, other than the Connecticut River, will continue to remain "catch-and-release only" for American Shad.

Current regulations

Commercial

To participate in the commercial fishery, Connecticut requires the purchase of an annual commercial shad license for the Connecticut River. The shad fishery is managed through area, gear, and season restrictions as well as rest days. The American Shad gill net season runs from April 1 through June 15. In the inland district (north of the Interstate 95 bridge), American Shad may be taken only in the main body of the Connecticut River from the I-95 Bridge to the William H. Putnam Memorial Bridge on Route 3 in Glastonbury/Wethersfield (Rkm 75) (Figure 2). In marine waters, American shad "shall not be netted between lines drawn south in Long Island Sound to the New York state line from Menunketesuck Point, Westbrook and Hatchetts Point, Old Lyme except with seines, pounds, and gill nets". This regulation effectively prohibits trawl-caught shad from being harvested near the mouth of the Connecticut River. The commercial shad license fee was doubled in 2009 to $200 and is the most expensive open-access commercial fishing license available in Connecticut.

Under the commercial shad fishing license, the following are prohibited: use of gill nets constructed of single or multiple-strand monofilament from sunrise to sunset, monofilament twine thickness greater than 0.28 mm (#69), commercial fishing for shad from sundown Friday to sundown Sunday except by the use of a scoop net, the use of nets with mesh size less than five inches stretched mesh, fishing in other than the main body of the Connecticut River (no coves), and the use of pound nets or other fixed or staked nets to take shad. A daily record detailing catch, effort, and landings is required in a report that must be submitted by July 15th of the fishing year.

The 2023 commercial landings data used in this report to generate the number of fish commercially landed and the total river population estimate are preliminary and may be adjusted before being finalized.

Recreational

Angling for American Shad is the only legal method of recreational take and may occur during the open season from April 1 through June 30. Fishing licenses are required for anyone 16 years of age or older fishing in either the Inland or Marine Districts. Recreational licenses are issued on a calendar basis and expire on December 31st. The daily possession limit is 6 American and hickory shad in the aggregate, per person, in both the inland and marine districts.

Fisheries Dependent Indices

Commercial Fishery

The commercial shad fishery in the Connecticut River is a spring (April-June) drift gillnet fishery that extends from the river mouth to Glastonbury, CT (river km 62). Monitoring of shad abundance (numbers and pounds) has been conducted annually from 1974 to 2023. The fishery has changed little since the adoption of outboard-powered vessels other than the change to drift gill nets from all other gear types (haul seine, fixed gill nets, and traps/pound nets).

Commercial shad fishermen are required to submit a complete catch report detailing the catch, effort, and landing activities associated with all landings made in Connecticut regardless of where the fishing takes place, as well as all fishing in Connecticut waters regardless of where the landings take place.

Recreational Fishery

Recreational shad landings in numbers have been estimated annually from 1980-1997 and periodically thereafter (2000, 2005, 2010) by a roving creel census (Figure 3). Before 1993, there was a thriving recreational fishery for American Shad in the Connecticut River from Enfield, CT (river km 99) to the Holyoke Dam, MA (river km 139). Before 1990, recreational landings often comprised as much as 60% of total landings. Recreational shad landings began to fall dramatically after 1995 to a point where harvest estimates from creel surveys were unreliable and imprecise as reflected by high (> 80%) proportional standard errors about the mean harvest estimates. Because of the low incidence of positive intercepts of anglers targeting shad in the creel survey in the late 1990s, annual Connecticut River surveys were discontinued in favor of surveys conducted on five-year intervals. Shad recreational harvest estimates between 1999, 2005, and 2010 did not differ significantly ($P < 0.05$) from zero (Figure 4). Most anglers that traditionally fished for shad have switched their efforts to pursue striped bass, which provides a quality fishery from Hartford up into Massachusetts. After 2010, the shad creel survey was not conducted due to budgetary and staffing shortfalls.

Fisheries Independent Indices

Holyoke Lift Passage Counts

Historically, there were no shad passed above Holyoke from the completion of the Holyoke Dam in 1849 until 1955 when a fish passage facility was completed, and small numbers of shad were lifted above the dam. Since opening, staff at the fish passage facility have maintained daily counts of American shad lifted each year (Watson 1970; Moffit et al 1982; Leggett et al 2004). Major technological improvements in the lift occurred in 1975, 1976, and 2005 (Henry 1976, Slater 2016). Information on the number of fish lifted daily, the number of lift days (days the lift is in operation), and the daily sex ratio at Holyoke are currently obtained from the Massachusetts Division of Fisheries.

Multiple tagging studies have been conducted to assess what portion of the total American Shad run to the Connecticut River passes above the Holyoke dam. One tagging study conducted in the 1970s estimated that 40-60% of the total shad run to the river passed above Holyoke (Leggett 1976). This study also documented that shad tagged during the latter portions of the spring migration season did not migrate upriver to Holyoke, but instead presumably spawned in the "lower river" (meaning the river stretch downstream of Holyoke, MA). The documentation of shad larvae in the lower river further corroborated that some level of shad spawning activity occurred below Holyoke. CT DEEP estimated the Connecticut River shad population from 1966-2004 using Holyoke lift data (Crecco and Savoy 1985). Information from the CT DEEP 1970s shad tagging study was subsequently used through the 1980-2000s to derive estimates of total shad run size from annual Holyoke passage numbers. This method to estimate the population was discontinued after 2005 when improvements were made to the Holyoke fish lift. In 2011-2012, a cooperative Connecticut River shad tagging study was initiated by the USFWS and the USGS Conte Anadromous Fish Research Center. Shad were collected in the lower river, radio- and PIT-tagged, and then subsequently detected if they passed at Holyoke. The estimated percentage of the run that passed beyond the Holyoke Dam in 2011 was 63% (Ken Sprankle USFWS personal communication).

For this sustainability plan, for years before 2005, we estimated the total shad run size to the Connecticut River from the annual Holyoke passage, using estimated proportions of the total run passing above Holyoke derived from earlier tagging studies (Crecco and Savoy 1985; Leggett 1976). For 2005 and later years, we estimated the total run size from Holyoke passage, assuming that 63% of the total run passed above Holyoke (based on 2011 results from the cooperative USFWS-USGS tagging study).

Juvenile Abundance Indices (JAI)

Annual American Shad reproductive success has been monitored in the Connecticut River since 1978 by collecting juvenile American Shad in a beach seine survey and calculating an annual index of relative abundance, or "JAI" (geometric mean catch/seine haul) (Table 1; Figure 5). Seining is conducted weekly from mid-July through mid-October at up to seven fixed stations located from Holyoke, MA to Essex, CT. The JAI is reported to ASMFC on an annual basis. The sampling protocol (including site locations, sampling intensity, and gear type) has remained consistent throughout the survey. This metric provides an early warning of a population decline due to inadequate stock reproduction. Due to the COVID-19 pandemic, JAI was not assessed in 2020.

SUSTAINABLE FISHERY DEFINITION: Amendment 3 (ASMFC 2010) defines a sustainable fishery as "those that demonstrate their stock could support a commercial and/or recreational fishery that will not diminish the future stock reproduction and recruitment."

Methods for Monitoring the Fishery and the Stock

A stop light style approach will be used to express the level of perceived risk to maintaining a Sustainable Fishery in the Connecticut River system. Risk will be assessed via a combination of two stock status (response) indicators and a fishing rate (stressor) indicator recognizing that factors other than in-river fishing (ocean environment, stream flow, temperature, dam & fish passage operations, etc.) significantly influence adult run size and recruitment.

The first response metric is PASSAGE, or the number of adult fish lifted at the first main stem dam in Holyoke MA (Figure 6). PASSAGE will be used as a proxy for total run size (i.e. adult stock). The threshold or trigger for PASSAGE is 140,000 fish. Recruitment (JAI) at this value has varied independent of adult stock size, indicating sufficient reproductive capacity to support future stock reproduction and recruitment. ***PASSAGE has not fallen below the threshold since Amendment 3 was adopted and the Sustainable Fisheries Management Plan was implemented. (Figure 6).***

The second metric is Recruitment Failure (hereafter abbreviated as RECRUITMENT), defined in Amendment 3 as three consecutive years of recruitment in the lower quartile of the time series. The time series of American shad JAI provided by the previously discussed CT DEEP seine survey will be used as the basis for the RECRUITMENT metric (Figure 7). ***RECRUITMENT fell into the lower quartile in 2022 (Figure 7) but increased out of the lowest quartile in 2023 (Figure 8).***

The third metric, ESCAPEMENT, is a measure of fishing pressure on the stock expressed as the proportion of the total run "escaping" the fishery to spawn (Figure 8). A very conservative trigger of 90% escapement was chosen to facilitate a timely review of potential implications for future stock production in the event of increasing fishery removals. Recent escapement has been over 90%, but lower escapement rates were common throughout the time series with no evident diminishment in subsequent recruitment. Median ESCAPEMENT between 1990 and 2023 was 95% with a range of 83% - 99%. All commercial fishing and virtually all sport fishing takes place below this dam. ***ESCAPEMENT has not fallen below the threshold since Amendment 3 and the Sustainable Fisheries Management Plan was implemented (Figure 8).***

For purposes of characterizing overall risk, a stop-light style scale has been developed (Figure 9). Each Sustainable Fishery metric will be scored annually as positive (favorable stock condition) or negative (unfavorable stock condition) relative to the trigger. The risk to maintaining a Sustainable Fishery will be judged by combining the results of the three metrics.

A "GREEN" stock status reflects all three indicators are positive, suggesting low risk to future stock reproduction. Management concern level is LOW. Management action is to continue monitoring.

A "YELLOW" stock status is indicated when two indicators are positive, and one is negative. Management concern level is GUARDED. Management action is to consider the values of these metrics in comparison to other relevant biological and environmental information (e.g. river flows, fish passage issues) to assess the threat to future stock production and recruitment. Fishery management action is contingent upon finding that harvest rates are materially contributing to diminished adult stock or recruitment. For example: if the ESCAPEMENT trigger has been exceeded, but both PASSAGE and RECRUITMENT are well above average, then no management action may be necessary. Conversely, if both ESCAPEMENT and PASSAGE are marginally "positive", but RECRUITMENT is strongly negative, then additional harvest restrictions may be warranted.

An "ORANGE" stock status is indicated when two of three metrics are negative. Management concern level is ELEVATED. Management action again includes a closer examination of actual metric values and other relevant biological and environmental factors contributing to the perceived stock condition. Fishery management action is contingent on a finding that harvest rates are materially contributing to diminished adult stock or recruitment. The likely need for fishery management action is greater than under the GUARDED concern level.

A "RED" stock status is indicated when all three metrics are negative. The management concern level is HIGH. Management action includes immediate steps to increase ESCAPEMENT above the threshold. Possible harvest restrictions could include but may not be limited to one or more of the following: decrease in length of season, increase in minimum gillnet mesh size, increase in number of rest days. The need for more aggressive fishery management measures including a harvest moratorium would be contingent on a full examination of the stock and its capacity to support harvest.

In addition to ASMFC, the Connecticut River Migratory Fish Restoration Cooperative (formerly known as the Connecticut River Atlantic Salmon Commission) –a compact of the states bordering the Connecticut River (CT, MA, VT, NH), NMFS, and USFWS –has an interest in the Connecticut River American Shad resource and will be party to any system-wide fishery management decisions.

We recommend continued use of the three metrics described here to determine the sustainability of the CT River American shad fishery, as previously approved under Connecticut's initial Sustainable Fisheries Management Plan.

All metrics used for this plan since the last update to the CT SFMP (submitted in 2017) have consistently been above the threshold, or trigger values, indicating a GREEN stock status and a low level of management concern. Management action is to continue monitoring. The RECRUITMENT metric fell into the lower quartile for one year (2022) but increased out of the

lower quartile in 2023. A change in management concern is only justified if the RECRUITMENT value falls into the lower quartile for three consecutive years.

LITERATURE CITED

ASMFC. 2010. Amendment 3 to the Interstate fishery management plan for shad and river herring. Atlantic States Marine Fisheries Commission, Washington, D.C. USA.

Crecco, V.A., and T.F. Savoy 1985. Density-dependent catchability and its potential causes and consequences on Connecticut River shad, *Alosa sapidissima*. Canadian Journal of Fisheries and Aquatic Sciences 42: 1649-1658.

Henry, S.M. 1976. Development of fish passage facilities for American shad at the Holyoke Dam on the Connecticut River. In: Proceedings of a Workshop on American Shad: December 14–16, 1976, Amherst, Massachusetts. pp. 289–304. University of Massachusetts, Amherst. 350 p.

Leggett, W.C. 1976. The American shad Alosa sapidissima, with special reference to its migrations and population dynamics in the Connecticut River. American Fisheries Society Monograph 1: 169-225.

Leggett, W. C., T. Savoy, and C. Tomichek. 2004. The impact of enhancement initiatives on the Connecticut River population of American shad. Pages 391-405. in P. M. Jacobson, D. A. Dixon, W.C. Leggett, B.C. Marcy, Jr. R.R. Massengill, editors. The Connecticut River Ecological Study (1965-1973) revisited: ecology of the lower Connecticut River 1973-2003. Am. Fish. Soc. Mon. 9. 545 pages.

Moffitt, C.M., B.Kynard, and S.G. Rideout. 1982. Fish passage facilities and anadromous fish restoration in the Connecticut River basin. Fisheries 7(6):2-11.

Slater, C. 2016. Anadromous Fish Investigations. Annual Report F-45-R-28. Massachusetts Division of Fisheries and Wildlife. 10p.

Watson, J.F. 1970. Distribution and population dynamics of American shad, Alosa sapidissima (Wilson), in the Connecticut River above Holyoke Dam, Massachusetts. Ph.D. Dissertation, University of Massachusetts, Amherst. 105 p.

Figure 1. Connecticut River American Shad Commercial Landings (N), 1990 – 2023.

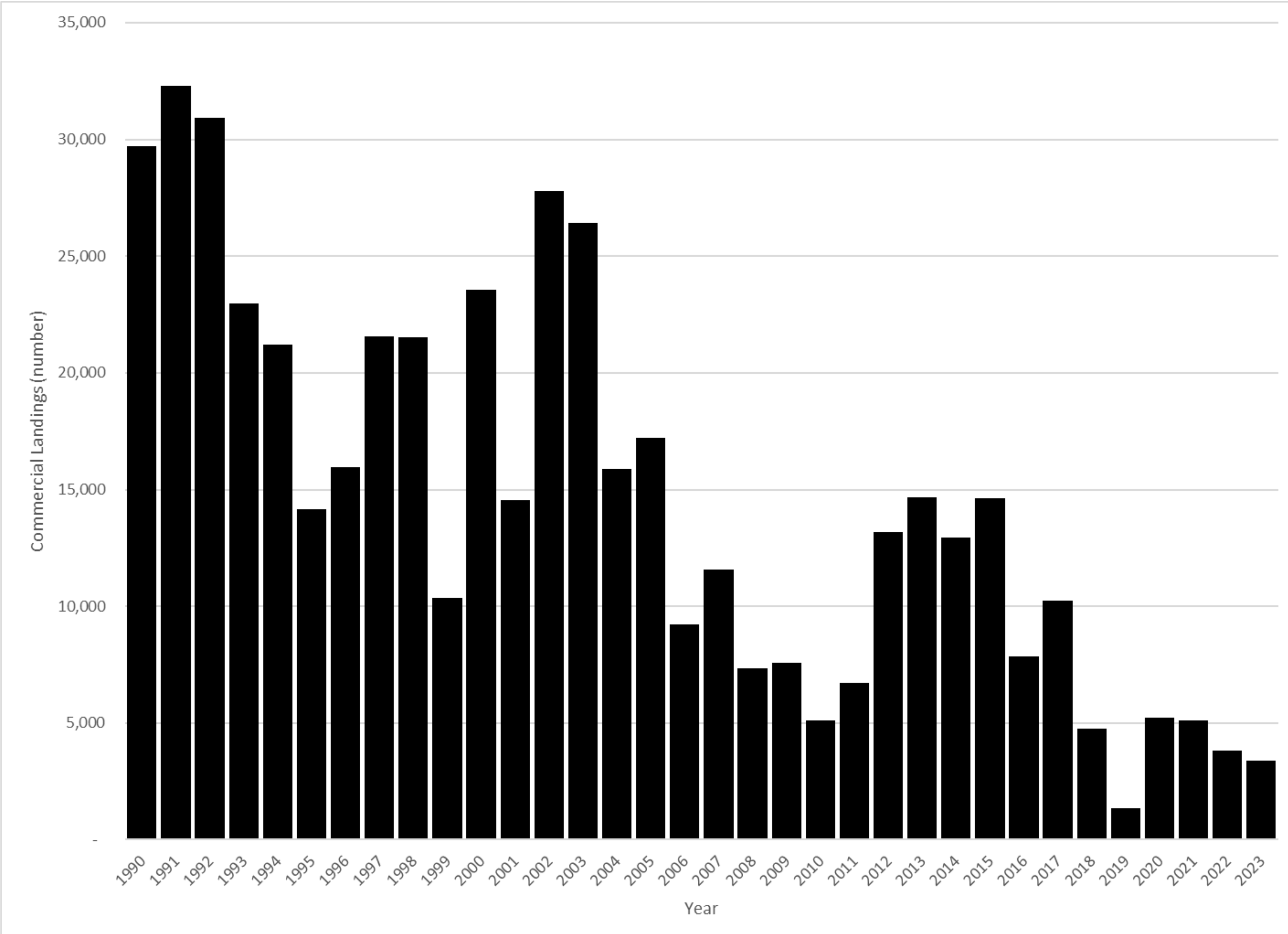

Figure 2. Connecticut River map showing range allowed for commercial shad gillnet fishery.

Figure 3. Map of the Connecticut River north of Hartford highlighting the creel survey sites for the American Shad recreational fishery. The sites marked in yellow indicate shad angler activity during the last creel survey conducted by CT DEEP in 2010.

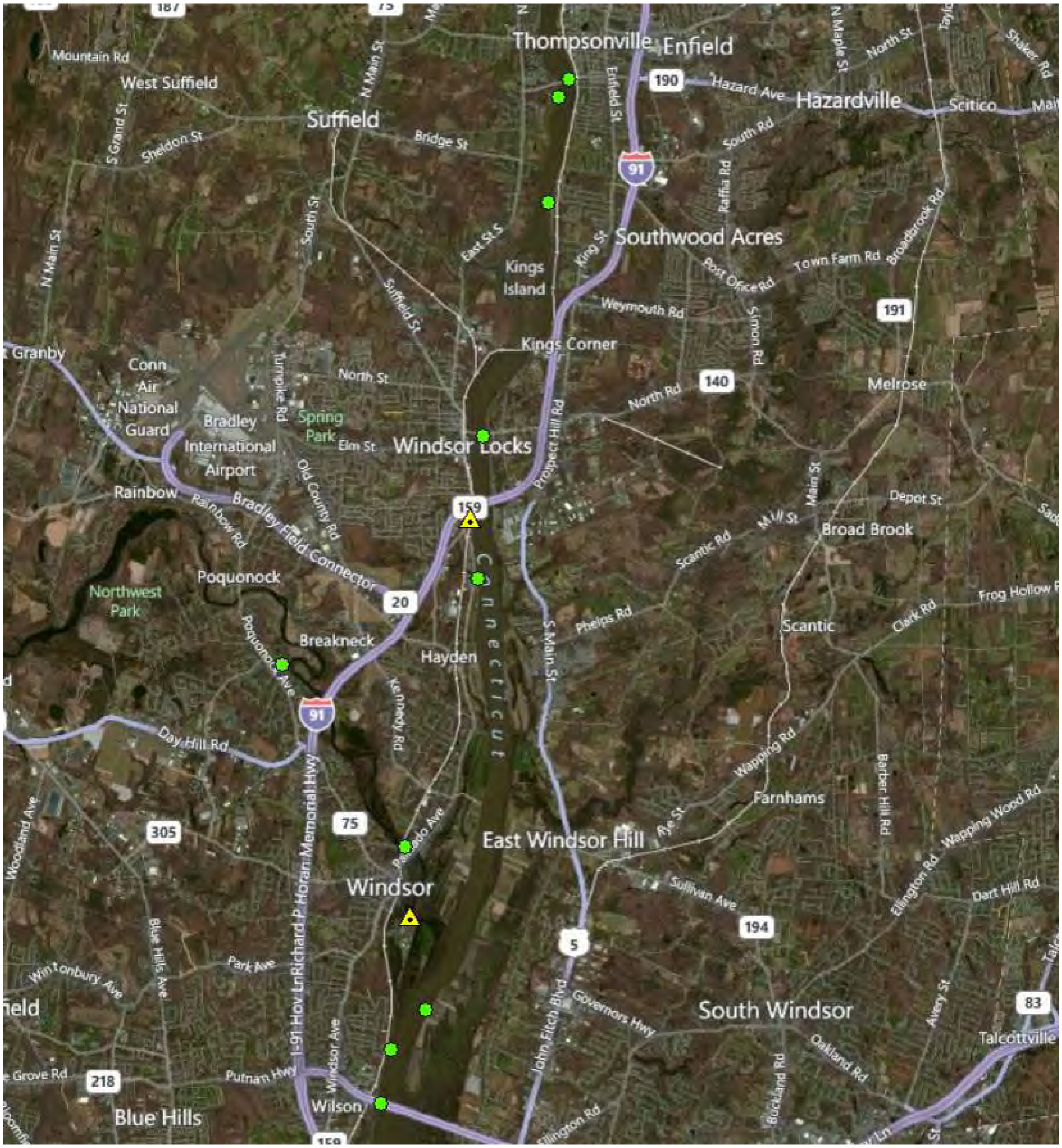

Figure 4. Annual Connecticut River American shad recreational landings (n), 1990-2023. Creel surveys have not been conducted by CT DEEP since 2010. For all years in which a creel survey was not conducted, recreational landings were estimated as 1% of the population estimate.

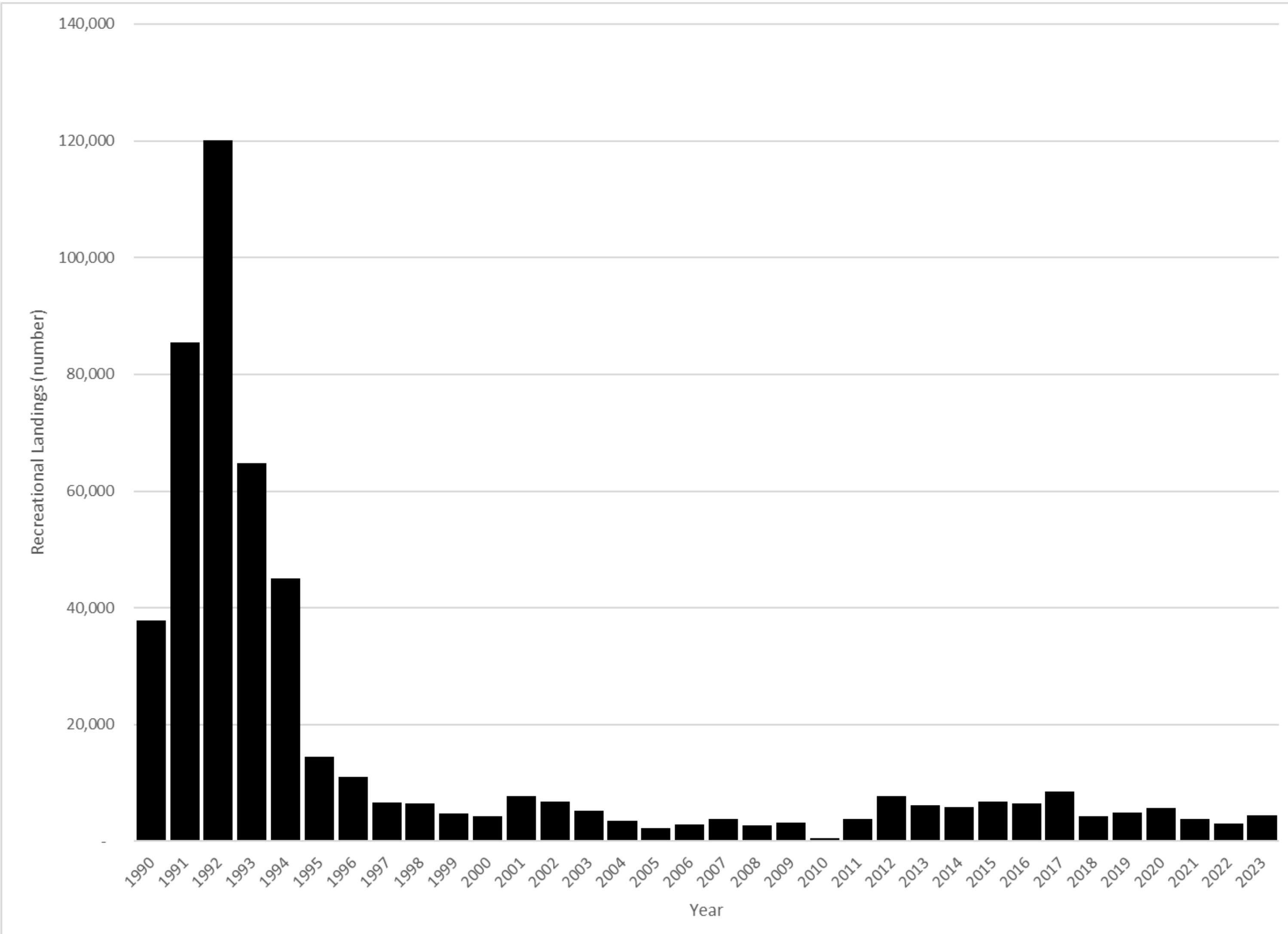

Figure 5. Map of the Connecticut River showing locations of juvenile seine survey sites.

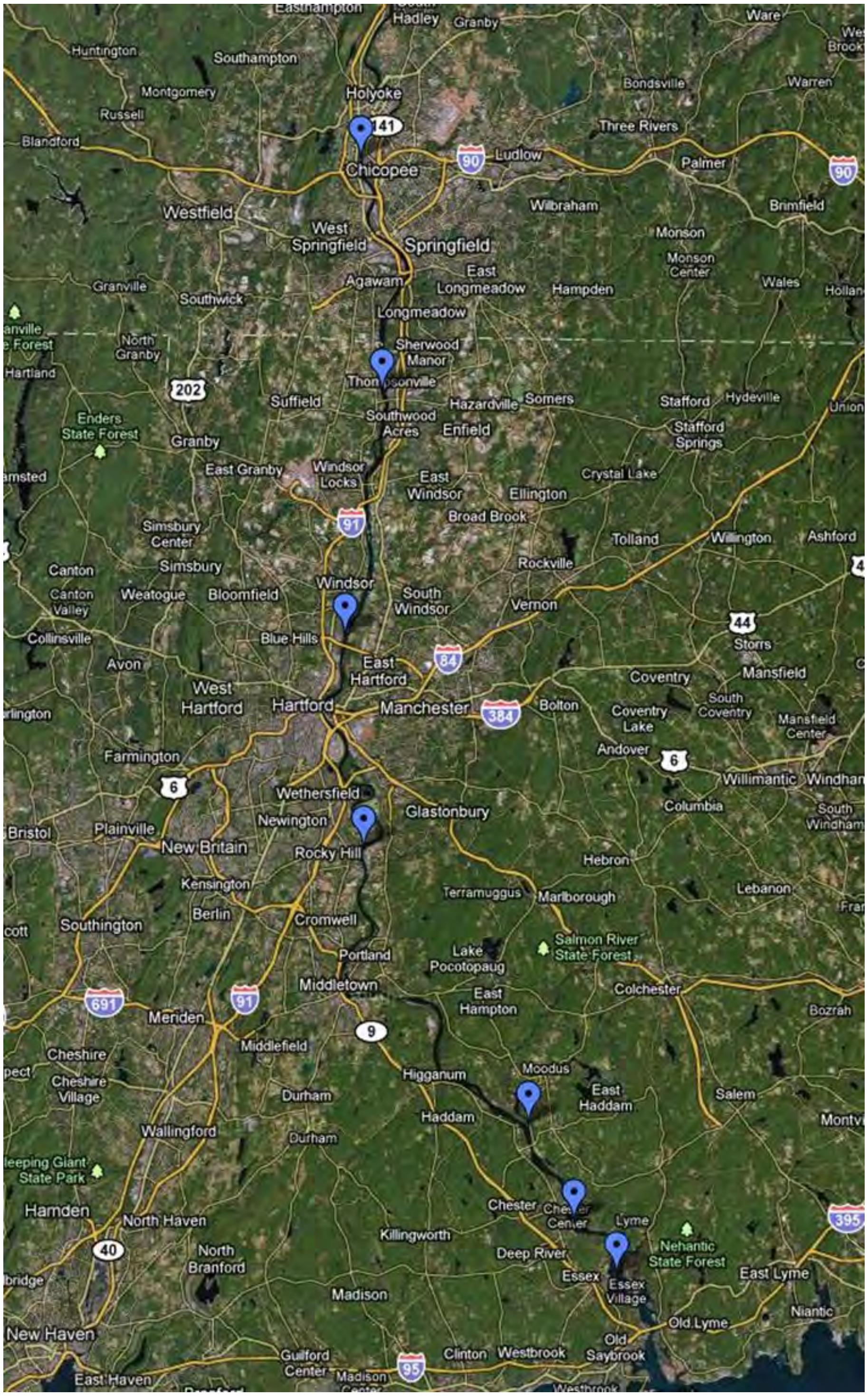

Figure 6. Number of American Shad lifted at the Holyoke Dam, 1990-2023. The orange line represents the minimum passage threshold of 140,000.

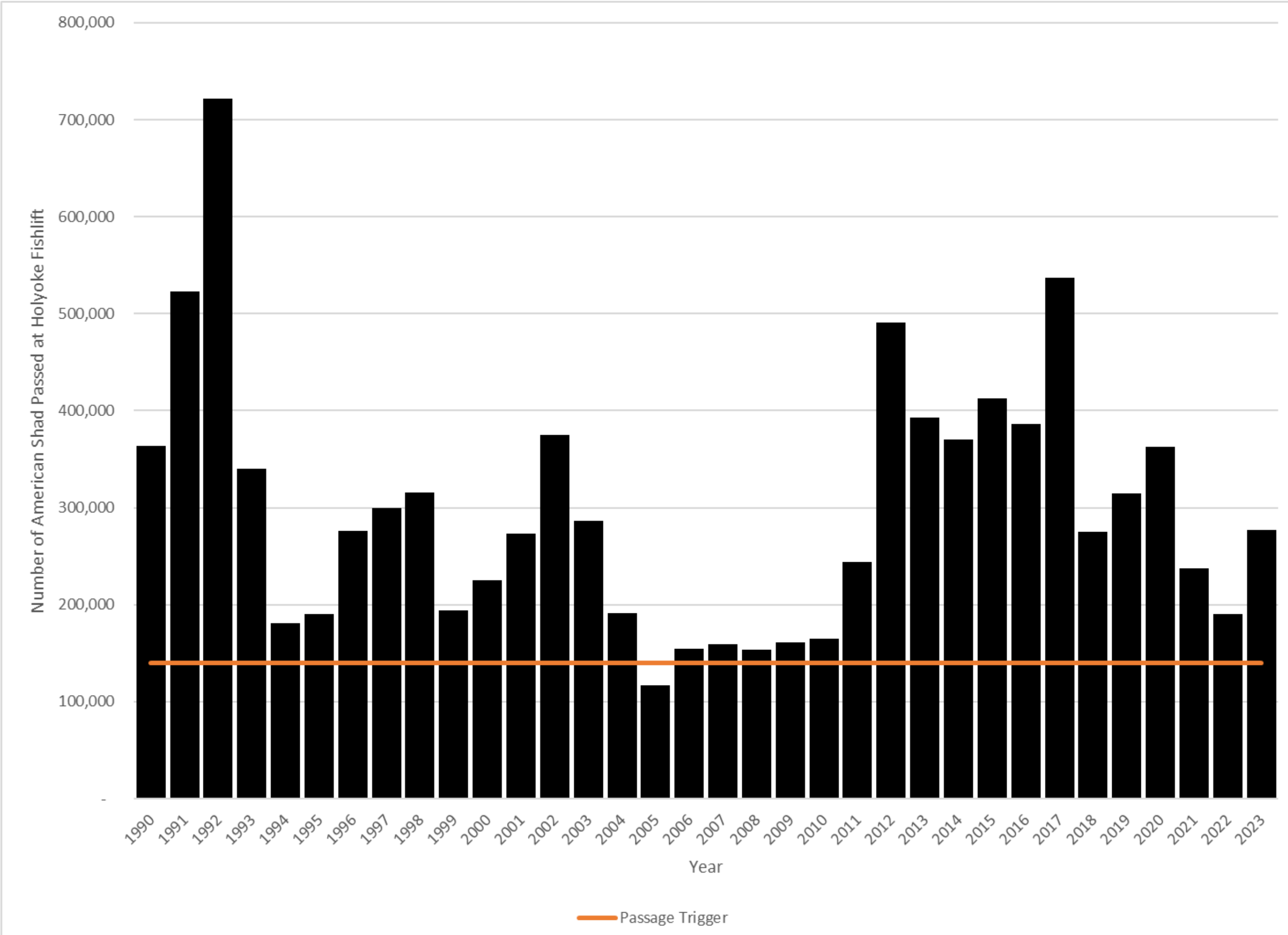

Figure 7. Connecticut River American shad juvenile geometric mean catch per unit effort, 1990-2023. The Orange line represents the low quartile value for the time series (1978-2023).

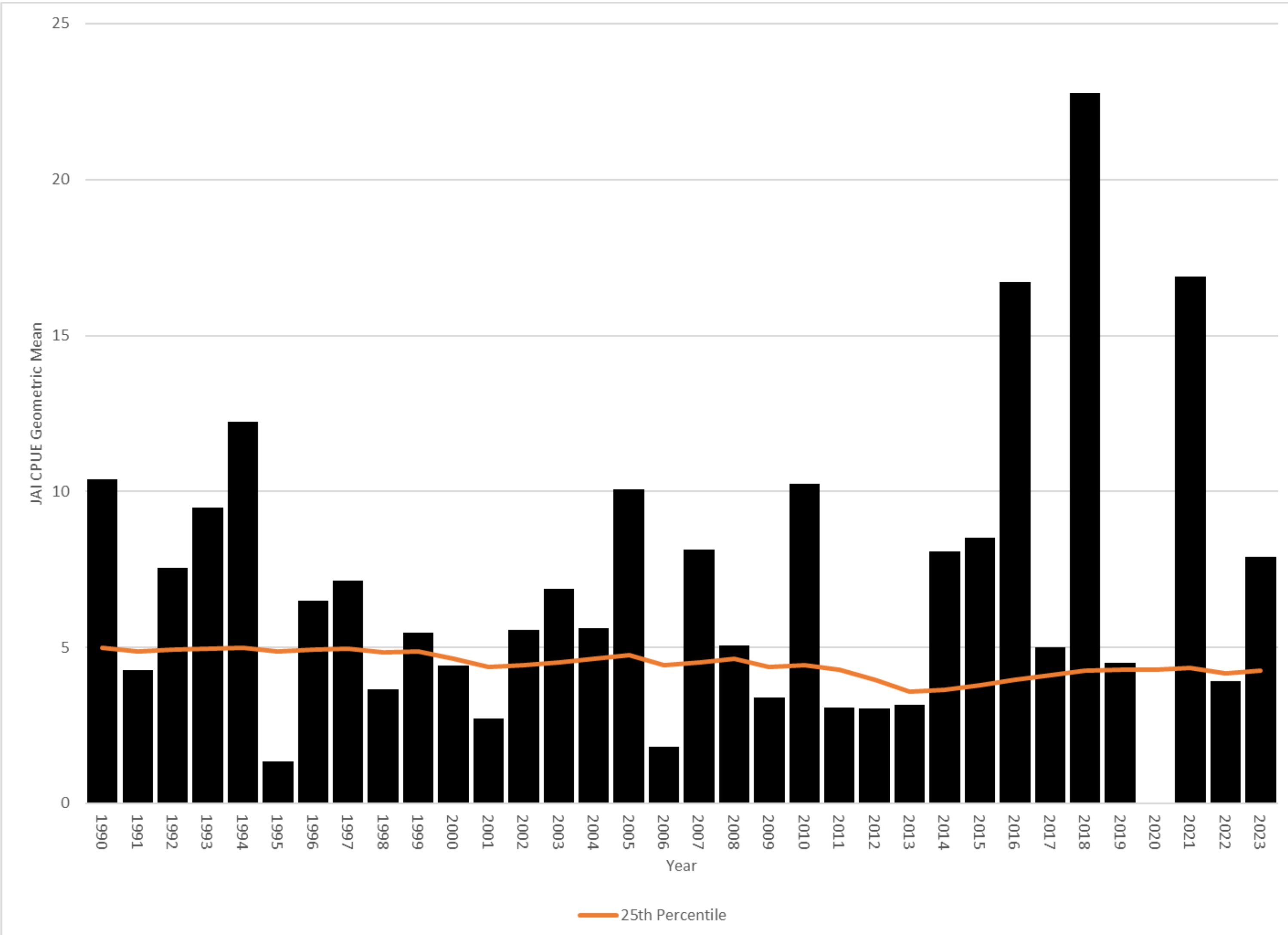

Figure 8. The annual percentage of escapement for Connecticut River American Shad; 1990-2023. The orange line indicates the threshold escapement value of 0.90.

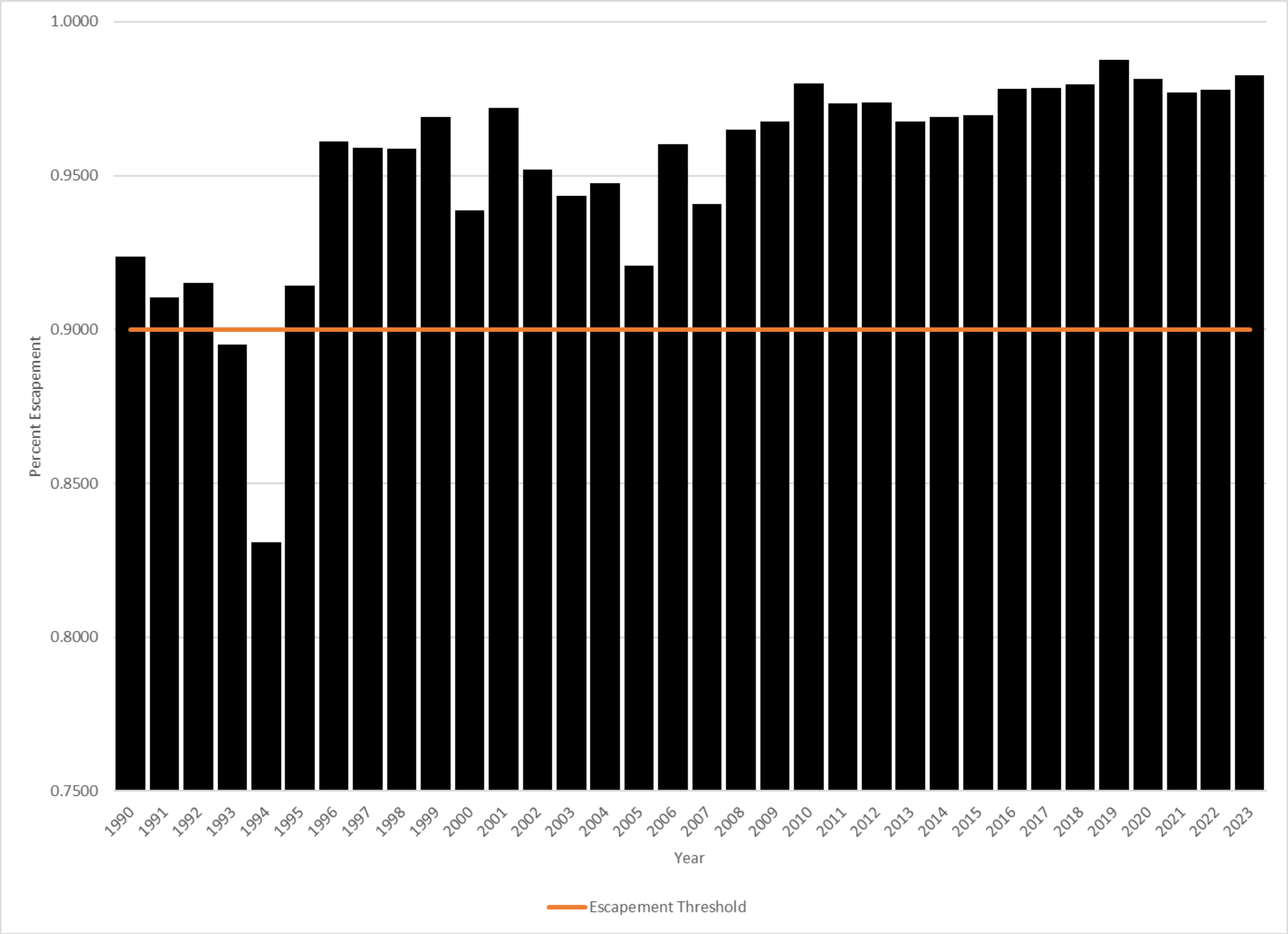

Figure 9. Sustainability Flow Chart for Connecticut River American shad stock monitoring.

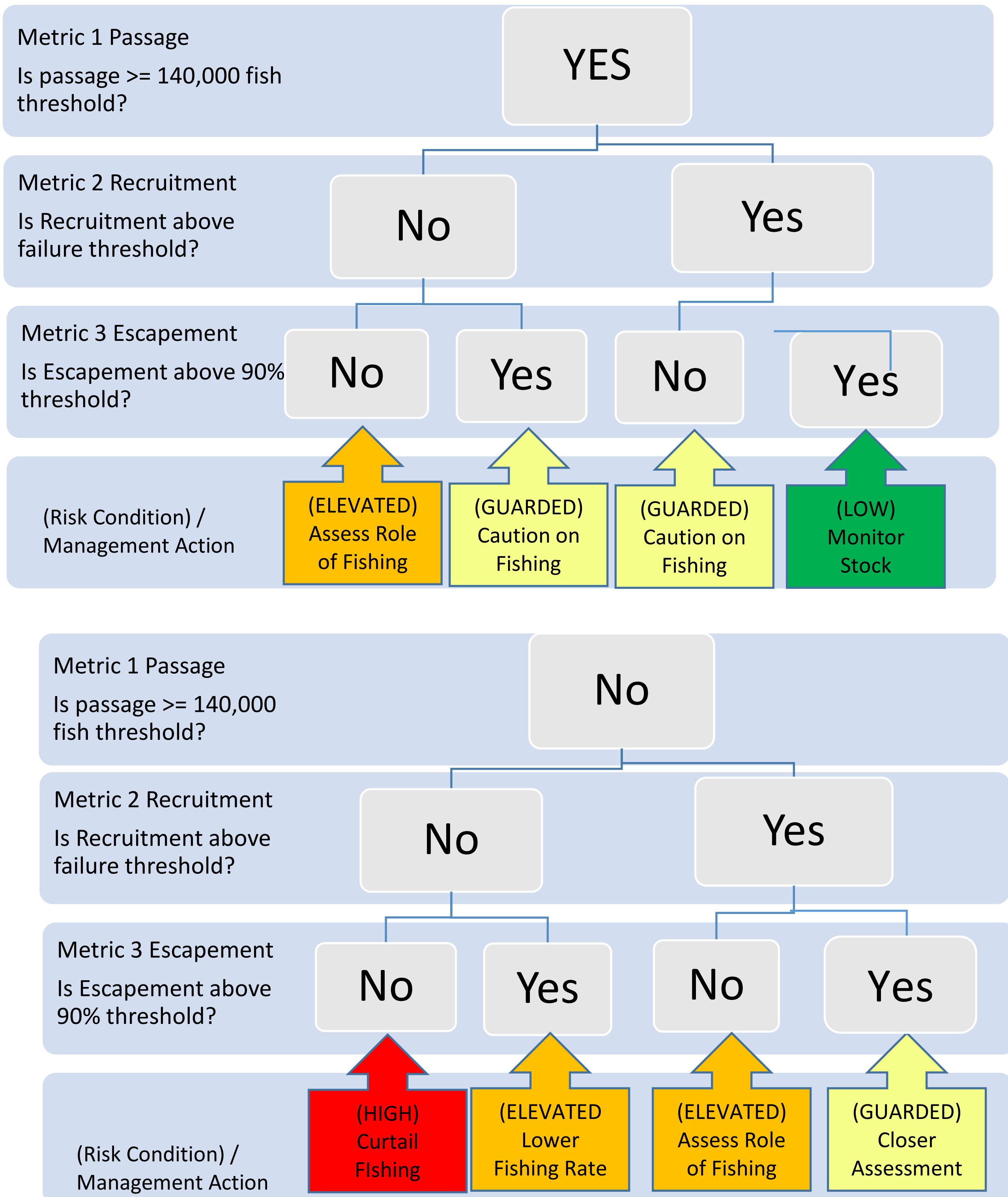

Table 1. Connecticut River American shad population estimates, commercial landings, recreational landings, and percent escapement, 1990 – 2023.

YEAR	CT POPULATION ESTIMATE (*N*)	CT COMMERCIAL LANDINGS (*N*)	CT RECREATIONAL LANDINGS (*N*)[1]	%ESCAPEMENT
1990	816,400	29,710	37,831	0.92
1991	1,195,900	32,286	85,494	0.90
1992	1,628,100	30,939	120,146	0.91
1993	749,200	22,963	64,855	0.88
1994	325,600	21,212	45,014	0.80
1995	304,500	14,161	14,425	0.91
1996	667,000	15,958	11,000	0.96
1997	659,000	21,555	6,590	0.96
1998	651,000	21,512	6,513	0.96
1999	475,000	10,378	4,751	0.97
2000	428,000	23,570	4,274	0.93
2001	773,000	14,543	7,731	0.97
2002	687,000	27,806	6,867	0.95
2003	527,000	26,420	5,273	0.94
2004	351,000	15,892	3,511	0.94
2005	226,000	17,209	2,260	0.91
2006	293,000	9,236	2,930	0.96
2007	244,000	11,576	3,820	0.94
2008	277,000	7,344	2,750	0.96
2009	321,000	7,593	3,210	0.97
2010	279,000	5,094	616	0.98
2011	387,000	6,725	3,870	0.97
2012	778,462	13,168	7,785	0.97
2013	623,757	14,661	6,236	0.97
2014	588,105	12,953	5,881	0.97
2015	687,760	14,637	6,878	0.97
2016	643,217	7,839	6,432	0.98
2017	852,776	10,260	8,528	0.98
2018	436,876	4,772	4,369	0.98
2019	498,986	1,341	4,990	0.99
2020	575,275	5,211	5,753	0.98
2021	376,676	5,119	3,767	0.98
2022	302,146	3,830	3,021	0.98
2023	440,265	3,397	4,403	0.98

[1] For years when a creel survey is not conducted, recreational landings are estimated as 1% of the population.

Table 2. Summary of SFMP values with triggers, 2013 – 2023.

YEAR	PASSAGE	PASSAGE TRIGGER	SUSTAINABILITY TARGET MET?
2013	392,967	140,000	YES
2014	370,506	140,000	YES
2015	412,656	140,000	YES
2016	385,930	140,000	YES
2017	536,670	140,000	YES
2018	273,979	140,000	YES
2019	314,361	140,000	YES
2020	262,244	140,000	YES
2021	237,306	140,000	YES
2022	190,074	140,000	YES
2023	277,367	140,000	YES

YEAR	JAI	JAI TRIGGER	SUSTAINABILITY TARGET MET?
2013	3.16	3.59	NO
2014	8.03	3.65	YES
2015	8.53	3.80	YES
2016	16.7	3.96	YES
2017	5.00	3.96	YES
2018	22.76	4.11	YES
2019	4.52	4.26	YES
2020	COVID 19		UNKNOWN
2021	16.88	4.34	YES
2022	3.93	4.18	NO
2023	7.89	4.26	YES

YEAR	% ESCAPEMENT	% ESCAPEMENT TRIGGER	SUSTAINABILITY TARGET MET?
2013	97	90	YES
2014	97	90	YES
2015	97	90	YES
2016	98	90	YES
2017	98	90	YES
2018	98	90	YES
2019	99	90	YES
2020	98	90	YES
2021	98	90	YES
2022	98	90	YES
2023	98	90	YES

Atlantic States Marine Fisheries Commission

Atlantic Striped Bass Management Board

October 23, 2024
1:30 – 5:00 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 *(M. Ware)*	1:30 p.m.
2.	Board Consent • Approval of Agenda • Approval of Proceedings from August 2024	1:30 p.m.
3.	Public Comment	1:35 p.m.
4.	Review Report from Work Group on Recreational Release Mortality *(C. Batsavage)* **Possible Action** • Technical Committee Report on Release Mortality and No-Targeting Calculations Task *(T. Grabowski)*	1:45 p.m.
5.	Consider 2024 Atlantic Striped Bass Stock Assessment Update • Presentation of Stock Assessment Report *(G. Nelson)* • Technical Committee Report on Considerations for 2025 Management Measures *(T. Grabowski)* • Consider Management Response **Action**	2:30 p.m.
6.	Other Business/Adjourn	5:00 p.m.

The meeting will be held at The Westin Annapolis (100 Westgate Circle, Annapolis, MD; 888.627.8994) and via webinar; click here for details.

MEETING OVERVIEW

Atlantic Striped Bass Management Board
October 23, 2024
1:30 – 5:00 p.m.

Chair: Megan Ware (ME) Assumed Chairmanship: 1/24	Technical Committee Chair: Tyler Grabowski (PA)	Law Enforcement Committee Rep: Sgt. Jeff Mercer (RI)
Vice Chair: Chris Batsavage (NC)	Advisory Panel Chair: Vacant	Previous Board Meeting: August 6, 2024
Voting Members: ME, NH, MA, RI, CT, NY, NJ, PA, DE, MD, DC, PRFC, VA, NC, NMFS, USFWS (16 votes)		

2. Board Consent

- Approval of Agenda
- Approval of Proceedings from August 2024

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. Report from Work Group on Recreational Release Mortality (1:45-2:30 p.m.) Possible Action

Background

- In May 2024, the Board established a Board Work Group (WG) to discuss recreational release mortality and approved four WG tasks addressing no-targeting closures, gear restrictions, stock assessment work, and public scoping.
- The WG presented initial recommendations to the Board in August 2024 on the stock assessment and public scoping tasks.
- The WG met four times in September 2024 to discuss no-targeting closures and gear restrictions, as well as continued discussion on public scoping **(Briefing Materials)**.
- The WG developed a report to the Board summarizing all WG conclusions and recommendations on all WG tasks **(Briefing Materials)**.
- Per the WG's August recommendation, the Board tasked the Technical Committee (TC) with calculations on reducing release mortality and quantifying the reduction associated with no-targeting closures. The TC met in September and October 2024 to address those tasks **(Supplemental Materials)**.

Presentations

- Overview of Work Group conclusions and recommendations by C. Batsavage

- Technical Committee Report on requested release mortality calculations and quantifying no-targeting closures by T. Grabowski

Possible Board action for consideration at this meeting

- Consider Work Group recommendations

5. 2024 Stock Assessment Update (2:30-5:00 p.m.) Action

Background

- The 2024 stock assessment update was completed in October 2024 **(Briefing Materials)**.
- The Technical Committee and Stock Assessment Subcommittee met in September and October 2024 to discuss different projection scenarios and considerations for management response **(Supplemental)**.

Presentations

- Assessment overview by G. Nelson
- Technical Committee and Stock Assessment Subcommittee Report on Considering Projections and Management Response by T. Grabowski

Board action for consideration at this meeting

- If necessary, consider management response to the 2024 stock assessment update

6. Other Business/Adjourn (5:00 p.m.)

Atlantic Striped Bass

Activity level: High

Committee Overlap Score: Medium (TC/SAS/TSC overlaps with BERP, Atlantic menhaden, American eel, horseshoe crab, shad/river herring)

Committee Task List

- TC – June 15: Annual compliance reports due
- TC-SAS – Conduct 2024 stock assessment update
- TC-SAS calculate potential management options if the assessment indicates a reduction is needed to achieve stock rebuilding by 2029
- TC-SAS review size-bag-season analysis methods

TC Members: Tyler Grabowski (PA, Chair), Michael Brown (ME), Gary Nelson (MA), Nicole Lengyel Costa (RI), Kurt Gottschall (CT), Caitlin Craig (NY), Brendan Harrison (NJ), Margaret Conroy (DE), Alexei Sharov (MD), Luke Lyon (DC), Ingrid Braun (PRFC), Brooke Lowman (VA), Charlton Godwin (NC), Jeremy McCargo (NC), Peter Schuhmann (UNCW), Tony Wood (NMFS), John Ellis (USFWS), Katie Drew (ASMFC)

SAS Members: Michael Celestino (NJ, Chair), Gary Nelson (MA), Alexei Sharov (MD), Brooke Lowman (VMRC), John Sweka (USFWS), Margaret Conroy (DE), Katie Drew (ASMFC)

Tagging Subcommittee (TSC) Members: Angela Giuliano (MD), Beth Versak (MD), Brendan Harrison (NJ), Chris Bonzek (VIMS), Gary Nelson (MA), Ian Park (DE), Jessica Best (NY), Victoria Lecce (USFWS), Julien Martin (USGS), Katie Drew (ASMFC)

DRAFT PROCEEDINGS OF THE

ATLANTIC STATES MARINE FISHERIES COMMISSION

ATLANTIC STRIPED BASS MANAGEMENT BOARD

The Westin Crystal City
Arlington, Virginia
Hybrid Meeting

August 6, 2024

These minutes are draft and subject to approval by the Atlantic Striped Bass Management Board.
The Board will review the minutes during its next meeting.

TABLE OF CONTENTS

INDEX OF MOTIONS

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

2. **Approval of Proceedings of May 1, 2024** by consent (Page 1).

3. **Move to approve the Atlantic Striped Bass FMP Review for the 2023 Fishing Year and State Compliance Reports** (Page 5). Motion by Mike Luisi; second by Emerson Hasbrouck. Motion passes by consent (Page 5).

4. **Move to approve Tom Fote representing New Jersey and Will Poston representing the District of Columbia to the Striped Bass Advisory Panel** (Page 19). Motion by Dennis Abbott; second by Joe Cimino. Motion passes (Page 19).

5. **Move to adjourn** by consent (Page 20).

ATTENDANCE

Board Members

Megan Ware, ME, proxy for P. Keliher (AA)
Steve Train, ME (GA)
Rep. Allison Hepler, ME (LA)
Cheri Patterson, NH (AA)
Doug Grout, NH (GA)
Dennis Abbott, NH, proxy for Sen. Watters (LA)
Nichola Meserve, MA, proxy for D. McKiernan (AA)
Raymond Kane, MA (GA)
Rep. Sarah Peake, MA (LA)
Jason McNamee, RI (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, CT (LA)
Marty Gary, NY (AA)
Emerson Hasbrouck, NY (GA)
Jim Gilmore, NY, proxy for Assbly. Thiele (LA)
Joe Cimino, NY (AA)
Jeff Kaelin, NJ (GA)
Adam Nowalsky, proxy for Sen. Gopal (LA)
John Clark, DE (AA)
Roy Miller, DE (GA)
Craig Pugh, DE, proxy for Rep. Carson (LA)
Michael Luisi, MD, proxy for L. Fegley (AA)
Robert Brown, MD, proxy for R. Dize (GA)
David Sikorski, MD, proxy for Del. Stein (LA)
Pat Geer, VA, proxy for J. Green (AA)
Chris Batsavage, NC, proxy for K. Rawls (AA)
Jerry Mannen, NC (GA)
Chad Thomas, NC, proxy for Rep. Wray (LA)
Ronald Owen, PRFC
Daniel Ryan, DC, proxy for R. Cloyd
Rick Jacobson, US FWS
Max Appelman, NOAA

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

Ex-Officio Members

Tyler Grabowski, Technical Committee Chair
Mike Celestino, Stk. Assmnt. Subcommittee Chair
Sgt. Jeff Mercer, Law Enforcement Committee Rep.

Staff

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

The Atlantic Striped Bass Management Board of the Atlantic States Marine Fisheries Commission convened in the Jefferson Ballroom of the Westin Crystal City Hotel, Arlington, Virginia, via hybrid meeting, in-person and webinar; Tuesday, August 6, 2024, and was called to order at 1:00 p.m. by Chair Megan Ware.

CALL TO ORDER

CHAIR MEGAN WARE: Good afternoon, everyone. We're going to call together the Striped Bass Board.

APPROVAL OF AGENDA

CHAIR WARE: We'll start with Approval of the Agenda. Are there any additions or modifications to the agenda? Seeing none; your agenda is approved by consent.

APPROVAL OF PROCEEDINGS

CHAIR WARE: We'll move on to Approval of the proceedings from May, 2024. Are there any edits to the proceedings? Seeing none; the proceedings are approved by consent.

PUBLIC COMMENT

CHAIR WARE: We'll now move into Public Comment. This is for items that are not on the agenda. We'll look for raised hands both in the room and on the webinar. We do have some folks interested in public comment, Des Kahn, I see your hand raised.

MR. DESMOND KAHN: I guess I've been called on then, is that correct?

CHAIR WARE: Yes, Des, we're ready to hear your comment. We have a three-minute timer for you.

MR. KAHN: Great, thank you. Well, I appreciate the chance to comment. I am speaking today about an issue that I don't believe the Board is fully aware of, but it has a major impact on coastwide abundance, and that is the Salem Nuclear Reactor on the Delaware River. This is an old-style reactor with once through cooling, and it pulls in over three billion gallons of water a day from the Delaware River estuary.

It is one of the largest, if not the largest industrial water intake in the world, and it kills millions to billions of fish every year, including in many years they provide estimates of the numbers killed by life stage. In the case of striped bass, I remember their estimate for 2002 sticks in my mind, was 400 million larvae and early juvenile.

I have been working on this ever since 1999, when I worked for the state of Delaware. I was also a member of the Striped Bass Technical Committee for years, and was even Chair for a while. But this issue has not come up. I have estimated using equivalent recruit analysis, which is a standard method for gauging the impact of entrainment and impingement, that this plant kills about on average among years on average a third of all the Delaware River striped bass that are produced. Now, this is highly variable. Some years the estimates show the plant killed over 80 percent of all striped bass produced in the river, and we partly gauge this using the data from the New Jersey Marine Fisheries Delaware River haul seine survey for striped bass that they do every year. That is part of the analysis, and it allows us to estimate the total mortality rate.

I think when you look at the last estimate of the Delaware River stock it was estimated to contribute 15 to 20 percent to the coastwide stock, and at least a third of it is being killed by Salem. That means the stock is being reduced by 10 percent due to Salem. There are efforts underway to try to change this, and I would suggest that the Commission might want to look into this and possibly support those efforts. Thank you.

CHAIR WARE: Thank you, Des, for your comment. Much appreciated. I think those were all the hands we had raised for public comment today.

CONSIDER APPROVAL OF FISHERY MANAGEMENT PLAN REVIEW AND STATE COMPLIANCE FOR THE 2023 FISHING YEAR

CHAIR WARE: We'll move on to Agenda Item 4, which is Approval of our Fishery Management Plan Review and State Compliance Reports for 2023. I will pass it over to Emilie.

MS. EMILIE FRANKE: Great, thank you, Chair. I will go over the components of the FMP Review, hitting some highlights, as well as the Plan Review Team comments and recommendations. Then the Board action for consideration today is to consider approving the 2024 FMP Review and State Compliance Reports.

Starting with the status of the stock. We are still operating under the 2022 Striped Bass Stock Assessment Update, which found the stock is overfished but not experiencing overfishing. As a reminder, this stock assessment incorporated data through 2021, and as we all know the next stock assessment, the 2024 Stock Assessment Update is currently in progress.

We will be getting those stock assessment results in just a few months. Moving on to status of the FMP. Last year, 2023, Amendment 7 was in place until the 2023 Emergency Action was implemented to reduce harvest of the 2015-year class. That action was approved on May 2nd of last year, and all states had to implement that action by July 2nd.

State implementation dates ranged from mid-May all the way until that July 2nd deadline. Then for this year in 2024 that Emergency Action was replaced by Addendum II, which was required to be implemented by May 1st. Here is the figure of total striped bass removals by sector in number of fish. You can see at the bottom commercial harvest and discards relatively stable, the quota managed fishery.

Then in the green is recreational harvest, and the purple is recreational release mortality. At the end of the time series, you can see that spike in 2022, and then a decrease we saw last year in recreational removals. In 2023, total striped bass removals across both sectors were 5.6 million fish. This is about an 18 percent decrease from 2022 removals.

You can see on the screen here the proportion of removals by source of mortality. As in recent years, the commercial sector accounts for about 11 percent of the total mortality, and then the recreational sector accounts for about 89 percent of those fishery removals. As far as the commercial fishery, last year in 2023 harvest was estimated at about 4.2 million pounds. This is very similar to harvest in the previous year, 2022, only a 2 percent decrease by weight. Then as far as commercial quota utilization, in 2023 the ocean utilized about 74 percent of the quota. Again, that underutilization of the ocean quota is due to the lack of availability of striped bass in North Carolina waters, as well as the four states that do not allow commercial fishing.

But all of the states that do allow commercial fishing, the ocean region used almost all of their quotas, between 94 to 98 percent of their quotas. The Chesapeake Bay used about 84 percent of their quota in 2023. Overall, neither the state quotas in the ocean nor the Chesapeake Bay quota was exceeded.

For the recreational fishery last year, harvest was estimated at 2.6 million fish. This is a 24 percent decrease from recreational harvest in 2022. About 26 million fish were released alive with our 9 percent release mortality rate. We assume that 2.3 million of those fish are assumed to have died, and that is about a 12 percent decrease in live releases from 2022.

When you look at these trends by region and by mode, you can sort of pick out a few things the PRT wanted to highlight. In 2023 we saw a larger decrease in harvest and directed trips in the ocean, as compared to the Chesapeake Bay. The PRT noted, you know this is likely, partly due at least to the Emergency Action, which had more of an impact in the ocean than the Bay, with that 31-inch maximum size limit.

When you are looking at private and shore harvest, those modes decreased pretty similarly both tin the ocean and the Chesapeake Bay. When you look at the for-hire modes there was a larger for-hire decrease in the ocean region, and actually a slight increase in for-hire harvest in the Chesapeake Bay.

In this year's FMP Review, the PRT included a breakdown of recreational harvest by Wave. The PRT anticipated there might be some questions or interest in considering the potential impact of the Emergency Action in 2023. The PRT, you know obviously caveat that not only is the harvest and catch impacted by the Emergency Action, but also by changes in fish availability, effort, et cetera.

But nonetheless, here are the Wave data. You can see for Wave 4 and Wave 5, in particular in the ocean, we saw pretty significant decreases in harvest in 2023, relative to 2022. For the Chesapeake Bay we saw a pretty big decrease in Wave 5. Again, the PRT notes that there are several factors that contribute to the level of harvest in both sectors.

Again, we have year class availability, those 2015s pretty available to the fishery in 2022 and '23. Then of course that Emergency Action in '23 to reduce harvest in angler behavior, overall stock abundance, whether the fish are available nearshore. You know all these factors contribute to the changes in harvest.

Another point from the FMP Review is the recruitment trigger. The Amendment 7 recruitment trigger is if any of the 4 juvenile abundance indices used in the assessment fall below 75 percent of the values from our high recruitment period for 3 years, then we have to use the low recruitment assumption when we're calculating our reference points. The recruitment trigger has been tripped; I think the past 2 years. It has been tripped again. We reviewed the '21, '22 and 2023 JAI values, and we had 3 states that tripped the trigger. What that means is the 2024 stock assessment update will continue to use that low recruitment assumption. Again, we did use the low recruitment assumption in the 2022 assessment, so it will continue to be used in the 2024 assessment.

Here on the screen, I know it's pretty small, but are the 4 JAIs used in the stock assessment. In the top left corner, you have the New York Hudson River. The top right is the New Jersey Delaware River, you can see circled in red is what trips the trigger. Bottom left is the Maryland JAI. You can see 5 years of recruitment below the trigger level, and then the Virginia JAI on the bottom right also tripping the trigger this year.

As far as the PRTs comments, the PRT found that in 2023 all states implemented management consistent with the provisions of the FMP and with the Emergency Action, and there are no de minimis requests. The PRT had previously noted in last year's FMP review some difference in regulatory language for the Amendment 7 gear restrictions that were required to be implemented in 2023.

That is the prohibition on gaffing, and the need to release striped bass caught on any unapproved method of take without unnecessary injury. The PRT had noted a couple of differences last year. The Board did not express any concern last year, but I just wanted to point it out again. Then as far as PRT recommendations, the PRT just continues to emphasize the importance of commercial tag accounting, and the PRT recommends that we continue to follow up with states as needed.

Then the PRT also recommends the Board task the PRT with a review of the commercial tagging program, just to review the program components. This isn't necessarily intended to change the program requirements, but instead review how the programs have been operating, identify any issues that states have encountered, how they resolved them.

It would also be important to include the Law Enforcement Committee. Another thing the PRT just wants to make sure the reporting for the tagging programs is streamlined. Right now, there is some duplicative reporting in the tagging reports and the compliance reports. Then one additional comment.

The PRT continues to leave this in the FMP Review just to highlight it, that the New York spawning stock monitoring in the Hudson does not provide an index of abundance. This was identified as a high priority recommendation in the last benchmark, but I think it could be considered potentially in the next benchmark. That's it, I'm happy to take any questions.

CHAIR WARE: Thank you very much, Emilie. Just a programming note. I was told that Captain Newberry, you had raised your hand as we were transitioning to the FMP Review for public comment. If we have time at the end of our agenda today, I will look to you for your public comment. But for now, we're going to continue on with our agenda. We will see, are there any questions for Emilie on the FMP Review? Emerson Hasbrouck.

MR. EMERSON C. HASBROUCK: Maybe I missed it in the presentation, but what was it that triggered the PRT to ask the Board to task them with review of commercial tagging program? Were there some issues with that? Then I have follow-up.

MS. FRANKE: Thanks, Emerson, there weren't any specific issues, just that the PRT realized in the past few years that it's been over a decade since the commercial tagging program was implemented, and you know states have had various issues come up that they've been able to resolve with that sort of reviewing how the program has been going, and also sort of giving states the chance to collaborate could be beneficial.

MR. HASBROUCK: Then are you looking for two separate motions from the Board, one to task the PRT and another to approve the review? Madam Chair, how do you want to proceed? I'm ready to make either or both motions.

CHAIR WARE: Thanks, Emerson, we don't need a motion for the tasking, so if that is the will of the Board, we can indicate that that is a task for the PRT and the Law Enforcement, or some members of the Law Enforcement Committee. I would just note, we have a really busy October ahead of us.,

I wanted expectations of timing, because there are some things we will try to address ahead of the annual meeting. If anyone has concerns about tasking the PRT with the tagging program, I think now would be an opportunity to speak up. But Nichola, I had seen your hand. You can comment on something else.

MS. NICHOLA MESERVE: I was just going to lend my support for the PRT to undertake that as time permits, recognizing the staffing and state resources to do that are less of a priority than the assessment and any lead-up management action to it.

CHAIR WARE: Great, thanks, Nichola. Any other questions? Yes, Mike.

MR. MICHAEL LUISI: I was curious, I think the last slide that was presented referenced the fact that New York, or the work they do in New York is not a relative abundance index. What would be required? I mean what would have to happen for them, for the state of New York to have an index that would be identified as an abundance index or relative abundance index?

DR. KATIE DREW: I think the issue with the New York work is that it is a tagging program, so it is focused on tagging those spawning fish, and as a result there is not really a systematic design, so it is basically, you go out and you try to find the fish to tag them, and so you can't really use it as index of abundance.

I think there is potentially some statistical work that the TC could maybe look into, to see if we could standardize it a little from that side, but I think the flip side would also then be working with New York to actually transition that, if they were so inclined, to a formal statistical design survey, and not through the more opportunistic tagging approach that it is right now.

CHAIR WARE: Marty, would you like to comment on that?

MR. MARTIN GARY: Yes, thanks, Madam Chair. I think to that point, where Katie mentioned New York's intent is to work with academic partners, to use that data from our tagging for the spawning stock to develop that index of relative abundance, you know for the spawning stock in the Hudson River. That is our intent, and we would hope to have that ready for the 2027 Benchmark.

CHAIR WARE: Not seeing any other hands, we would be looking for a motion to approve the FMP Review and State Compliance Reports. Mike Luisi, do you want to read that motion in, please?

MR. LUISI: Sure, **move to approve the Atlantic Striped Bass FMP Review for the 2023 Fishing Year and State Compliance Reports**.

CHAIR WARE: Great, motion by Mike Luisi, we have a second from Emerson Hasbrouck online**. Is there any objection to this motion? Seeing none; the motion is approved by unanimous consent**.

CONSIDER INITIAL RECOMMENDATIONS FROM WORK GROUP ON RECREATIONAL RELEASE MORTALITY

CHAIR WARE: We'll move on to Agenda Item Number 5, which is Considering Initial Recommendations from our Work Group on the Recreational Release Mortality.

I want to just give a shout out to Chris Batsavage, Nichola Meserve, Marty Gary, Adam Nowalsky, Mike Luisi, Dave Sikorsky and Max Appelman. It's been a really great Work Group so far. I appreciate the time you guys have taken to work through a pretty difficult topic. We're going to look to Chris Batsavage, who has been chairing that Work Group for an update.

MR. CHRIS BATSAVAGE: Yes, let's go ahead right into the presentation. Just a quick background. This Work Group was formed by the Board at their last meeting to discuss recreational release mortality issues, and there are four tasks that the Work Group was given to look at. Just quickly go through them again is to review the existing non-targeting closures, including effort and enforceability, review the Massachusetts DMF study and other hook and line studies, to evaluate gear restrictions.

Identify stock assessment work to inform our discussion on recreational release mortality, and to consider public scoping on measures to address release mortality. As Megan mentioned, here is the roster of Work Group members, so I just won't repeat them again. Just a kind of timeline of where we are now versus a couple months ago and where we're going.

I already mentioned that this all started back in May. The Work Group held meetings in June and July, to primarily discuss the stock assessment and public scoping task that is Number 3 and 4. Of course today, we're providing our initial recommendations to the Board on the stock assessment and public scoping tasks, and also for full consideration of the Work Group's recommendations.

Looking ahead for late summer into October, we'll have a couple more Work Group meetings to discuss the non-targeting closures and gear restrictions, and revisit Task 3 and 4 as needed, and then we'll wrap things up with a final report that will be presented to the Board at their meeting in October. I'll cover the discussions the Work Group had on the stock assessment work, so Task 3. This task was to identify stock assessment sensitivity runs on how low release mortality must get to see a reduction in total removals. This task considered the tradeoff between reducing the recreational mortality rate and reducing overall number of recreational releases. The Work Group reviewed the past Technical Committee work that explored how different release mortality rates throughout the time series would impact the stock assessment results.

This task is to understand how reducing recreational release mortality in the future will impact the stock. After that discussion the Work Group recommends the following items for the TC to analyze. The first one is, if a reduction is needed to keep rebuilding, determine how low the release mortality rate would need to be, to achieve that entire reduction through the release mortality rate alone.

If the number of live releases ins constant, what would the release mortality rate need to be to achieve reduction? The second task is, if a reduction is needed to achieve rebuilding, determine the percent reduction of live releases needed to achieve the entire reduction through live releases alone. Using the current 9 percent release mortality rate, how many fewer live releases would there need to be to achieve the reduction?

These tasks are looking at the extreme cases for reducing recreational release mortality, with the first one looking at the release mortality rate, and the second one looking at the number of released fish. Both of these assume constant recreational harvest, but each of these has different iterations for the commercial fishery.

One has the constant commercial harvest, and the other is for an equal reduction of commercial harvest. The third item we're asking the TC to look at is, if a reduction is needed to achieve rebuilding, determine the percent reduction and number of live releases needed under the current 9 percent mortality rate, assuming there is an associated reduction in recreational harvest due to no-targeting closures.

This assumes a no-targeting closure will release harvest and live releases. The TC will need to determine how best to quantify release reductions during no-targeting closures. The Work Group recommends TC input on the timing of the no-targeting closures, and like the other tasks this one will also have two iterations for the commercial fishery, one with a constant harvest, another with an equal reduction in commercial harvest.

The fourth item that we're asking for the TC to look at is to identify the tradeoffs of implementing no-targeting closures at different times of the year, with different assumed release mortality rates to help inform when and where implementing no-targeting closures would result in highest reduction.

Factors could include water temperature and salinity, which with the assumption that the release mortality rate is higher when the water temperature is high, and the salinity is low. The Work Group understands that reductions from no-targeting closures depend on where and when they occur, so TC guidance would be very helpful for this task.

Just to sum things up for Task 3, the Work Group recommends tasking the TC as described, to address these things during the ongoing 2024 stock assessment. Next, I will cover the Work Group's discussions on public scoping. Just a reminder, this task is for if the Board considers taking action by a Board vote instead of an addendum, if the upcoming stock assessment indicates additional reductions are needed for stock rebuilding. The Work Group supports an online survey approach to get public input on the different issues regarding recreational release mortality, but we're concerned that conducting the survey prior to October isn't going to give us enough time to have a well-developed survey to roll out to the public.

This is a very important opportunity to inform management beyond just the next stock assessment, so we want to take a little more time on this, and with that the additional time for the survey development would be beneficial for us, and also the fact that as was mentioned a few times, none of the Work Group members are trained in survey design.

We at least want to be careful in how we craft these questions. With that, if we could, we would like to consult with the Commission's Committee on Economic and Social Sciences, their membership, maybe look at potential external survey experts, and also look for industry input on the Striped Bass Advisory Panel.

Based on these concerns and any considerations, the Work Group recommends the Board extend the timeline for the public survey on release mortality. The survey could be conducted soon after the annual meeting, which could inform Board action later in 2024. Before you do this, it would require a special meeting for the Board, or a survey can be conducted in 2025.

The Board could still take action without the survey results if the upcoming stock assessment indicates a reduction is needed. I won't do a full stop on what we were thinking about possibly doing after we get the assessment. The Work Group thinks it is important for input from survey experts and the Advisory Panel before releasing the survey out to the public.

The Work Group also identified need for an outreach strategy for disseminating the survey, to make sure we canvas and get as much input from the public as possible. That summarizes the last two Work Group meetings. Again, I want to thank special thanks to Emilie and the Work Group. I think it's been very productive meetings we've had, and also thanks to the public participating. We provide some opportunity for the public comment, and they had some very helpful comments to kind of guide us along the way.

CHAIR WARE: Thank you very much, Chris, and thank you for chairing the Work Group. We're going to start with any questions for the Work Group. We'll talk about their recommendations on the stock assessment sensitivity runs and public scoping next, but we'll just start with questions. Okay, no questions. We'll go to their recommendations. We'll start with the stock assessment sensitivity runs.

We have four sensitivity runs that the Work Group is recommending, so this would be an opportunity if folks have modifications or additions, deletions to that list to let us know. If not, then we will work to task the TC and SAS. Okay, great. We were going to collectively task the TC and SAS with those four sensitivity-runs, and we look forward to seeing that at the October meeting. We'll move on to the public scoping and the development of a survey. We have a Work Group recommendation to take a little more time to develop that survey. I think it would be helpful if folks around the table have thoughts on whether that survey should be ready to go by the October board meeting. If some time in 2025 is okay that might help prioritize the workload of staff and the Work Group members as we move forward. Are there any thoughts on the timing of the survey or if folks are still interested in a survey that would be helpful to hear as well. Yes, Jay.

DR. JASON McNAMEE: I agree with what was in the report, I think. The benefit of having that would have been to get some, like we have some standard things we think about with respect to what we can do to decrease release mortality. But it would have been good to get, I don't know, like larger scope on that, like get some ideas maybe we haven't heard yet.

That is an attribute of the survey, however, I agree to create a survey to actually get like actionable good pieces of information from it takes time and thought. I'm in agreement, you know and working on that a little longer and delaying the survey. Nice job on all this. It was a really thoughtful document. I appreciated it.

CHAIR WARE: I have Jim Gilmore and then Bill Hyatt.

MR. JAMES J. GILMORE: Just in terms of practicality, and I agree 100 percent on the survey. It should be delayed a bit from experience from last year, when we ran a survey and the original parameters for it were delayed, and we ran the survey very late, very short period of time. It was reported in the newspaper that 56 percent are opposed to this change, whatever, but then the reality was they didn't report we only reached 2 percent of the fishing community. It was a useless survey, but the danger of misusing numbers like that becomes an important issue. Do it right, so delay it a little bit and I think it will be more useful.

CHAIR WARE: Bill Hyatt.

MR. WILLIAM HYATT: Yes, I also support the additional time, particularly for getting some expert consultation on the construction of the survey. The idea that it's going to be online adds additional bias. They might think any type of consultation you get on the wording and the format, to make sure an online survey is as accurate as possible is for long term benefit.

CHAIR WARE: Great, so what I am hearing so far for feedback is continued interest in the survey, wanting to make sure we're developing it correctly. I would say encouraging the Work Group to consult with the staff as they can, and continuing on, and we'll see where we get by October. I'll look to Work Group members and make sure folks feel like that is enough feedback for you guys. Yes, okay, great.

MR. ERIC REID: Sorry, Madam Chair, I'm late to the game. I did hear a comment about socioeconomics. One reason to delay is to make sure we get good socioeconomic response, based on how the survey is conducted. I guess I want to make sure socioeconomics are included in the survey. I think that's an easier way to say it.

MS. FRANKE: Just from a sort of staff perspective, could you expand on that a little bit? I mean I think in terms of the survey distribution, you know if the Board is looking to reach as many people as possible, of course the Commission will push the survey through our channels, but I think we would look to the Board members to make sure that the stakeholders in their states are receiving the survey. But if you are interested in specific type of questions on the survey related to socioeconomics that would be great.

MR. REID: No, I'm not going to even dare to recommend any specific questions. I just want to make sure we reach out to a wide variety of stakeholders. I think a wider variety versus a lot of surveys in general is more important. How do you pinpoint your target audience, and make sure you get all the different user groups in the response? It is important.

CHAIR WARE: David Borden.

MR. DAVID V. BORDEN: I just wanted to follow up on Eric's point about economics and soliciting a broad group. If we are going to consider gear changes at some point, which we might want to. Some constituents are already advocating that. Then I think it's important to get the direct input from the gear manufacturers, particularly on the issue of lead time to change lures and those types of consideration. Whether that is done as part of the committee or an individual on the committee then goes and talks to them directly. But I think their input is important at this stage.

CHAIR WARE: Any other comments on the survey? Yes, John Clark and then Ray Kane.

MR. JOHN CLARK: I'm just trying to be clear on the timeline of these various tasks going on. In other words, we would be looking at the first and second, which would be kind of estimating how much of a reduction in recreational mortality we would have to see. Then we would be coming up with ideas as how we could reduce it, and then the survey would take a while to develop. When the survey is actually out, is it going to have specific ideas in the survey, or is it going to be the whole kind of long list of possible methods that can be used to reduce recreational mortality?

MS. FRANKE: I can start the answer, and Work Group members feel free to jump in. But I think because the survey is not directly tied to a management document with management options, it will be a little bit more general, trying to encompass, you know recreational release mortality as a whole, including a list of potential ways to address it. I think also asking for feedback from the public on ways to address it. It won't be Option A, Option B, Option C, it will be marginal.

CHAIR WARE: Ray Kane.

MR. RAYMOND W. KANE: Madam Chair, this has to do with Emilie's presentation. I don't want to take you off track. If I could get this question now. On tasking the TC under Number 2, it closed out the Working Group recommends 2 iterations for each scenario, one with constant commercial harvest and one with an equal reduction of commercial harvest. What are the thoughts about that? I mean we just, commercial fishermen just took a cut of 7 percent. Can you give me some background why you would be tasking the TC with this once again?

MS. FRANKE: Right, so that detail is just sort of how to parameterize the projections the TC would be running for these four tasks. For these four tasks, like there are four sources of removals; release mortality, recreational harvest, and then commercial harvest and discards. The focus of these tasks and resulting TC projections would be figuring out what that reduction in release mortality would look like.

Then the question is, how do we parameterize the other variables in those projections? We would assume recreational harvest is constant, because we are trying to focus on that recreational release mortality, and then the point about 2 iterations for the commercial fishery, one assuming constant commercial harvest, and the other assuming equal reduction in commercial.

It's just getting to the fact that the Board has had discussions before about how to split reductions, which we'll get to in the next agenda item as well. But I think that just covered all of the bases, so it would provide sort of a range of results, as far as those scenarios. It's not a specific management option, it's just different ways to parameterize those reductions.

CHAIR WARE: Last call on any comments on the survey, otherwise we'll have the Work Group continue working. You've gotten some feedback on things to consider. I've also heard feedback just on a Work Group call that I do think we want to keep this manageable for the public. I just want to set expectations on all the topics that we can cover in a survey and still be effective.

I am hearing we have a member of the public that wants to comment. We're going to keep trucking along here on our agenda, but if we do have time at the end I will go to a member of the public.

PROGRESS UPDATE AND BOARD GUIDANCE ON 2024 STOCK ASSESSMENT UPDATE

CHAIR WARE: Next, we have Agenda Item Number 6, an Update on the 2024 Stock Assessment and Board Guidance. I'll turn it over to Katie Drew.

TIMELINE AND PROGRESS OVERVIEW

DR. DREW: I will be presenting on essentially a quick update on where we are with the assessment, and then turn to you guys for a request for guidance on some of the things that we're working on with this assessment. In terms of the assessment update timeline, all of the data have been submitted, which is great.

We are in the period now doing some initial model runs, with input from the staff as needed. September 4 to 5 we will be having an in-person TC and staff meeting to discuss the final model runs, and discuss potential management measures if a reduction is needed to achieve rebuilding. After that meeting, we will finalize the report and have it ready for the Board during the week of October 21, during annual meeting.

As you perhaps recall, Addendum II specified that if an upcoming stock assessment prior to the rebuilding deadline of 2029 indicates that the stock is not projected to rebuild by 2029, with a probability greater than or equal to 50 percent, the Board can respond via Board action, essentially by changing management measures via a vote to pass a motion, as opposed to an addendum or an amendment.

This is different from the Emergency Action process, but this was specifically written into Addendum II to allow the Board to respond more quickly to a finding that the rebuilding had been delayed and additional action needed to be taken. Essentially, what will happen is that in 2024 the assessment update will be presented at annual meeting in October. At this point we will tell you stock status, so whether we are overfishing and whether or not we are overfished, and then we will also report on the set of projections that we have done to determine what level of harvest and what level of removals is necessary to ensure that we will be rebuilt by 2029.

If the projections indicate there is a less than 50 percent probability of rebuilding by 2029 under the current F rate and the current regulations, the TC would then calculate new management options to present concurrently with the assessment. We would say, here is the percent reduction that we need, in order to rebuild by 2029.

Here are the options that will achieve that, so that the Board can consider this altogether and make a decision in October, as opposed to traditionally we will generally present you with stock status and the percent removals, and then we would be tasked with developing options, and that you would review at the next meeting, and then et cetera.

In this case the TC will come up with some options to present with the assessment if a reduction is necessary. If a reduction is needed, the TC could consider quota reductions for the commercial sector, and changes to the size, bag and season for the recreational sector. However, keep in mind the range of viable recreational options may be limited.

There is not a lot we can do that we have not already done on that front. Keeping that in mind, to ensure that the TC develops viable options for the Board, we are looking for guidance on the following questions. Number one, how should any potential reductions be allocated across sectors? Number two, what types of recreational options should be considered?

In terms of how should potential reduction be allocated across sectors, I think some of the things we're looking for are things like should all sectors take an equal percent reduction, or just one sector takes more or less of a reduction? If you want unequal reduction, how do you want that split out? That kind of guidance you would like right now, because that will allow us to provide more concrete, more viable options for you.

Then, if the recreational sector can't achieve the required reduction exactly, so for example, if we need a X percent reduction but we can only get a Y percent or a Z percent, you're a little above or you're a little below. How should that difference be handled? For example, would you allow the recreational sectors to sort of undershoot that reduction and have the rest of it made up by the commercial sector?

Would you prefer that the recreational sector overshoots their reduction, that is take a higher reduction, and then have the commercial sector take the same flat required reduction, or sort of the commercial sector then gets the leftover reductions and take a lower reduction if the rec side overshoots their percent reduction?

This would be more on how are we allocating the reduction across the sectors, and then Question 2, what types of recreational options should be considered? Are there specific things that you want to see the numbers run for? Some things would be are you more interested in; I think seasons? Obviously, that may be one of our few options left that has some flexibility. Is the Board more interested in a no-targeting or a no harvest type of closure? Then secondarily, is the Board interested in maybe a moving or a non-fixed slot limit or a size limit to protect a 2018-year class for more years? Just the 2018-year class, it was not as strong as the 2015, but it was above average, one of the few above average ones we've had in a while. In 2025, when these measures will take place, they will be in the same position that the 2015s were in 2023, so they will be 8 years old and entering that ocean slot.

If we move the slot up to protect 2025, it's going to move into it in 2026. Is the Board interested in some kind of measure that would change over time to protect the 2018-year class for more years? Generally, when the TC has presented options, the

Board has put a lot of emphasis on management stability, and so we have presented sort of one option that does not change into the future.

If the Board is interested in revisiting that emphasis on management stability, and would be more interested in pursuing maybe something closer to what was done during the original rebuilding plan for striped bass, where that size limit or that slot moved to protect a strong year class. Now would be a good time for the Board to request us to look into that, and we could consider that going forward.

Those are the two specific aspects that we would like guidance on, and additionally for additional recreational options, if there is something specific the Board wants, make sure that we look at, now would be a great time for you to tell us. I would be happy to take any questions, and of course happy to take any guidance from the Board.

CHAIR WARE: I know those are some challenging questions, particularly in the absence of knowing what the assessment says. I also suspect there are some varying opinions around the table as to how to answer those. I think we're going to just open it up and see what Board member's thoughts are. I'm not planning to take any motions, and we'll see how the discussion goes. Robert Brown, did you have your hand up?

PROVIDE GUIDANCE TO THE TECHNICAL COMMITTEE FOR MANAGEMENT OPTIONS TO CONSIDER IF THE ASSESSMENT INDICATES REDUCTION IS NEEDED FOR REBUILDING

MR. ROBERET T. BROWN: Yes. The commercial industry heard talk about possibly another reduction if it was necessary. We just took a 7 percent reduction, and on top of that 7 percent reduction it wasn't given to us in time, and our quotas were already given to us in our tags for the year. Now we may possibly be facing as much as an extra 7 percent if we happen to go over that 7 percent.

I don't think it's justified at this time for the TC to even consider the commercial fishery a reduction of any kind at this time. The last reduction that the recreational had they took a slot limit. A slot limit doesn't work, because number one, it causes more dead discards, and it also, they really didn't take a cut. They can go out every day that the season is open and catch one fish per person per day, and that has to be addressed.

CHAIR WARE: Next I have Chris Batsavage.

MR. BATSAVAGE: I guess to be consistent with what I've said in the past, it's kind of hard to think about reductions in general. I'm more in favor of equal reductions for the commercial and recreational sectors, or at least close to equal, to account for potential recruitment. We know that the recreational catch is overall higher than the commercial, but that is with the percent of commercial recreational in a given area varies by state and by region. I think that's important, and also how we've done reductions for the commercial fishery in the past, it's a reduction in quota not in landings, so it's a little different than what we did while we were hoping to reduce harvest or catch for the recreational fishery. In terms of things to look at, yes, I mean I think harvest season closures is kind of one of the last remaining things we have available to us.

I think that should be explored, understanding that there still could be some catch and release fishing going on, which will result in mortality, but I think we've seen at least in North Carolina, we've seen when we've had closed seasons or closed days for the recreational fishery, that there is less overall effort during those times where that is the case. In the rest of the coast, I don't know.

Then I guess there is a consideration for the TC if there is like an X percent reduction needed. Instead of trying to hit that number on the mark exactly, we know there is a lot of inherent uncertainty in recruitment and things like that. If the TC would, if they think it's prudent to recommend aiming a little higher than that to ensure that we actually get the reduction we hope, because we are running out of time with 2029 rebuilding not too far away from now. If we continue to fall short, we may not get to where we need to be by the stock rebuilding schedule.

CHAIR WARE: Next we have Marty Gary.

MR. GARY: Question for Katie and a possible follow up or comment for her. Katie, could you characterize for us at the Board how the assessment model will be presented to us? I guess I'll put it in this this context. I'm getting personally a lot of questions about if and how the chasm of 6 weak year classes in Chesapeake Bay will be captured in this next upcoming assessment, or if it will be captured in the upcoming assessment.

If those year classes are projected into the model, how far out do you take it? I guess we have a sense that we know, as you just sort of said, we have several year classes, '11, '14, '15, '17, '18 that are probably lifting our biomass toward that target rebuild in 2029, but then we have this dearth of year classes, weak year classes coming in afterwards.

I guess really the question is, does the model, output you are going to present to us in October going to capture part of that, all of it? I guess if it isn't, I'm curious if we have options, the Board has options to ask the TC to see if we could capture some of that to better inform us.

DR. DREW: Sure, so we will have new information on recruitment. We will be able to include the 2022 indices for a 2023 terminal year. We start our model with Age 1, so we're sort of always a year behind on the recruitment. We will be able to use the 2023 value in the projections going forward. That period of weak recruitment will be encompassed, or it will be folded into the projections through, I think right now we are very focused on 2029 as the rebuilding year.

I think we will see that those strong year classes of 2015, 2018, 2014 and '17 to a lesser extent, are supporting that rebuilding, but they will be replaced by even weaker year classes. That will sort of show the trajectory that if those year classes were average, we would probably be rebuilding faster. But then when we get to 2029, that is when they are going to be starting to fully mature. The 2021-year class will be Age 9, 8 or 9 will be fully mature at that point in 2029, and what is coming behind them to continue to support that SSB is going to be those weaker year classes. I think we will be able to rebuild or we will be able to develop calculations to rebuild to 2029, and then a question of what happens after we rebuild is probably one that the Board should start thinking about. I think we are thinking of 2029 as sort of the end goal, and it's an important goal, it's mandated by the FMP.

But biologically what is going to happen after 2029 is there is not going to be a sudden miraculous, even if there were a sudden miraculous flip the switch and recruitment went back to the long-term average or the boom years. It is still going to take years for those strong year classes to propagate through the population.

What happens after rebuilding, after we get to that benchmark is definitely something the Board should maybe start thinking about. If the Board would like to start thinking about it during this assessment, we could extend our projection timeline a few years, so if we hit 2029, great. What's going to happen after that?

Are we going to be able to continue at that level or are we going to decline below the target again as the poor year classes come through and the stronger year classes die off? I think that is not clear, you know what that would look like from a fishing mortality or fishery perspective, but for sure, what we have sort of in the bank is not promising for being able to fish at the levels that we fished at during Amendment 6.

If the Board would like to task the TC with maybe looking out beyond the rebuilding horizon, we could, obviously recognizing that that gets more uncertain as you go forward. But if the Board would like to start thinking about that now, I think we could. If the Board would like to make that a bigger focus of the next benchmark assessment, which we will have to start working on, basically as soon as this assessment update is done, that could also be a directive from the Board.

CHAIR WARE: Follow up, Marty.

MR. GARY: Just very quickly. Thank you, Katie, that helped a lot. I don't know how the Board guidance would be, but I think my concern is in October the public sees that rising spawning stock biomass based on the way you characterized it, but doesn't see the longer-range picture.

I guess my personal feeling is that I know the confidence intervals start getting a little bit less favorable for penny and dam specifics, but I would like to see, I guess another couple of years built into those projections. I'm not sure how the other Board members feel, but I don't know if you need formal guidance on that in front of a motion or something. But I would like to see how other Board members feel about that as well.

CHAIR WARE: Next I have John Clark.

MR. CLARK: I agree with Chris and Marty about looking at all the recreational options. I would just like to add and disagree with Chris. I would like to see, in terms of the sector breakdown to do it proportionally also, to look at reduction where each sector would be taking a reduction based on the proportion of removals, they are responsible for in the stock. As long as we are looking at the rebuilding, I would also once again be curious as to just where the rebuilding would look if the target was closer to the threshold as the reference point. As I've stated before, I just think the target is extremely high, very difficult to reach, and I don't know if that's a possibility, but I know that based on the Amendment we're kind of stuck with these reference points. But I just think they are setting us up for continual crisis here.

DR. DREW: I think we can, obviously we're not changing reference points at this point, but when we do the projections, we always show the probability of being above the threshold, as well as the probability of being above the target. We can continue to show that as well. Then I think as for your proportional reduction question.

Just to be clear, I think it would be something along the lines of what we talked about during one of our last actions, where for example, if you need an 18 percent reduction that the commercial sector makes up 10 percent of the overall catch, the commercial sector would take a 1.8 percent reduction, and the rest of the reduction would come from the recreational. Okay.

CHAIR WARE: Next I have Jason McNamee.

DR. McNAMEE: Thanks, Katie for the presentation, and kind of seeding the thoughts there. I always appreciate that. I have a couple of things for you. Just a confirmation, maybe. I like the idea that you offered about trying to move that slot limit a little bit and seeing the effects. I don't know if there is some way to kind of optimize that kind of find a slot limit that optimizes reductions or rebuilding.

Maybe both of those could be looked at if they are not the same. It's something that we had talked about, you know when we developed a slot limit, this notion that slot limits perform best when they are dynamic, in particular when we're trying to protect very specific year classes. By its nature then you'll have to move to do that as the fish grow.

That was one idea. Another one, which I'm guessing might spark a little more conversation around the table, is investigating some split mode options. Peeling off the party and charter sector separately and dealing with them. I'm not saying not to have them take reductions as well, but to kind of treat them separately, so that whatever reductions would need to take place could be different than the overall recreational fishery. I was wondering, you guys have a lot to do and we just gave you a bunch more, but here is another.

I know it's an update and what I'm about to suggest can't be done for determining stock status and things like that. I recognize that. But I wonder if you could actually treat party/charter as a separate fleet in the model, because I think when we talk about these things we are sort of talking about the management aspect. But I don't think we've had a lot of information or any information on the effects to the population by doing this change. That could help that.

I'm fine if the answer is no, we don't have time to do that. But maybe that could be like a longer-term task as well, to kind of split out party and charter. I think the information should be there, right? We have information to inform selectivities and things like that, because most of the sampling information is from the party and charter sector anyways, and then MRIP has separate removals. I think it can be done, but maybe I'm wrong. But it's just a thought. Then one more to the discussion you just had a moment ago, I think it was with Marty. But longer term, so I'm not talking about now. But kind of future thinking, maybe during the benchmark process. I do think it makes a lot of sense to start looking at some sustainable management options under a low recruitment future.

I think we all kind of think of these things as all right, we've just got to get the population back, then we can get back to the good old days, and maybe the good old days are not going to be here maybe for a while, so it might be smart if our slot limits in the future here, do we need to get comfortable with them, and then what does that look like? Things like that. Yes, thanks, happy to take any feedback as well. But thanks for the time.

DR. DREW: I think in terms of the pulling the party/charter fleet out as a separate fleet within the model. We can't do that, well we could, but I think that would be such a significant change that it would warrant a benchmark. Right now, we do not have the sectors as specific fleets, we have a Bay fleet and an ocean fleet.

We would need to do basically a Bay charter and an ocean charter fleet. I think it would be a pretty significant change to model structure, as well as the data input that we could accomplish in an update. But we could look at the mode split option as one of the options that we do for if a reduction is needed, what would a different reg for the for-hire fleet look like.

DR. McNAMEE: Just a quick follow up, Madam Chair. Thank you for that, I appreciate the comment. It just sparked another thought. Thinking ahead to the benchmark, yes. A reconstruction of the fleet structure might make a lot of sense this go around, and particularly some of the discussions we have about the commercial sector.

Now I think the way the model works is the selectivity. It's because of the predominantly recreational fishery that it is mostly like a rod and reel type selectivity. But I think there is enough difference now, in particular with the slot limit that peeling out the commercial as a fleet as well, and doing like logistic selectivity or something like that maybe makes sense. I don't know that it will do anything, but just kind of future through idea.

CHAIR WARE: Justin Davis.

DR. JUSTIN DAVIS: If you'll allow me, I've got a question and then some follow up comments. The question is for Dr. Drew and it relates to the current slot limit. Will the current 28–31-inch slot limit in the ocean fishery be protective of the 2018-year class for like at least next year, probably, and then maybe even the year after, based on the size of the fish in that year class?

DR. DREW: We have some slides on this. This is basically the size distribution of the 2018-year class in 2025, 2026, and 2027 with the current slot limit on it now. Similar to this, this is basically just a length distribution, it's not about abundance, but it's about how that population is distributed over those length bins.

What you can see is that in 2025 it is basically moving into, like 2024 it's starting to move in there right now, 2025 it's going to basically be hitting the peak of them, and then slowly start moving out. This is kind of where if we were to adjust the slot limit in the hopes of taking a reduction, you know one option on the table would be to move that up for 2025. But obviously as you can see, as you move that up, they are just going to move into it. I don't know if we would want to move it down, but from like as you said, a biological reproductive standpoint.

But maybe the option is instead, have a higher limit that continues to move with them, as opposed to a single constant option. But basically, this is right now on the status quo regulations this is how that plus that 2018-year class will move through the slot for the next few years.

DR. DAVIS: Okay, thanks, that is helpful. Some general comments on the various questions that were posed bout what we should look at. The topic of how to allocate the reduction across sectors, I mean that has been a topic of debate in the last three management actions we've done, and there is no way we are going to any kind of agreement today around the table about that.

I don't think we should really have the debate today. I think the best thing to do would be for whatever options the TC develops for us to consider in October, that we kind of have two sets, one if the commercial sector takes no reduction and one if the commercial sector takes an equal percent reduction to the recreational sector, because that at least sort of puts guardrails on it.

Then we can potentially pick something in the middle. I think harvest closures are the obvious option here, and I remember in Amendment VII, I think it was, we kind of had a suite of harvest closure options that we ultimately voted to take out of the document. I think that is what we need to return to and look to as potential options to adopt in October.

I do remember that there was a lot of options in there, in terms of regional splits, and then also where to place those closures. I think there is a lot of potential variation in there. Then especially if you're going to develop two sets, one for no commercial reduction, one for equal percent commercial reduction. That seems like a lot of work.

I don't know, it might be possible between now and October to put that information back in front of the Board, even by e-mail, and try to gather some input on what sort of regional splits people would be willing to consider. I remember that was a really tricky issue with those closures, maybe that is possible.

No -targeting closures, from my standpoint I still feel like those are an option of last resort. I would not be comfortable with adopting any sort of coastwide no-targeting closure option in October by Board action, without going through our normal addendum process, particularly because we're not going to have the benefit of any public scoping or public survey on that question ahead of that action.

That is just where I am on the no-targeting closure issue. The last thing I'll say is I'm totally in agreement with the idea of extending out the stock assessment projection timelines, maybe to 2034, to better show that impact of that big gap in the stock that is coming with that recruitment failure.

DR. DREW: This is related to the point about the region to emphasize. Under our current Amendment 7, conservation equivalency is not allowed for these recreational options. What we pick in October is what everybody is, there are a few limited exceptions in the Delaware Bay and the Hudson River, and in Pennsylvania, for a very limited. But otherwise, what you pick for the Bay and what you pick for the ocean is what everybody is going to be stuck with for the future.

CHAIR WARE: Thanks, Katie. I have Doug Grout, then Nichola Meserve, Mike Luisi and then Emerson Hasbrouck, and then at the end of that list I think we're going to assess time and see where we're at. Next, I have Doug Grout.

MR. DOUGLAS E. GROUT: I would like to agree with Jason McNamee that to look at some kind of method of optimizing the slot limit, whether it's a 3- or 5-inch slot limit, how can we optimize the reduction we would get from a slot limit. I'm certainly in favor of all sectors taking some kind of a reduction, not necessarily equal, but some kind of a reduction, if we do have to take it.

The other concept I am going to throw out here, and I'm not sure how the Technical Committee could address this. There are many states that have five-wave fisheries, some even longer. There are other states, particularly the states of Maine and New Hampshire that have less than, about a two-wave fishery, essentially four months of fishing.

Taking reductions from a seasonal closure, if we're looking from seasonal closures, is a very difficult thing to get down to, depending on what kind of percentages we're going to have to get. To be honest with you, when you look at New Hampshire and Maine's fisheries, and how much they are contributing to the overall harvest, harvest and catch-and-release fishery, they are very, very small compared to a lot of the major producer states.

If there is some way that we can have some flexibility in seasonal closures when you have such a short season already, I would appreciate if the Board could take that or the Technical Committee could come up with something that would take that into consideration. Am I being clear about what I'm looking for here? Do you understand?

DR. DREW: I guess are you thinking of something along the lines of the regional approach that was proposed last time, where it' s like states in these regions will close during these specific weeks to actually, you know if you were closed during March that affects you not at all, versus you know when would you get the best reduction for an effective reduction according to the height of the fishery in different regions.

I think that is possible, that is we could tailor when and how long those reductions are in each region, in order to get sort of the effective reduction that we're looking for, or are you talking about different reductions in different states, based on the timing of your fisheries?

MR. GROUT: What you had come up with before, for the previous regional reductions. The only ones that looked reasonable to me were the Maine and New Hampshire one. But even within that, because again, we have such a short season that fish are actually available to us. That getting down to, you might have to take a week reduction some place, and that is really, excuse my language, kind of a crap shoot when you pick it. The other aspect I'm looking at is, can different regions that have lower contributions to the overall mortality rate have less seasonal reductions, proportional reductions that they would have to take. Those are my two concepts that I'm hoping might be able to get in there. But that might make things too complicated.

DR. DREW: I mean it would definitely be complicated, but I think there is a larger, it sounds like basically you are asking for your state to take a smaller reduction than other states, like in terms of, so it's a required reduction of 18 percent then you guys would ask to take a smaller reduction than that, because it would require closing your season too long if you were to achieve an 18 percent reduction.

That is more of, that is like now we're getting to state-by-state allocation. I think the TC could do it if you were interested in it, but I feel like we would need to see specifically have to look at that, and probably giving some guidance on what constitutes, how much less of a reduction do you get to take, versus other states?

CHAIR WARE: Next I have Nichola Meserve.

MS. MESERVE: The issue that Doug just brought up and the seasonality of our fisheries, makes me think about how the comment that Dr. Davis made about no-targeting closures being something that he wouldn't be comfortable doing without an addendum. I think I would put harvest closures in that as well.

It's just such a complex item that I struggle to see the Board being able to take an action without an addendum and public comment on that process. But I actually had a question about the projections for Dr. Drew. There is going to be an assumption made about the 2024 catch in those projections that will of course incorporate our management measures that were implemented this year in them.

I'm wondering what type of assumptions the TC will make about catch in future years out. We talked about how you have the five-years of poor recruitment are going to influence the abundance in the spawning stock in those projections. As numbers decline, what kind of assumptions will be made about recreational catch? Catch in total, but recreational catch in particular, we know it's not a one-to-one liner response of angler effort to abundance.

DR. DREW: Right, the 2024 will be using sort of our best prediction of what catch is going to be under the new regulations for 2024. We'll incorporate sort of the expected reductions on the actions taken into 2024. The Striped Bass Technical Committee also has a work group that is working on trying to do a better job of predicting total catch, total removals under different management scenarios, under different abundance scenarios into the future. Some things, like the recreational demand model that has been developed for some Mid-Atlantic species.

But more tailored to striped bass, probably not as fancy, because we're just starting working out on this. But something similar of trying to predict what catch will be taking in to account the actual abundance, and how that effects effort or availability, as well as different management approaches. We'll look at our suite of like constant catch on the task as well, but we'll also be trying to develop some better projections of what we think X could be, based on what we've seen in the past.

CHAIR WARE: Mike Luisi, you're next.

MR. LUISI: I want to thank you for allowing the Board the opportunity to provide input to this process to the TC. We're going to be sitting around this table in October, it will be in Annapolis. We'll be having this discussion again. As much as I appreciate all the thoughts and comments, I think it's clear to me, and these are complicated issues.

Earlier just this afternoon, an hour and a half ago, we kind of came to the conclusion that even something as simple as a survey requires a little extra thought and time to prepare in a way that is going to be meaningful. I think that, and I agree, and I had a running list in my head with all the people who have spoken about what I agree with them on, but I've lost that since it started, that was a while ago.

But I do agree with a lot of what has been said. I think the proportional reductions, whether they are recreational or commercial, I think is something to consider, to bring back into the fold. I like the idea that Jason brought up about the sectors, and possibly exploring some type of split mode options for moving into the future.

What I find to be challenging, and I'm sitting here thinking, okay over the last hour we've heard a number of really good ideas. But in reality, in October, if the Board decides to move forward with something, it's going to have to be pretty simple. Nothing that I've heard today is very simple. Even some of the things that I would assume to be simple, for those comments regarding seasonal closures that may be more challenging than what I have the background and knowledge to understand.

I don't want to go on and on about the decisions we have to make down the road. But I'm challenged right now in thinking about how we're going to take this discussion today, with all the other work that the Technical Committee and staff need to do, to prepare for the presentation of the assessment update, and then follow that up with management actions that I would assume would be expected to be taken in 2025. We're going to be facing some challenges.

To back up and to say that I think exploring the things that have been brought up today is a great idea. Again, I think it was good to ask the Board for that feedback. In reality though, I think what we are going to look at in October are going to have to be some pretty simple concepts, if we decide to take action without going through the normal addendum process, which we can do, based on our decisions earlier this year.

I just want to make sure that for the public's expectation on what we might be able to do. I think we're going to find some challenges in being able to do it all together. I think that is without the conservation equivalency dynamic that we've had in the past, I think there are going to be some challenges. But I'll look forward to seeing what the Technical Committee comes up with, and be ready to go in October.

CHAIR WARE: Emerson Hasbrouck, Steve Train, and then we are going to move on to our next agenda item. Emerson Hasbrouck.

MR. HASBROUCK: Thank you, Dr. Drew for your presentation. My thoughts on options in October. What my thoughts are on options that we're going to have to choose in October, including my thoughts on no-targeting, are going to be guided by what we just, an hour or two ago, tasked the TC with doing, you know with those four sensitivity-runs.

I'm anxious to see what the results of those four sensitivity runs are going to show, and that is going to help me decide how I would like to go forward in October. Also, I agree with John Clark that we need to take a look at proportional reductions. I agree with Jay Mac about split-mode options, and I agree with Marty Gary about long term projections.

You know our horizon should not be only 2029. We have to get a sense of what is going to happen after that. Then I have a process or procedural question. That is, can we both take action in October if it's warranted, take some action in October if it's warranted, as well as initiate another addendum at that time, for perhaps some options that are a little bit more complicated?

MS. FRANKE: Thanks, Emerson, yes. The Board can take action via Board action if the assessment shows the stock has a less than 50 percent probability of rebuilding, and of course the Board can always initiate an addendum.

CHAIR WARE: Steve Train and then David Borden has assured he is very quick.

MR. STEPHEN TRAIN: Thank you, Madam Chair, I'm good. Everything I wanted to say has been said.

CHAIR WARE: Thanks, Steve, David Borden.

MR. BORDEN: I'll be very brief. Emerson raised the issue of targeting and non-targeting, and so my question is, has the Enforcement Committee every reviewed the experience that some of the states have had with that, Maryland, and if not, is it possible to get the Enforcement Committee to review the experience that some states have had, and then provide us whatever guidance they could provide us. I think that would be useful in anticipation, if we're going to consider the concept.

MS. FRANKE: As part of the Board Work Group on release mortality, enforceability is something the work group is reaching out to the states with current closures, as well as NOAA Fisheries about, so that should be included in the Work Group Report.

CHAIR WARE: All right, that was a great discussion. I thank everyone for their participation. I agree with Mike Luisi, this is quite daunting, and a lot of this is going to depend on what we see in October. We will be prepared and take it as it comes. Our next agenda item is an update on the 2024 Winter Striped Bass Tagging Cruise. I believe Sig VanDrunen is going to provide us some update.

MS. FRANKE: Sig, if you're speaking, we can't hear you.

REVIEW AND POPULATE ADVISORY PANEL MEMBERSHIP

CHAIR WARE: While that gets flipped on, I'm actually going to go to Addendum Item Number 8, the Advisory Panel, Tina Burger. We'll do those and then we'll come back and see if Sig's audio is working.

MS. FRANKE: Yes, for the Advisory Panel nominations, there are two nominations, Tom Fote from New Jersey, a recreational angler from New Jersey, as well as Will Poston, recreational angler from the District of Colombia.

CHAIR WARE: Great, so Dennis Abbott, you're willing to make that motion. Can you read it into the record, please?

MR. DENNIS ABBOTT: **Move to approve Tom Fote representing New Jersey and Will Poston representing the District of Columbia to the Striped Bass Advisory Panel.**

CHAIR WARE: Great, so a motion by Dennis Abbott, I saw a second by Joe Cimino. Is there any opposition to this motion? Yes, you would like to speak to the motion, Dennis?

MR. ABBOTT: I recognize the familiar name at the top of the list. I'm sure that he will be able to add a lot to the Advisory Panel, and I'm sure they will enjoy his presence there.

CHAIR WARE: Thank you, Dennis. I'll try again**, is there any opposition to the motion? Seeing none; the motion is approved by consent**.

UPDATE ON 2024 WINTER STRIPED BASS TAGGING CRUISE

CHAIR WARE: All right, we're going to try Sig's audio again, and see if we are able to hear.

MS. SIGNE VANDRUNEN: Do we have anything?

MS. FRANKE: Yes.

MS. VANDRUNEN: Awesome. That was really weird. I didn't really do anything to fix it. Apparently, it just decided. Today I am going to talk about the Striped Bass Cooperative Winter Tagging Cruise. To get everyone on the same page, Maryland Fish and Wildlife Conservation Office, North Carolina DEQ and then Maryland DNR, coordinate and carry out the Atlantic Striped Bass Cooperative Tagging Program, which targets the offshore winter migratory stock.

These surveys began as trawl surveys from 1985 to 2010, and switched to a hook and line survey in 2011. This year in 2024, I acted as the U.S. Fish and Wildlife Coordinator for the survey, but our coordinator position will switch over to our new database coordinator and biologist Victoria Lecce for 2025 on. This is the 13th consecutive year of offshore hook and line striped bass tagging collections. Captain Ryan and the Midnight Sun crew, fishery staff and volunteer anglers carried out a total of 12 surveys from January 15 to February 6.

Trips launched from Virginia Beach on January 15, 16 and 22. The team departed Virginia Beach and fished up the coast as they traveled to Ocean City, where staff fished from January 24, 26 and 27. Then the Midnight Sun would make its return to Virginia Beach to target rockfish on January 31 and then February 1st, 2nd, 4th, 8th and 9th.

Poor weather conditions prevailed throughout our season, and it delayed the initial start date set for January 1, and reduced consistent public reports of migrating fish. Some public reports we received on striped bass came from New Jersey, and mostly the Chesapeake Bay. On January 24, our team collected 39 fish and tagged 38 of the 39, while fishing offshore of Ocean City, and all remaining trips did not yield fish. Since 2011, the ASMFC has caught 8,601 fish and has tagged 8,439 of these fish over the course of 136 survey trips. This slide shows the movement of tagging trips, beginning in '85 with our trawl surveys, and going on to the hook and line surveys. Unfortunately, they do not have the year displayed, but I just want to draw attention to this northern movement of our surveys to find fish. This tagging program is the only program that targets and tags the overwintering offshore migratory stock of striped bass, excluding the crew of the Midnight Sun, but including our data collection and fishing to win team about 75 anglers signed up for fishing slots over the course of the season.

Not all of our anglers were able to attend fishing trips, due to weather cancellations and other factors. The total cost incurred by our Fish and Wildlife Service for this year's tagging survey was $3,916.00. This total included boat trips, boat fuel, travel for employees, coordinator salary, Fish and Wildlife Services gas, and then supplies.

The 35K of NOAA provided ACFCMA funds, covered the cost of the hook and line survey. However, this left Fish and Wildlife Service to cover all the other costs incurred by the MDFWCO related to the management of the coastwide striped bass, horseshoe crab, and sturgeon tagging databases.

The cost to run those programs is around $36,000.00 in supplies posted, et cetera, but does not cover any of the staff salaries. I just have one more slide next that shows a breakdown of the hook and line survey sites versus the trawl sites. With that we can start discussion.

CHAIR WARE: Thank you very much, Sig. Marty Gary had actually requested this be put on the agenda, so Marty, I'll go to you if you want to make any comments. But the funding for this has always been year to year, so I think we wanted to flag this for the Board, just so folks are aware of the data that is being collected. Marty, do you want to comment?

MR. GARY: Thanks, Madam Chair, and I think everyone around the table knows I've been a pretty strong advocate for the continuity of the survey. I'll ask the obligatory question, Katie, because I know I've asked you before. Could you characterize the value of this now, it's pushing toward a 40-year dataset for us. Thank you, and I might have one follow up.

DR. DREW: This information is not currently used directly in the assessment. I think it is our goal for the next benchmark assessment to be able to use these tagging data from this program and from the state tagging program, more directly into a more spatially structured model, or potentially incorporate it.

We do the estimates of total mortality during the benchmark process from these surveys, and so I think we haven't fully recognized the potential benefits of this information, and we've been held back by our modeling framework. But we continue to develop that, and hopefully we will be able to more fully utilize and leverage these data in the assessment going forward.

I think it's not fully clear yet from our analyses, you know what is the value of the winter tagging cruise on the offshore mixed populations versus the state-specific tagging programs that also continue. But it is as Sig pointed out, kind of a unique dataset, or a unique timing of when those fish are tagged and what we are able to get from that going forward. I hope that is helpful.

MR. GARY: Thanks, Katie, and I'll just simply say, you know we have this discussion every year, usually it's in October, as we approach the deadline to determine whether or not we have the funding to go forward. Again, it's a dataset that is pushing toward 40 years, only data we collect on the wintering grounds, which as we saw in Sig's presentation is dramatically changed. Not only are the fish further north, but they are further offshore.

I just put it out there, I'm hoping instead of having the conversation every year and pleading to see if we can somehow come up with the money, we as a Board somehow with all of our collective partnership, we could figure out a way to fund this. I guess my next step if we don't get that is I'll start a Go Fund Me campaign and everybody can contribute. I'll turn it back to you, Madam Chair.

CHAIR WARE: I would encourage folks to discuss this between now and October. If folks want a call let me know, I'm happy to set one up if that would be helpful. Any other burning questions or comments? Okay, I did say I would provide Captain Newberry an opportunity for a quick public comment at the end of our meeting today. Captain Newberry, if you are on, I will need two minutes for your comment.

MS. TONI KEARNS: Captain Newberry, if you are on, can you please raise your hand.

ADJOURNMENT

CHAIR WARE: Okay, with that I think we are at Other Business. Is there any other business before this Board? Otherwise, I look for a motion to adjourn. So moved by Ray Kane, second by, I think Steve Train raised his hand. Thank you.

(Whereupon the meeting adjourned at 2:30 p.m. on Tuesday, August 6, 2024)

Atlantic States Marine Fisheries Commission

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Striped Bass Board Work Group on Recreational Release Mortality
Report to Striped Bass Management Board

Work Group Members: Chris Batsavage (NC, WG Chair), Nichola Meserve (MA), Marty Gary (NY), Adam Nowalsky (NJ), Mike Luisi (MD), David Sikorski (MD), Max Appelman (NOAA)

October 2024

In May 2024, the Atlantic Striped Bass Management Board established a Board Work Group (WG) to discuss recreational release mortality (RRM) and address four specific tasks . The WG met via webinar six times from June through September 2024 to discuss these tasks. An interim report was provided to the Management Board in August 2024. This report summarizes the WG's conclusions and recommendations for each task, and the enclosed meeting summaries provide more detail on the information reviewed by the WG and the WG discussions.

Task 1: No-Targeting Closures
Review existing no-targeting closures in state and federal waters, including any information on impacts to striped bass catch and effort as well as their enforceability. Identify potential angler responses/behavior change to those closures.

The WG reviewed information on existing no-targeting closures for striped bass and freshwater species in several jurisdictions (see Table 1), including general insight on compliance, enforcement, and how anglers may have responded to the closures. The WG also reviewed information previously provided by the Law Enforcement Committee (LEC) regarding enforceability of no-targeting closures.

Based on the information reviewed and subsequent discussions, the WG developed the following conclusions:

1) **It is difficult to isolate the effects of no-targeting closures on catch and effort alone.** For example, while Marine Recreational Information Program (MRIP) data suggest that catch (harvest and live releases) and effort declined in the Maryland portion of the Chesapeake Bay after a no-targeting closure was implemented in 2020, other factors like fish size, year-class strength, and other coinciding management changes (e.g., private angler trip limit reduction from 2 fish to 1 fish) are likely contributing to the decline. Additionally, it is difficult to isolate the effect on catch and effort from the no-catch-and-release part of the closure versus the no-harvest part; i.e., no-harvest closures are likely to dissuade some level of effort (although unlikely enough to offset the increase in releases from a no-harvest closure).

2) **The effect of no-targeting closures on catch and effort will vary based on angler responses to the new measures**. The WG noted that Maryland anglers appeared to target other species more heavily during the striped bass no-targeting closure, and to target striped bass more heavily in the weeks before and after the no-targeting closure. A shift in targeting to other species during a closure may diminish the expected reduction in striped bass releases if the fishing methods are similar. Shifting the timing of effort rather than reducing it would similarly affect the expected reduction in striped bass releases but could still meet a management objective to shift releases to a time period where environmental conditions are more favorable for survival post-release. Overall, because there is limited information on how anglers respond to no-targeting closures, the added savings (in terms of releases) from prohibiting targeting are difficult to calculate and predict.

3) **Compliance with no-targeting closures seems to be best achieved through early and frequent communication, where strong stakeholder support exists, and as the closure continues into the future (i.e., remains in effect year after year).** In every example, effective communication with stakeholders to garner buy-in and support for the no-targeting closure, including the perceived problem/rationale and management objectives, were key to success. The WG discussed that stakeholder buy-in may vary by state, constituent group, and closure objective/rationale. There are potentially higher initial costs in the first years of implementation to ensure communication materials are reaching angling communities, however, compliance tends to improve as awareness and general acceptance increases over time, and thus decreasing costs.

4) **Although compliance appears to be good in all examples, no-targeting closures are widely considered difficult and resource intensive to enforce; they are generally viewed as more enforceable when implemented in discrete times and areas, and where there are few other species to target or the closure is for fishing in general.** This was evident in the Kennebec River and Hudson River examples where the extent and timing of the striped bass no-targeting closures coincides with generally low effort and/or few other species for anglers to target. In most other cases, targeting violations are issued largely in conjunction with retention violations, demonstrating the challenge with proving angler intent to target without possession or verbal admission. The enforcement of no-targeting closures that overlap with other fisheries may be aided by concurrent gear restrictions where feasible (e.g., prohibiting the possession of certain terminal tackle that demonstrates an intent to fish for striped bass). Although it is difficult to successfully adjudicate no-targeting violations in many situations (due to the need to demonstrate angler intent), the WG discussed that repeated verbal warnings alone can achieve desirable enforcement outcomes.

5) **Although no-targeting closures may be difficult to enforce, they are not without merit and should not be rejected as an effective tool to reduce release mortality (or total fishing mortality) solely due to enforcement concerns**. There is certainly a tradeoff between conservation gains and enforceability, which is ultimately a policy decision. Regardless of how enforceable a management measure might be, the WG supports exploring "every tool

in the toolbox," especially considering the limited tools available to further reduce striped bass fishing mortality, if necessary.

6) **No-targeting closures may not be a "one size fits all" approach.** The Atlantic coast states vary widely in the seasonality of their striped bass fisheries, spatial area, degree to which multiple recreational fisheries overlap, environmental conditions affecting release mortality rate, enforcement resources, and stakeholder interests, among other factors. This inherent variability between striped bass fisheries across the coast presents certain inequities (real or perceived) and feasibility concerns with mandatory no-targeting closures -- whether at the coastwide, regional, or state-level. There have also been concerns about the inequity of implementing only no-harvest closures (i.e., allowing catch-and-release fishing) since a no-harvest closure would likely only impact removals from fishing trips from anglers who intend to harvest striped bass. No-targeting closures would likely reduce removals from catch-and-release trips as well as harvest trips. This range of stakeholder values is another aspect for the Board to consider.

Recommendation: **Overall, the WG finds that no-targeting closures have been successfully applied in some circumstances to achieve fishery management objectives, including reducing recreational releases. However, the mandatory implementation of no-targeting closures would have varying degrees of effectiveness, enforceability, and compliance across states. If further reductions in fishing mortality are needed, the WG supports the consideration of seasonal closures to reduce recreational effort and catch, but recommends that no-targeting closures only be pursued in a flexible manner**.

One such approach could provide a state/region the option to select between implementing a seasonal closure as either no-harvest or no-targeting to meet a certain required reduction according to standardized methods, whereby a no-targeting closure can be shorter in duration due to the additional conservation benefit of prohibiting catch-and-release fishing. Importantly, this approach would rely on the use of standardized methods to estimate the reduction from both types of closures. As of October 2024, after reviewing the outcomes of Maryland DNR's no-targeting closures implemented in 2020, the Technical Committee agreed that the method used by Maryland during the Addendum VI process to estimate the reduction from no-targeting closures is a reasonable method to apply more broadly if the Board were to consider that type of management option. Further, some WG members would support adding an uncertainty buffer to any proposed no-targeting closure options to address uncertainty around angler response to closures (i.e., noncompliance and effort shifts). Alternatively, the Board could adopt no-harvest closures but encourage states to implement them as no-targeting closures where fishery conditions are favorable or environmental conditions warrant it. However, unless there is some additional incentive to states, this option may not advance no-targeting as a means of reducing recreational releases in striped bass fisheries.

See enclosed WG meeting summary from September 3 for more detail.

Table 1. Summary Information on Compliance and Enforcement of No Targeting Closures Reviewed by Workgroup

Spp.	Area	Closure Dates	Years	Impetus	Perception of Compliance	Perception of Enforceability
Striped bass	Maine Kennebec watershed	Dec 1 – Apr 30	1990+	Spawning protection	High b/c strong stakeholder buy-in, long-term rule, and low seasonal fishing effort in general.	Enforceable b/c small spatial area, limited species availability. Labor intensive to detect, but summonses have been successfully adjudicated.
	New York Hudson River (above Cuomo Bridge)	Dec 1 – Mar 31	1983+	Unknown	Generally good b/c long-term rule/good awareness; note lag in compliance when closure dates changed.	Enforcement benefits from few other species available to target in the area at time of closure.
	New Jersey all non-ocean waters	Jan 1 – Feb 28	1991+	Protection of overwintering fish	Difficult to determine b/c mixed fishery area.	Very difficult. Largely enforced in conjunction with no-harvest violation.
	New Jersey Delaware River and tributaries	Apr 1 – May 31	1991+	Spawning protection		
	Maryland Chesapeake Bay	Apr 1 – Apr 30 Jul 16 – Jul 31	2020+	Reduction in removals (through CE)	Generally good. Supported by data suggesting reduction in fishing effort, directed trips, harvest, and releases (note likely influence of other variables e.g., year-class strength, bag limit reduction).	Challenging. Largely enforced in conjunction with no-harvest violation.
	Potomac River	Jul 7 – Aug 20	2020+	Reduction in removals (through CE)	Difficult to determine b/c mixed fishery area; possible decrease in vessel activity.	Very difficult. Largely enforced in conjunction with no-harvest violation.
	Exclusive Economic Zone (EEZ)	All Year	1990+	Rebuilding measure/ precautionary management	Generally good, aside from bad actors and hot spots, b/c long-term rule. WG note worse when large aggregations of fish in EEZ near the 3-mile line.	Largely enforced in conjunction with no-harvest violation.
Small/large-mouth bass	Pennsylvania Susquehanna and Juniata Rivers	May 1 – mid-June	2012-2017	Spawning protection (not intended to be permanent)	Complaints of violations and unenforceability (in addition to stock status improvement) led to repeal of closure.	
All species	North Carolina multiple discrete freshwater times/areas of concern for a particular freshwater species		various	various	Due to overlapping species/fishing techniques and inability to enforce a species-specific no targeting closure, complete fishing closures were implemented in discrete times/areas although concern was for a particular freshwater species.	

Note: Maryland also has spring no-targeting closures on spawning grounds that have been in place since the late 1980s. The WG did not discuss these closures.

Task #2: Gear Modifications

Review the MA DMF discard mortality study and other relevant reports to evaluate the efficacy of potential gear modifications.

The WG reviewed information on studies from the Massachusetts Division of Marine Fisheries (MA DMF) and the University of Massachusetts-Amherst (UMASS-Amherst) on evaluating post-release mortality of striped bass in the recreational fishery and received an overview of key findings regarding gear type (other than circle hooks) and release mortality for past studies on striped bass and other species. The WG also received input from the ASMFC's Law Enforcement Committee (LEC) on the enforceability of recreational gear regulations and method of take.

Overall, the WG finds that the type of gear used to catch striped bass can impact post-release mortality, gear modifications have the potential to reduce post-release mortality of striped bass, and regulations on recreational gear types and methods of take are moderately enforceable.

Specific WG conclusions include:

1) **Recent studies by MA DMF and UMASS-Amherst suggest lure-hook and bait-hook configurations impact post-release mortality and could be an area for education and/or regulation.** The results from the MA DMF study suggest that post-release mortality was highest using baited circle hooks followed by lures, while flies had the lowest post-release mortality rate. Among lures, those with a single hook had the lowest mortality rate and those with double treble hooks had the highest mortality rate. The UMASS-Amherst study had similar results with some differences possibly attributed to sample sizes and the different survey design than the MA DMF study.

2) **There are many variables to consider regarding gear modifications to reduce post-release mortality, and it is hard to isolate one particular gear to get the most impact (e.g., how often is a gear configuration used by anglers?).** Fight time, handling time, water and air temperatures, angler experience, and fish size also impact the post-release mortality rate and some of these variables are correlated to each other. Further analysis is needed to better understand these interrelated variables. The relative use of different gear configurations in the striped bass fishery is currently unknown, so the impact of particular gear modifications on overall post-release mortality is also unknown. However, MA DMF is conducting a tackle configuration survey in 2025 to understand how often different gear configurations are used by striped bass anglers, which should inform the impact gear modifications can have on post-release mortality.

3) **The recent study by UMASS-Amherst suggests that striped bass anglers largely support adopting science-based catch and release best practices, and adequate enforcement of the regulations.** The study also found that striped bass anglers often employ best angling practices such as proper and limited handling of fish, minimizing the fight time and using circle hooks and barbless hooks. Although it is uncertain if these results apply to the entire

striped bass recreational fishery, the study revealed fishing practices and attitudes that currently exist among at least a portion of the recreational fishery. Strong stakeholder buy-in facilitates acceptance of best management practices and compliance with regulations if gear modification regulations are considered.

4) **The Board should consider the impacts to the industry of any potential gear modification from the perspective of manufacturer, retailer, tackle store, etc.** Gear modification regulations would impact the sale of gear types that are no longer allowed for striped bass fishing and would also impact anglers and for-hire captains who possess gear types that can no longer be used for striped bass fishing. In addition, some fishing tackle manufacturers are already modifying fishing lures for striped bass that support survival of released fish.

5) **The Board should consider enforceability and how these types of gear restrictions would interact with management of other species but should not rule out gear restrictions based on enforceability alone.** The LEC's Guidelines for Resource Managers on the Enforceability of Fishery Management Measures rates gear regulations and method of take as moderately enforceable. To facilitate enforcement, the regulations must be clearly written, relatively easy for anglers to adopt (align well with fishing practices), should be in place for a long time period, and should include concerted outreach and education efforts. The regulations need to standardize gear requirements, measurement procedures, equipment, and techniques across all appropriate jurisdictions and time periods. Prohibiting the possession of gear types where feasible would also facilitate enforcement. In some cases, enforcement can consider other gear and fishing techniques to determine whether an angler is targeting a species that requires a certain gear. However, this is challenging if anglers target a variety of species in an area as opposed to anglers targeting only a few species. Although there may not be many citations written for all gear restrictions, enforcement also provides compliance assistance to help anglers understand the regulations and learn how to come into compliance instead of issuing a citation.

6) **Regardless of whether the Board chooses gear modifications as a management measure, education and outreach efforts should continue to ensure that anglers use best management practices for striped bass fishing.** Amendment 7 to the Striped Bass FMP recommends states continue to promote best striped bass handling and release practices by developing public education and outreach campaigns. Results from the MA DMF post-release mortality studies should be incorporated into best management practices states and jurisdictions communicate to their anglers.

7) **States can implement gear restrictions as they see fit (e.g., statewide, area/time-specific) without Board action.** Some states already do this for striped bass and other species. This allows for specificity for gear restrictions in a state or jurisdiction that addresses concerns about enforcement and any interactions with other recreational fisheries. However, this could also result in gear restriction regulations that are not consistent along the coast, which could minimize the impact of reducing post-release mortality of striped bass coastwide, complicate enforcement, and create regulations that are confusing to anglers. If

states choose to implement gear restrictions for their recreational striped bass fishery, then the WG recommends that they communicate with ASMFC and neighboring states and jurisdictions to minimize the inconsistency in gear restrictions in areas fished by anglers from multiple states.

If the Board considers additional recreational gear modifications as management measures, then **the WG recommends they consider modifications that support the survival of released striped bass based on release mortality study results, are easy for anglers to adopt, are consistent among states and regions, and understand that any reduction in post-release mortality is currently unquantifiable. The WG also recommends that the Board should consider impacts to the recreational anglers and fishing tackle industry, current efforts by the fishing tackle industry to produce/promote gear that supports post-release survival, potential enforcement challenges, and the uncertainty in the results from post-release mortality studies.**

See enclosed WG meeting summaries from September 12 and September 24 for more detail.

Task #3: Stock Assessment Work to Inform RRM Discussions
Identify assessment sensitivity runs which may inform Board discussion around release mortality (e.g., how low would you have to reduce the release mortality rate in order to see a viable reduction in removals with the same level of effort?). Consider the tradeoff of reducing the release mortality rate vs. reducing the number of releases overall.

The WG reviewed past work by the Technical Committee (TC) in late 2020 to explore the sensitivity of the stock assessment model to different recreational release mortality rates (TC Memo M21-04). The WG noted this past TC work was valuable to understand how different constant RRM rates impact the historical time series. Notably though, none of the scenarios simulated a midstream shift in the RRM during the historical time series, such as might result from hypothetical management changes. **Given the Board's current interest in understanding how actions to reduce RRM would impact the stock moving forward, the WG recommended tasking the TC as follows. The Board approved this tasking in August 2024.**

These tasks are intended to help the Board understand the tradeoff between reducing the release mortality rate vs. reducing the number of releases overall. The WG recommends the TC address these tasks as part of the ongoing 2024 Stock Assessment.

1) If a reduction is needed to achieve rebuilding, determine how low the release mortality rate would need to be to achieve that entire reduction through the release mortality rate alone. In other words, if the number of live releases is constant, what would the release mortality rate need to be to achieve the reduction?

2) If a reduction is needed to achieve rebuilding, determine the percent reduction in number of live releases needed to achieve the entire reduction through live releases alone. In other words, using the current 9% release mortality rate, how many fewer live releases would there need to be to achieve the reduction?

   TC Tasks 1 and 2 represent the two extremes of reducing RRM. Task 1 focuses entirely on reducing the RRM rate to achieve a reduction (i.e., decreasing mortality from the fishing interaction), while Task 2 focuses entirely on reducing the number of live releases (i.e., controlling effort). These are hypothetical scenarios, which are not necessarily realistic for management implementation but would help characterize the tradeoff between the two management approaches to reduce RRM. Recreational harvest would be assumed constant for these scenarios in order to isolate the reduction to RRM. Considering commercial harvest in the overall calculation for the reduction, the WG recommends two iterations for each scenario: one with constant commercial harvest and one with an equal reduction for commercial harvest.

3) If a reduction is needed to achieve rebuilding, determine the percent reduction in number of live releases needed under the current 9% mortality rate, assuming there is an associated reduction in recreational harvest due to no-targeting closures.

   TC Task 3 assumes the implementation of no-targeting closures would result in a reduction in both harvest and live releases. The TC would need to determine how to best quantify the reduction in live releases from no-targeting closures, which depends on several assumptions including how many striped bass are still caught and released as incidental catch when targeting other species. The WG again recommends two iterations for each scenario to account for commercial harvest in the calculations: one with constant commercial harvest and one with an equal reduction for commercial harvest. The WG recommends the TC also comment on how potential reductions from no-targeting closures could vary depending on season, as catch varies throughout the year and by region.

4) Identify the tradeoffs of implementing no-targeting closures at different times of the year with different assumed release mortality rates to help inform when and where implementing no-targeting closures would result in the highest reduction. Factors could include water temperature and salinity, with the assumption that the release mortality rate is higher when the water temperature is high and the salinity is low.

   TC The WG acknowledges that a reduction associated with specific no-targeting closures depends on several factors including assumed release mortality rate, length of closure, current level of harvest and releases, angler behavior, etc. Any guidance from the TC on the best use of no-targeting closures to achieve reductions would be helpful.

See enclosed WG meeting summary from July 17 for more detail.

Task 4: Public Scoping

Consider public scoping on measures to address release mortality (e.g., online public survey ahead of the October Board meeting).

The WG discussed the scope of a potential survey of stakeholders on measures to reduce recreational release mortality. After the Board's August 2024 decision to delay survey development in order to get input from survey experts (as recommended in the WG's interim report to the Board), members from the Committee on Economics and Social Sciences (CESS) provided guidance to the WG on general survey approaches to consider (open survey, randomized survey, focus groups), as well as high-level comments on the WG's first-draft survey questions. The WG considered what type of information different survey approaches would provide, and the benefits, challenges, and resources required for each. The WG agreed to the following conclusions:

1) A survey does not seem feasible to adequately gather all the complex information on stakeholder responses to management measures, nor will a survey meet the original timeline at this point of gathering public input ahead of potential Board action in late 2024 in response to the stock assessment update. The absence of a survey or other ASMFC-led public scoping does not prevent states and/or Board members from gathering stakeholder input to understand their perspectives through state processes or other channels in advance of a potential Board action. Additionally, public comment opportunities are expected at any Board meeting when Board action is being considered.

2) If the Board is interested in public input beyond this next management action, focus groups of stakeholders representative of the recreational striped bass fishery could be a useful approach to 1) paint the landscape of potential stakeholder responses to measures being considered to address release mortality (e.g., no targeting closures, gear modifications) and 2) discuss outreach on best fishing and handling practices for striped bass.

3) Conducting an open survey could also be considered, but the inherent biases would need to be acknowledged. Survey fatigue should also be considered. For example, there is currently an open survey of striped bass stakeholders being conducted by Virginia Tech on stock structure and migration patterns, and MADMF is planning to conduct a survey on terminal tackle use in 2025.

Ultimately, if the Board wants to gather public input on stakeholder buy-in and potential responses to management measures to address release morality outside of the public comment processes associated with an addendum or amendment, the WG recommends focus groups as the best approach to collect that information.

If the Board were to proceed with focus groups in the future, the Board would need to address logistics, including who would be leading the focus groups and identifying stakeholders to participate. A focus group approach would likely require significant State staff time on these logistics and planning. CESS members noted they could advise the process, and the Board could consider the benefits of leveraging a graduate student(s) in the process. Additionally, depending on the timing of focus groups, the Board could consider adding other topics for stakeholder input (e.g., assessment-related topics ahead of the next benchmark stock assessment).

See enclosed WG meeting summary from September 20 for more detail.

Striped Bass Board Work Group on Recreational Release Mortality Meeting Summary

Webinar
June 24, 2024

Work Group Members: Chris Batsavage (NC, WG Chair), Nichola Meserve (MA), Marty Gary (NY), Adam Nowalsky (NJ), Mike Luisi (MD), David Sikorski (MD), Max Appelman (NOAA)

ASMFC Staff: Emilie Franke, Kurt Blanchard

Public: Allison Colden, Andy Danylchuk, Armando Guerrero, Caitlin Craig, Chris Scott, Corrin Flora, Jeff Mercer, Jessica Best, Justin Pellegrino, Lucas Griffin, Olivia Dinkelacker, Sascha Clark Danylchuk, Will Poston

The Striped Bass Board Work Group (WG) on recreational release mortality (RRM) met for the first time on June 24 via webinar. The WG Chair reviewed the four WG tasks approved by the Board and reviewed the WG timeline. The WG has two meetings scheduled for the summer and will provide a progress update and initial recommendations to the Board at the 2024 Summer Meeting in August. The WG will meet a few more times in August and September to continue working on the WG tasks and develop final WG recommendations. The WG will provide a report to the Board at the 2024 Annual Meeting in October with a summary of all tasks and any recommendations on how the Board should address recreational release mortality based on the findings of those tasks.

WG Tasks Approved by the Board

1. Review existing no-targeting closures in state and federal waters, including any information on impacts to striped bass catch and effort as well as their enforceability. Identify potential angler responses/behavior change to those closures.
2. Review the MA DMF discard mortality study and other relevant reports to evaluate the efficacy of potential gear modifications.
3. Identify assessment sensitivity runs which may inform Board discussion around release mortality (e.g., how low would you have to reduce the release mortality rate in order to see a viable reduction in removals with the same level of effort?). Consider the tradeoff of reducing the release mortality rate vs. reducing the number of releases overall.
4. Consider public scoping on measures to address release mortality (e.g., online public survey ahead of the October Board meeting).

Tasks #3 on the stock assessment and task #4 on public scoping are time-sensitive and require Board input at the 2024 Summer Meeting, so the WG's progress report at the Summer Meeting will cover those two tasks.

Task #4: Public Survey

The WG first discussed Task #4 on public scoping, which emerged from the possible scenario of the Board considering management action via Board vote (i.e., no addendum process) in October 2024, or shortly after, if the 2024 Stock Assessment Update indicated a reduction to achieve rebuilding was necessary. If that were to occur, public scoping completed prior to October could provide the Board with public input on measures to address RRM as the Board considered that action. A survey would need to be conducted from about mid-August to mid-September in order to gather and process the information prior to the October Board meeting.

ASMFC staff provided a summary of previous public comments gathered through the Amendment 7 process in 2022 on measures to address recreational release mortality. Draft Amendment 7 included options for gear restrictions and options for no-targeting closures for which the public provided comments. Ultimately, the Board implemented some gear restrictions in Amendment 7 but did not implement any no-targeting closures.

The WG noted support for conducting a survey to gather input on release mortality measures and that it would be informative to the Board. The WG discussed what topics potential survey questions could cover and discussed how the survey could be conducted. The WG suggested numerous topics for potential inclusion in a survey, which are listed below. ASMFC staff categorized all the WG suggestions following the call.

<u>Suggested Survey Topics and WG Rationale</u>

Current Measures/Socioeconomic

- What have the impacts been with the narrow slot limit? How has this slot limit affected trips? What are anglers/captains seeing on the water as far as how release rates are going up?
  - Gather socioeconomic data on impacts on the effect of the narrow slot limit on trips. This is new ground for the Board and is the Commission's role to dig into this.
  - The greatest interest about narrow slot is getting information from people and hearing the potential change of perspective. Before the recent narrow slow limit, there were public comments opposing no-targeting closures. Now with the narrow slot, there could be a potential change of perspective about measures to address release mortality.
  - Management measures (i.e., narrow slot) have changed in the past couple of years, and therefore angler perspective may have also changed. Do we want to be more specific about no-targeting closures? Changing perception among anglers?

  - Some WG members were unsure about addressing the current slot limit in the survey, and noted the focus should be on the future rather than asking about the current measures.
  - Wave-specific data was used for Maryland closures, and it is important to look at the effects across time of year. For example, during the no target closure a tackle shop lost significant business. Need to look at what fish we are saving vs. the impacts on communities.

- What is causing people's catch and release (preference versus regulations)? This could help inform socioeconomic considerations.

Big-Picture

- When we talk about doing things that are more difficult to enforce or quantify, there seems to be a reaction from the Board with some hesitancy to implement unquantifiable measures. Does the public need us to quantify the result and are we accountable as a Board? For release mortality measures, is it as important to meet a percent reduction or just to reduce overall effort? Is the public comfortable reducing effort without being able to pinpoint reduction?
  - We are at a point in management where we need to stretch to see a reaction from the stock. How willing would the public be with going forward to reduce effort without an estimated reduction in removals?

- From a policy perspective, what level of release mortality is too much for this fishery? Release mortality has been high for decades and is only recently getting a lot of attention. Is the high attention due to poor stock status? How much is too much? Is stock status connected to the perception that release mortality is too high?

- Question to catch-and-release fishery participants: how can you be part of the solution? How can this segment of the fishery participate in reducing release mortality?

Seasonal Closures

- How would the public respond to a no-targeting closure; 1-week, 2-week, 3-week, etc.? Not go fishing, target other species, go to another state?
  - This information would be very informative to no-targeting closures
  - Data is missing on how anglers would respond to seasonal closures; great first step; not sure how the Striped Bass Technical Committee (TC) would analyze seasonal closures. TC could weigh in on how to collect this data to fold into those calculations.

- Do we want more feedback on focused no-targeting closures? Closures when water/air temperatures are warm? Certain months and location? Certain parts of a waterbody, e.g. estuaries instead of ocean?
  - Easier to implement and enforce closures in a specific area/time of year. Anglers still have the opportunity to fish elsewhere.

- Have opinions on seasonal closures changed since Amendment 7? What is the goal of the closures that people would support? What times of year would reduce effort the most? Or are closures based on environmental conditions? Should we be balancing this? If people support temperature-based closure, how do you balance that up north in areas like New England where the temperatures are not as high?
    - No-targeting closures were implemented in Maryland and the Potomac River Fisheries Commission (PRFC) to both meet the reduction and due to environmental conditions. Recreational management and environmental conditions continue to change and we need to understand behavior along the coast.

- If we consider no-targeting closures, there has to be information gathered about the impacts on different sectors. There is one group of the fishery that won't be impacted by a no-harvest closure, while everyone would share the burden with a no-targeting closure. Have to discuss fairness issues.

- Between ME and NC there are major differences in fishing practices. If environmental conditions are such that it makes sense to reduce targeting during time periods when fishing mortality can be extreme (i.e., actions in the Chesapeake Bay to expand no-targeting closures), in order to be fair/equitable, what in addition to action in the Bay could happen on the coast in areas when the environmental conditions aren't as poor? How can we balance the recreational impact by not focusing on one particular area? If environmental conditions aren't a concern of New England fishermen, what would the stakeholders be willing to do to reduce mortality while other states have no-targeting?
    - Not sure we can apply a broad brush. Trying to think outside of conventional approaches.

Gear Restrictions

- Could be open-ended question to collect input on what individuals do or see on the water to reduce release mortality.
    - There are a lot of different ideas, views, and perspectives about tackle. Close to receiving information from Massachusetts Division of Marine Fisheries (MADMF) (e.g. two treble hooks are the worst). First DMF report may be available later in 2024. MADMF study doesn't look at everything (e.g., doesn't look at barbless hooks).

- How comfortable is the public going to be with measures that we don't have data for, but it is perceived to have a reduction factor?

- What do you do with a fish boatside?
    - Akin to tarpon regulations in Florida. Exposure to air and temperature components affect survivability. For example, un-hook the fish in the water. States have general language, release without undue harm; handling is a big part of it.

- Should state agencies be regulating fishing gear, or should changing gear be part of education/outreach/best management practices? Would best management practices as outreach be enough vs. regulation?
- Support a question about wire line (discussed during Draft Amendment 7 process), but specifically in the vein of how do you believe it will impact mortality? This is probably the fastest way to get the fish to the boat which may be beneficial, but people may be opposed to it because it's not the most "sporty" way to catch striped bass.
- In general, could ask why you support a gear restriction and why it would decrease release mortality.

The WG generally discussed other points about the survey. The WG noted the survey should be focused and keep the questions to a point that is reasonable. The survey should focus on questions about future actions, which may not be conventional management measures. Non-conventional measures (no-targeting, expansion of current gear restrictions) are not things managers often address. A WG member noted gear restrictions don't necessarily benefit all species. The NC Marine Fisheries Commission asked about requiring circle hooks for all species. While it would benefit some species, it would impact other species that are hard to catch with a circle hook or won't have the expected benefit for some species. Another WG member noted educating the public about release mortality is challenging, and there are better ways to communicate how the 9% rate works.

Regarding the survey format, the WG noted the survey would likely be conducted via an online survey link. There was some concern about participation in an online-only survey and the value of proactive outreach like port meetings or webinars to collect information. There was also concern about not getting enough feedback via a survey. There should be background information provided with link to the survey with the same information presented to everyone that fills out the survey. And the WG should carefully consider how folks are identified/grouped in different sectors. Given the time constraints of conducting the survey in the next few months, an online survey makes sense to cover the diversity of stakeholders and how they fish for striped bass.

The WG acknowledged there would not be sufficient time to consult experts on survey design. Logistically, ASMFC could host the survey on an online survey platform and compile/analyze the results. The Board members would be responsible for distributing the survey to ensure stakeholders have the opportunity to participate. Regarding timeline, if the Board approved the survey effort in August, the survey could be live for about a month from mid-August to mid-September. ASMFC staff would then process the responses for WG review prior to the October Board meeting.

Next Step: Three WG members (N. Meserve, D. Sikorski, M. Gary) will draft an initial set of survey questions based on WG input today, and will provide the draft for discussion at the next WG meeting.

Task #2: Gear Restrictions

The WG then discussed task #2 on gear restrictions and the need to identify any other studies, in addition to the MADMF study, that should be considered in the discussion of gear restrictions.

As background, ASMFC staff reviewed the Board's past consideration of gear restrictions in the FMP (Addendum VI and Amendment 7).

The WG noted the MADMF study seems to indicate the conservation benefit may not be as clear for circle hooks as expected. In the late 1990s, early 2000s, Maryland conducted release mortality studies showing benefits of circle hooks based on incidence of deep hooking. Hooks are very complicated, and the style of circle hooks is different than what was used in earlier studies. Bait types and terminal tackle are also different along the coast. WG members will send ASMFC staff the past Maryland studies for reference.

From the MADMF study, treble hooks seem to have the highest mortality rate. A single treble hook on a lure had a lower mortality rate, but double treble hook lures had the highest mortality rate. One question to consider is are there states that have rules on the maximum number of hooks on a lure (maybe just during the spawning season)? There was also worse survival at water temperatures above 75 degrees Fahrenheit. Bait fishing also had a higher mortality rate. The WG noted there is a wide range of predicted mortality from the different lures. The challenge is what is available for anglers to purchase. Barbless hooks are easier on the fish and the angler.

The WG also noted that release mortality also depends on environmental conditions, not just hook type. Even if the hook was set in the lip, there still could be a high mortality rate if water and air temperatures are high.

WG members will identify additional studies on gear restrictions and send to ASMFC staff. The WG will return to the gear restrictions discussion at a later WG meeting.

Task #1: No Targeting Closures

The WG briefly discussed no targeting closures and the potential type of information available from enforcement agencies. M. Appelman will be talking with NOAA Office of Law Enforcement (OLE). The WG suggested reaching out to Caleb Gilbert from OLE who provides reports to the Mid-Atlantic Council and has referred to no-targeting violations. The WG also asked whether contacting the US Coast Guard was needed.

The WG is interested in how many tickets are written for targeting striped bass. However, based on initial information, it seems like enforcement interactions regarding no-targeting violations alone are verbal and not necessarily written citations.

Next Step: WG will request information from MDDNR, PRFC/VMRC, NOAA on no-targeting closures to be discussed at a later WG meeting.

Public Comments

- Will Poston (ASGA) – There is a fine line between asking the recreational community too much on the survey. Focus on the key questions. Focus on the tradeoffs associated with no-targeting vs. no-harvest and public opinions on gear restrictions. Be as specific as possible for the survey.
- Jeff Mercer (RIDEM, Law Enforcement Committee rep for Striped Bass Board) – Coast Guard violations go through NOAA OLE. State enforcement also works in EEZ, and there are a lot of violations for possession and often verbal warnings. The Law Enforcement Committee recently ranked management measures on how enforceable they are, and no-targeting closures were last on that list (i.e., least enforceable). Not sure if any cases have been made in the Northeast on the targeting prohibition. There are challenges with prosecuting this and proving intent.
- Andy Danylchuk – Conducting a UMass lab study on how striped bass respond to capture and handling. This is the second year of data collection, and data should be available on capture-handling. There was also an angler survey distributed from Carolinas to Canada related to perceived threats to striped bass fishery.

Atlantic States Marine Fisheries Commission

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Striped Bass Board Work Group on Recreational Release Mortality Meeting Summary

Webinar
July 17, 2024

Work Group Members: Chris Batsavage (NC, WG Chair), Nichola Meserve (MA), Marty Gary (NY), Adam Nowalsky (NJ), Mike Luisi (MD), David Sikorski (MD), Max Appelman (NOAA)

ASMFC Staff: Emilie Franke, Katie Drew, Kurt Blanchard

Other Board Members: Megan Ware (ME, Board Chair), Ray Kane (MA)

Public: Allison Colden, Angela Giuliano, Corrin Flora, Daniel Herrick, Michael Woods, Mike Waine, Ralph Vigmostad, Ross Squire, Tony Friedrich, Will Poston

The Striped Bass Board Work Group (WG) on recreational release mortality (RRM) met for the second time on July 17 via webinar. The WG Chair reviewed the four WG tasks approved by the Board and reviewed the WG timeline. After this meeting, the WG will provide a progress update and initial recommendations to the Board on Task #3 on the stock assessment and Task #4 on public scoping at the 2024 Summer Meeting in August. The WG will meet a few more times in August and September to continue working on the WG tasks and develop final WG recommendations. The WG will provide a report to the Board at the 2024 Annual Meeting in October with a summary of all tasks and any recommendations on how the Board should address recreational release mortality based on the findings of the WG tasks.

Task #3 Stock Assessment and Release Mortality

Task #3. Identify assessment sensitivity runs which may inform Board discussion around release mortality (e.g., how low would you have to reduce the release mortality rate in order to see a viable reduction in removals with the same level of effort?). Consider the tradeoff of reducing the release mortality rate vs. reducing the number of releases overall.

ASMFC Staff, K. Drew, reviewed past work by the TC in late 2020 to explore the sensitivity of the stock assessment model to different recreational release mortality rates (TC Memo M21-04). The TC ran the assessment model under five RRM scenarios:

- Base case: 9% rate for all regions and seasons
- Low rate: 3% for all regions and seasons
- High rate: 26% for all regions and seasons
- Seasonal rates: 5% for Jan-June, 12% for July-Dec for both regions
- Regional rates: 16% for the Chesapeake Bay, 9% for the ocean for all seasons

Overall, changing the release mortality rate assumption for the entire time series of the stock assessment changed the scale of the estimates of female spawning stock biomass (SSB), fishing mortality (*F*), and recruitment but did not change the overall trend, or change stock status in 2017. Significant changes to the release mortality rate (i.e., going from 9% to 3% or 26%) resulted in significant changes to the scale of the population, but did not affect the final stock status determination. The higher release mortality rate did result in a stock trajectory where striped bass became overfished earlier in the time series than the other scenarios, but the 2017 stock status was consistent across all scenarios.

The seasonal and regional release mortality rates, which the TC felt were the more realistic scenarios, had minimal impacts on the estimates of SSB, *F*, and recruitment, and minimal impacts on stock status. Therefore, the TC concluded that the model is somewhat sensitive to major misspecifications of release mortality rate, but less sensitive to smaller scale misspecifications. Refining the overall coastwide estimate to reflect regional and/or seasonal differences can be pursued for the next benchmark assessment; it would likely not result in significant changes to population estimates or stock status but could produce minor improvements in the estimates.

To address the Board's interest in the tradeoff between reducing the release mortality rate vs. reducing the number of live releases, ASMFC staff presented three potential questions that the TC could address during the 2024 stock assessment. The WG could recommend the Board task the TC with these (or other) questions related to RRM.

<u>Potential Questions for TC</u>

1. If a reduction is needed to achieve rebuilding, how low would the release mortality rate need to be to achieve that entire reduction through the release mortality rate alone? In other words, if the number of live releases is constant, what release mortality rate applied to those live releases would achieve the reduction?

2. If a reduction is needed to achieve rebuilding, what percent reduction in number of live releases is needed to achieve the entire reduction through live releases alone? In other words, using the current 9% release mortality rate, how many fewer live releases would there need to be to achieve the reduction?

3. If a reduction is needed to achieve rebuilding, what percent reduction in number of live releases under the current 9% mortality rate is needed, assuming there is an associated reduction in recreational harvest due to no-targeting closures?

Staff noted Questions 1 and 2 represent the two extremes of reducing RRM. Question 1 would rely entirely on reducing the RRM rate to achieve a reduction (i.e., decreasing mortality from the fishing interaction), while Question 2 would rely entirely on reducing the number of live releases (i.e., controlling effort). These are hypothetical scenarios which are not necessarily realistic for management implementation but would demonstrate the tradeoff between the two approaches to reduce RRM. Recreational harvest would be assumed constant for these scenarios in order to isolate the reduction to RRM. For all three questions, two iterations could be run for each scenario to account for commercial harvest in the calculations: one with constant commercial harvest and one with an equal reduction for commercial harvest.

The WG asked staff to clarify the difference between the past TC work on sensitivity runs and the RRM rate and the first question regarding how low the RRM rate would need to be to achieve a reduction. Staff clarified that the past TC sensitivity runs looked back in time and applied different RRM rates to the historical time series to address the scenario of if the RRM rate was different in the past, how stock status would be affected over time. These three potential questions for the TC look to the future assuming management occurs to reduce the RRM and by how much RRM would need to be reduced in the next several years to achieve the reduction. The 9% assumption for the historical time series would not change.

For question 3, the TC would need to determine how to best quantify the reduction in live releases from no-targeting closures, which depends on several assumptions including how many striped bass are still caught and released as incidental catch when targeting other species. The WG noted that harvest and effort is not constant throughout the year, so a no-targeting closure (question 3) would have different potential reductions depending on the time of year. Staff noted this is something the TC would have to consider in determining the estimated reduction overall ,and how effort might change under a no targeting closure. It's possible the TC could present a range of estimated reductions depending on assumptions about effort, timing, etc.

Staff also clarified that it's difficult to tease apart why live releases might decrease in the future, either from management or from reduced effort due to reduced availability from weaker year classes entering the populations (i.e., poor recruitment). However, the projection scenarios are hypothetical and a reduction in live releases is achieved to compare to reducing the RRM rate.

The WG supports moving the three proposed questions forward to the Board for potential tasking to the TC. The WG noted these questions would be useful. Staff also clarified this would be a realistic task for the TC to complete during the 2024 assessment, and there is a sub-group of TC members working on the challenge of quantifying estimated reductions from no-targeting closures.

The WG added one additional question to bring to the Board:

> 4. Identify the tradeoffs of implementing no-targeting closures at different times of the year with different assumed release mortality rates. Generally, when/where would implementing a no-targeting closure result in the highest reduction? Factors could include water temperature and salinity with the assumption that the release mortality rate is higher when the water temperature is high and the salinity is low.

For example, if we close during a time when RRM is less than 3%, is it worth a closure during that time? If we close during a time when RRM is high, are there more savings? The WG noted any guidance from the TC on the best use of no-targeting closures to achieve reductions and the different factors to consider would be helpful. Staff noted the TC may not be able to provide a perfect answer but could perhaps provide a tool to understand different factors like length of closure, time of year, and associated RRM and what may be feasible management options. A WG member noted past Maryland conservation equivalency proposals applied methodologies to quantify the impact of no-targeting closures and circle hook implementation and could be used as a starting point.

Next Step: Recommend the four questions to the Board for potential TC tasking via WG memo for August meeting.

Task #4: Public Survey

The WG continued discussion on this task from the June 24 WG call. Staff reviewed the origin of this task again, which emerged from the possible scenario of the Board considering management action via Board vote (i.e., no addendum process) in October 2024, or shortly after, if the 2024 Stock Assessment Update indicated a reduction to achieve rebuilding was necessary. If that were to occur, public scoping completed prior to October could provide the Board with public input on measures to address RRM as the Board considered that action. A survey would need to be conducted from about mid-August to mid-September in order to gather and process the information prior to the October Board meeting.

Since the first WG call on June 24, three WG members drafted survey questions for WG discussion. The draft survey questions incorporated several issues associated with these types of measures into the questions, including angler response to closures, voluntary vs. mandatory gear restrictions, equity, enforceability, ability to quantify impacts, and general level of support for these types of measures. The survey questions also asked for information about survey participants such as where they fish, what type of recreational stakeholder they identify as, how frequently they target striped bass, and why they release striped bass (preference vs. regulation).

WG members generally supported the progress on the survey questions and continue to support the idea of a survey but expressed additional concerns about the proposed fast timeline to potentially conduct a survey starting in August. The WG noted they are not survey design experts, and this is a very important issue that the Board may want additional input on to develop the best survey possible before taking it out to the public. The WG noted this is a critical, valuable opportunity to gather input from the public on RRM, and the survey should be done right.

WG members suggested potentially extending the timeline for this survey and conducting it this fall, potentially after the October meeting but before the Board takes any action, or a longer-term timeline of conducting the survey in 2025. The Board should also develop an outreach plan to make sure states have a plan in place with resources to distribute the survey to stakeholders.

WG members suggested getting input from the ASMFC Committee on Economics and Social Science (CESS), which may have some members who are experienced with similar surveys, as well as input from the Striped Bass Advisory Panel. If funds are available, the Board could also consider consulting an outside expert on survey design.

The WG decided to pause work on further developing the survey questions until the Board provides guidance on the timeline and other committees/experts can be involved in the process. The WG decided the Board should decide on the timeline and process first, and then the draft survey questions can be further developed and shared with others at that time. The WG did have initial feedback on the first set of survey questions as follows:

- Need for email validation and/or gather additional personal information from participants to ensure only one reply per person. Could ask for name, city, state. Validating emails would be the most effective.
- Original goal of 15 minutes for a participant to complete, but this might be too long. Consider a goal of 5-10 minutes. We want to be comprehensive but unrealistic to try and collect a complete view of what people think of the fishery. Shorter is better. Focus on the areas where we want impact.
- Concern about leading questions. For example, the questions state there is a concern about enforcement rather than letting the participant express their concerns about no-targeting closures.
- Emphasize that MRIP data are estimates of harvest and release numbers. They are not absolute, these are estimates.
- We should think intentionally about how we ask stakeholders to identify themselves (private, for-hire, shore-side).
- The topics of fish handling and gear restrictions should be separate.
- Question about how angler behavior would change with a no-targeting closure is difficult because the answer could depend on when the no-targeting closure would occur. If striped bass were the only species available, that would mean one answer. But if there were other species available to target, the answer might be different.

Next Step: WG recommend the Board extend the survey timeline and identify people to involve in the process (possibly CESS, AP, outside experts if Board desires and funds allow).

Public Comments

- Will Poston (ASGA) - Appreciate including the broader industry (e.g., tackle shops), in addition to people who are actually fishing. Consider asking the broad question of if a reduction is needed, what is the preference/trade-off of the ability to target striped bass throughout the year vs. the ability to harvest at certain times.

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Striped Bass Board Work Group on Recreational Release Mortality
Meeting Summary

Webinar
September 3, 2024

Work Group Members: Chris Batsavage (NC, WG Chair), Nichola Meserve (MA), Marty Gary (NY), Adam Nowalsky (NJ), Mike Luisi (MD), David Sikorski (MD), Max Appelman (NOAA)

Other Board Members: Megan Ware (ME, Board Chair)

Public: Abby Remick, Angela Giuliano (MDDNR), Chris Moore, Jeff Mercer (RIDEM), Lynn Fegley (MDDNR), Mike Waine, Ross Squire, Tony Friedrich, Will Poston

ASMFC Staff: Emilie Franke, Toni Kerns

The Striped Bass Board Work Group (WG) on recreational release mortality (RRM) met for the third time on September 3 via webinar. The WG Chair reviewed the four WG tasks and the WG timeline. The WG will meet three more times during September and compile the WG report to the Board for the October 2024 Board meeting. The WG report will include a summary of all tasks, and any recommendations on how to address recreational release mortality for Board consideration.

TASK #1 STOCK ASSESSMENT AND RELEASE MORTALITY

Task #1. Review existing no-targeting closures in state and federal waters, including any information on impacts to striped bass catch and effort as well as their enforceability. Identify potential angler responses/behavior change to those closures.

The WG was presented with information from several jurisdictions that currently have no targeting closures in place for striped bass (Table 1). Each jurisdiction was asked to provide information on their no targeting closures, including the number of tickets written for targeting (if available), general insight on compliance and enforcement, and how anglers have responded to the closure (e.g., switched to other species, not fishing).

The Law Enforcement Committee (LEC) also provided information to the WG regarding their evaluation on the enforceability of no targeting closures, and their insight on how enforcement would identify a trip as targeting striped bass.

For other species, Pennsylvania provided information on a previous no targeting closure for smallmouth and largemouth bass.

Table 1. No targeting closures currently in place for striped bass.

Area	No Targeting Closure Dates
Maine Kennebec watershed	December 1 – April 30
New York Hudson River (above Cuomo Bridge)	December 1 – March 31
New Jersey all marine waters except Atlantic ocean	January 1 – February 28
New Jersey Delaware River and tributaries	January 1 – February 28 April 1 – May 31
Maryland Chesapeake Bay	April 1 – April 30 July 16 – July 31
Maryland spawning grounds	March 1 – May 31
Potomac River Fisheries Commission	July 7 – August 20
EEZ	All Year

Maryland Spring and Summer Closures

M. Luisi presented the following information at the WG meeting. In 2020 as part of Addendum VI conservation equivalency, Maryland DNR implemented no targeting closures for striped bass from April 1 through April 30 (half of Wave 2) and 16 days during Wave 4. In 2020, the Wave 4 closure was August 16 through August 31, and from 2021 onward, the closure is July 16 through July 31. In addition to these closures, Maryland implemented additional recreational management changes: shortened trophy season by delaying start until May 1 instead of mid-April; last day of season changed to December 10 from December 15; private angler bag limit reduced to 1 fish from 2 fish; charter bag limit maintained at 2 fish for charter captains enrolled in the charter electronic reporting system.

DNR reviewed MRIP data for striped bass directed trips, harvest, and live releases to compare effort and removals in Wave 2 and Wave 4 for the five years prior to the no targeting closures (2015-2019) to the four years since the no targeting closures were implemented (2020-2023). Data indicates there was a substantial drop in directed fishing effort for striped bass in Maryland's Chesapeake Bay after No Targeting Closures were established in 2020, as well as more modest increases in directed trips in the adjacent waves. Striped Bass harvest, live releases and total removals estimates also declined after the no targeting closures were implemented, however, other factors (e.g., fish availability, year-class strength, and private angler trip limit changing from 2 fish to 1 fish) are likely influencing these results. It is difficult to determine if anglers were fishing in other states/jurisdictions during the summer closure, however, the two other Bay jurisdictions were also closed to harvest during the Maryland summer closures and. Further PRFC was also closed to targeting. The data do indicate that other Bay species were targeted more heavily during the closures as compared to prior to the closures when striped bass was the most targeted species; the proportion of angler intercepts that indicated "no target species" also increased, and some striped bass targeting still occurred. DNR notes enforcement of the no targeting closures is occurring, but primarily in conjunction with violations of retention. DNR Natural Resources Police (NRP) agrees with ASMFC's LEC that enforcement of no-targeting provisions is challenging.

WG Questions: The WG was interested in how much of a role the 'no targeting' aspect of the closures played in reducing effort vs. if the closures had been only no harvest (i.e., how much does the inability to keep a fish dissuade fishing?).

Regarding the MRIP data, the WG noted there was a higher percent of angler intercepts indicating "no target species" during the years with the closures vs. the years prior to closure implementation. The WG also noted the potentially high PSE of these Wave-specific data and curiosity about the number of intercepts. DNR staff noted there is uncertainty, but the use of MRIP data has been consistent throughout this process.

The WG asked about displacement of effort and the potential for effort to be displaced to other times of year due to these closures. DNR noted the analysis did not look at trips by wave for the entire year, but noted the summer closure is only two weeks in the middle of a two-month wave so anglers could still take their trip during Wave 4 even if displaced by the closure.

Potomac River Summer Closure

A law enforcement Officer from the Virginia Marine Police provided written correspondence to ASMFC staff with insight on the Potomac River summer no targeting closure (also implemented in 2020), which is summarized here. It is difficult at times to determine compliance because other game fish can be caught using similar methods. Enforcement is not seeing a lot of boats actually trolling like they would see during normal seasons. Closures are affecting the law abiding anglers who follow the rules. The Officer does not believe it has any effect on those who are frequent violators or those who are knowledgeable enough to avoid detection. The Officer noted that no targeting closures are nice on paper, but are next to impossible to enforce. Anglers who know the area can state that they are fishing for other species using the same methods. All summonses were the result of direct confessions when approached by the officers. These anglers were usually from outside the area and claimed ignorance of the law. The Officer again noted it is a very difficult to enforce.

Maine Winter/Spring Spawning Closure

M. Ware presented the following information on Maine's no targeting closure in the Kennebec River watershed during winter and spring. The closure was established in 1990 to protect the spawning population of striped bass in Maine's Kennebec River. The no targeting closure is from December through April. From May to June, catch and release is allowed using hook/line with a single artificial lure, and during this period, it is unlawful to possess or use bait while hook and line fishing for *any* finfish species (and possession of this gear with bait is prima facie evidence of violation). It is important to note the closure is primarily in the winter and early spring, so recreational effort is low at that time. The closure is also in a specific river system, where species diversity is relatively low (i.e., striped bass is the primary target), and there is strong public buy-in to the measure. DMR enforcement communicated that the recreational community has demonstrated an awareness of the closure so there have been very few violations. DMR enforcement also communicated that the measure has been overall relatively enforceable, and summonses have been written and successfully adjudicated in the past. The strong public buy-in has been very important.

New York Winter/Early Spring Spawning Closure

M. Gary provided insight on the New York Hudson River closure during the winter and early spring. The Hudson River no targeting closure for striped bass is north of Cuomo Bridge. DEC staff noted the closure has been in place for a long time, although staff have been recently emphasizing it. Compliance generally seems good, and the Hudson is unique in that there aren't other similar species to fish for during the closure. Anglers could maybe say they were fishing for catfish or carp, but enforcement officers would know better based on their techniques. When the Hudson season was shortened in 2015 to an April 1 start date from the previous March 15 start date (i.e., extending the no targeting closure until April 1), most folks complied with the new rules readily. New regulations always take some time to "kick in" as people were used to the same regulations for decades. DEC staff noted if new no-targeting rules are to be effective, they would have to be widely publicized so there is a foundation of familiarity and community support and for the rules to be effective quickly. Easy-to-understand public outreach explaining the actions would help.

DEC noted any enforcement charges would be for either illegally taking or illegally possessing protected fish. There are multiple enforcement regions covering parts of the River depending on how far upstream you are. DEC also noted the genesis of the closure was from inland fisheries, and other inland species have similar closures as well.

New Jersey Winter and Spring Spawning Closure

New Jersey DEP staff coordinated with New Jersey Bureau of Law Enforcement (BLE) to provide written correspondence to ASMFC staff with insight on the winter and spring closures in New Jersey. Since 1991, the no targeting closure has been in place from January 1 through February 28 for all non-ocean waters, and from April 1 through May 31 for the spawning closure in the Delaware River. BLE reported that compliance on the take of striped bass during the closure is generally good, but compliance for not targeting striped bass is hard to determine since proving intent is very difficult. Due to the difficulty of proving intent, BLE generally issues warnings for targeting, whereas summons for possession during the closed season range from 1–19 per year since 2018. BLE reiterated how difficult it is to enforce no-targeting closures because people still fish during the closure and can say they are fishing for other species. This is very common, especially on nice weather days during the January-February closure and/or after a long winter during the spawning ground closure. BLE noted that no-targeting closures may sound good on paper but out on the front lines it is a different matter altogether.

NOAA Fisheries Year-Round Exclusive Economic Zone Closure

M. Appelman presented the following update on information gathered from NOAA Fisheries Office of Law Enforcement (OLE) on the EEZ closure. After discussions with OLE Officer Caleb Gilbert, who also provides enforcement updates to the Mid-Atlantic Council, there don't seem to be any striped bass "fishing" violations being issued where "possession", "harvest", or "retention" wasn't also identified. In other words, written violations for targeting alone without possession seem very rare. The WG could pursue a FOIA request to obtain a more comprehensive history of striped bass violations over a specific time period, but this does not seem worth pursuing. It was acknowledged that some illegal targeting and harvest is taking place in the EEZ, but input from both state and federal officers indicate that compliance is good overall, aside from some bad actors and a few hot spots. The general sentiment among officers is anglers know the rules by now, since the ban has been in place for nearly 35 years, which greatly improves compliance.

WG Questions: The WG noted that state law enforcement officers are deputized to enforce federal waters regulations, and all reports from state officers and the US Coast Guard are sent to NOAA Fisheries OLE for potential charging. So NOAA Fisheries is the data source for all federal waters violations. The WG also noted the period during the early 2000s when there were many federal waters violations for striped bass when striped bass were schooling tightly off the mouth of the Chesapeake Bay, and that scale of striped bass availability in the same area is not the same as it used to be.

Pennsylvania Closure for Smallmouth/Largemouth Bass

C. Batsavage presented a summary of the Pennsylvania no targeting closure for smallmouth and largemouth bass provided by PA Board member K. Kuhn. From 2012-2018, a no targeting closure for smallmouth and largemouth bass was in place from May 1 through mid-June in the Susquehanna and Juniata Rivers and tributaries. The no targeting closure was intended to reduce angling related stress during the spawning period. The no targeting closure was removed in 2018. It was noted that the closure was not intended to be permanent, and the Pennsylvania Fish and Boat Commission received a number of complaints stating that anglers are violating the closed season and the regulation is largely unenforceable. Additionally, new data indicated that species recovery benchmarks had been met allowing removal of the closed season regulations.

Law Enforcement Committee (LEC) Input

The LEC provided written correspondence to the WG summarizing their evaluation on the enforceability of no targeting closures, and their insight on how enforcement would identify a trip as targeting striped bass.

The LEC noted their *Guidelines for Resource Managers on the Enforceability of Fishery Management Measures* lists targeting prohibitions as the least enforceable of the 27 measures considered in the Guidelines with an average overall rating of 1.87 (1=least enforceable; 5=most enforceable). A targeting prohibition is defined as a regulation that prohibits the act of fishing for a particular species, to the exclusion of effort to catch other species. Further, the Guidelines note that enforcement would require a level of physical observation and surveillance beyond the scope of most agencies. Any regulation that requires law enforcement to prove the "intent" of a fisher is less enforceable and difficult to prosecute.

The WG Chair asked the LEC how enforcement identifies a trip as targeting striped bass, especially when there is overlap in fishing techniques and locations for other species. LEC consensus is that any regulations that prohibit the targeting of a marine species are resource intensive. The ability to prove the intent of an angler when the techniques used are the same as for other species in a shared location is nearly impossible.

Individual LEC member comments emphasized the near impossibility of enforcing no targeting without a verbal admission from the angler. It was noted that people who know they are illegally targeting striped bass are prepared to say they are targeting other species, and that those who might admit they are targeting striped bass are not the intentional violators who enforcement is most focused on catching. LEC members noted examples of the difficulty of proving intent for other species like great white sharks in MA and goliath grouper in FL.

Individual WG Member Comments

The WG discussed key takeaways from the above updates from states, NOAA, and the LEC. Individual WG members noted the following:

- The importance of stakeholder buy-in on compliance rates with no targeting closures. The level of buy-in may differ based on the rationale for the no-targeting closure (e.g., discrete time/area closures to protect spawning fish or address times of higher release mortality vs. more general closures to reduce fishing mortality). Survey questions (WG Task #4) about these rationales could be informative. Having no targeting closures in place as a long-term management measure also benefitted compliance.

- No targeting closures are viewed as more enforceable when there are fewer other species to target and the closures are in discrete times and areas. The ability to implement discrete time-area closures when few other species are available would vary across states.

- The difficulty of teasing out the difference in impacts on the number of releases between no targeting closures compared to if they were no harvest closures. No targeting closures try to address the number of releases directly, but some amount will still occur from targeting other species and non-compliance. No harvest closures do not directly address releases and will convert all catch to releases (except for non-compliance) but likely may reduce some level of effort (and hence catch). The MDDNR data suggest that their no targeting closures have reduced effort, releases, and harvest (again noting the additional impacts of the other regulatory changes). How would those reductions have differed if the closures were no harvest instead of no targeting?

- MDDNR noted their intention to continue exploring no targeting closures given changing water quality and environmental conditions. There are concerns that the FMP won't give credit for no targeting closures beyond that given for no harvest closures. MDDNR is concerned with how to move forward with no targeting closures to get credit without other states having to also implement them. In Maryland waters, the benefits of no targeting closures seem to be worth it and have a measurable effect. No targeting closures may not be for everyone, but seem to be working in Maryland.

- That there are specific places and times where no targeting closures are useful, and there seems to be a difference between compliance and enforcement. The state updates indicate compliance is pretty good, but it cannot be enforced. The WG is interested in exploring what type of language would help enforcement, and is interested in Maine DMR's language about terminal tackle (if tackle X is onboard, then you can be charged). However, this will not be effective in areas like the ocean when there are other species that could be targeted.

- In areas with less diverse fisheries, no targeting closures are easier to apply.

- How labor-intense it is to enforce no targeting closures.

- The Board may not want to be labeled as a group pursing management measures that are not enforceable, but we cannot use that as an excuse to ignore angler actions. A regulation may not need to be enforceable. We are on a precipice with striped bass, and in that particular instance we need every available tool to reduce mortality. Regardless of how enforceable something should be, we should endorse the concept of putting forward every tool in the toolbox. Something could be unenforceable but still have a benefit in reducing mortality because there is a portion of the angling community that wants to follow the law and will comply. There will also be anglers that aren't following the rules, but a large number of anglers may still stop targeting there would be a reduction in mortality. Even if regulations are unenforceable, they still might have a positive benefit of reducing mortality. The question is for the Board, but the idea should not be thrown out entirely, regardless of enforceability.

- The importance of considering displacement of effort, which there was some evidence of in the MDDNR presentation. If effort is displaced to a time period when the release mortality rate is improved, there is a benefit. But if increasing effort is displaced to a period with a worse or the same release mortality rate, there is not as much benefit from the closure.

WG Next Step: C. Batsavage, M. Appelman, and N. Meserve will start drafting report content on Task #1.

UPDATE ON TASK #4

Regarding Task #4 on public scoping, members from the Committee on Economics and Social Sciences (CESS) will provide input on draft survey questions as well as discuss the survey approach overall. Currently, the approach is similar to a public comment process but in survey format. This could result in input on no targeting questions, but it would not be a random sample of the angling population at large so we could not draw any quantitative or population-level conclusions. The CESS members will outline other possible approaches (e.g., random survey) and pros/cons/resources/timeline on the September 20th call. Materials will be sent around prior to the call.

UPCOMING CALLS AND TIMELINE

- Thursday, September 12 from 1:00pm-3:30pm: Task #2 gear restrictions, MADMF study summary, other studies; continue Task #1 no targeting discussion as needed
- Friday, September 20 from 9:30am-12:00pm: Task #4 survey, CESS survey experts
- Tuesday, September 24 from 9:30am-12:00pm: Wrap-up on all tasks and WG recommendations
- Friday, September 27 internal WG deadline for report to review
- October 4 deadline for Main Meeting Materials

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Striped Bass Board Work Group on Recreational Release Mortality
Meeting Summary

Webinar
September 12, 2024

Work Group Members: Chris Batsavage (NC, WG Chair), Nichola Meserve (MA), Marty Gary (NY), Adam Nowalsky (NJ), Mike Luisi (MD), David Sikorski (MD), Max Appelman (NOAA)

Public: Ben Gahagan (MADMF), Micah Dean (MADMF), Jeff Mercer (RIDEM, LEC striped bass representative), Brendan Harrison (NJDEP), Corrin Flora (MEDMR), Jesse Hornstein (NYDEC), Maxwell Kleinhans, Michael Woods, Mike Waine, Tony Friedrich, Will Poston

ASMFC Staff: Emilie Franke, James Boyle

The Striped Bass Board Work Group (WG) on recreational release mortality (RRM) met for the fourth time on September 12 via webinar. The WG Chair reviewed the four WG tasks and the WG timeline. The WG will meet two more times during September and compile the WG report to the Board for the October 2024 Board meeting. The WG report will include a summary of all tasks, and any recommendations on how to address recreational release mortality for Board consideration.

TASK #2 GEAR MODIFICATIONS

Task #2. Review the MA DMF discard mortality study and other relevant reports to evaluate the efficacy of potential gear modifications.

The WG was presented with a review of the Law Enforcement Committee's input on gear restrictions, an overview of the release mortality study currently being conducted by Massachusetts Division of Marine Fisheries (MADMF), and a summary of key findings related to gear restrictions (other than circle hooks) and release mortality from past studies on striped bass and other species.

Law Enforcement Committee (LEC) Input

The LEC's *Guidelines for Resource Managers on the Enforceability of Fishery Management Measures* rates gear regulations and method of take as 3.42 and 3.37, respectively, on a scale of 1 as least enforceable and 5 as most enforceable. Gear regulations are regulations in which specific gear types or gear modifications are restricted or prohibited. A method of take regulation stipulates a particular type of gear or fishing operation for legally harvesting a species. For both types of measures, the LEC recommendations note that when considering specific gear restrictions within the recreational sector, such as terminal tackle in a hook and line fishery or prohibited use of a "gaffing" type device to retrieve a specific species of fish, officers must prove use of said equipment. The possession is not typically a violation unless possession on board a vessel or possession while fishing is articulated in the regulation.

For gear regulations, the LEC recommendations also include the need to standardize gear requirements, measurement procedures, equipment, and techniques across all appropriate jurisdictions and time periods.

For the WG's consideration, the LEC also emphasized that regulations should avoid frequent changes. When a change does occur, there must be a concerted outreach and educational effort to adequately inform the public. This principle especially applies to recreational angling. As an example, the Striped Bass Board just went through this process for circle hooks and needed to define bait and exemptions to the rule (i.e. "Tube and Worm") after the regulation had been implemented. The LEC also emphasized that effective regulations should promote rather than hinder voluntary compliance.

In addition to the LEC input, C. Batsavage relayed information gathered from North Carolina's enforcement representative on gear restrictions that are currently implemented for other species (e.g., circle hooks required to harvest shark species; single, barbless hooks required in the Roanoke River to protect striped bass spawning, circle hooks required in the Pamlico Sound adult red drum fishery). In addition to the specific gear being used, enforcement can consider other gear and fishing techniques to determine whether an angler is targeting a species that requires a certain gear. NC enforcement emphasized the need for straightforward regulations that are clearly written, and noted the longer regulations are in place, the easier it is for enforcement. Although there may not be many citations written for all gear restrictions, enforcement also provides compliance assistance to help anglers understand the regulations and learn how to come into compliance instead of immediately issuing a citation. NC enforcement cautions managers to consider certain types of gear restrictions, notably any requirements for hook size since hook sizes are not uniform across brands and manufacturers. They also caution regulations that are resource-intensive for enforcement (i.e., require a lot of time for enforcement to determine whether an angler is in compliance).

WG Question: Why is having to prove intent/targeting not specifically included as a component of the LEC guidelines on gear requirements?

- J. Mercer noted targeting is a concern when determining compliance with using circle hooks and bait when fishing for striped bass. There are the same challenges discussed with no targeting closures regarding difficulty to prove intent. It is easier to enforce this requirement for possession. The Amendment 7 requirement that striped bass caught on any unapproved method of take must be returned to the water immediately without injury gives an 'out' for catch-and-release fishermen who catch striped bass with a non-circle hook; they can release the striped bass and say it was incidental catch.

MADMF Study on Release Mortality

B. Gahagan presented an overview of the MADMF study on evaluating post-release mortality for striped bass. The study includes three phases to develop a release mortality rate for striped bass:

1. Telemetry study, which tagged 350 striped bass over two years 2020-2021 to quantify difference in J-hook and circle hook mortality. They developed a model to estimate the probability of mortality based on a condition score ranging from no injury to dead fish. Guidelines were developed to keep condition scoring consistent.
2. Citizen science study to determine what factors affect condition, knowing that condition influences mortality. Conducted 2023 and 2024. Several variables are being considered, including biological characteristics of the fish, what type of fishing, and environmental factors. Many of these variables are interrelated.
3. Angler Tackle Configuration Survey coming in 2025 to describe variables for the fishery.

For the citizen science dataset, over 6,000 fish were reported for the study. Most fish reported were from Massachusetts anglers, and vast majority of fish from New England. Anglers have reported various tackle types, with a majority spread between bait, midwater lures, and surface lures. Other tackle types used were bottom lures and flies. There is variability in bait and tackle use by region, and the prevalence of different bait types and tackle along the coast is important to consider. Certain bait types have higher mortality rates, like mackerel, for example, which is only typically used from MA north. The future angler survey will be important to understand how often these different tackle types and baits are used.

There are three main factors that affected release condition: vitality (swimming ability upon release), injury (like amount of blood), and hooking location (mouth, body, esophagus, stomach, and gill). Release condition is the worst for fish hooked in the stomach or gills. Mortality is higher for fish in a worse condition.

Each of the three main factors is influenced by several variables, and the interaction of these variables needs to be considered. The first key takeaway is tackle and lure choices impact release mortality. Bait has the highest mortality rate, followed by surface lures; flies have the lowest mortality rate. For lure-hook configuration, a single hook lure had the lowest mortality and double treble hooks had the highest mortality. Fishing stress seems to be an important factor with mortality increasing as fight and handling time increase. Increasing fish length and water temperature indicate increasing mortality, but there are several interrelated variables to consider. For example, swimming ability is also impacted by water temperature, and fight time and handling time both increase with fish size.

Regarding project timeline, the citizen science data collection ends in December. Analysis of mortality rates is expected to occur in early 2025. Tackle configuration survey expected to occur in 2025 over 5-6 states. The telemetry portion of the study was recently published (Dean et al., 2024). Additional publications are expected for 2026.

These are preliminary results with more data incoming and statistical analysis to be conducted. Overall, the study found mortality rate is directly related to release condition. Release condition appears to be influenced by fight and handling times, hook number, type, location, and water temperature. There are a lot of correlated variables, and analysis is required to tease apart effects. Regulations may not be most effective tool for all factors (e.g., handling time). Information and outreach can effectively be applied to all important factors. Mortality rates decrease as angler experience increases, so outreach and education is important to change behaviors.

WG Questions: Several questions were asked by WG members and MADMF staff provided the following clarifications and information:

- Anglers participating in the study do receive information on how to classify striped bass condition, and reviving fish is being attempted by anglers.

- Regarding lighter tackle and fish time, fly has the lowest mortality rate, which includes variables like fight time and handling time. It does not appear that fighting and handling time makes a certain gear a higher risk choice.

- Difficult to separate impacts like gear type on fish size. The key theme is there are a lot of variables to consider simultaneously, and this gets more difficult with smaller sample sizes. For fish caught on fly, the upper size classes are missing as most observations are 15-30 inch fish. For other tackle types, larger fish were caught.

- Fight time is somewhat longer for flies (avg = 95 sec) than other lures (avg = 83 sec) in the MADMF dataset, but bait had the longest fight time (100 sec).

- A separate component of the MADMF study was the telemetry tagging study to model release mortality. 350 striped bass were tagged over two years to model release mortality and what factors affect release mortality rate. They can apply the model to any tackle choice.

- Fish that were marked as dead in the tagging study were confirmed to be dead.

- No matter the hook choice, multiple hooks on lures are more harmful to fish. Mortality increases with double hook lures compared to single hook lures. The greatest increase in mortality is seen from double treble hook lures. The second largest increase is between a single hook lure and a single treble hook lure. Results indicate that having one hook on your lure is best, and double treble hooks is worst.

- Cannot define statistical significance as this point. Analysis is forthcoming. There are many correlated variables. For example, the relationship between lure size and size of fish, and large fish and fight time. MADMF staff need to tease apart the marginal effect of a hook beyond fight time or handling time. These results are being shared at this point to communicate back to the community who participated in the study.

Past Studies on Gear Restrictions

E. Franke presented an overview of key findings regarding gear type (other than circle hooks) and release mortality for past studies on striped bass and other species. This was not a full literature review. As a starting point, staff reviewed studies that had been previously referenced in ASMFC documents and then reviewed other related studies to identify key findings regarding gear type. Findings related to circle hooks were <u>not</u> summarized since the FMP circle hook requirement is already implemented. Staff noted that gear type is only one factor affecting release mortality. Several other factors affect striped bass release mortality including hooking location on the fish (often related to gear type), temperature, salinity, and angler experience (Diodati & Richards 1996, Lukacovic & Uphoff 2007, Millard et al. 2000, Millard & Mohler 2005, Nelson 1998, RMC 1990).

A summary of key findings from other studies regarding gear type and release mortality are enclosed as an Appendix to this meeting summary.

<u>Current Ongoing Study at UMass Amherst</u>

At the June 2024 WG meeting, Dr. Andy Danylchuk (University of Massachusetts Amherst) made a public comment noting his current work on striped bass release mortality. They study is led by Dr. Danylchuk and Dr. Lucas Griffin of UMass Amherst. The objective of the study is to quantify the short-term activity patterns, behavior, and mortality of striped bass caught in Massachusetts across a range of angling techniques, environmental settings, and life history stages. The study is using a rapid assessment approach that combines quantifying detailed metrics of angling events, indices of reflex impairment once striped bass are landed, and measuring short-term activity patterns and mortality following release. The study is applying the 'Research Angler' model working side by side anglers to do the science. Currently, the second year of project data are being analyzed.

In addition to the release mortality study, Dr. Danylchuk also recently conducted a survey of recreational anglers to learn about perceptions and beliefs about the striped bass fishery.

The project team is tentatively planning to provide a brief presentation to the WG at the September 24 WG meeting.

Individual WG Member Comments

The WG discussed key takeaways from the release mortality studies and discussed factors the Board should consider regarding gear restrictions and lessons learned from implementing the circle hook requirement. <u>Individual</u> WG members noted the following:

- Recent study information suggests considering management measures for lure-hook configurations. Maryland already prohibits using bait on a treble hook, as an example of this type of measure already in place in other states.

- The MADMF study has not completed the formal statistical analysis to determine significance, so there should be caution on what conclusions are brought to the full

Board at this time. There should be an understanding that the current results may not have the statistical backing after analysis is complete. The Board should make decisions on sound science and not something that has not been fully analyzed.

- There are a lot of variables to consider, and it is hard to isolate one particular gear to get the most bang for buck. The Board should consider bang for buck for potential gear restrictions. For example, if only a small number of users employ a particular gear type, is that type of regulatory requirement worth the effort?

- Implementation was not as simple as we thought for circle hook requirement and we had to spend time dealing with the fallout.

- Treble hooks are most problematic. Could support eliminating treble hooks altogether. Maryland has already eliminated treble hooks with bait, but has not eliminated treble hooks with artificial lures.

- Recognize that new gear restrictions are not going to change the release mortality rate used now, and we may not be able to quantify the regulations. However, not using treble hooks with bait would be an improvement.

- Could not support mandating removing a single treble hook and replacing it with a single J hook. Management decisions cannot be based on the preliminary results of this study and just a ‘feel-good’ mentality.

- Any WG recommendation does not preclude states from implementing gear restrictions as they see fit in states/areas. The WG can note this in the report.

- Torn between waiting until final completion of the MADMF study to consider gear measures, as the findings are compelling.

- Board should consider the impacts to the industry of any potential gear modification from the perspective of manufacturer, retailer, tackle store, etc. There may be more to consider from these perspectives.

- Potential restrictions that could be discussed are prohibiting treble hooks with bait, prohibiting treble hooks overall, or prohibiting double treble hooks.

- Board should consider enforceability and how these types of gear restrictions would interact with management of other species. Anglers may be fishing for multiple species and it could be difficult to have restrictions that only apply to one species.

During the WG discussion, MADMF staff commented that their current study results are beyond raw data. The study has applied the peer-reviewed model to the citizen science data that has been collected, but statistical significance tests have not been done yet. They noted the difference between hooks is real, and they have good sample sizes. It may not take much of a difference between mortality rates to have significant results.

WG Discussion on Potential Consensus Statement

The WG attempted to develop a consensus statement to provide to the Board on gear restrictions, but consensus was not reached. Some WG members support the following statement: *If the Board were to consider additional gear restrictions, hook configuration on a lure is a good place to start for management.* Rationale included that this is a logical starting point based on the current MADMF study results to reduce release mortality. It was noted that for any management measure considered, all implications must be considered (e.g., impacts to tackle industry).

However, some WG members do not support that statement. They noted they could support continued focus on data for hook-lure configurations from studies, but they could not support management consideration of new gear restrictions at this time. Rationale included the preliminary nature of the MADMF study results without statistical significance analysis and the unknown bang-for-buck associated with specific gear restrictions at this point (i.e., only a small portion of anglers may employ a certain hook-lure configuration).

The above comments from individual WG members indicate a difference of opinion on the value of pursuing gear restrictions via regulatory requirements at this time.

Next Step: A. Nowalsky, M. Luisi, and C. Batsavage begin drafting the WG report content for this task. Follow-up discussion on future WG call as needed.

UPCOMING CALLS AND TIMELINE

- Friday, September 20 from 9:30am-12:00pm: Task #4 survey with CESS members
- Tuesday, September 24 from 9:30am-12:00pm: Potential presentation from UMass Amherst on release mortality study; wrap-up on all tasks and WG recommendations
- Friday, September 27 internal WG deadline for report to review
- October 4 deadline for Main Meeting Materials
- October 11 deadline for Supplemental Materials (if needed)
- October 23 Striped Bass Board Meeting

PUBLIC COMMENTS

Mike Waine from the American Sportfishing Association (ASA) noted gear restrictions are a topic of interest for ASA, particularly for gear manufacturers and retailers. The Board has previously discussed education campaigns to try to improve release mortality from an education standpoint. He asked the WG whether this will be part of the WG report? If there isn't a firm recommendation for making gear changes, is there plans to make a recommendation around education campaign that would help anglers understand what the status of the science is and consider making some of those gear changes on their own? If the Board is not ready to make a regulatory change and the science is not ready to support that, perhaps education, outreach and awareness is the way to go. If a regulation is implemented, you'll need a ton of education and outreach to get the outcome that you want to achieve. Do not see any issue starting sooner rather than later on outreach, and the industry would rally around that.

- M. Luisi noted support for including a point on education and outreach in the report. He noted that in addition to the Board potentially considering a terminal tackle or gear modification as a management action, this information from the release mortality studies is good information for states and ASMFC to consider advocating best management practices.
- C. Batsavage and E. Franke noted the WG may revisit this topic if desired at the upcoming WG meetings.

Will Poston from the American Saltwater Guides Association (ASGA) noted ASGA is already conducting outreach based on the results of the MADMF study and working with fishing tackle manufacturers.

Appendix. Key Findings from Past Studies on Gear Types (other than circle hooks) and Release Mortality

Note: This is not a comprehensive overview of all findings from each study. This description highlights findings from each study specifically related to the impacts of gear type and fish handling on release mortality.

Studies on Striped Bass

Diodati and Richards (1996) conducted a study on striped bass in Massachusetts. They found gear type (1-3 treble hooks on lures vs. single hooks with bait or jig), anatomical site of hooking, depth of hook in oral cavity, and angler experience to be significantly related to release mortality. The highest mortality was associated with single hooks, hooks deep in the oral cavity, and inexperienced anglers. They found hook size, handling technique, release technique, and time from hook to release were not significantly related to mortality. However, it was noted that handling/release was correlated with angler experience.

Nelson (1998) conducted a study on striped bass in the Roanoke River, North Carolina. He found hooking location and water temperature to be significantly related to mortality. Hooking location was significantly different between gear types, with 14% of fish caught on live bait hooked in sensitive locations (e.g., esophagus, gills) vs. 3% of fish caught on artificial lures hooked in sensitive locations. The study notes this suggests increased mortalities when live bait is used. There was no significant difference in mortality between live bait and artificial lures. Combined landing and handling time was not significantly different between bait and lures, although the results suggest some influence of handling time on mortality. If there are different fight or handling times between gears, this can confound observed mortality differences between gear types. The study did not find a significant relationship between mortality and fish length. The study encourages fishing methods with low incidence of deep hooking to reduce injury-related mortality.

Wilde et al. 2000 conducted a meta-analysis of seven striped bass release mortality studies in freshwater. Two studies were striped bass in the Susquehanna River/Flats (RMC 1990, Lukakovic & Florence 1998) and one study was striped bass in the Roanoke River, NC (Nelson 1998). The remaining four studies were conducted in lakes or reservoirs across Tennessee, Texas, Oklahoma, and South Carolina. The study modeled the effects of bait type and water temperatures on mortality and found both variables to be significant, with water temperature explaining more variation than bait type. Mortality was higher for natural baits vs. artificial tackle. There was a small mortality difference between bait and artificial at lower temperatures, but that difference increased rapidly at higher temperature above 16 degrees C. The study found no significant relationship between fish length and mortality. The authors encourage fishing/handling techniques to minimize stress and note the need to inform anglers on using natural bait vs. artificial.

Studies on Other Species

Muoneke & Childress 1994 conducted a review of many studies for several taxa on multiple factors impacting release mortality. They found mortality was high when fish are hooked in vital organs. Single hooks with natural baits had higher mortality than treble hooks, but some there was some variability across studies and some studies indicated no difference at all. Natural baits are often swallowed more deeply, so they are associated with higher mortality than artificial lures and flies. The impacts of barbed vs. barbless hooks had varying results for different species. The degree of handling depends on many factors including fish size, angler experience, terminal gear, etc., and environmental conditions also affect mortality, notably high water temperature and low dissolved oxygen.

Taylor & White (1992) conducted a meta-analysis of eighteen studies for non-anadromous trout. They found higher hooking mortality for bait vs. artificial flies or lures, and higher hooking mortality for barbed hooks vs. barbless hooks. There was a significant correlation between fish hooked in critical locations and mortality. There was only a few percentage point difference in mortality for barbed hooks vs. barbless hooks when on a lure or fly, but a larger difference for barbed vs. barbless hooks when using bait. They did not find a significant relationship between mortality and the number and size of hooks.

Nuhfer & Alexander (1992) conducted a study on brook trout in Michigan. They found a higher hooking mortality for treble vs. single hooks, and noted it took more time to unhook treble hooks and those hooks resulted in more tissue damage. Of fish hooked in the gills or esophagus, over 70% caught with treble-hook lures died as compared to 50% of those caught with single hooks. They noted the probability of hooking in gill/throat, heavy bleeding, and mortality increase with larger fish. They also found higher mortality with higher water temperatures, especially if heavy bleeding occurred.

Schaefer & Hoffman (1992) conducted a multi-species study off the coast of St. Petersburg, Florida in the Gulf of Mexico. The majority of species caught were sand perch, blue runners, grunts, and grey triggerfish. They found mortality was influenced by anatomical hook placement, severity of injury or bleeding, and hook extraction times. In comparing barbed vs. barbless hooks, they found barbed hooks landed more fish but barbed hooks had longer unhooking time. They did not find a difference between barbed and barbless hooks for anatomical hook placement and bleeding since most fish in the study were hooked in the jaw. They found that barbless hooks reduced unhooking injuries. Overall for their study fishery, they noted barbless hooks may confer only slight benefits at the expense of reduced catches. They also noted the small sample sizes and narrow size range of fish in their study.

Matlock et al. (1993) conducted a study on red drum and spotted seatrout in Texas Bays. They compared single barbed hooks vs. treble hooks, and natural vs. artificial baits. They found no significant difference in mortality between hook types or bait types for both species. They did note overall low hooking mortality for both species.

Malchoff & Heins (1993) conducted a study on weakfish in Great South Bay, New York. They compared single barbed hooks with natural bait vs. single barbed hook with artificial lures. They found no significant difference between bait and artificial lures. They noted that the study used small hooks on small fish.

References

Dean, M.J., Hoffman, W.S., Gahagan, B.I., Nelson, G.A. and Armstrong, M.P., 2024. Evaluating the conservation benefit of circle hooks for the Atlantic Striped Bass recreational fishery. *Marine and Coastal Fisheries*, *16*(5), p.e10308.

Diodati, P.J. and R.A. Richards. 1996. Mortality of Striped Bass Hooked and Released in Salt Water. Transactions of the American Fisheries Society 125:300-307.

Lukacovic, R., and B. Florence. 1998. Mortality rates of striped bass caught and released with artificial lures during spring on the Susquehanna Flats. Maryland Department of Natural Resources, Annapolis.

Lukacovic, R. and J. Uphoff. 2007. Recreational Catch-and-Release Mortality of Striped Bass Caught with Bait in Chesapeake Bay. Fisheries Technical Report Series No. 50. Maryland DNR Fisheries Service. Annapolis, Maryland. 21 pp.

Malchoff, M.H. and Heins, S.W. 1997. Short-Term Hooking Mortality of Weakfish Caught on Single-Barb Hooks. North American Journal of Fisheries Management, 17: 477-481.

Matlock, G.C., McEachron, L.W., Dailey, J.A., Unger, P.A. and Chai, P. 1993. Management Briefs: Short-Term Hooking Mortalities of Red Drums and Spotted Seatrout Caught on Single-Barb and Treble Hooks. North American Journal of Fisheries Management, 13: 186-189.

Millard, M.J., S. Welsh, J. Skjeveland, J. Fletcher, J. Mohler, and M. Hendrix. 2000. Mortality Associated with Catch and Release of American Shad and Striped Bass in the Hudson River. Final Report Submitted to New York State Department of Environmental Conservation. New Paltz, New York. 26 pp.

Millard, M.J., J.W. Mohler, A. Kahnle, and A. Cosman. 2005. Mortality associated with catch-and-release angling of striped bass in the Hudson River. North American Journal of Fisheries Management, 25(4): 1533-1541.

Muoneke, M.I. and W. Michael Childress. 1994. Hooking mortality: A review for recreational fisheries. Reviews in Fisheries Science, 2:2, 123-156.

Nelson, K.L. 1998. Catch-and-Release Mortality of Striped Bass in the Roanoke River, North Carolina. North American Journal of Fisheries Management, 18: 25-30.

Nuhfer, A.J. and Alexander, G.R. 1992. Hooking Mortality of Trophy-Sized Wild Brook Trout Caught on Artificial Lures. North American Journal of Fisheries Management, 12: 634-644.

RMC, Inc. 1990. An evaluation of angler induced mortality of striped bass in Maryland. Completion Report (P.L. 89-304, AFC-18-1) to National Marine Fisheries Service, Gloucester, Massachusetts.

Schaeffer, J.S. and Hoffman, E.M. 2002. Performance of Barbed and Barbless Hooks in a Marine Recreational Fishery. North American Journal of Fisheries Management, 22: 229-235.

Taylor, M.J. and White, K.R. 1992. A Meta-Analysis of Hooking Mortality of Nonanadromous Trout. North American Journal of Fisheries Management, 12: 760-767.

Wilde, G.R., Muoneke, M.I., Bettoli, P.W., Nelson, K.L. and Hysmith, B.T. 2000. Bait and Temperature Effects on Striped Bass Hooking Mortality in Freshwater. North American Journal of Fisheries Management, 20: 810-815.

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Striped Bass Board Work Group on Recreational Release Mortality
Meeting Summary

Webinar
September 20, 2024

Work Group Members: Chris Batsavage (NC, WG Chair), Nichola Meserve (MA), Marty Gary (NY), Adam Nowalsky (NJ), Mike Luisi (MD), David Sikorski (MD), Max Appelman (NOAA)

Committee on Economics and Social Sciences Members: Robert Murphy (NOAA), Jorge Holzer (UMD), Syma Ebbin (CT Sea Grant)

Other Board Members: Megan Ware (ME, Board Chair)

Public: Beth Versak, Charisma Daniel, Corrin Flora, Delmarva Fisheries Association, Harry Hornick, Jesse Hornstein, Jim Uphoff, Jordan Zimmerman, Micah Dean, Mike Waine, Ross Squire, Sarah Cvach, Shannon Moorhead, Tony Friedrich

ASMFC Staff: Emilie Franke, Katie Drew, Kurt Blanchard

The Striped Bass Board Work Group (WG) on recreational release mortality (RRM) met for the fifth time on September 20 via webinar. The WG Chair reviewed the four WG tasks and the WG timeline. The WG will meet one more time during September and compile the WG report to the Board for the October 2024 Board meeting. The WG report will include a summary of all tasks, and any recommendations on how to address recreational release mortality for Board consideration.

TASK #4 PUBLIC SCOPING

Consider public scoping on measures to address release mortality (e.g., online public survey ahead of the October Board meeting).

The WG revisited Task #4 following the Board's August decision to delay the timeline for developing a survey to allow for input from survey experts. Three members of the Commission's Committee on Economics and Social Sciences (CESS) provided guidance to the WG on general survey approaches to consider, as well as high-level comments on the WG's first-draft survey questions.

R. Murphy presented three possible survey approaches for the WG to consider to gather input from stakeholders on measures to address recreational release mortality. Each approach has different benefits and challenges, and the most appropriate approach will depend on what the WG's objective is with the survey.

Possible Survey Approaches

Approach 1 is an open survey, which is also referred to as convenience sampling. This is the WG's current approach to conduct a survey open to any striped bass stakeholders. This approach would provide focused survey responses from striped bass stakeholders on addressing recreational release mortality. The benefits of this approach would be gaining more information on the suite of perspectives across stakeholders relatively quickly with existing resources. This approach could also reach stakeholders who are not necessarily licensed anglers, like tackle shops, for example. Questions could be added to the survey to characterize respondents to some extent (demographics, fishing experience, etc.). The challenge of this approach is the Board could not draw conclusions about the angling population at-large since the survey respondents would not be a representative sample of the population. Respondents will likely be those that typically participate in striped bass public comment periods and follow the management process closely (i.e., specialized striped bass anglers). This approach would be a relatively short-term approach requiring Commission staff time and use of the Commission survey platform; however, potentially significant staff time may be required to process the responses.

Approach 2 is a randomized survey, which would be similar to Approach 1 with the distinction of surveying a random sample of stakeholders, likely a random draw of people who are registered saltwater fishing license holders. The benefit of this approach is the Board would be able to draw some quantitative conclusions that would be more representative of the population than Approach 1, since Approach 2 uses a random sample. One major challenge is that not all anglers have a license and not all states have available license databases (and some license databases may not have email addresses). Additionally, this approach would not cover all stakeholder groups (e.g., tackle shops). The literature has found that electronic survey respondents can be biased toward younger, Caucasian anglers with more specialized experience. This approach would be medium to long-term, depending on how rigorous the survey methodology is, and would require a social scientist to conduct the survey and process the results.

CESS members clarified that one of the primary differences between Approach 1 and 2 is the ability to generalize to the population at-large. You could still get some quantitative information from Approach 1 (i.e., the proportion of survey respondents who support closures), but that result could not be generalized to the larger population because the open survey sample is not representative of the population. For example, responses of those who respond after seeing the survey through a social media blast vs. those who are randomly sampled would be different. Social media is important to consider here and how that will impact who responds to the survey. Approach 2 would be more representative, but there would still be limitations and drawing conclusions to the population at-large would still not be perfect. For example, response rates could be low and there could still be bias in those that do respond to the survey. CESS members also highlighted potential survey fatigue if stakeholders are being asked to complete multiple striped bass surveys for different survey efforts. For example, MADMF is planning to conduct a comprehensive stakeholder survey on terminal tackle use in 2025, so it may be beneficial to not conduct a survey at the same time as the MADMF survey.

Approach 3 is stakeholder focus groups, which would provide comprehensive input from a representative group of stakeholders. The benefits of this approach are focus groups can capture more context from participants as compared to responses to narrow survey questions. The focus groups would paint the landscape of potential stakeholder responses to various regulatory changes. There is potential for some quantitative analysis but would mostly be qualitative analysis. The sample would not be necessarily representative, but the focus groups could try to engage people from major stakeholder groups to capture the range of opinions and possible responses to management measures of interest. One major challenge of this approach is the coordination and execution of focus groups and ensuring a representative group of participants. This approach would be medium to long-term and would require someone to conduct the focus groups and process the input. The person(s) conducting the groups could be advised by CESS members and others.

WG Questions and Discussion

The WG acknowledged there is no perfect approach to capture the complexity of potential stakeholder input, and each approach has its benefits and challenges for gathering information from striped bass stakeholders. CESS members also noted it can be difficult to capture the regional differences in perspectives of striped bass stakeholders, and the need for future work to understand fishing motivations. CESS members noted recreation demand models (RDMs) are an important and powerful tool being used for other species and could be considered for striped bass. A choice experiment survey would inform RDMs, and the past striped bass choice experiment survey could be updated in the future.

The WG discussed that if achieving a representative sample of stakeholder is difficult, it may be more important to get a better understanding of the range of stakeholder responses to these types of management measures. CESS members commented that the initial draft survey questions were written in a way that would be hard for potential respondents to follow, but they could potentially be reframed to Likert style questions (Agree, Disagree) that would be easier to understand.

The WG discussed some concern about an open survey and the potential for respondents to submit multiple responses and the impact of many responses from large interest groups weighting the results. One WG member noted they would not support the use of an open survey as the only approach but could support it if used in conjunction with another approach. One WG member also noted the concern about the randomized survey not capturing all stakeholders may not be a huge issue, as most people in the industry (like tackle shop owners) participate in the fishery, and for-hire captains could provide insight on their customers' perspectives.

CESS members noted that if a survey was conducted prior to focus groups, the survey could ask respondents whether they would be willing to participate in a focus group and provide their contact information to do so. This could help identify more diverse focus group participants that would be harder to find otherwise.

The WG noted the focus group approach would be useful to identify the universe of stakeholder responses to specific measures and to allow for nuanced discussion and responses from participants. For example, understanding angler responses to no targeting closures is a critical piece of information that may be best captured through stakeholder discussion in focus groups instead of a survey. The survey, as currently framed, may not provide as much value since its initial intent was to provide quick input to the Board ahead of potential action in Fall 2024. At this point, there is not enough time to conduct a survey, and narrow survey responses may not provide the understanding of these complex issues the Board is considering. There was also concern that no matter how many caveats are provided around survey results, the results may be misconstrued.

The focus groups could have multiple objectives, including painting the landscape of stakeholder responses to potential management measures and input on how to conduct communication and outreach around those measures. Additionally, if focus group meetings are far enough ahead of the benchmark stock assessment, the Board could consider whether the focus groups should also cover any assessment-related topics the Board is seeking input on (e.g., reference points).

WG Conclusions and Recommendations

The WG agreed on the following conclusions regarding gathering public input on potential management measures to address recreational release mortality:

- A survey does not seem feasible to adequately gather complex information on stakeholder response to management measures, nor will a survey meet the original timeline at this point of gathering public input ahead of potential Board action in late 2024 in response to the stock assessment.

- If the Board is interested in public input beyond this next management action, focus groups could be a useful approach to 1) paint the landscape of potential stakeholder responses to measures being considered to address release mortality (e.g., no targeting closures, gear modifications) and 2) discuss outreach on best fishing/gear/handling practices.

- Conducting an open survey could also be considered, but the inherent biases would need to be acknowledged. Survey fatigue should also be considered. For example, there is currently an open survey of striped bass stakeholders being conducted by Virginia Tech on stock structure and migration patterns, and MADMF is planning to conduct a survey on terminal tackle use in 2025.

- In response to the 2024 stock assessment, and for any management actions, states should continue to do their own internal scoping through their established state processes to understand perspectives from their stakeholders, separate from focus groups.

Ultimately, if the Board wants to gather public input on stakeholder buy-in and potential responses to management measures to address release morality, the WG recommends focus groups as the best approach to collect that information.

If the Board were to proceed with focus groups in the future, the Board would need to address logistics, including who would be leading the focus groups and identifying stakeholders to participate. A focus group approach would likely require significant State staff time on these logistics and planning. CESS members noted they could advise the process, and the Board could consider the benefit of involving a graduate student(s) in the process. Additionally, depending on the timing of focus groups, the Board could consider adding other topics for stakeholder input (e.g., assessment-related topics ahead of the benchmark stock assessment).

UPCOMING CALLS AND TIMELINE

- Tuesday, September 24 from 9: 00 am-12:00 pm: Potential presentation from UMass Amherst on release mortality study; wrap-up on all tasks and WG recommendations
- Friday, September 27 internal WG deadline for report to review
- October 4 deadline for Main Meeting Materials
- October 11 deadline for Supplemental Materials (if needed)
- October 23 Striped Bass Board Meeting

PUBLIC COMMENTS

No public comments.

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Striped Bass Board Work Group on Recreational Release Mortality
Meeting Summary

Webinar
September 24, 2024

Work Group Members: Chris Batsavage (NC, WG Chair), Nichola Meserve (MA), Marty Gary (NY), Adam Nowalsky (NJ), Mike Luisi (MD), David Sikorski (MD), Max Appelman (NOAA)

Public: Olivia Dinkelacker (UMass Amherst), Brendan Harrison, Corrin Flora, Evan D, Jesse Hornstein, Michael Woods, Mike Waine, Stephanie Ruiz, Tony Friedrich, Will Poston

ASMFC Staff: Emilie Franke

The Striped Bass Board Work Group (WG) on recreational release mortality (RRM) met for the sixth time on September 24 via webinar. The WG Chair reviewed the four WG tasks and the WG timeline. The WG will compile the WG report to the Board for the October 2024 Board meeting. The WG report will include a summary of all tasks, and any recommendations on how to address recreational release mortality for Board consideration.

TASK #2 GEAR MODIFICATIONS

Task #2. Review the MA DMF discard mortality study and other relevant reports to evaluate the efficacy of potential gear modifications.

O. Dinkelacker from the University of Massachusetts Amherst presented an overview of a striped bass release handling and mortality study that has been ongoing for the past two years in Massachusetts. In addition, an angler survey was conducted to better understand social norms in the fishery that drive individual angler behavior and willingness to adopt best practices and management strategies. The survey had over 1,600 respondents, ranging from New England to the Mid-Atlantic. The results of the studies are intended to help inform targeted education and outreach programs on best practices to increase the probability of survival of striped bass, and to close knowledge-action gaps to promote adoption of science-based best practices when striped bass intended for release are handled.

The field assessment quantified the response of striped bass after capture, handling, and release based on five reflexes measured (at the time of landing and immediately following handling) and the use of accelerometer biologgers to measure activity after release across various angling types and locations. Note that the reflexes used in the study are used quite often in similar studies and have been validated against physiological stresses imposed by angling on fish. The study applied the Research Angler approach with the researchers working alongside the anglers, in comparison to more typical citizen science models of data collection.

Initial results from the studies are as follows. Please note these are preliminary results that will be submitted for publication in the near future. As fight time and air exposure increases, striped bass were more physiologically impaired based on the reflexes assessed. Interestingly, the angler survey revealed that although the science indicates air exposure has a negative impact on striped bass, many anglers do lift their fish from the water.

The results indicate that the cumulative reflex score decreases with larger fish and when striped bass are caught at warmer temperatures. The angler survey indicated that when asked about which factors negatively impact survival, anglers indicated fish size and water temperature were considered least influential. This is another example where the knowledge-action gap can be closed with adequate education and outreach.

Although the sample sizes for fish hooked in the gills and the gut were relatively low, results indicate that fish hooked in the gills were more impaired than fish hooked elsewhere, with gill-hooking most commonly occurring with single J-hooks. For fish hooked in multiple locations, those hooked in the stomach were more impaired, and all of those gut-hookings were caused by double treble hooks. External injuries resulting from foul hooking (outside the body) were most common with double treble hooks (for hook location 1 and 2). While external hooking did not result in lower reflex scores, it may have long-term lethal or sublethal effects.

The results indicate fish with longer air exposure times had lower levels of activity after release. Longer fight times also resulted in the lower the activity levels following release. Fish exposed to air for longer times took longer to recover. Interestingly, fish had higher activity levels during the first minute after release as compared to 3-6 minutes, which is consistent with the fight or flight response. After the short burst, striped bass displayed lower activity levels, especially for those air exposed for longer durations. This initial high activity may be misleading to anglers thinking the fish is okay when it still may be injured.

The survey results indicate most survey respondents rate the commercial fishery as a high threat to the fishery. There seems to be a misconception here since the commercial fishery is a relatively small part of the fishery. Many survey respondents also indicated non-compliance as being as issue. There was strong support among survey respondents for enforcement of regulations, implementing appropriate management measures, a science-based understanding of the striped bass population, and implementing science-based catch-and-release practices.

Regarding agreement with the 2023 emergency action, the survey indicates that over 50% of respondents who fish with conventional gear agree with the emergency action, while 75% of fly fishers agree with the emergency action.

WG Questions: A WG member asked how to interpret the survey results since it seems like most survey participants are catch-and-release fishers and may not represent all striped bass anglers (some who value harvest, and some who value catch-and-release). O. Dinkelacker noted that half of the respondents (51.6%) reported to release all striped bass they catch (even if those fall within the slot limit), while others reported to harvest at least some of their catch. As such, there seems to be a balanced representation of different angler preferences in the survey.

A WG member asked about the potential conflict between the conservation mindset of catch-and-release fishing with the potential for lighter tackle/fly fishing to result in longer fight times. O. Dinkelacker noted that they observed some catch-and-release anglers using heavier tackle to reel fish in faster, so that tension does not exist among all catch-and-release anglers. Approaching this issue both from the regulation side (e.g., requiring heavy tackle for tournaments) and from and outreach side to communicate the impacts of different tackle is important. Another WG member noted anecdotal observations of fly fishing resulting in shorter fight time due to fly fishers' high level of technical skill.

A WG member asked about the survey results indicating respondents perceive the commercial fishery as a primary threat to the stock. O. Dinkelacker noted the important role of education and outreach for recreational anglers to understand their role in conservation. The survey also included a question about responsibility for protecting the stock, and some anglers did indicate they have responsibility themselves. Another WG member noted anglers may not realize the scale of the striped bass recreational fishery, and the additive effect of that effort on the stock.

A WG member asked about how single hook lures can cause so much injury, possibly related to the way striped bass gulp feed. O. Dinkelacker noted that because single hooks are so small, they can end up in the gill rakers where they get stuck and cause serious injury. A treble hook, which is much bigger, may get stuck sooner in the jaw before getting to the gill rakers.

TASK #1 NO TARGETING CLOSURES AND TASK #2 GEAR MODIFICATIONS

The WG reviewed and discussed draft conclusions and possible WG consensus statements for task #1 on no targeting closures and task #2 on gear modifications. That discussion is reflected in the conclusions and recommendations presented in the WG report.

TIMELINE

- Friday, September 27 internal WG deadline for report to review
- October 4 deadline for Main Meeting Materials
- October 11 deadline for Supplemental Materials (if needed)
- October 23 Striped Bass Board Meeting

PUBLIC COMMENTS

Will Poston from the American Saltwater Guides Association noted concern about the WG's draft conclusion about the effectiveness of no-targeting closures. The presentations from the WG calls seem to indicate only circumstantial effectiveness of no targeting closures. For Maryland closures, it is hard not to conflate the lack of abundance of striped bass in the Bay with a reduction in fishing effort. Recognize the difficulty of parsing out the impacts of fish availability compared to the regulatory effects but suggest caution to the WG about making strong statements on the effectiveness of closures based on the WG discussions.

Atlantic States Marine Fisheries Commission

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MEMORANDUM

TO: **Striped Bass Management Board**

FROM: **Striped Bass Technical Committee and the Stock Assessment Subcommittee**

DATE: **October 9, 2024**

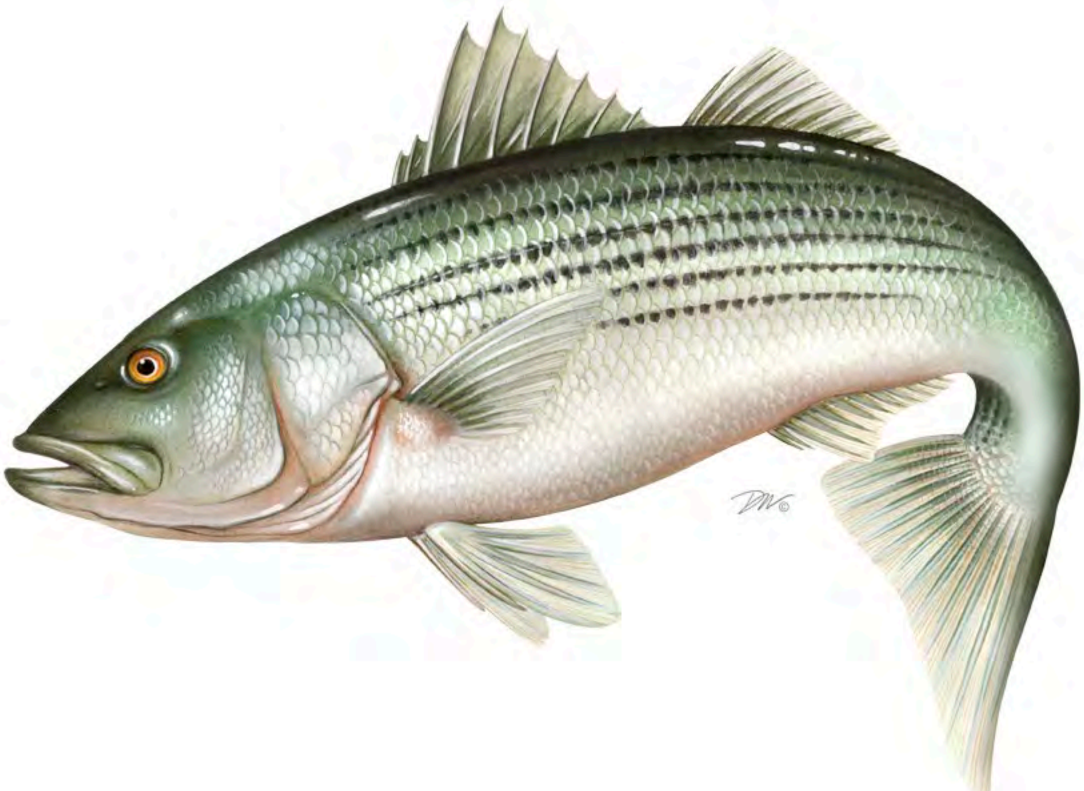
SUBJECT: **2024 Stock Assessment Update and Range of Projections**

The 2024 Stock Assessment Update Report is enclosed. The assessment presents a range of projections to convey uncertainty and different assumptions about what could happen in the future. The Technical Committee and Stock Assessment Subcommittee recognize this presents a challenge for managers, and will provide a summary of TC-SAS discussion on the likelihood of various projection scenarios and the implications for rebuilding in Supplemental Materials ahead of the October Board meeting.

M24-82

Atlantic States Marine Fisheries Commission

2024 Atlantic Striped Bass Stock Assessment Update Report



Sustainable and Cooperative Management of Atlantic Coastal Fisheries

Atlantic States Marine Fisheries Commission

Atlantic Striped Bass Stock Assessment Update

Prepared by the
ASMFC Striped Bass Stock Assessment Subcommittee
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EXECUTIVE SUMMARY

The time series of striped bass removals and indices from the 2022 assessment update were extended to include data from 2022-2023. Total removals from 2022-2023 averaged 6.18 million fish, a 20% increase from 2021, the terminal year of the last assessment. From 2022-2023, recreational release mortality made up 40% of total removals, with recreational harvest making up 49%, commercial harvest making up 10%, and commercial discards making up 0.5% of the total. This is a change from 2018-2021, where recreational release mortality made up 50% of total removals and recreational harvest accounted for 37%.

The single-stock statistical catch-at-age (SCA) model was updated through 2023. The model parameterization was the same as in the 2022 assessment update, including the new selectivity block starting in 2020 in the Bay and Ocean fleets to account for the regulation changes from Addendum VI to Amendment 6. A sensitivity run was conducted to look at the effect of adding a new selectivity block for 2023 to account for the Emergency Action, but the estimated selectivity curves for the 2023 block did not align with the expected change in selectivity based on the regulation changes, likely due to the difficulty in estimating the selectivity pattern from a single year of data. For the reference points and the projections, an empirically-derived selectivity curve was used to better capture the effects of the Emergency Action in 2023 and Addendum II in 2024.

Because the recruitment trigger in Amendment 7 was tripped based on 2021-2023 data for the New Jersey, Maryland, and Virginia juvenile abundance indices, the biological reference points were calculated using the low recruitment regime assumption. This resulted in a lower *F* target and *F* threshold compared to the benchmark assessment.

In 2023, the Atlantic striped bass stock was overfished. Fishing mortality was above the *F* target, but below the *F* threshold, indicating overfishing was not occurring. Female spawning stock biomass in 2023 was estimated at 86,536 metric tons (191 million pounds) which is below the updated SSB threshold of 89,513 metric tons (197 million pounds), and below the updated SSB target of 111,892 metric tons (247 million pounds). Total fishing mortality in 2023 was estimated at 0.18 which is below the updated *F* threshold of 0.21 per year, but above the updated *F* target of 0.17 per year. Although the stock is not experiencing overfishing, these results trip the *F* target trigger in Amendment 7 since *F* has exceeded the *F* target for two consecutive years while SSB is below the SSB target.

The retrospective pattern remained moderate to low in magnitude for the 2024 assessment update, with the model underestimating *F* and overestimating SSB in the most recent peels. The retrospective-adjusted estimates of *F* and SSB were within the 90% confidence intervals of the unadjusted estimates, so correcting for retrospective pattern was not necessary for status determination or projections.

Projections were run to determine the probability of SSB being at or above the SSB target by 2029, the rebuilding deadline. If *F* is reduced to the *F* target by 2025, and *F* target is maintained through 2029, there is less than a 5% chance that the stock will be rebuilt in 2029.

The *F* rate necessary to have a 50% chance of being above the SSB target in 2029 ($F_{rebuild}$) depends on the extent of the reductions realized by Addendum II, implemented in 2024. The TC initially predicted that the Add. II measures would result in a 13.7% reduction in total removals relative to 2022, equivalent to 5.86 million fish, slightly higher than the 2023 total removals. In this scenario, *F* in 2024 is estimated to be 0.20, while $F_{rebuild}$=0.11 for 2025 onward. To achieve $F_{rebuild}$ in 2025, total removals would have to be reduced to 3.16 million fish, a 46% reduction from the predicted removals in 2024. However, the preliminary MRIP numbers for 2024 Waves 2-3 are 36% lower than the Waves 2-3 numbers for 2023. Expanding the preliminary 2024 Waves 2-3 estimates to the full year, based on the proportion of total landings that occurred in those waves in earlier years, and accounting for a 7% decrease in commercial removals relative to 2023 due to the quota reduction, resulted in estimated total removals of 3.89 million fish in 2024. In this scenario, *F* in 2024 is estimated to be 0.13, and fishing at this rate each year through 2029 would result in a 50% probability of being above the SSB target in 2029. In order to maintain this *F* rate in 2025, a 4% reduction from estimated 2024 removals would be needed. The TC considers the low 2024 removals scenario based on preliminary MRIP numbers to be more likely than the high 2024 removals scenario.

However, in 2025, the above-average 2018 year-class will be age-7, the same age the strong 2015 year-class was in 2022, and just entering the 28-31" slot in the ocean fishery. When the 2015 year-class entered the ocean slot, total removals increased by 32% from 2021 to 2022, and *F* in 2022 was 39% higher than 2021. Although total removals decreased in 2023, *F* in 2023 under the Emergency Action slot limit was still 17% higher than in 2021. If *F* in 2025 increases by the same percentage seen in 2022 or 2023 and remains there, the probability of rebuilding under that *F* rate is well under 50%. Historically, an increase in *F* due to a strong year-class recruiting to the fishery has been followed by a decrease in subsequent years, although the rate of change has been variable. If *F* increases only in 2025 and decreases to the level estimated for 2024 as the 2018 year-class moves out of the slot, the probability of rebuilding by 2029 is 43%.

The level of removals and *F* in 2024, 2025, and subsequent years is a major source of uncertainty in these projections. Although predicted removals for 2024 based on preliminary 2024 MRIP data for Waves 2-3 can support rebuilding by 2029, it is likely that removals will increase in 2025 and the Board should be prepared to respond to this eventuality.

	Target	Threshold	2023 Value	Status
Fishing Mortality	0.17	0.21	0.18	Not overfishing
Female SSB	111,892 mt (247 million lbs)	89,513 mt (197 million lbs)	86,536 mt (191 million lbs)	Overfished

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TERMS OF REFERENCE (TOR) REPORT

TOR 1. Update fishery-dependent data (landings, discards, catch-at-age, etc.) that were used in the previous peer-reviewed and accepted benchmark stock assessment.

The time series of striped bass recreational and commercial removals from the 2022 assessment update (ASMFC 2022) was extended to include data from 2022-2023. This included recreational harvest, recreational release mortalities, commercial harvest, and commercial discards.

Total removals from 2022-2023 averaged 6.18 million fish, a 20% increase from 2021, the terminal year of the last assessment (Table 1, Figure 1). Approximately 76% of the removals came from the ocean fleet over that time period, while 24% came from the Chesapeake Bay fleet, which is a higher than average percentage from the ocean fleet, reflecting the availability of the strong 2015-year class in the ocean and the weak year-classes available to the Chesapeake Bay fleet (Table 1, Figure 1).

From 2022-2023, recreational release mortality made up 40% of total removals, with recreational harvest making up 49%, commercial harvest making up 10%, and commercial discards making up 0.5% of the total (Figure 2). This is a change from 2018-2021, where recreational release mortality made up 50% of total removals and recreational harvest accounted for 37%.

The MRIP CPUE index of abundance was updated with data through 2023. The index was developed using the same species associations identified in the previous benchmark. Imputed records were excluded from the intercept data pull for 2020. The index declined somewhat from 2018-2021 but was relatively stable from 2022-2023 (Figure 3).

TOR 2. Update fishery-independent data (abundance indices, age-length data, etc.) that were used in the previous peer-reviewed and accepted benchmark stock assessment.

Where possible, the fishery independent age-1+ and recruitment indices used in the most recent benchmark assessment (Table 2) were updated through 2023.

The assessment used seven fishery independent indices of age-1+ abundance: the Chesapeake Bay Multispecies Monitoring and Assessment Program (ChesMMAP), the Maryland Spawning Stock Survey (MDSSN), the Delaware Spawning Stock Electrofishing Survey (DESSN), the Delaware 30' Bottom Trawl Survey (DE30), the New York Ocean Haul Seine (NYOHS), the New Jersey Bottom Trawl Survey (NJTRL), and the Connecticut Long Island Sound Trawl Survey (CT LISTS). The NJ Trawl did not operate from 2019-2021 due to COVID and vessel issues, but operated as usual for 2022-2023. ChesMMAP changed vessels in 2018 and the calibration process was completed in time for this assessment update, so calibrated estimates were available for the full time-series. Age-1+ surveys with data through 2023 showed mixed trends, with some surveys increasing since 2021 and some decreasing (Figure 3).

The assessment uses four age-0 juvenile abundance indices (JAI) and two age-1 indices as recruitment indices: the MD, VA, NJ, and NY JAIs and the MD and NY age-1 indices. The MD and VA JAIs were combined into a single composite JAI for Chesapeake Bay using the Conn (2010) method. The NJ, MD, and VA JAIs all tripped the recruitment trigger based on 2021-2023 data, with each index having three consecutive years below the Amendment 7 recruitment threshold[1].

TOR 3. Tabulate or list the life history information used in the assessment and/or model parameterization (M, age plus group, start year, maturity, sex ratio, etc.) and note any differences (e.g., new selectivity block, revised M value) from benchmark.

Model equations are shown in Appendix 1 Table 1. The model parameterization was the same as used in the 2022 assessment update (ASMFC 2022), including the new selectivity block starting in 2020 in the Bay and Ocean fleets to account for the regulation changes from Addendum VI (Table 3). A sensitivity run was conducted to look at the effect of adding a new selectivity block for 2023 to account for the Emergency Action.

Re-weighting of survey indices was required with the addition of two years of removal data and missing index data for several surveys. Survey CVs were adjusted to bring the RMSE close to one and effective sample sizes were adjusted once by using the Francis multipliers (Francis 2011). The RMSEs, CV weights and effective samples from the 2019 benchmark and 2022 assessment models are given in Table 2 in Appendix 1. The largest change in CV weight occurred for the NJ Trawl survey, where the correct CV time series was substituted for the incorrect values input in the benchmark.

No changes were made to the life history information used in the assessment (Table 4).

TOR 4. Update accepted model(s) or trend analyses and estimate uncertainty. Include sensitivity runs and retrospective analysis if possible and compare with the benchmark assessment results. Include bridge runs to sequentially document each change from the previously accepted model to the updated model.

Model Fit

The model fit the observed total catches and catch age compositions of all fleets well (Appendix 2). The model fit the MDYOY (1970-1981) and MD & VA composite indices very well and the MD Age-1, NYOHS, and MDSSN poorly. It fit the other indices reasonably well (Appendix 2).
The predicted trends matched the observed trends in age composition of survey indices reasonably well for NYOHS, MDSSN, MRIP, CTLIST, and ChesMMAP. The model fit the age composition of NJTrawl, DESSN, and DE30FT survey adequately. Resulting contributions to total likelihood are listed in Table 3 of Appendix 2. Estimates of fully-recruited fishing mortality for each fleet and total fishing mortality, recruitment, parameters of the selectivity functions for

[1] Threshold = 25th percentile of respective JAI from 1992-2006.

the selectivity periods, catchability coefficients for all surveys, and parameters of the survey selectivity functions are given in Table 4 of Appendix 2.

Estimates of the catch selectivity patterns for each fleet showed that, although the patterns varied over time with changes in regulation, selectivity was dome-shaped for Chesapeake Bay and primarily flat-topped for the Ocean over time (Figure 6). There was a steep shift in the descending limb of the selectivity pattern in 2020-2023 for Chesapeake Bay compared to the previous selectivity block, and a shift in the selectivity for the Ocean to a more dome-shaped pattern, as would be expected with the implementation of a slot limit for 2020-2023 (Figure 6).

Fishing Mortality

Fully-recruited annual fishing mortality in 2023 for the Bay and Ocean was 0.05 and 0.15 (Figure 7), and peaked at ages 5 and 7, respectively (Appendix 2 Table X5). Total fully-recruited *F* in 2023 was 0.18 (Table 5, Figure 7) and peaked at age 7. Coefficients of variation indicated region-specific and total fishing mortality estimates were precise (CVs mostly less than 0.20) (Appendix 2 Table X4).

Recruitment

Recruit numbers increased steadily through 1993 (Figure 8). Large recruitment events occurred in 1994, 1997, 2002, and 2004 as the large Chesapeake Bay 1993, 1996, 2001 and 2003 year-classes became age-1. Average to below-average year-classes were produced during 2004-2010, which resulted in a decline of age-1 numbers. Subsequently, strong year-classes were produced in 2011 and 2015. After 2016, recruit abundance fluctuated slightly and has averaged 112.6 million age-1 fish (Table 5, Figure 8). Six of the last seven year-classes since 2015 have been below average, although generally not as low as the levels seen in the 1980s; the 2018 year-class was above average (Table 5, Figure 8). The below-average 2022 and 2023 recruits will start contributing to female SSB in 2029 and 2030 as those fish approach full maturity.

Population Abundance (January 1)

Striped bass abundance (ages 1+) increased steadily from 1982 through 1997 when it peaked around 423.5 million fish (Table 5, Figure 9). Total abundance fluctuated without trend through 2004. From 2005-2009, age 1+ abundance declined to about 187.1 million fish. Total abundance spiked again in 2012 and 2016 as a result of two large year-classes (2011 and 2015) entering the age-1+ population (Table 5, Figure 9). Total abundance declined from 2019-2022, but ticked upward slightly in 2023 to 177.9 million fish (Figure 9).

Abundance of striped bass age 8+ increased steadily through 2004 to 17.2 million fish, but then declined to 11.9 million fish through 2010 (Table 5, Figure 9). A small increase in 8+ abundance occurred in 2011 as the 2003 year-class became age 8 (Table 5, Figure 9). Abundance of age 8+ fish declined steadily through 2018 but has increased recently to 11.6 million fish in 2023 as the 2011 and 2015 year-classes recruited to the age-8+ group (Table 5, Figure 9).

Spawning Stock Biomass and Total Biomass

Female SSB grew steadily from 1982 through 2003 when it peaked at about 120,000 metric tons (Table 5, Figure 10). Female SSB declined steadily from 107,053 metric tons in 2010 to 60,808 metric tons in 2018, but in recent years, has steadily increased (Table 5, Figure 10). SSB in 2023 was 86,536 metric tons. Estimates of female spawning stock biomass were very precise (CVs less than 0.14; Table 8 of Appendix 2).

Exploitable biomass (January 1) increased from 36,012 metric tons in 1982 to its peak at 341,699 metric tons in 1999 but declined steadily through 2015 (Figure 10). Since 2016, exploitable biomass steadily increased albeit at a slow pace.

Retrospective Analysis

Moderate retrospective patterning was evident in the more recent estimates of fully-recruited total *F* and female SSB (Figure 11). The retrospective pattern suggested that fishing mortality is likely slightly under-estimated by 2.5% and female spawning biomass is over-estimated by less than 10%. Recruitment appeared to be over-estimated in most years, although underestimation did occur in a few years (Figure 11). The Mohn's rho values for fishing mortality, female SSB and recruitment were estimated to be -0.025, 0.007 and 0.09, respectively.

The current retrospective trends are consistent with the 2022 update, but are different from what was observed in the 2019 benchmark and earlier assessments (NEFSC 2019). The past retrospective patterns showed that female SSB was typically under-estimated and fishing mortality was over-estimated.

Sensitivity Runs

An additional sensitivity run was made to explore the effects of adding a new selectivity block in 2023 to account for the changes due to the Emergency Action. In this run, the Ocean fleet had a new selectivity block for 2020-2022 reflecting Addendum VI changes, and a new block in 2023, while the Bay fleet had a single block from 1996-2022, since no size limit changes were implemented through Addendum VI, and a new block in 2023. Full results and diagnostics for this sensitivity run is presented in Appendix 2. Overall, diagnostics were very similar for both runs. The sensitivity run results were similar to the base run, with a higher estimate of *F* in 2023 and slightly lower estimates of SSB from 2020-2023 (Figure 12). The TC did not consider the estimated selectivity curves for the 2023 block reliable, as they did not align with the expected change in selectivity based on the regulation changes. For both the Ocean and the Bay fleet, the 2023 selectivity curve was significantly lower for ages 13-15+, even though the majority of those fish were already outside of the 28-35" slot in the ocean and thus not likely to be affected by the change to a 28-31" slot or the imposition of a 31" maximum size in the Bay (Figure 13). In addition, for the Ocean fishery, the selectivity on fish ages 3-7 was lower in the 2023 block than in the 2020-2022 block, even though the Emergency Action did not change the minimum size in the ocean (Figure 13). This was likely due to the difficulty in estimating the selectivity pattern from a single year of data.

Comparison of Results from the 2019 Benchmark Assessment and the 2022 Assessment Update with the 2024 Assessment Update

Fully-recruited fishing mortality and female spawning stock biomass estimates from the 2024 update, the 2022 update, and benchmarks assessment are shown in Figure 14 and are generally very similar. The 2024 assessment produced lower estimates of fishing mortality from 1996-2017 compared to the benchmark and 2022 updates, and slightly higher estimates of female spawning stock biomass from 1992-2010 compared to the benchmark and 2022 update. From 2015 onward, the 2024 update estimate of SSB was lower than the benchmark but higher than the 2022 update.

TOR 5. Update the biological reference points or trend-based indicators/metrics for the stock. Determine stock status.

The fishing mortality and spawning stock biomass reference points were updated using the same methods as the benchmark assessment (NEFSC 2019), with the exception of the selectivity curve. Because the estimates of the selectivity curve for 2023 as a separate block were considered unreliable, a hybrid selectivity pattern (Appendix 3) was developed for 2024 and subsequent years based on the selectivity curve estimated for 2020-2022 and the regulations for 2024, which includes the extension of the Emergency Action regulations for the Ocean fleet and a more restrictive slot for the Bay fleet. The spawning stock biomass threshold is the 1995 estimate of SSB from the current assessment and the SSB target is 125% of the threshold. The fishing mortalities associated with the SSB target and threshold in the long term were determined using a stochastic projection method. Empirical estimates of recruitment, selectivity, and the starting population came from the SCA model results. The selectivity pattern used in the projections was the empirically derived hybrid selectivity pattern (Figure 15). Estimates of recruitment were restricted to 2008-2023 to represent the "low" recruitment regime. The population was projected for 100 years and fully-recruited *F* was adjusted until the median of the projected SSB reached the SSB target or threshold.

The updated SSB reference points and associated fishing mortalities are:

$SSB_{threshold}$ = 89,513 metric tons	**$F_{threshold}$ = 0.21**
SSB_{target} = 111,892 metric tons	**F_{target} = 0.17**

Status of the Stock

Before stock status can proceed, analyses must be done to determine if the estimates of F and SSB in 2023 should be corrected for the apparent pattern observed in the retrospective analyses. Here we used the National Marine Fisheries Service standard procedure in which the estimates are adjusted for the retrospective pattern using Mohn's rho values (average of proportion differences over five-year peels) and then compared to the unadjusted estimates and their associated 90% confidence intervals. If either retrospective-adjusted value falls outside an unadjusted value's 90% confidence intervals, then the retrospective-adjusted values are used. If not, the unadjusted values are sufficient for stock determination. Figure 16 shows a bivariate plot of the unadjusted estimates and their associated 90% confidence interval along with the retrospective-adjusted values. Because the retrospective-adjusted values fall within the 90% confidence intervals, retrospective adjustment is not needed.

In 2023, the Atlantic striped bass stock was overfished. Fishing mortality was above the *F* target, but below the *F* threshold, indicating overfishing was not occurring. Female spawning stock biomass in 2023 was estimated at 86,536 metric tons (191 million pounds) which is below the updated SSB threshold of 89,513 metric tons (197 million pounds), and below the updated SSB target of 111,892 metric tons (247 million pounds) (Table 6, Figure 17). When accounting for the uncertainty in these estimates, there is a 60% probability that the 2023 female SSB estimate is below the SSB threshold and a 99% probability that the 2023 estimate is below the target.

Total fishing mortality in 2023 was estimated at 0.18 which is below the updated F threshold of 0.21 per year, but above the updated *F* target of 0.17 per year (Table 6, Figure 17). There is a 26% probability that the 2023 fully-recruited fishing mortality is above the fishing mortality threshold, and a 63% probability that *F* is above the F target.

The estimate of *F* in 2023 was higher for the sensitivity run with a new selectivity block in 2023, equal to the *F* threshold. However, stock status relative to the *F* triggers in the FMP was the same for both runs: *F* was above the target in both of the last two years and the stock was overfished in both years.

TOR 6. Conduct short term projections when appropriate. Discuss assumptions if different from the benchmark and describe alternate runs.

The projections used the same methods as the benchmark assessment (NEFSC 2019), with the exception of the use of the hybrid selectivity pattern to better account for the management changes in 2023 and 2024, and the application of the "low" recruitment regime. Because the retrospective adjusted values of *F* and SSB fell within the 90% confidence intervals of the unadjusted estimates, retrospective-adjustment was not needed.

The model begins in year 2023 with the estimates of January-1 abundance-at-age and associated standard errors from the SCA assessment model. The observed 2023 catch-at-age and natural mortality at age are used to calculate the 2024 January-1 abundance-at-age for ages 2-15+; recruitment in 2024 is predicted from the MD young-of-year survey value for 2023. The predicted 2024 total removals, the hybrid selectivity pattern, and natural mortality are used to calculate the 2025 January-1 abundance-at-age. For the remaining years, the January-1 abundance-at-age is projected and is calculated by using the previous year's abundance-at-age, the scenario fully-recruited F, and natural mortality following the standard exponential decay model. Female spawning stock biomass is calculated using the average Rivard weights-at-age from 2019-2023 along with proportion of female by age and maturity-at-age.

The TC initially predicted that the Add. II measures adopted by the Board would result in a 13.7% reduction in total removals relative to 2022, equivalent to 5.86 million fish in 2024, slightly higher than the 2023 total removals (high removals scenario). However, the preliminary

MRIP numbers for Waves 2-3 are 36% lower than the Waves 2-3 numbers for 2023. Expanding the preliminary Waves 2-3 estimates to the full year, based on the proportion of total landings that occurred in those waves in earlier years, and accounting for a 7% decrease in commercial removals relative to 2023 due to the quota reduction, results in estimated total removals of 3.89 million fish in 2024 (low removals scenario). The TC considers the low removals scenario based on preliminary MRIP numbers to be more likely than the high removals scenario for 2024. Projections were run for both the high and low 2024 removals scenarios assuming the *F* in 2024 was maintained each year through 2029.

Another source of uncertainty for the rebuilding trajectory is the effect of the above-average 2018 year-class becoming age-7 in 2025 and entering the 28-31" slot in the ocean fishery. When the strong 2015 year-class was age-7 in 2022, total removals increased by 32% from 2021 to 2022, and *F* in 2022 was 39% higher than 2021 (Table 7). With the implementation of the Emergency Action slot limit in 2023, total removals in 2023 decreased relative to 2022, but were still 8% higher in 2023 than in 2021 and *F* was 17% higher in 2023 than in 2021. Additional projections were conducted with a constant *F* for 2025 forward assuming *F* increased from 2024 (low removals scenario) to 2025 by either the rate seen in 2023 relative to 2021 (17%) or the rate seen in 2022 relative to 2021 (39%), reflecting the potential progression of the 2018 year-class through the fishery in 2024-2025 (Table 8). Historically, an increase in *F* due to a strong year-class recruiting to the fishery has been followed by a decrease in subsequent years, although the rate of change has been variable. Therefore, a fourth projection was done where *F* in 2025 increased by the rate seen in 2023 relative to 2021, but then decreased to F_{2024}.

For each year of the projection, the probability of SSB being above the SSB target and threshold reference points was calculated from 10,000 simulations using function *pgen* in R package *fishmethods*.

Projection Results

The base run with the single 2020-2023 selectivity block and the sensitivity run with a new selectivity block in 2023 produced similar results, with both models having a low probability of rebuilding by 2029 under F_{2023} or under F_{target} (Appendix 2).

The *F* rate necessary to have a 50% chance of being above the SSB target in 2029 ($F_{rebuild}$) depended on the extent of the reductions realized by Addendum II, implemented in 2024. In the high 2024 removals scenario, *F* in 2024 is estimated to be 0.20, which would have a less than 1% chance of rebuilding by 2029 (Table 9, Figure 18) if that rate was maintained in subsequent years. For the high 2024 removals scenario, $F_{rebuild}$=0.11; to achieve $F_{rebuild}$ in 2025, total removals in 2025 would have to be reduced to 3.16 million fish, a 46% reduction from the predicted removals in 2024 (Appendix 3 Table 6). In the low 2024 removals scenario, *F* in 2024 is estimated to be 0.13, and fishing at this rate would result in a 50% probability of being above the SSB target in 2029 (Table 9, Figure 18). In order to maintain this *F* rate in 2025, a 4% reduction from estimated 2024 removals would be needed. For both the low and high removal scenarios, fishing at F_{target} would have a less than 50% chance of rebuilding.

If *F* in 2025 increases by the same amount seen in 2022 or 2023 and remains there, the probability of rebuilding under that *F* rate is well under 50% (Table 10, Figure 19). If *F* increases in 2025 as the 2018 year-class enters the slot by the same amount seen in 2023, but then decreases to the F_{2024} and remains there, the probability of rebuilding by 2029 is 43% (Table 10, Figure 19). If *F* decreases further after 2025, the probability of rebuilding will be higher, but if it remains above 2024 levels, the probability will be lower.

The level of removals and *F* in 2024, 2025, and subsequent years is a major source of uncertainty in these projections. Although predicted removals for 2024 based on preliminary 2024 MRIP data for Waves 2-3 are sustainable and can support rebuilding by 2029, it is likely that removals will increase in 2025 and the Board should be prepared to respond to this eventuality.

TOR 7. Comment on research recommendations from the benchmark stock assessment and note which have been addressed or initiated. Indicate which improvements should be made before the stock undergoes a benchmark assessment.

The research recommendations identified in the benchmark assessment (NEFSC 2019) remain relevant, particularly the research recommendations on enhanced collection of life history and biological information including paired scale-otolith samples, migration rates, and sex ratio data. Additional work on refining migration rates and stock composition estimates as well as incorporating tagging data into the spatial statistical catch-at-age model will be required before the next benchmark assessment; modeling work on this is underway through Virginia Tech and University of Maryland, the results of which should be available to incorporate into the 2027 benchmark assessment.

Given the uncertainty around removals in 2024, 2025, and subsequent years, the TC recommended prioritizing improvements in methods to estimate removals as a function of regulations, year-class strength, and, to the extent possible, angler behavior, during the next benchmark, to better predict future removals and improve projections.

Literature Cited

ASMFC. 2022. 2022 Atlantic Striped Bass Stock Assessment Update Report. Arlington, VA. 48 pp. Available here: https://asmfc.org/uploads/file/646d15d5AtlStripedBassAssessmentUpdate_Nov2022_SuppMay2023.pdf

Conn, P.B. 2010. Hierarchical analysis of multiple noisy abundance indices. Canadian Journal of Fisheries and Aquatic Sciences 67(1), 108-120.

Francis, R.I.C.C. 2011. Data weighting in statistical fisheries stock assessment models. Canadian Journal of Fisheries and Aquatic Sciences. 68(6): 1124-1138.

Northeast Fisheries Science Center (NEFSC). 2019. 66th Northeast Regional Stock Assessment Workshop (66th SAW) Assessment Report. US Dept. Commer., Northeast Fish. Sci. Cent. Ref. Doc. 19-08; 1170 p.

List of Appendices

TABLES

Table 1. Total removals by fleet in numbers of fish

Year	Bay Fleet	Ocean Fleet	Total Removals
1982	228,561	676,621	905,183
1983	337,753	709,655	1,047,408
1984	478,219	357,273	835,492
1985	71,726	853,576	925,301
1986	133,255	306,878	440,133
1987	61,787	231,254	293,041
1988	122,906	331,754	454,660
1989	139,941	519,632	659,573
1990	663,107	570,887	1,233,994
1991	793,117	927,558	1,720,675
1992	996,912	1,245,235	2,242,148
1993	947,652	1,088,687	2,036,339
1994	1,336,923	1,580,166	2,917,089
1995	1,984,773	3,045,596	5,030,369
1996	2,512,795	3,757,970	6,270,765
1997	3,155,158	4,234,674	7,389,832
1998	2,944,305	4,980,353	7,924,657
1999	3,192,950	4,870,978	8,063,929
2000	3,434,057	4,953,092	8,387,149
2001	2,594,109	5,184,562	7,778,672
2002	2,680,649	5,517,119	8,197,768
2003	3,333,218	5,531,943	8,865,161
2004	3,324,511	6,196,845	9,521,356
2005	2,976,513	6,136,660	9,113,172
2006	4,092,180	6,983,100	11,075,279
2007	3,163,519	5,131,913	8,295,432
2008	2,627,393	5,591,747	8,219,139
2009	3,149,853	4,879,861	8,029,714
2010	2,937,163	5,433,710	8,370,873
2011	2,519,531	5,038,365	7,557,897
2012	2,677,220	4,413,404	7,090,624
2013	2,756,433	5,754,209	8,510,642
2014	3,230,107	3,840,484	7,070,591
2015	2,786,524	3,313,254	6,099,778
2016	3,593,612	3,598,628	7,192,240
2017	2,497,355	4,553,408	7,050,763
2018	2,366,960	3,419,948	5,786,908
2019	2,116,191	3,342,474	5,458,665
2020	2,013,480	3,075,104	5,088,584
2021	1,639,919	3,508,423	5,148,342
2022	1,577,381	5,215,422	6,792,803
2023	1,418,439	4,163,671	5,582,110

Table 2. Summary of indices used in the striped bass stock assessment model.

Index Name	Index Metric	Design	Time of Year	Years	Age
MRIP Total Catch Rate Index	Total catch per unit effort	Stratified random	Mar-Dec	1982-2023	1+
Connecticut Long Island Sound Trawl Survey (CTLISTS)	Mean number per tow	Stratified random	Apr-Jun	1984-2023	1+
New York Ocean Haul Seine (NYOHS)	Geometric mean per haul	Fixed station	Sep-Oct	1987-2006	1+
New York Young-of-the-Year (NYYOY)	Geometric mean per haul	Fixed station	Jul-Nov	1985-2023	YOY
New York Western Long Island Beach Seine Survey (NY Age-1)	Geometric mean per haul	Fixed station	May-Aug	1984-2023	1
New Jersey Bottom Trawl Survey (NJTRL)	Stratified mean per tow	Stratified random	April	1990-2023	1+
New Jersey Young-of-the-Year Survey (NJYOY)	Geometric mean per haul	Fixed station	Aug-Oct	1982-2023	YOY
Delaware Spawning Stock Electrofishing Survey (DESSN)	Geometric mean per tow	Fixed station	Apr-Jun	1996-2023	1+
Delaware 30' Bottom Trawl Survey (DE30)	Geometric mean per tow	Fixed station	Nov-Dec	1990-2023	1+
Maryland Spawning Stock Survey (MDSSN)	Selectivity-corrected CPUE	Stratified random	Mar-May	1985-2023	1+
Maryland Young-of-the-Year and Yearlings Surveys (MDYOY and MD Age-1)	Geometric mean per haul	Fixed station	Jul-Sep	1954-2023	0-1
Virginia Young-of-the-Year Survey (VAYOY)	Geometric mean per haul	Fixed station	Jul-Sep	1980-2023	YOY
Chesapeake Bay Multispecies Monitoring and Assessment Program (ChesMMAP)	Stratified mean per tow	Stratified random	Mar-Nov	2002-2023	1+

Table 3. Model structure summary for the 2024 striped bass update.

Value(s)	
Years in Model	1982-2023
Size/Age Plus Group	15+
Fleets	2 (Bay and Ocean)
Selectivity blocks	Bay fleet: 1982-1984, 1985-1989, 1990-1995, 1996-2019, 2020-2023 Ocean fleet: 1982-1984, 1985-1989, 1990-1996, 1997-2019, 2020-2023

Table 4. Striped bass life history information used in the 2024 stock assessment update.

Age	Proportion Mature	Proportion Female	Natural Mortality
1	0	0.53	1.13
2	0	0.56	0.68
3	0	0.56	0.45
4	0.09	0.52	0.33
5	0.32	0.57	0.25
6	0.45	0.65	0.19
7	0.84	0.73	0.15
8	0.89	0.81	0.15
9	1	0.88	0.15
10	1	0.92	0.15
11	1	0.95	0.15
12	1	0.97	0.15
13	1	1	0.15
14	1	1	0.15
15+	1	1	0.15

Table 5. Population estimates from the 2024 striped bass assessment update.

Year	Full *F*	Recruitment (millions of age-1 fish)	Female SSB (mt)	Total Abundance (millions of fish)	Age 8+ Abundance (millions of fish)
1982	0.18	38.3	18,183	55.6	1.7
1983	0.15	77.3	15,260	99.6	1.5
1984	0.07	63.6	15,303	101.2	1.3
1985	0.20	69.3	15,889	110.8	1.4
1986	0.05	68.6	14,335	115.1	1.7
1987	0.03	73.9	17,833	124.1	1.9
1988	0.04	93.1	24,060	148.2	2.4
1989	0.05	107.2	36,685	171.8	3.3
1990	0.06	131.8	43,233	206.6	5.6
1991	0.09	105.3	51,104	193.9	6.8
1992	0.11	109.9	64,985	197.8	7.9
1993	0.09	134.8	73,416	224.9	8.4
1994	0.11	286.9	82,760	387.1	9.1
1995	0.21	187.6	89,513	342.0	10.0
1996	0.27	234.8	100,240	383.7	10.4
1997	0.20	259.5	95,367	423.6	10.7
1998	0.21	148.1	89,027	328.1	10.3
1999	0.19	153.1	88,543	306.5	10.0
2000	0.19	124.8	101,106	268.2	10.4
2001	0.19	196.9	104,898	325.2	14.3
2002	0.21	222.1	117,078	365.6	14.8
2003	0.22	127.9	118,927	285.5	16.0
2004	0.25	304.6	114,562	438.5	17.2
2005	0.24	158.2	113,787	337.3	15.0
2006	0.29	136.4	107,341	290.0	13.6
2007	0.22	89.2	105,029	223.5	11.4
2008	0.23	129.4	110,318	240.1	12.1
2009	0.22	76.4	108,198	187.1	13.1
2010	0.26	99.6	107,053	191.2	11.9
2011	0.27	128.6	99,623	216.6	14.4
2012	0.27	200.3	97,903	294.3	12.9
2013	0.36	68.9	87,353	188.3	11.3
2014	0.29	85.8	76,882	173.9	8.5
2015	0.25	157.1	67,520	237.1	7.8
2016	0.29	230.0	69,211	328.5	6.7
2017	0.32	111.2	62,436	240.9	6.1
2018	0.24	129.6	60,808	237.4	6.1
2019	0.21	164.8	62,544	270.7	7.9
2020	0.15	124.3	65,921	241.0	7.0
2021	0.16	86.7	69,791	196.4	7.2
2022	0.22	76.7	83,892	171.7	9.1
2023	0.18	94.9	86,536	177.9	11.6

Table 6. Updated biological reference points and 2023 estimates for *F* and female SSB compared with the estimates from the 2019 benchmark.

Metric	2019 Assessment Target	2019 Assessment Threshold	2024 Assessment Target	2024 Assessment Threshold	2023 Value
Fishing Mortality	0.20	0.24	0.17	0.21	0.18
Female SSB	114,295 mt (252 million lbs)	91,436 mt (202 million lbs)	111,892 mt (247 million lbs)	89,513 mt (197 million lbs)	86,536 mt (191 million lbs)

Table 7. **Progression of the 2015 year-class through the slot limit, 2021-2023.**

	2021	**2022**	**2023**
Ocean Slot limit	28-35”	28-35”	28-31” (mid-year)
2015 year-class age	6 years old	7 years old	8 years old
2015 year-class status	Most below slot	Within slot	Most above narrower slot
Fishing Mortality	0.16	0.22	0.18
Percent Change in F relative to 2021	--	+39%	+17%
Total Removals	5.15 million fish	6.79 million fish	5.58 million fish
Percent Change in Removals relative to 2021	--	+32%	+8%

Table 8. Potential progression of the 2018 year-class through the slot limit, 2024-2025.

	2024	**2025**
Ocean Slot limit	28-31”	(28-31”)
2018 year-class age	6 years old	7 years old
2018 year-class status	Below slot	Within current slot
Fishing Mortality	0.126 (low removals)	0.148 0.175
Percent Change in F relative to 2024	--	*Scenario 1:* +17% (same as 2021-2023) *Scenario 2:* +39% (same as 2021-2022)
Total Removals	3.89 million fish (low removals)	*Scenario 1:* 4.36 million fish *Scenario 2:* 5.10 million fish
Percent Change in Removals relative to 2024	--	*Scenario 1:* +12% *Scenario 2:* +31%
F rebuild	--	0.126
Removals under F rebuild	3.89 million fish	3.76 million fish

Table 9. Probability of SSB being at or above the SSB threshold or target under different constant *F* and estimated 2024 removals scenarios. Shaded row indicates 2029, the rebuilding deadline.

	High 2024 Removals Scenario				Low 2024 Removals Scenario			
Year	**F**	**Catch**	**Probability of being above the SSB threshold**	**Probability of being above the SSB target**	**F**	**Catch**	**Probability of being above the SSB threshold**	**Probability of being above the SSB target**
2024	0.20	5,862,189	34%	0%	0.13	3,890,793	37%	0%
2025	0.20	5,408,210	55%	0%	0.13	3,757,347	81%	2%
2026	0.20	5,153,984	61%	1%	0.13	3,646,236	96%	12%
2027	0.20	5,147,266	58%	1%	0.13	3,716,509	99%	30%
2028	0.20	5,350,692	47%	0%	0.13	3,885,103	100%	42%
2029	0.20	5,546,570	35%	0%	0.13	4,098,339	100%	50%
2030	0.20	5,689,808	24%	0%	0.13	4,235,455	100%	57%
2031	0.20	5,762,085	22%	0%	0.13	4,299,751	100%	64%
2032	0.20	5,824,269	19%	0%	0.13	4,361,570	100%	69%
2033	0.20	5,850,744	20%	0%	0.13	4,416,924	100%	73%
2034	0.20	5,863,982	22%	0%	0.13	4,432,941	100%	77%

Table 10. Probability of SSB being at or above the SSB target under different constant *F* scenarios if *F* increases in 2025. Shaded row indicates 2029, the rebuilding deadline.

	Low 2024 Removals Scenario							
	F=2023 Increase		*F*=2022 Increase		*F* Increase in 2025 Only		$F = F_{2024}$	
Year	F	Probability of being above the SSB target	F	Probability of being above the SSB target	F	Probability of being above the SSB target	F	Probability of being above the SSB target
2024	0.13	0%	0.13	0%	0.13	0%	0.13	0%
2025	0.15	2%	0.18	2%	0.15	2%	0.13	2%
2026	0.15	9%	0.18	5%	0.13	9%	0.13	12%
2027	0.15	16%	0.18	6%	0.13	24%	0.13	30%
2028	0.15	19%	0.18	5%	0.13	36%	0.13	42%
2029	0.15	19%	0.18	3%	0.13	43%	0.13	50%

FIGURES

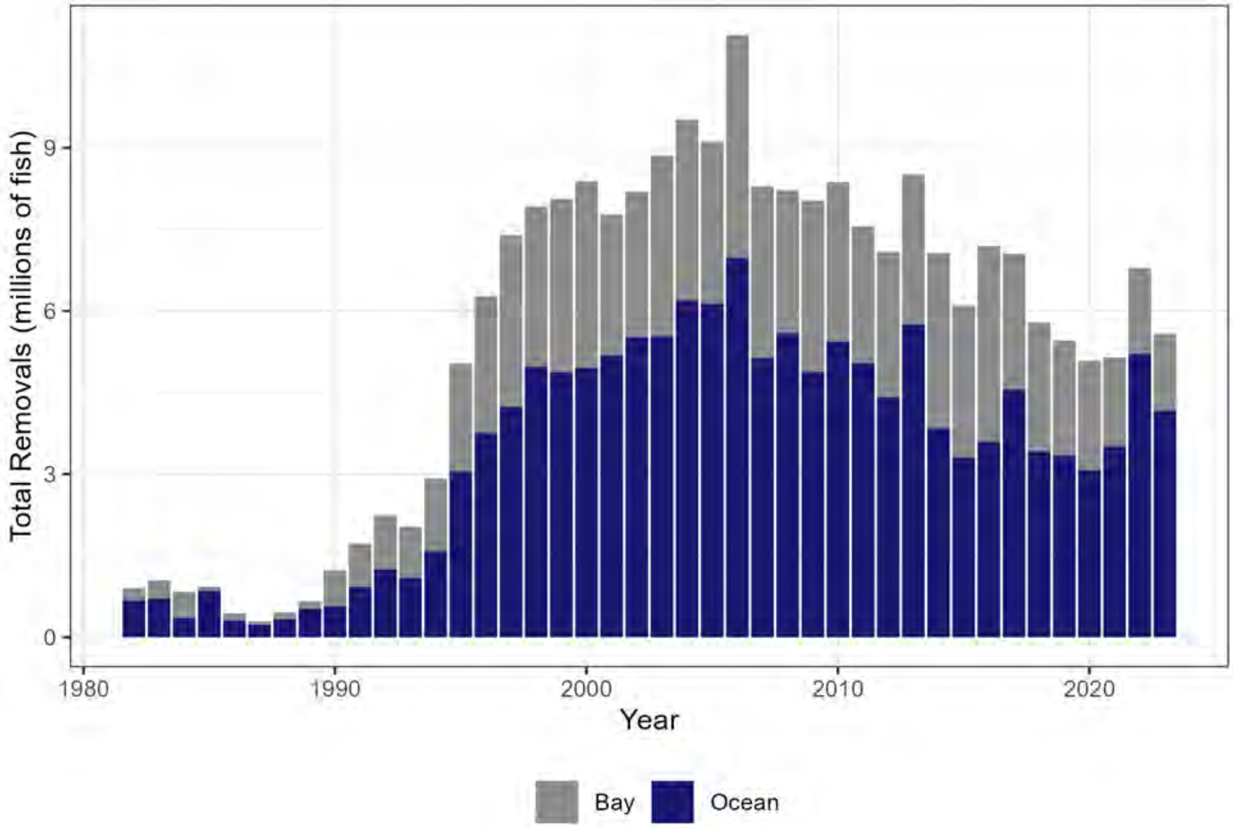


Figure 1. Total striped bass removals by fleet.

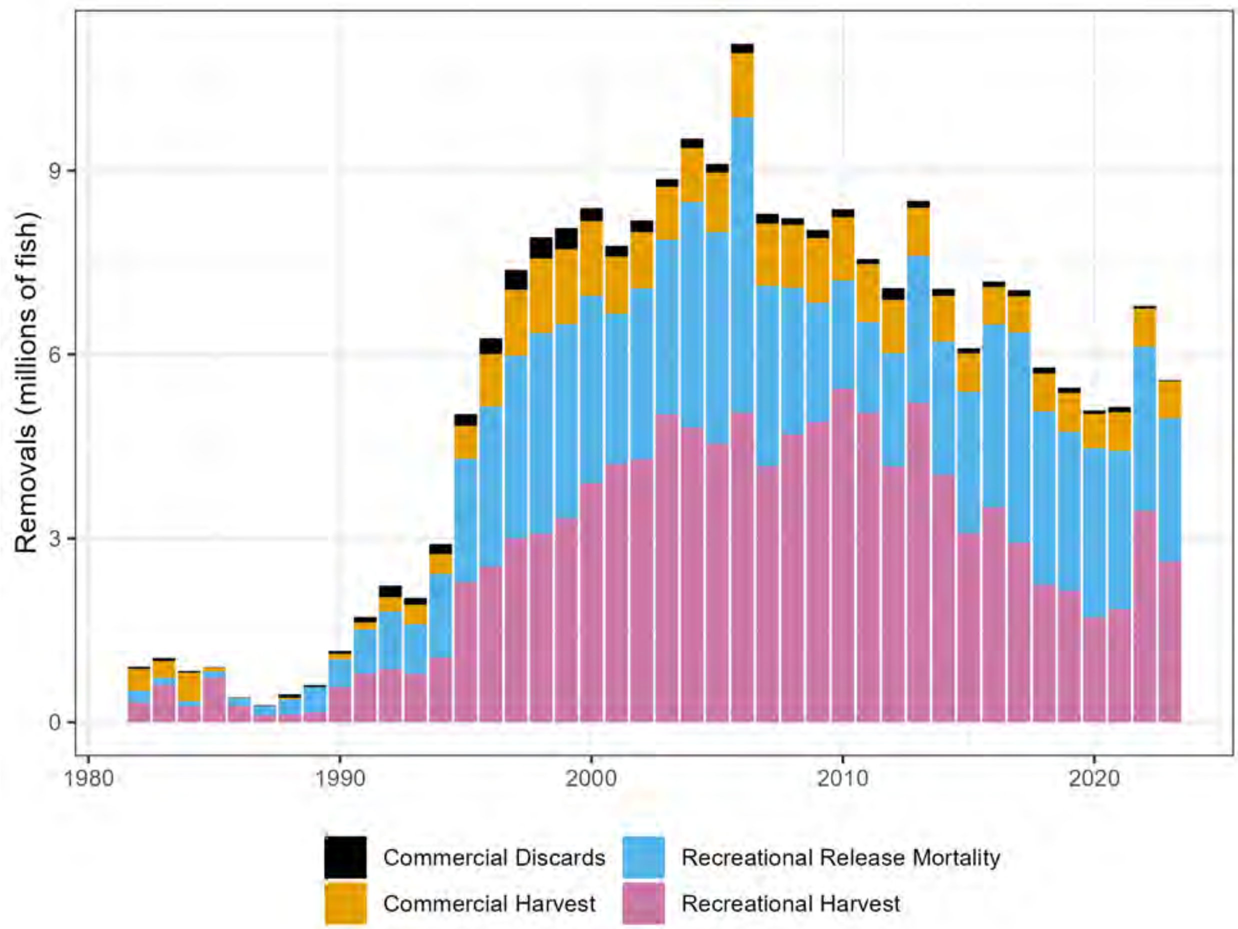


Figure 2. Total striped bass removal by sector, 1982-2023.

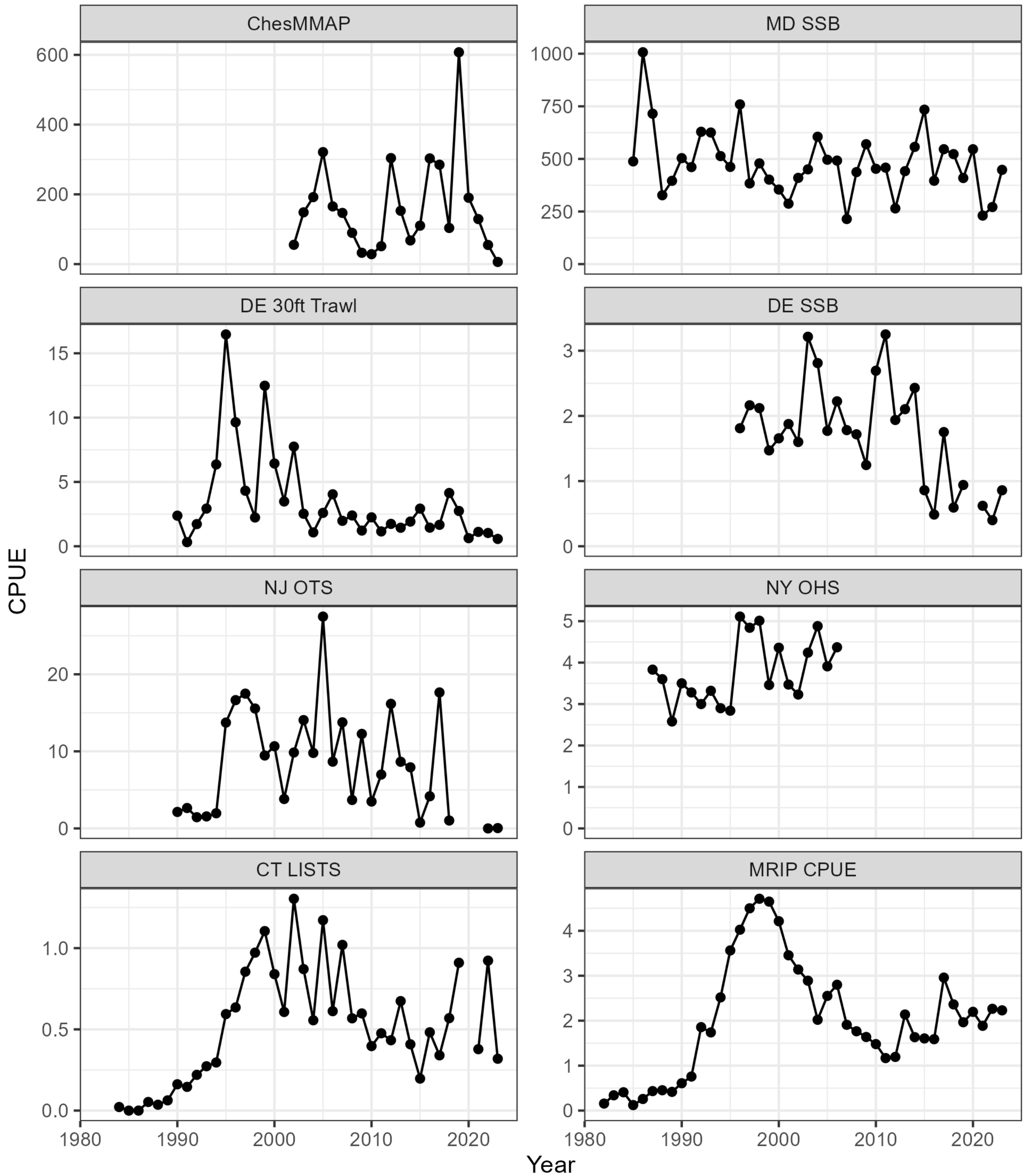


Figure 3. Indices of age-1+ abundance for striped bass, 1982-2023.

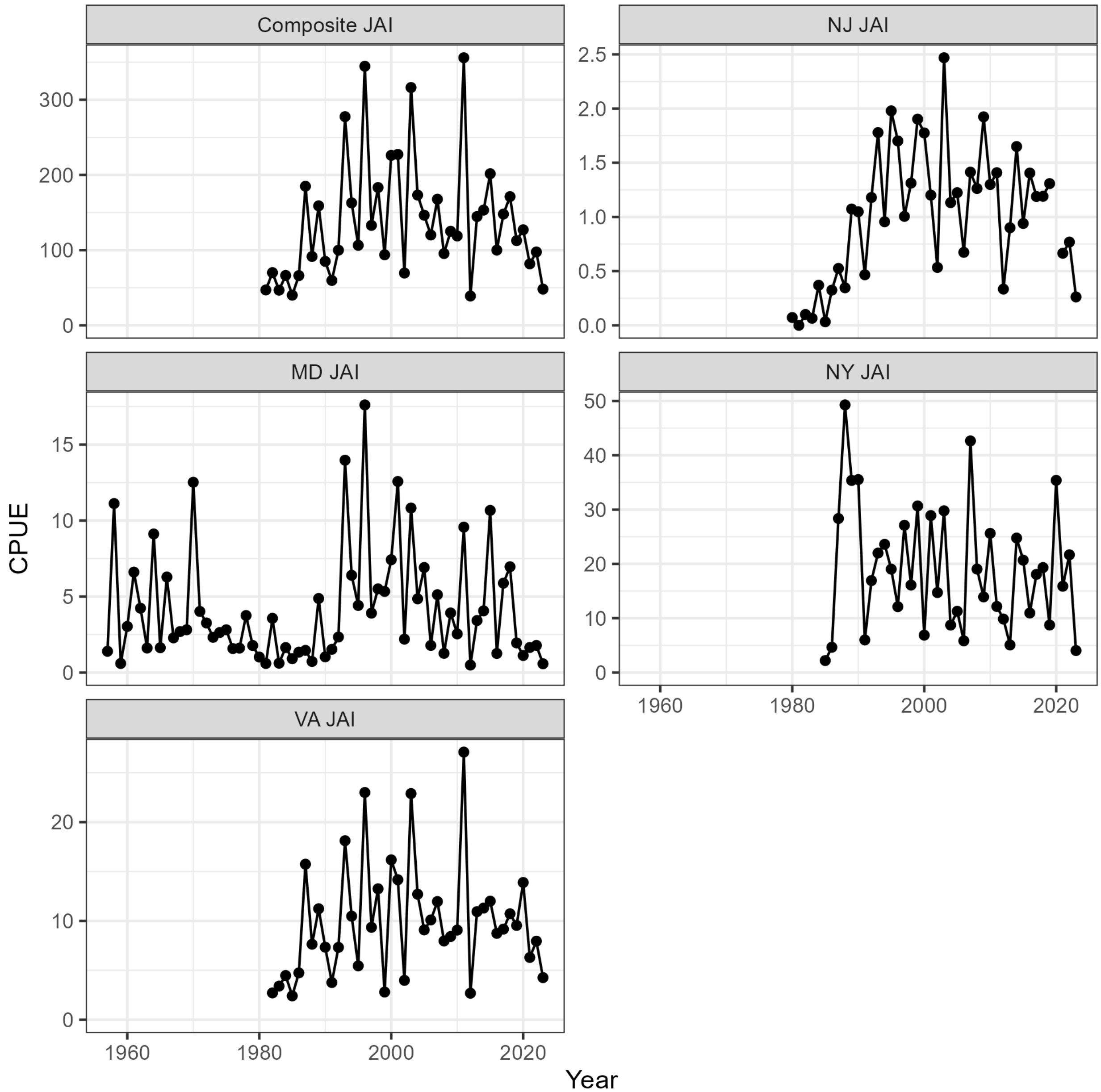


Figure 4. Striped bass juvenile abundance indices, including the composite Chesapeake Bay index (MD-VA), 1954-2023.

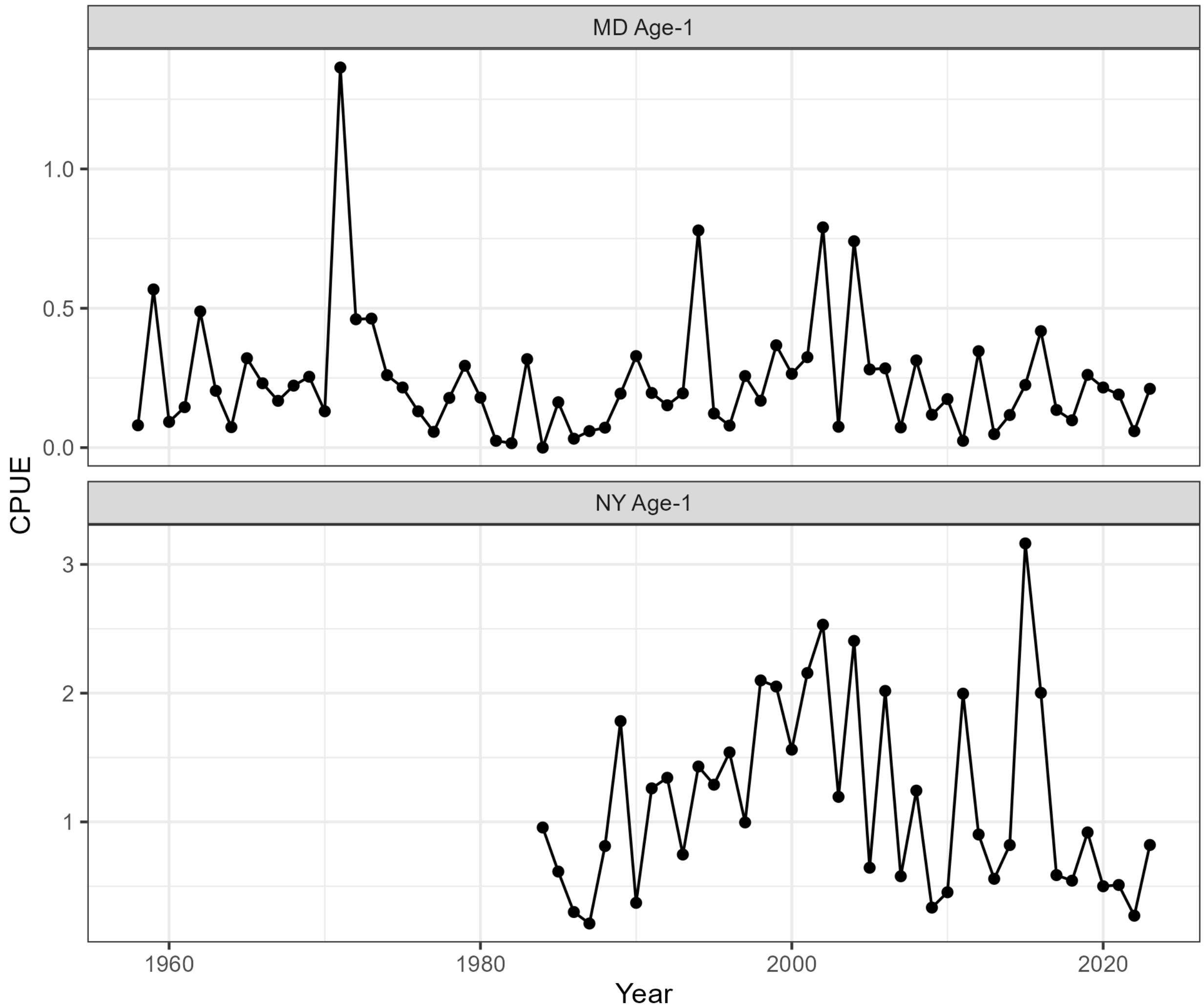


Figure 5. Age-1 recruitment indices for striped bass, 1954-2023.

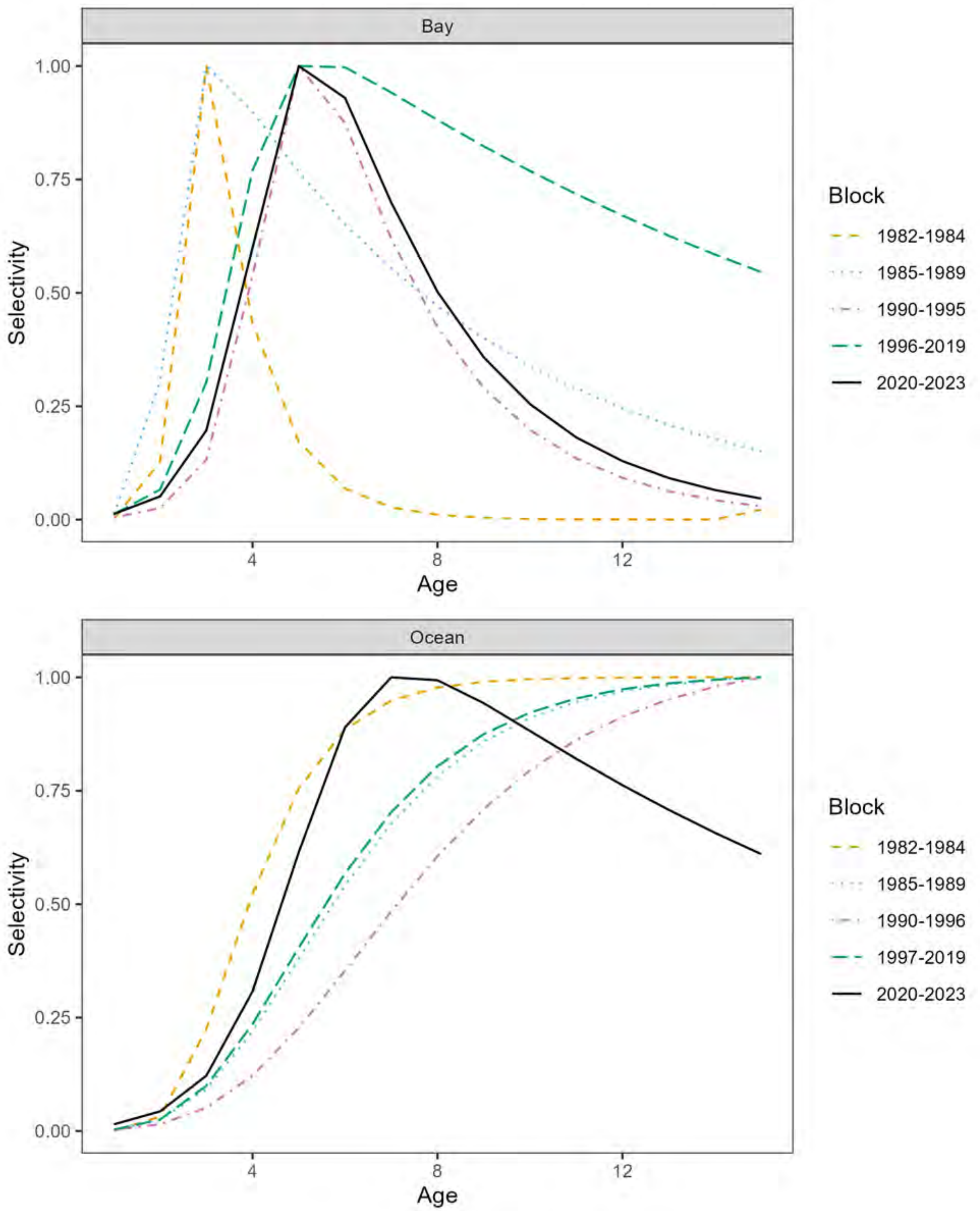


Figure 6. Selectivity patterns for the Bay fleet (top) and the Ocean fleet (bottom).

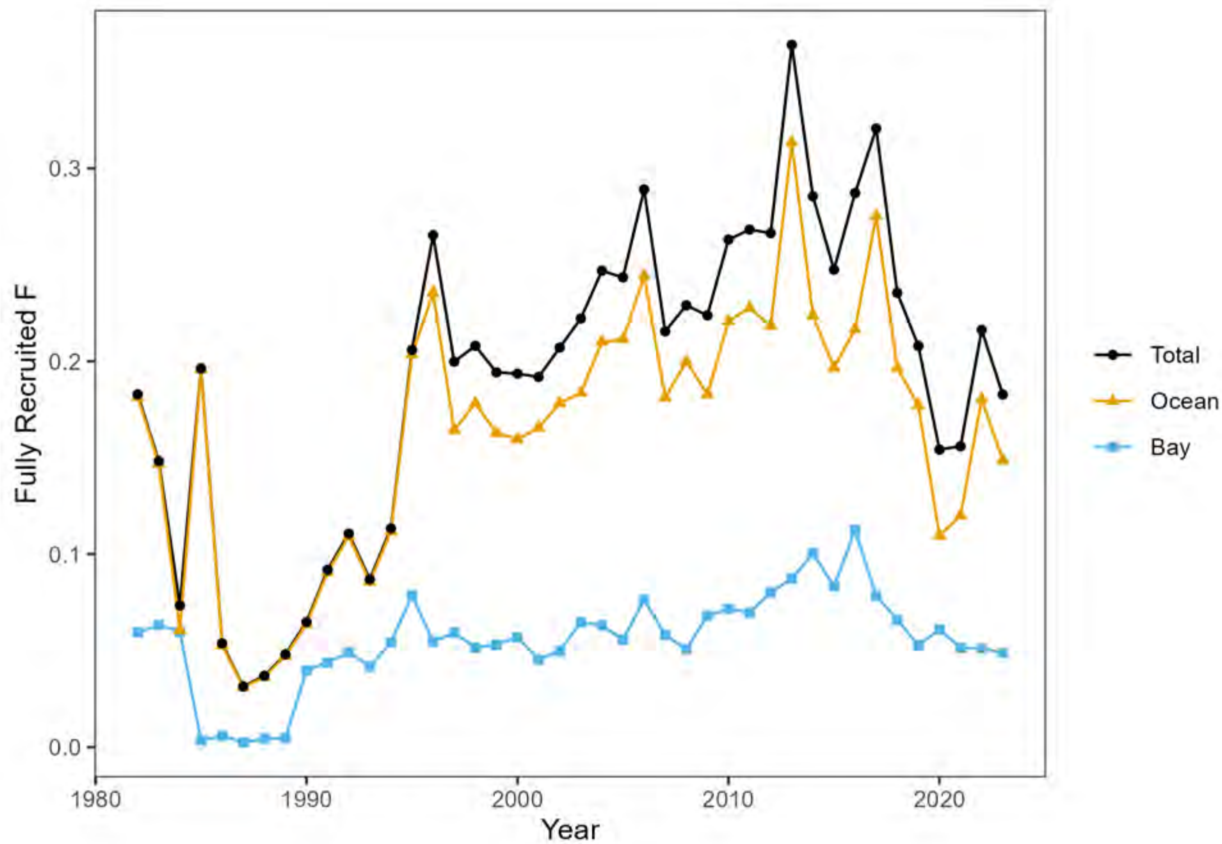


Figure 7. Fully recruited fishing mortality for the Bay and Ocean fleets plotted with the total fully recruited *F*.

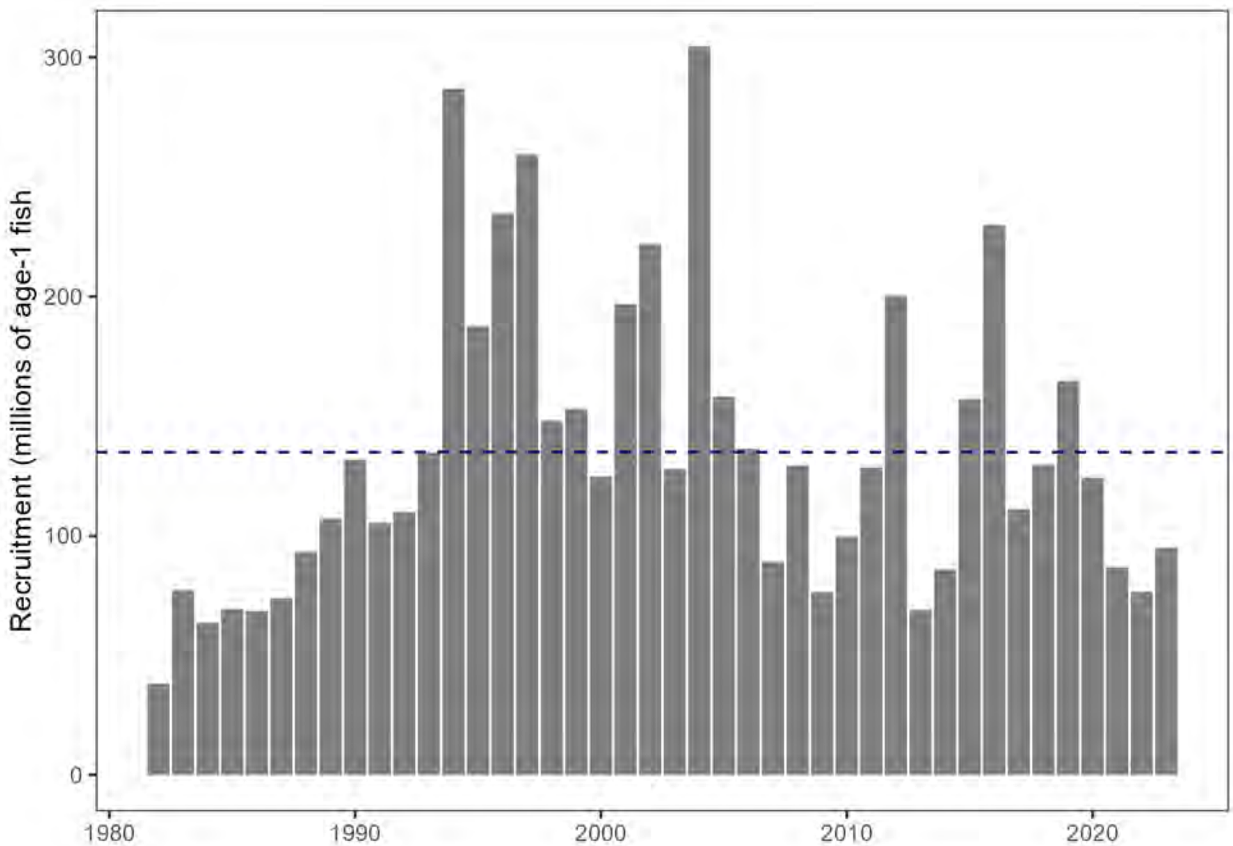


Figure 8. Estimates of striped bass recruitment plotted with the time series mean.

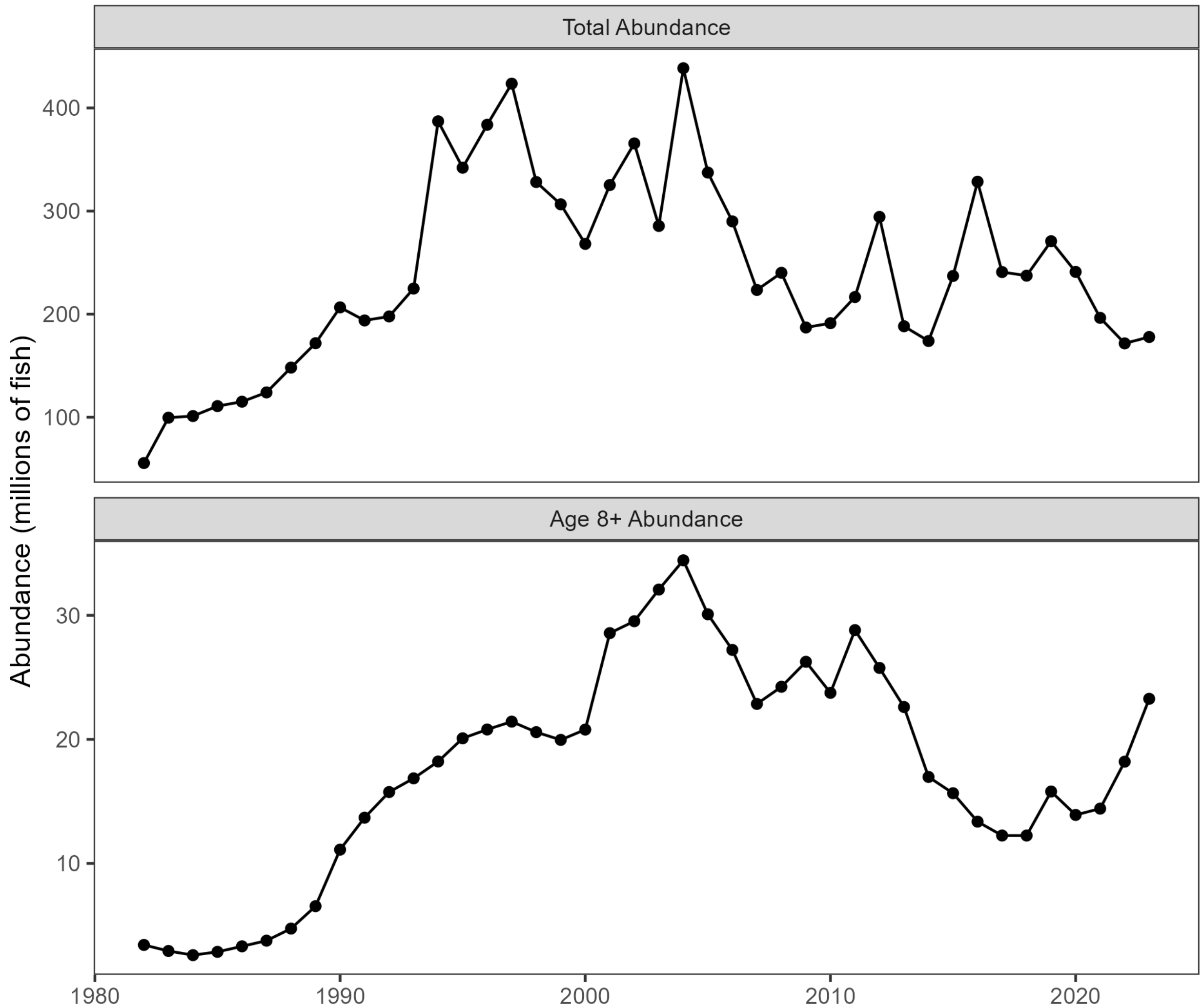


Figure 9. Total abundance (top) and age-8+ abundance (bottom) of striped bass over time.

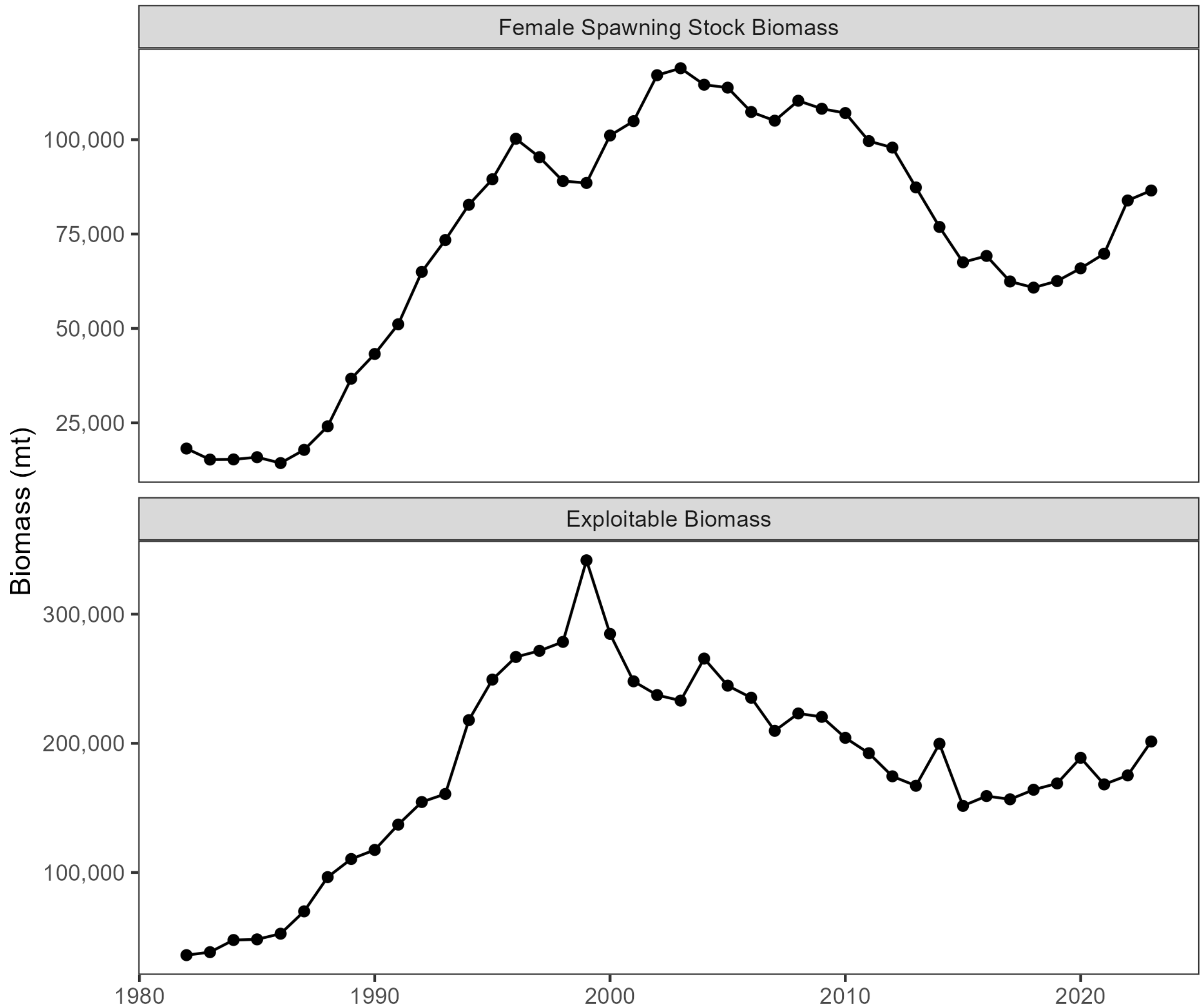


Figure 10. Female spawning stock biomass (top) and exploitable biomass (bottom) of striped bass over time.

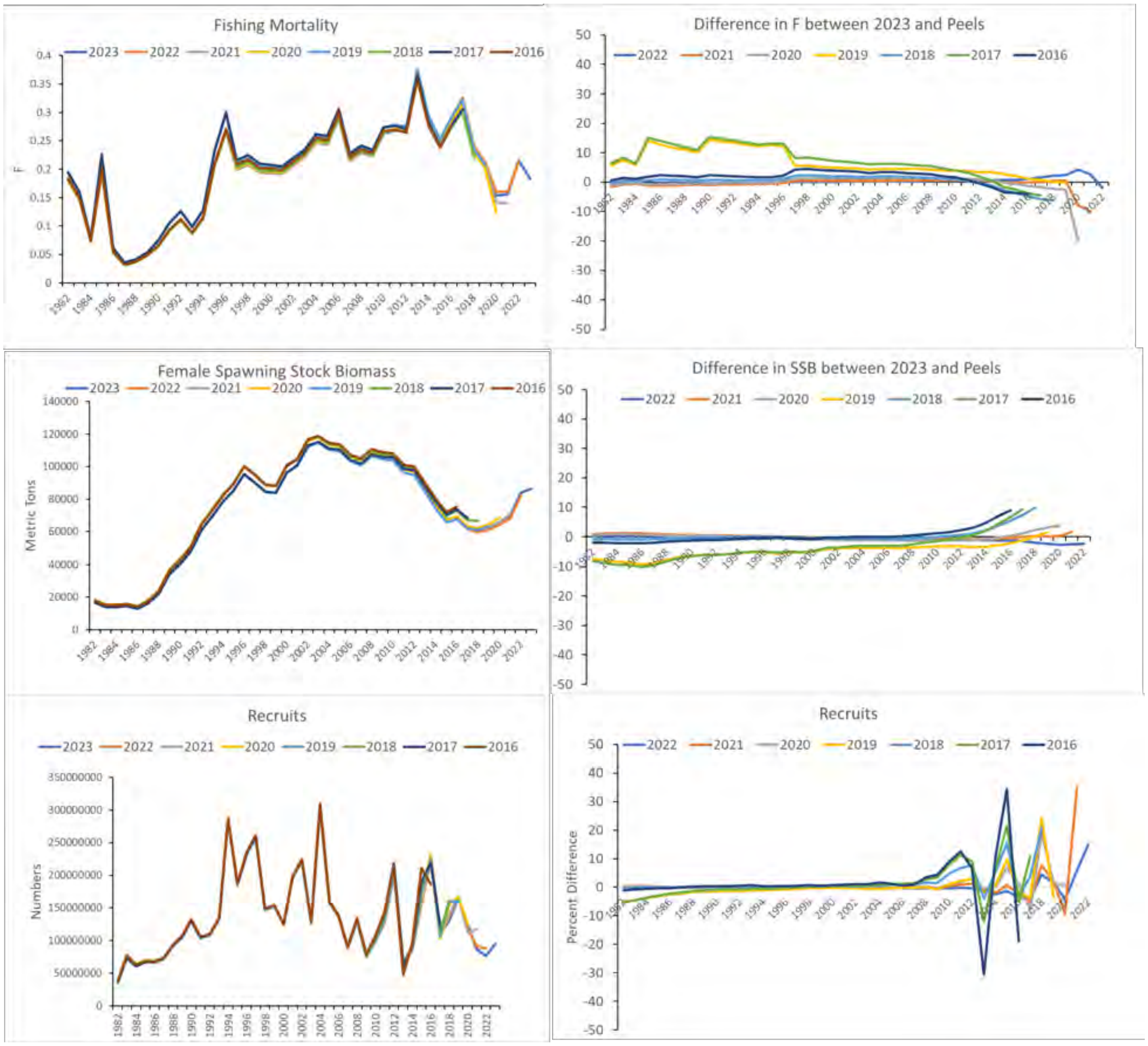


Figure 11. Retrospective plots of five-year peels for fishing mortality (top), female spawning stock biomass (middle), and recruitment (bottom).

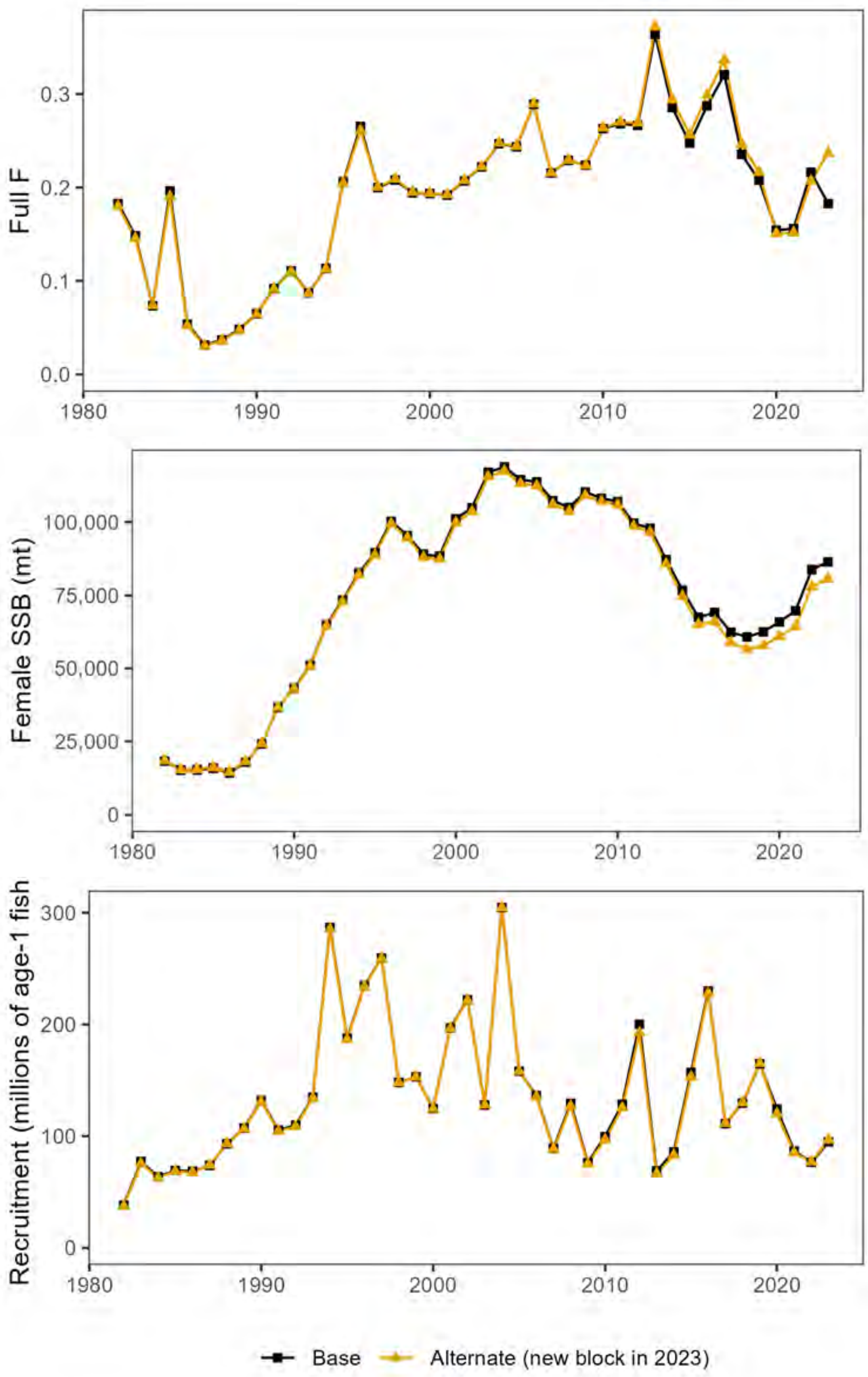


Figure 12. Comparison of fully-recruited fishing mortality (top), female SSB (middle) and recruitment (bottom) from the update assessment base model and sensitivity run with a new 2023 selectivity block for both fleets.

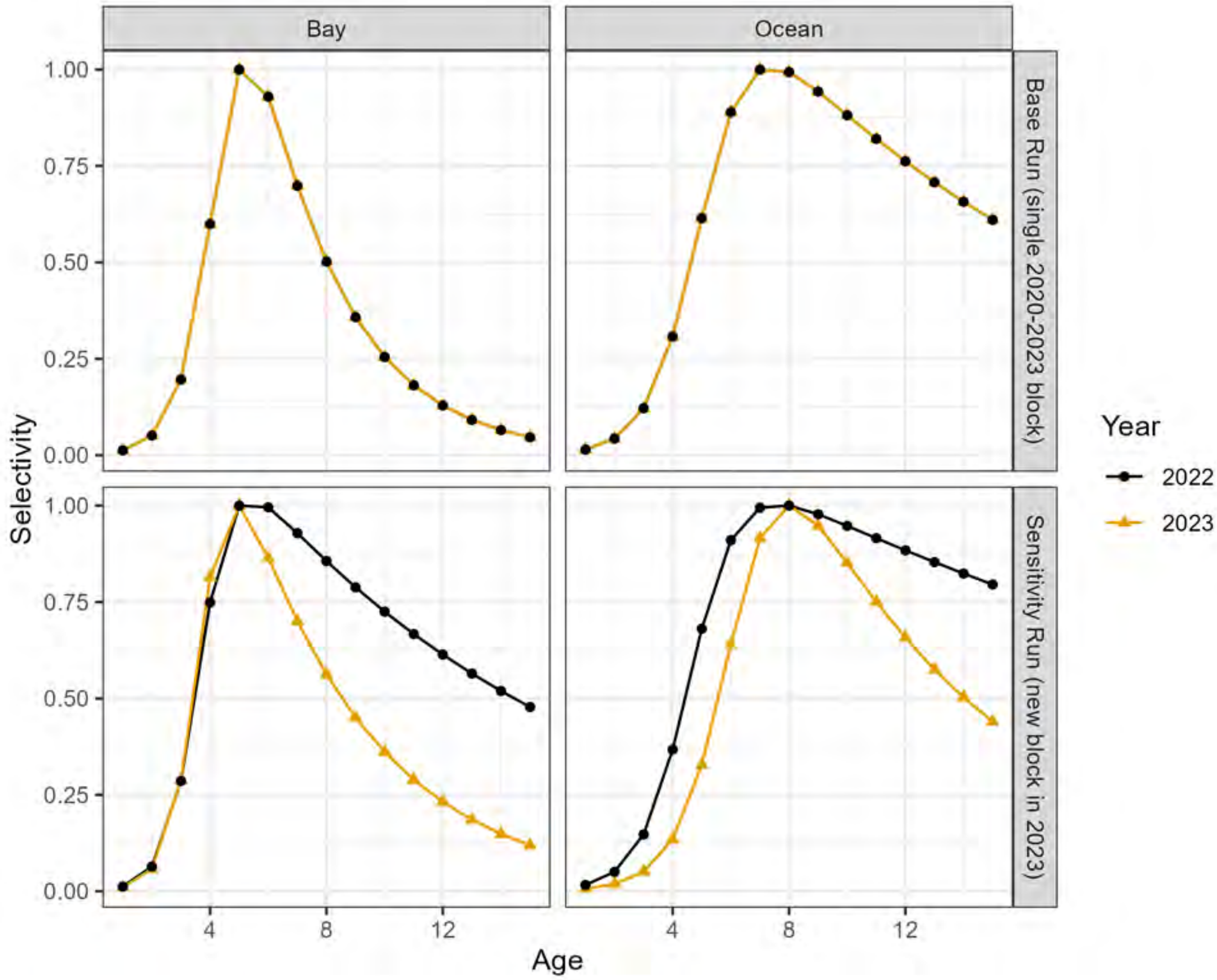


Figure 13. Selectivity curves for 2022 and 2023 for the Bay and Ocean fleets from the base run with a single 2020-2023 block (top row) and the sensitivity run with a new block in 2023 (bottom row).

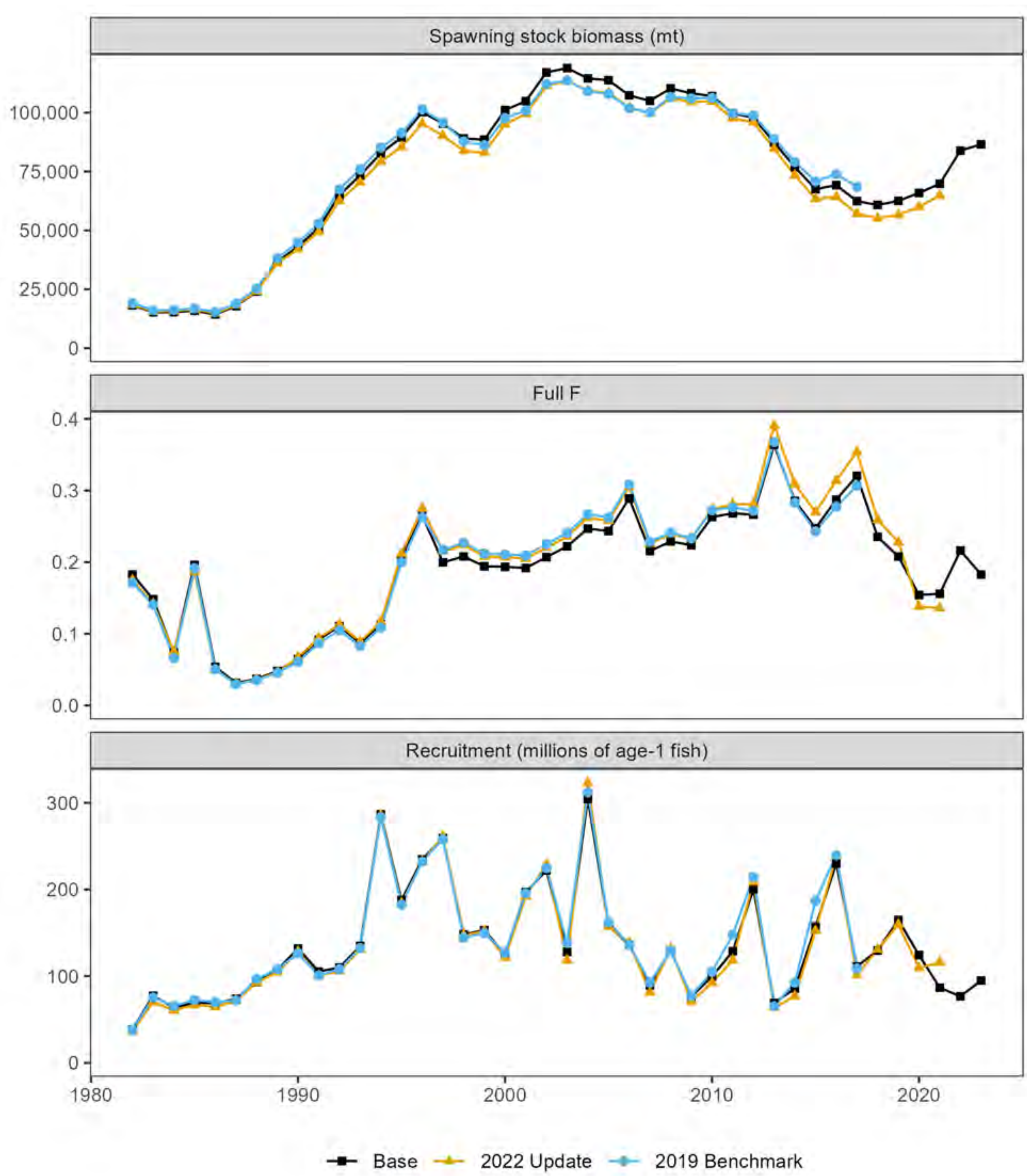


Figure 14. Comparison of estimates of female spawning stock biomass (top), total fishing mortality (middle), and recruitment (bottom) from the 2019 benchmark assessment, the 2022 assessment update, and the current assessment update.

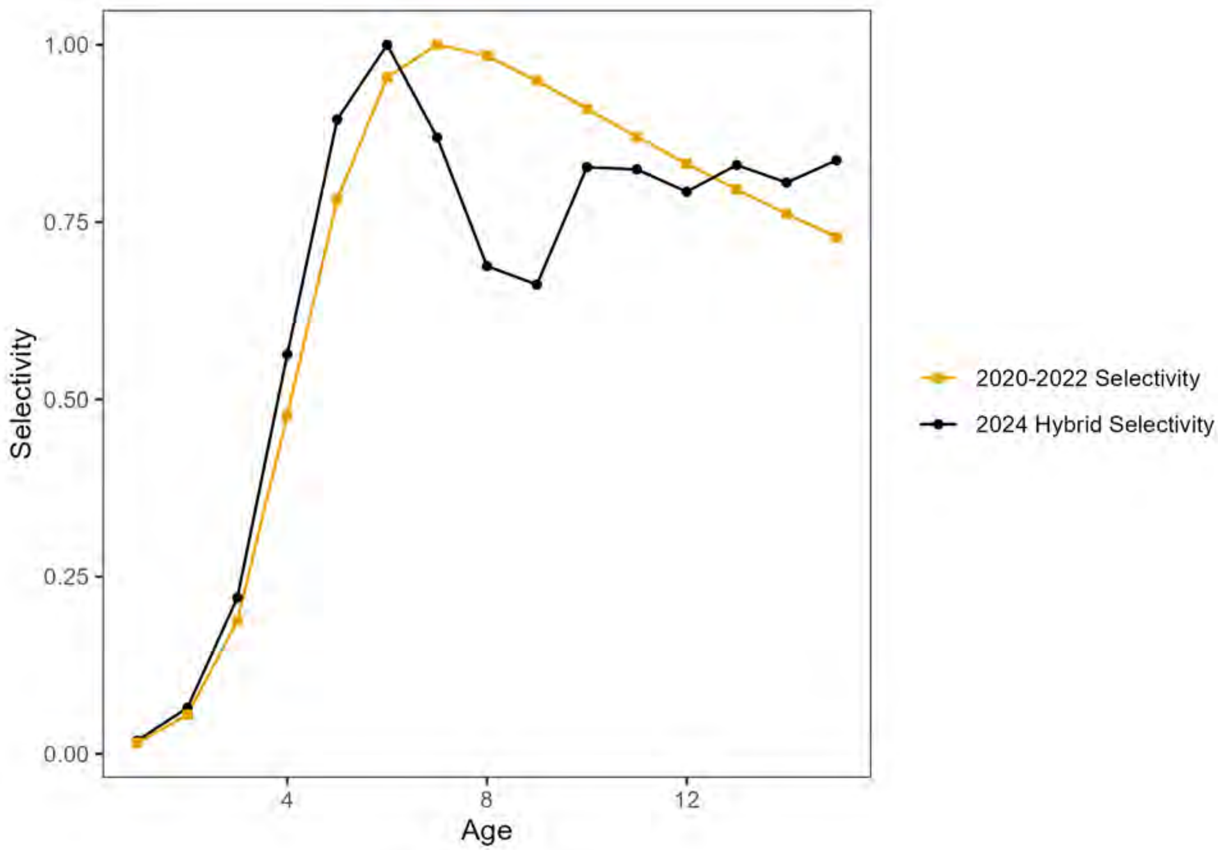


Figure 15. Hybrid selectivity pattern based on 2024 regulations used in the reference point calculations and rebuilding projections plotted with the 2020-2022 selectivity curve.

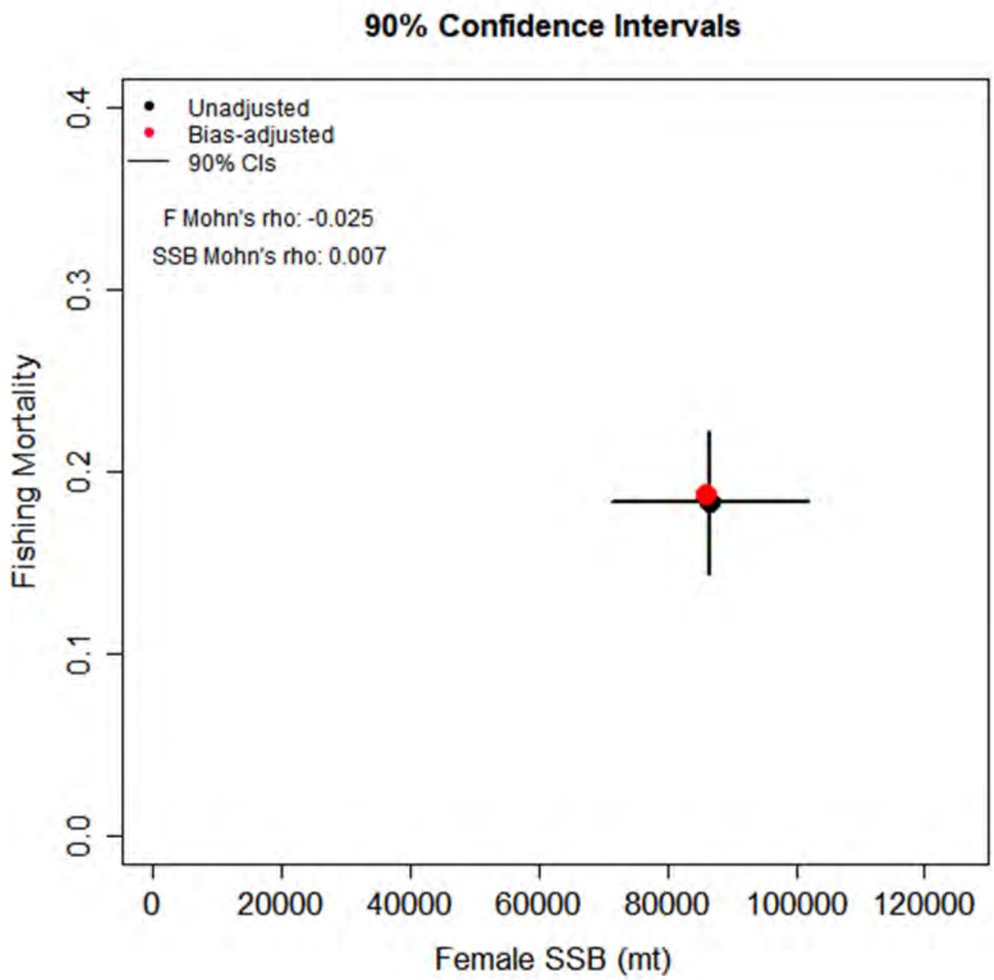


Figure 16. Plot comparing the 2023 retrospective-adjusted *F* and female SSB values with the unadjusted *F* and SSB estimates and their associated 90% confidence intervals.

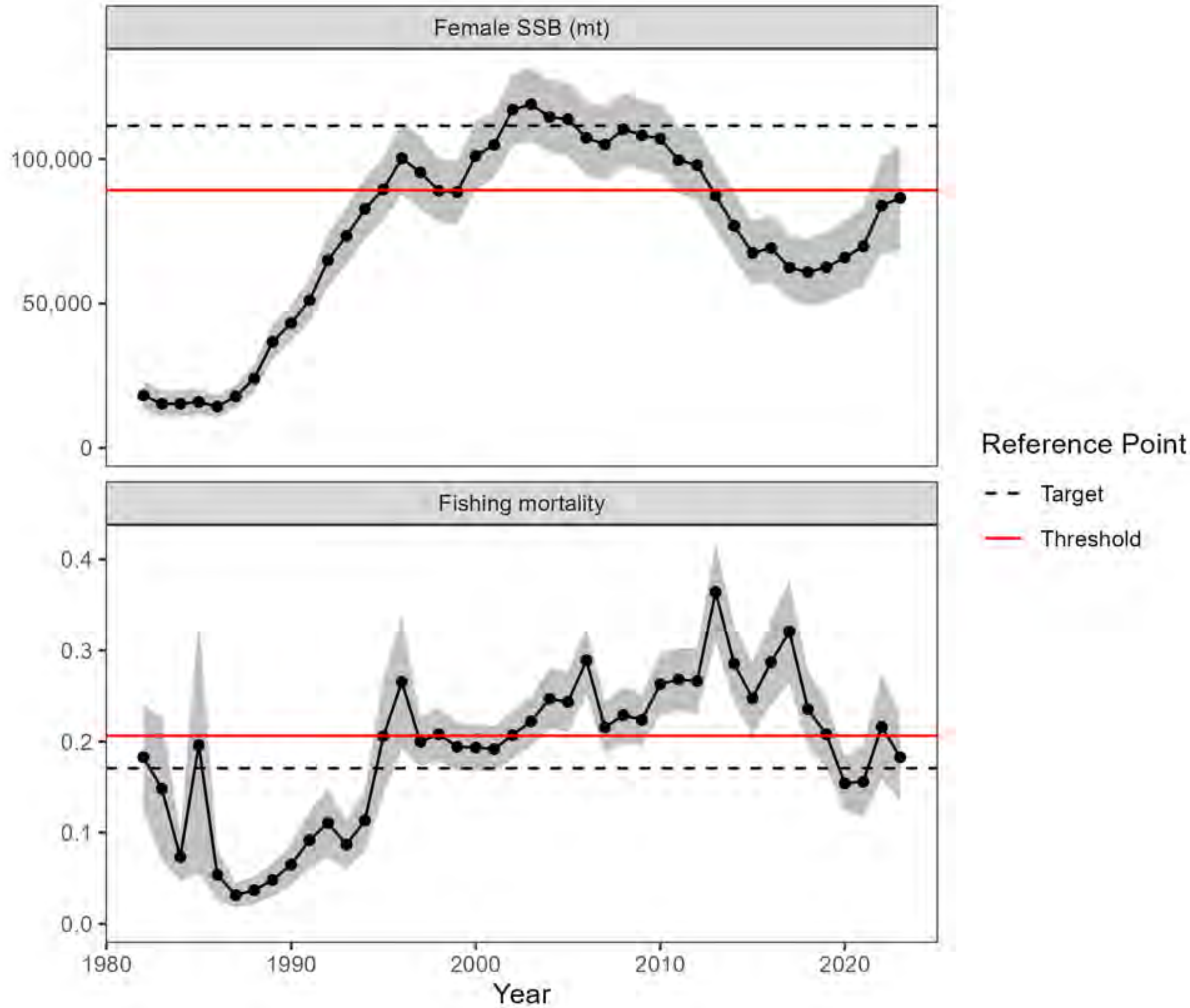


Figure 17. Female SSB (top) and total F estimates (bottom) plotted with their respective targets and thresholds. Shaded area indicates 95% confidence intervals of the estimates.

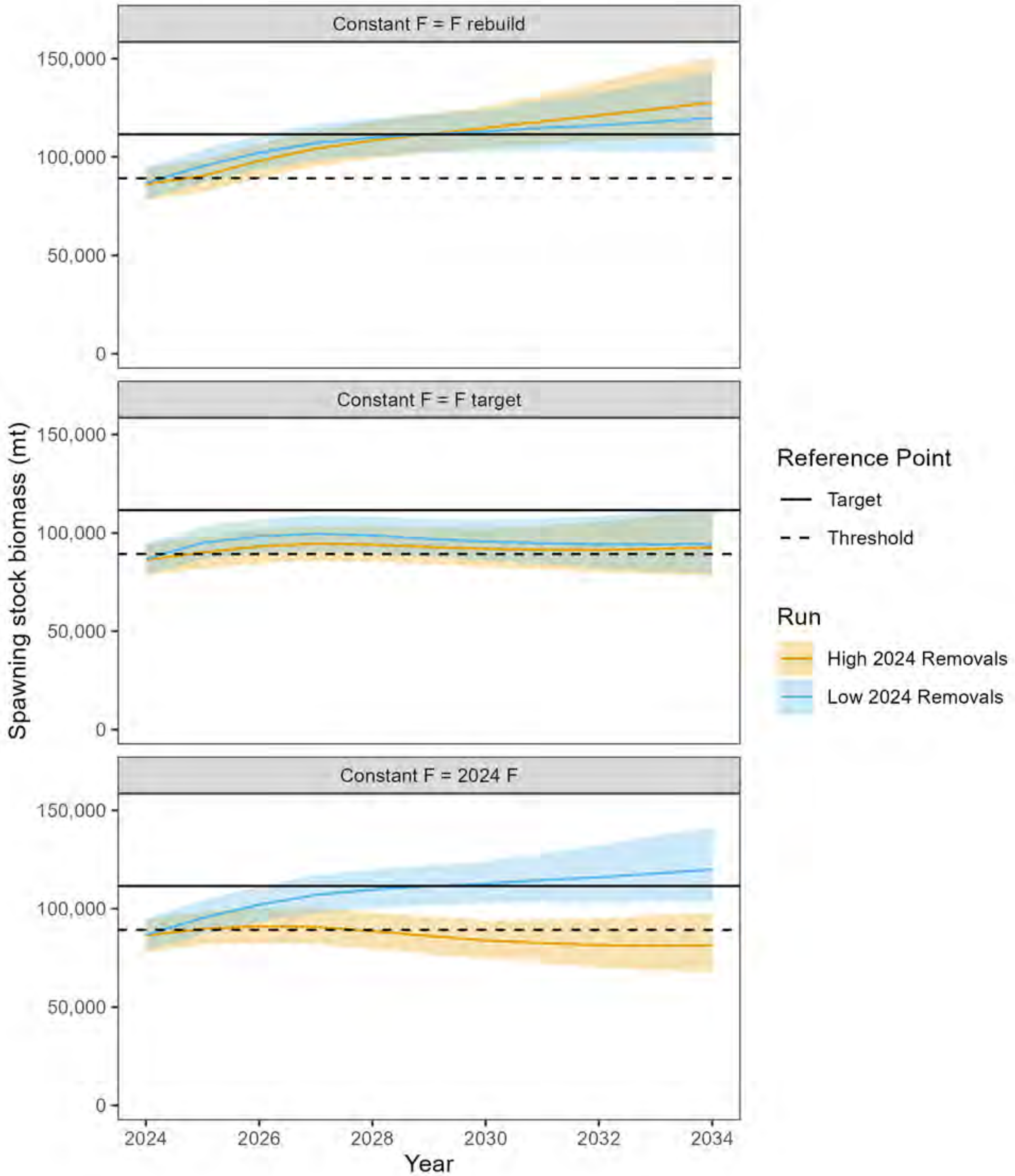


Figure 18. Projections of female spawning stock biomass through 2034 under constant $F_{rebuild}$ (top), F_{target} (middle), and estimated 2024 *F* (bottom) under different 2024 removal scenarios.

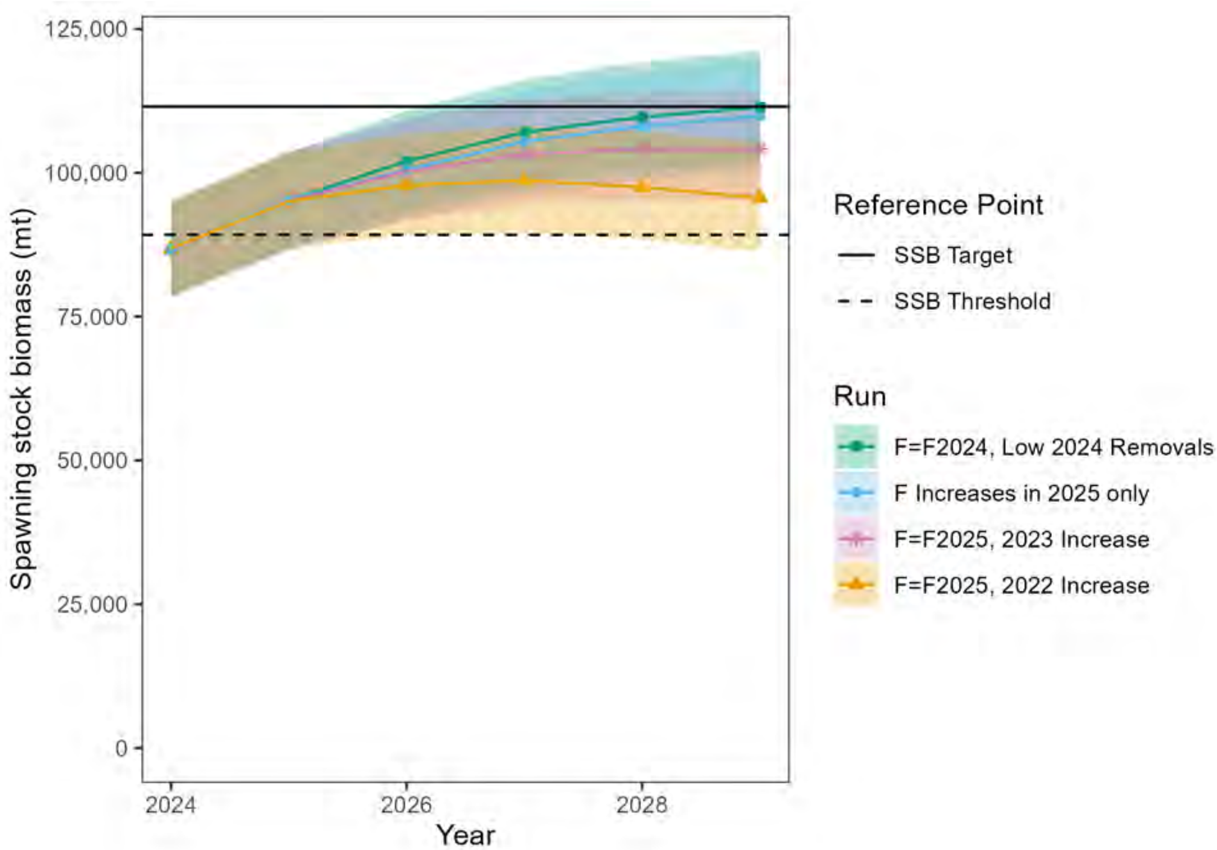


Figure 19. Projections of female spawning stock biomass through 2029 under different future *F* scenarios: assuming *F* stays the same as in 2024 under the low removals scenario (*F=F 2024)*, increases at a rate comparable to what was observed in 2022 (*F=F 2025, 2022 Increase)* or 2023 (*F=F2025, 2023 Increase)*, or increases in 2025 only and then returns to 2024 levels.

Appendix 1
Model Structure

General Definitions	Symbol	Description/Definition
Year Index	y	y = {1982,..,2021} for catch. y = {1970,..,2021} for indices.
Age Index	a	a = {1,..,15+}
Fleet Index	f	f = {1: Chesapeake Bay, 2: Coast }
Indices Index:	t	t = {1,..,14}
Input Data	**Symbol**	**Description/Definition**
Observed Fleet Catch	$C_{f,y}$	Reported number of striped bass killed each year (y) by fleet (f)
Coefficient of Variation for Fleets	$CV_{f,y}$	Calculated from MRIP harvest and releases estimates with associated proportional standard errors (commercial harvest from census – no error)
Observed Fleet Age Compositions	$P_{f,y,a}$	Proportion-at-age (a) for each year (y) and fleet (f)
Observed Total Indices of Relative Abundance	$I_{t,y}$	Reported by various states. YOY and Age 1 Indices: 6 Indices with Age Composition: 8 (one fisheries-dependent, 7 fishery-independent)
Coefficient of Variation for Indices	$CV_{t,y}$	Calculated from indices and associated standard errors
Observed Age Compositions of Indices of Relative Abundance	$P_{t,y,a}$	Proportion-at-age (a) for each year (y) and index (t)
Effective Sample Size	$\hat{\hat{n}}$	Starting Values from 2018 Benchmark Fleets: Bay – 68.4, Ocean – 71 Indices: NYOHS – 21.4, NJ Trawl – 5.2, MDSSN – 16.8, DESSN – 19.7, MRIP – 35.6, CTLIST – 12.4, DE30FT – 7.3, ChesMap – 10.7 The multiplier from equation 1.8 method of Francis (2011) is used to adjust the starting values.

Population Model	Symbol	Equation
Age-1 numbers	$\hat{N}_{y,1}$	$\hat{N}_{y,1} = \bar{N}_1 e^{\hat{\varepsilon}_y - 0.5\sigma_R^2}$ $\hat{\sigma}_R = \sqrt{\frac{\sum_y(\hat{\varepsilon}_y - \hat{\bar{\varepsilon}})^2}{n-1}}$ where ε_y are independent and identically distributed normal random variables with zero mean and constant variance and are constrained to sum to zero over all years
Abundance-at-Age	$\hat{N}_{y,a}$	First year (ages 2-A in 1970): $\hat{N}_{y,a} = \hat{N}_{y,a-1} \exp^{-\hat{F}_{1982,a-1} - M_{1982,a-1}}$ Rest of years (ages 2-15): $\hat{N}_{y,a} = \hat{N}_{y-1,a-1} \exp^{-\hat{F}_{y-1,a-1} - M_{y-1,a-1}}$
Plus-group abundance-at-age	$\hat{N}_{y,A}$	$\hat{N}_{y,A} = \hat{N}_{y-1,A-1} \exp^{-\hat{F}_{y-1,A-1} - M_{y-1,A-1}} + \hat{N}_{y-1,A} \exp^{-\hat{F}_{y-1,A} - M_{y-1,A}}$
Fishing Mortality	$\hat{F}_{f,y,a}$	$\hat{F}_{f,y,a} = \hat{F}_{f,y} \cdot \hat{s}_{f,a}$ where $F_{f,y}$ and $s_{f,a}$ are estimated parameters
Total Mortality	$\hat{Z}_{y,a}$	$Z_{y,a} = F_{y,a} + M_{y,a}$
Fleet Selectivity Time Blocks and Selectivity Equations	$\hat{s}_{f,a}$	Fleet 1 (Chespeake Bay): 1982-1984, 1985-1989, 1990-1995, 1996-2019, 2020-2021 $\hat{s}_a = \frac{1}{1-\hat{\gamma}} \cdot \left(\frac{1-\hat{\gamma}}{\hat{\gamma}}\right)^{\hat{\gamma}} \frac{\exp^{\hat{\alpha}\hat{\gamma}(\hat{\beta}-a)}}{1+\exp^{\hat{\alpha}(\hat{\beta}-a)}}$ Fleet 2 (Ocean): 1982-1984, 1985-1989,1990-1996,1997-2019, 2020-2021 $\hat{s}_a = \exp^{(-\exp^{-\hat{\beta}(a-\hat{\alpha})})}$
Predicted Catch-At-Age	$\hat{C}_{f,y,a}$	$\hat{C}_{f,y,a} = \frac{\hat{F}_{f,y,a}}{\hat{F}_{f,y,a} + M_{y,a}} \cdot (1 - \exp^{-\hat{F}_{y,a} - M_{y,a}}) \cdot \hat{N}_{y,a}$

Population Model	Symbol	Equation
Predicted Total Catch	$\hat{C}_{f,y}$	$\hat{C}_{f,y} = \sum_{a} \hat{C}_{f,y,a}$
Predicted Proportions of Catch-At-Age	$\hat{P}_{f,y,a}$	$\hat{P}_{f,y,a} = \frac{\hat{C}_{f,y,a}}{\sum_{a} \hat{C}_{f,y,a}}$
Predicted Aggregated Indices of Relative Abundance	$\hat{I}_{t,y,\sum a}$	$\hat{I}_{t,y,\Sigma a} = \hat{q}_t \cdot \sum_{a} \hat{N}_{y,a} \cdot \exp^{-p_t \cdot Z_{y,a}}$ where q_t is the estimated catchability coefficient of index t and p_t is the fraction of the year when the survey takes place.
Predicted Age-Specific Indices of Relative Abundance	$\hat{I}_{t,y,a}$	$\hat{I}_{t,y,a} = \hat{q}_t \cdot \hat{s}_{t,a} \cdot \hat{N}_{y,a} \cdot exp^{-p_t \cdot \hat{Z}_{y,a}}$ where $\hat{s}_{t,a}$ is the selectivity-at-age a for index t
Predicted Total Indices of Relative Abundance with Age Composition Data	$\hat{I}_{t,y}$	$\hat{I}_{t,y} = \hat{q}_t \sum_{a} \hat{s}_{t,a} \cdot \hat{N}_{y,a} \cdot \exp^{-p_t \cdot \hat{Z}_{y,a}}$
Predicted Age Composition of Survey	$\hat{U}_{t,y,a}$	$\hat{U}_{t,y,a} = \frac{\hat{I}_{t,y,a}}{\sum_{a} \hat{I}_{t,y,a}}$
Female Spawning Stock Biomass (metric tons)	SSB_y	$SSB_y = \sum_{a=1}^{A} N_{y,a} \cdot sr_a \cdot m_a \cdot w_{y,a}/1000$ where sr_a is the female sex ratio at age a and m_a is female maturity at age a.

Likelihood	Symbol	Equation
Concentrated Lognormal Likelihood for Fleet Catch (F) and Indices of Relative Abundance (T)	$-L_F$; $-L_T$	$-L_F = 0.5 * \sum_f n_f * ln\left(\frac{\sum_f RSS_f}{\sum_f n_f}\right)$ $-L_T = 0.5 * \sum_t n_t * ln\left(\frac{\sum_t RSS_t}{\sum_t n_t}\right)$ where $RSS_f = \lambda_f \sum_y \left(\frac{ln(C_{f,y} + 0.00001) - ln(\hat{C}_{f,y} + 0.00001)}{\delta_f \cdot CV_{f,y}}\right)^2$ $RSS_t = \lambda_t \sum_y \left(\frac{ln(I_{t,y} + 0.00001) - ln(\hat{I}_{t,y} + 0.00001)}{\delta_t \cdot CV_{t,y}}\right)^2$ *ln* is the natural log. $CV_{f,y}$ and $CV_{t,y}$ are the annual coefficient of variation for the observed total catch (f) and index (t) in year *y*, δ_f and δ_t is the CV weights for total catch *f* and index *t* , and λ_t and λ_f are relative weights.
Multinomial fleet catch (FC) and index (TC) age compositions	$-L_{FC}$; $-L_{TC}$	$-L_{FC} = \lambda_f \sum_y -n_{f,y} \sum_a P_{f,y,a} \cdot ln(\hat{P}_{f,y,a} + 0.0000001)$ $-L_{TC} = \lambda_t \sum_y -n_{t,y} \sum_a U_{t,y,a} \cdot ln(\hat{U}_{t,y,a} + 0.0000001)$ where λ_f and λ_t are a user-defined weighting factors and n_y are the effective sample sizes.
Constraints Added To Total Likelihood	P_{n1}, P_{rdev}, P_{fadd}	$P_{n1} = \lambda_{n1}(\hat{N}_{y,1} - N^e_{y,1})^2$ - forces $N_{1,1}$ to follow S-R curve $P_{rdev} = \lambda_R \sum_y log_e(\hat{\sigma}_R) + \frac{\hat{\varepsilon}_y^2}{2\hat{\sigma}_R^2}$ - for bias correction to constrain deviations $P_{f_{add}} = \begin{cases} \text{phase} < 3, & 10 \cdot \sum_y (F_{f,y} - 0.15)^2 \\ \text{phase} \geq 3, & 0.000001 \cdot \sum_y (F_{f,y} - 0.15)^2 \end{cases}$ - avoid small F values at start

Diagnostics	Symbol	Equation
Standardized residuals (lognormal – catch and surveys)	$r_{f,y,a}$ or $r_{t,y,a}$	$$r_{t,y} = \frac{\ln I_{t,y} - \widehat{\ln I_{t,y}}}{\sqrt{\ln((\delta_t CV_{t,y})^2 + 1)}}$$ $$r_{f,y} = \frac{\ln C_{f,y} - \widehat{\ln C_{f,y}}}{\sqrt{\ln(CV_{f,y}^2 + 1)}}$$
Standardized residuals (age compositions – catch and surveys)	$ra_{f,y,a}$ or $ra_{t,y,a}$	$$ra_{f,y,a} = \frac{P_{f,y,a} - \hat{P}_{f,y,a}}{\sqrt{\frac{\hat{P}_{f,y,a}(1-\hat{P}_{f,y,a})}{\hat{\bar{n}}_f}}}$$ $$ra_{t,y,a} = \frac{P_{t,y,a} - \hat{P}_{t,y,a}}{\sqrt{\frac{\hat{P}_{t,y,a}(1-\hat{P}_{t,y,a})}{\hat{\bar{n}}_t}}}$$
Root mean square error	$RMSE$	Total catch $$RMSE_f = \sqrt{\frac{\sum_y r_{f,y}^2}{n_f}}$$ Index $$RMSE_t = \sqrt{\frac{\sum_y r_{t,y}^2}{n_t}}$$

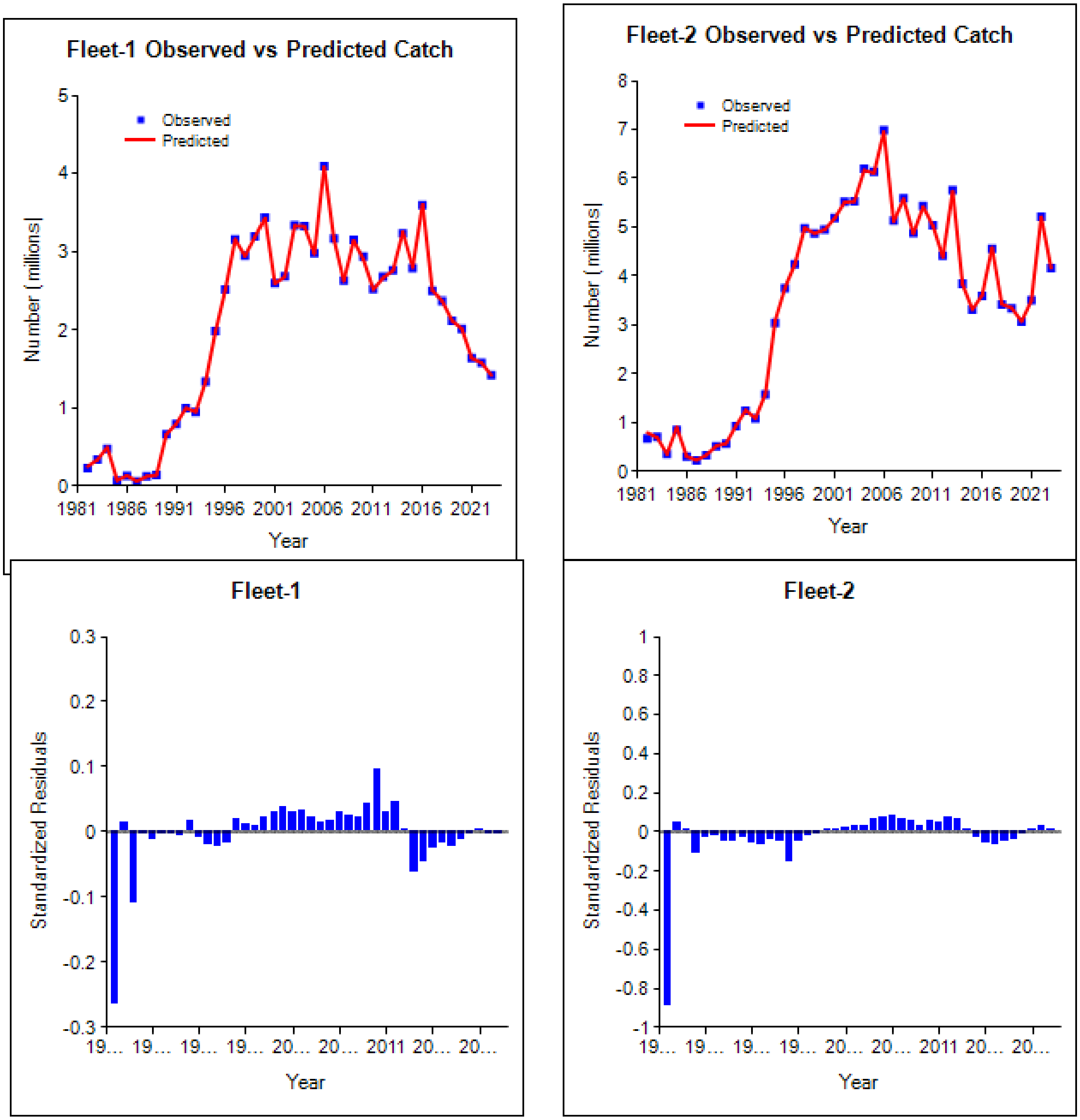
Appendix 2
Diagnostic plots, detailed results, and projections for the base model and sensitivity run

Base Run

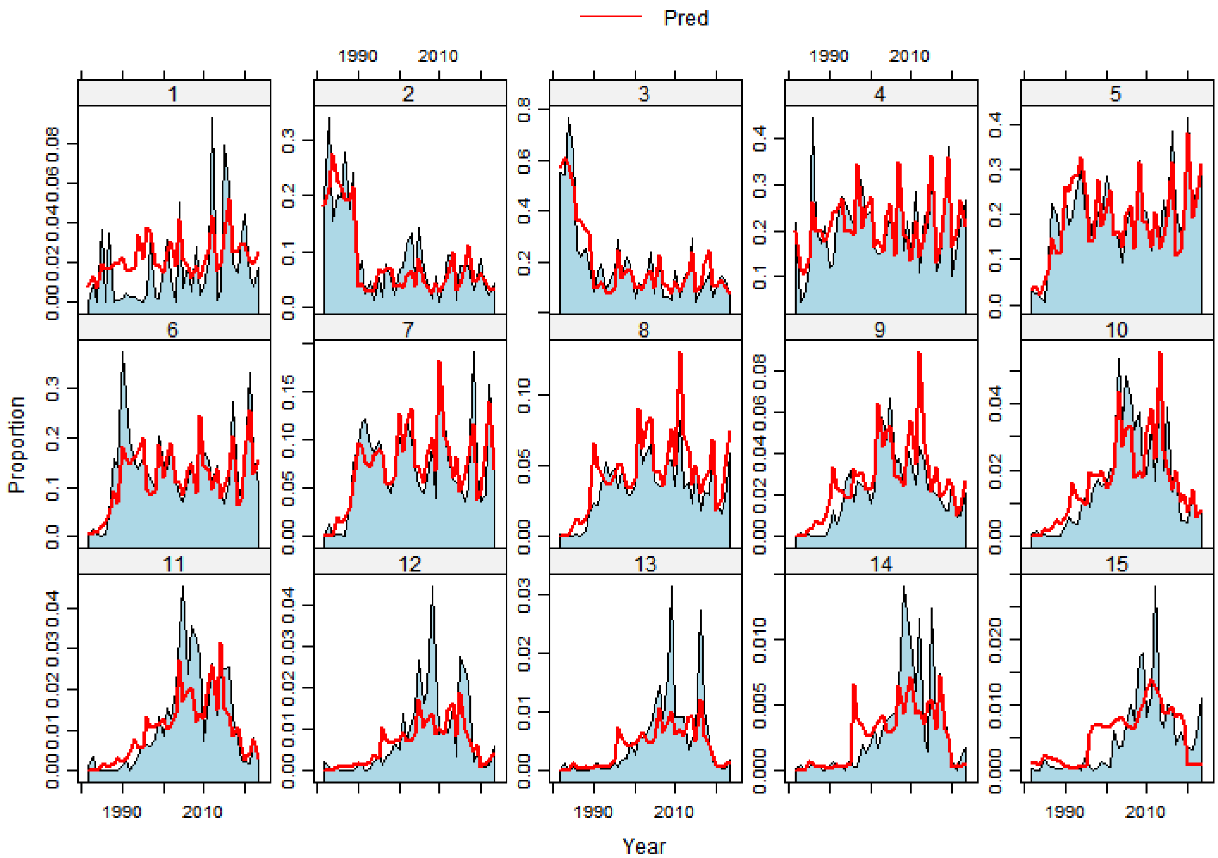
Run configuration:

Bay and Ocean fleets: 2020-2023 selectivity block (no separate 2023 block)

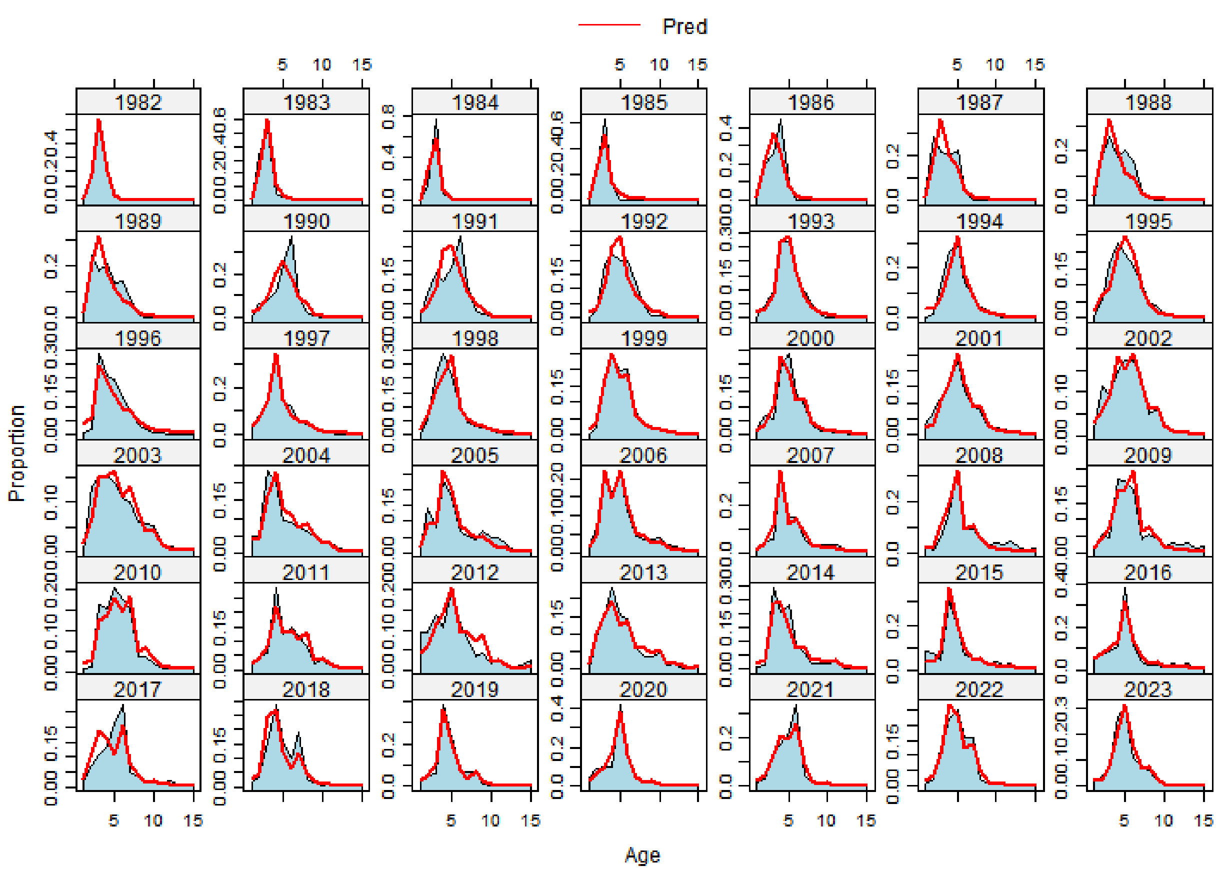
Diagnostic Plots



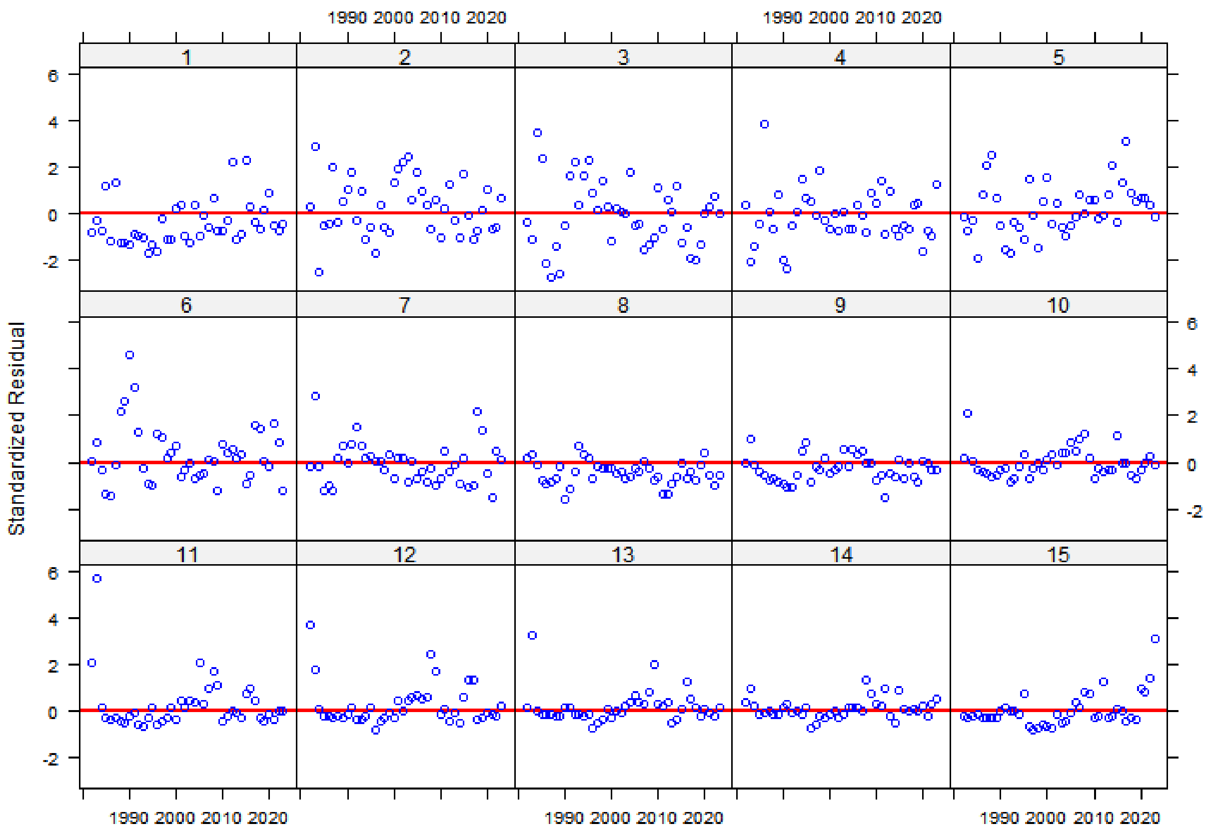
Fleet 1 Catch Age Composition By Age



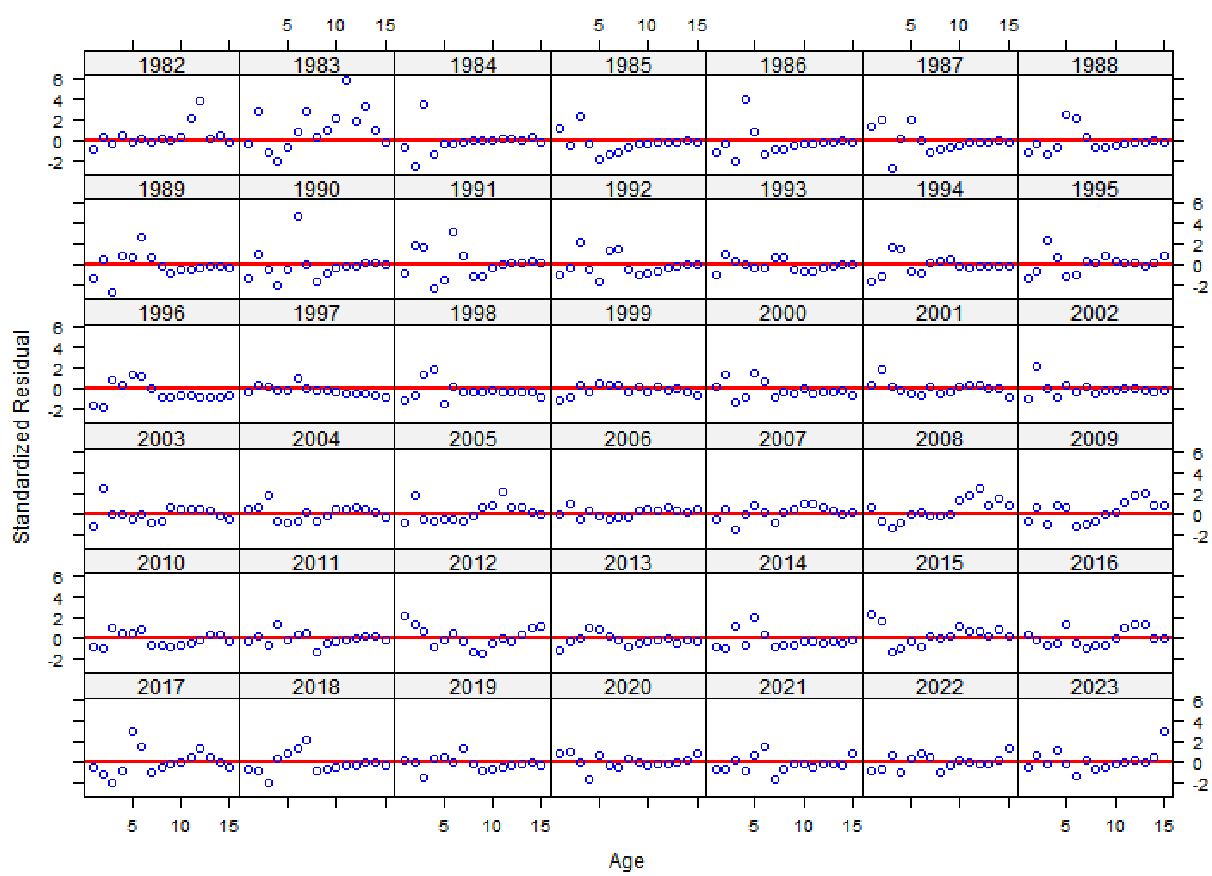
Fleet 1 Catch Age Composition By Year

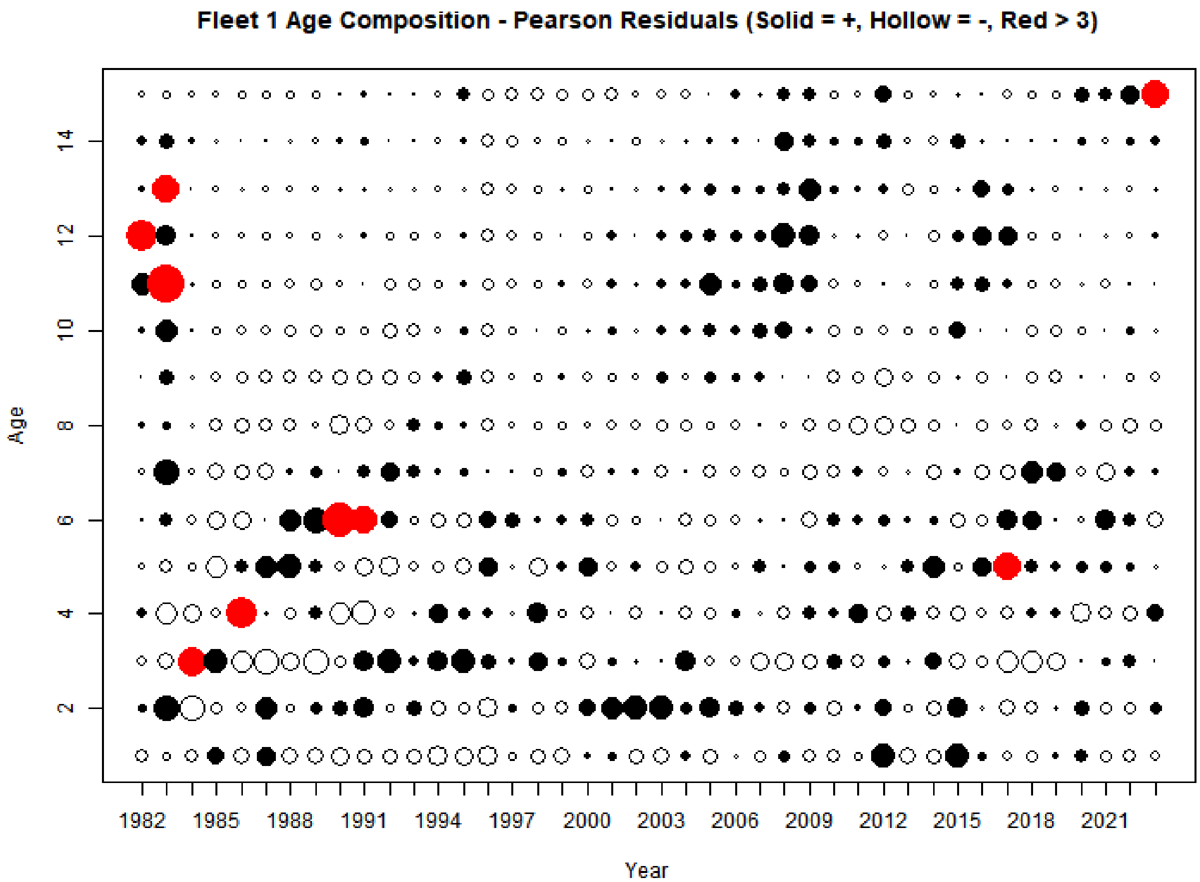


Fleet 1 Residuals of Age Composition By Age



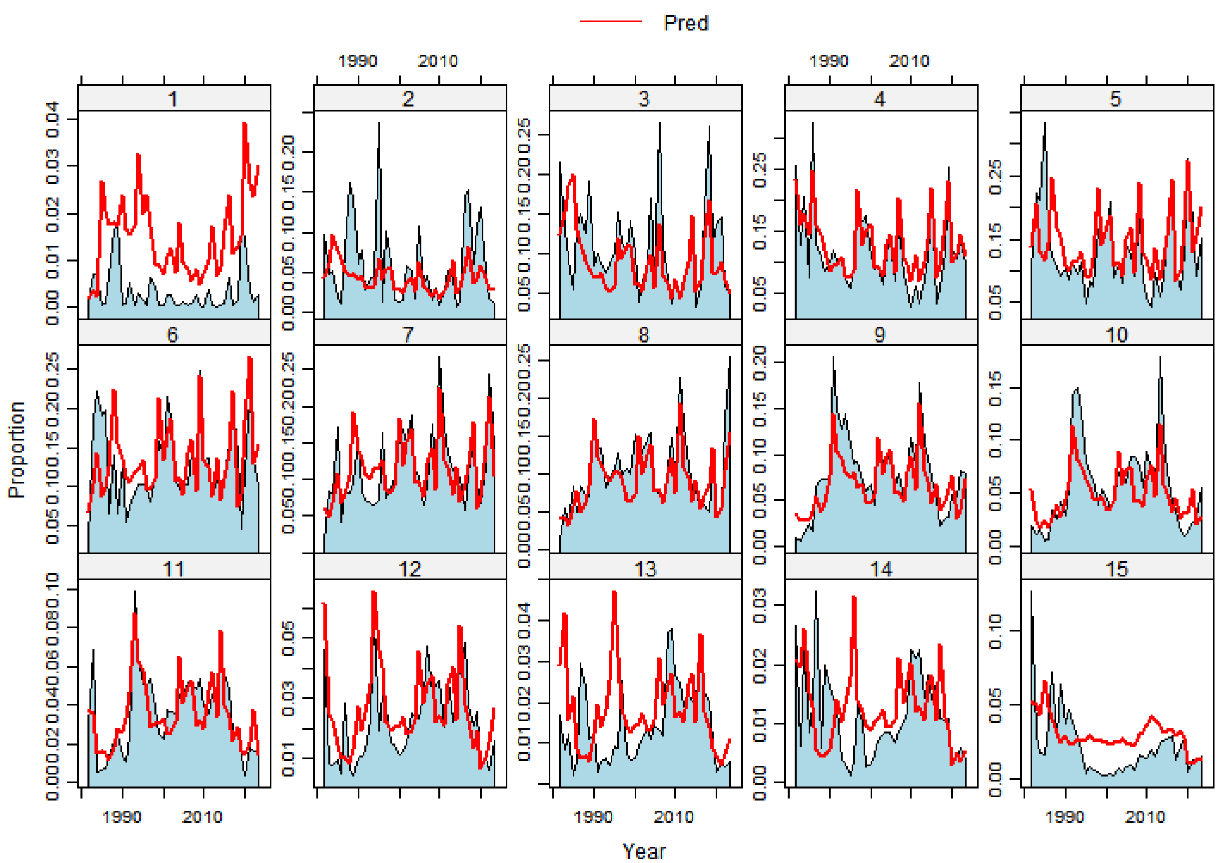
Fleet 1 Residuals of Age Composition By Year



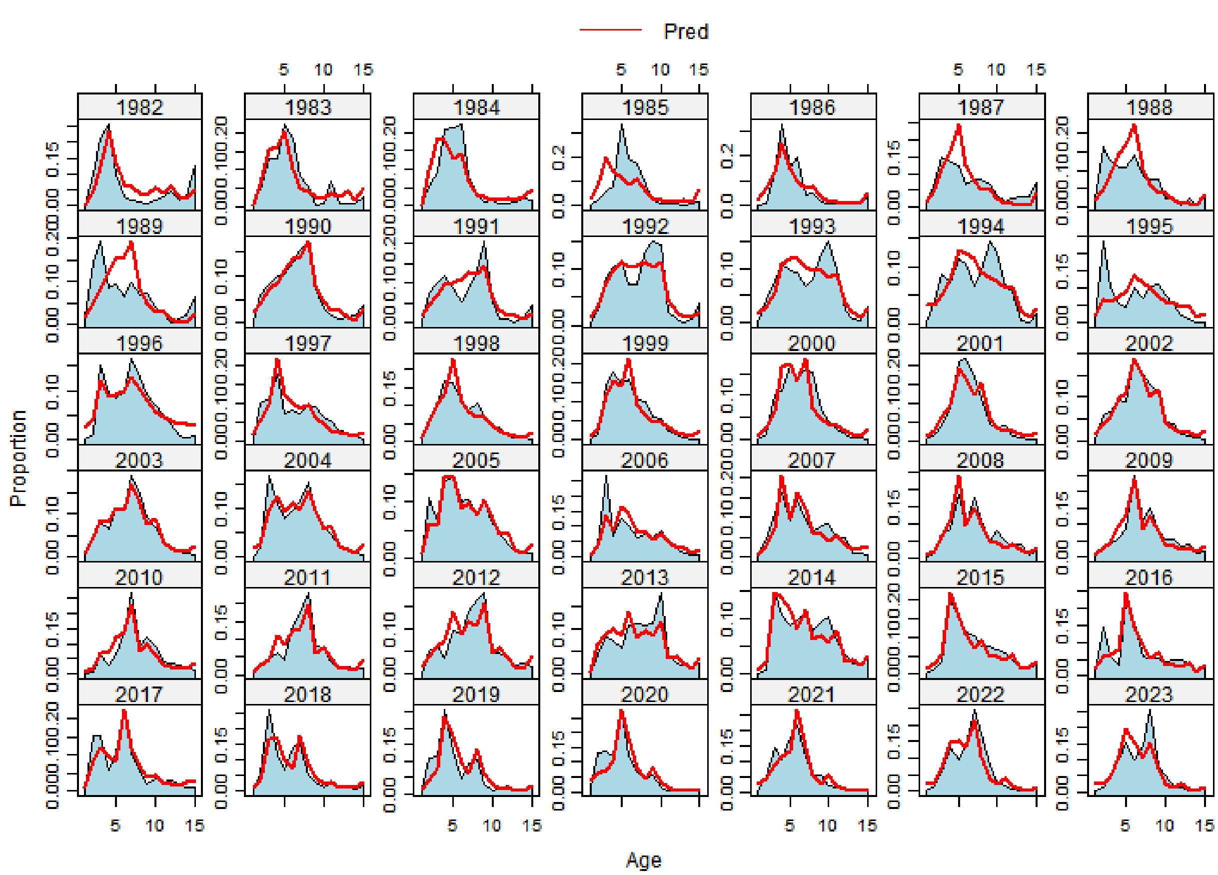


Fleet 1 Age Composition - Pearson Residuals (Solid = +, Hollow = -, Red > 3)
Age
2
4
6
8
10
12
14
Year
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
2015
2018
2021

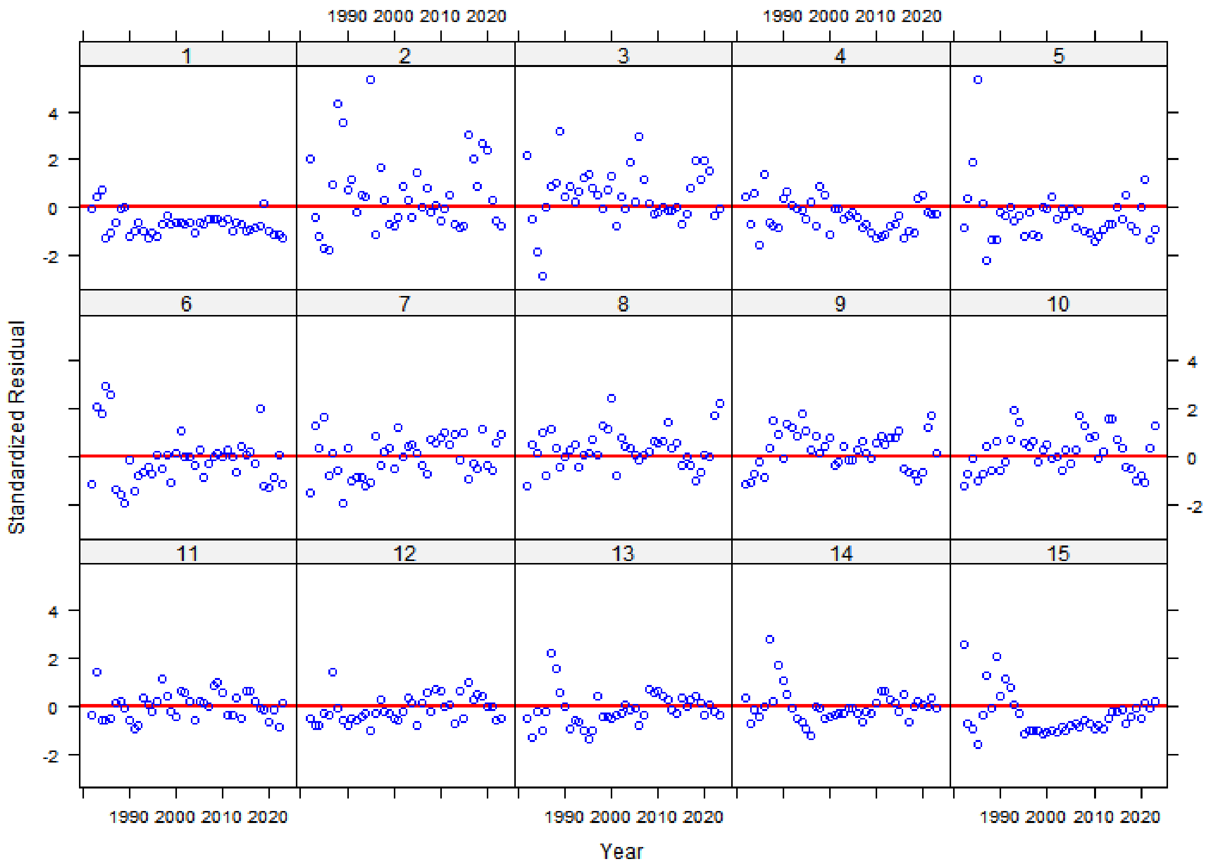
Fleet 2 Catch Age Composition By Age



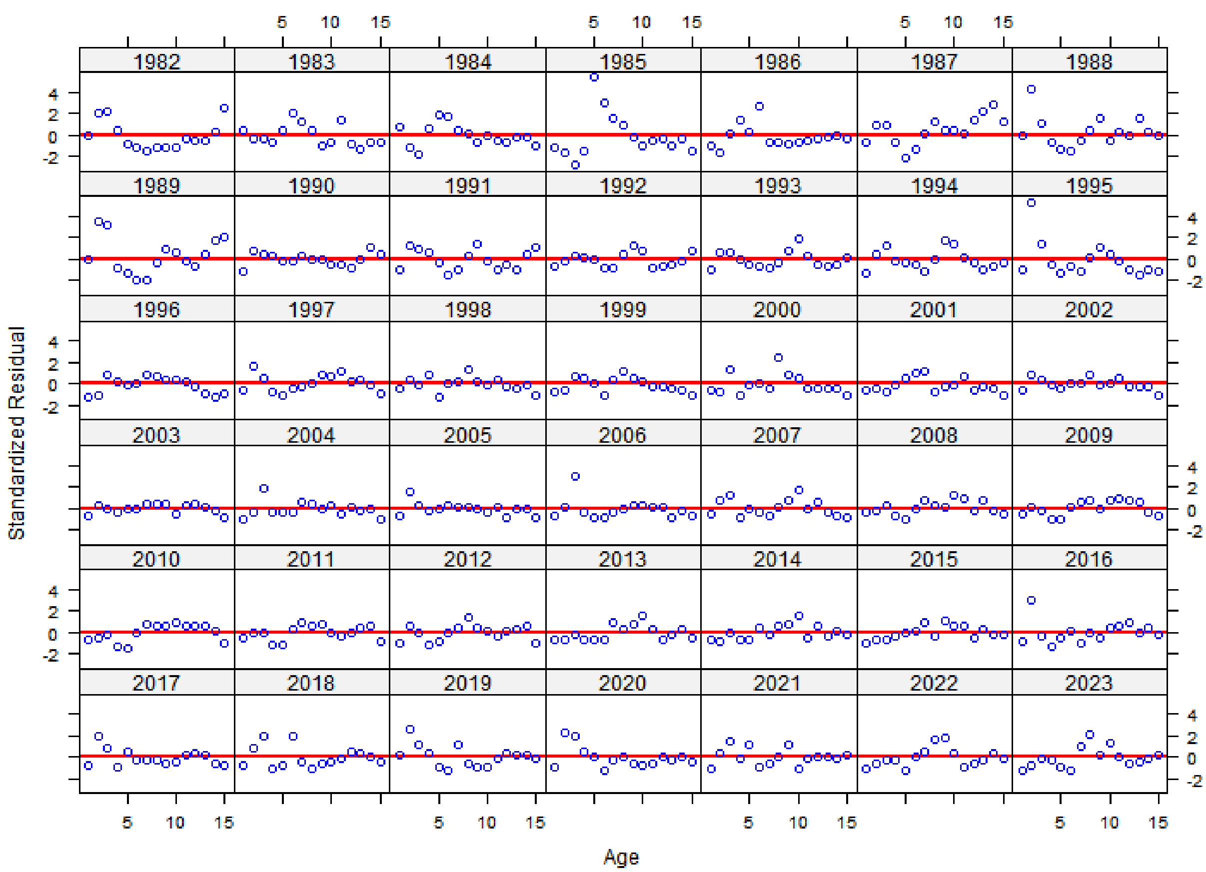
Fleet 2 Catch Age Composition By Year

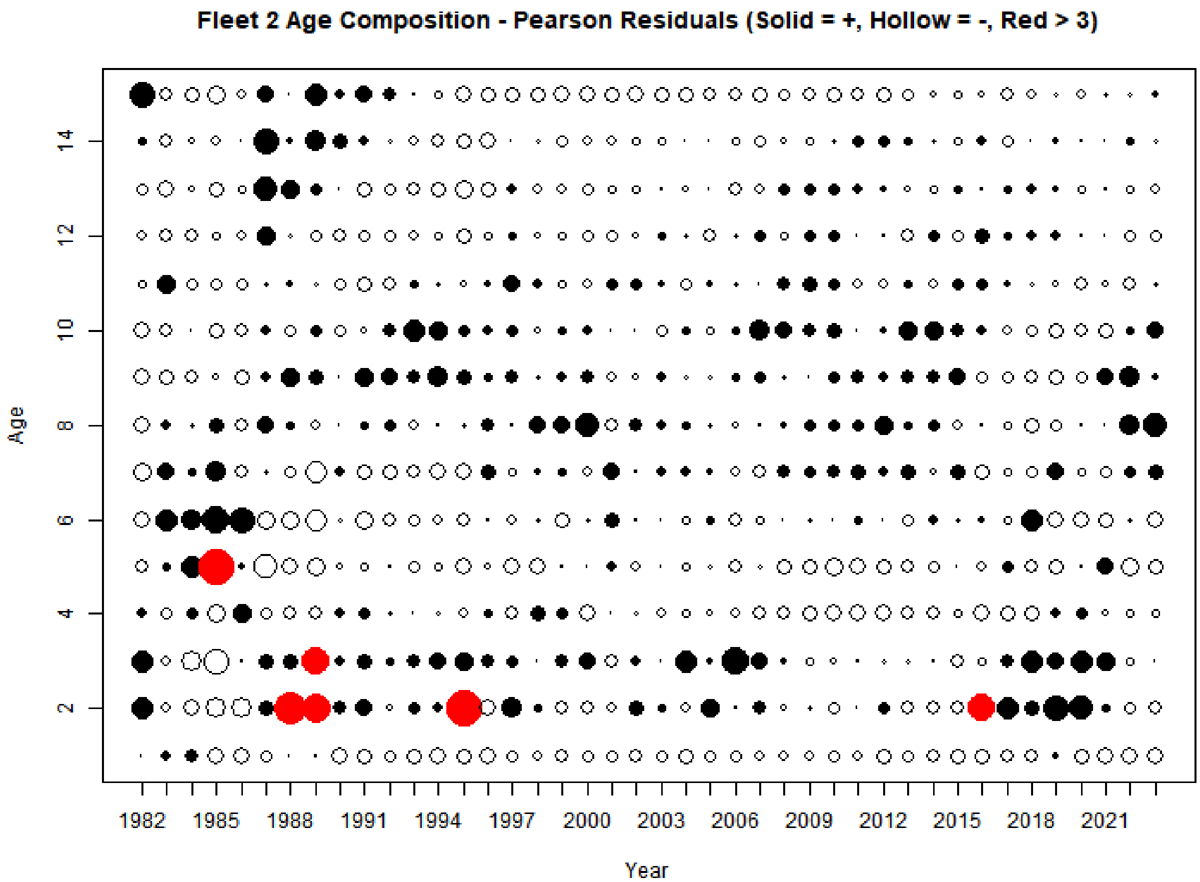


Fleet 2 Residuals of Age Composition By Age

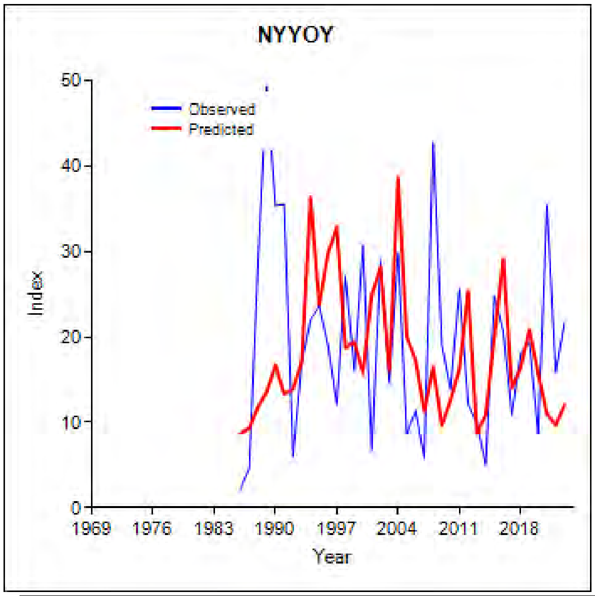


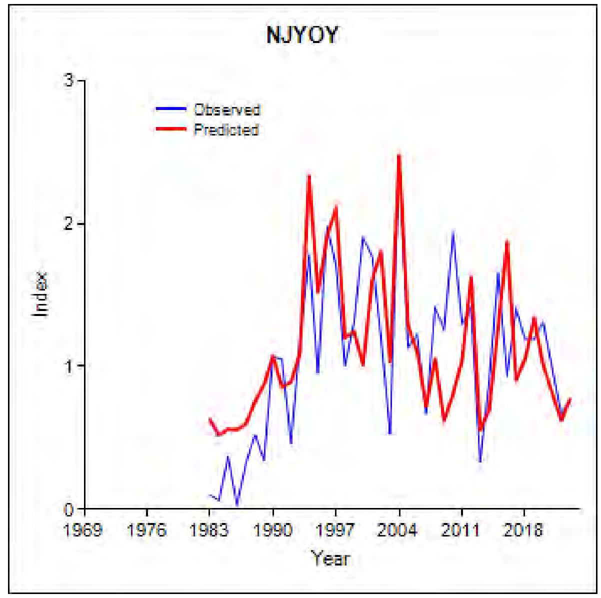
Fleet 2 Residuals of Age Composition By Year





Fleet 2 Age Composition - Pearson Residuals (Solid = +, Hollow = -, Red > 3)
Age
2
4
6
8
10
12
14
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
2015
2018
2021
Year


NYYOY
Observed
Predicted
Index
Year
0
10
20
30
40
50
1969
1976
1983
1990
1997
2004
2011
2018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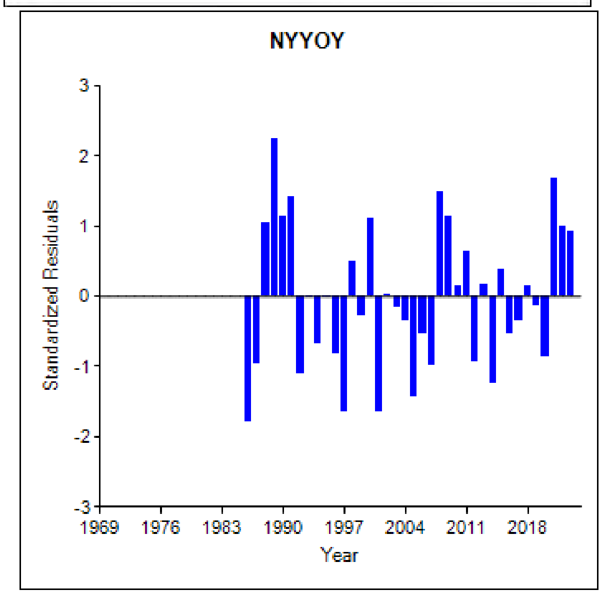
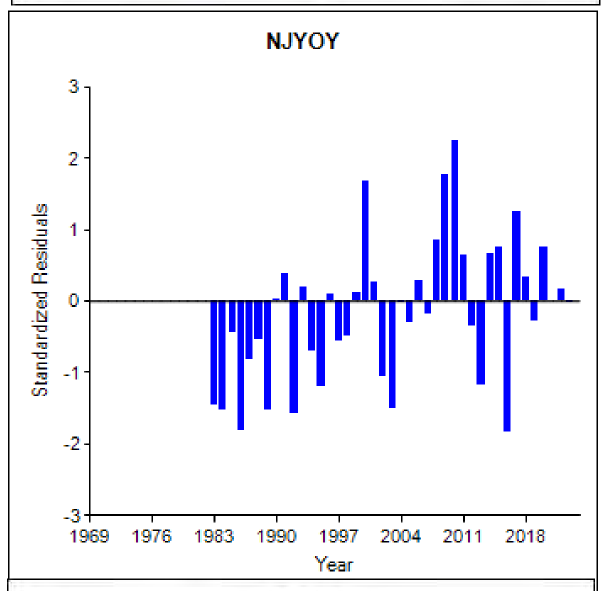
Observed
Predicted
Index
Year
0
1
2
3
1969
1976
1983
1990
1997
2004
2011
2018


NYYOY
Standardized Residuals
Year
-3
-2
-1
0
1
2
3
1969
1976
1983
1990
1997
2004
2011
2018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Standardized Residuals
Year
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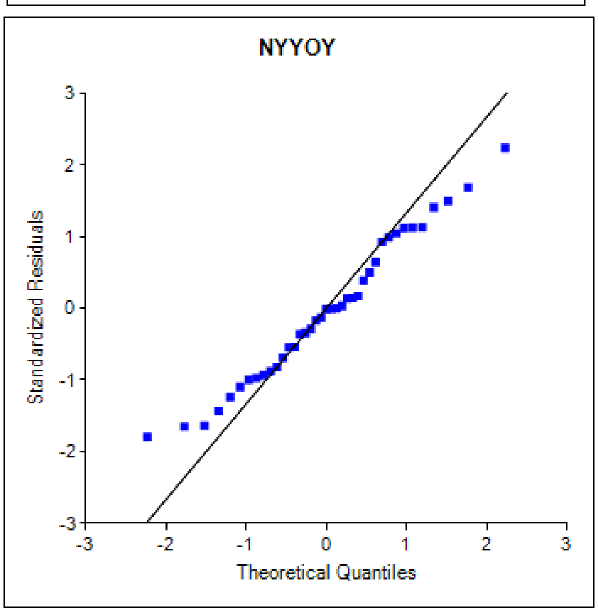
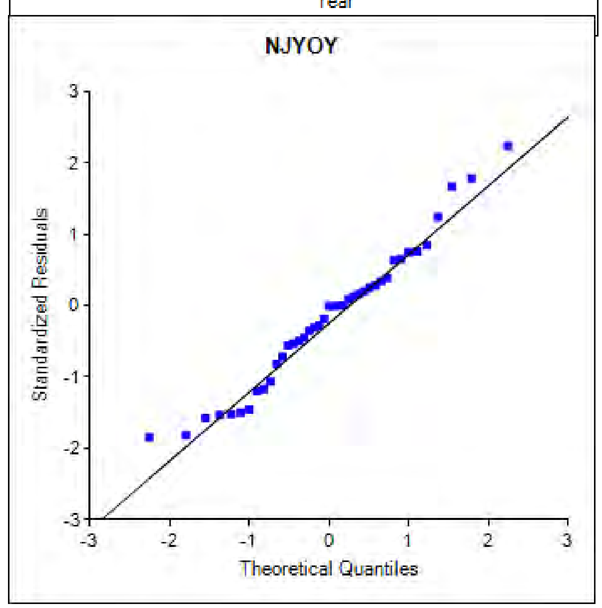
1
2
3
1969
1976
1983
1990
1997
2004
2011
2018


NYYOY
Standardized Residuals
Theoretical Quantiles
-3
-2
-1
0
1
2
3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Standardized Residuals
Theoretical Quantiles
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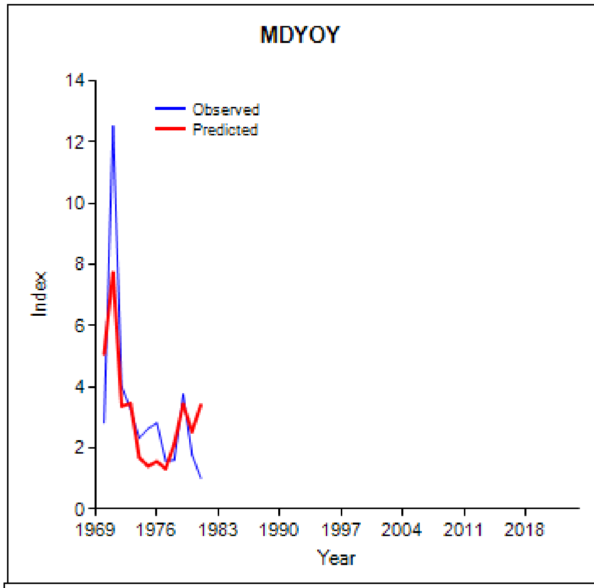
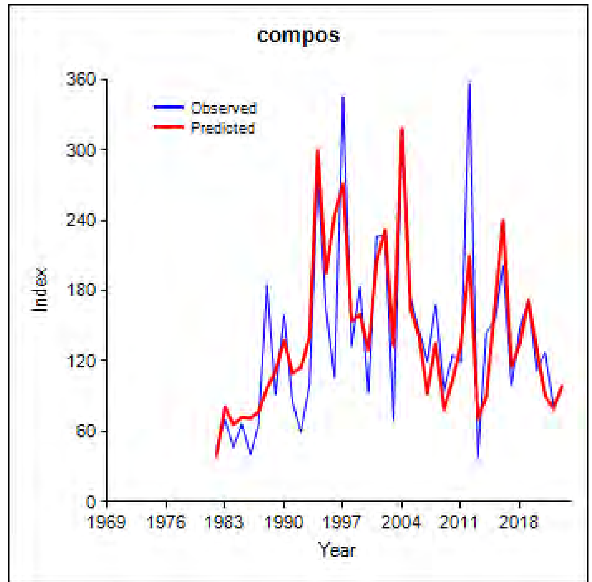
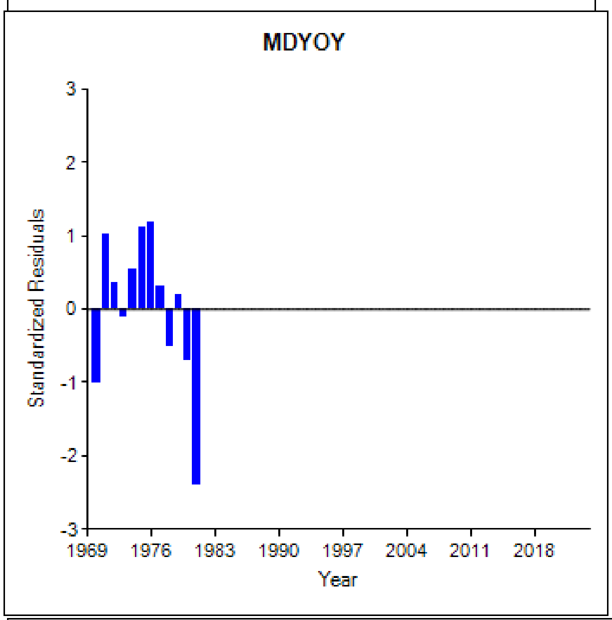
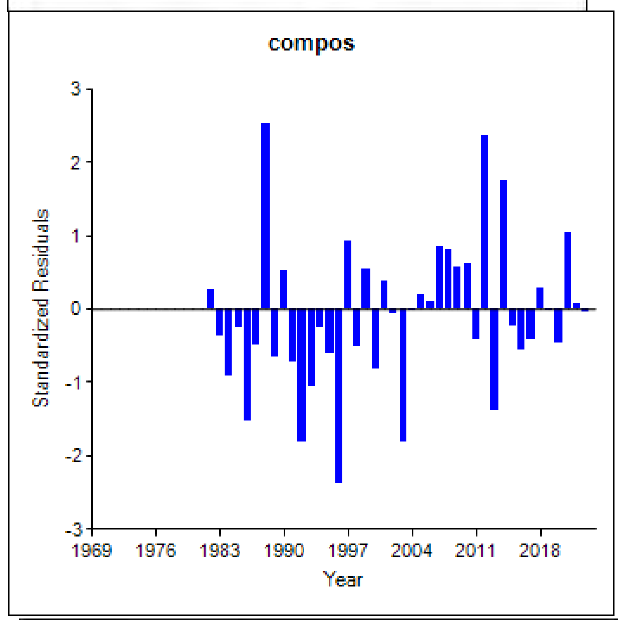
-2
-1
0
1
2
3


MDYOY
Observed
Predicted
Index
Year
14
12
10
8
6
4
2
0
1969 1976 1983 1990 1997 2004 2011 2018


compos
Observed
Predicted
Index
Year
360
300
240
180
120
60
0
1969 1976 1983 1990 1997 2004 2011 2018


MDYOY
Standardized Residuals
Year
3
2
1
0
-1
-2
-3
1969 1976 1983 1990 1997 2004 2011 2018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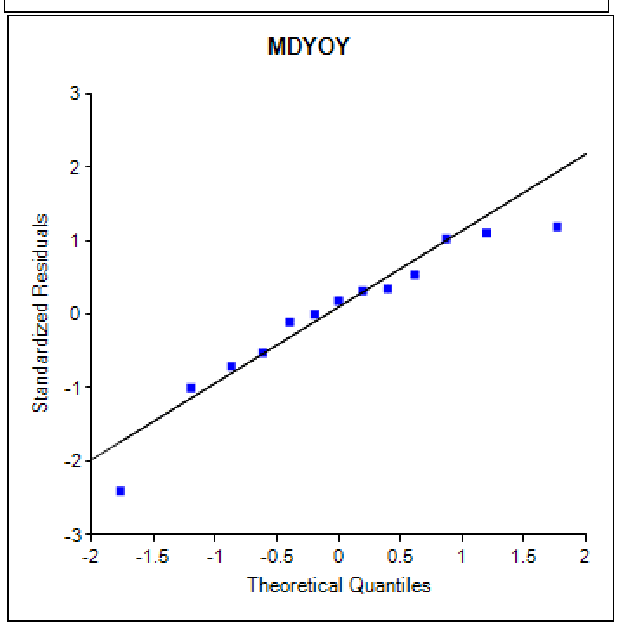
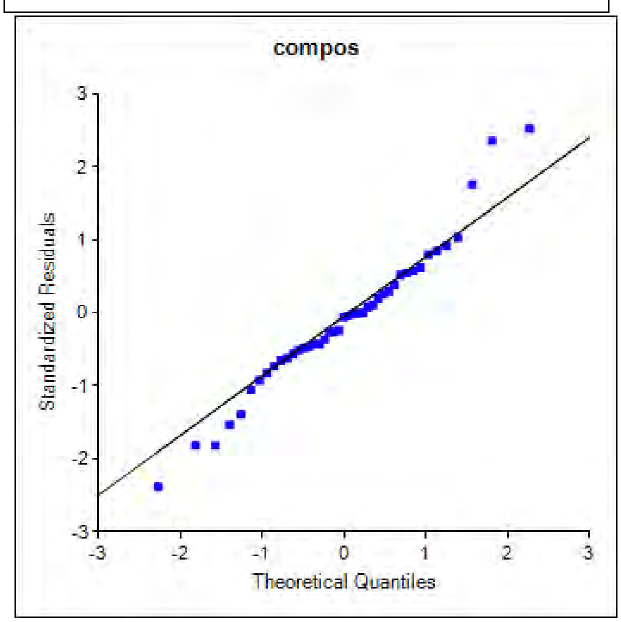
Standardized Residuals
Year
3
2
1
0
-1
-2
-3
1969 1976 1983 1990 1997 2004 2011 2018


MDYOY
Standardized Residuals
Theoretical Quantiles
3
2
1
0
-1
-2
-3
-2 -1.5 -1 -0.5 0 0.5 1 1.5 2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Theoretical Quantiles
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1
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-3
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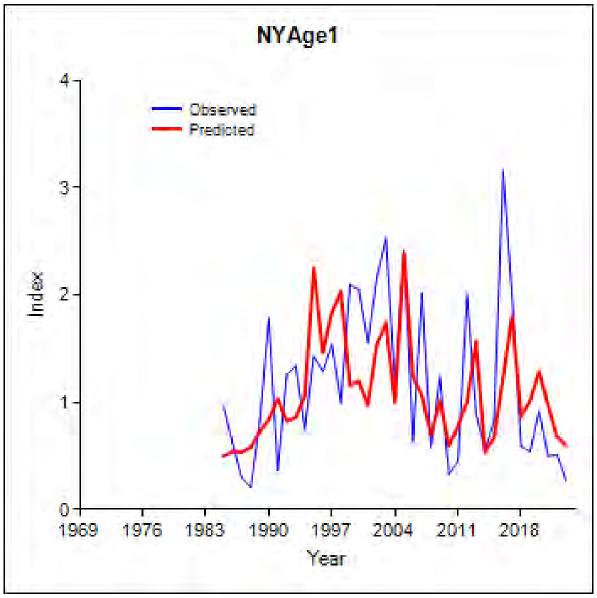
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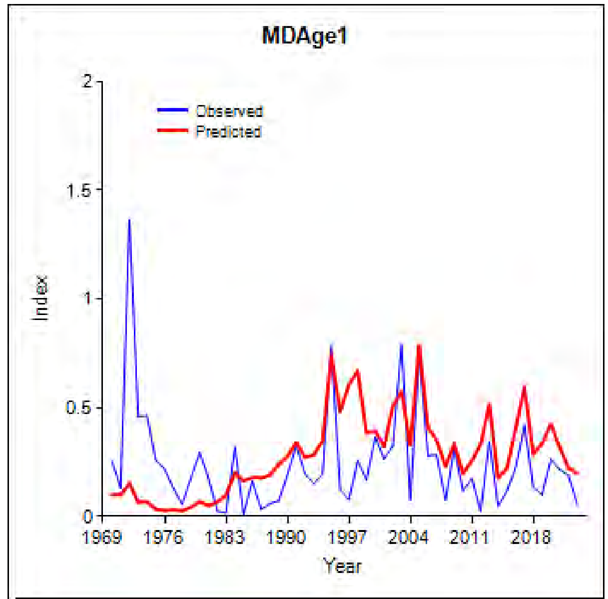
Observed
Predicted
Index
0
1
2
3
4
1969 1976 1983 1990 1997 2004 2011 2018
Year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Observed
Predicted
Index
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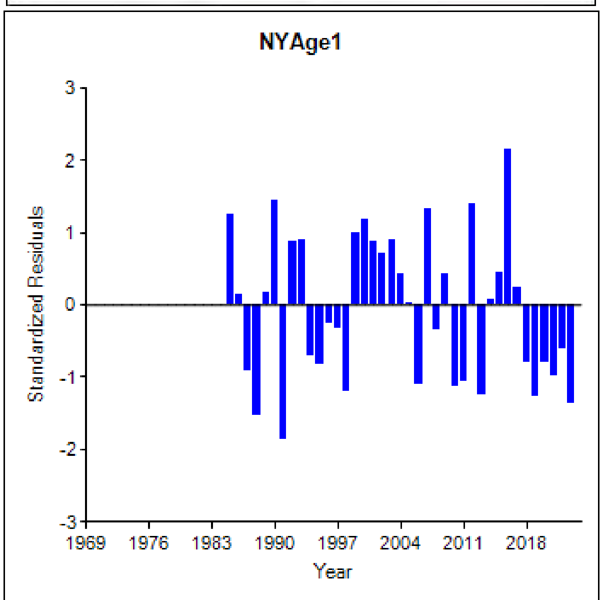
0.5
1
1.5
2
1969 1976 1983 1990 1997 2004 2011 2018
Year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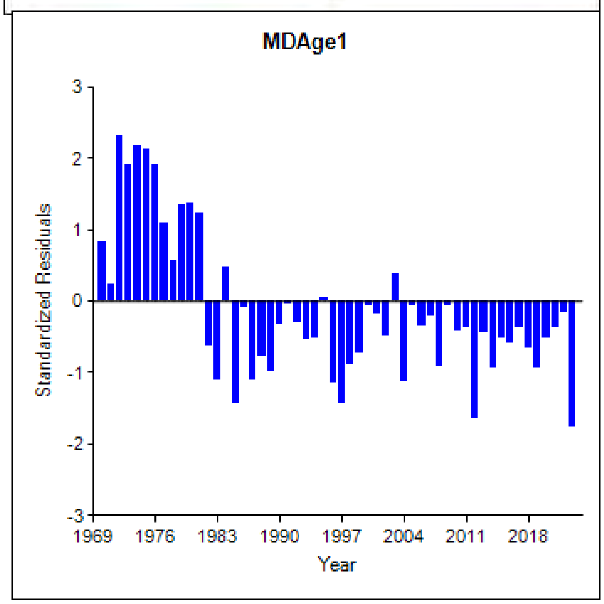
Standardized Residuals
-3
-2
-1
0
1
2
3
1969 1976 1983 1990 1997 2004 2011 2018
Year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1
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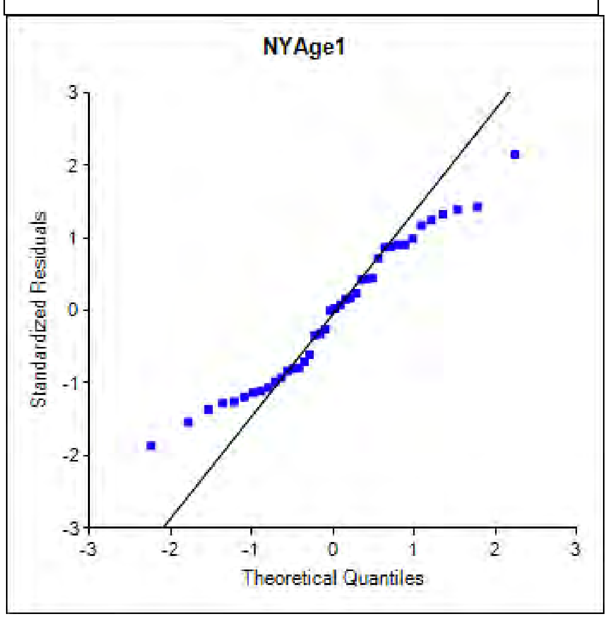
3
1969 1976 1983 1990 1997 2004 2011 2018
Year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3
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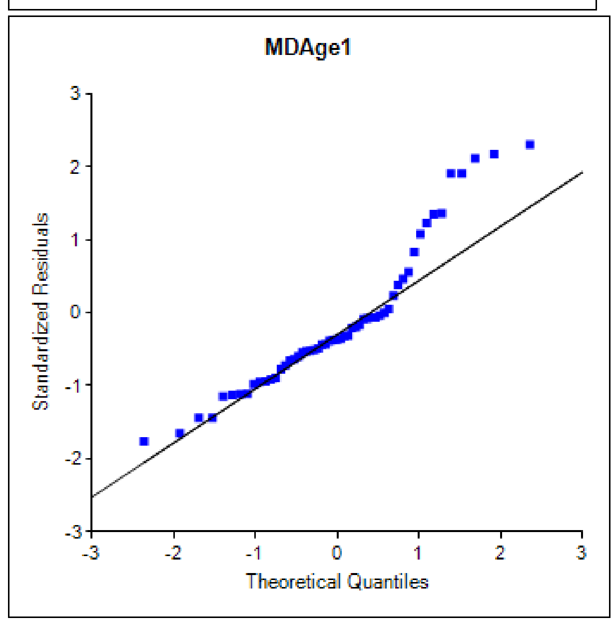
Theoretical Quantiles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Standardized Residuals
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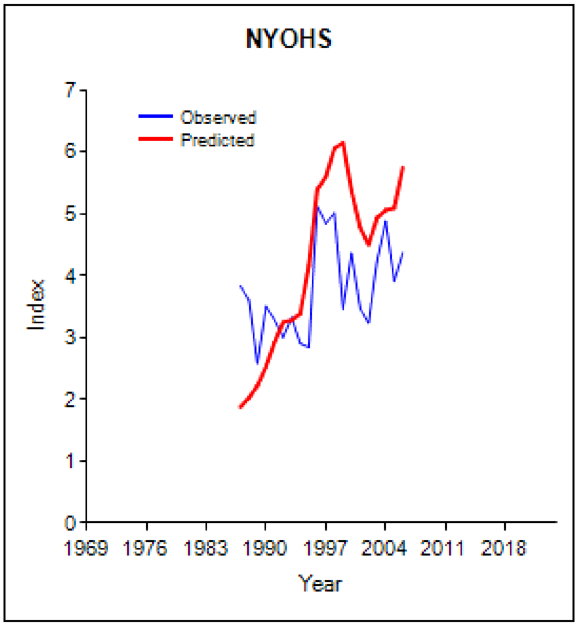
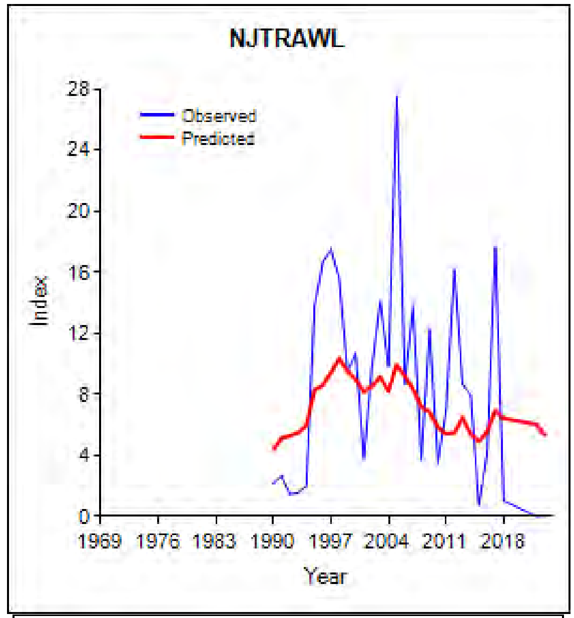
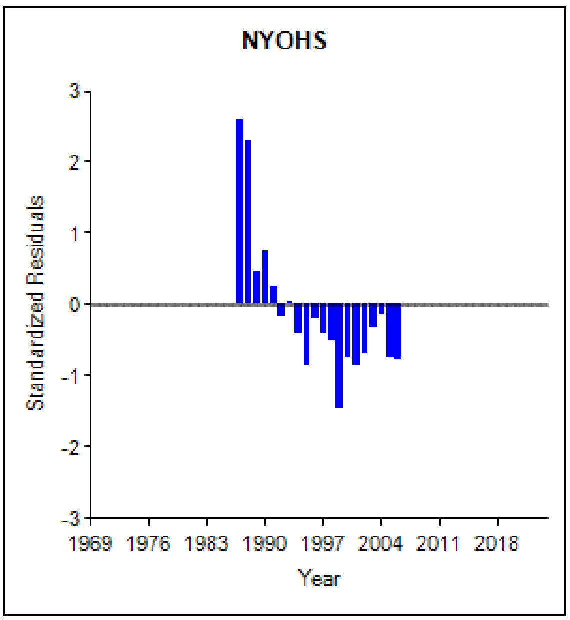
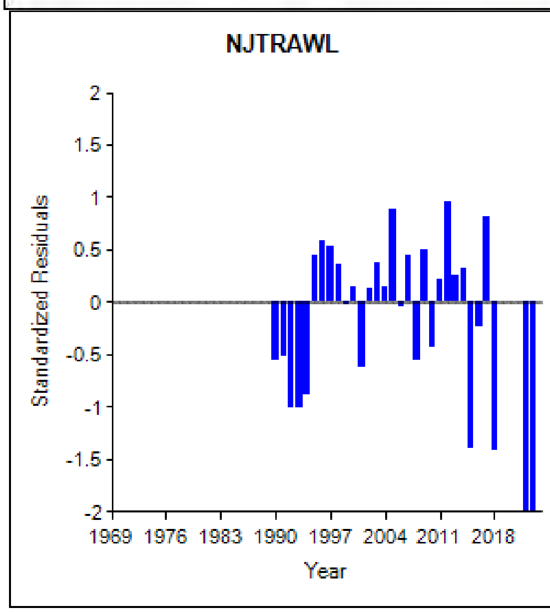
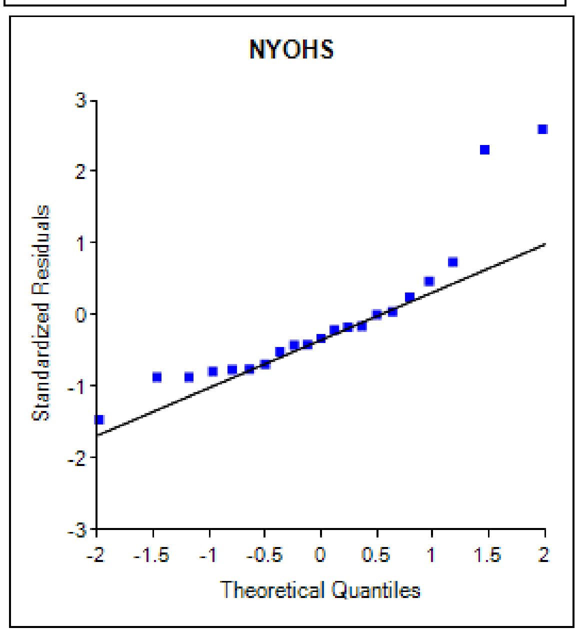
Theoretical Quantiles

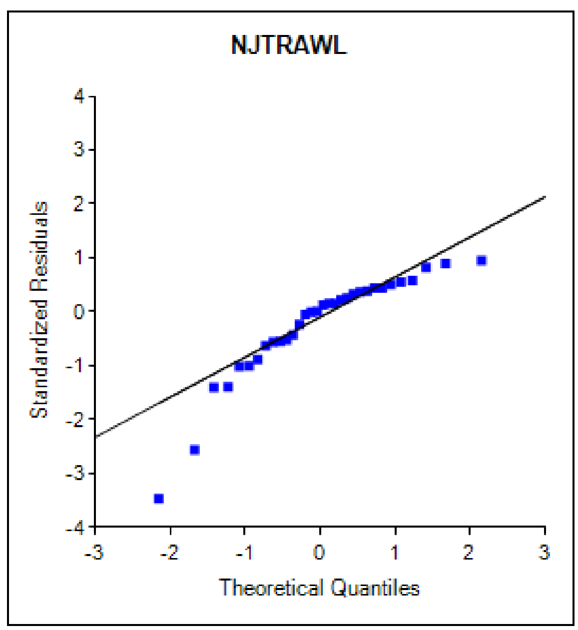

NYOHS
Observed
Predicted
Index
Year

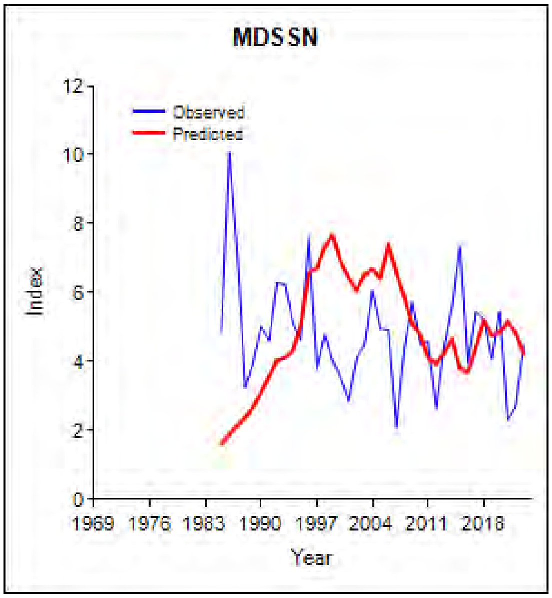

NJTRAWL
Observed
Predicted
Index
Year

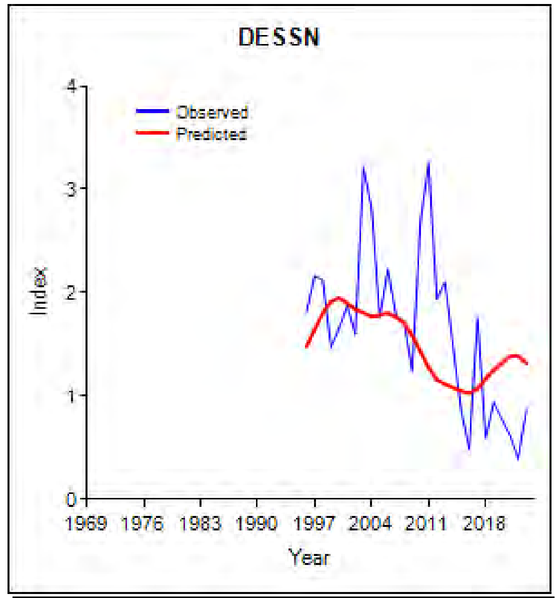

NYOHS
Standardized Residuals
Year

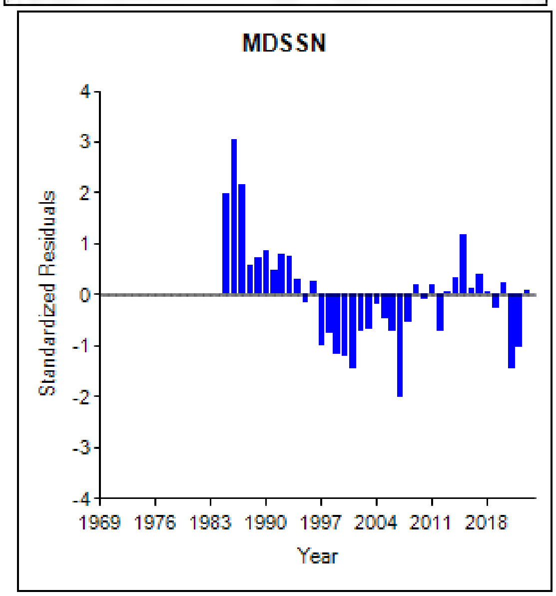

NJTRAWL
Standardized Residuals
Year

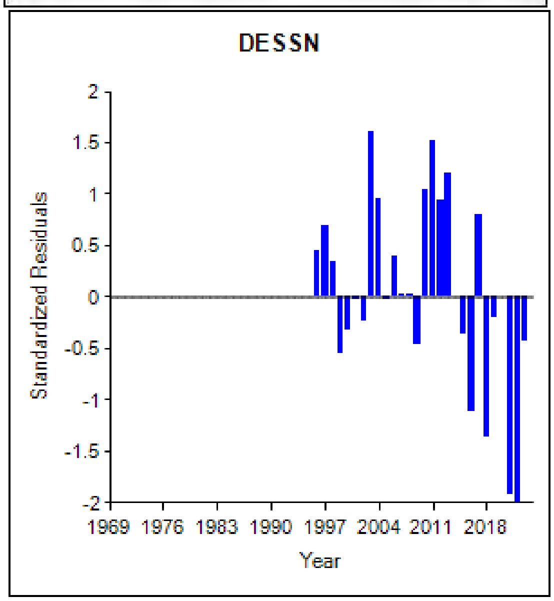

NYOHS
Standardized Residuals
Theoretical Quantiles

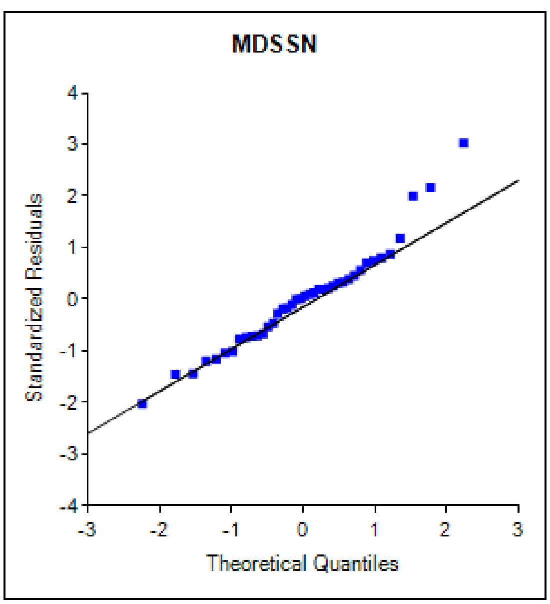

NJTRAWL
Standardized Residuals
Theoretical Quantiles

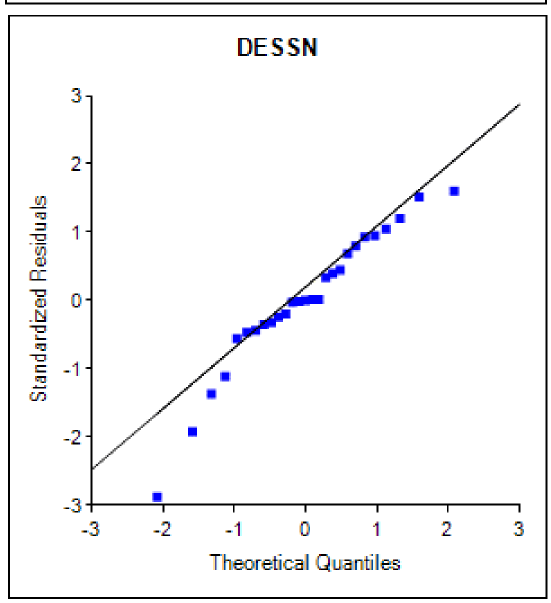

MDSSN
Observed
Predicted
Index
Year
1969 1976 1983 1990 1997 2004 2011 2018

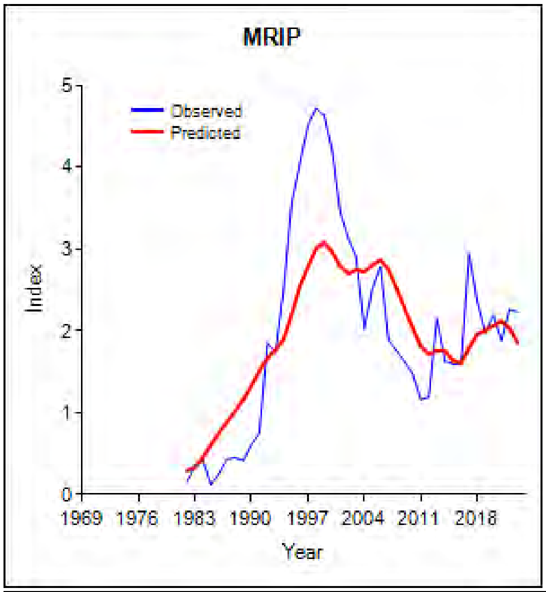

DESSN
Observed
Predicted
Index
Year
1969 1976 1983 1990 1997 2004 2011 2018

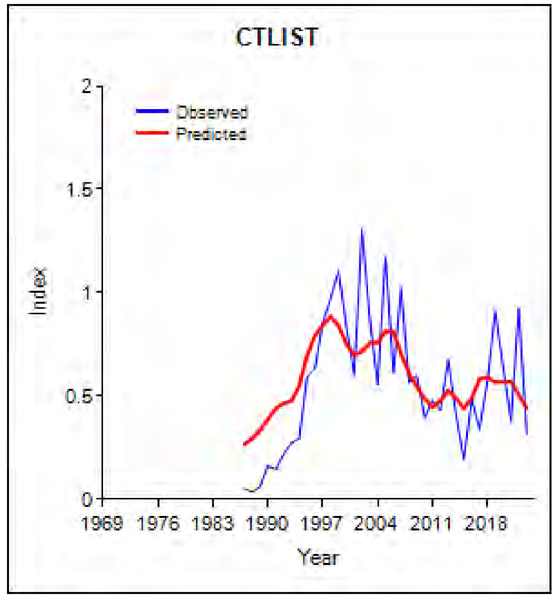

MDSSN
Standardized Residuals
Year
1969 1976 1983 1990 1997 2004 2011 2018

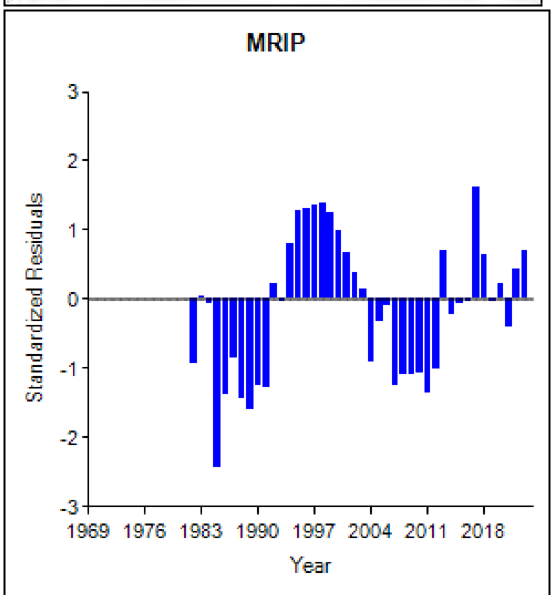

DESSN
Standardized Residuals
Year
1969 1976 1983 1990 1997 2004 2011 2018

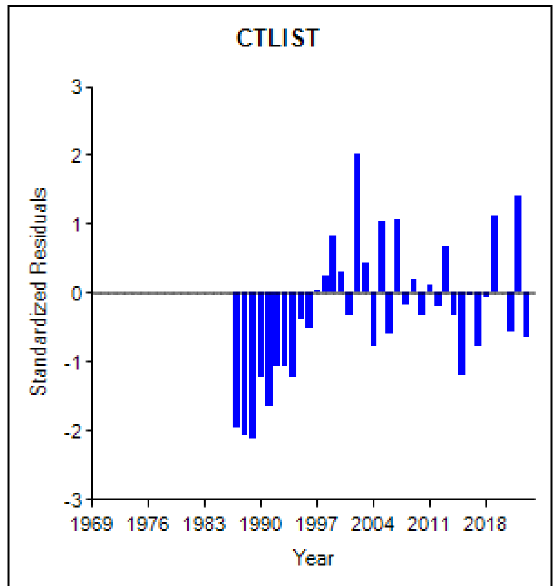

MDSSN
Standardized Residuals
Theoretical Quantiles

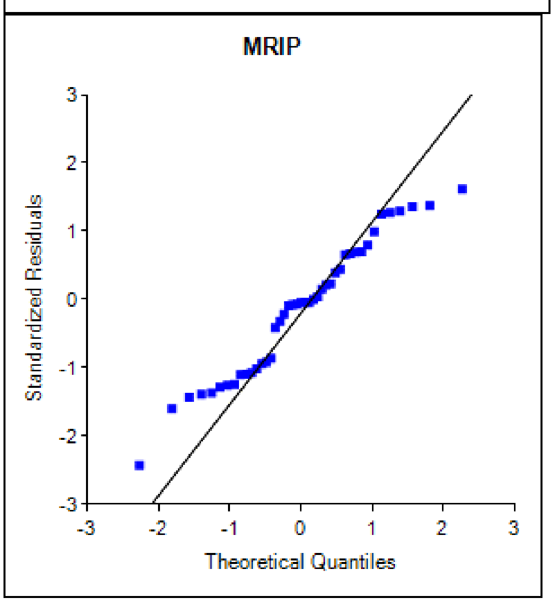

DESSN
Standardized Residuals
Theoretical Quantiles

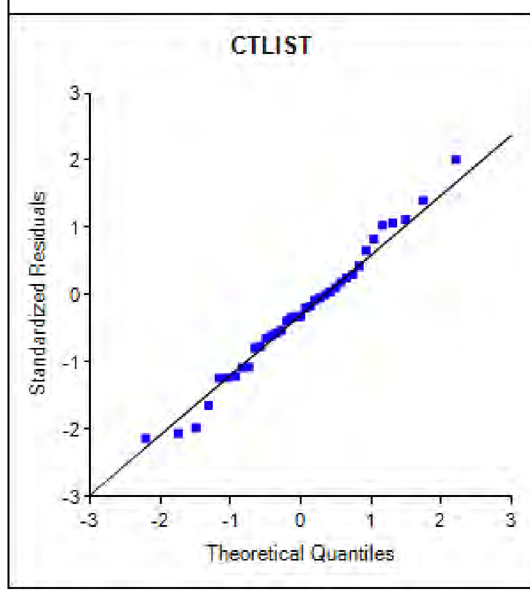

MRIP
Observed
Predicted
Index
0
1
2
3
4
5
1969 1976 1983 1990 1997 2004 2011 2018
Year

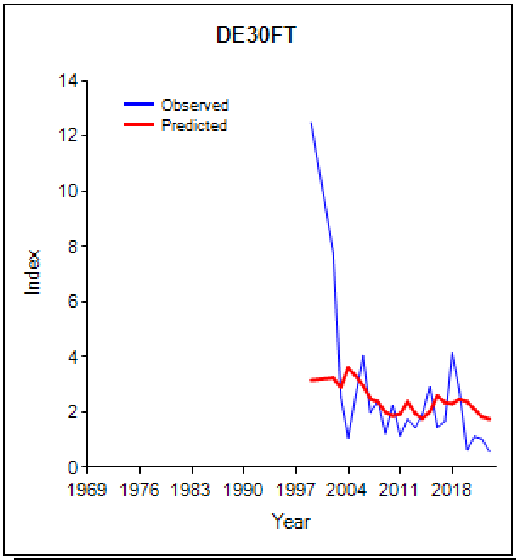

CTLIST
Observed
Predicted
Index
0
0.5
1
1.5
2
1969 1976 1983 1990 1997 2004 2011 2018
Year

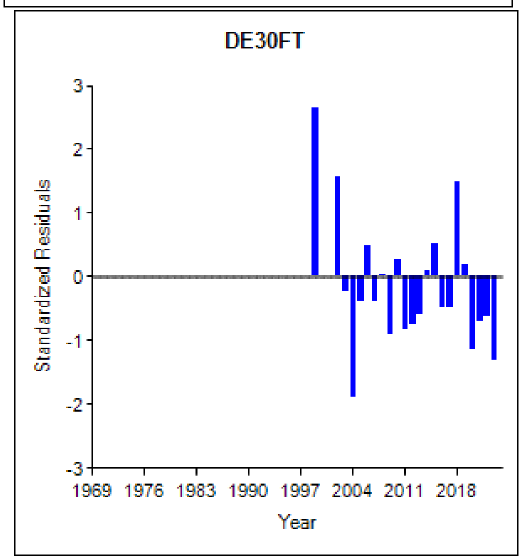

MRIP
Standardized Residuals
-3
-2
-1
0
1
2
3
1969 1976 1983 1990 1997 2004 2011 2018
Year

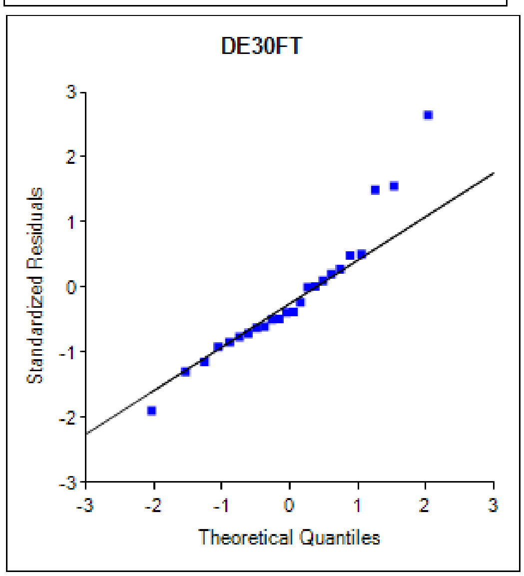

CTLIST
Standardized Residuals
-3
-2
-1
0
1
2
3
1969 1976 1983 1990 1997 2004 2011 2018
Year

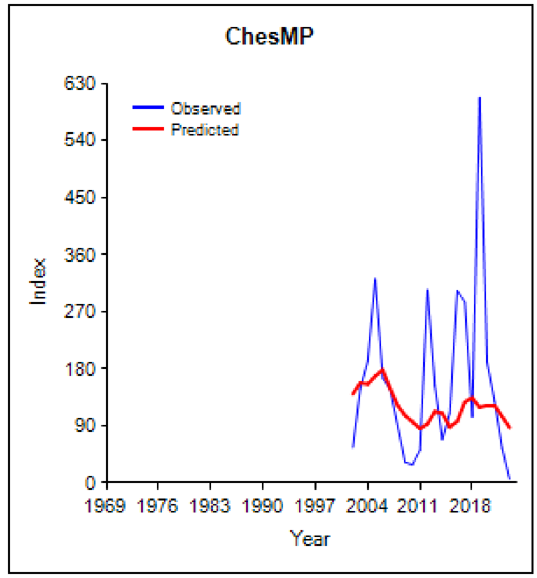

MRIP
Standardized Residuals
-3
-2
-1
0
1
2
3
-3 -2 -1 0 1 2 3
Theoretical Quantiles

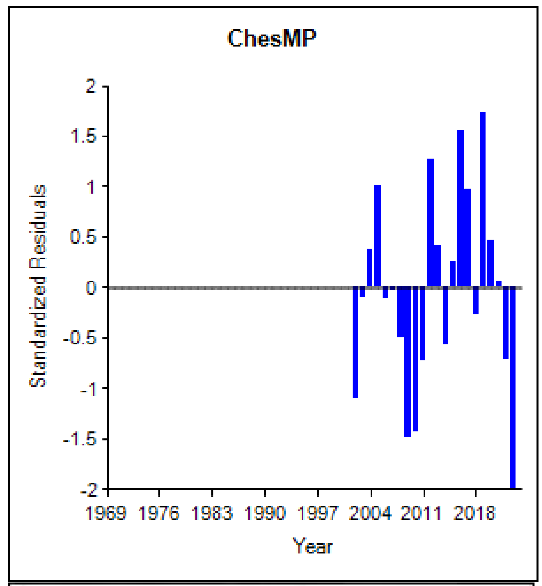

CTLIST
Standardized Residuals
-3
-2
-1
0
1
2
3
-3 -2 -1 0 1 2 3
Theoretical Quantiles

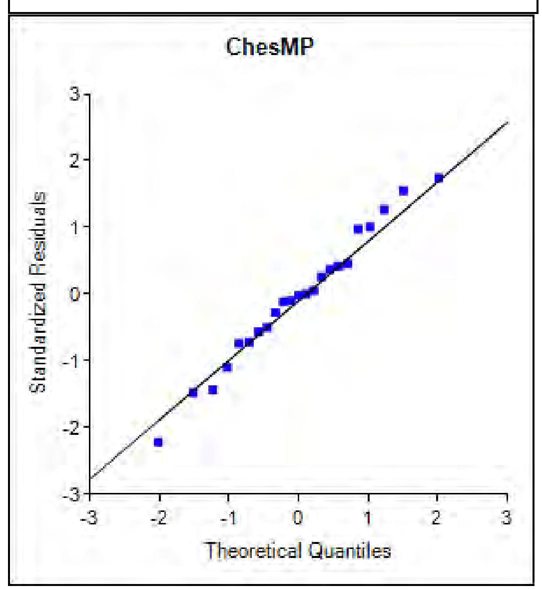

DE30FT
Observed
Predicted
Index
0
2
4
6
8
10
12
14
1969 1976 1983 1990 1997 2004 2011 2018
Year


DE30FT
Standardized Residuals
-3
-2
-1
0
1
2
3
1969 1976 1983 1990 1997 2004 2011 2018
Year

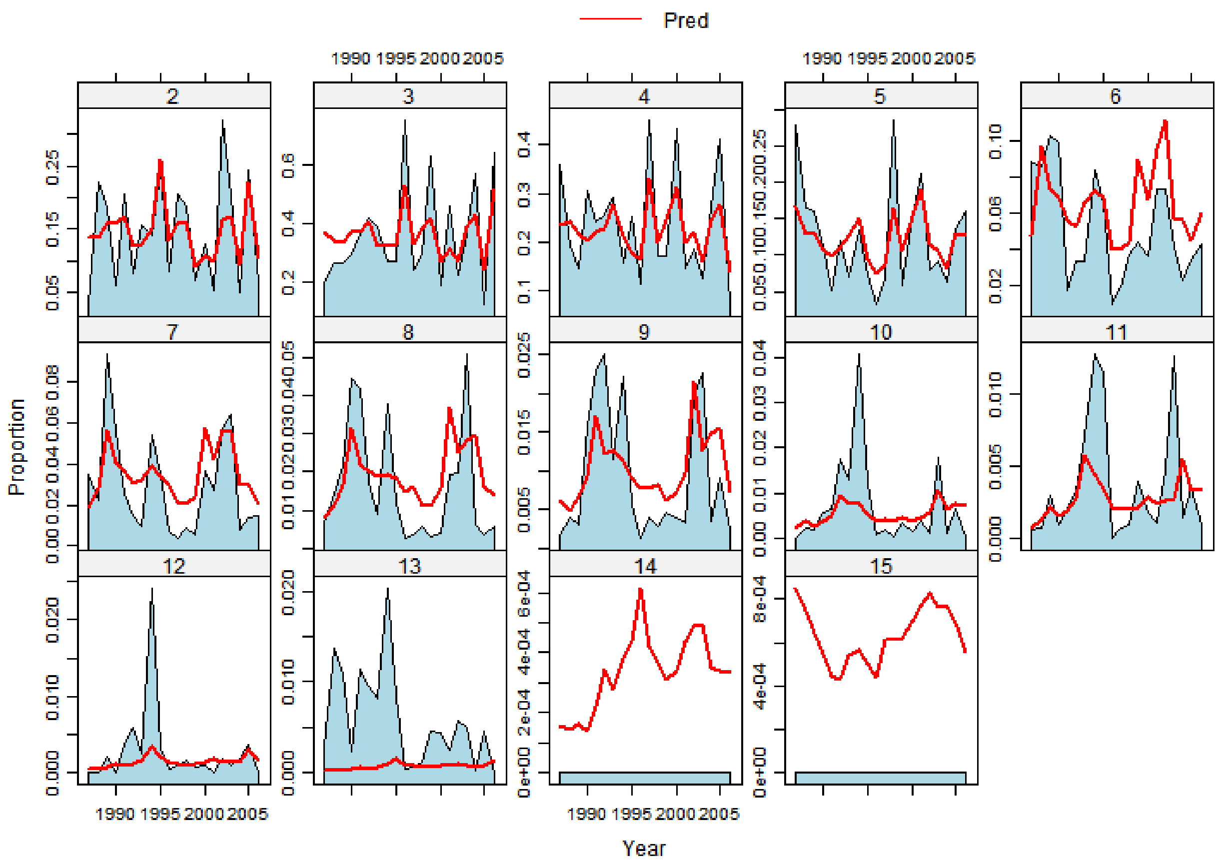

DE30FT
Standardized Residuals
-3
-2
-1
0
1
2
3
-3 -2 -1 0 1 2 3
Theoretical Quantiles


ChesMP
Observed
Predicted
Index
0
90
180
270
360
450
540
630
1969 1976 1983 1990 1997 2004 2011 2018
Year

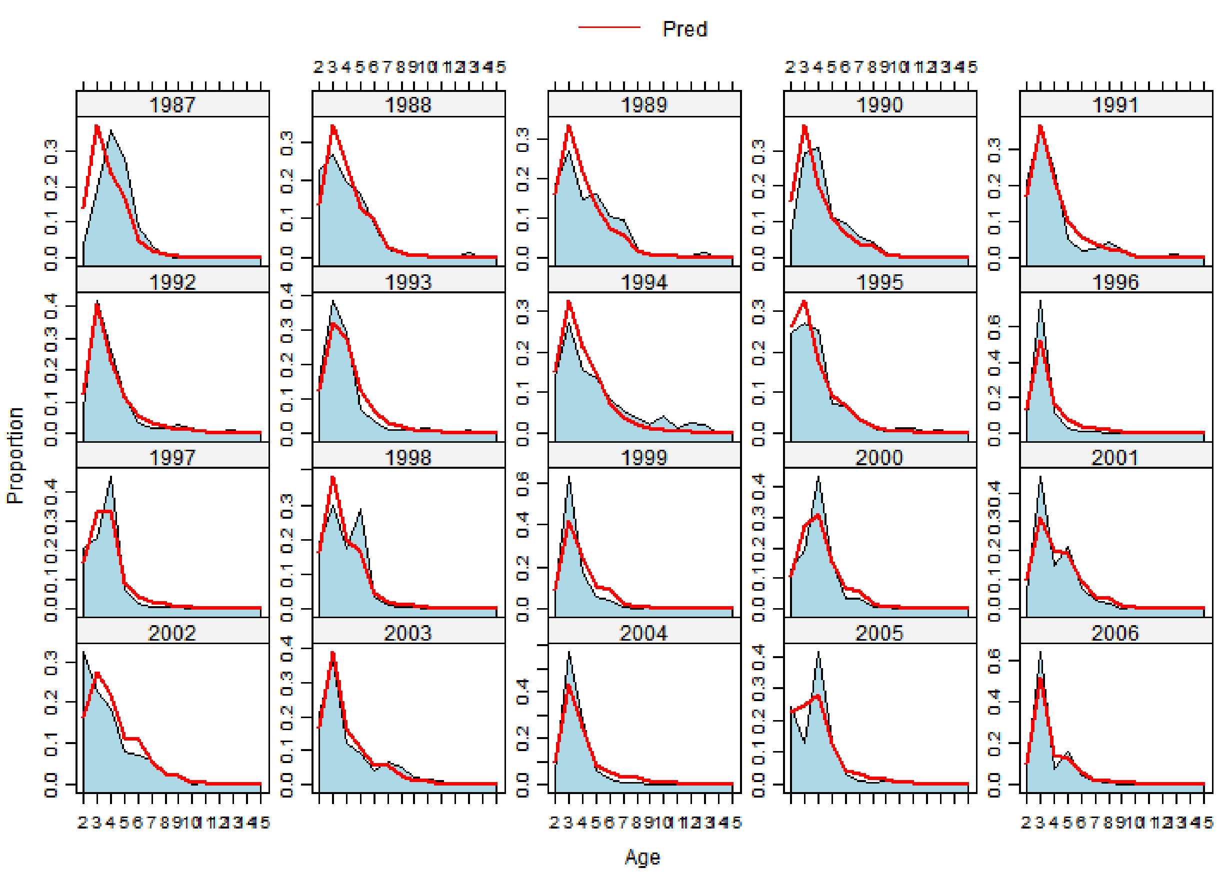

ChesMP
Standardized Residuals
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
1969 1976 1983 1990 1997 2004 2011 2018
Year

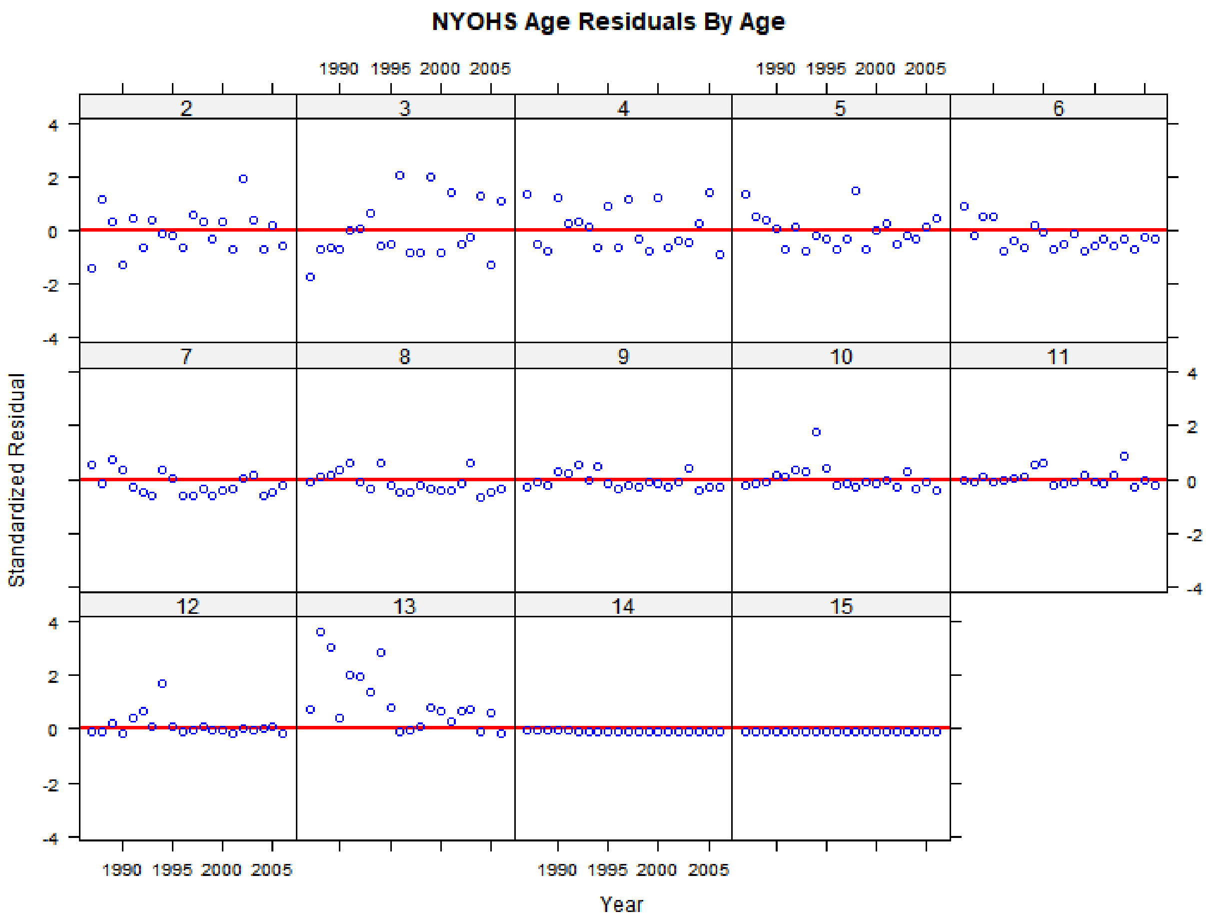

ChesMP
Standardized Residuals
-3
-2
-1
0
1
2
3
-3 -2 -1 0 1 2 3
Theoretical Quantiles

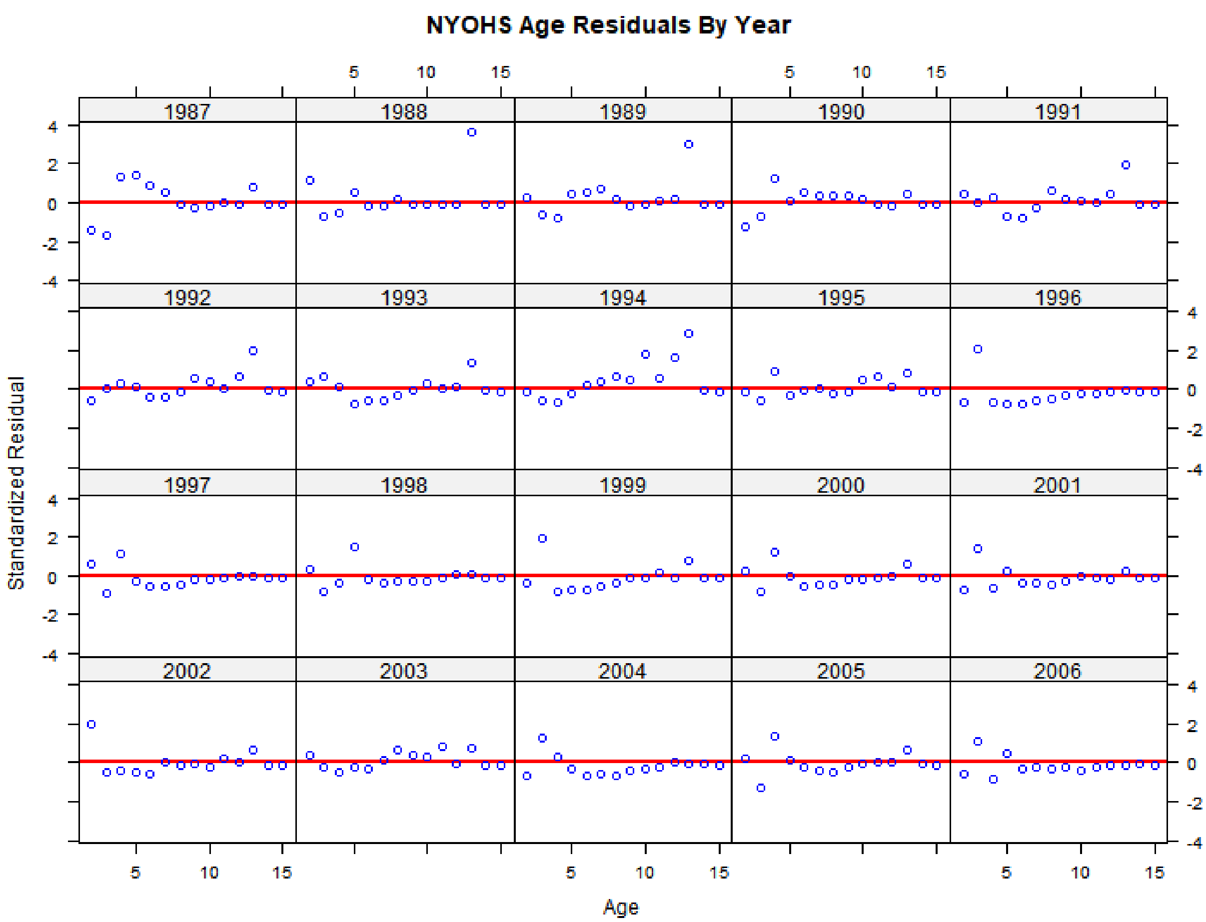
NYOHS Age Composition By Age

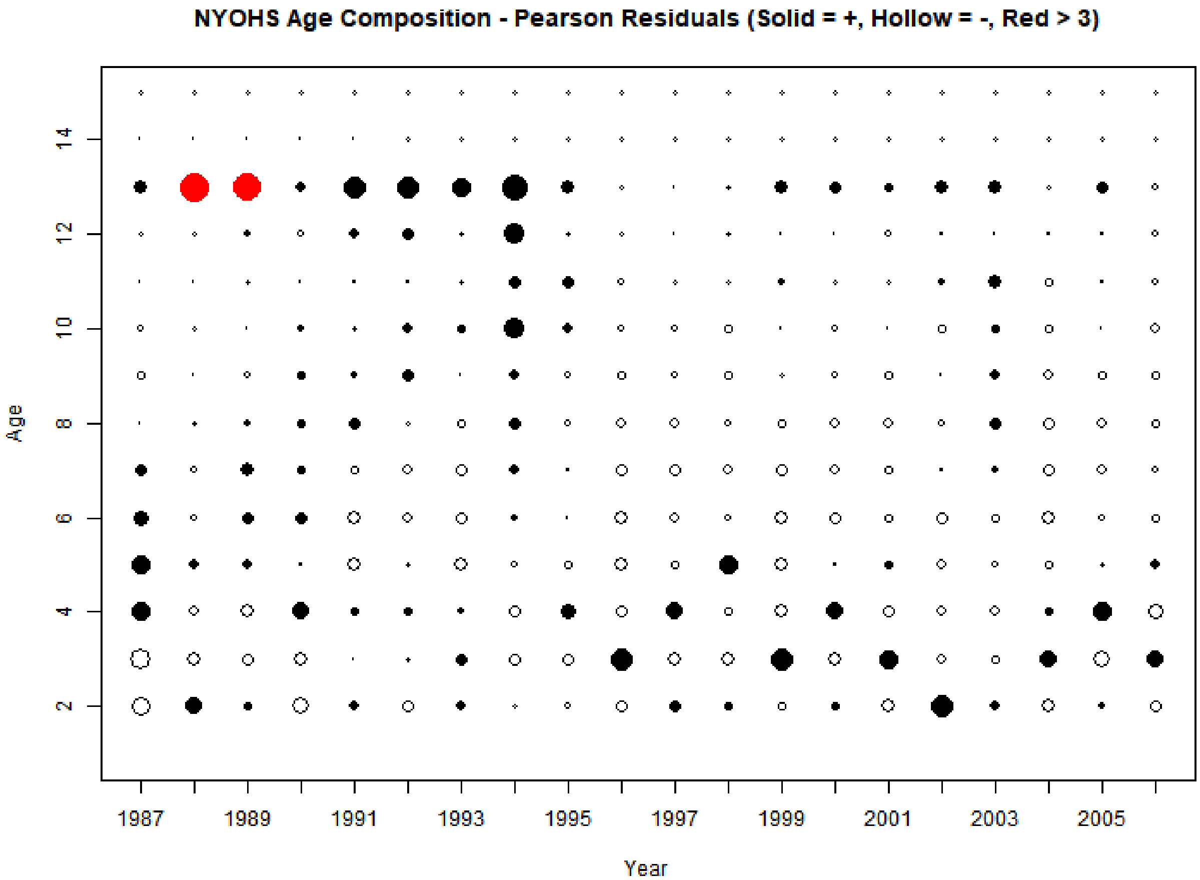


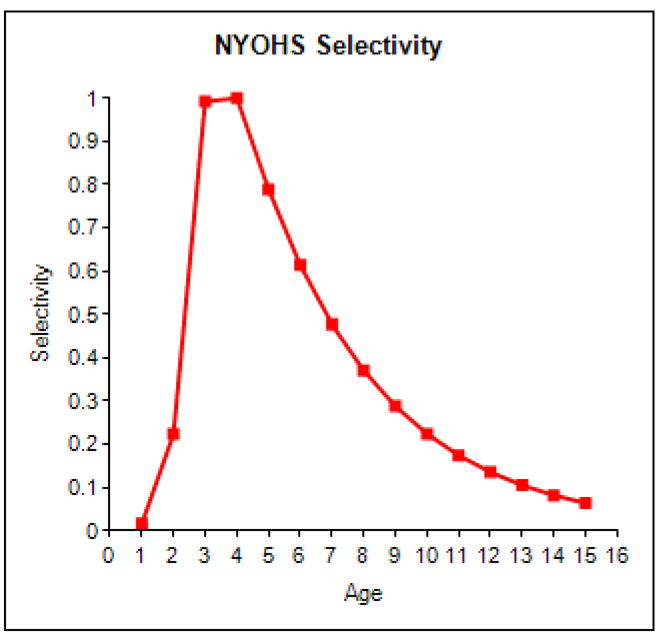
NYOHS Age Composition By Year

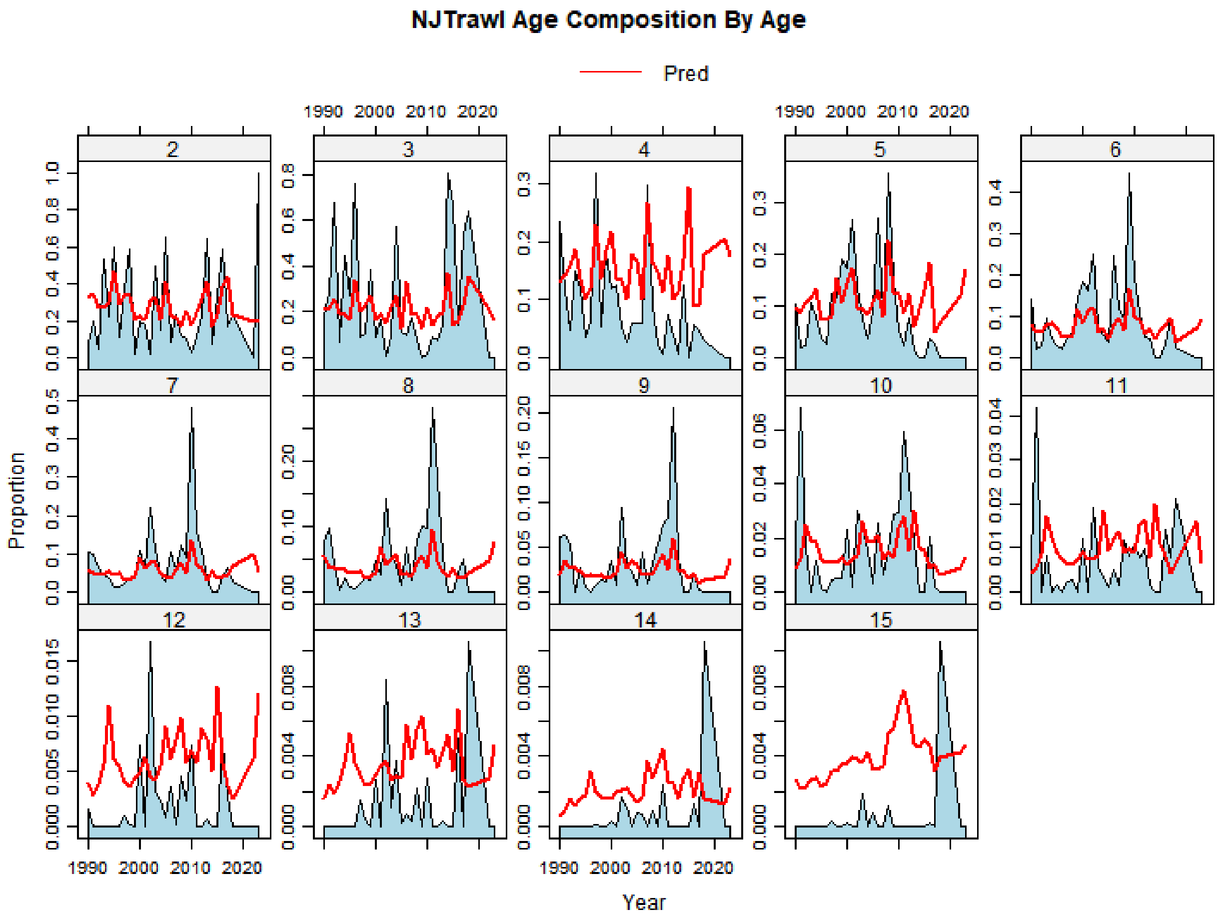



NYOHS Age Residuals By Age
Standardized Residual
Year

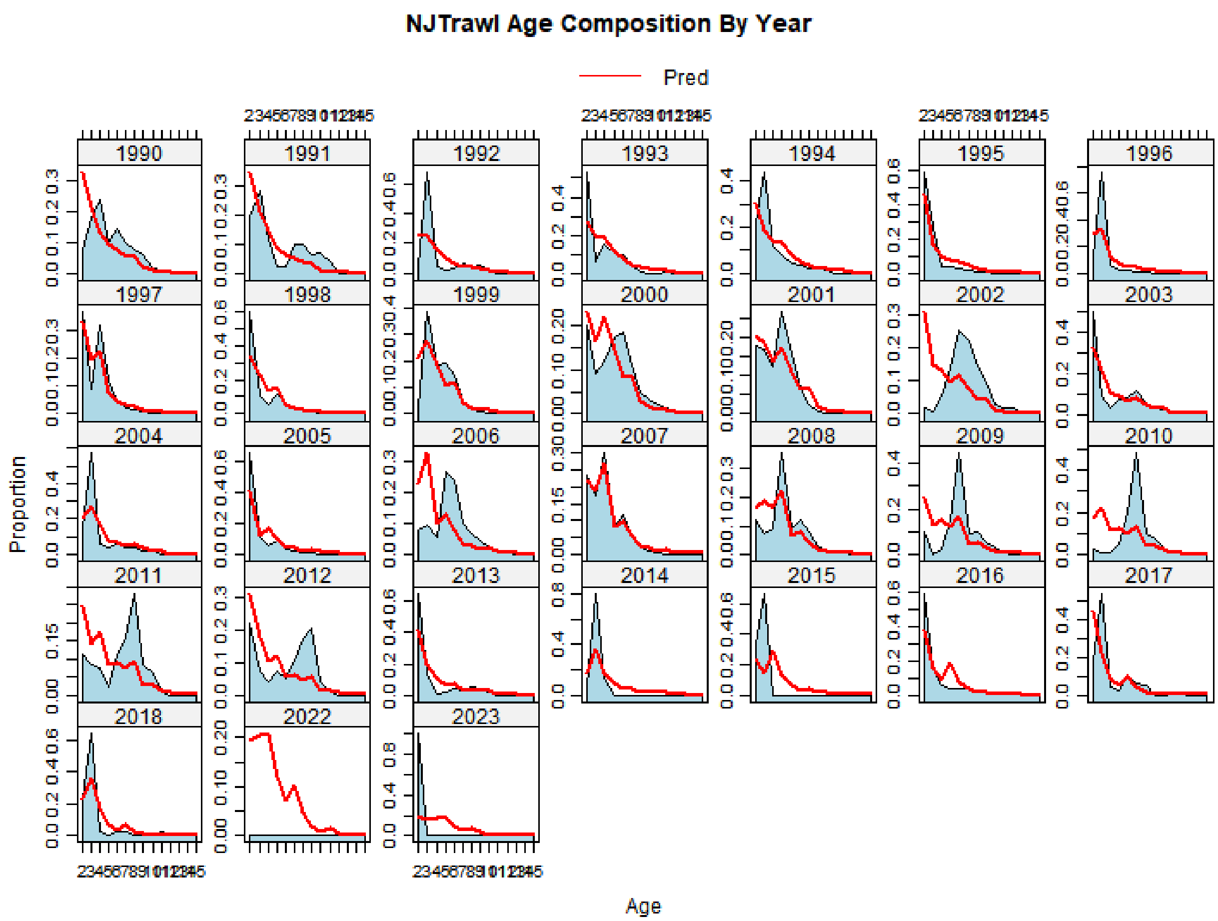

NYOHS Age Residuals By Year
Standardized Residual
Age


NYOHS Age Composition - Pearson Residuals (Solid = +, Hollow = -, Red > 3)
Age
2
4
6
8
10
12
14
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
Year


NYOHS Selectivity
Selectivity
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Age

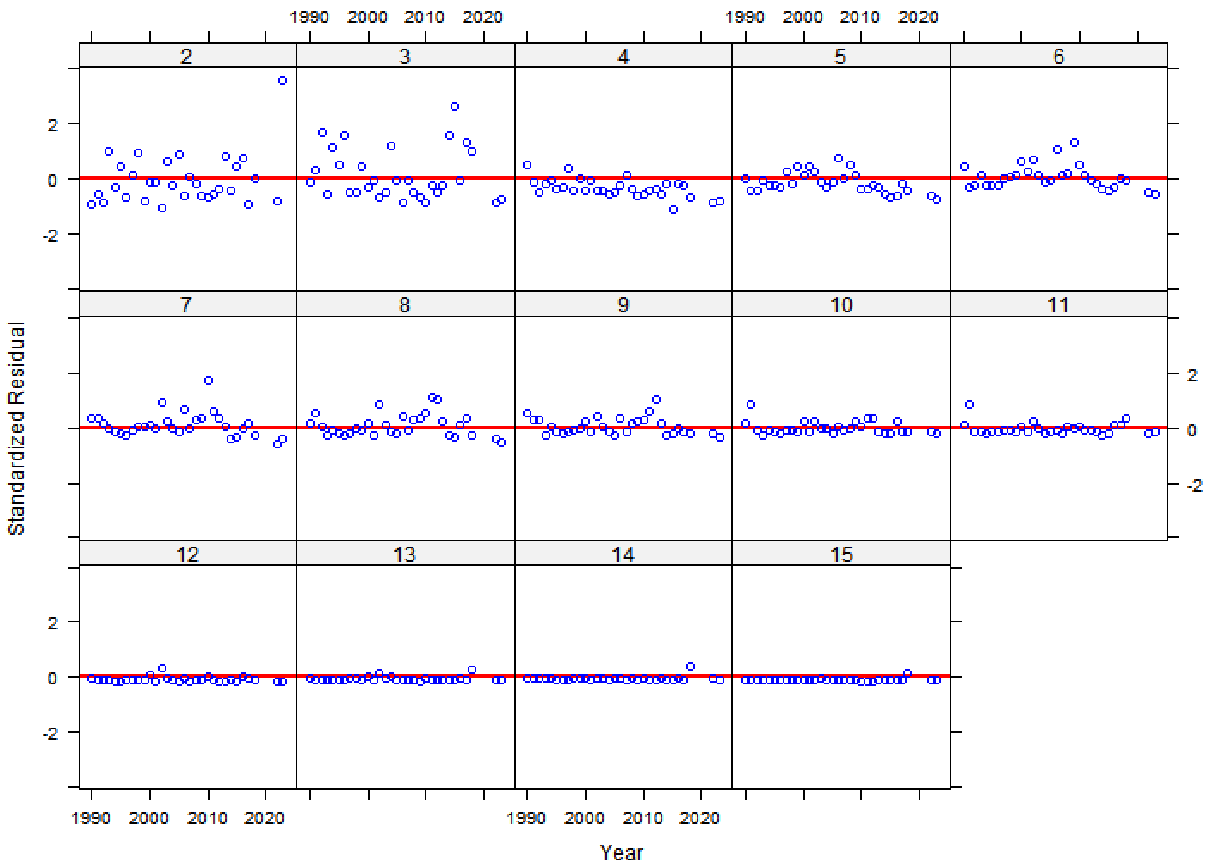


NJTrawl Age Composition By Age
Pred
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Proportion
Year

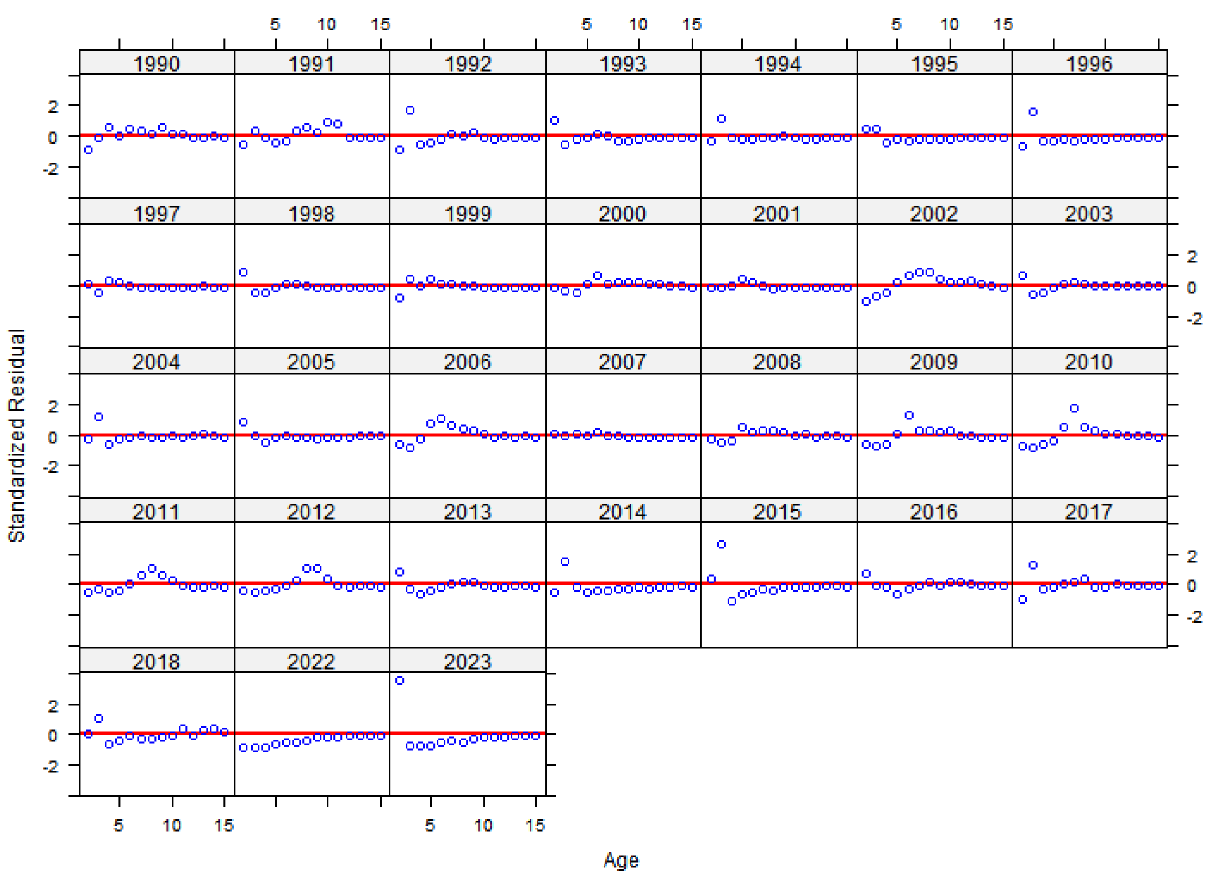


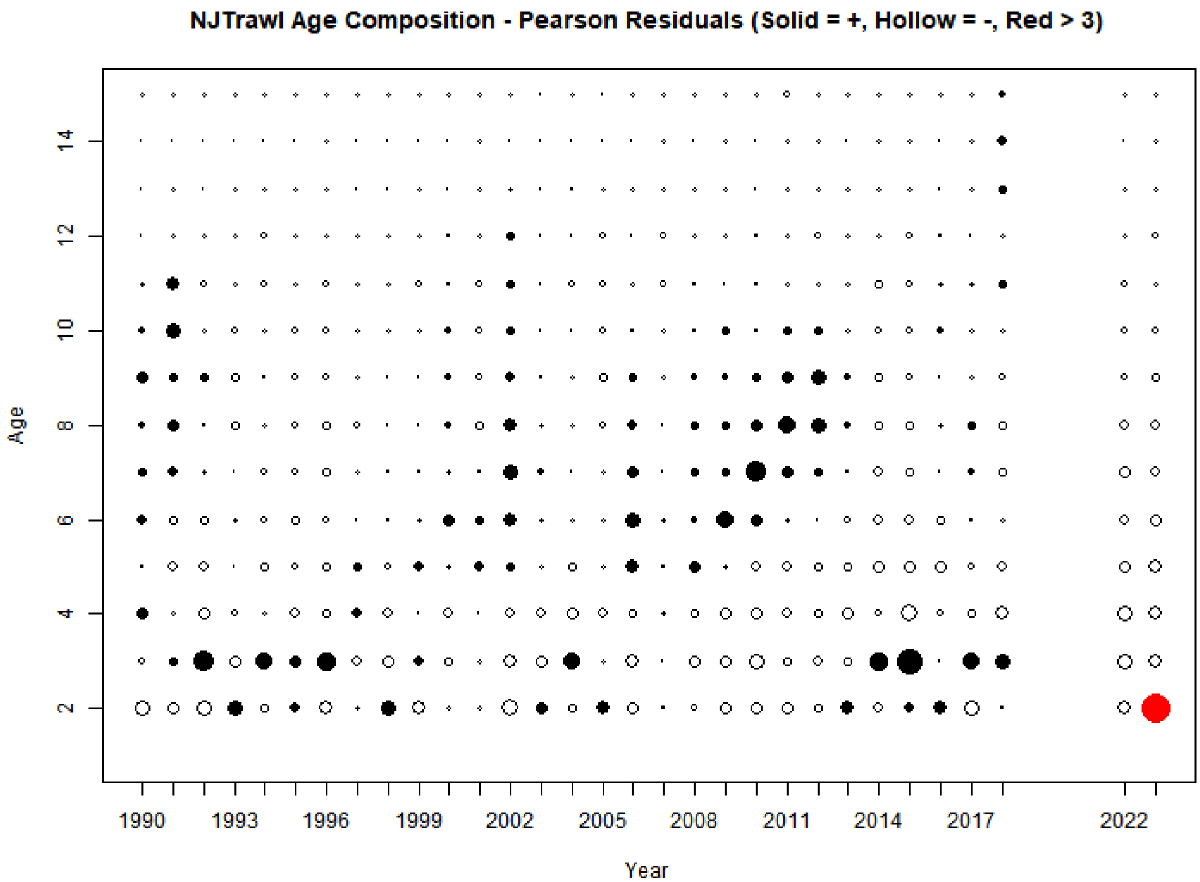
NJTrawl Age Composition By Year
Pred
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2022
2023
Proportion
Age

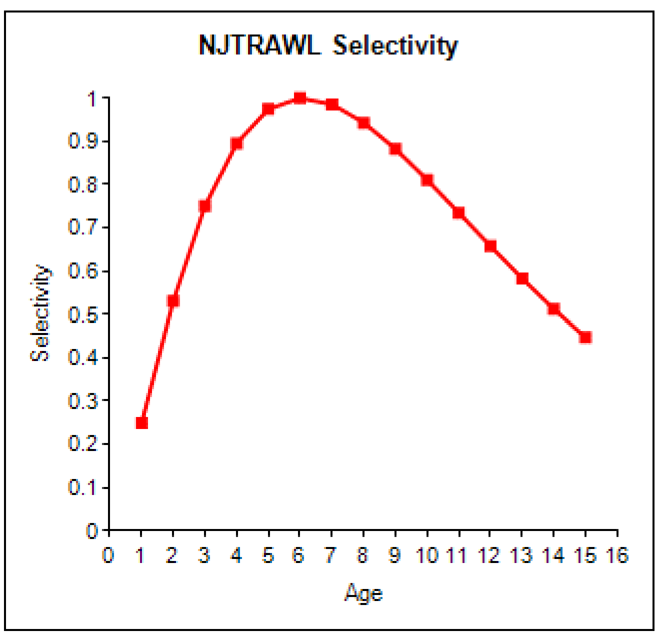
NJTrawl Age Residuals By Age

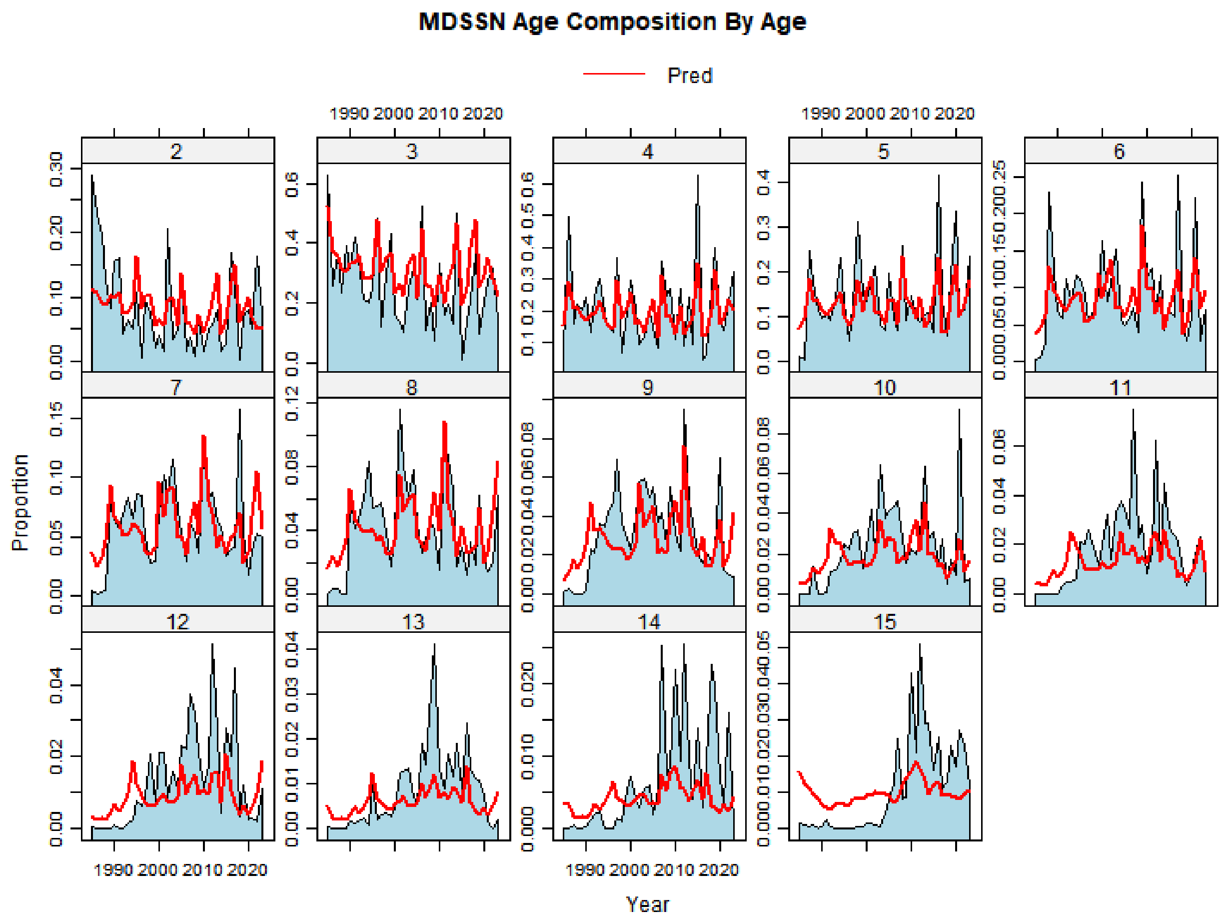


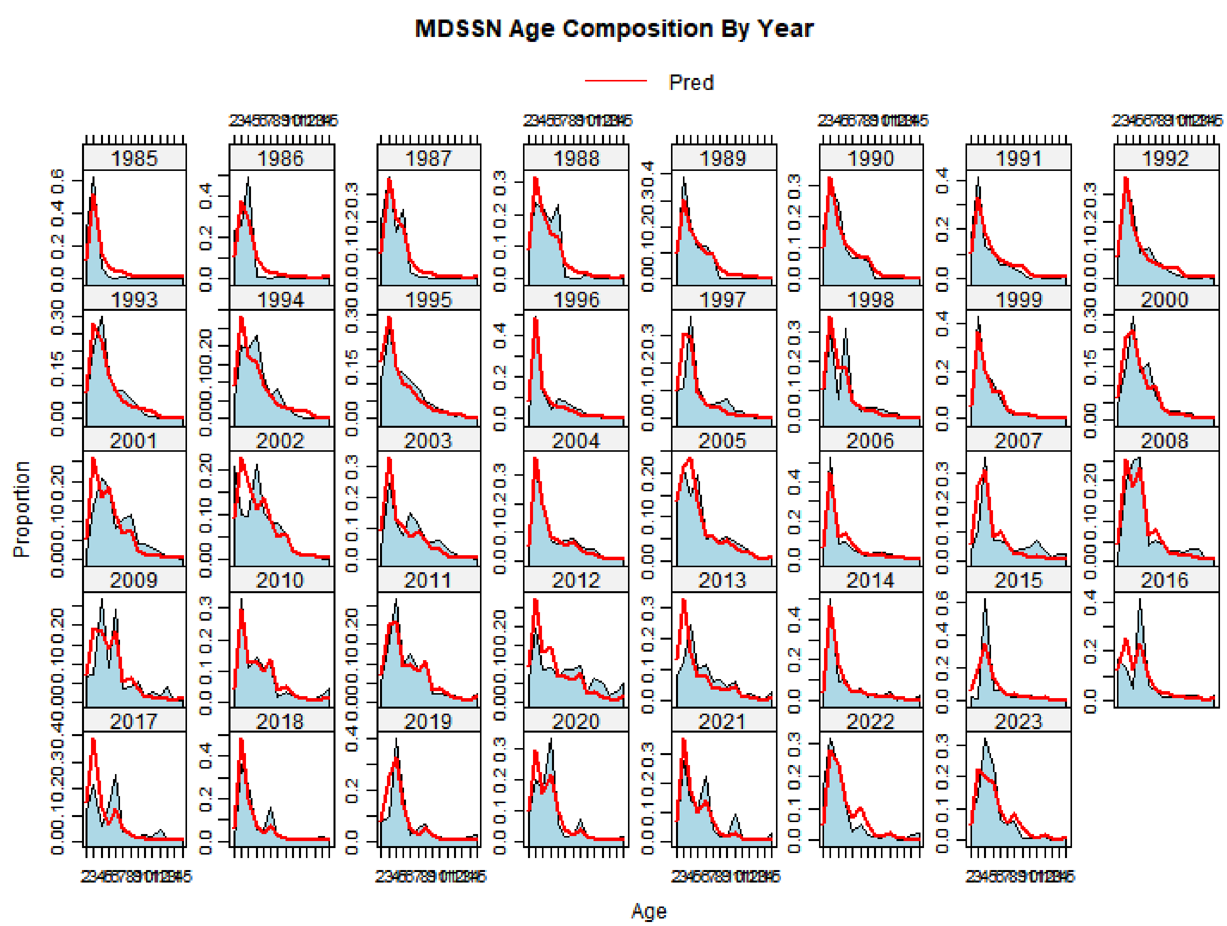
NJTrawl Age Residuals By Year

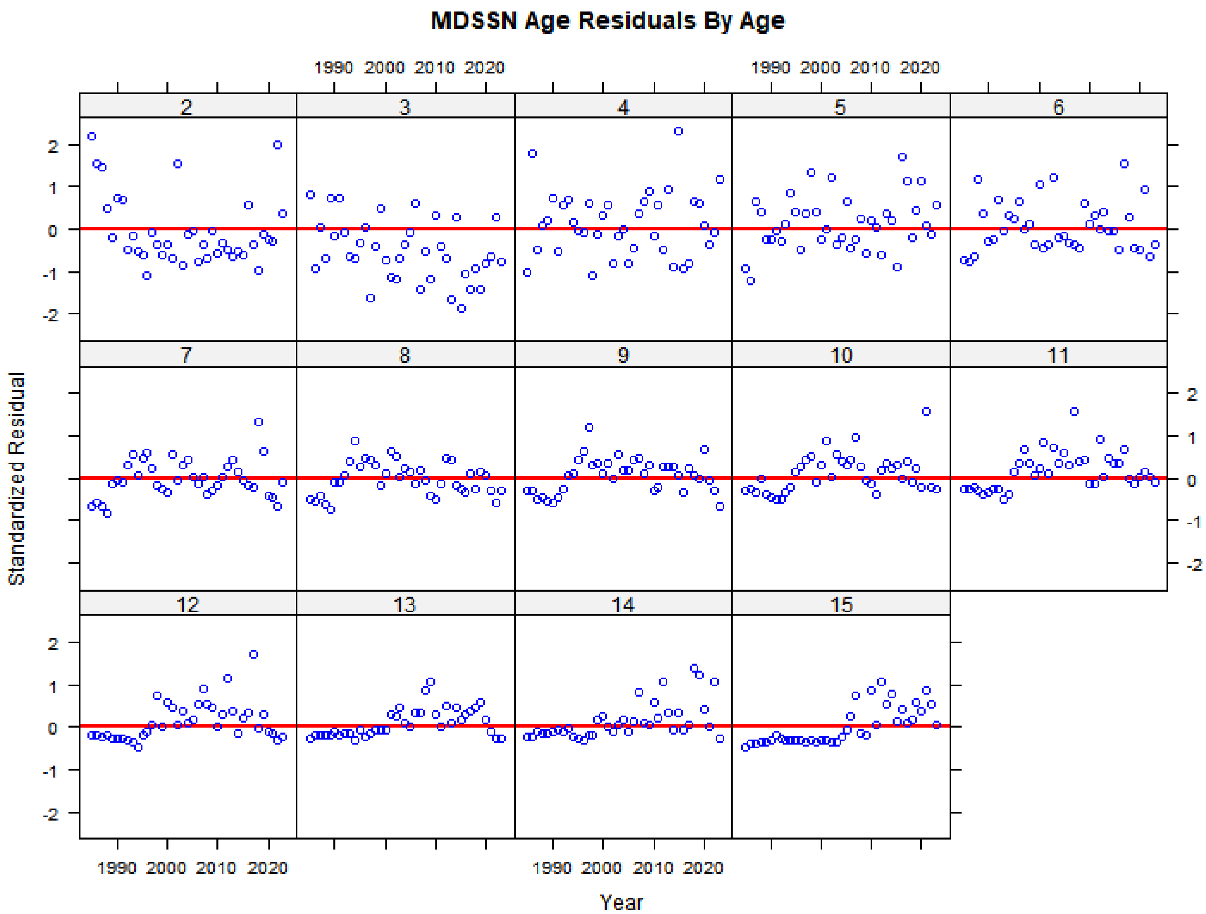


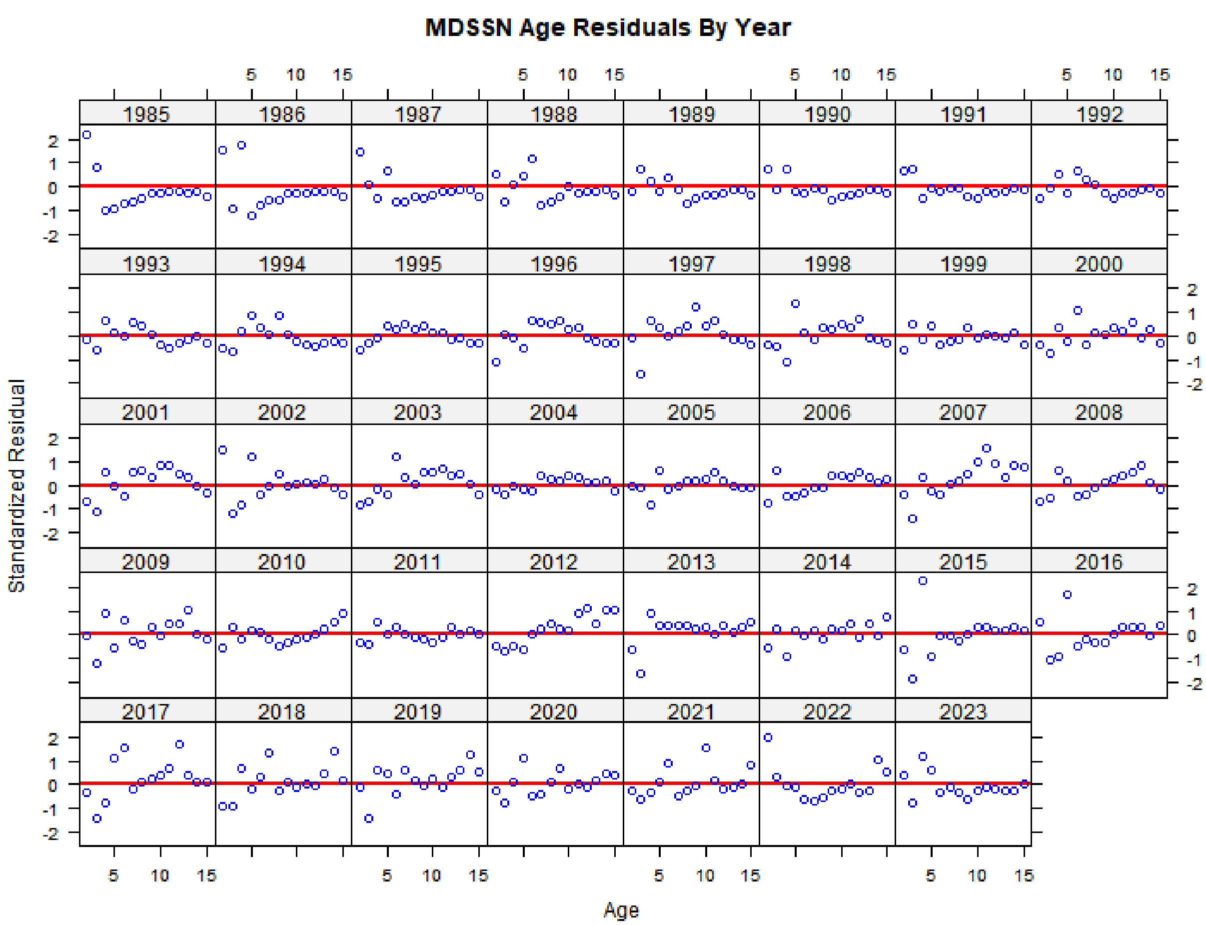

NJTrawl Age Composition - Pearson Residuals (Solid = +, Hollow = -, Red > 3)
Age
2
4
6
8
10
12
14
Year
1990
1993
1996
1999
2002
2005
2008
2011
2014
2017
2022

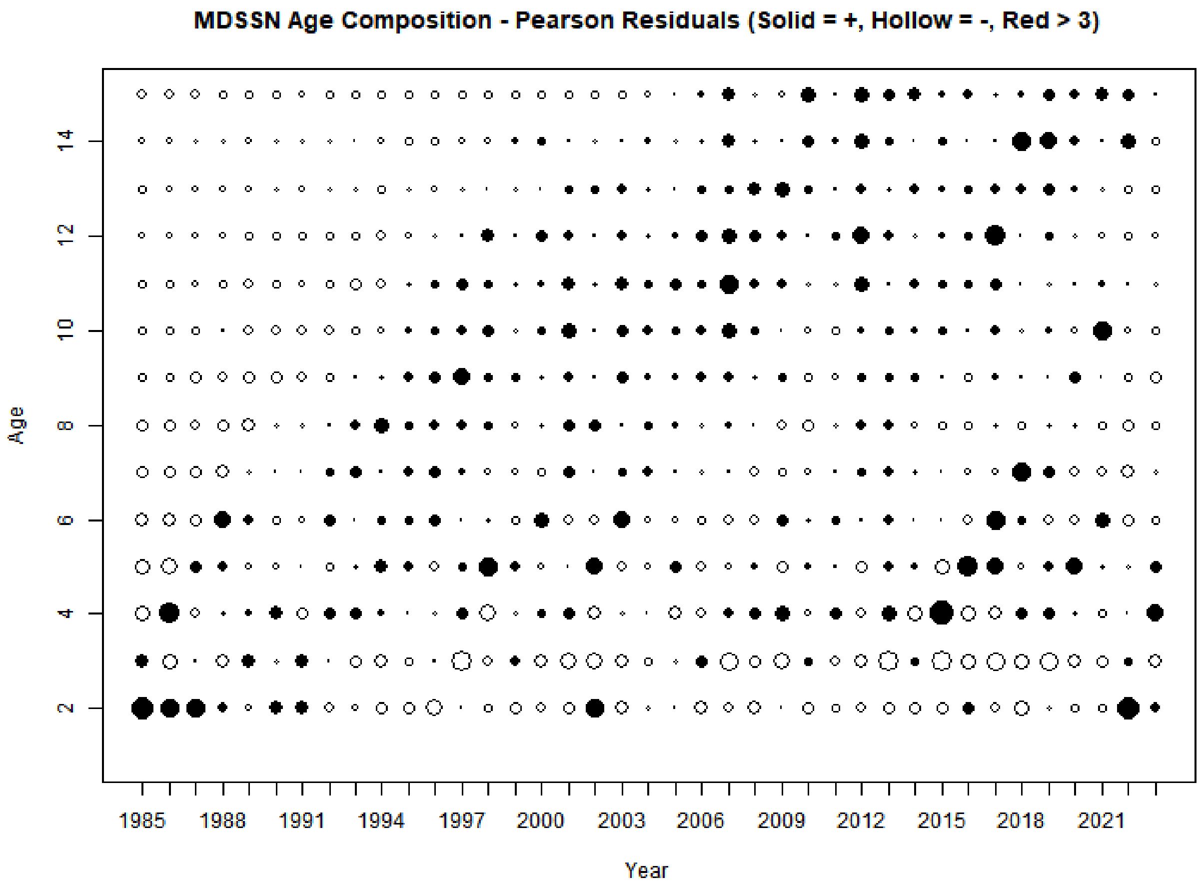

NJTRAWL Selectivity
Selectivity
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Age
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

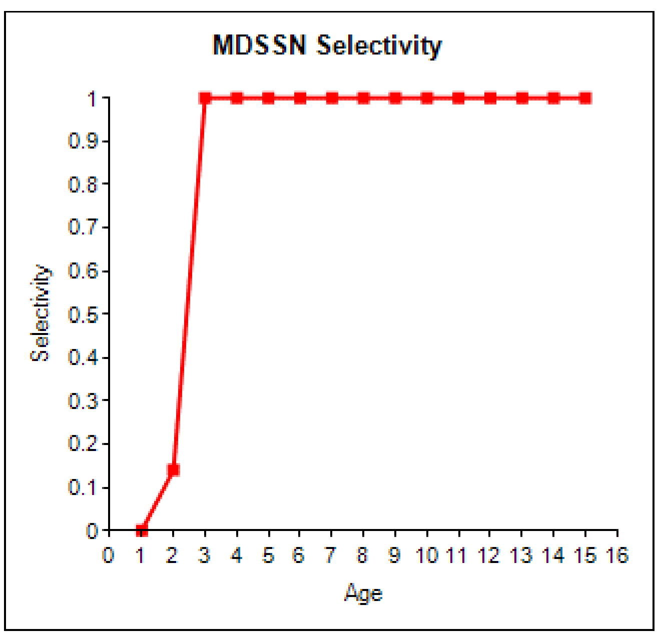

MDSSN Age Composition By Age
Pred
Proportion
Year
1990 2000 2010 2020
2
3
4
5
6
7
8
9
10
11
12
13
14
15


MDSSN Age Composition By Year
Pred
Proportion
Age
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023

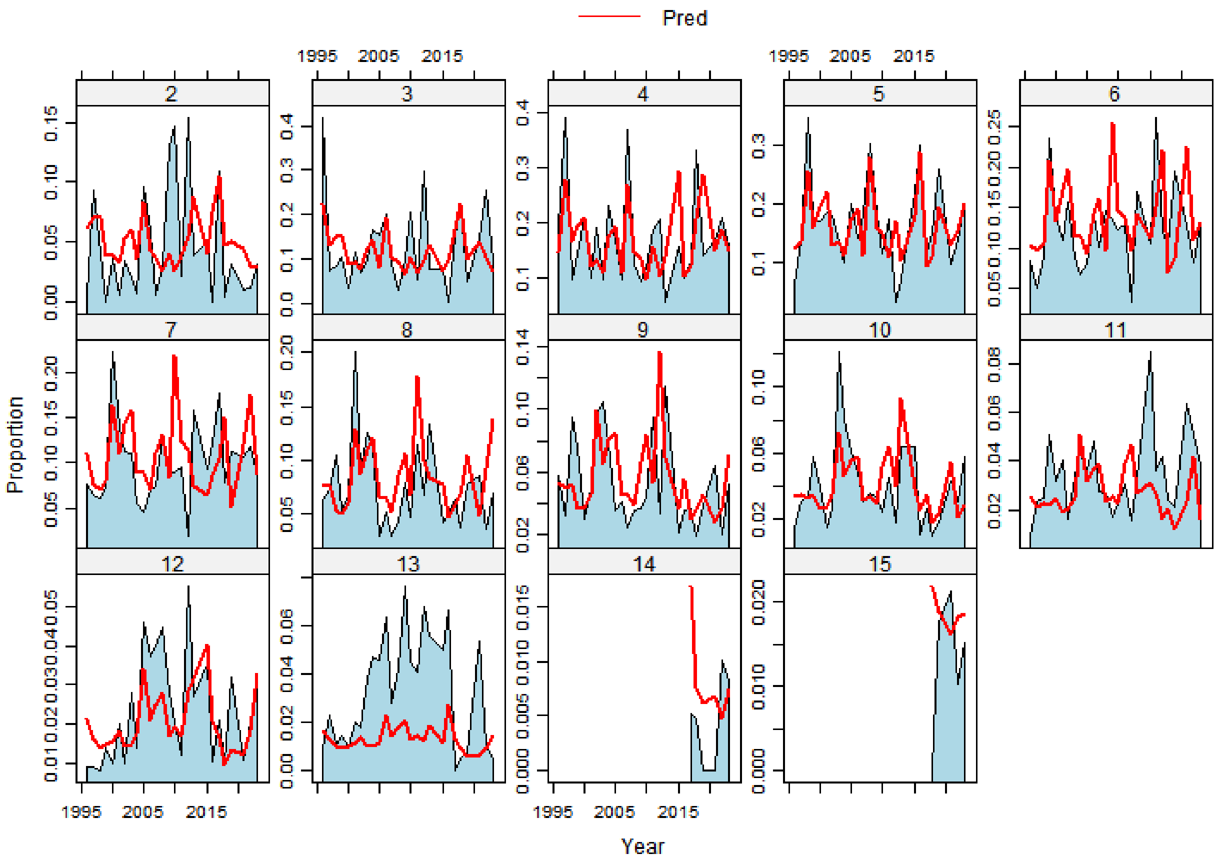

MDSSN Age Residuals By Age
Standardized Residual
Year


MDSSN Age Residuals By Year
Standardized Residual
Age

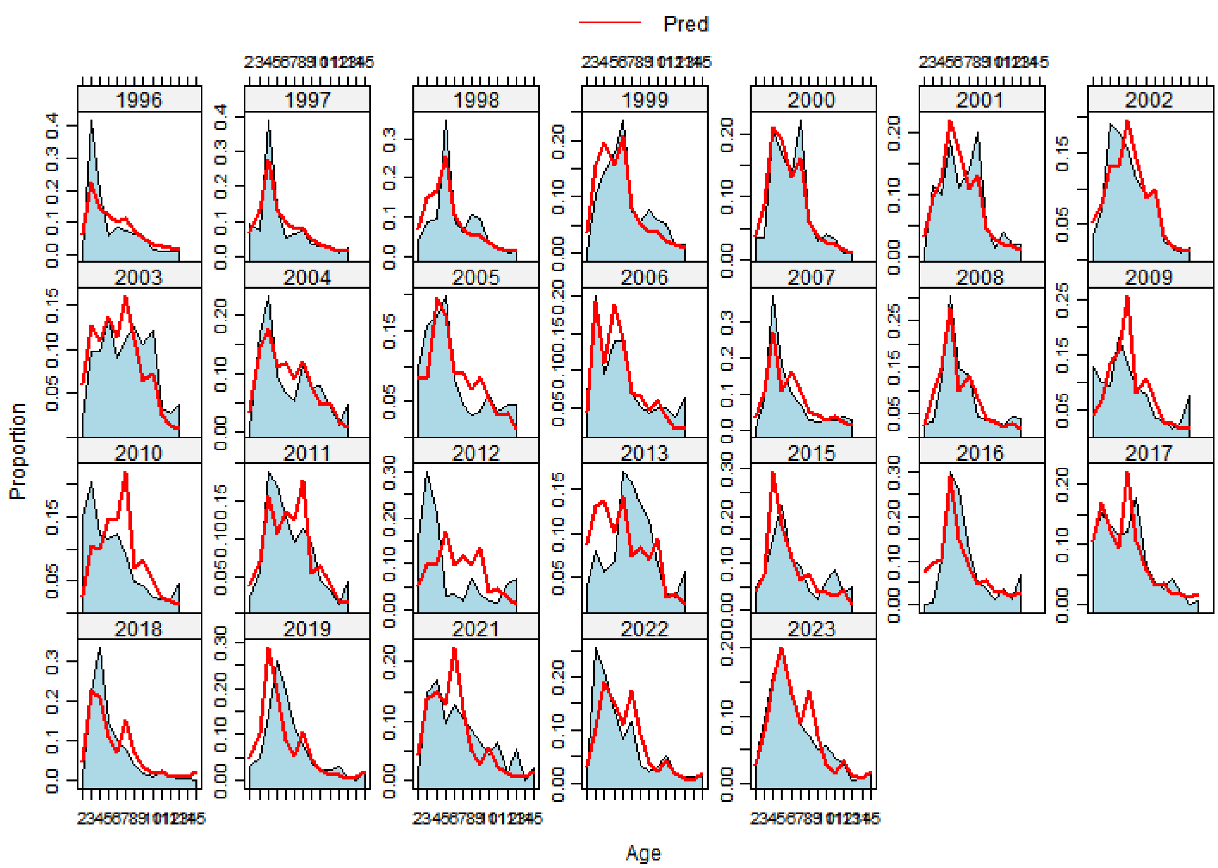

MDSSN Age Composition - Pearson Residuals (Solid = +, Hollow = -, Red > 3)
Age
2
4
6
8
10
12
14
Year
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
2015
2018
2021

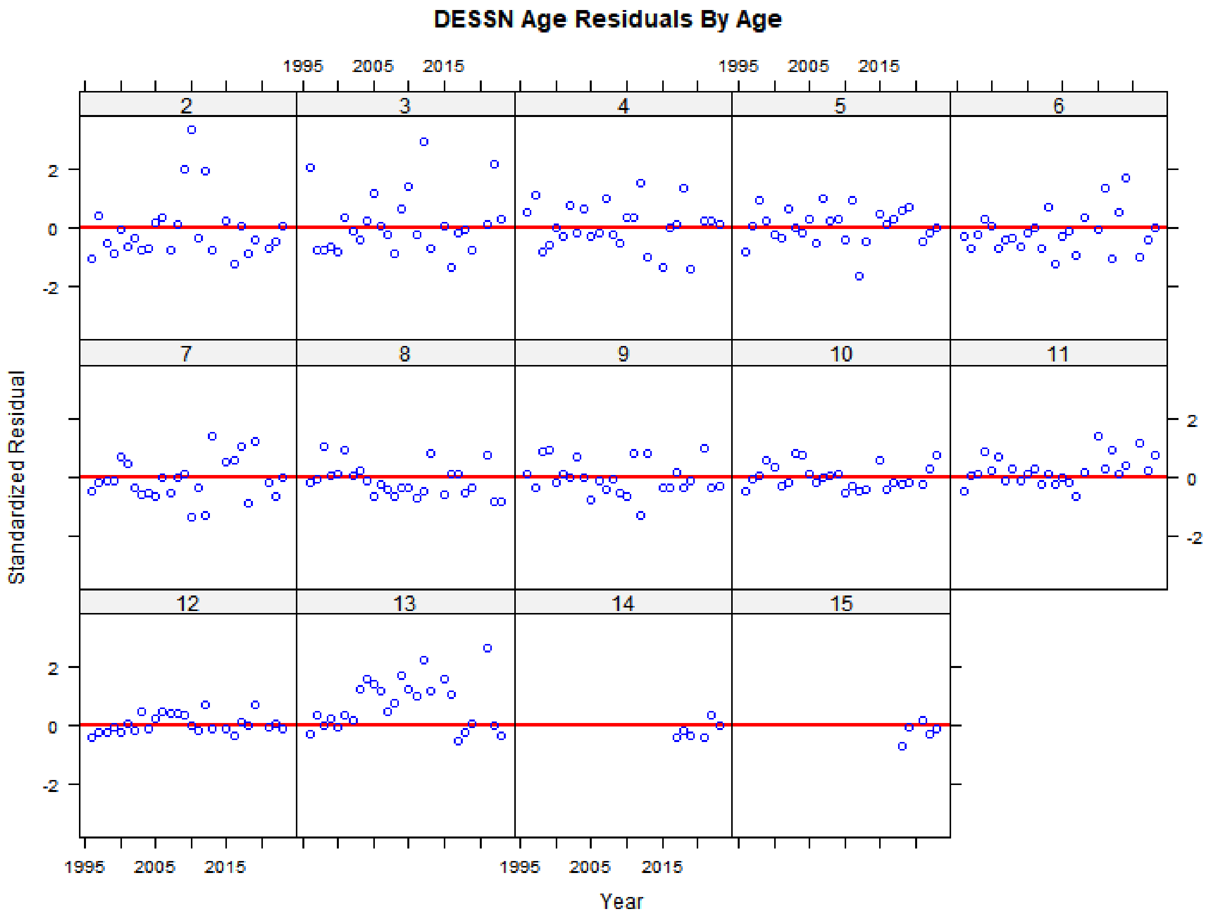

MDSSN Selectivity
Selectivity
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Age
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

DESSN Age Composition By Age

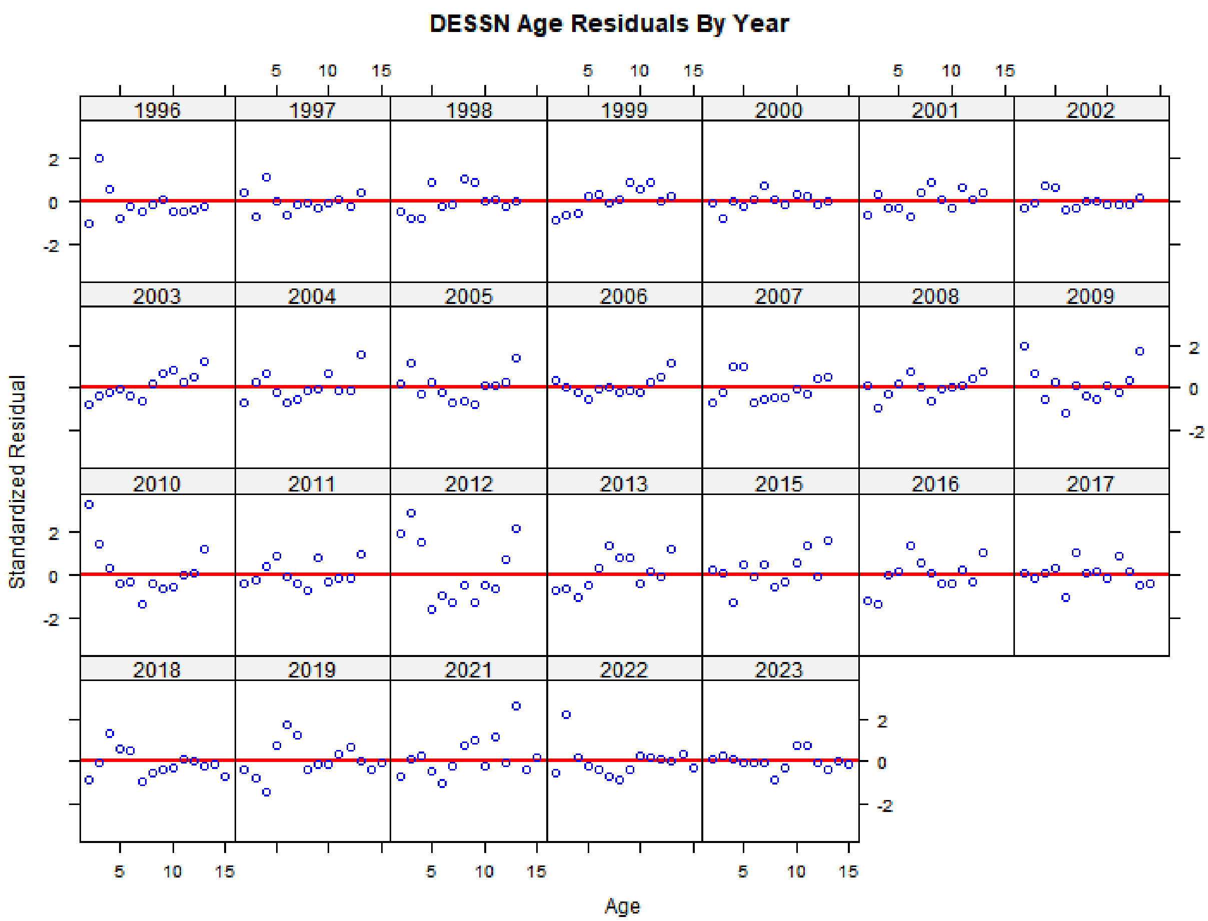


DESSN Age Composition By Year

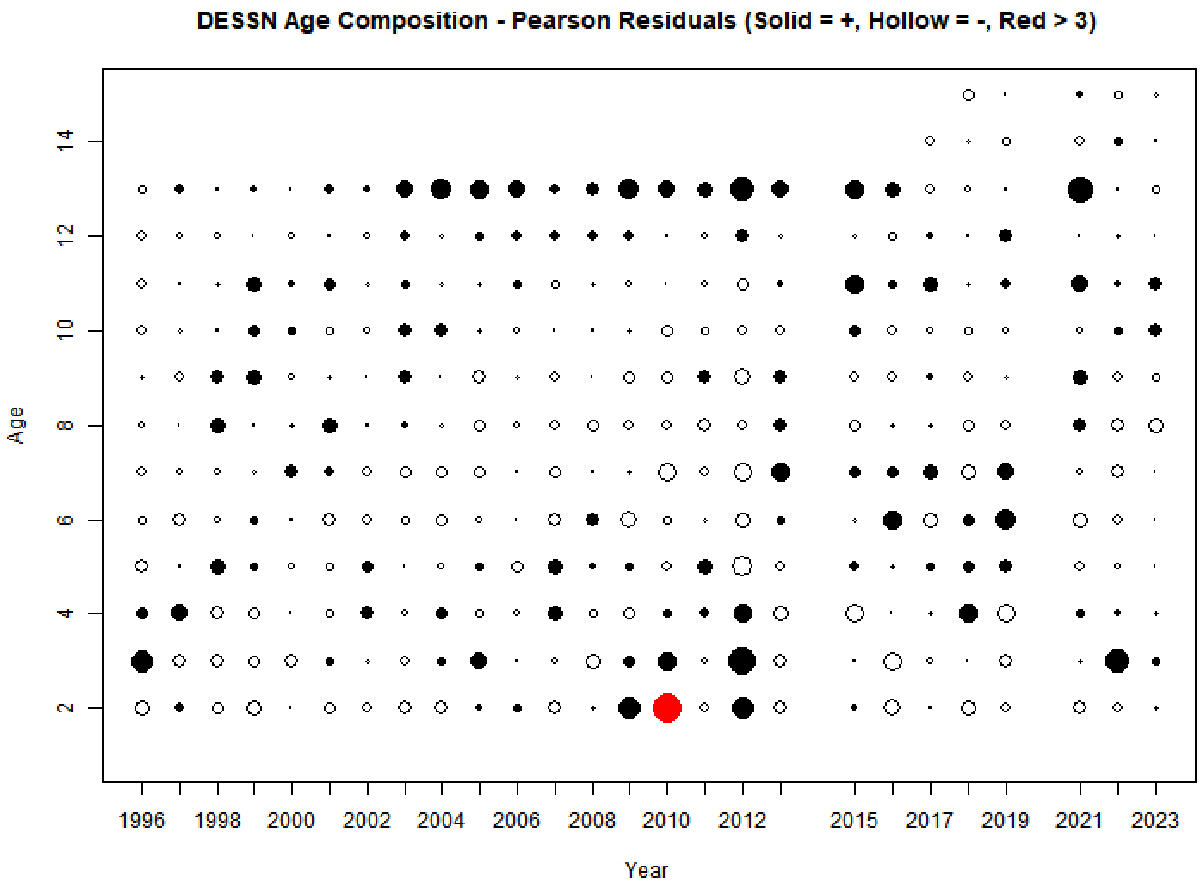


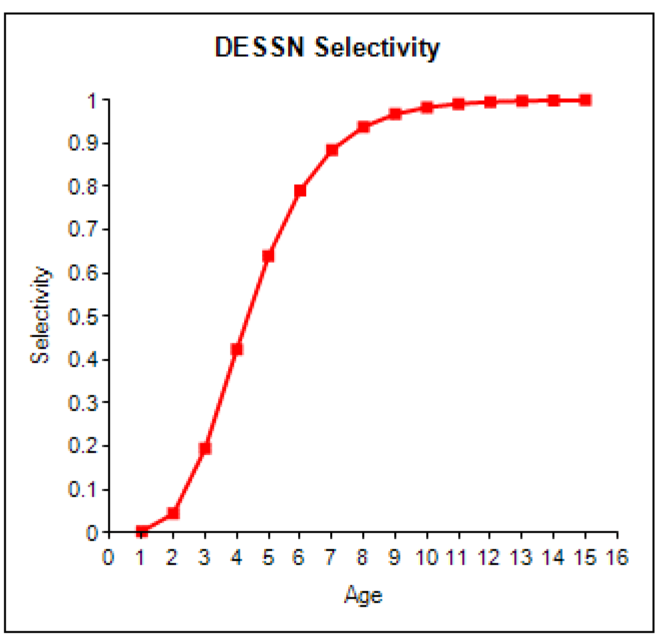


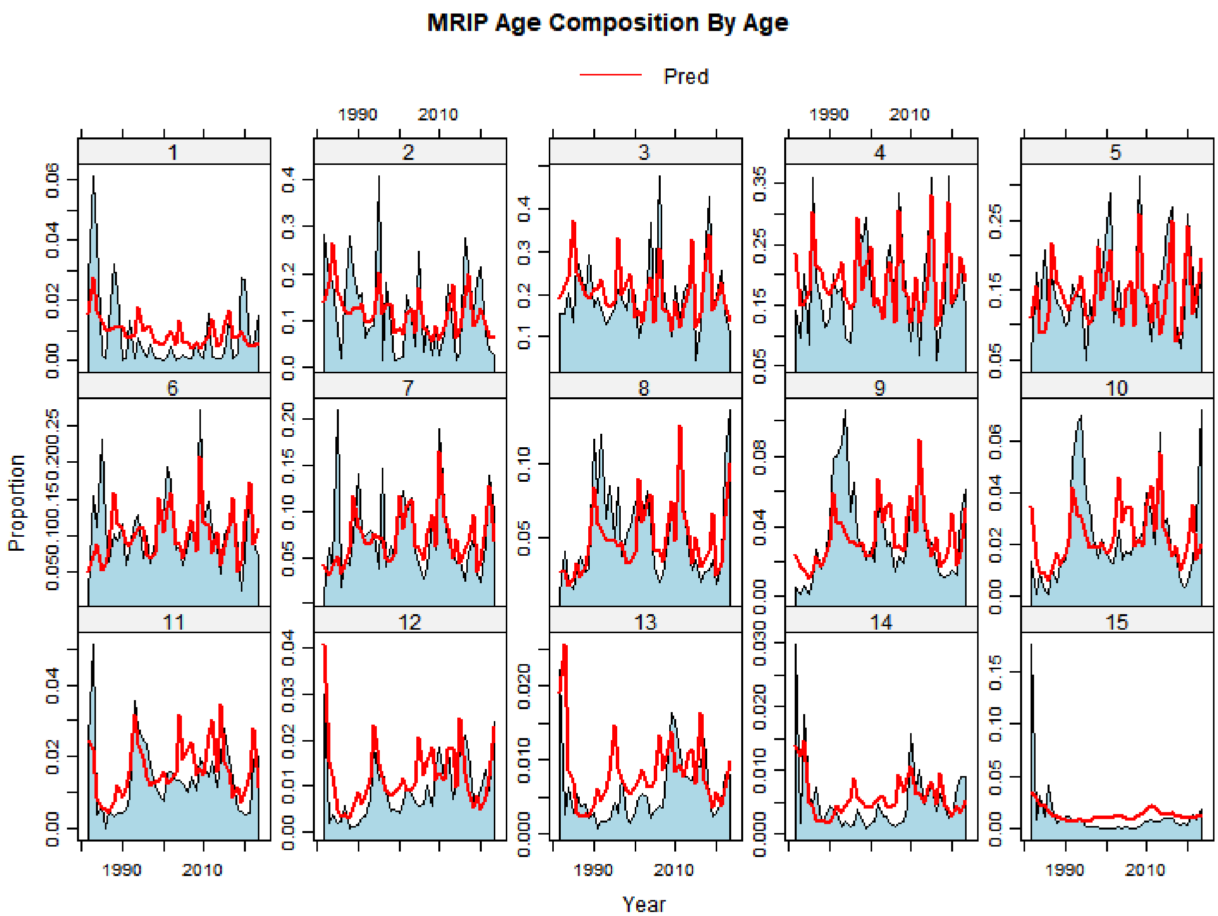
DESSN Age Residuals By Age
Standardized Residual
Year
2
3
4
5
6
7
8
9
10
11
12
13
14
15
1995
2005
2015

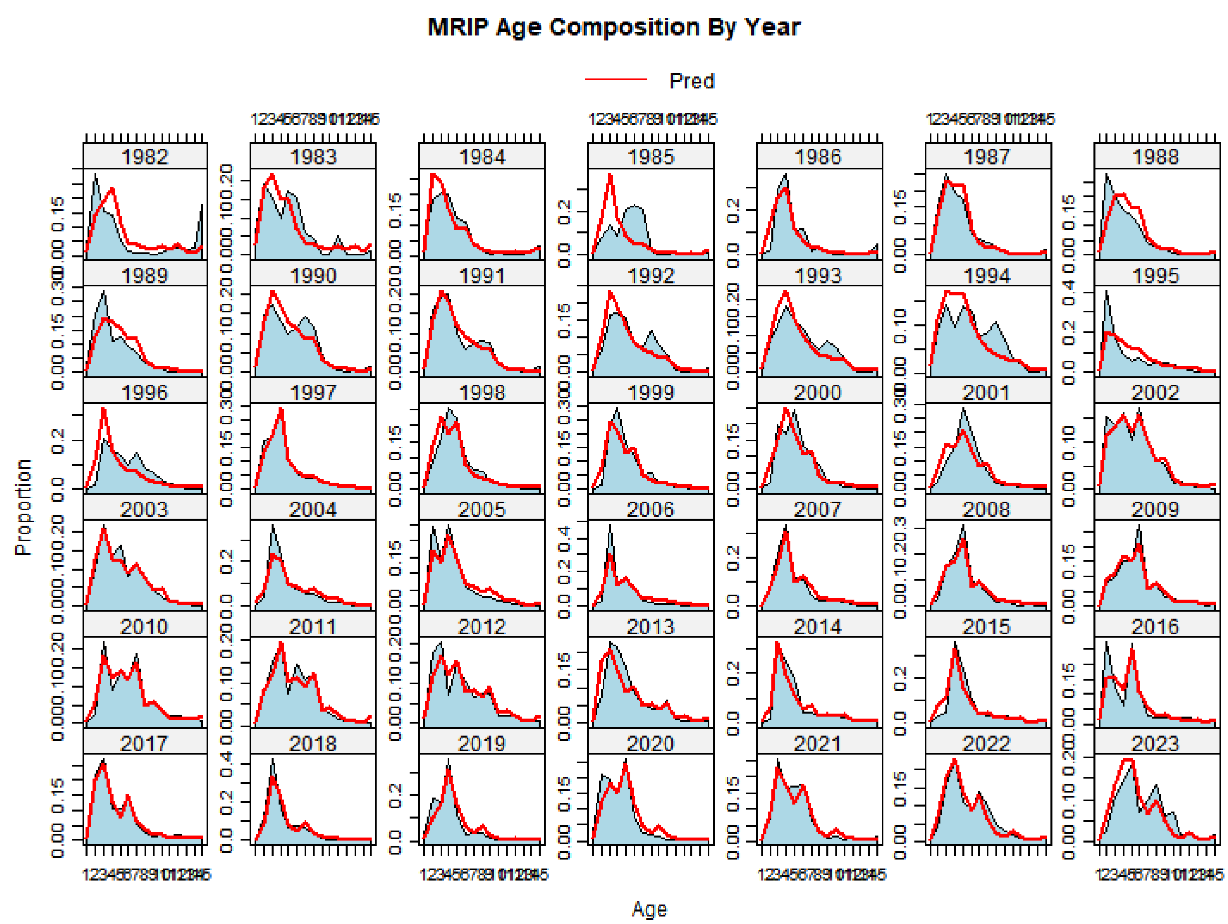


DESSN Age Residuals By Year
Standardized Residual
Age
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2015
2016
2017
2018
2019
2021
2022
2023

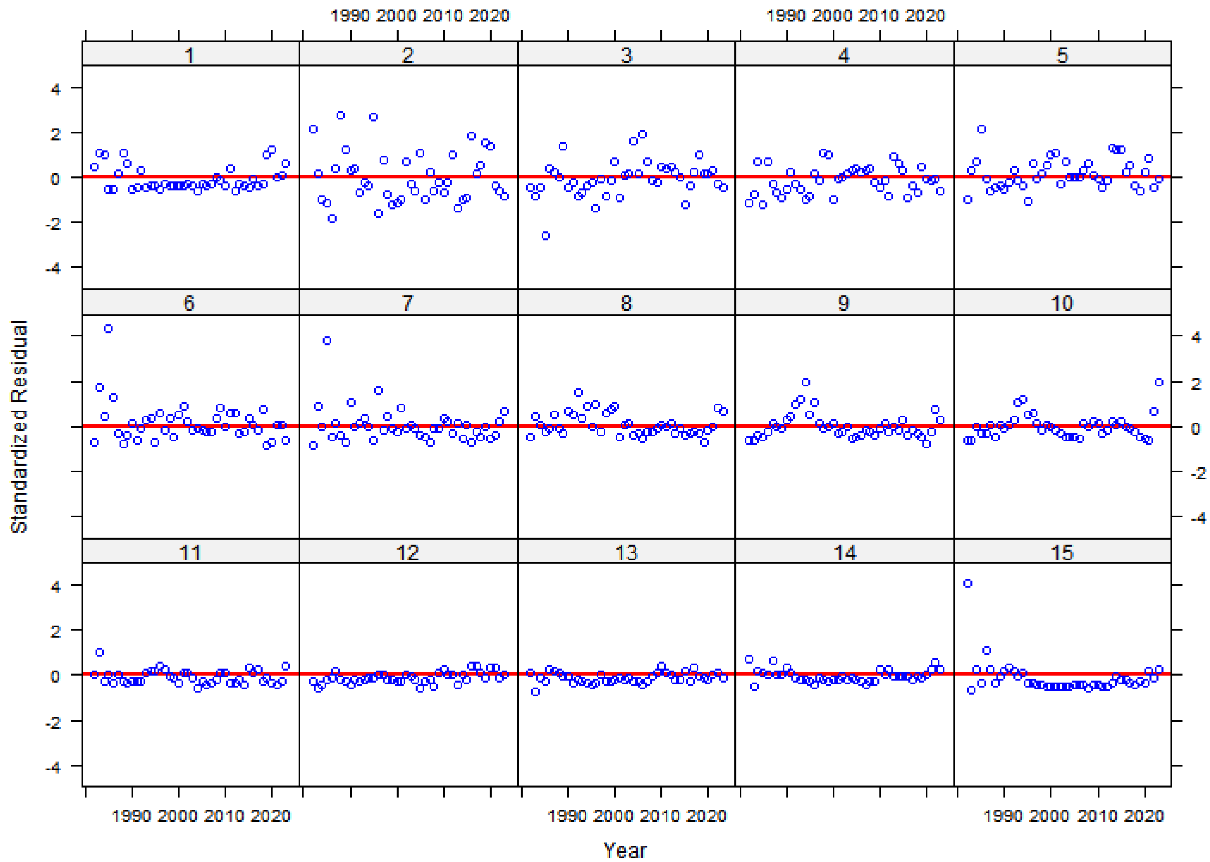

DESSN Age Composition - Pearson Residuals (Solid = +, Hollow = -, Red > 3)
Age
Year
1996
1998
2000
2002
2004
2006
2008
2010
2012
2015
2017
2019
2021
2023
2
4
6
8
10
12
14


DESSN Selectivity
Selectivity
Age
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

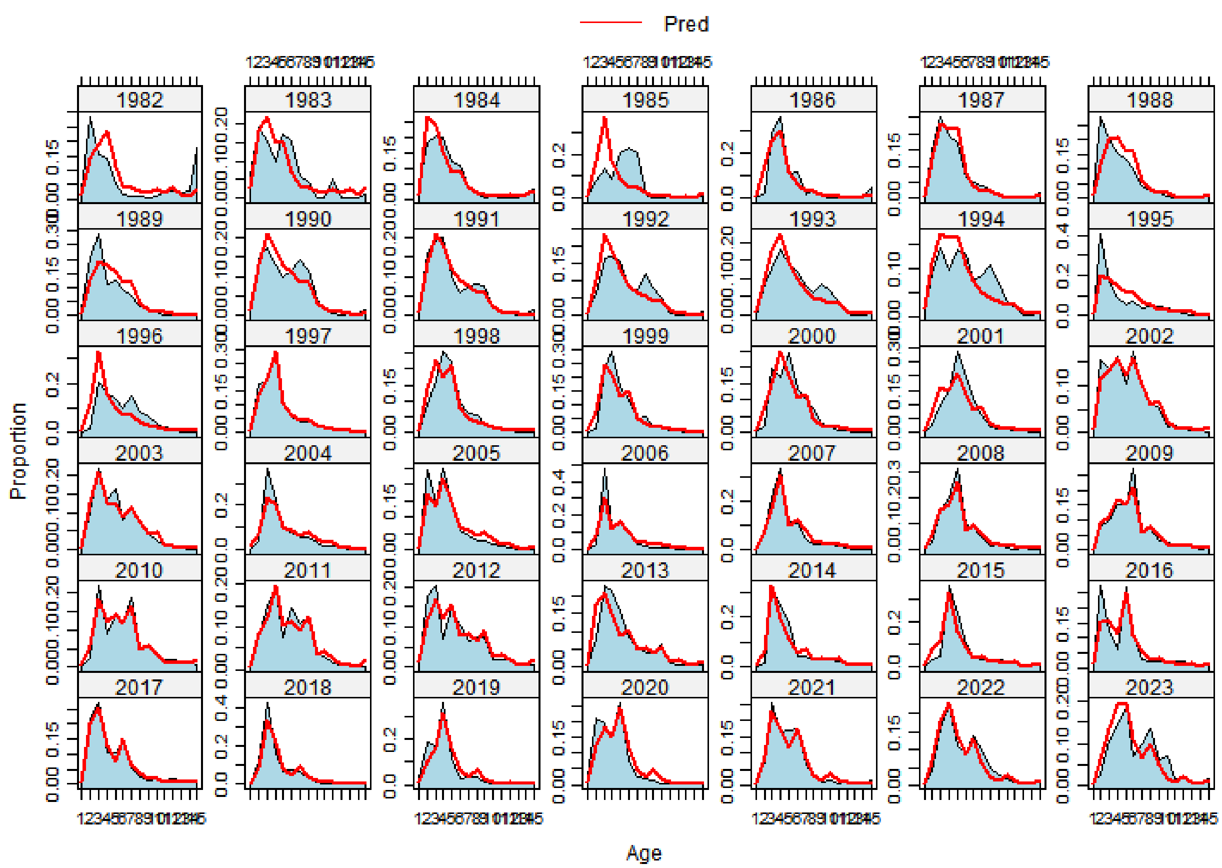

MRIP Age Composition By Age
Pred
Proportion
Year
1990
2010

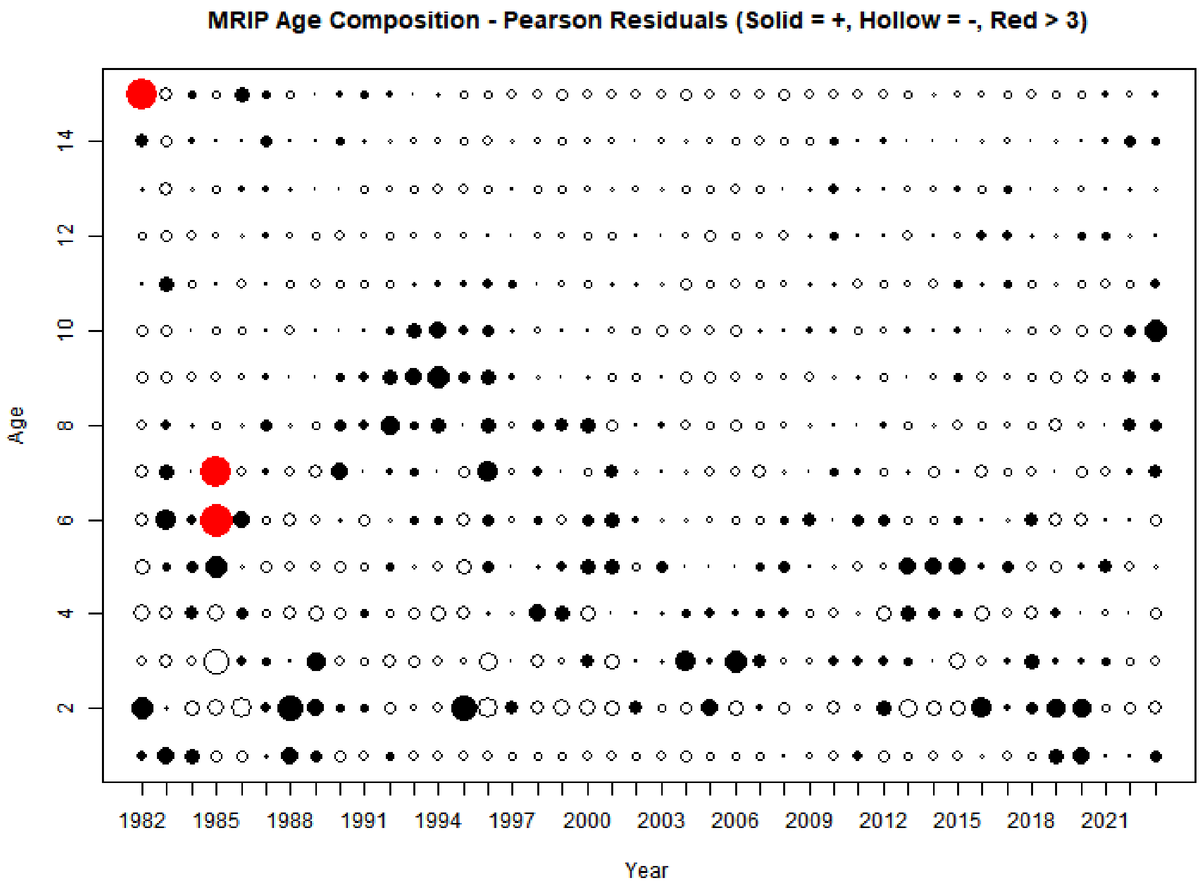

MRIP Age Composition By Year
Pred
Proportion
Age

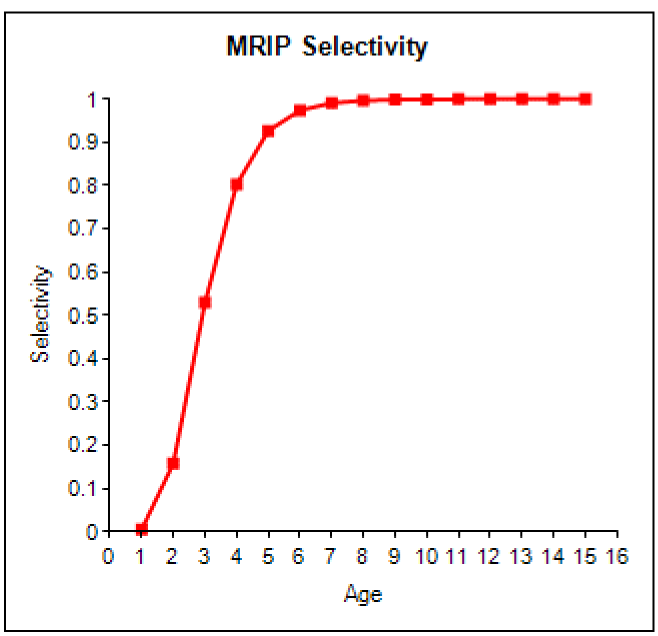
MRIP Age Residuals By Age



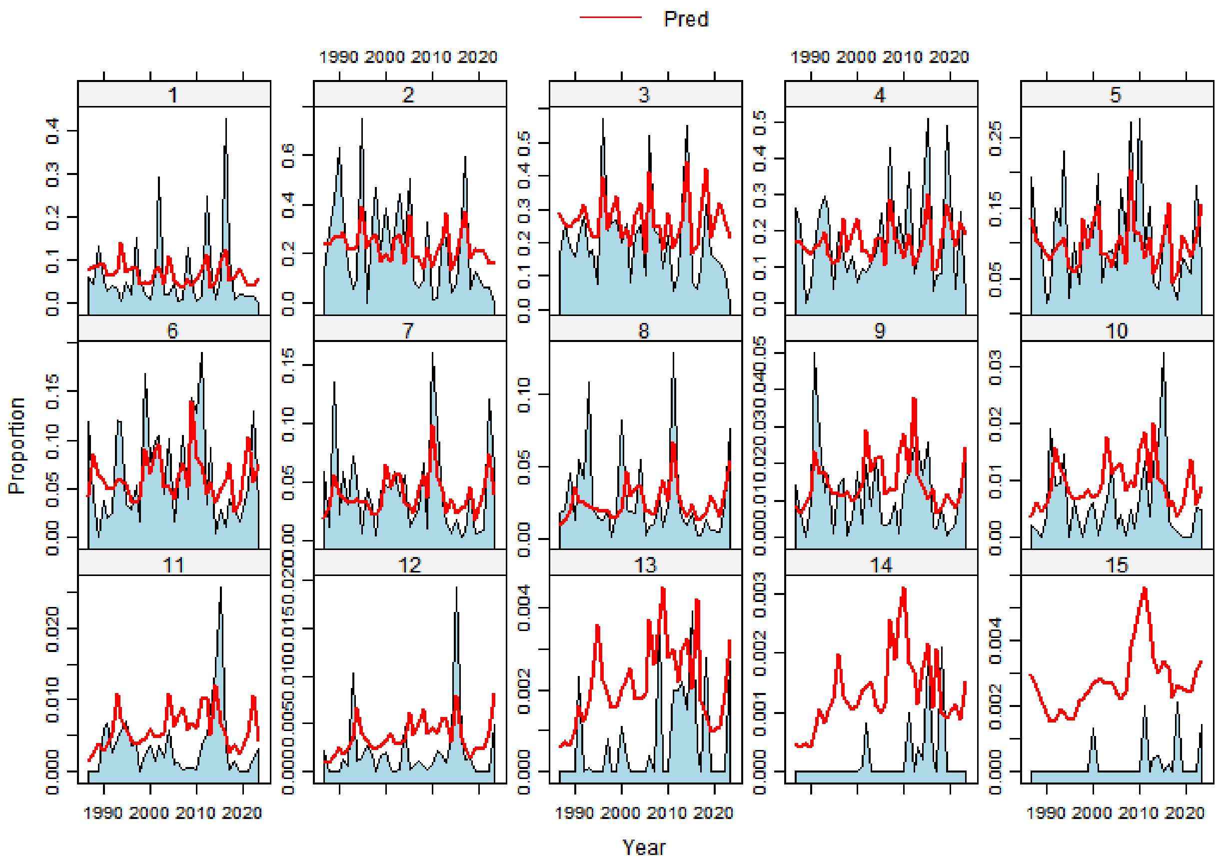
MRIP Age Composition By Year



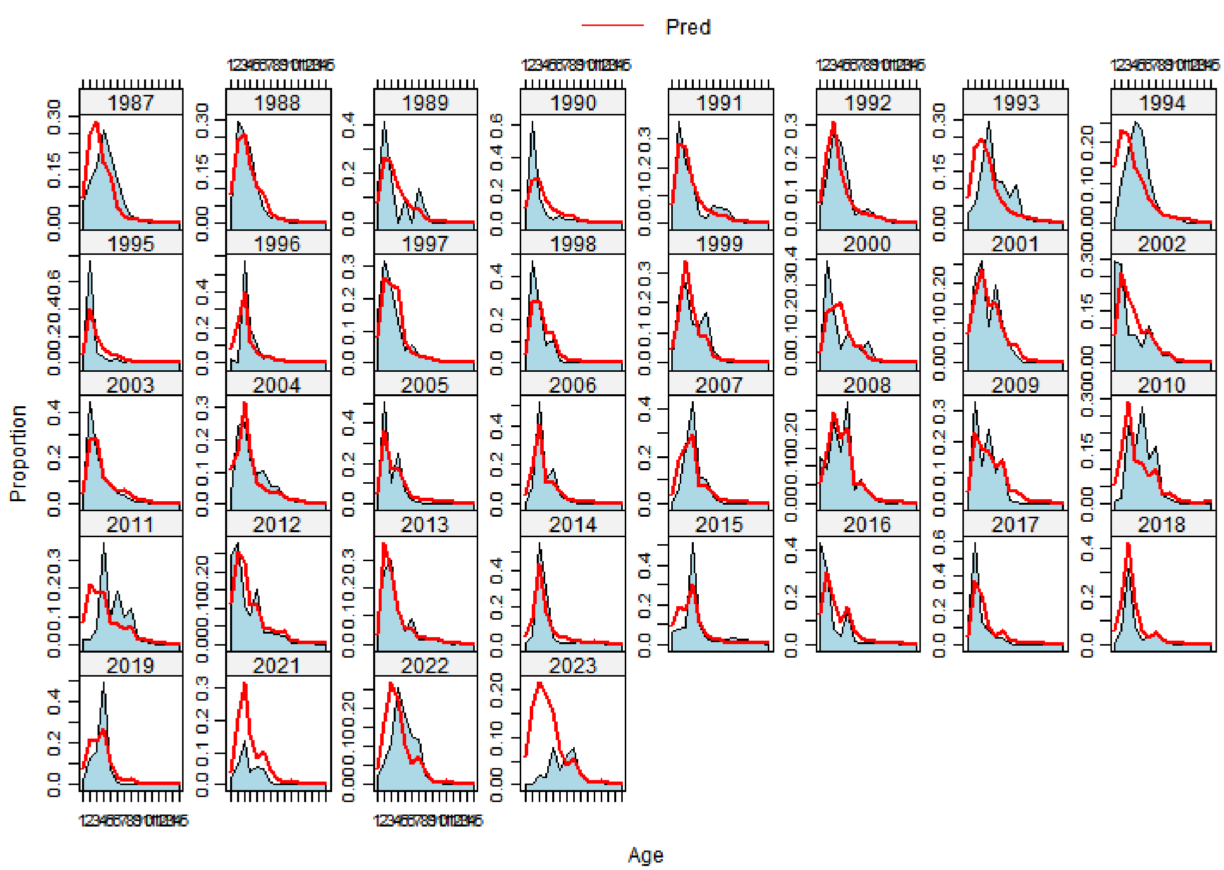

MRIP Age Composition - Pearson Residuals (Solid = +, Hollow = -, Red > 3)
Age
2
4
6
8
10
12
14
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
2015
2018
2021
Year

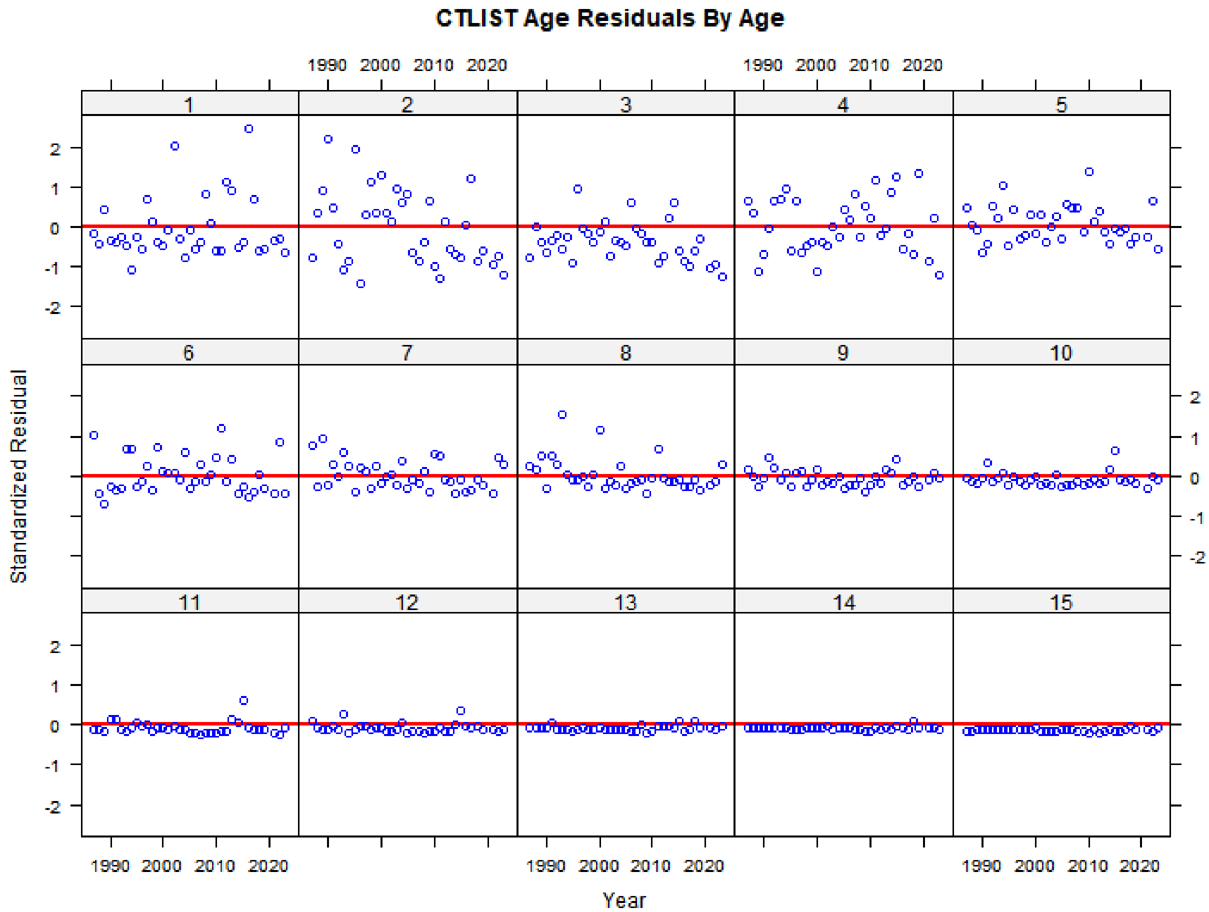

MRIP Selectivity
Selectivity
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Age

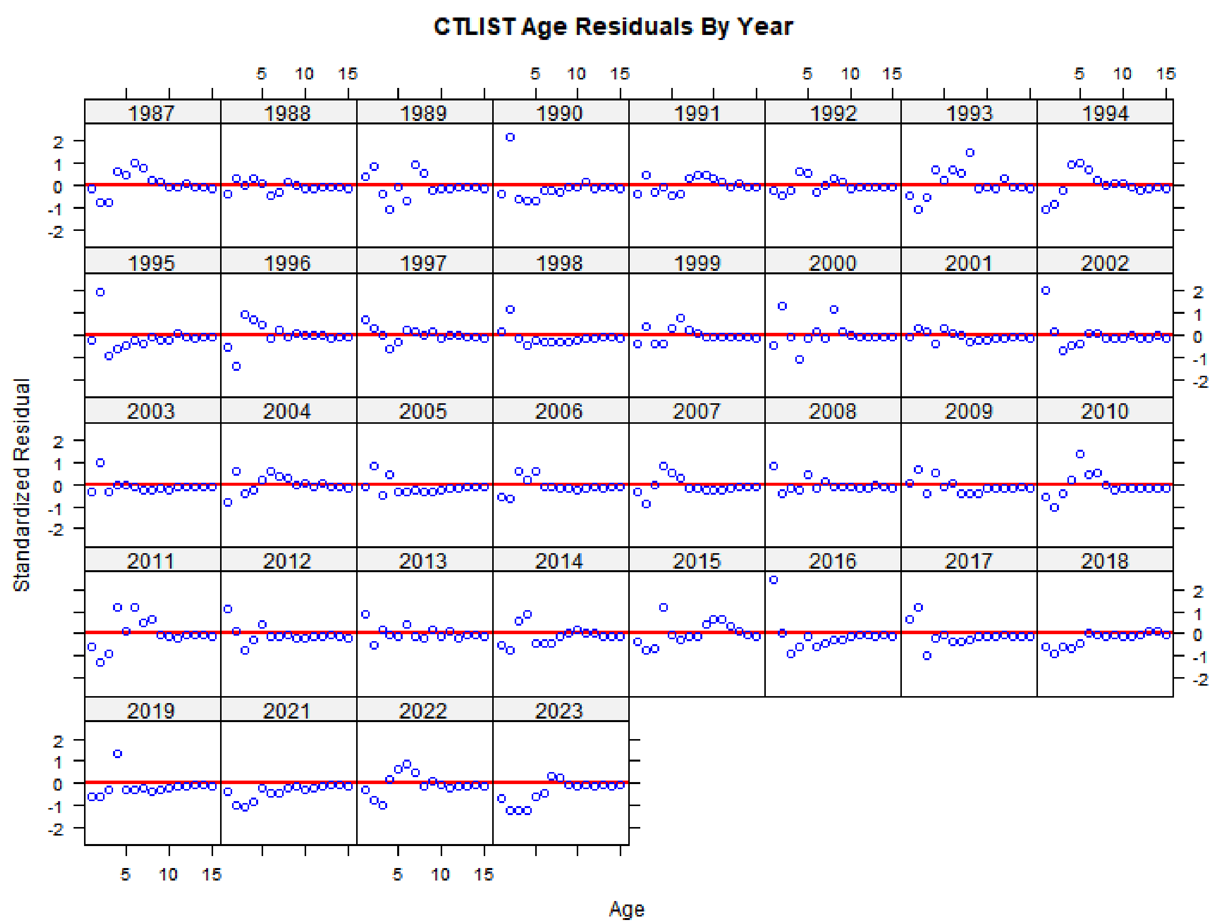
CTLIST Age Composition By Age

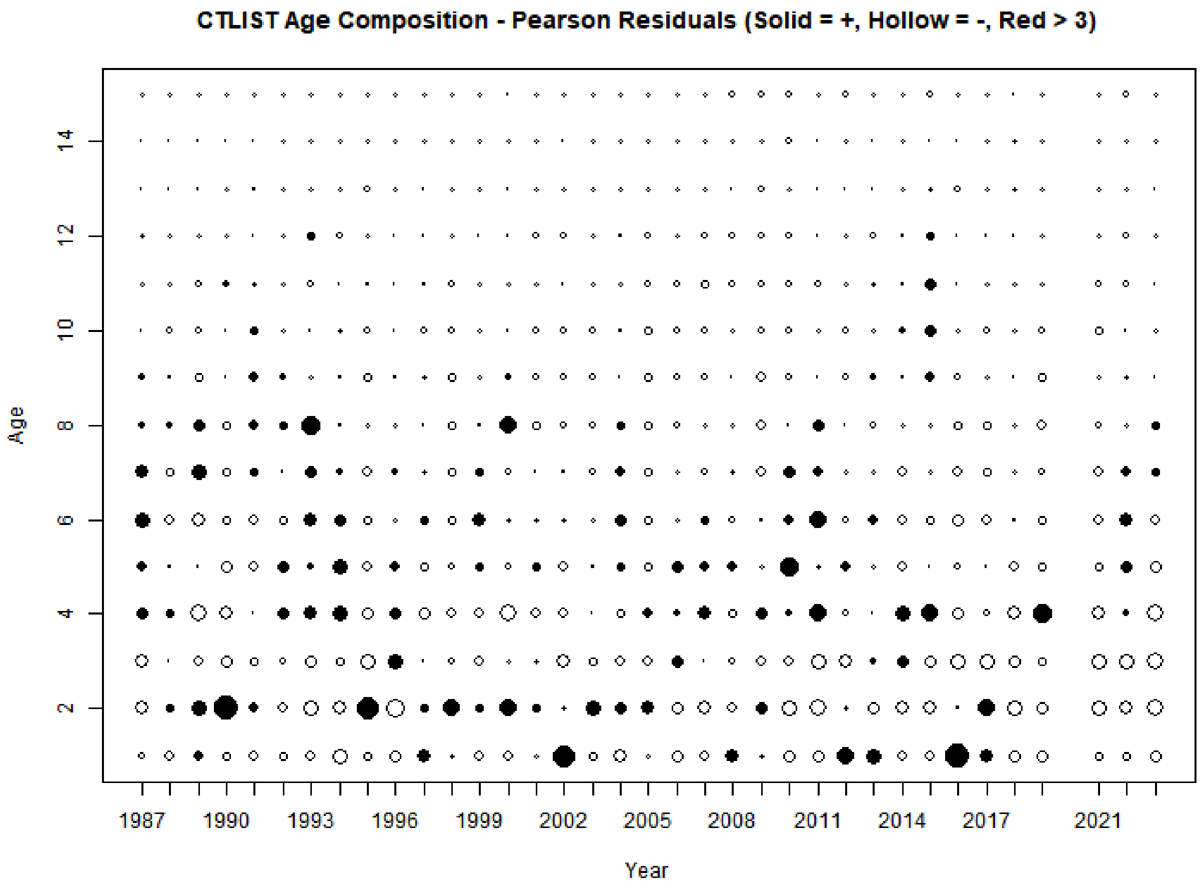


CTLIST Age Composition By Year

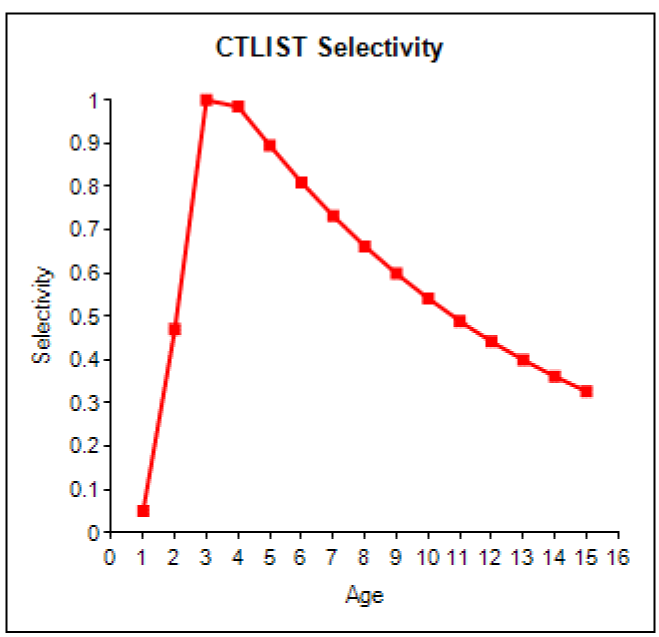



CTLIST Age Residuals By Age
Standardized Residual
Year


CTLIST Age Residuals By Year
Standardized Residual
Age

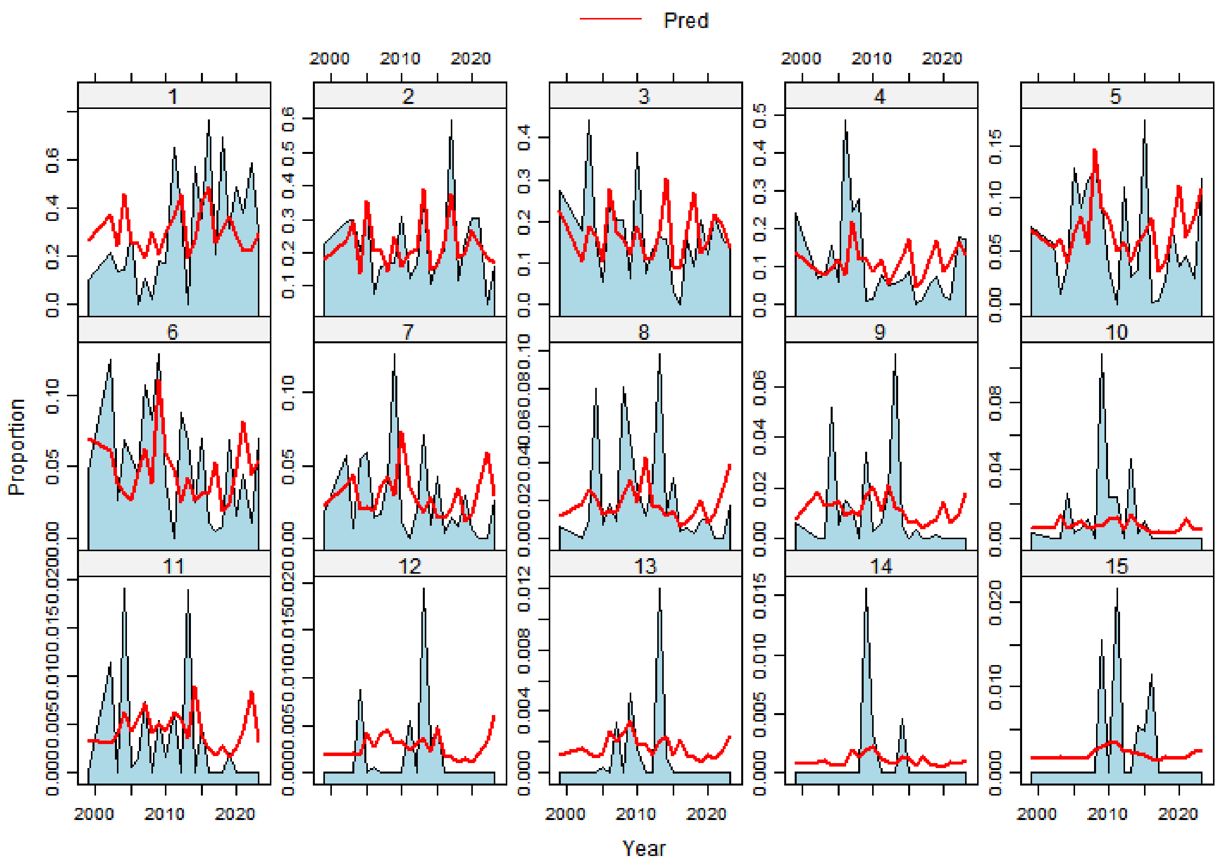


CTLIST Age Composition - Pearson Residuals (Solid = +, Hollow = -, Red > 3)
Age
2
4
6
8
10
12
14
1987
1990
1993
1996
1999
2002
2005
2008
2011
2014
2017
2021
Year

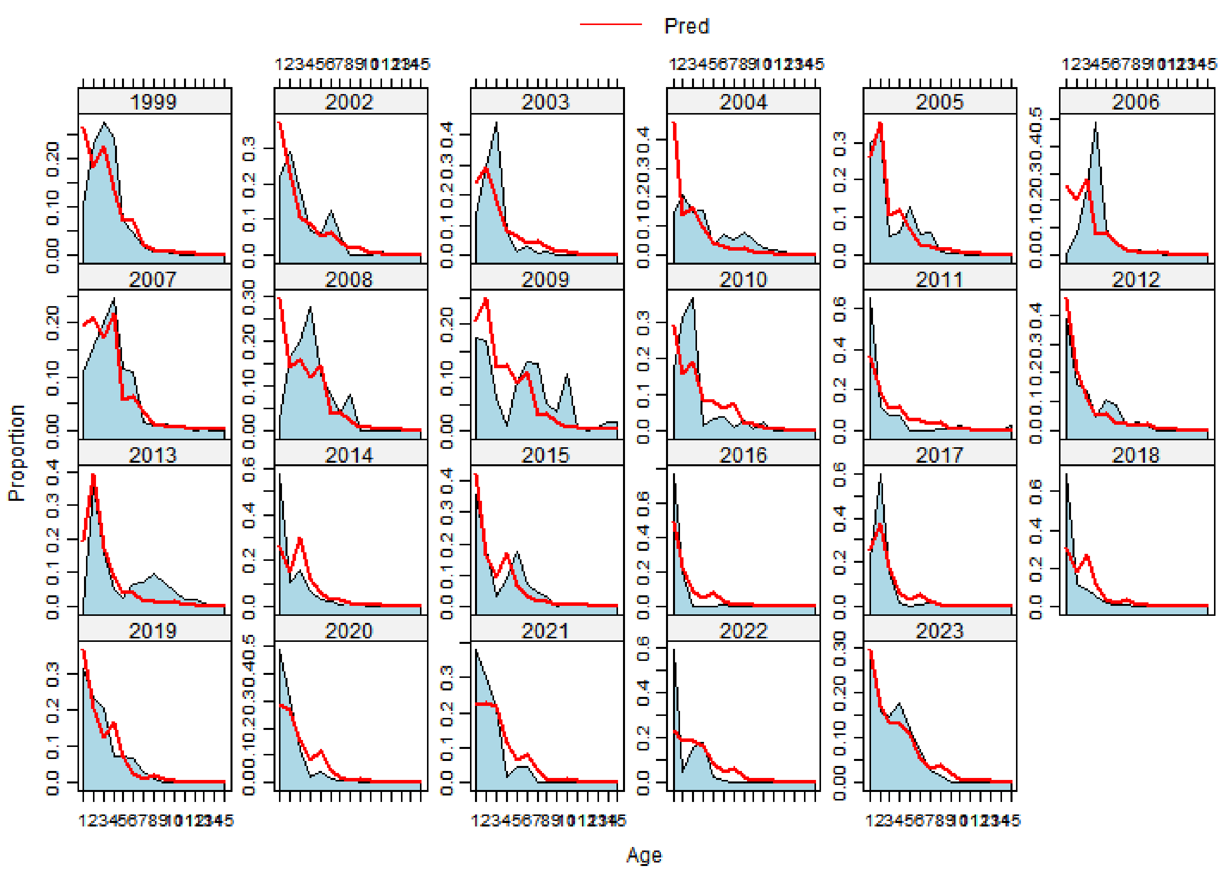


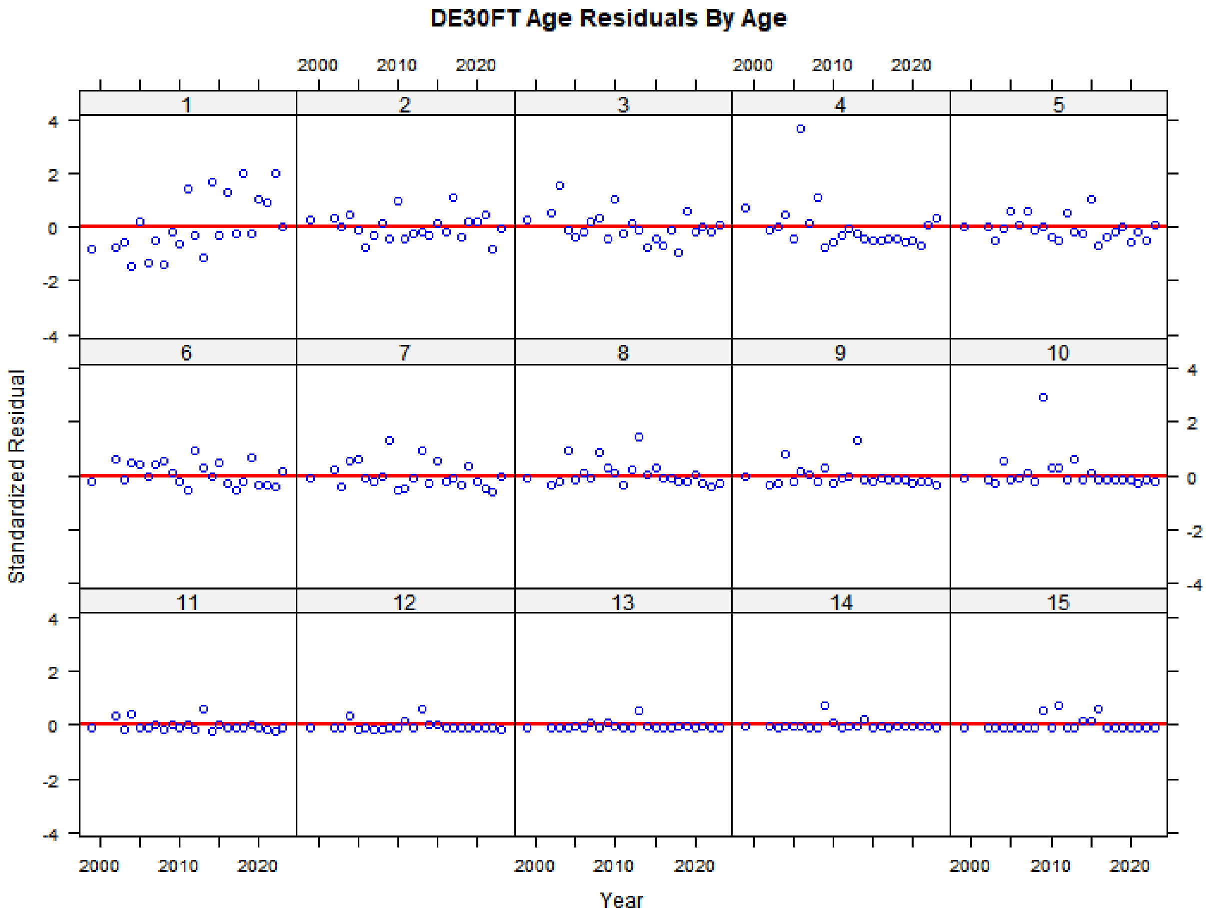
CTLIST Selectivity
Selectivity
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Age

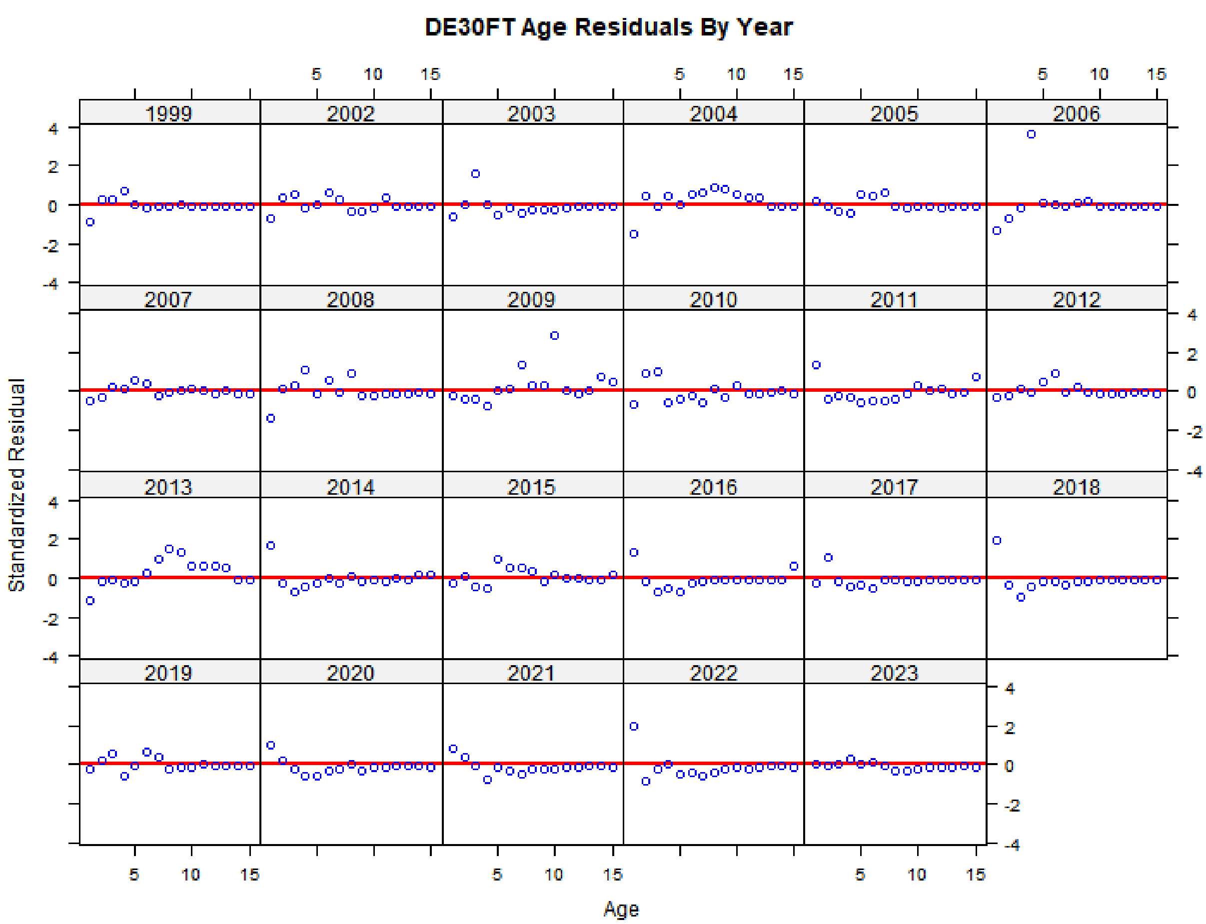
DE30FT Age Composition By Age

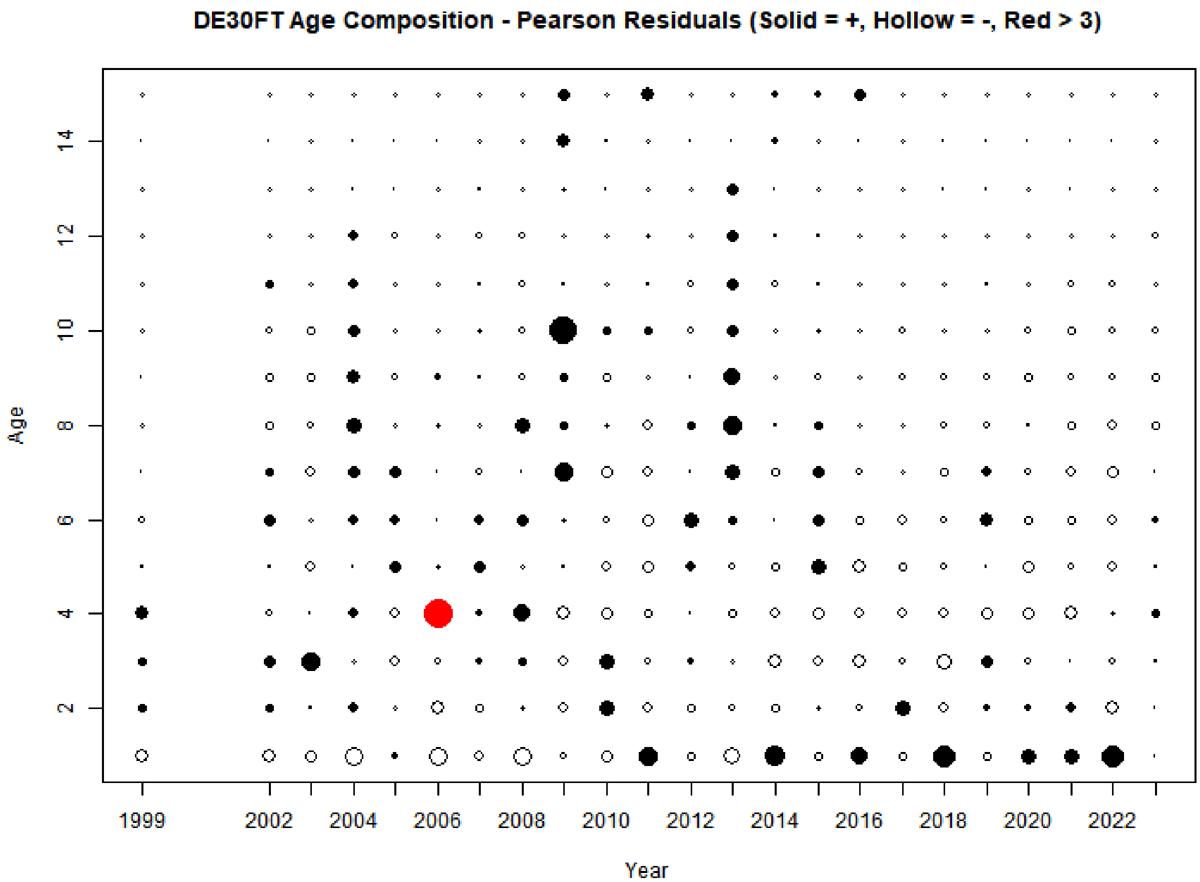


DE30FT Age Composition By Year

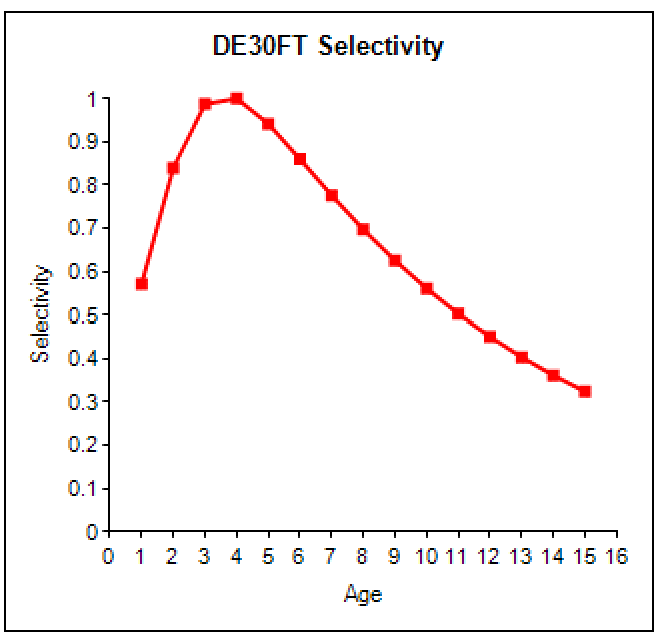



DE30FT Age Residuals By Age
Standardized Residual
Year
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
2000
2010
2020

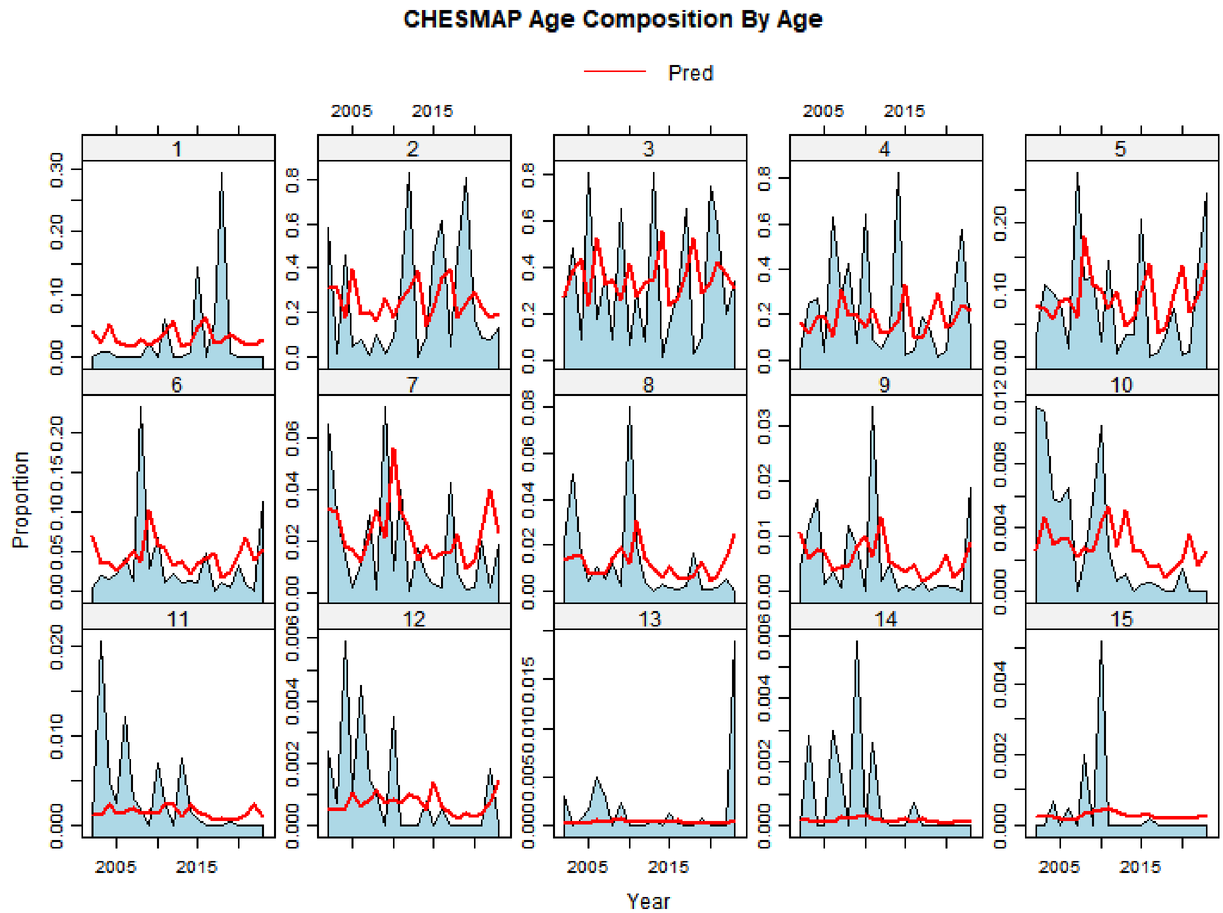

DE30FT Age Residuals By Year
Standardized Residual
Age
1999
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023

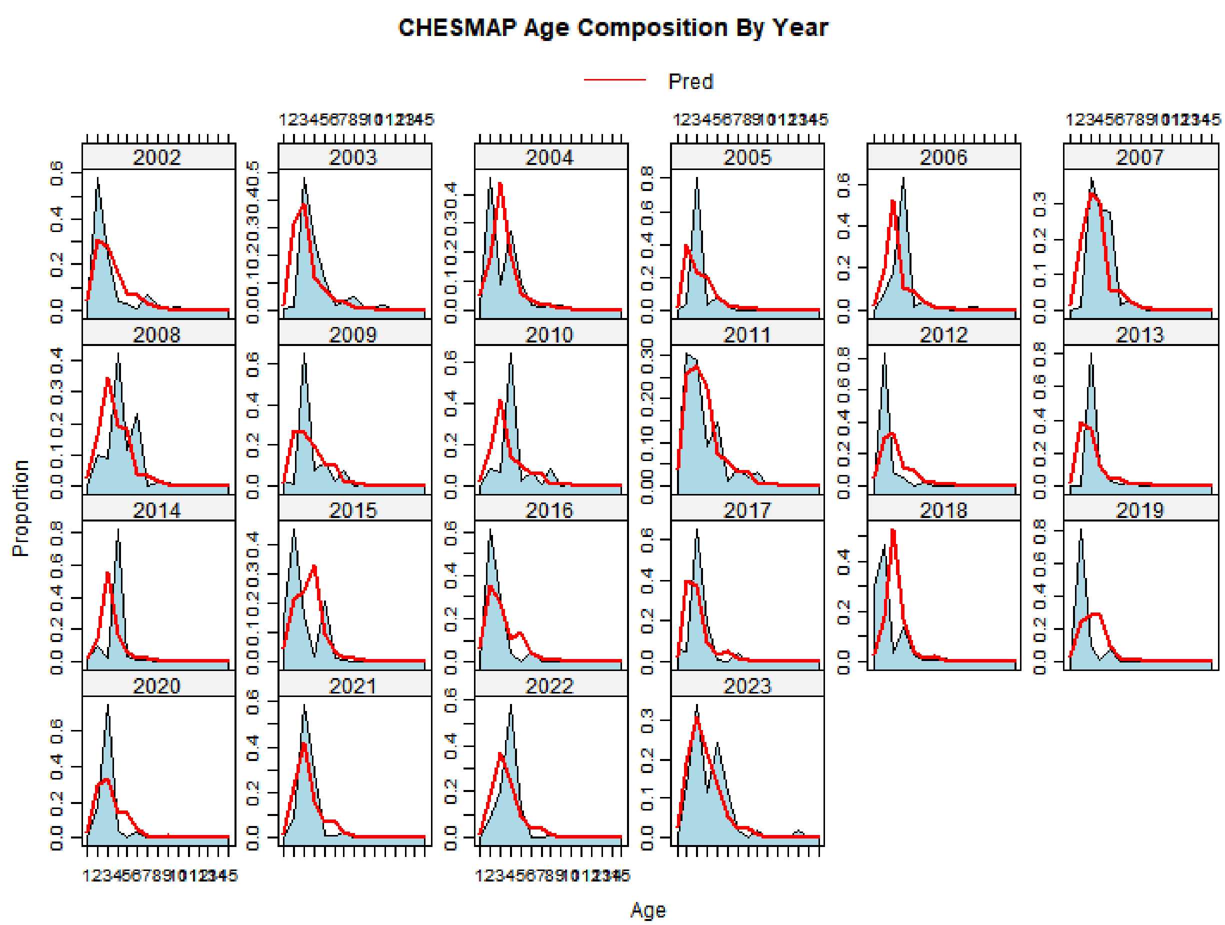


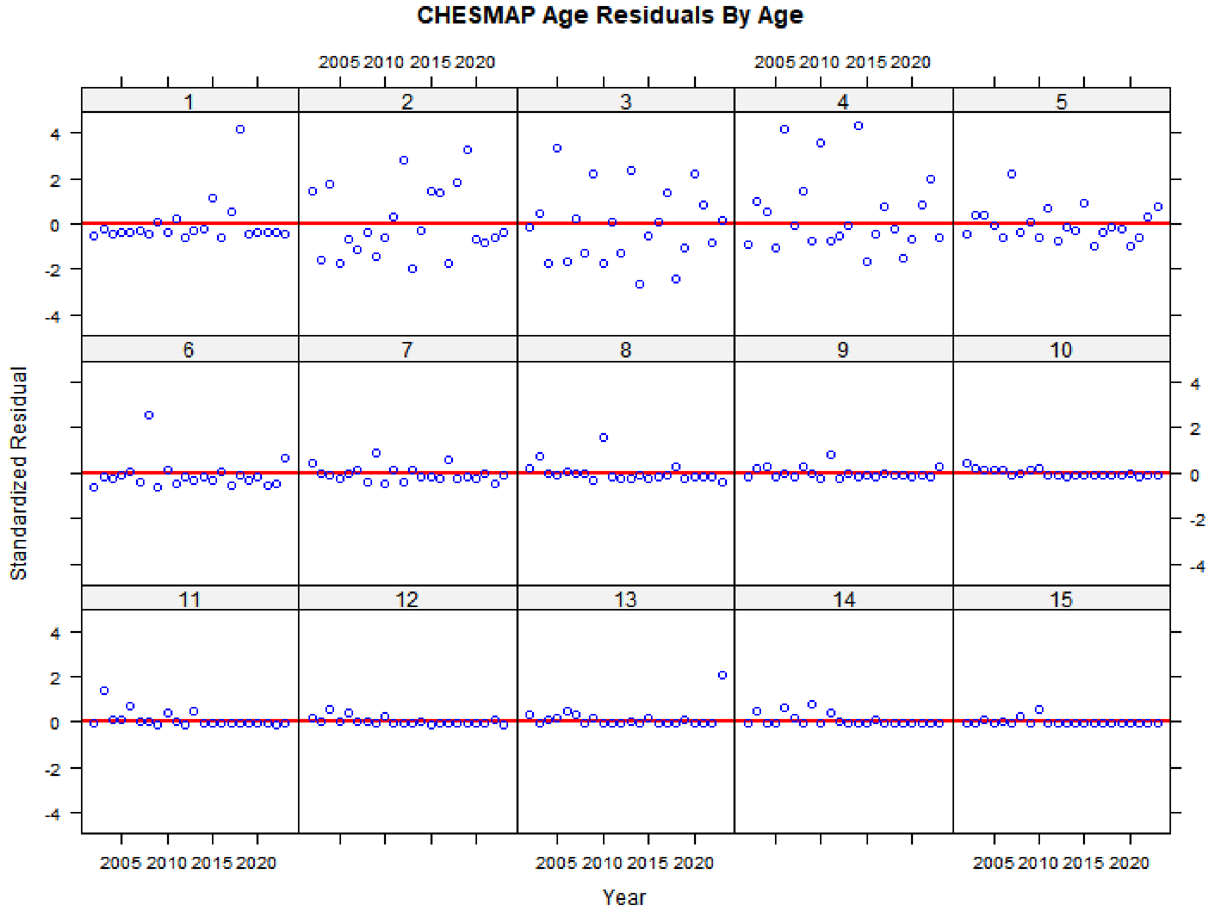
DE30FT Age Composition - Pearson Residuals (Solid = +, Hollow = -, Red > 3)
Age
Year

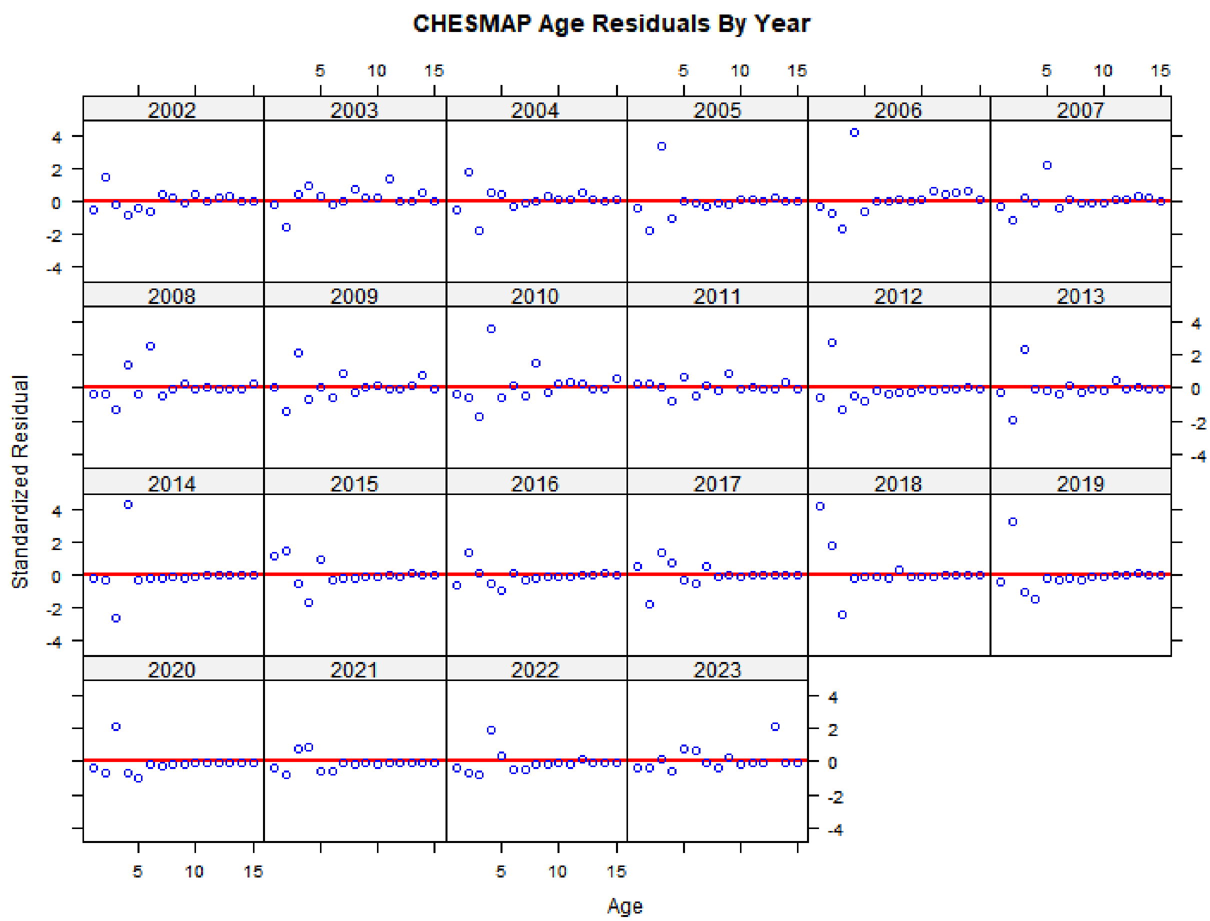


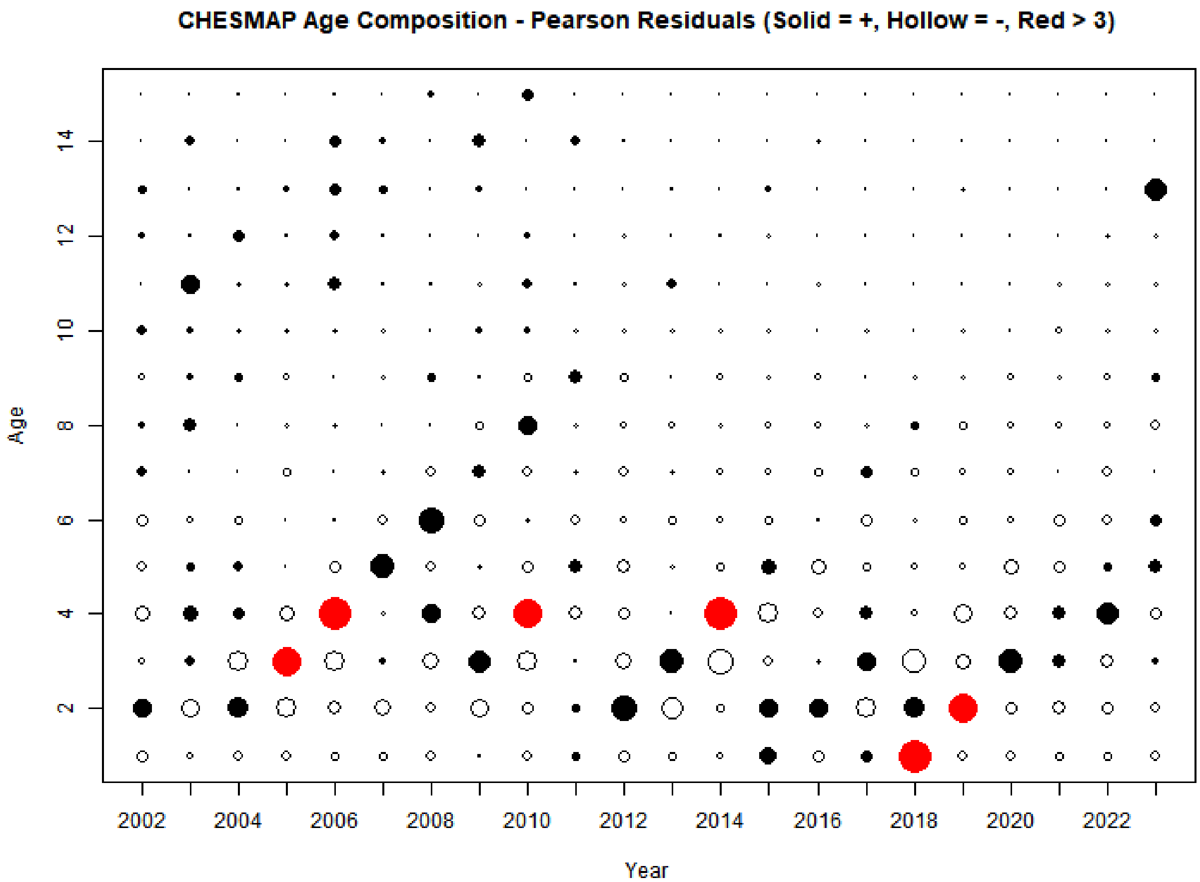
DE30FT Selectivity
Selectivity
Age

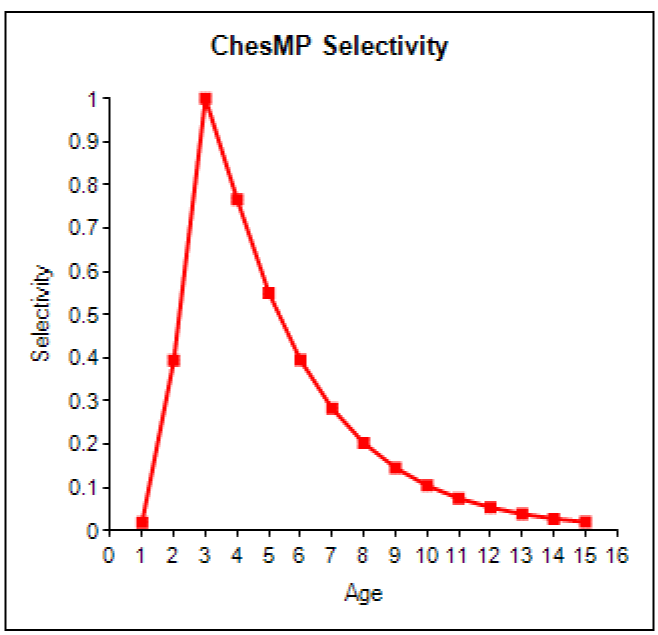

CHESMAP Age Composition By Age
Pred
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
2005
2015
Proportion
Year


CHESMAP Age Composition By Year
Pred
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
Proportion
Age


CHESMAP Age Residuals By Age
Standardized Residual
Year
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
2005 2010 2015 2020


CHESMAP Age Residuals By Year
Standardized Residual
Age
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023


CHESMAP Age Composition - Pearson Residuals (Solid = +, Hollow = -, Red > 3)
Age
Year
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
2
4
6
8
10
12
14


ChesMP Selectivity
Selectivity
Age
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

Results and Projections

Table X2. Comparison of RMSE, CV weights and effective sample sizes from the 2024 Base and 2024 Alternate Assessment.

2024 Base Update Assessment

Index	n	RMSE	CV Weight	Effective Sample Size
NYYOY	38	1.00932	2.97	
NJYOY	40	1.01128	1.63	
MDYOY	12	1.0054	1.96	
compos	42	1.01242	1.00	
NYAge1	39	1.00882	1.19	
MDAge1	54	1.00057	3.25	
NYOHS	20	0.996985	2.55	21.34
NJTRAWL	31	0.999935	5.85	2.98
MDSSN	39	1.00736	2.40	15.57
DESSN	26	1.00552	1.42	19.45
MRIP	42	0.994992	2.27	27.47
CTLIST	36	1.00365	3.05	7.22
DE30FT	23	0.998003	0.85	5.62
ChesMP	22	0.995453	3.40	6.10

2024 Alternate Run

Index	n	RMSE	CV Weight	Effective Sample Size
NYYOY	38	1.01062	2.97	
NJYOY	40	1.00465	1.63	
MDYOY	12	0.99246	1.92	
compos	42	1.002	1	
NYAge1	39	1.00667	1.19	
MDAge1	54	0.998896	3.25	
NYOHS	20	0.989164	2.55	21.31
NJTRAWL	31	1.00093	5.85	2.99
MDSSN	39	1.00337	2.4	15.61
DESSN	26	1.0164	1.42	19.39
MRIP	42	0.995036	2.25	27.82
CTLIST	36	1.00515	3.05	7.21
DE30FT	23	1.00116	0.85	5.44
ChesMP	22	0.992707	3.4	6.04

Table X3. Summary of likelihood component values.

	Likelihood Weight	RSS
Fleet 1 Total Catch:	2	0.216277
Fleet 2 Total Catch:	2	1.80129
Aggregate Abundance Indices		
NYYOY	1	30.7946
NJYOY	1	32.1672
MDYOY	1	10.3112
Composite	1	40.0734
NYAge1	1	34.3205
MDAge1	1	26.5649
Age Comp Abundance Indices		
NYOHS	1	18.6032
NJTrawl	1	6.56288
MDSSN	1	33.5359
DESSN	1	23.7251
MRIP	1	36.8262
CTLIST	1	29.1962
DE30FT	1	18.6787
CHESMAP	1	13.862
Total RSS		357.24
No. of Obs		548
Conc. Likel.		-117.236
Age Composition Data		
Fleet 1 Age Comp	1	7028.36
Fleet 2 Age Comp	1	6137.48
NYOHS	1	710.515
NJTrawl	1	169.297
MDSSN	1	1243.94
DESSN	1	1155.37
MRIP	1	2516.32
CTLIST	1	463.009
DE30FT	1	234.301
CHESMAP	1	233.231
Recr Devs	1	41.6345
Total Likelihood		19743.3
AIC		39882.5

Table X4. Estimates of Bay and Ocean fully-recruited fishing mortality and total fully-recruited fishing mortality with associated standard errors.

	Bay			Ocean			Total		
	Fully-recruited			Fully-recruited			Fully-recruited		
Year	F	SD	CV	F	SD	CV	F	SD	CV
1982	0.059	0.014	0.240	0.182	0.003	0.019	0.183	0.030	0.161
1983	0.063	0.029	0.461	0.147	0.012	0.084	0.148	0.040	0.269
1984	0.060	0.008	0.132	0.061	0.004	0.060	0.073	0.014	0.189
1985	0.004	0.040	11.075	0.196	0.016	0.082	0.196	0.071	0.364
1986	0.006	0.013	2.259	0.053	0.004	0.072	0.054	0.014	0.262
1987	0.002	0.012	4.844	0.031	0.015	0.494	0.031	0.007	0.216
1988	0.004	0.001	0.132	0.036	0.005	0.125	0.037	0.008	0.213
1989	0.005	0.071	15.619	0.047	0.018	0.371	0.048	0.009	0.191
1990	0.040	0.002	0.048	0.064	0.004	0.059	0.065	0.012	0.180
1991	0.044	0.014	0.319	0.091	0.013	0.148	0.092	0.016	0.175
1992	0.049	0.001	0.013	0.109	0.003	0.027	0.111	0.019	0.171
1993	0.042	0.007	0.161	0.086	0.015	0.173	0.087	0.014	0.159
1994	0.054	0.001	0.017	0.112	0.004	0.036	0.113	0.017	0.151
1995	0.079	0.008	0.099	0.204	0.013	0.064	0.206	0.033	0.159
1996	0.055	0.001	0.018	0.236	0.007	0.028	0.265	0.038	0.142
1997	0.059	0.009	0.154	0.164	0.016	0.097	0.200	0.014	0.068
1998	0.052	0.005	0.103	0.178	0.005	0.026	0.208	0.015	0.072
1999	0.053	0.012	0.217	0.163	0.016	0.100	0.194	0.013	0.069
2000	0.057	0.007	0.122	0.160	0.006	0.040	0.194	0.013	0.067
2001	0.045	0.016	0.350	0.166	0.017	0.100	0.192	0.013	0.066
2002	0.050	0.005	0.102	0.178	0.006	0.031	0.207	0.013	0.065
2003	0.065	0.019	0.290	0.184	0.025	0.134	0.222	0.014	0.061
2004	0.063	0.004	0.062	0.210	0.008	0.039	0.247	0.017	0.069
2005	0.056	0.014	0.246	0.211	0.020	0.094	0.244	0.017	0.068
2006	0.077	0.005	0.060	0.244	0.006	0.024	0.289	0.019	0.065
2007	0.058	0.017	0.291	0.181	0.018	0.098	0.216	0.014	0.067
2008	0.051	0.006	0.124	0.200	0.009	0.044	0.229	0.016	0.069
2009	0.068	0.033	0.478	0.183	0.020	0.111	0.224	0.014	0.064
2010	0.072	0.004	0.049	0.221	0.006	0.029	0.263	0.017	0.066
2011	0.070	0.036	0.522	0.228	0.026	0.114	0.268	0.018	0.065
2012	0.080	0.003	0.040	0.218	0.005	0.023	0.266	0.019	0.070
2013	0.087	0.012	0.140	0.314	0.019	0.062	0.364	0.027	0.074
2014	0.100	0.003	0.027	0.224	0.004	0.017	0.286	0.022	0.077
2015	0.084	0.014	0.163	0.197	0.018	0.090	0.248	0.020	0.082
2016	0.112	0.003	0.024	0.217	0.005	0.025	0.287	0.024	0.082
2017	0.079	0.012	0.158	0.275	0.018	0.065	0.321	0.029	0.090
2018	0.066	0.003	0.049	0.196	0.005	0.024	0.235	0.021	0.090
2019	0.053	0.012	0.223	0.177	0.018	0.103	0.208	0.019	0.092
2020	0.061	0.002	0.039	0.110	0.005	0.047	0.154	0.015	0.098
2021	0.051	0.012	0.224	0.120	0.027	0.228	0.156	0.020	0.131
2022	0.051	0.003	0.055	0.180	0.005	0.027	0.216	0.029	0.136
2023	0.049	0.012	0.246	0.149	0.022	0.151	0.183	0.024	0.133

Table X4 cont.

Year	Recruitment	SD	CV
1982	38296700	3654460	0.095
1983	77301100	6167490	0.080
1984	63603600	5047760	0.079
1985	69323200	5215200	0.075
1986	68551600	5141120	0.075
1987	73855100	5382970	0.073
1988	93137700	6438600	0.069
1989	107221000	7324070	0.068
1990	131811000	8541010	0.065
1991	105317000	7693570	0.073
1992	109903000	8167730	0.074
1993	134808000	9302590	0.069
1994	286886000	14658400	0.051
1995	187595000	11521500	0.061
1996	234759000	13265600	0.057
1997	259536000	13803100	0.053
1998	148101000	9952600	0.067
1999	153117000	9938990	0.065
2000	124771000	8982140	0.072
2001	196937000	11333500	0.058
2002	222073000	11997600	0.054
2003	127874000	8798540	0.069
2004	304610000	13910500	0.046
2005	158237000	9633660	0.061
2006	136369000	8712020	0.064
2007	89174400	6734280	0.076
2008	129419000	8190850	0.063
2009	76363900	6033890	0.079
2010	99619400	7126830	0.072
2011	128567000	8405000	0.065
2012	200280000	11453200	0.057
2013	68928800	6110650	0.089
2014	85838800	6954950	0.081
2015	157070000	11041100	0.070
2016	229985000	15528700	0.068
2017	111203000	9427490	0.085
2018	129634000	11108600	0.086
2019	164809000	14493500	0.088
2020	124284000	12813500	0.103
2021	86716700	11651300	0.134
2022	76653000	10730500	0.140
2023	94898600	15356800	0.162

Catch Selectivity Parameters

Bay	Estimate	SD	CV
1982-1984			
α	-5.449	0.188	0.03
β	2.554	0.041	0.02
ϒ	0.831	0.020	0.02
1985-1989			
α	-3.934	0.473	0.12
β	2.286	0.085	0.04
ϒ	0.959	0.013	0.01
1990-1995			
α	-2.062	0.096	0.05
β	4.470	0.180	0.04
ϒ	0.815	0.032	0.04
1996-2019			
α	-1.815	0.063	0.03
β	3.623	0.084	0.02
ϒ	0.962	0.009	0.01
2020-2023			
α	-1.745	0.109	0.06
β	4.471	0.220	0.05
ϒ	0.805	0.039	0.05

Ocean	Estimate	SD	CV
1982-1984			
α	3.481	0.205	0.06
β	0.836	0.094	0.11
1985-1989			
α	4.951	0.448	0.09
β	0.446	0.052	0.12
1990-1996			
α	6.257	0.570	0.09
β	0.340	0.037	0.11
1997-2019			
α	4.807	0.175	0.04
β	0.464	0.025	0.05
2020-2023			
α	-1.167	0.136	0.12
β	5.069	0.717	0.14
ϒ	0.936	0.070	0.07

Survey Selectivity Parameters			
NYOHS	Estimate	SD	CV
α	-3.027	0.511	0.17
β	2.620	0.154	0.06
ϒ	0.917	0.026	0.03
NJ Trawl			
α	1.434	0.739	0.51
β	0.236	0.156	0.66
MDSSN			
s_2	0.140	0.021	0.15
DE SSN			
α	3.763	0.237	0.06
β	0.647	0.087	0.13
MRIP			
α	2.576	0.076	0.03
β	1.064	0.064	0.06
CTLIST			
α	-2.805	0.393	0.14
β	2.163	0.160	0.07
ϒ	0.964	0.017	0.02
DE30FT			
α	-0.993	0.736	0.74
β	1.495	1.239	0.83
ϒ	0.890	0.162	0.18
ChesMap			
α	-3.659	0.598	0.16
β	2.282	0.139	0.06
ϒ	0.909	0.027	0.03

Catchability Coefficients			
Survey	Estimate	SD	CV
NYYOY	1.27E-07	1.24E-08	0.10
NJYOY	8.13E-09	4.94E-10	0.06
MDYOY	1.32E-07	2.02E-08	0.15
compos	1.04E-06	4.62E-08	0.04
NYAge1	2.42E-08	1.77E-09	0.07
MDAge1	8.00E-09	1.31E-09	0.16
NYOHS	8.78E-08	8.11E-09	0.09
NJTRAWL	9.26E-08	2.70E-08	0.29
MDSSN	7.60E-08	6.35E-09	0.08
DESSN	4.14E-08	5.39E-09	0.13
MRIP	4.32E-08	2.92E-09	0.07
CTLIST	7.90E-09	7.35E-10	0.09
DE30FT	2.63E-08	4.53E-09	0.17
ChesMP	2.43E-06	4.34E-07	0.18

Table X5. Region-specific and total fishing mortality-at-age, 1982-2021

Bay Fishing Mortality-At-Age

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982	0.0001	0.0076	0.0595	0.0257	0.0102	0.0041	0.0016	0.0006	0.0003	0.0001	0.0000	0.0000	0.0000	0.0000	0.0013
1983	0.0001	0.0081	0.0634	0.0274	0.0109	0.0043	0.0017	0.0007	0.0003	0.0001	0.0000	0.0000	0.0000	0.0000	0.0014
1984	0.0001	0.0076	0.0598	0.0259	0.0103	0.0041	0.0016	0.0006	0.0003	0.0001	0.0000	0.0000	0.0000	0.0000	0.0013
1985	0.0000	0.0011	0.0036	0.0032	0.0028	0.0023	0.0020	0.0017	0.0014	0.0012	0.0010	0.0009	0.0008	0.0006	0.0005
1986	0.0001	0.0018	0.0059	0.0053	0.0045	0.0038	0.0033	0.0028	0.0024	0.0020	0.0017	0.0015	0.0012	0.0010	0.0009
1987	0.0000	0.0008	0.0024	0.0022	0.0019	0.0016	0.0014	0.0012	0.0010	0.0008	0.0007	0.0006	0.0005	0.0004	0.0004
1988	0.0000	0.0014	0.0045	0.0040	0.0034	0.0029	0.0025	0.0021	0.0018	0.0015	0.0013	0.0011	0.0009	0.0008	0.0007
1989	0.0000	0.0014	0.0046	0.0041	0.0035	0.0030	0.0025	0.0022	0.0018	0.0016	0.0013	0.0011	0.0010	0.0008	0.0007
1990	0.0002	0.0010	0.0053	0.0215	0.0399	0.0349	0.0247	0.0169	0.0116	0.0079	0.0054	0.0037	0.0025	0.0017	0.0012
1991	0.0002	0.0011	0.0058	0.0236	0.0439	0.0384	0.0272	0.0186	0.0127	0.0087	0.0059	0.0040	0.0028	0.0019	0.0013
1992	0.0002	0.0013	0.0065	0.0265	0.0492	0.0430	0.0305	0.0209	0.0143	0.0097	0.0067	0.0045	0.0031	0.0021	0.0014
1993	0.0002	0.0011	0.0055	0.0225	0.0417	0.0365	0.0258	0.0177	0.0121	0.0083	0.0056	0.0039	0.0026	0.0018	0.0012
1994	0.0003	0.0014	0.0072	0.0292	0.0543	0.0475	0.0336	0.0230	0.0157	0.0107	0.0073	0.0050	0.0034	0.0023	0.0016
1995	0.0004	0.0020	0.0104	0.0423	0.0787	0.0688	0.0487	0.0334	0.0228	0.0156	0.0106	0.0073	0.0050	0.0034	0.0023
1996	0.0007	0.0036	0.0166	0.0421	0.0547	0.0545	0.0515	0.0482	0.0450	0.0420	0.0393	0.0367	0.0342	0.0320	0.0299
1997	0.0007	0.0039	0.0180	0.0456	0.0593	0.0591	0.0558	0.0522	0.0488	0.0455	0.0425	0.0397	0.0371	0.0346	0.0324
1998	0.0006	0.0034	0.0156	0.0397	0.0515	0.0514	0.0485	0.0454	0.0424	0.0396	0.0370	0.0345	0.0323	0.0301	0.0281
1999	0.0006	0.0035	0.0161	0.0409	0.0531	0.0530	0.0500	0.0468	0.0437	0.0408	0.0381	0.0356	0.0333	0.0311	0.0290
2000	0.0007	0.0038	0.0172	0.0439	0.0569	0.0568	0.0536	0.0502	0.0469	0.0438	0.0409	0.0382	0.0356	0.0333	0.0311
2001	0.0006	0.0030	0.0138	0.0350	0.0454	0.0453	0.0428	0.0400	0.0374	0.0349	0.0326	0.0305	0.0285	0.0266	0.0248
2002	0.0006	0.0033	0.0151	0.0384	0.0498	0.0497	0.0469	0.0439	0.0410	0.0383	0.0358	0.0334	0.0312	0.0291	0.0272
2003	0.0008	0.0043	0.0196	0.0499	0.0647	0.0645	0.0609	0.0570	0.0533	0.0497	0.0465	0.0434	0.0405	0.0378	0.0353
2004	0.0008	0.0042	0.0191	0.0486	0.0631	0.0629	0.0594	0.0556	0.0519	0.0485	0.0453	0.0423	0.0395	0.0369	0.0344
2005	0.0007	0.0037	0.0169	0.0430	0.0558	0.0557	0.0526	0.0492	0.0459	0.0429	0.0401	0.0374	0.0349	0.0326	0.0305
2006	0.0009	0.0051	0.0232	0.0590	0.0765	0.0763	0.0721	0.0674	0.0630	0.0588	0.0549	0.0513	0.0479	0.0447	0.0418
2007	0.0007	0.0039	0.0176	0.0448	0.0581	0.0579	0.0547	0.0512	0.0478	0.0447	0.0417	0.0390	0.0364	0.0340	0.0317
2008	0.0006	0.0034	0.0154	0.0391	0.0507	0.0506	0.0478	0.0447	0.0418	0.0390	0.0364	0.0340	0.0318	0.0297	0.0277
2009	0.0008	0.0045	0.0206	0.0525	0.0681	0.0679	0.0641	0.0600	0.0561	0.0524	0.0489	0.0457	0.0426	0.0398	0.0372
2010	0.0009	0.0048	0.0217	0.0552	0.0717	0.0715	0.0675	0.0632	0.0590	0.0551	0.0515	0.0481	0.0449	0.0419	0.0391
2011	0.0008	0.0046	0.0211	0.0536	0.0696	0.0695	0.0656	0.0614	0.0573	0.0535	0.0500	0.0467	0.0436	0.0407	0.0380
2012	0.0010	0.0053	0.0243	0.0618	0.0802	0.0800	0.0755	0.0706	0.0660	0.0616	0.0576	0.0538	0.0502	0.0469	0.0438
2013	0.0011	0.0058	0.0265	0.0673	0.0874	0.0871	0.0823	0.0770	0.0719	0.0672	0.0627	0.0586	0.0547	0.0511	0.0477
2014	0.0012	0.0067	0.0304	0.0774	0.1005	0.1002	0.0946	0.0885	0.0827	0.0772	0.0721	0.0673	0.0629	0.0587	0.0548
2015	0.0010	0.0055	0.0253	0.0643	0.0835	0.0833	0.0787	0.0736	0.0687	0.0642	0.0600	0.0560	0.0523	0.0488	0.0456
2016	0.0014	0.0075	0.0341	0.0866	0.1124	0.1121	0.1059	0.0991	0.0925	0.0864	0.0807	0.0754	0.0704	0.0657	0.0614
2017	0.0010	0.0052	0.0238	0.0605	0.0786	0.0783	0.0740	0.0692	0.0646	0.0604	0.0564	0.0527	0.0492	0.0459	0.0429
2018	0.0008	0.0044	0.0200	0.0508	0.0660	0.0658	0.0621	0.0581	0.0543	0.0507	0.0474	0.0442	0.0413	0.0386	0.0360
2019	0.0006	0.0035	0.0160	0.0407	0.0528	0.0527	0.0497	0.0465	0.0435	0.0406	0.0379	0.0354	0.0331	0.0309	0.0288
2020	0.0008	0.0031	0.0120	0.0366	0.0610	0.0567	0.0426	0.0306	0.0218	0.0155	0.0111	0.0079	0.0056	0.0040	0.0028
2021	0.0007	0.0026	0.0101	0.0309	0.0515	0.0478	0.0360	0.0259	0.0184	0.0131	0.0093	0.0066	0.0047	0.0034	0.0024
2022	0.0007	0.0026	0.0101	0.0307	0.0513	0.0476	0.0358	0.0257	0.0184	0.0131	0.0093	0.0066	0.0047	0.0034	0.0024
2023	0.0006	0.0025	0.0096	0.0293	0.0488	0.0454	0.0341	0.0245	0.0175	0.0124	0.0089	0.0063	0.0045	0.0032	0.0023

Table X5 cont.

Ocean Fishing Mortality-At-Age

	Age														
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982	0.0001	0.0058	0.0407	0.0950	0.1371	0.1608	0.1722	0.1775	0.1798	0.1808	0.1812	0.1814	0.1815	0.1815	0.1816
1983	0.0001	0.0047	0.0329	0.0768	0.1109	0.1300	0.1393	0.1436	0.1454	0.1462	0.1466	0.1468	0.1468	0.1468	0.1469
1984	0.0000	0.0019	0.0136	0.0318	0.0459	0.0538	0.0576	0.0594	0.0601	0.0605	0.0606	0.0607	0.0607	0.0607	0.0607
1985	0.0006	0.0047	0.0182	0.0429	0.0745	0.1059	0.1327	0.1533	0.1681	0.1783	0.1852	0.1897	0.1927	0.1946	0.1958
1986	0.0002	0.0013	0.0049	0.0116	0.0201	0.0286	0.0359	0.0414	0.0454	0.0482	0.0500	0.0513	0.0521	0.0526	0.0529
1987	0.0001	0.0008	0.0029	0.0068	0.0118	0.0168	0.0211	0.0243	0.0267	0.0283	0.0294	0.0301	0.0306	0.0309	0.0311
1988	0.0001	0.0009	0.0034	0.0080	0.0138	0.0196	0.0246	0.0284	0.0312	0.0330	0.0343	0.0352	0.0357	0.0361	0.0363
1989	0.0001	0.0012	0.0044	0.0104	0.0180	0.0256	0.0321	0.0371	0.0407	0.0432	0.0448	0.0459	0.0466	0.0471	0.0474
1990	0.0002	0.0010	0.0033	0.0078	0.0145	0.0225	0.0308	0.0386	0.0452	0.0506	0.0549	0.0582	0.0606	0.0624	0.0637
1991	0.0002	0.0014	0.0046	0.0111	0.0206	0.0320	0.0439	0.0549	0.0644	0.0721	0.0782	0.0828	0.0863	0.0888	0.0907
1992	0.0003	0.0016	0.0056	0.0134	0.0248	0.0386	0.0529	0.0661	0.0776	0.0869	0.0942	0.0998	0.1039	0.1070	0.1092
1993	0.0002	0.0013	0.0044	0.0105	0.0195	0.0303	0.0415	0.0519	0.0609	0.0682	0.0740	0.0783	0.0816	0.0840	0.0858
1994	0.0003	0.0017	0.0057	0.0137	0.0254	0.0395	0.0541	0.0677	0.0794	0.0889	0.0964	0.1021	0.1064	0.1095	0.1118
1995	0.0006	0.0031	0.0104	0.0249	0.0463	0.0720	0.0986	0.1233	0.1446	0.1619	0.1755	0.1859	0.1937	0.1994	0.2036
1996	0.0006	0.0035	0.0121	0.0288	0.0535	0.0832	0.1140	0.1426	0.1672	0.1873	0.2031	0.2151	0.2241	0.2307	0.2355
1997	0.0005	0.0042	0.0164	0.0387	0.0665	0.0934	0.1156	0.1322	0.1438	0.1516	0.1568	0.1601	0.1622	0.1636	0.1644
1998	0.0005	0.0045	0.0178	0.0420	0.0720	0.1012	0.1252	0.1432	0.1558	0.1643	0.1699	0.1735	0.1758	0.1772	0.1781
1999	0.0005	0.0041	0.0162	0.0384	0.0659	0.0925	0.1146	0.1310	0.1425	0.1503	0.1554	0.1587	0.1608	0.1621	0.1630
2000	0.0005	0.0041	0.0159	0.0376	0.0645	0.0906	0.1122	0.1283	0.1396	0.1472	0.1522	0.1554	0.1575	0.1588	0.1596
2001	0.0005	0.0042	0.0165	0.0390	0.0670	0.0941	0.1165	0.1332	0.1449	0.1528	0.1580	0.1613	0.1635	0.1648	0.1657
2002	0.0005	0.0045	0.0178	0.0420	0.0721	0.1013	0.1253	0.1433	0.1560	0.1644	0.1700	0.1736	0.1759	0.1774	0.1783
2003	0.0005	0.0047	0.0183	0.0432	0.0742	0.1043	0.1291	0.1476	0.1606	0.1693	0.1751	0.1788	0.1812	0.1827	0.1836
2004	0.0006	0.0053	0.0210	0.0495	0.0850	0.1194	0.1478	0.1690	0.1838	0.1938	0.2004	0.2046	0.2074	0.2091	0.2102
2005	0.0006	0.0054	0.0211	0.0498	0.0855	0.1201	0.1486	0.1700	0.1849	0.1950	0.2016	0.2058	0.2086	0.2103	0.2114
2006	0.0007	0.0062	0.0243	0.0575	0.0987	0.1387	0.1717	0.1963	0.2136	0.2252	0.2328	0.2378	0.2409	0.2429	0.2442
2007	0.0005	0.0046	0.0181	0.0427	0.0733	0.1030	0.1275	0.1458	0.1586	0.1673	0.1729	0.1766	0.1789	0.1804	0.1813
2008	0.0006	0.0051	0.0199	0.0471	0.0808	0.1135	0.1405	0.1607	0.1749	0.1844	0.1906	0.1947	0.1972	0.1989	0.1999
2009	0.0005	0.0046	0.0182	0.0431	0.0740	0.1039	0.1286	0.1471	0.1600	0.1687	0.1745	0.1781	0.1805	0.1820	0.1829
2010	0.0006	0.0056	0.0220	0.0520	0.0893	0.1254	0.1553	0.1775	0.1932	0.2037	0.2106	0.2150	0.2179	0.2197	0.2208
2011	0.0007	0.0058	0.0227	0.0536	0.0920	0.1292	0.1600	0.1829	0.1990	0.2099	0.2170	0.2216	0.2245	0.2264	0.2276
2012	0.0006	0.0055	0.0218	0.0515	0.0883	0.1241	0.1536	0.1756	0.1911	0.2015	0.2083	0.2127	0.2155	0.2173	0.2184
2013	0.0009	0.0080	0.0313	0.0738	0.1268	0.1781	0.2204	0.2521	0.2743	0.2892	0.2990	0.3053	0.3093	0.3119	0.3135
2014	0.0006	0.0057	0.0223	0.0527	0.0905	0.1271	0.1573	0.1799	0.1958	0.2064	0.2134	0.2179	0.2208	0.2226	0.2238
2015	0.0006	0.0050	0.0196	0.0463	0.0795	0.1117	0.1383	0.1582	0.1721	0.1814	0.1876	0.1915	0.1941	0.1957	0.1967
2016	0.0006	0.0055	0.0216	0.0510	0.0876	0.1230	0.1523	0.1742	0.1895	0.1998	0.2066	0.2109	0.2137	0.2155	0.2166
2017	0.0008	0.0070	0.0274	0.0648	0.1113	0.1563	0.1935	0.2213	0.2407	0.2538	0.2624	0.2680	0.2715	0.2738	0.2752
2018	0.0006	0.0050	0.0196	0.0463	0.0794	0.1115	0.1381	0.1579	0.1718	0.1812	0.1873	0.1913	0.1938	0.1954	0.1964
2019	0.0005	0.0045	0.0177	0.0417	0.0717	0.1006	0.1246	0.1425	0.1550	0.1635	0.1690	0.1726	0.1749	0.1763	0.1772
2020	0.0016	0.0047	0.0134	0.0337	0.0674	0.0975	0.1096	0.1089	0.1033	0.0966	0.0899	0.0835	0.0776	0.0720	0.0669
2021	0.0018	0.0052	0.0146	0.0369	0.0738	0.1068	0.1200	0.1192	0.1132	0.1058	0.0985	0.0915	0.0850	0.0789	0.0732
2022	0.0027	0.0078	0.0220	0.0556	0.1110	0.1606	0.1805	0.1793	0.1702	0.1591	0.1481	0.1376	0.1278	0.1186	0.1101
2023	0.0022	0.0064	0.0181	0.0458	0.0914	0.1323	0.1487	0.1477	0.1402	0.1311	0.1220	0.1133	0.1053	0.0977	0.0907

Table X5 cont.

Total Fishing Mortality-At-Age

	Age														
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982	0.0002	0.0133	0.1002	0.1207	0.1473	0.1648	0.1739	0.1781	0.1800	0.1809	0.1813	0.1814	0.1815	0.1816	0.1829
1983	0.0001	0.0127	0.0963	0.1042	0.1218	0.1344	0.1410	0.1442	0.1457	0.1463	0.1466	0.1468	0.1468	0.1469	0.1483
1984	0.0001	0.0095	0.0734	0.0576	0.0561	0.0579	0.0592	0.0600	0.0604	0.0606	0.0607	0.0607	0.0607	0.0607	0.0621
1985	0.0006	0.0058	0.0218	0.0462	0.0772	0.1082	0.1347	0.1550	0.1695	0.1795	0.1862	0.1906	0.1934	0.1952	0.1964
1986	0.0002	0.0031	0.0108	0.0169	0.0246	0.0324	0.0391	0.0442	0.0478	0.0502	0.0517	0.0527	0.0533	0.0536	0.0538
1987	0.0001	0.0015	0.0053	0.0090	0.0137	0.0184	0.0224	0.0255	0.0277	0.0291	0.0301	0.0307	0.0311	0.0313	0.0315
1988	0.0002	0.0023	0.0079	0.0120	0.0172	0.0225	0.0271	0.0305	0.0329	0.0346	0.0356	0.0363	0.0366	0.0369	0.0370
1989	0.0002	0.0025	0.0090	0.0145	0.0215	0.0286	0.0347	0.0393	0.0425	0.0447	0.0461	0.0470	0.0476	0.0479	0.0481
1990	0.0004	0.0020	0.0085	0.0293	0.0544	0.0574	0.0555	0.0555	0.0568	0.0585	0.0603	0.0618	0.0631	0.0641	0.0648
1991	0.0005	0.0025	0.0104	0.0347	0.0645	0.0704	0.0710	0.0735	0.0771	0.0808	0.0841	0.0868	0.0890	0.0907	0.0920
1992	0.0005	0.0029	0.0121	0.0399	0.0741	0.0817	0.0833	0.0870	0.0918	0.0966	0.1008	0.1043	0.1070	0.1091	0.1107
1993	0.0004	0.0024	0.0099	0.0329	0.0612	0.0668	0.0673	0.0696	0.0730	0.0765	0.0796	0.0822	0.0842	0.0858	0.0870
1994	0.0006	0.0031	0.0129	0.0429	0.0797	0.0870	0.0877	0.0907	0.0951	0.0997	0.1037	0.1071	0.1098	0.1118	0.1134
1995	0.0009	0.0051	0.0208	0.0672	0.1250	0.1407	0.1472	0.1567	0.1674	0.1775	0.1862	0.1932	0.1987	0.2028	0.2059
1996	0.0013	0.0072	0.0286	0.0709	0.1082	0.1378	0.1655	0.1908	0.2122	0.2293	0.2423	0.2517	0.2583	0.2626	0.2654
1997	0.0012	0.0081	0.0343	0.0844	0.1257	0.1525	0.1714	0.1844	0.1926	0.1972	0.1993	0.1998	0.1993	0.1982	0.1968
1998	0.0011	0.0079	0.0334	0.0817	0.1236	0.1526	0.1738	0.1886	0.1982	0.2039	0.2069	0.2080	0.2080	0.2073	0.2063
1999	0.0011	0.0077	0.0323	0.0793	0.1190	0.1455	0.1646	0.1778	0.1863	0.1911	0.1935	0.1943	0.1940	0.1932	0.1920
2000	0.0012	0.0078	0.0332	0.0814	0.1215	0.1474	0.1658	0.1785	0.1865	0.1910	0.1930	0.1936	0.1931	0.1920	0.1907
2001	0.0010	0.0072	0.0303	0.0740	0.1124	0.1394	0.1593	0.1732	0.1823	0.1877	0.1906	0.1918	0.1919	0.1914	0.1905
2002	0.0011	0.0078	0.0329	0.0804	0.1219	0.1509	0.1722	0.1872	0.1969	0.2027	0.2058	0.2070	0.2071	0.2065	0.2055
2003	0.0013	0.0090	0.0379	0.0931	0.1390	0.1688	0.1900	0.2046	0.2139	0.2191	0.2215	0.2222	0.2217	0.2205	0.2189
2004	0.0014	0.0095	0.0401	0.0981	0.1481	0.1823	0.2072	0.2245	0.2358	0.2423	0.2457	0.2469	0.2468	0.2460	0.2446
2005	0.0013	0.0091	0.0380	0.0928	0.1413	0.1757	0.2012	0.2191	0.2308	0.2379	0.2416	0.2433	0.2435	0.2429	0.2419
2006	0.0016	0.0113	0.0475	0.1165	0.1753	0.2150	0.2437	0.2637	0.2766	0.2840	0.2878	0.2891	0.2888	0.2877	0.2860
2007	0.0012	0.0085	0.0357	0.0875	0.1314	0.1609	0.1822	0.1970	0.2064	0.2119	0.2146	0.2155	0.2153	0.2144	0.2131
2008	0.0012	0.0084	0.0353	0.0862	0.1316	0.1641	0.1883	0.2054	0.2166	0.2234	0.2270	0.2287	0.2290	0.2285	0.2276
2009	0.0014	0.0092	0.0389	0.0956	0.1421	0.1718	0.1928	0.2071	0.2161	0.2211	0.2233	0.2238	0.2231	0.2218	0.2201
2010	0.0015	0.0104	0.0437	0.1072	0.1610	0.1969	0.2228	0.2407	0.2522	0.2588	0.2620	0.2631	0.2628	0.2616	0.2600
2011	0.0015	0.0104	0.0438	0.1072	0.1616	0.1987	0.2256	0.2443	0.2564	0.2634	0.2670	0.2683	0.2681	0.2671	0.2656
2012	0.0016	0.0109	0.0461	0.1132	0.1685	0.2040	0.2291	0.2463	0.2571	0.2631	0.2659	0.2665	0.2657	0.2642	0.2622
2013	0.0020	0.0138	0.0577	0.1412	0.2142	0.2652	0.3027	0.3291	0.3462	0.3563	0.3617	0.3639	0.3640	0.3630	0.3612
2014	0.0019	0.0123	0.0527	0.1301	0.1909	0.2273	0.2519	0.2684	0.2784	0.2836	0.2855	0.2853	0.2837	0.2814	0.2786
2015	0.0016	0.0105	0.0449	0.1107	0.1631	0.1950	0.2169	0.2317	0.2408	0.2456	0.2475	0.2475	0.2464	0.2445	0.2423
2016	0.0020	0.0130	0.0556	0.1376	0.2000	0.2351	0.2582	0.2732	0.2820	0.2862	0.2873	0.2863	0.2841	0.2812	0.2780
2017	0.0017	0.0122	0.0512	0.1253	0.1898	0.2346	0.2674	0.2905	0.3054	0.3142	0.3188	0.3206	0.3207	0.3197	0.3181
2018	0.0014	0.0094	0.0396	0.0971	0.1454	0.1773	0.2002	0.2160	0.2261	0.2319	0.2346	0.2355	0.2351	0.2340	0.2324
2019	0.0012	0.0080	0.0337	0.0824	0.1245	0.1533	0.1743	0.1890	0.1985	0.2041	0.2069	0.2080	0.2079	0.2072	0.2061
2020	0.0024	0.0079	0.0254	0.0703	0.1284	0.1542	0.1522	0.1395	0.1252	0.1122	0.1010	0.0914	0.0832	0.0760	0.0697
2021	0.0024	0.0078	0.0247	0.0678	0.1252	0.1546	0.1560	0.1451	0.1316	0.1189	0.1078	0.0981	0.0897	0.0822	0.0756
2022	0.0033	0.0104	0.0321	0.0863	0.1622	0.2082	0.2163	0.2050	0.1885	0.1722	0.1574	0.1442	0.1325	0.1220	0.1125
2023	0.0028	0.0089	0.0277	0.0750	0.1402	0.1777	0.1828	0.1722	0.1577	0.1435	0.1308	0.1196	0.1097	0.1009	0.0930

Table X6. Estimates of age-specific population abundance, 1982-2023

	Age															
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total	8+
1982	38,296,700	8,340,660	3,115,980	2,426,610	963,810	401,321	330,477	216,139	186,669	274,688	192,524	317,028	149,222	107,118	271,568	55,590,514	1,714,956
1983	77,301,100	12,369,200	4,169,560	1,797,470	1,546,240	647,793	281,447	239,054	155,683	134,197	197,304	138,235	227,592	107,118	271,568	99,583,561	1,470,751
1984	63,603,600	24,967,300	6,187,210	2,414,570	1,164,360	1,066,130	468,347	210,378	178,120	115,831	99,780	146,659	102,739	169,141	281,139	101,175,304	1,303,787
1985	69,323,200	20,543,900	12,528,700	3,665,860	1,638,700	857,300	832,081	379,925	170,528	144,325	93,837	80,826	118,796	83,219	364,422	110,825,618	1,435,877
1986	68,551,600	22,380,000	10,347,300	7,816,770	2,516,570	1,181,390	636,221	625,945	280,064	123,888	103,808	67,044	57,496	84,268	316,665	115,089,028	1,659,177
1987	73,855,100	22,139,800	11,303,200	6,526,960	5,525,510	1,912,230	945,774	526,600	515,473	229,810	101,413	84,844	54,743	46,919	327,025	124,095,401	1,886,827
1988	93,137,700	23,854,900	11,199,600	7,168,980	4,650,280	4,244,760	1,552,510	795,995	441,849	431,571	192,121	84,700	70,817	45,675	311,899	148,183,357	2,374,627
1989	107,221,000	30,082,100	12,058,200	7,085,350	5,092,510	3,559,770	3,431,990	1,300,570	664,531	367,979	358,835	159,575	70,306	58,760	296,602	171,808,078	3,277,158
1990	131,811,000	34,629,800	15,201,400	7,619,980	5,020,450	3,881,590	2,860,740	2,853,350	1,076,320	548,160	302,872	294,925	131,036	57,700	291,511	206,580,834	5,555,874
1991	105,317,000	42,563,900	17,509,300	9,610,570	5,320,270	3,703,030	3,030,900	2,329,310	2,323,360	875,273	444,983	245,433	238,626	105,888	281,733	193,899,576	6,844,606
1992	109,903,000	34,005,600	21,510,000	11,048,600	6,673,720	3,884,710	2,854,100	2,429,860	1,862,780	1,851,380	694,893	352,112	193,677	187,896	304,426	197,756,754	7,877,024
1993	134,808,000	35,483,600	17,177,800	13,550,600	7,632,850	4,826,460	2,960,610	2,260,120	1,917,080	1,462,640	1,446,750	540,734	273,050	149,781	379,574	224,869,649	8,429,729
1994	286,886,000	43,528,800	17,934,200	10,845,200	9,426,270	5,591,480	3,733,410	2,382,280	1,814,440	1,533,890	1,166,220	1,149,960	428,695	216,031	417,795	387,054,671	9,109,311
1995	187,595,000	92,621,500	21,984,800	11,289,000	7,469,600	6,778,730	4,238,710	2,943,530	1,872,610	1,420,010	1,195,010	904,883	889,256	330,622	487,318	342,020,579	10,043,239
1996	234,759,000	60,543,300	46,685,800	13,729,600	7,588,290	5,134,020	4,869,770	3,148,820	2,166,160	1,363,390	1,023,450	853,845	642,024	627,496	573,716	383,708,681	10,398,901
1997	259,536,000	75,736,800	30,453,100	28,928,700	9,194,840	5,303,680	3,699,220	3,552,200	2,239,550	1,507,950	933,003	691,345	571,367	426,812	794,049	423,568,616	10,716,276
1998	148,101,000	83,739,100	38,059,900	18,762,400	19,115,000	6,314,940	3,765,770	2,682,500	2,542,610	1,589,960	1,065,640	657,939	487,280	402,920	862,693	328,149,652	10,291,542
1999	153,117,000	47,787,400	42,088,100	23,471,800	12,431,100	13,156,400	4,483,340	2,724,240	1,911,960	1,794,920	1,116,050	745,814	459,946	340,639	885,983	306,514,692	9,979,552
2000	124,771,000	49,407,000	24,025,200	25,982,800	15,587,900	8,595,090	9,406,450	3,273,240	1,962,810	1,365,980	1,276,130	791,583	528,578	326,059	871,073	268,170,893	10,395,453
2001	196,937,000	40,258,900	24,835,300	14,819,600	17,218,600	10,751,400	6,133,630	6,859,180	2,356,830	1,402,040	971,340	905,555	561,425	375,065	851,196	325,237,061	14,282,631
2002	222,073,000	63,551,900	20,249,200	15,363,400	9,894,030	11,983,900	7,734,110	4,502,030	4,964,740	1,690,470	1,000,200	690,961	643,403	398,847	872,159	365,612,350	14,762,810
2003	127,874,000	71,657,000	31,945,400	12,494,100	10,192,300	6,821,200	8,521,970	5,603,520	3,213,330	3,509,300	1,188,020	700,782	483,519	450,197	890,486	285,545,124	16,039,154
2004	304,610,000	41,253,500	35,979,100	19,611,800	8,183,900	6,908,030	4,764,720	6,065,590	3,930,510	2,233,230	2,426,230	819,350	483,009	333,429	926,560	438,528,958	17,217,908
2005	158,237,000	98,264,700	20,701,700	22,040,600	12,782,000	5,496,480	4,760,860	3,333,710	4,170,720	2,672,520	1,508,510	1,633,380	550,916	324,795	848,863	337,326,754	15,043,414
2006	136,369,000	51,050,300	49,333,200	12,708,200	14,441,600	8,643,100	3,812,990	3,351,020	2,304,740	2,849,820	1,813,320	1,019,680	1,102,310	371,699	792,924	289,963,903	13,605,513
2007	89,174,400	43,980,000	25,573,000	29,996,600	8,131,870	9,439,080	5,764,880	2,572,010	2,215,620	1,504,410	1,846,370	1,170,450	657,328	710,764	752,687	223,489,469	11,429,639
2008	129,419,000	28,771,100	22,093,400	15,734,700	19,759,200	5,553,150	6,645,480	4,135,400	1,817,940	1,551,300	1,047,590	1,282,230	812,096	456,184	1,017,250	240,096,020	12,119,990
2009	76,363,900	41,756,900	14,453,400	13,598,900	10,378,100	13,491,400	3,897,170	4,738,050	2,898,430	1,259,980	1,067,930	718,532	878,045	555,924	1,009,760	187,066,421	13,126,651
2010	99,619,400	24,634,800	20,961,800	8,864,620	8,885,580	7,011,960	9,395,570	2,766,250	3,315,250	2,009,910	869,367	735,198	494,433	604,596	1,080,680	191,249,414	11,875,684
2011	128,567,000	32,132,100	12,351,800	12,794,000	5,724,910	5,891,090	4,762,210	6,471,910	1,871,580	2,217,460	1,335,500	575,780	486,408	327,226	1,117,810	216,626,784	14,403,674
2012	200,280,000	41,469,200	16,110,300	7,538,550	8,262,610	3,793,100	3,993,930	3,271,220	4,363,080	1,246,620	1,466,630	880,152	378,977	320,202	953,348	294,327,919	12,880,229
2013	68,928,800	64,593,800	20,782,000	9,810,020	4,839,520	5,437,030	2,557,870	2,733,820	2,200,970	2,904,070	824,754	967,648	580,355	250,074	842,900	188,253,631	11,304,591
2014	85,838,800	22,222,800	32,277,300	12,508,100	6,124,220	3,042,450	3,448,870	1,626,560	1,693,240	1,340,080	1,750,270	494,423	578,823	347,095	655,249	173,948,280	8,485,740
2015	157,070,000	27,677,400	11,120,300	19,523,800	7,895,460	3,940,520	2,004,520	2,307,400	1,070,410	1,103,200	868,587	1,132,320	319,941	375,144	652,306	237,061,308	7,829,308
2016	229,985,000	50,659,100	13,874,900	6,779,290	12,565,700	5,223,860	2,681,360	1,388,840	1,575,220	724,153	742,744	583,678	760,896	215,246	693,483	328,453,470	6,684,260
2017	111,203,000	74,145,700	25,334,400	8,368,210	4,247,160	8,012,180	3,414,780	1,782,770	909,619	1,022,650	468,159	479,672	377,310	492,949	591,874	240,850,433	6,125,003
2018	129,634,000	35,859,800	37,108,200	15,347,400	5,307,490	2,735,810	5,240,150	2,249,410	1,147,640	576,892	642,876	292,950	299,608	235,655	678,816	237,356,697	6,123,847
2019	164,809,000	41,819,100	17,997,900	22,743,500	10,012,800	3,574,150	1,894,770	3,691,900	1,559,920	787,898	393,781	437,601	199,243	203,851	623,609	270,749,023	7,897,803
2020	124,284,000	53,177,800	21,017,400	11,096,100	15,057,100	6,885,270	2,535,560	1,369,940	2,630,370	1,100,920	552,977	275,583	305,924	139,297	579,418	241,007,659	6,954,429
2021	86,716,700	40,051,700	26,729,600	13,065,800	7,435,710	10,313,700	4,880,090	1,874,220	1,025,570	1,997,590	847,029	430,241	216,477	242,295	576,241	196,402,963	7,209,663
2022	76,653,000	27,944,400	20,132,600	16,627,000	8,777,720	5,109,230	7,307,150	3,593,770	1,395,330	773,887	1,526,580	654,555	335,705	170,342	651,928	171,653,197	9,102,097
2023	94,898,600	24,679,400	14,010,100	12,431,900	10,965,600	5,812,440	3,430,900	5,066,100	2,519,770	994,613	560,736	1,122,630	487,738	253,097	631,181	177,864,805	11,635,865

Table X7. Estimates of female spawning stock biomass, 1982-2023.

Year	Age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
1982	0	0	0	139	357	406	892	836	890	2,001	1,864	3,141	1,838	1,474	4,345	18,183.4
1983	0	0	0	97	546	535	610	844	765	877	1,642	1,319	2,572	1,398	4,054	15,259.6
1984	0	0	0	142	439	903	1,236	733	946	734	747	1,588	1,190	2,252	4,393	15,302.9
1985	0	0	0	255	555	777	2,144	1,376	909	902	722	737	1,346	1,038	5,128	15,889.3
1986	0	0	0	642	934	924	1,426	2,144	1,271	675	717	561	544	890	3,606	14,335.3
1987	0	0	0	509	2,293	1,460	1,917	1,632	2,324	1,246	668	721	523	498	4,043	17,832.9
1988	0	0	0	547	2,206	4,154	3,573	2,396	1,885	2,107	1,385	753	695	495	3,865	24,060.2
1989	0	0	0	555	2,342	4,024	9,970	5,070	3,144	2,454	2,571	1,384	731	659	3,781	36,685.0
1990	0	0	0	574	1,945	3,839	7,989	11,305	5,224	2,857	2,105	2,447	1,192	584	3,173	43,233.3
1991	0	0	0	743	2,188	2,971	7,980	8,643	12,225	4,637	3,364	1,814	2,217	1,073	3,249	51,103.9
1992	0	0	0	806	2,931	3,571	7,259	9,135	10,208	12,346	5,432	3,737	2,179	2,444	4,937	64,984.7
1993	0	0	0	1,016	3,225	4,438	7,703	8,904	10,674	9,828	11,892	5,200	3,163	1,929	5,443	73,415.9
1994	0	0	0	879	4,092	5,027	9,844	9,420	9,965	9,842	9,672	10,910	4,689	2,646	5,775	82,759.6
1995	0	0	0	963	3,244	6,300	11,777	11,589	10,775	10,129	8,017	7,972	9,037	3,712	5,997	89,513.4
1996	0	0	0	1,159	3,691	5,563	15,528	14,055	13,072	10,120	8,305	7,223	6,729	7,259	7,534	100,240.4
1997	0	0	0	2,604	4,085	5,070	9,576	12,853	12,553	11,404	8,062	6,255	6,237	5,294	11,374	95,367.1
1998	0	0	0	1,169	7,296	4,979	9,508	9,658	13,221	9,485	7,636	5,882	4,847	4,562	10,785	89,027.4
1999	0	0	0	1,345	3,782	8,700	8,371	9,075	9,937	11,685	8,157	6,223	4,805	4,023	12,441	88,543.2
2000	0	0	0	1,467	4,693	5,905	18,824	10,121	10,521	8,400	10,412	7,280	5,860	4,194	13,428	101,106.2
2001	0	0	0	962	5,688	8,342	13,167	21,784	11,659	9,173	7,161	7,071	5,498	4,164	10,229	104,898.3
2002	0	0	0	896	3,387	9,394	17,445	15,469	23,482	10,502	7,748	5,912	6,368	4,587	11,888	117,078.5
2003	0	0	0	678	3,381	5,357	18,761	18,557	15,644	20,705	8,672	5,898	4,784	5,082	11,409	118,926.8
2004	0	0	0	1,049	2,867	5,315	10,573	19,852	18,775	13,074	16,958	6,564	4,597	3,596	11,341	114,561.9
2005	0	0	0	1,272	4,188	4,463	10,571	11,682	20,661	15,781	10,836	13,995	5,467	3,667	11,206	113,787.1
2006	0	0	0	682	4,468	6,140	7,986	11,263	12,050	17,312	13,086	8,385	11,163	4,267	10,538	107,340.6
2007	0	0	0	1,441	2,535	7,003	12,783	8,484	11,756	9,721	14,460	10,269	6,981	8,699	10,897	105,029.4
2008	0	0	0	843	6,188	4,593	16,971	14,403	9,413	10,485	8,178	11,235	8,561	5,500	13,949	110,318.3
2009	0	0	0	739	3,065	10,765	9,392	17,701	15,444	8,045	8,186	6,097	8,945	6,471	13,349	108,198.2
2010	0	0	0	480	2,681	5,493	21,452	9,300	16,605	12,771	6,617	5,992	4,886	6,836	13,939	107,052.7
2011	0	0	0	758	1,734	4,381	10,584	21,232	9,299	13,616	9,474	5,028	4,844	3,755	14,918	99,622.6
2012	0	0	0	464	2,844	2,939	9,231	11,766	21,995	8,280	11,164	7,759	4,055	3,876	13,531	97,903.2
2013	0	0	0	521	1,673	4,465	5,644	9,203	11,534	17,893	6,482	8,677	6,214	3,063	11,985	87,352.8
2014	0	0	0	614	1,946	2,326	7,919	5,413	8,996	9,075	13,434	4,961	6,779	4,693	10,728	76,881.8
2015	0	0	0	1,115	2,754	3,464	4,728	8,197	5,696	7,077	6,755	10,380	3,549	4,698	9,107	67,520.2
2016	0	0	0	325	4,153	4,413	6,828	5,227	8,579	5,167	6,124	5,556	8,892	2,867	11,079	69,211.1
2017	0	0	0	462	1,467	6,360	8,086	6,136	4,652	7,084	3,918	4,550	4,373	6,579	8,769	62,435.9
2018	0	0	0	824	1,721	2,414	11,216	7,612	6,465	4,062	5,707	3,185	3,505	3,013	11,084	60,808.2
2019	0	0	0	1,199	3,163	2,746	4,354	13,766	8,865	5,681	3,464	4,563	2,617	2,720	9,407	62,544.0
2020	0	0	0	680	4,704	4,878	5,894	5,326	14,420	8,035	5,001	2,943	3,744	1,824	8,471	65,920.7
2021	0	0	0	751	2,624	6,967	10,210	6,357	4,888	13,744	5,178	4,279	2,727	3,188	8,877	69,791.5
2022	0	0	0	1,091	3,169	4,691	16,560	11,572	7,346	4,766	12,719	5,946	4,005	2,161	9,865	83,892.4
2023	0	0	0	844	4,153	5,059	8,491	16,700	12,354	5,919	4,780	10,799	5,570	3,289	8,576	86,535.7

Table x8. Estimate of total female spawning stock biomass with associated standard errors and coefficients of variation.

Year	Total	SE	CV
1982	18,183	2,616	0.144
1983	15,260	2,314	0.152
1984	15,303	2,308	0.151
1985	15,889	2,234	0.141
1986	14,335	1,905	0.133
1987	17,833	2,097	0.118
1988	24,060	2,377	0.099
1989	36,685	3,104	0.085
1990	43,233	3,296	0.076
1991	51,104	3,701	0.072
1992	64,985	4,700	0.072
1993	73,416	5,099	0.069
1994	82,760	5,430	0.066
1995	89,513	5,595	0.062
1996	100,240	6,380	0.064
1997	95,367	6,515	0.068
1998	89,027	5,639	0.063
1999	88,543	5,610	0.063
2000	101,106	6,067	0.060
2001	104,898	5,742	0.055
2002	117,078	6,351	0.054
2003	118,927	6,451	0.054
2004	114,562	6,391	0.056
2005	113,787	6,596	0.058
2006	107,340	6,452	0.060
2007	105,029	6,530	0.062
2008	110,318	6,475	0.059
2009	108,198	6,214	0.057
2010	107,053	6,046	0.056
2011	99,623	5,914	0.059
2012	97,903	6,148	0.063
2013	87,353	5,977	0.068
2014	76,882	6,046	0.079
2015	67,520	5,519	0.082
2016	69,211	5,925	0.086
2017	62,436	5,676	0.091
2018	60,808	5,963	0.098
2019	62,544	6,198	0.099
2020	65,921	6,516	0.099
2021	69,792	6,982	0.100
2022	83,892	8,420	0.100
2023	86,536	9,309	0.108

Table x9 . Estimates of exploitable biomass, 1982-2023.

	Age															
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
1982	2,420	4,405	3,030	3,012	2,000	1,501	1,515	1,228	1,013	2,271	2,120	3,381	1,940	1,527	4,649	36,012
1983	8,926	3,307	3,234	2,197	2,954	1,828	1,058	1,216	918	951	1,798	1,464	2,677	1,471	4,323	38,323
1984	9,575	8,649	5,965	2,980	2,227	3,022	1,913	971	1,072	791	824	1,614	1,191	2,279	4,644	47,716
1985	1,349	7,861	10,039	6,140	3,087	2,654	3,395	1,999	1,055	1,024	784	766	1,462	1,100	5,495	48,210
1986	4,092	4,139	9,107	12,526	5,065	3,088	2,396	3,117	1,526	795	789	609	588	963	3,809	52,610
1987	6,925	7,269	10,133	10,685	13,535	5,095	3,174	2,279	2,722	1,366	698	739	534	502	4,261	69,914
1988	17,645	10,177	10,307	11,978	11,932	13,457	5,543	3,279	2,202	2,404	1,434	761	719	506	4,077	96,420
1989	7,274	15,259	12,705	11,097	12,535	13,383	15,946	6,794	3,541	2,482	2,544	1,459	758	670	3,992	110,437
1990	3,110	13,068	14,787	12,051	11,493	13,288	13,492	16,142	6,414	3,292	2,434	2,657	1,266	626	3,355	117,474
1991	12,201	11,547	18,761	15,116	12,330	10,107	13,009	12,258	14,416	5,220	3,344	1,929	2,287	1,095	3,446	137,067
1992	3,987	12,945	23,614	17,433	16,480	12,046	11,249	12,823	11,671	13,434	5,426	3,820	2,049	2,340	5,245	154,561
1993	2,437	9,782	16,332	21,879	17,648	15,308	12,426	12,367	12,231	10,921	12,750	5,544	3,367	2,036	5,770	160,797
1994	40,316	11,801	20,325	18,453	22,449	17,410	15,700	12,996	11,696	11,160	10,296	11,607	4,855	2,753	6,137	217,954
1995	27,125	37,964	26,175	21,668	18,481	21,863	18,393	16,238	12,572	11,022	9,022	8,805	9,625	3,967	6,433	249,353
1996	15,618	32,828	47,358	24,298	20,136	18,166	23,518	19,475	15,025	11,150	9,295	7,466	6,903	7,499	8,130	266,864
1997	13,863	22,314	33,897	55,012	23,477	18,186	16,702	20,219	15,492	12,761	8,922	6,750	6,366	5,465	12,189	271,614
1998	38,022	26,494	32,829	25,941	44,971	18,182	15,559	13,553	14,951	10,936	8,989	6,517	5,129	4,913	11,569	278,555
1999	100,793	28,312	38,911	30,855	21,867	31,266	14,115	13,232	11,650	13,133	8,723	6,491	4,936	4,091	13,325	341,699
2000	45,554	28,851	23,905	32,963	26,188	19,841	29,393	13,537	11,738	9,498	11,136	7,633	5,880	4,250	14,381	284,748
2001	22,637	15,096	19,492	20,561	30,823	27,135	20,796	30,311	13,410	10,434	7,756	8,120	5,928	4,557	10,955	248,011
2002	11,918	14,154	12,851	19,980	19,325	31,719	28,540	21,392	27,315	11,722	8,417	6,345	6,290	4,651	12,751	237,371
2003	7,039	19,228	17,786	15,220	18,577	18,016	30,723	26,156	18,579	23,123	9,523	6,478	4,994	5,368	12,253	233,063
2004	47,517	7,494	25,543	23,205	15,095	18,070	17,343	27,926	22,082	14,718	18,620	7,178	4,810	3,796	12,212	265,608
2005	12,032	33,323	12,697	25,869	22,534	15,399	17,165	16,109	23,953	17,680	11,742	14,773	5,565	3,765	12,062	244,670
2006	15,355	11,347	31,396	15,765	25,892	21,549	13,429	15,847	14,168	19,595	14,262	9,120	11,713	4,472	11,394	235,302
2007	4,204	12,655	15,284	30,781	13,692	23,154	20,027	11,625	13,452	10,903	15,401	10,907	7,028	8,878	11,697	209,688
2008	15,817	6,103	15,281	18,243	32,957	14,990	26,166	20,153	10,846	11,703	8,892	12,313	8,863	5,788	14,994	223,109
2009	12,100	15,067	9,840	16,468	17,196	35,798	15,383	25,510	17,833	9,061	9,110	6,703	9,270	6,813	14,339	220,490
2010	8,841	10,510	17,390	10,683	14,884	17,757	35,216	13,379	19,889	14,571	7,239	6,601	5,067	7,199	15,032	204,257
2011	16,598	9,268	10,539	16,782	9,614	14,585	17,623	30,290	10,816	15,247	10,577	5,448	4,955	3,906	16,097	192,343
2012	6,474	12,849	11,675	9,935	15,601	9,671	14,770	16,062	25,330	9,098	12,115	8,132	4,168	3,990	14,596	174,464
2013	7,698	12,789	14,107	11,624	9,423	15,160	9,383	13,262	13,804	20,453	7,235	9,406	6,519	3,232	13,057	167,149
2014	54,674	7,184	21,315	13,811	10,587	8,032	13,118	7,619	10,306	10,064	14,563	5,192	6,872	4,765	11,591	199,693
2015	13,915	10,433	7,910	23,225	14,069	11,189	7,500	11,387	6,506	8,088	7,545	11,132	3,818	5,061	9,804	151,582
2016	23,268	12,866	6,599	7,270	23,341	15,230	11,317	7,295	9,984	5,710	6,523	5,852	9,049	2,913	11,970	159,185
2017	13,932	21,180	17,104	9,319	7,493	21,376	13,298	8,953	5,651	7,955	4,373	4,995	4,569	6,959	9,511	156,668
2018	20,188	12,622	25,451	18,562	9,698	8,168	18,766	10,885	7,242	4,362	6,127	3,294	3,584	3,185	11,920	164,056
2019	19,877	15,467	14,761	26,449	17,126	9,178	7,312	18,207	9,847	6,375	3,779	4,907	2,728	2,843	10,090	168,946
2020	32,140	17,637	15,947	14,986	25,571	16,805	9,425	7,069	17,069	8,962	5,322	3,084	3,851	1,960	8,964	188,790
2021	5,098	15,860	19,423	16,242	14,388	24,272	16,300	8,999	6,123	15,055	6,282	4,642	2,804	3,330	9,398	168,215
2022	7,116	6,845	15,373	22,218	17,029	15,375	25,345	16,171	8,360	5,094	13,779	5,605	4,061	2,314	10,483	175,169
2023	29,297	7,682	11,252	18,245	23,408	17,128	14,286	24,161	14,238	6,843	5,002	11,518	5,836	3,453	9,095	201,445

Table X10. Reference points and probability of female spawning stock biomass being greater or equal to the SSB target and SSBthreshold over a six-year projection under the current fully-recruited 2023 F, Ftarget and Fthreshold.

	Reference Points	
	SSB	F
Target	111,891.8	0.1707
Threshold	89,513.4	0.2064
Current	86,535.7	0.1828

	Current F		Ftarget		Fthreshold	
Year	Pr SSB>= SSBthreshold	Pr SSB>= SSBtarget	Pr SSB>= SSBthreshold	Pr SSB>= SSBtarget	Pr SSB>= SSBthreshold	Pr SSB>= SSBtarget
2023	0.333	0.001	0.334	0.000	0.328	0.000
2024	0.756	0.016	0.771	0.018	0.756	0.016
2025	0.880	0.459	0.910	0.062	0.820	0.031
2026	0.913	0.073	0.952	0.111	0.802	0.029
2027	0.915	0.077	0.960	0.141	0.745	0.021
2028	0.894	0.066	0.958	0.138	0.632	0.011
2029	0.854	0.051	0.951	0.131	0.533	0.007

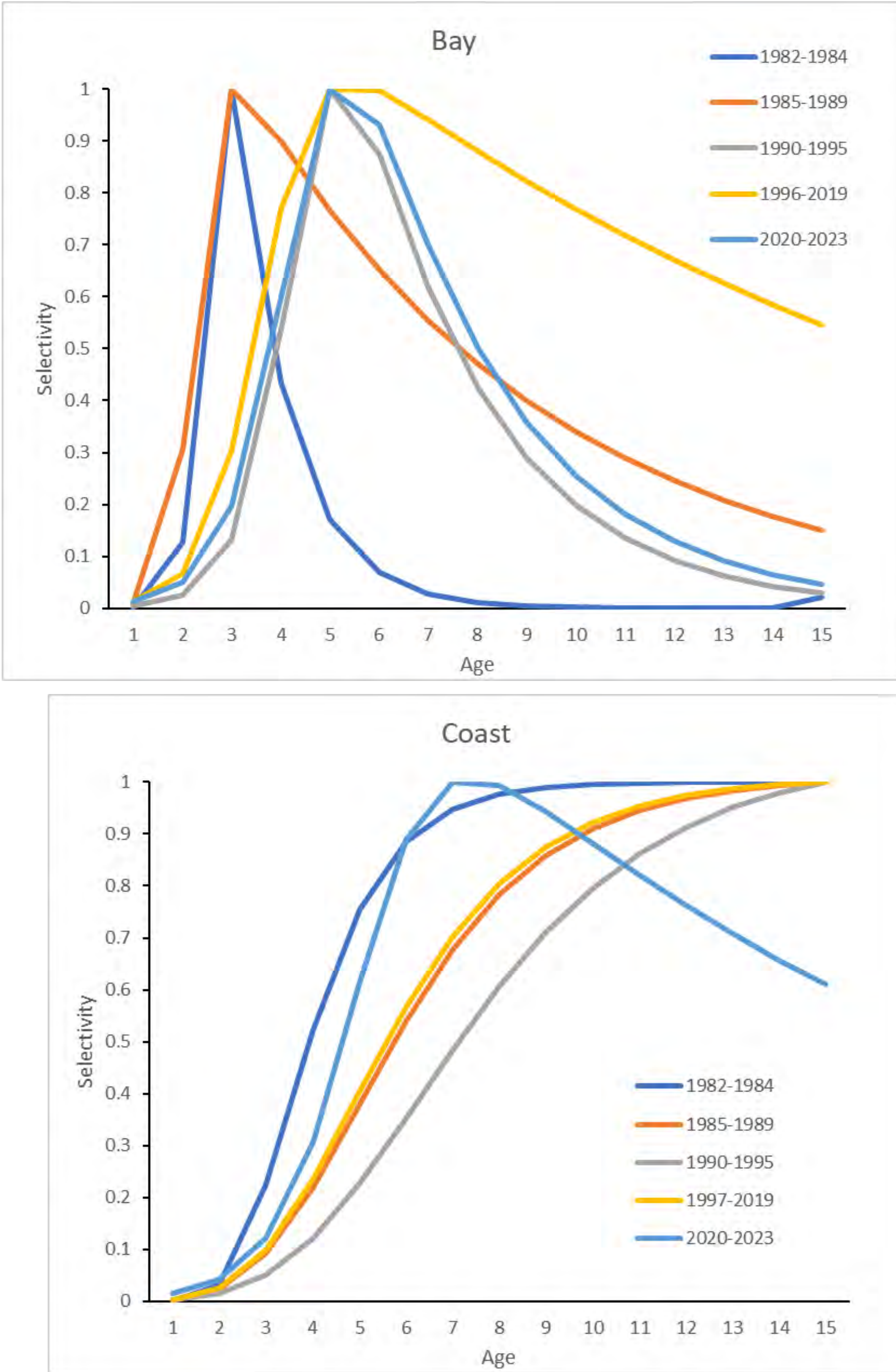


Figure 1. Estimates of selectivity patterns for the five Bay and Ocean time blocks.

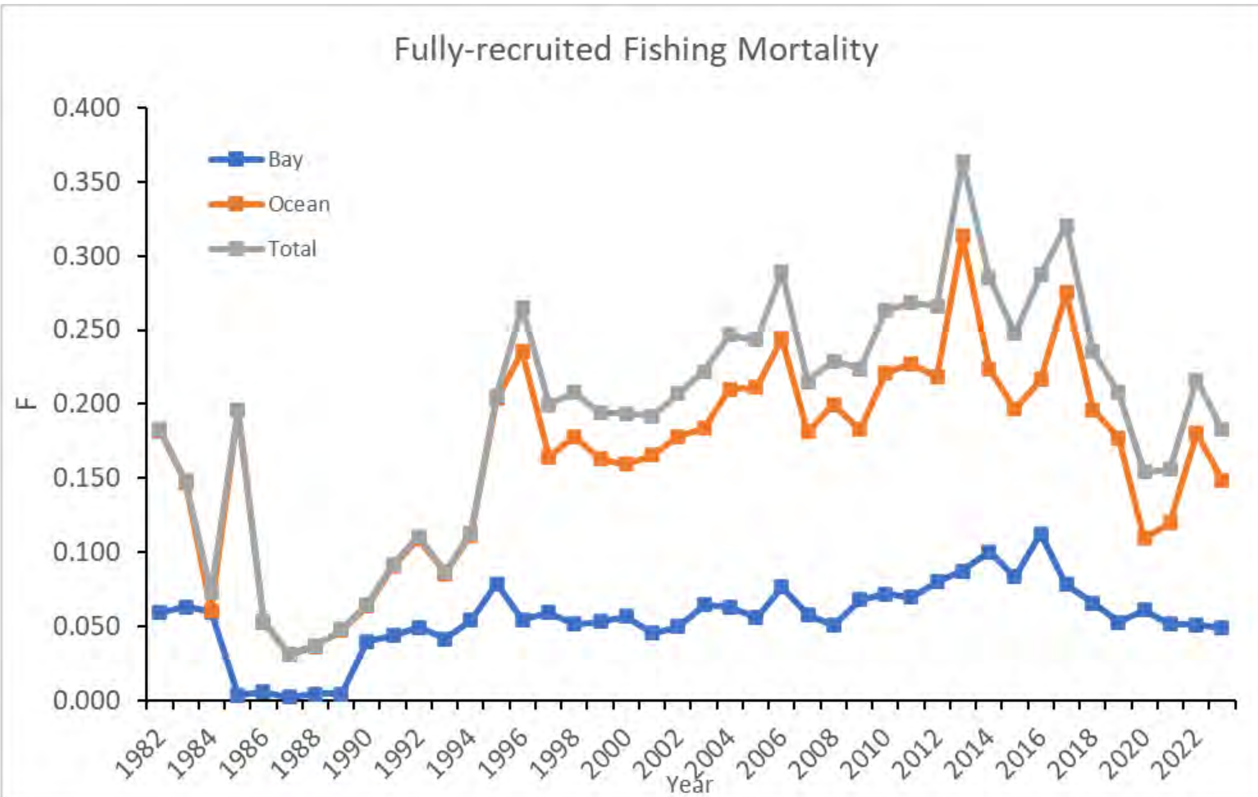


Figure 2. Estimates of region-specific and total fully-recruited fishing mortality in the Bay and Ocean, 1982-2023.

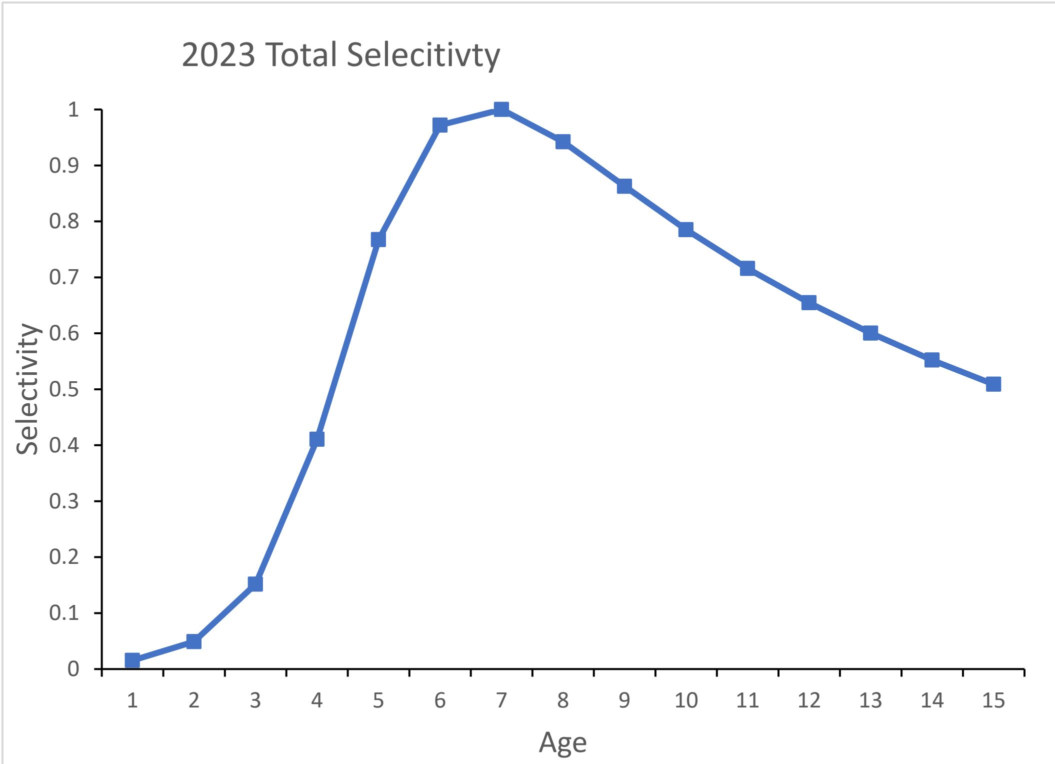


Figure 3. Total selectivity pattern for 2023 (Bay and Ocean combined) derived from total fishing mortality-at-age.

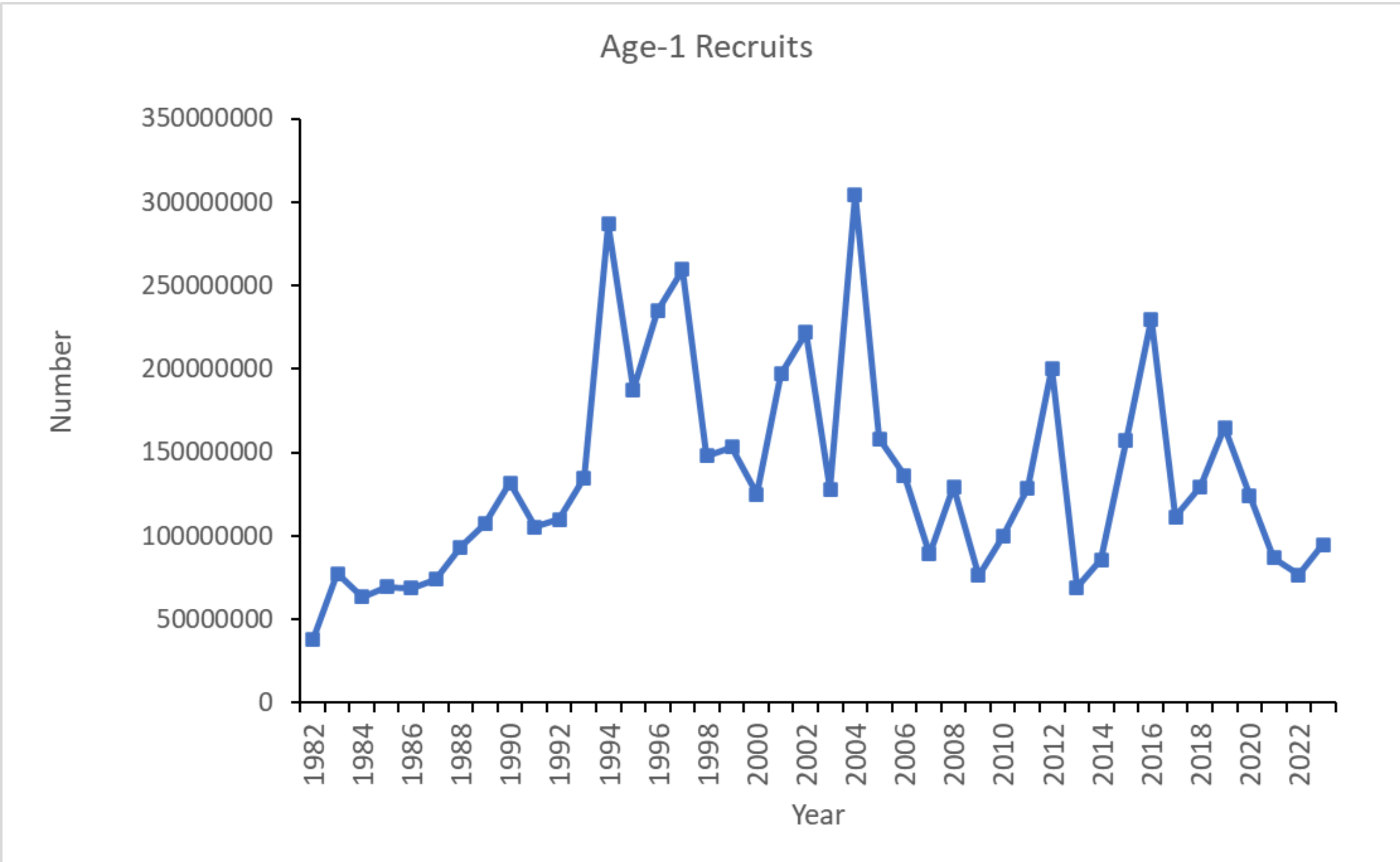


Figure 4. Estimates of recruit (age-1) abundance, 1982-2023.

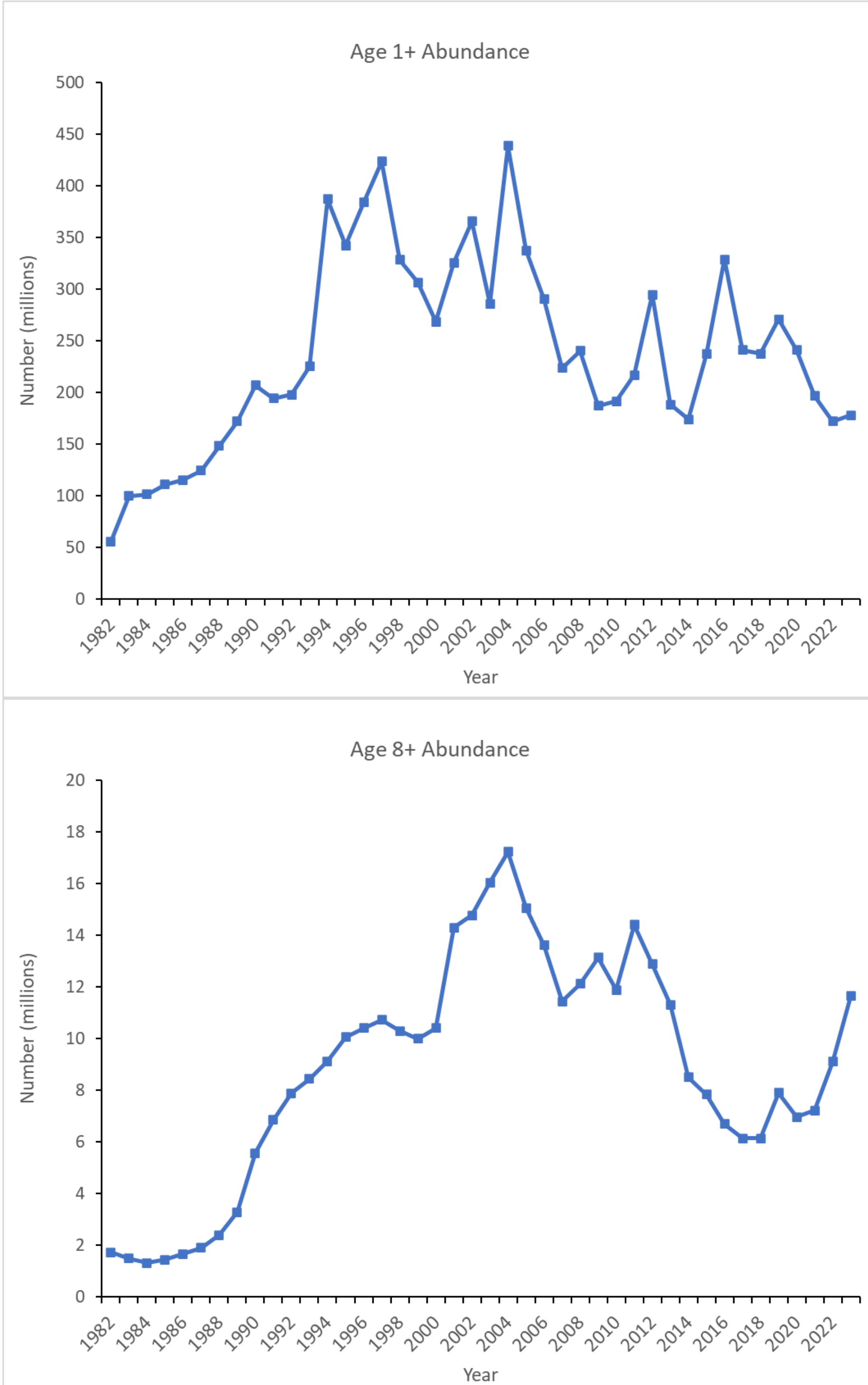


Figure 5. Estimates of total (top) and age-8 + (bottom) abundance from the updated stock assessment, 1982-2023.

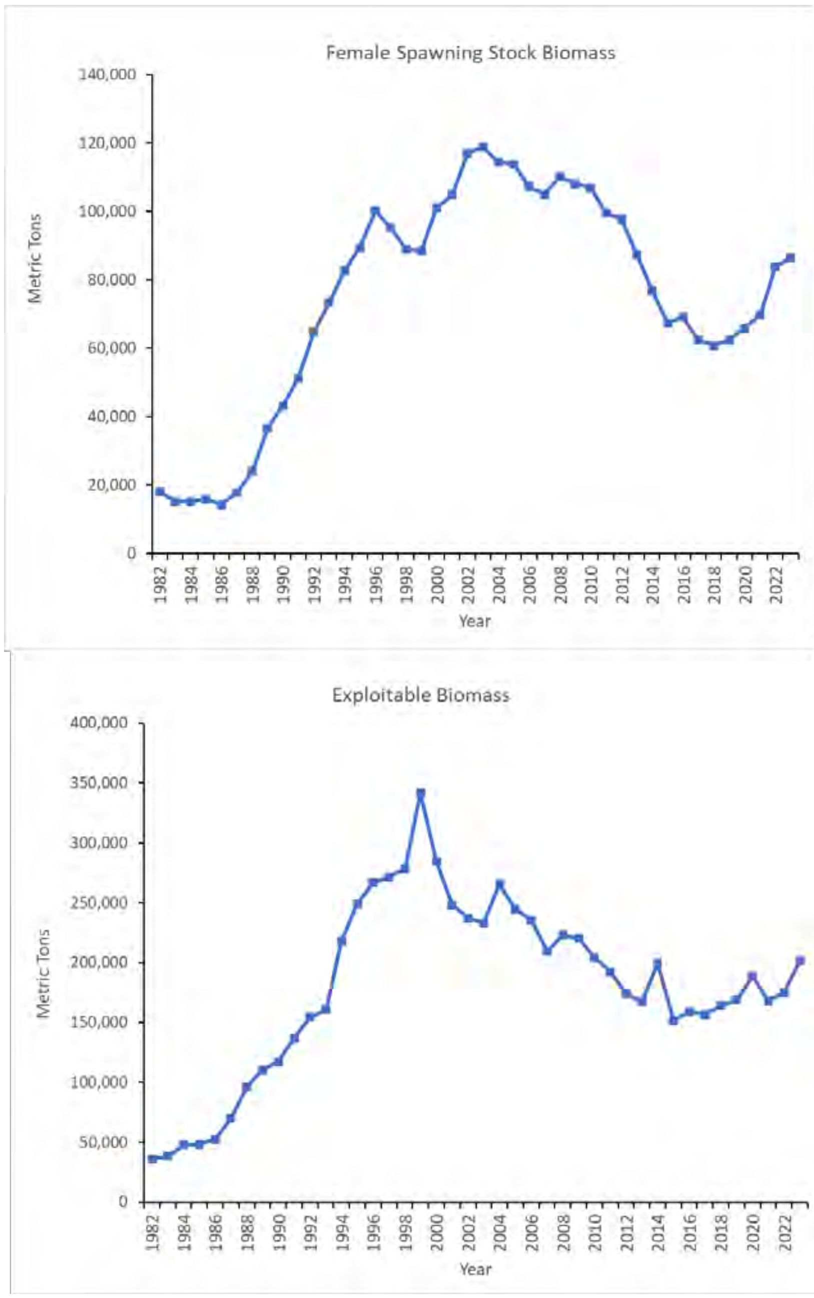


Figure 6. Estimates of female spawning stock biomass (top) and exploitable biomass (bottom), 1982-2023

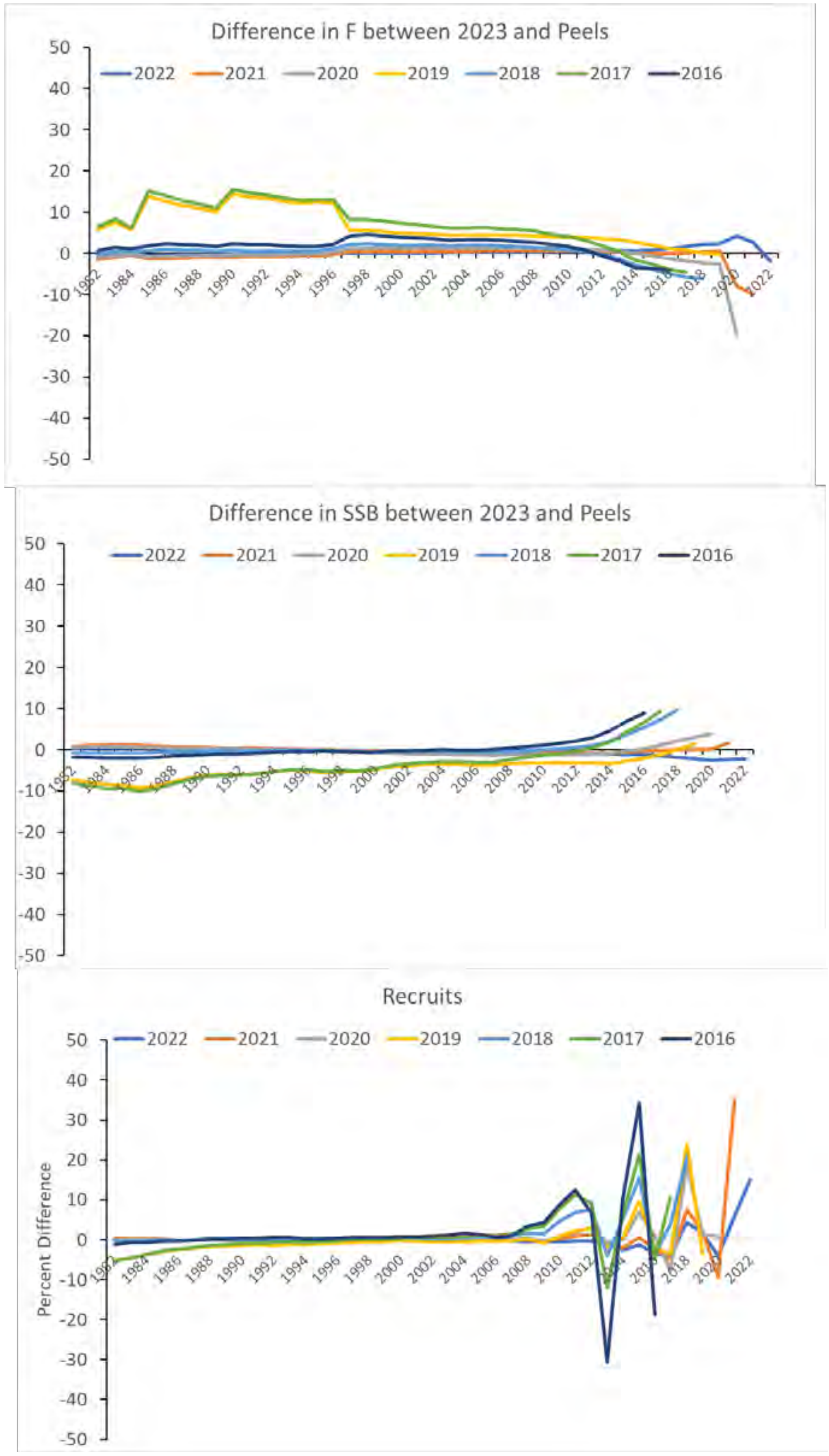


Figure 7. Retrospective plots of seven-year peels for fishing mortality, female spawning stock biomass and recruitment.

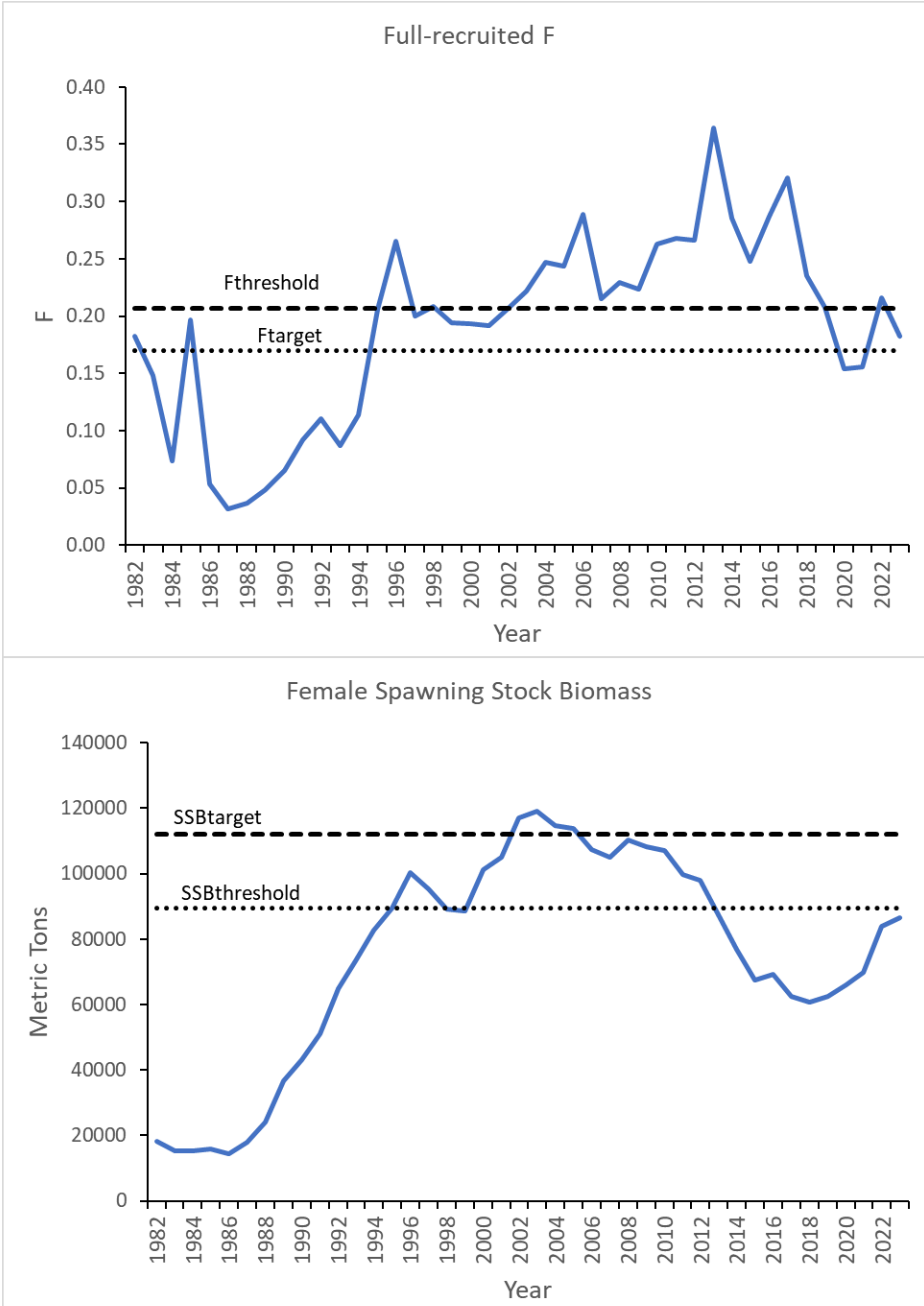


Figure 13. Comparison of SSB and F estimates to SSB and F reference points.

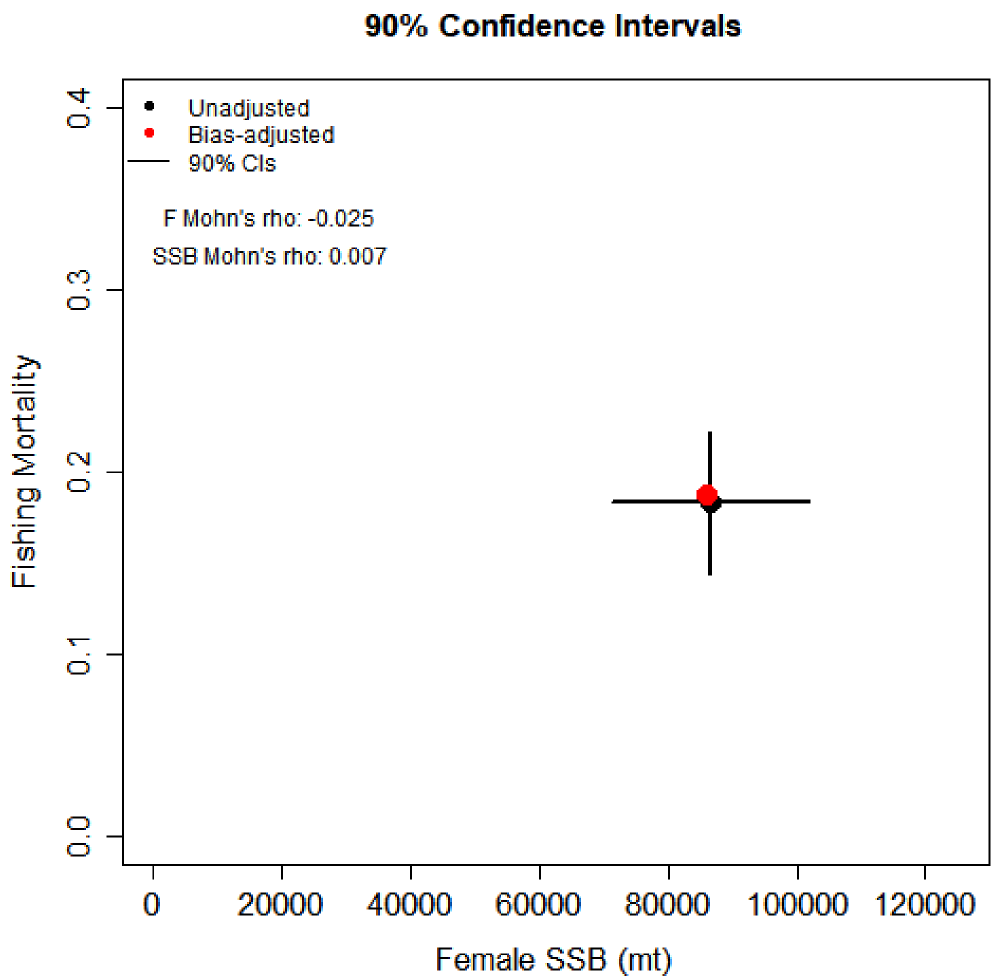


Figure 14. Plot comparing the 2023 bias-corrected F and female SSB values the uncorrected F and SSB estimates and their associated 90% confidence intervals. Because the retrospective adjusted values fall within the 90% confidence intervals, bias-correction is not needed.

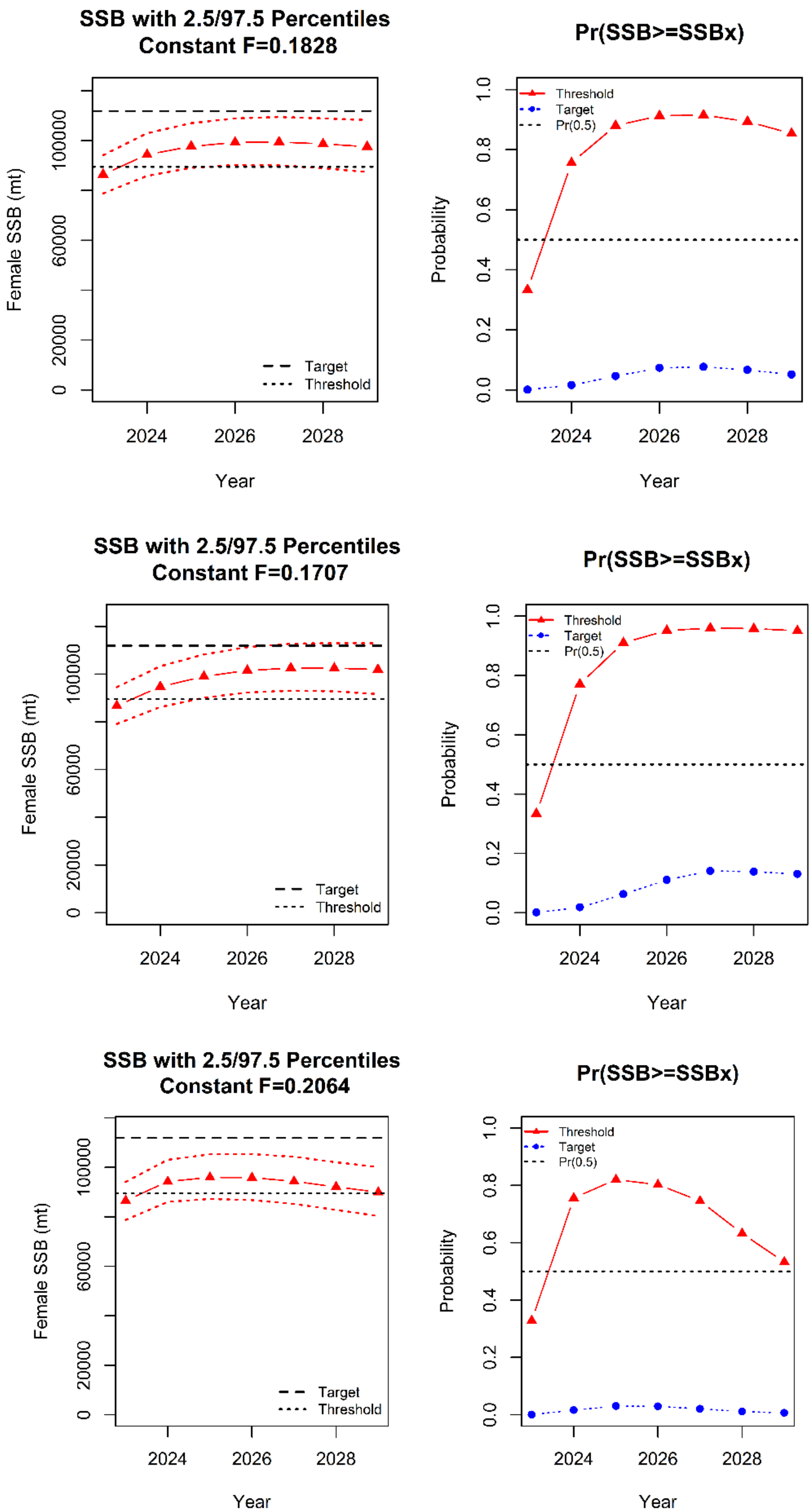


Figure 15. Projections of female spawning stock biomass through 2029 under current, target and threshold fishing mortality (left) and the probability of female SSB being above the target and threshold values of 111,891 and 89513 metric tons, respectively, over time (right).

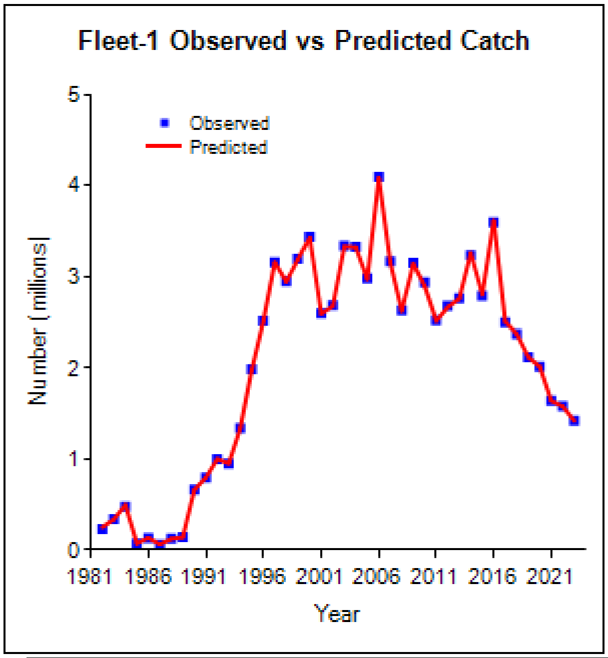
Sensitivity Run

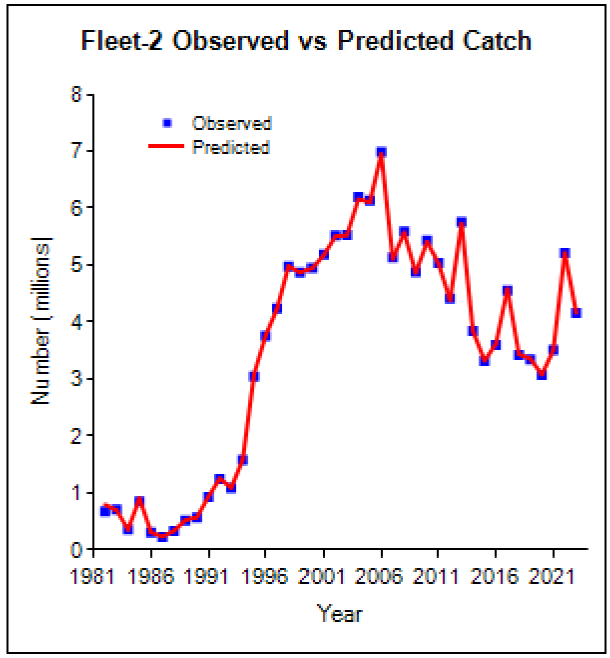
Model configuration:

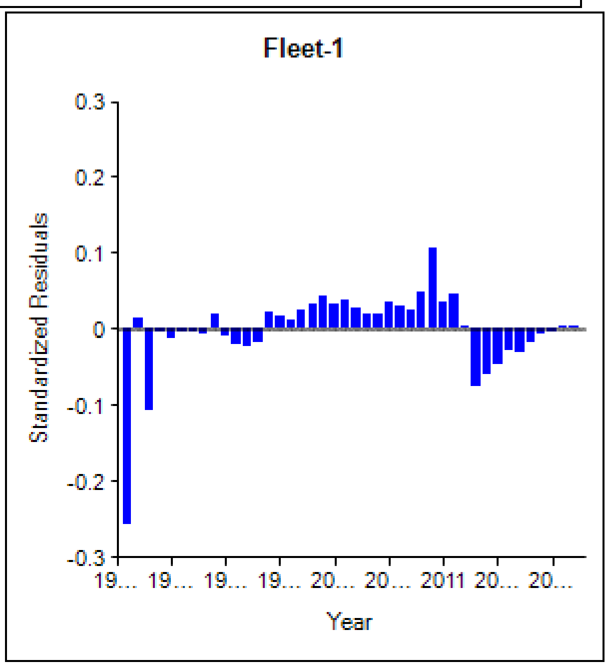
Ocean recent selectivity blocks: 2020-2022, 2023 (new blocks in 2020 and 2023)

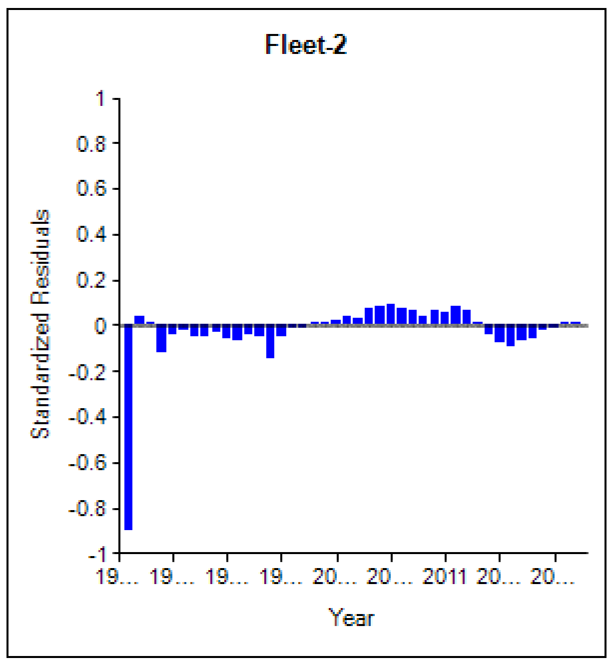
Bay recent selectivity blocks: 1996-2022, 2023 (new block in 2023 only)

Diagnostics

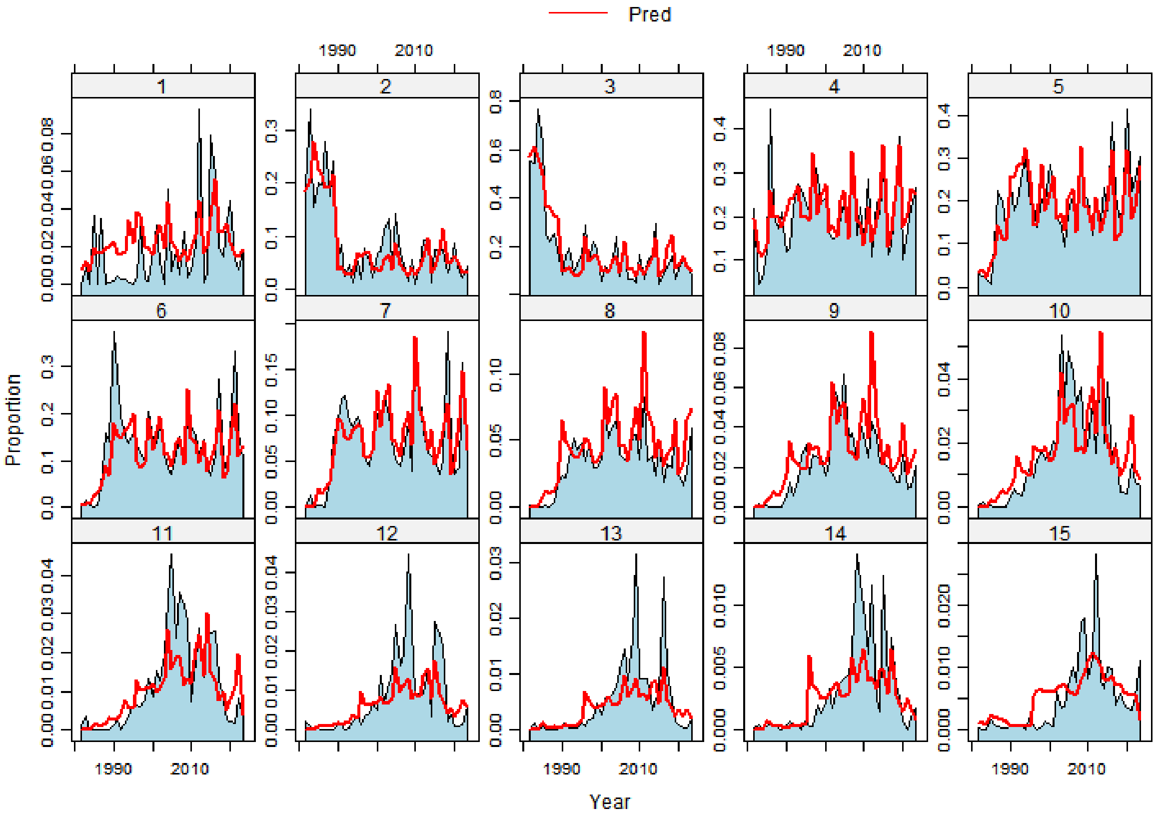




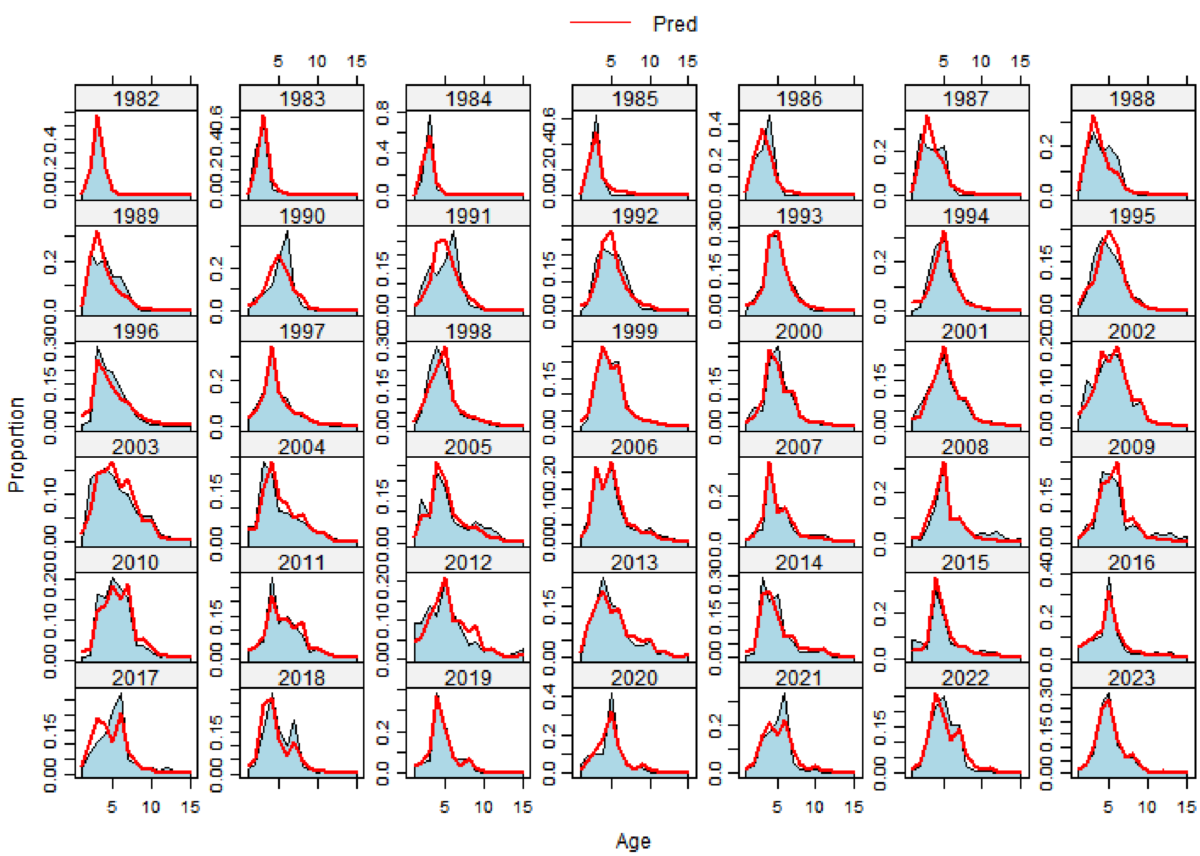




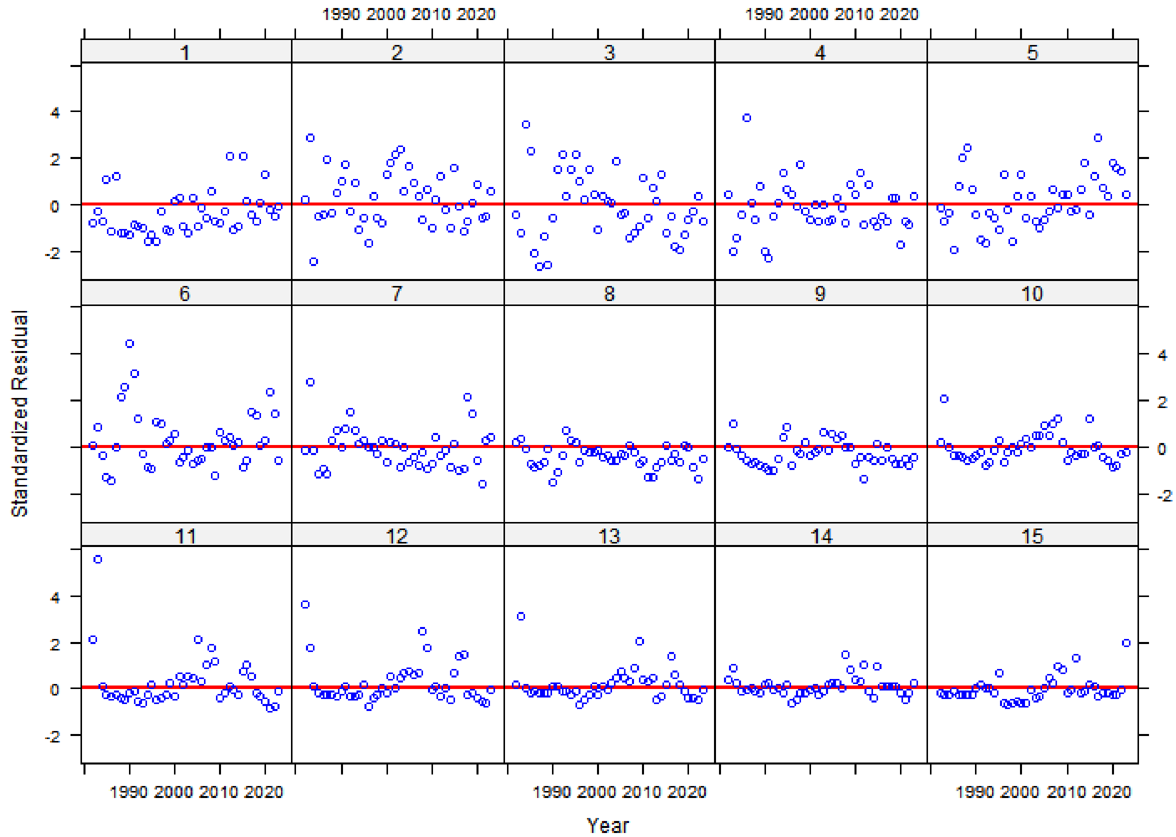
Fleet 1 Catch Age Composition By Age



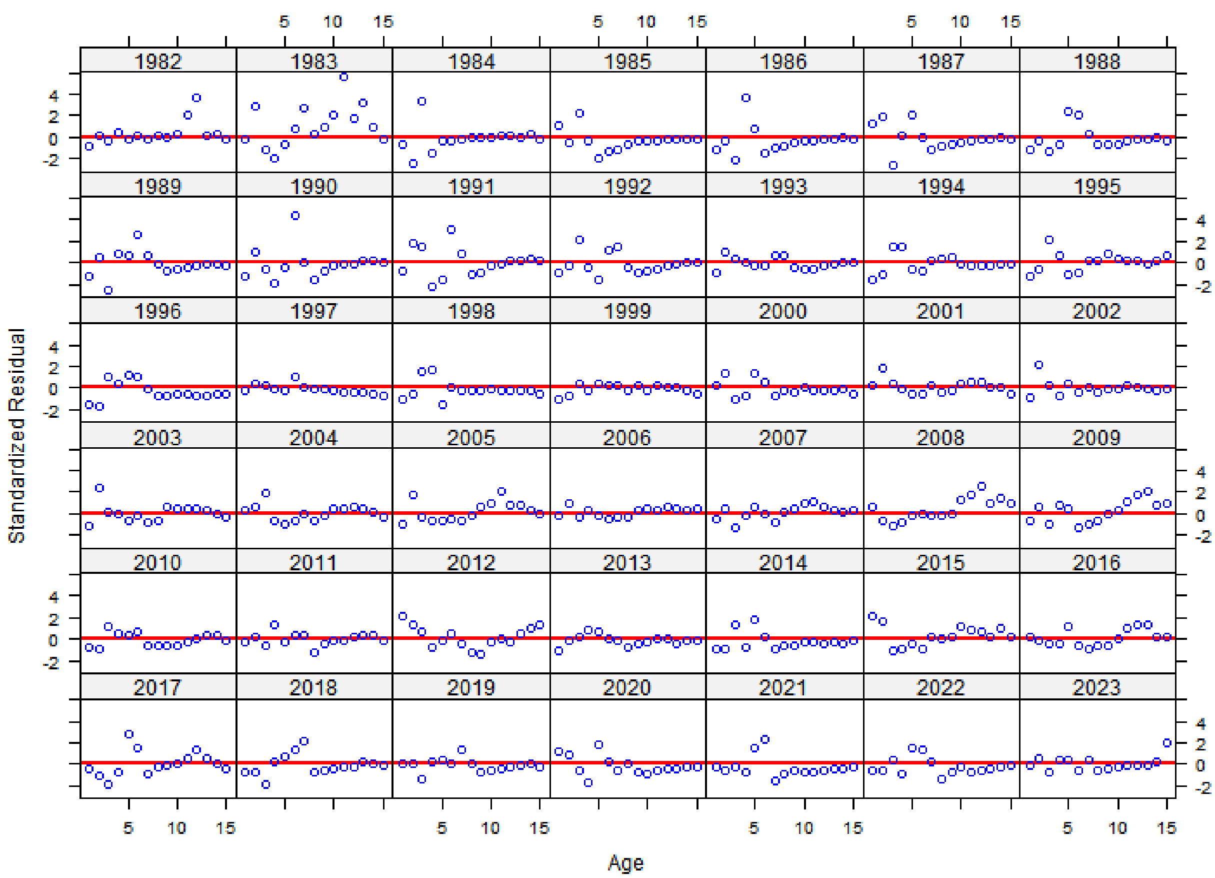
Fleet 1 Catch Age Composition By Year

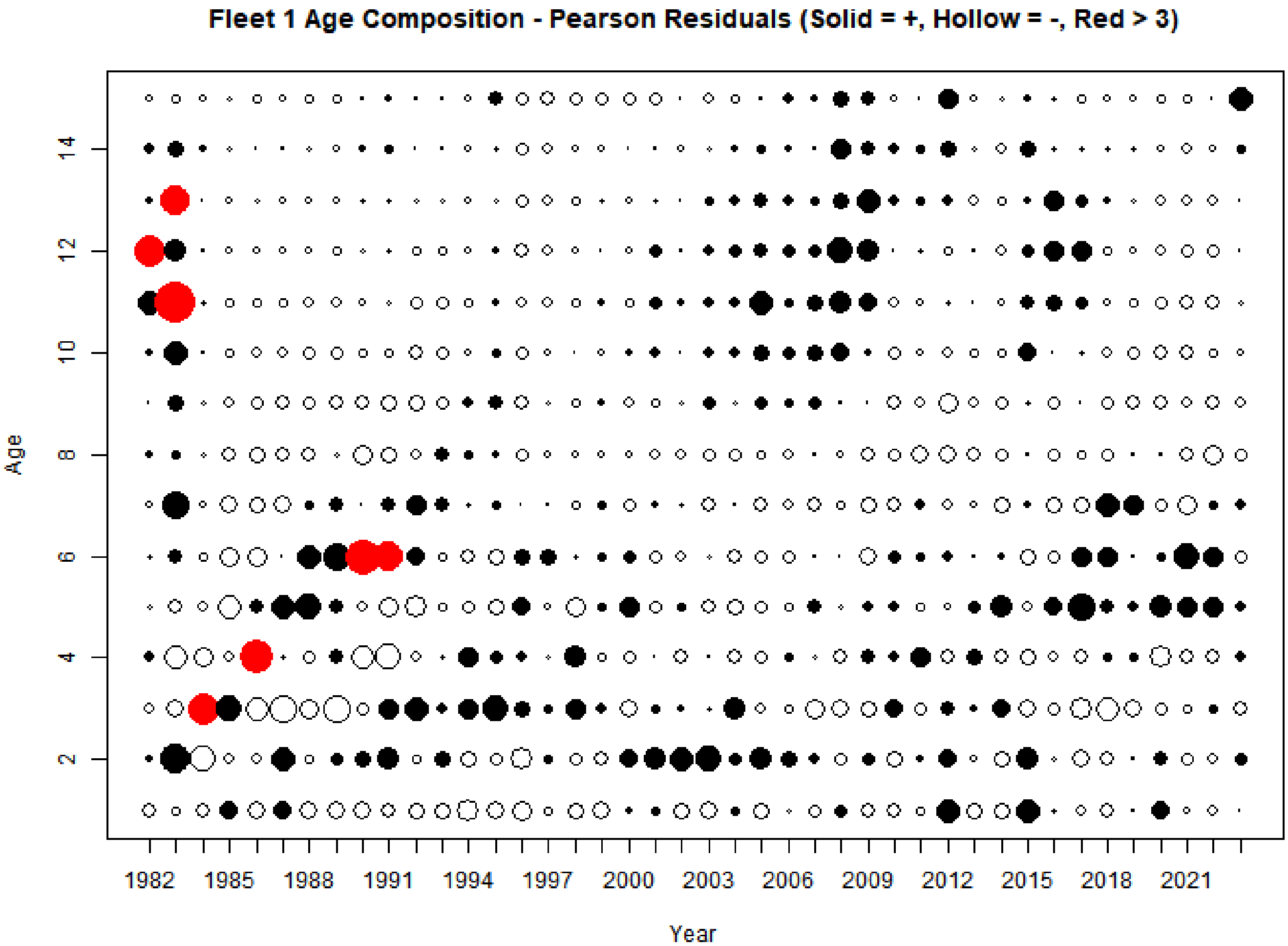


Fleet 1 Residuals of Age Composition By Age



Fleet 1 Residuals of Age Composition By Year




Fleet 1 Age Composition - Pearson Residuals (Solid = +, Hollow = -, Red > 3)
Age
2
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Year
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2012
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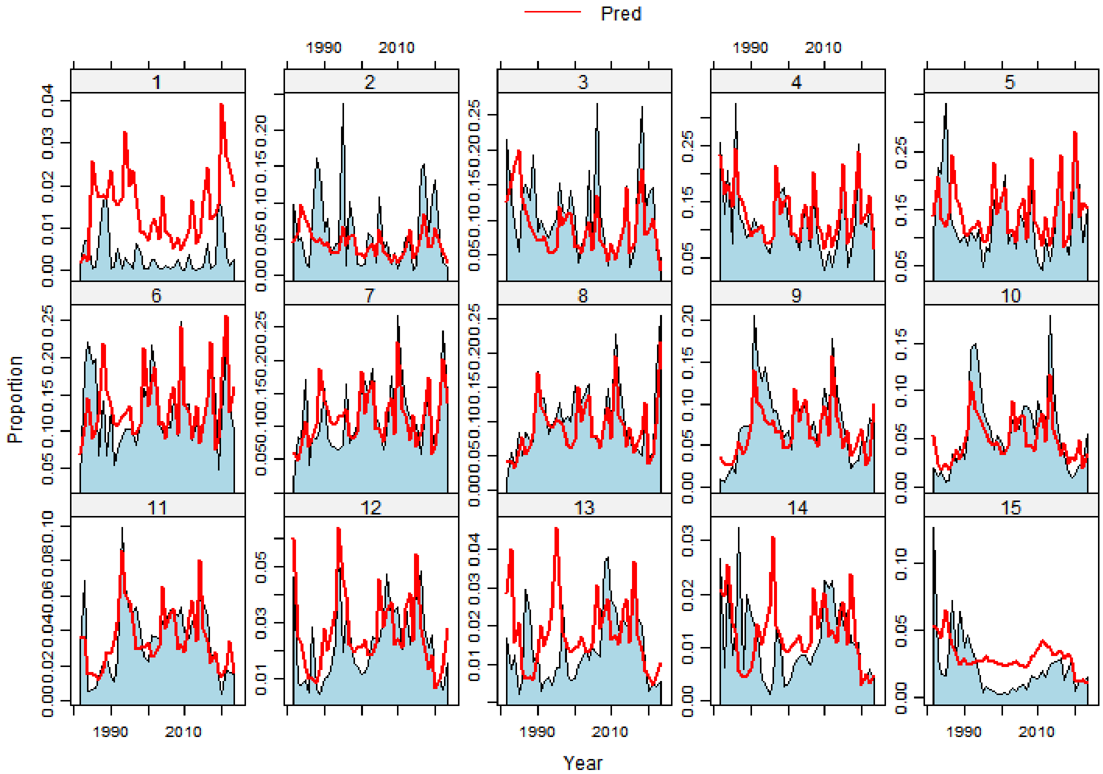
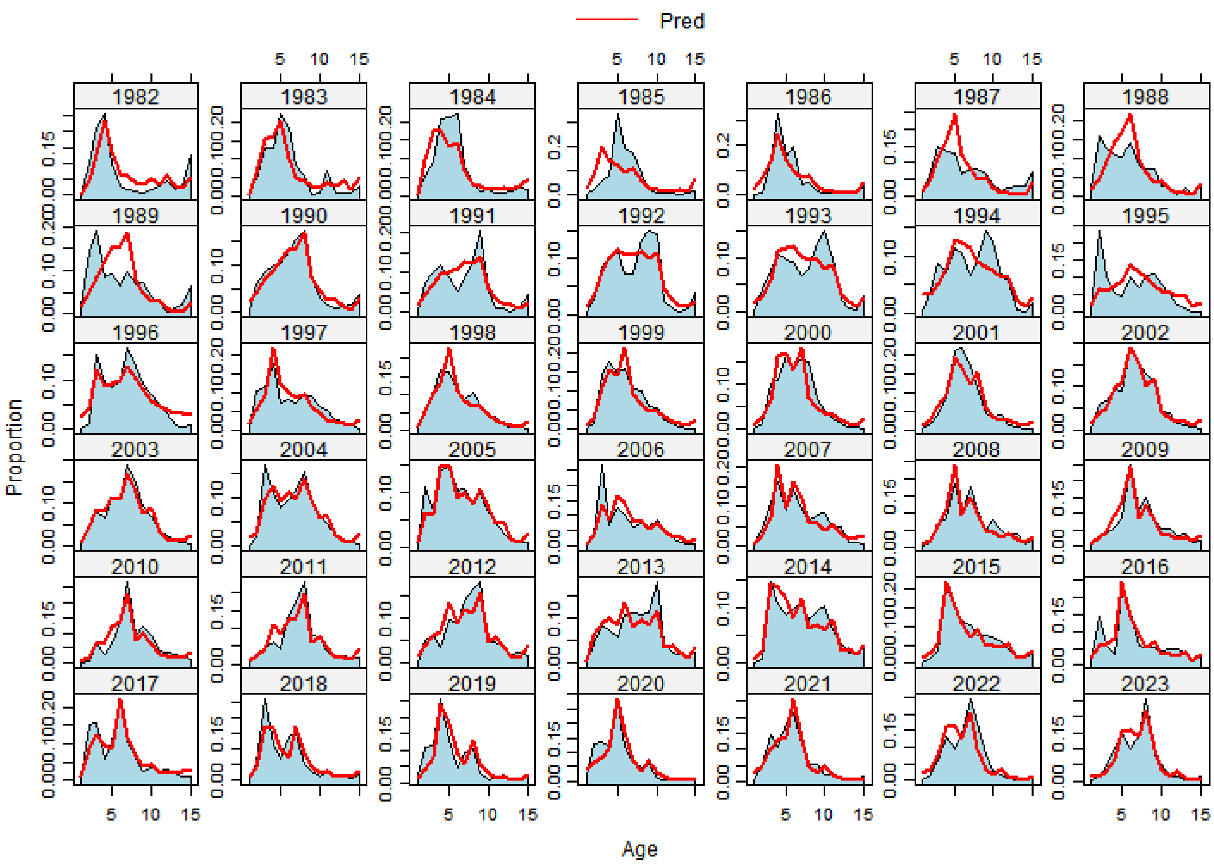
2018
2021

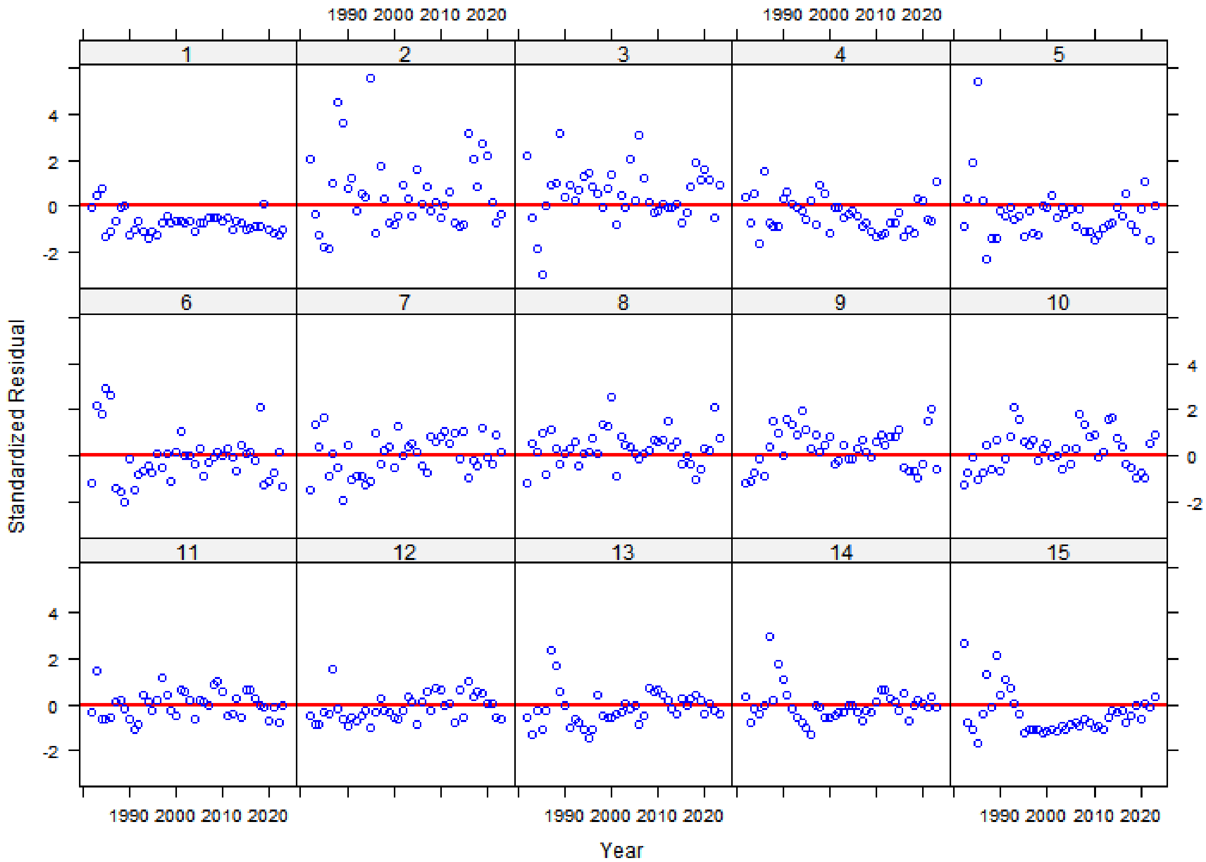
Fleet 2 Catch Age Composition By Age



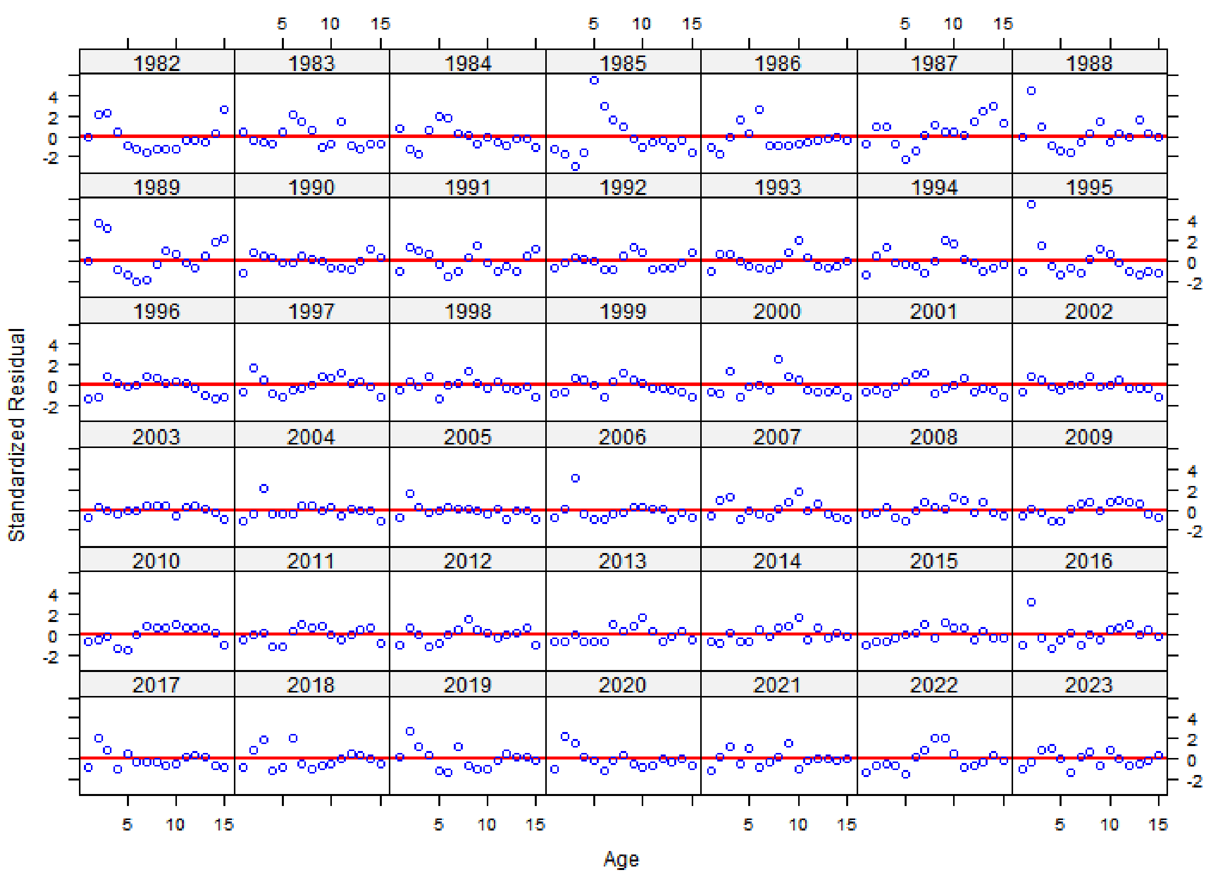
Fleet 2 Catch Age Composition By Year

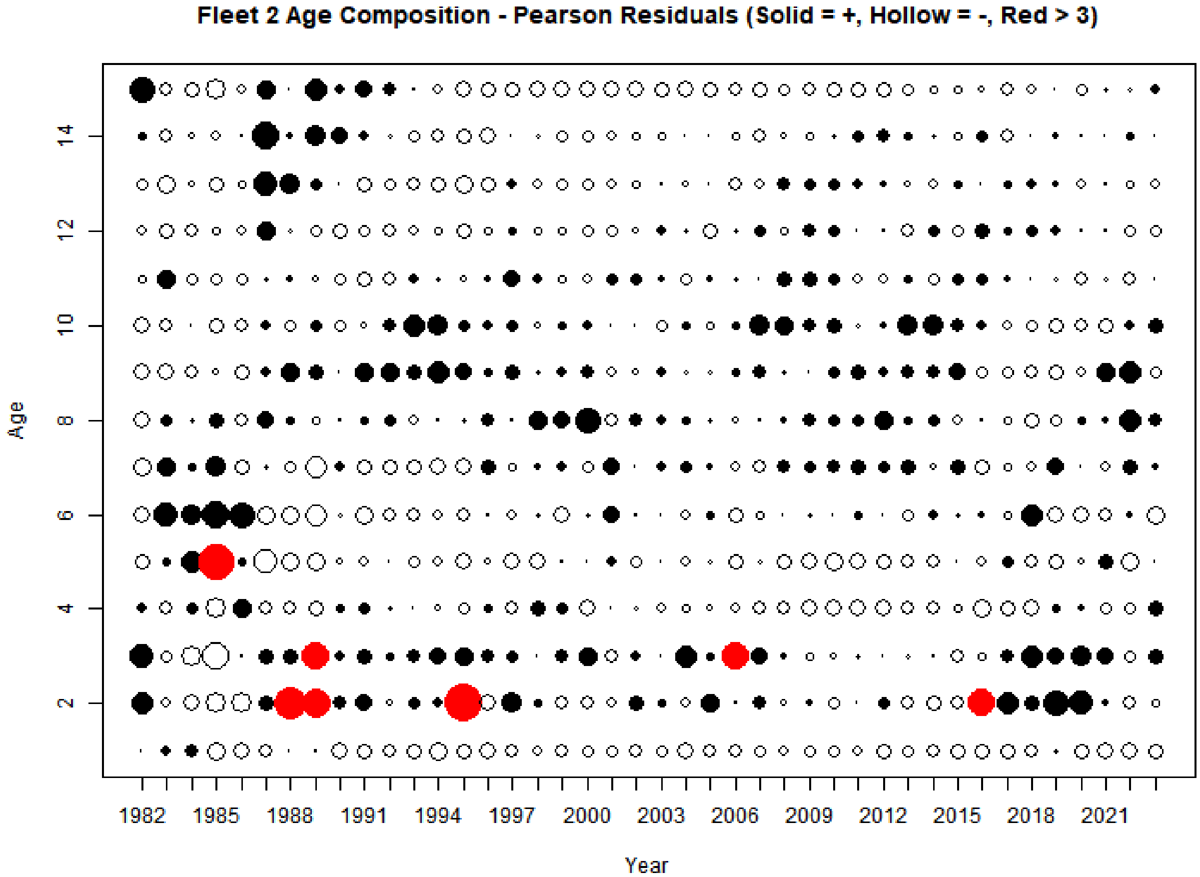


Fleet 2 Residuals of Age Composition By Age



Fleet 2 Residuals of Age Composition By Year





Fleet 2 Age Composition - Pearson Residuals (Solid = +, Hollow = -, Red > 3)
Age
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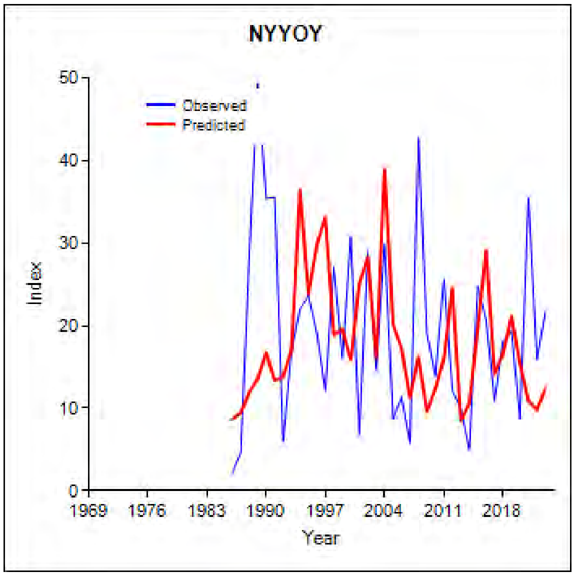
NYYOY
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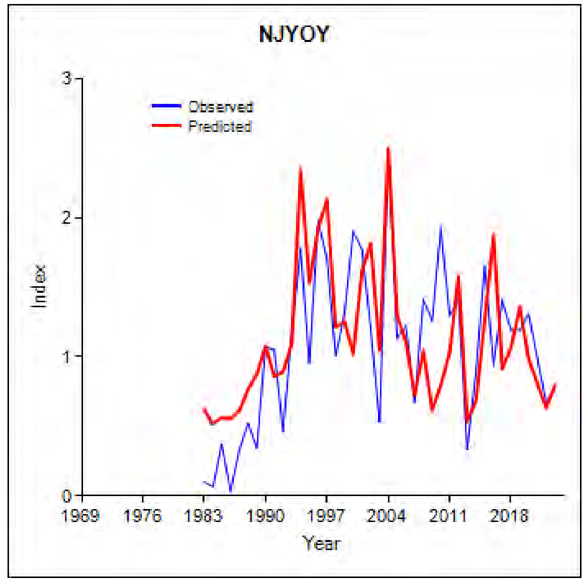
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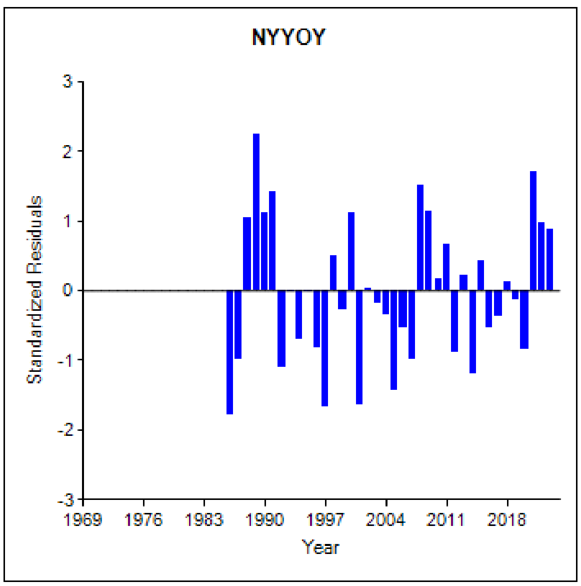
NYYOY
Standardized Residuals
Year
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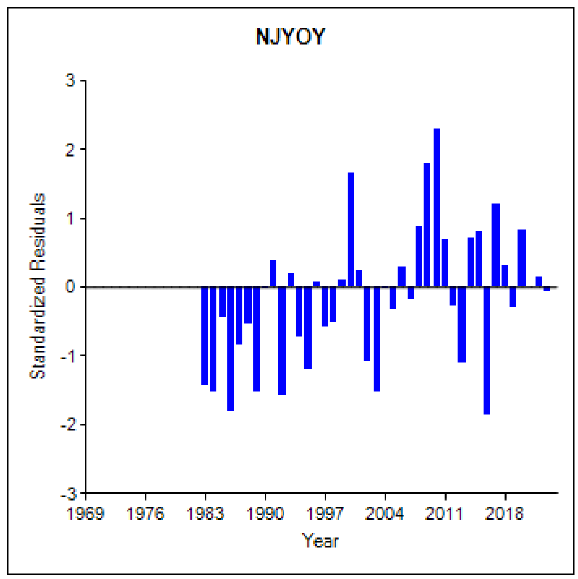
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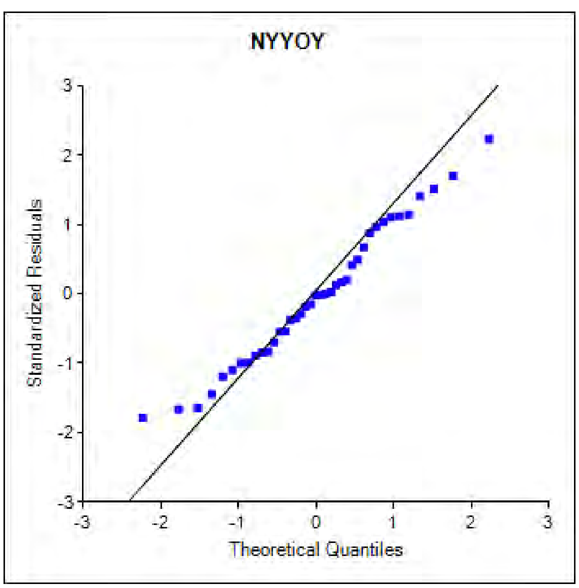
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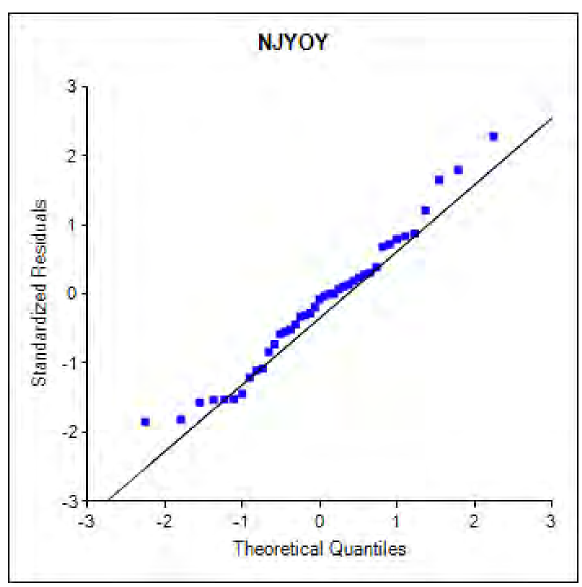
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Standardized Residuals
Theoretical Quantiles
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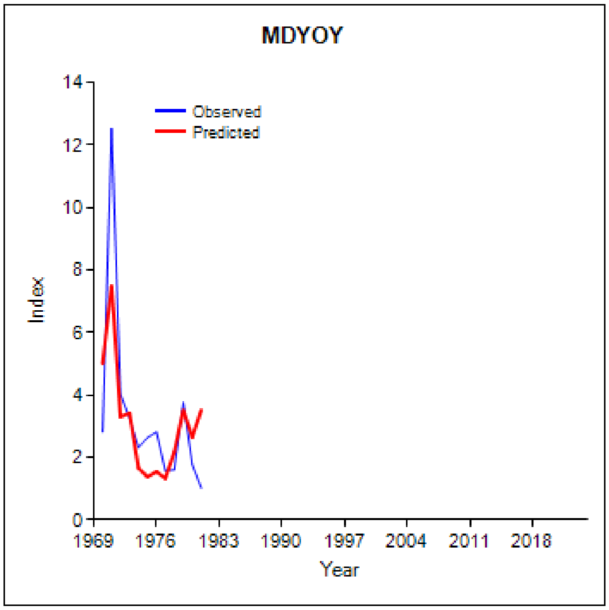
MDYOY
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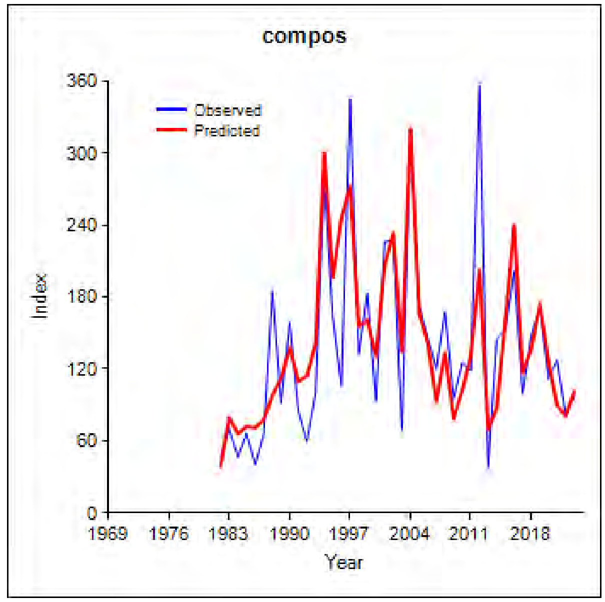
2018
Year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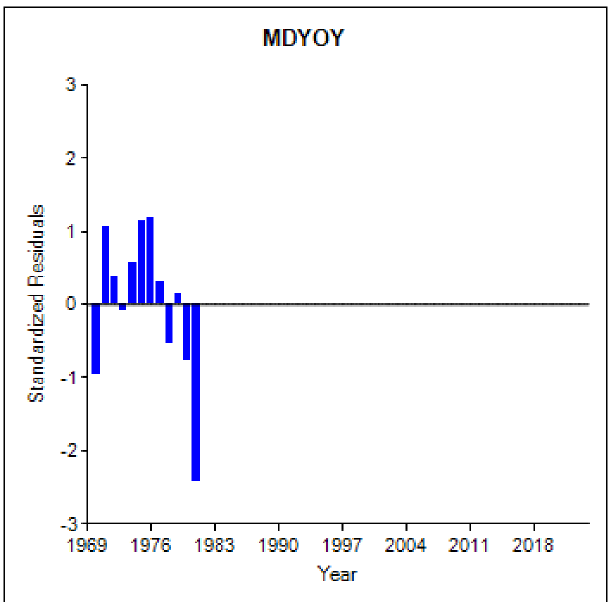
2011
2018
Year


MDYOY
Standardized Residuals
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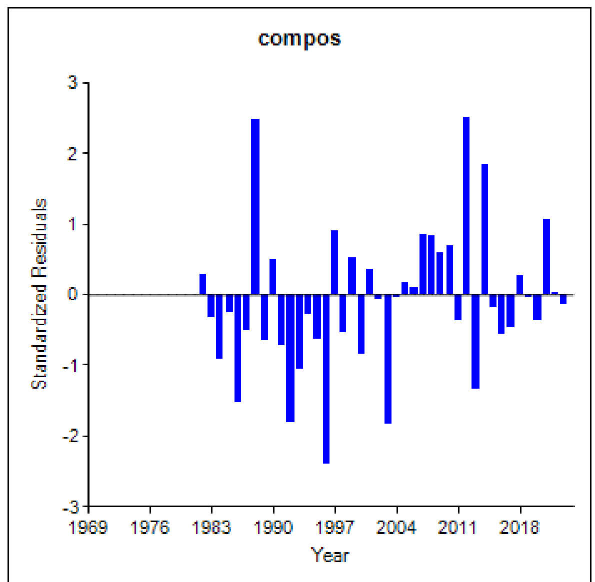
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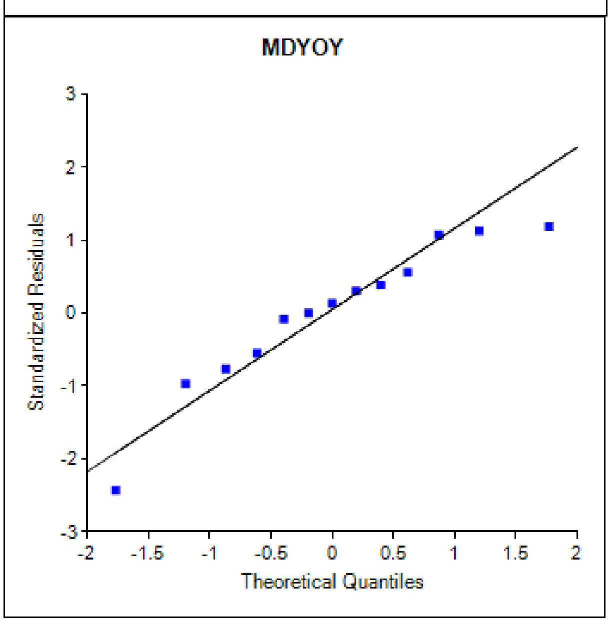
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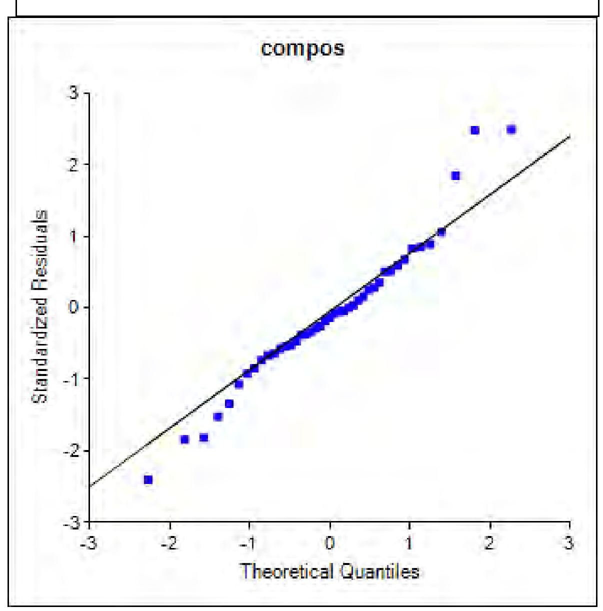
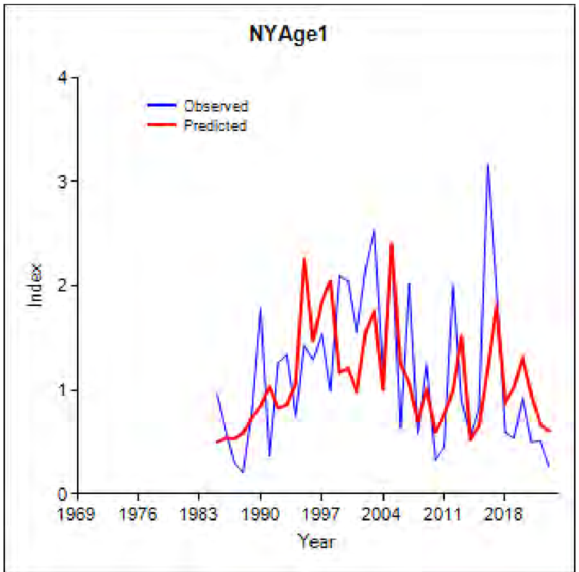
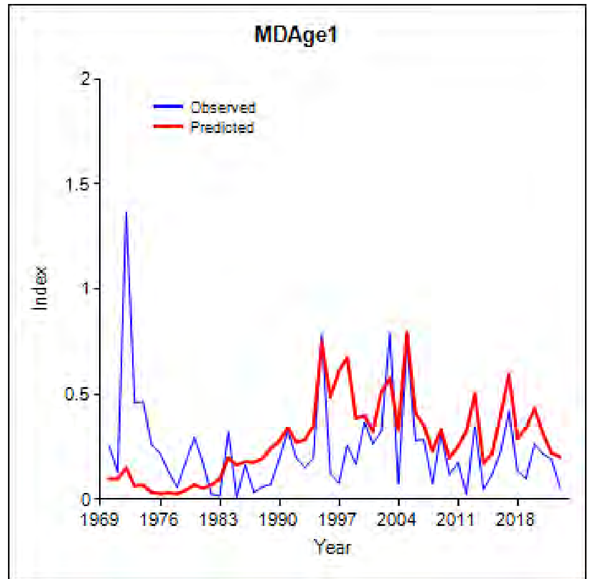
2
3
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
Theoretical Quantiles


compos
Standardized Residuals
-3
-2
-1
0
1
2
3
-3
-2
-1
0
1
2
3
Theoretical Quantiles


NYAge1
Observed
Predicted
Index
0
1
2
3
4
1969
1976
1983
1990
1997
2004
2011
2018
Year


MDAge1
Observed
Predicted
Index
0
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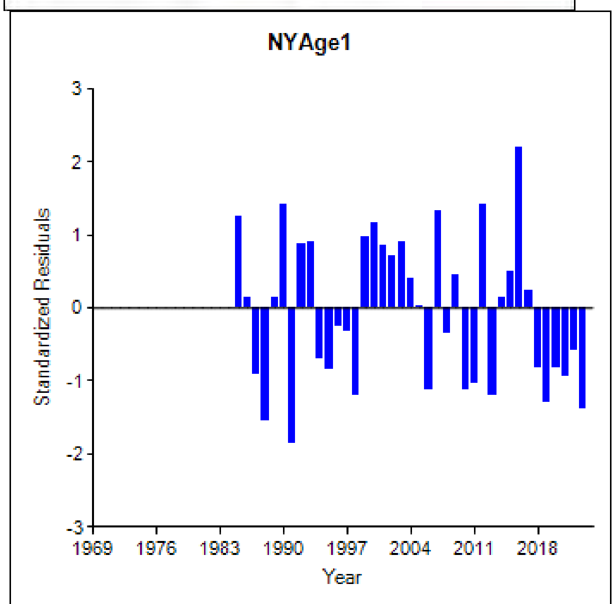
1
1.5
2
1969
1976
1983
1990
1997
2004
2011
2018
Year


NYAge1
Standardized Residuals
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-1
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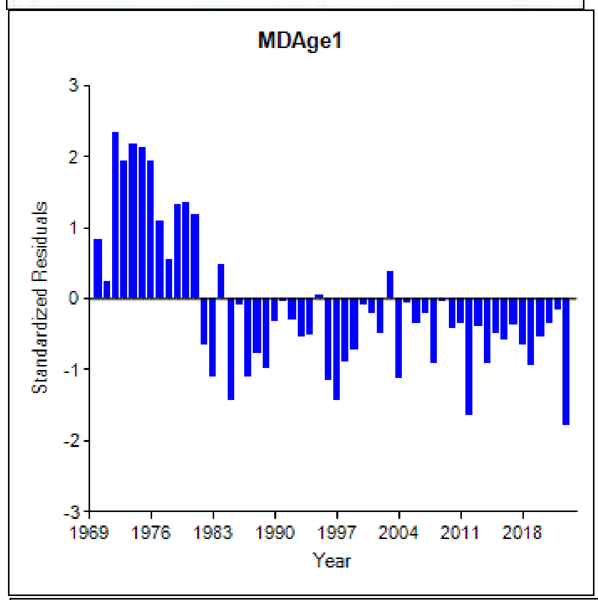
1
2
3
1969
1976
1983
1990
1997
2004
2011
2018
Year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-1
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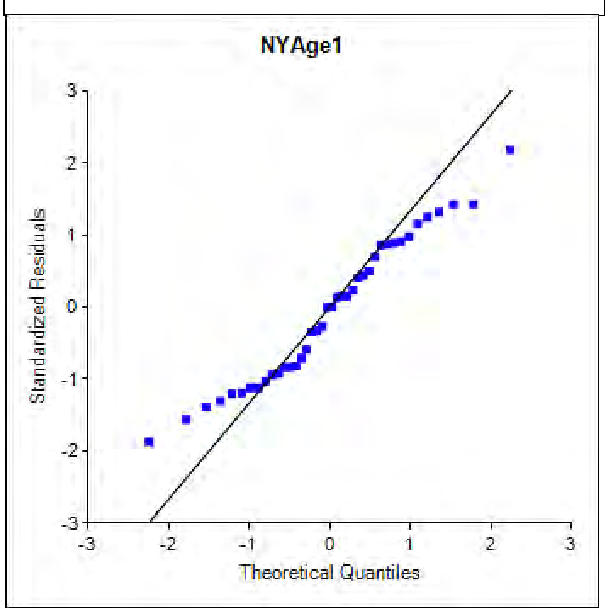
1
2
3
1969
1976
1983
1990
1997
2004
2011
2018
Year


NYAge1
Standardized Residuals
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1
2
3
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-1
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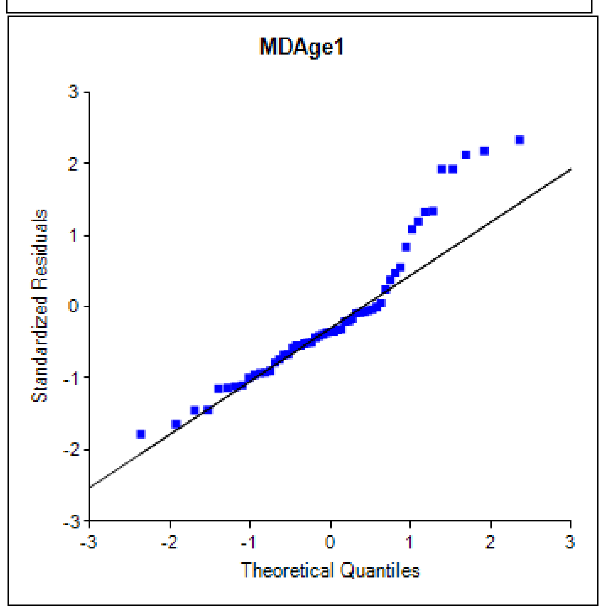
1
2
3
Theoretical Quantiles


MDAge1
Standardized Residuals
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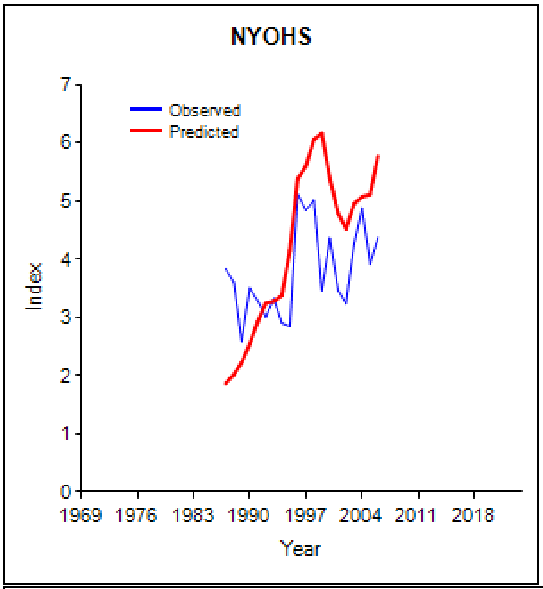
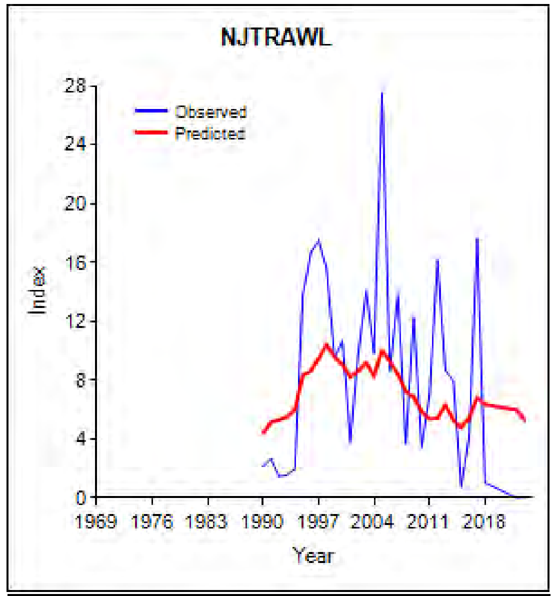
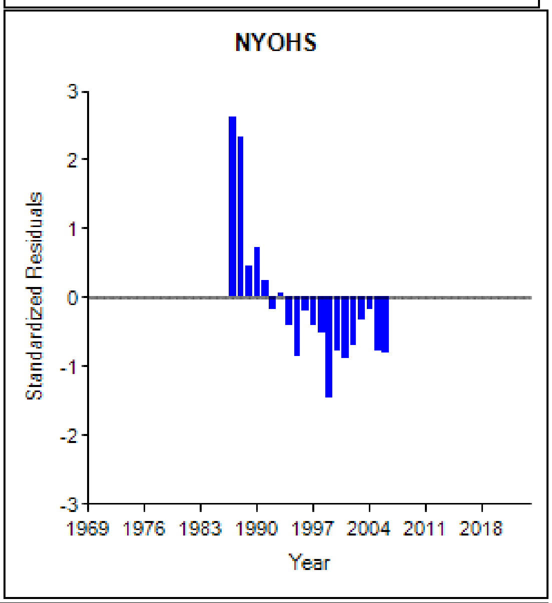
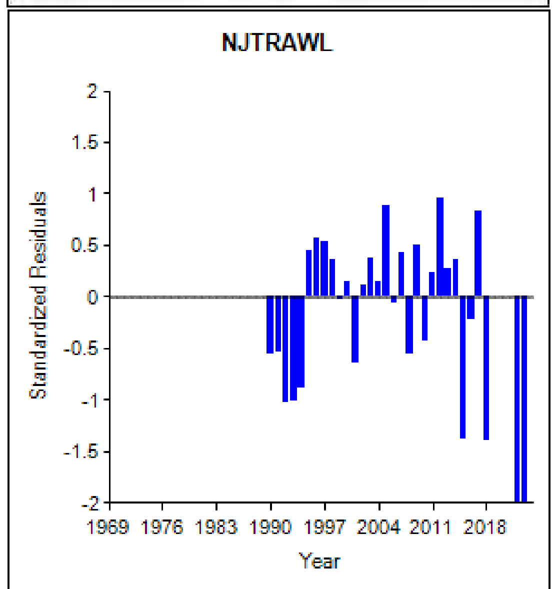
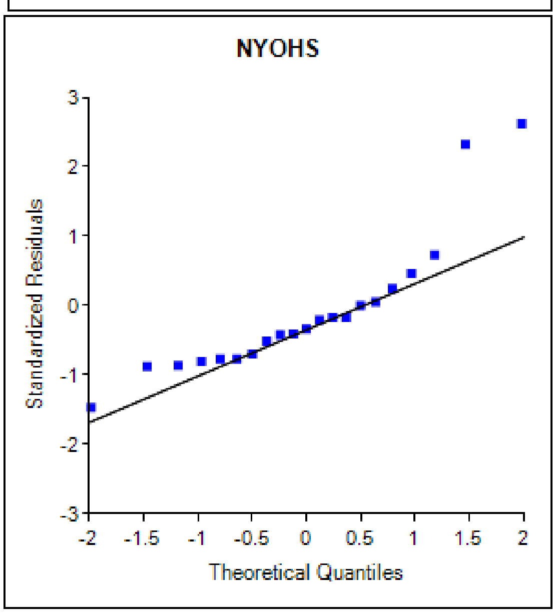
1
2
3
-3
-2
-1
0
1
2
3
Theoretical Quantiles

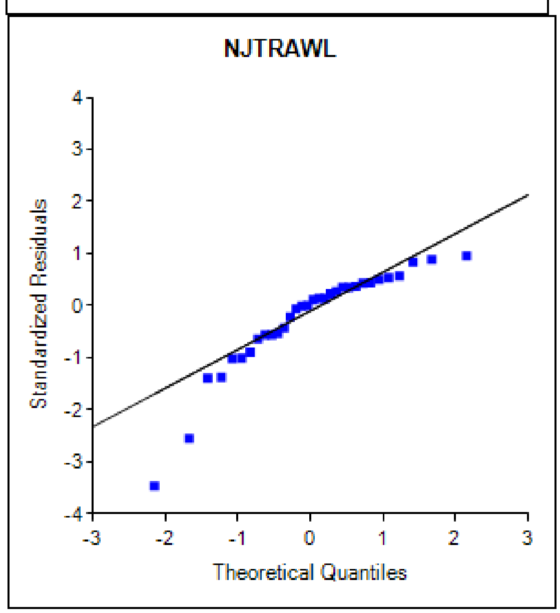

NYOHS
Observed
Predicted
Index
Year
7
6
5
4
3
2
1
0
1969 1976 1983 1990 1997 2004 2011 2018

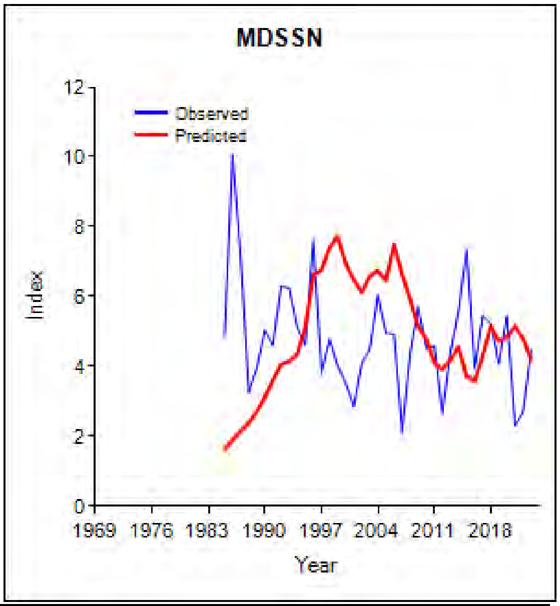

NJTRAWL
Observed
Predicted
Index
Year
28
24
20
16
12
8
4
0
1969 1976 1983 1990 1997 2004 2011 2018

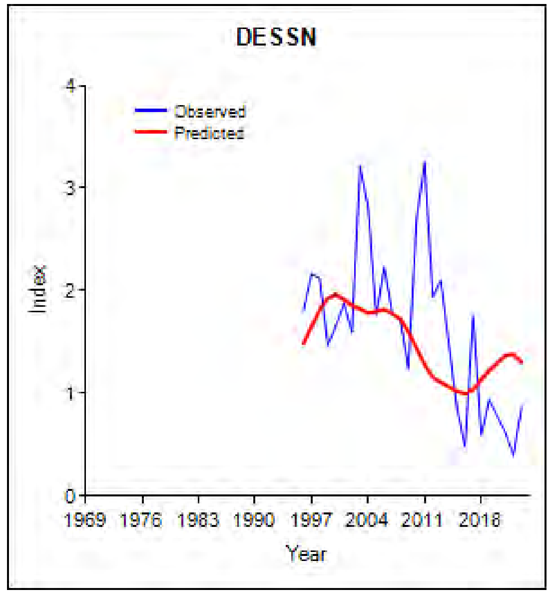

NYOHS
Standardized Residuals
Year
3
2
1
0
-1
-2
-3
1969 1976 1983 1990 1997 2004 2011 2018

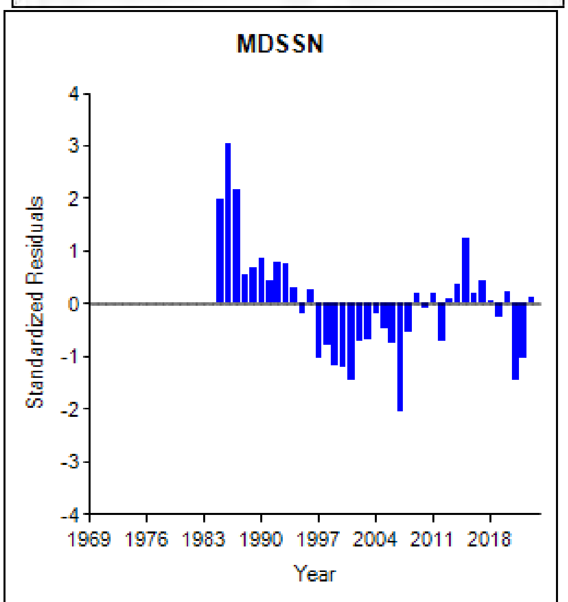

NJTRAWL
Standardized Residuals
Year
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
1969 1976 1983 1990 1997 2004 2011 2018

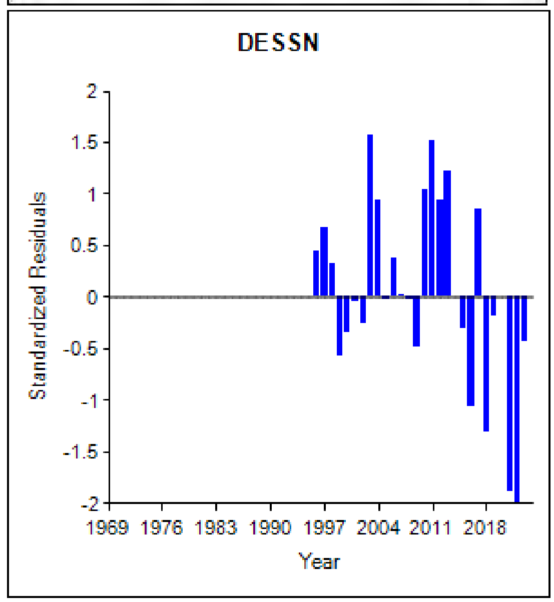

NYOHS
Standardized Residuals
Theoretical Quantiles
3
2
1
0
-1
-2
-3
-2 -1.5 -1 -0.5 0 0.5 1 1.5 2


NJTRAWL
Standardized Residuals
Theoretical Quantiles
4
3
2
1
0
-1
-2
-3
-4
-3 -2 -1 0 1 2 3


MDSSN
Observed
Predicted
Index
12
10
8
6
4
2
0
1969 1976 1983 1990 1997 2004 2011 2018
Year


DESSN
Observed
Predicted
Index
4
3
2
1
0
1969 1976 1983 1990 1997 2004 2011 2018
Year


MDSSN
Standardized Residuals
4
3
2
1
0
-1
-2
-3
-4
1969 1976 1983 1990 1997 2004 2011 2018
Year


DESSN
Standardized Residuals
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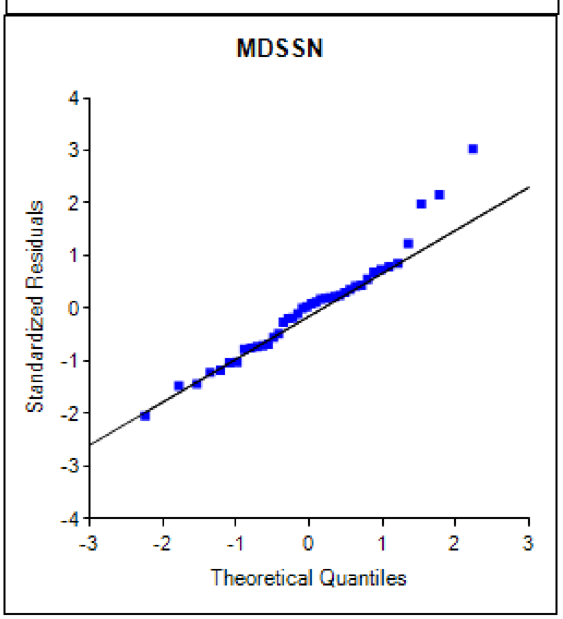
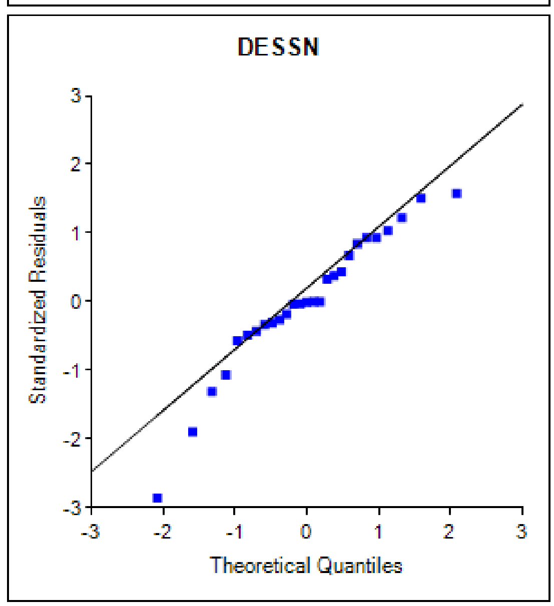
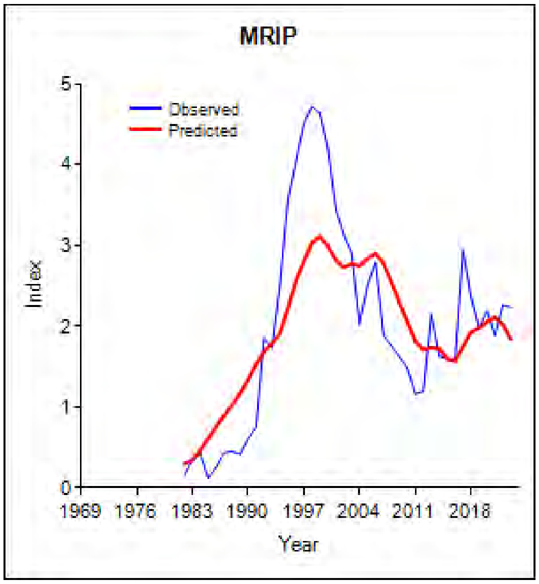
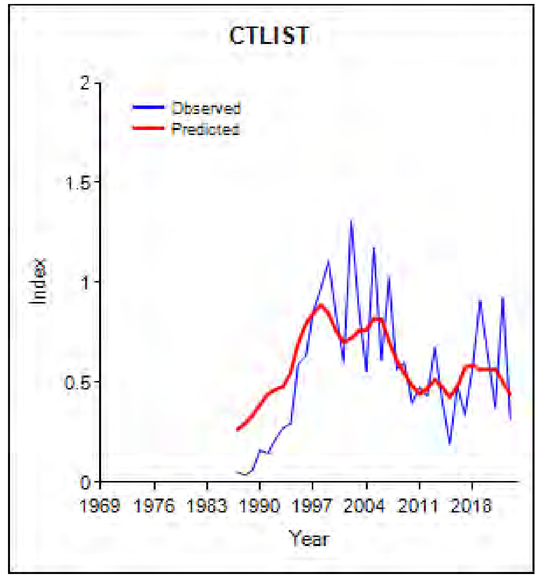
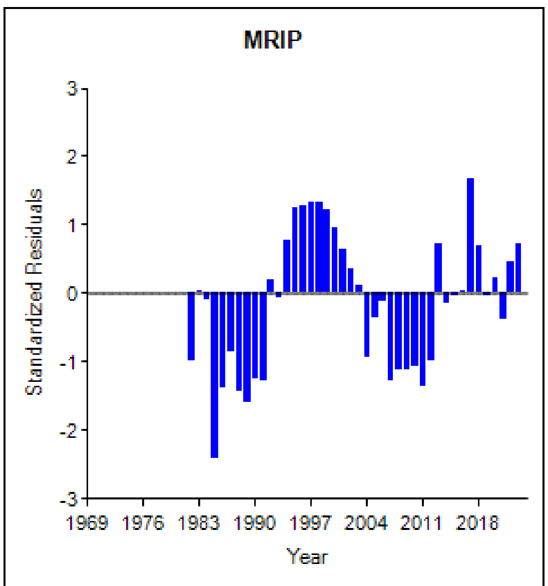
1
0.5
0
-0.5
-1
-1.5
-2
1969 1976 1983 1990 1997 2004 2011 2018
Year

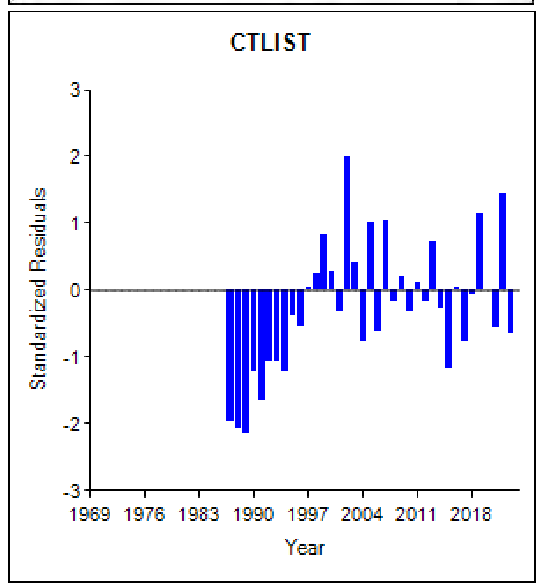

MDSSN
Standardized Residuals
4
3
2
1
0
-1
-2
-3
-4
-3 -2 -1 0 1 2 3
Theoretical Quantiles

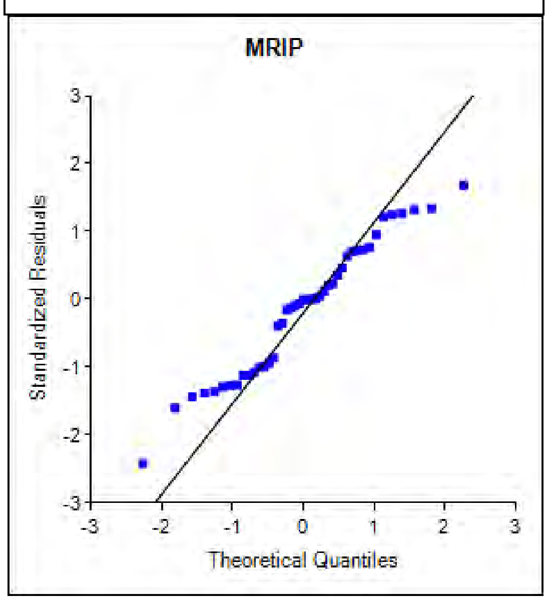

DESSN
Standardized Residuals
3
2
1
0
-1
-2
-3
-3 -2 -1 0 1 2 3
Theoretical Quantiles

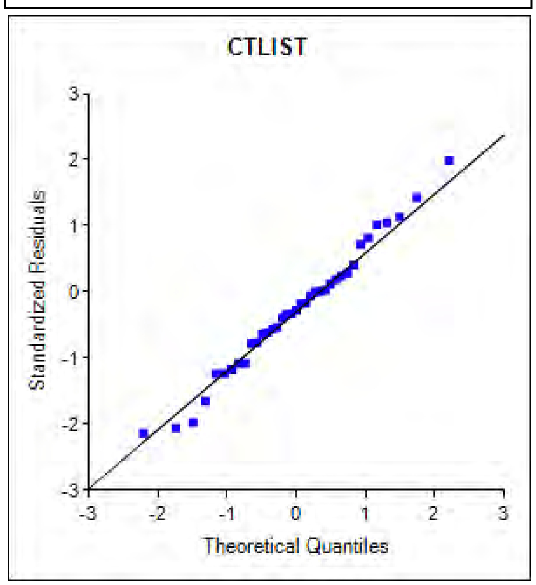

MRIP
Observed
Predicted
Index
5
4
3
2
1
0
1969 1976 1983 1990 1997 2004 2011 2018
Year

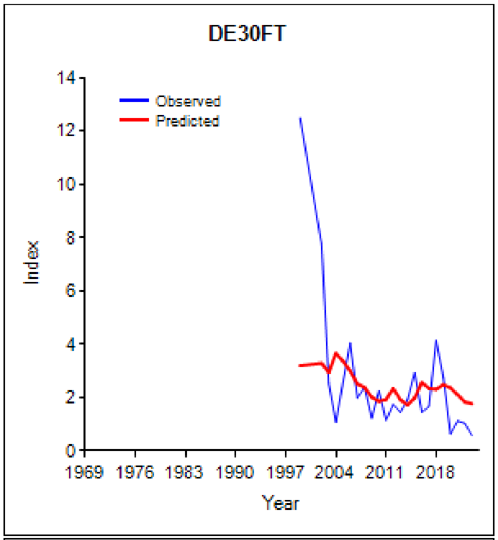

CTLIST
Observed
Predicted
Index
2
1.5
1
0.5
0
1969 1976 1983 1990 1997 2004 2011 2018
Year

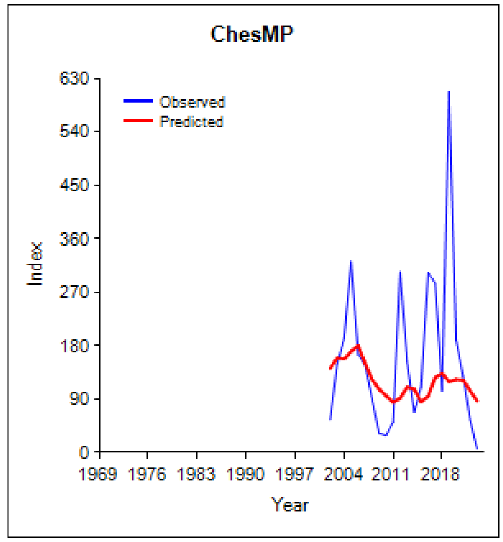

MRIP
Standardized Residuals
3
2
1
0
-1
-2
-3
1969 1976 1983 1990 1997 2004 2011 2018
Year

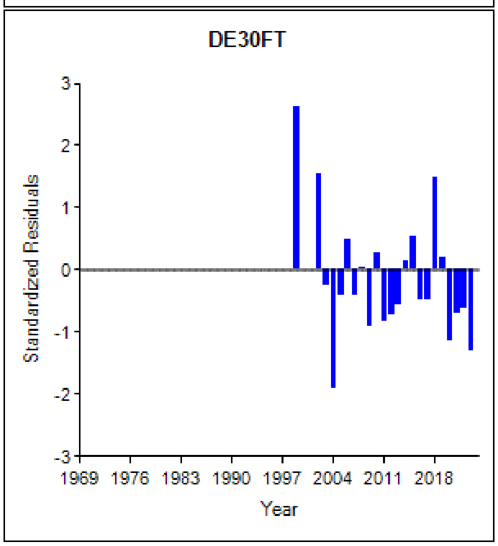

CTLIST
Standardized Residuals
3
2
1
0
-1
-2
-3
1969 1976 1983 1990 1997 2004 2011 2018
Year

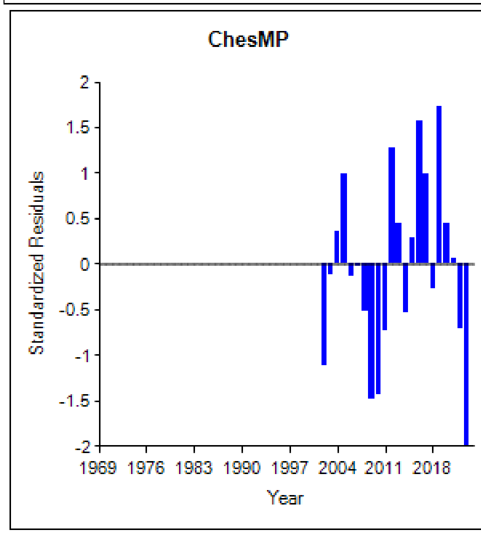

MRIP
Standardized Residuals
3
2
1
0
-1
-2
-3
-3 -2 -1 0 1 2 3
Theoretical Quantiles

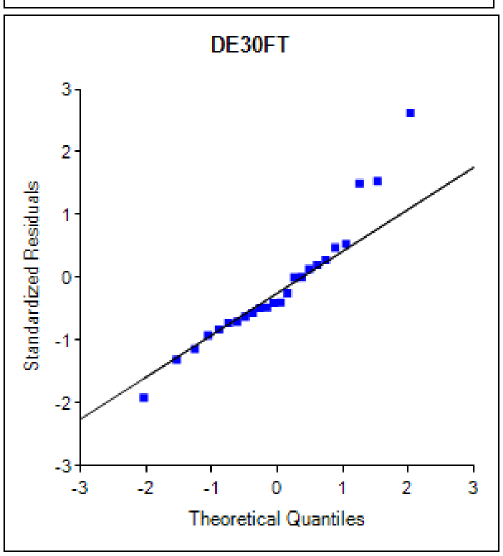

CTLIST
Standardized Residuals
3
2
1
0
-1
-2
-3
-3 -2 -1 0 1 2 3
Theoretical Quantiles

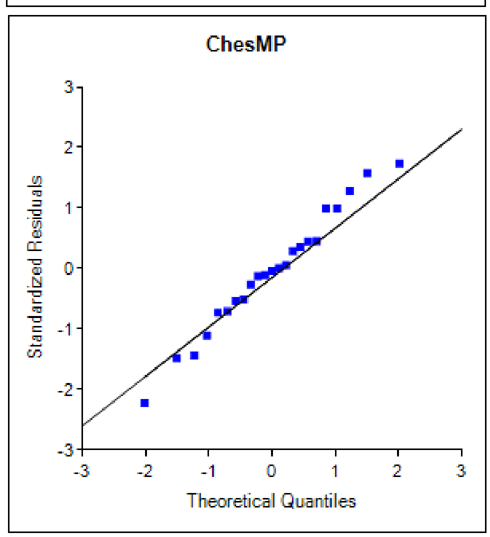

DE30FT
Observed
Predicted
Index
14
12
10
8
6
4
2
0
1969 1976 1983 1990 1997 2004 2011 2018
Year


ChesMP
Observed
Predicted
Index
630
540
450
360
270
180
90
0
1969 1976 1983 1990 1997 2004 2011 2018
Year

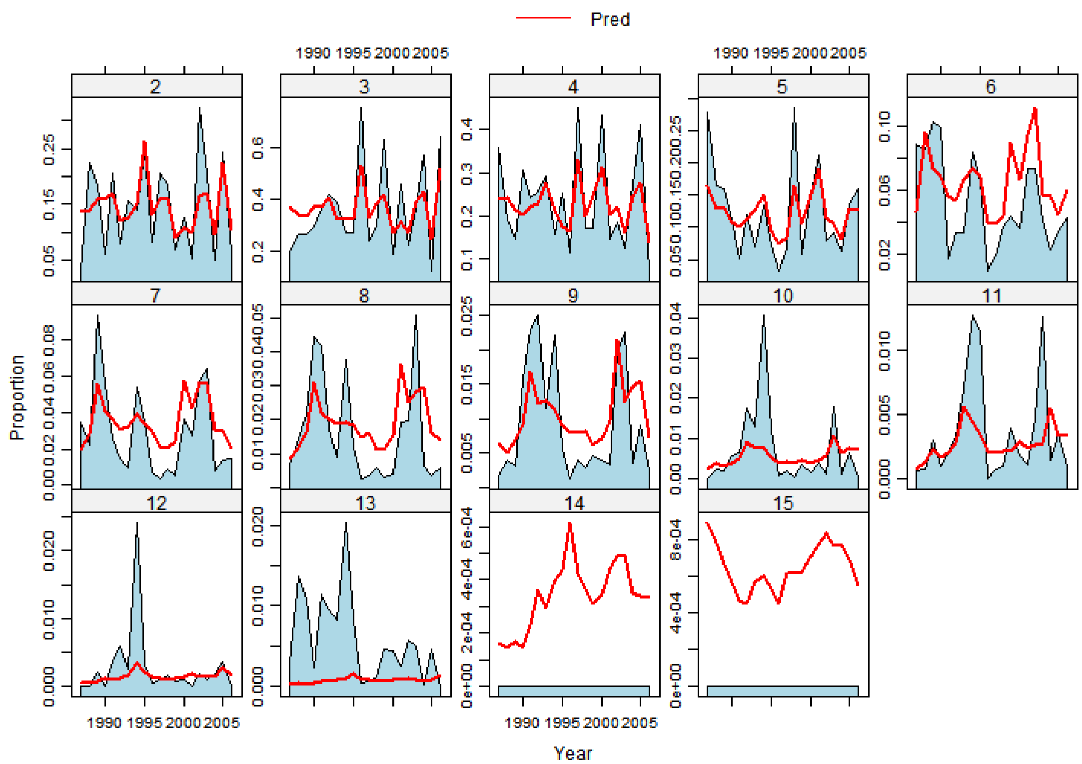

DE30FT
Standardized Residuals
3
2
1
0
-1
-2
-3
1969 1976 1983 1990 1997 2004 2011 2018
Year


ChesMP
Standardized Residuals
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
1969 1976 1983 1990 1997 2004 2011 2018
Year

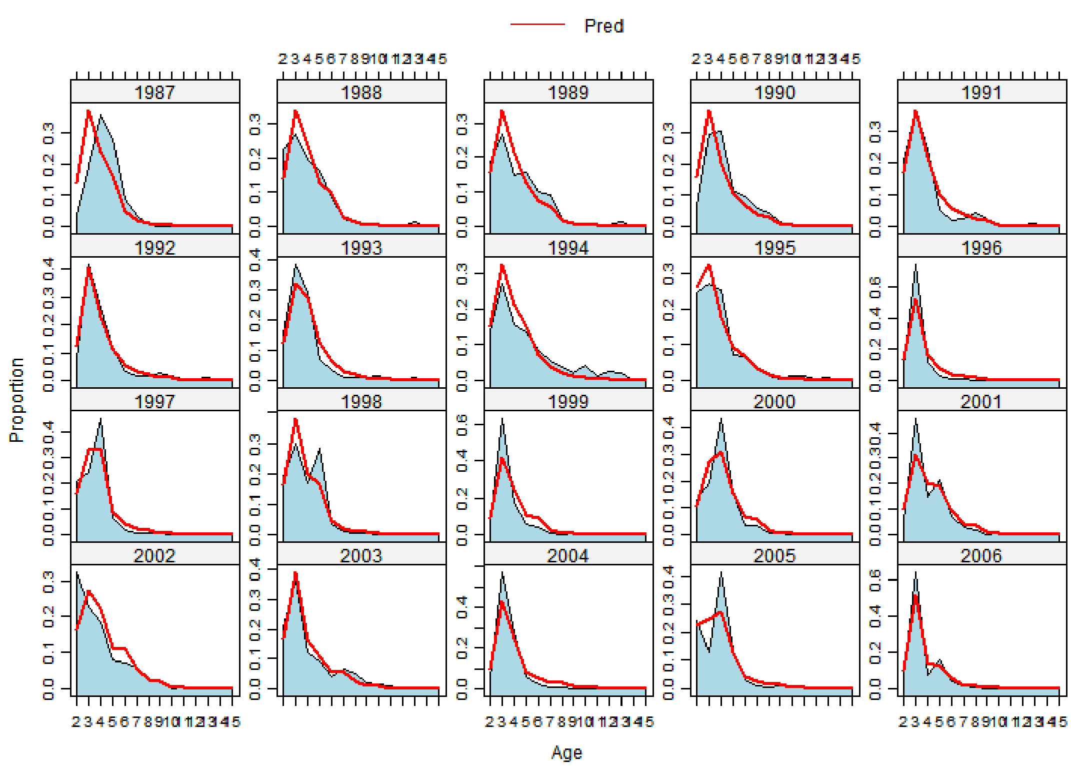

DE30FT
Standardized Residuals
3
2
1
0
-1
-2
-3
-3 -2 -1 0 1 2 3
Theoretical Quantiles

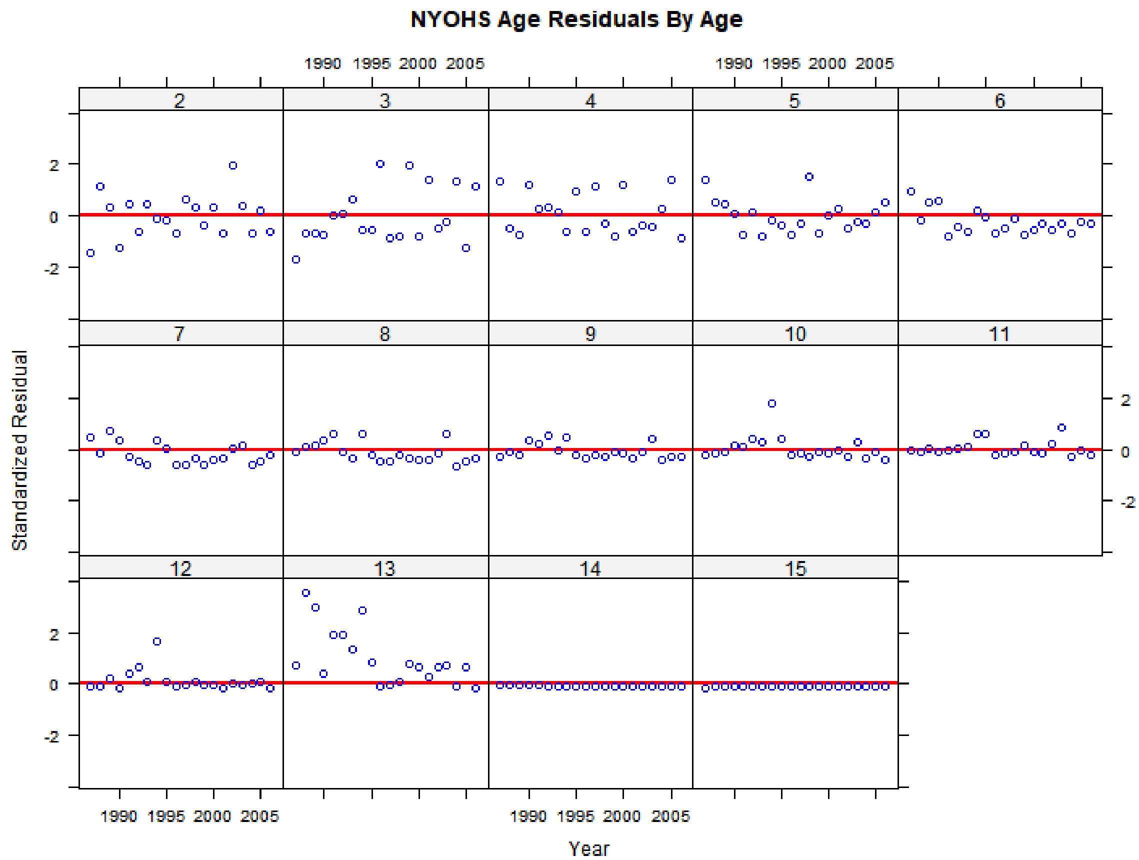

ChesMP
Standardized Residuals
3
2
1
0
-1
-2
-3
-3 -2 -1 0 1 2 3
Theoretical Quantiles

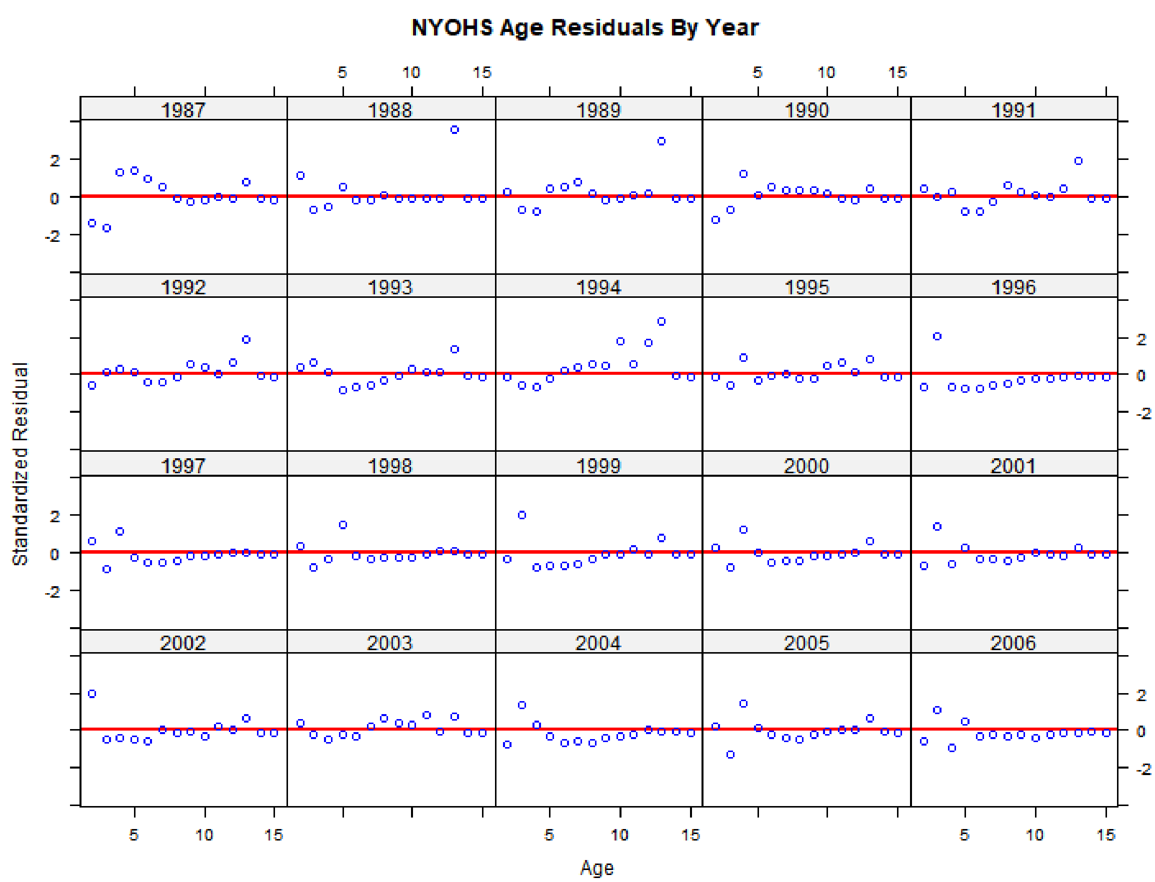
NYOHS Age Composition By Age

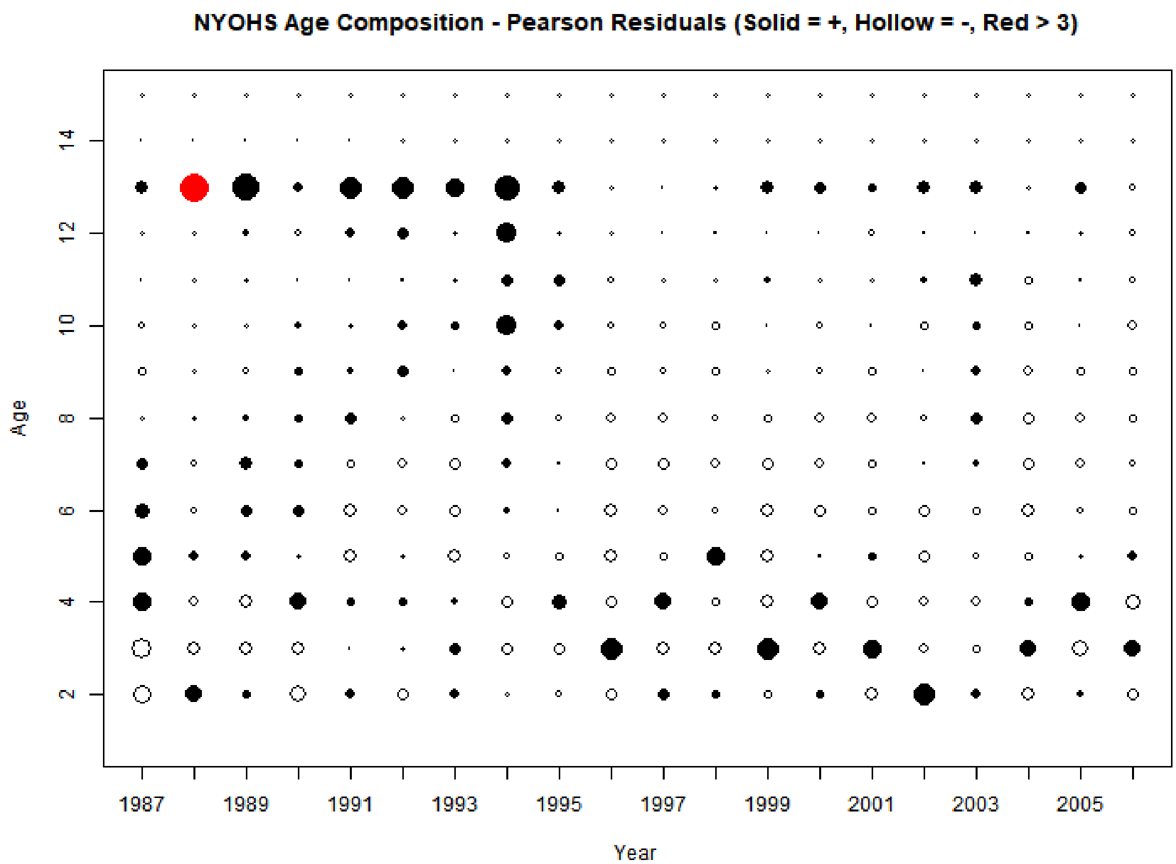


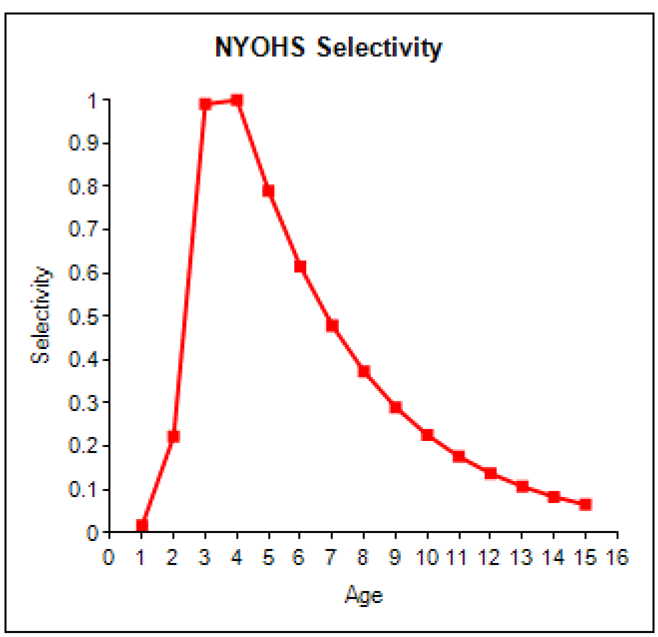
NYOHS Age Composition By Year



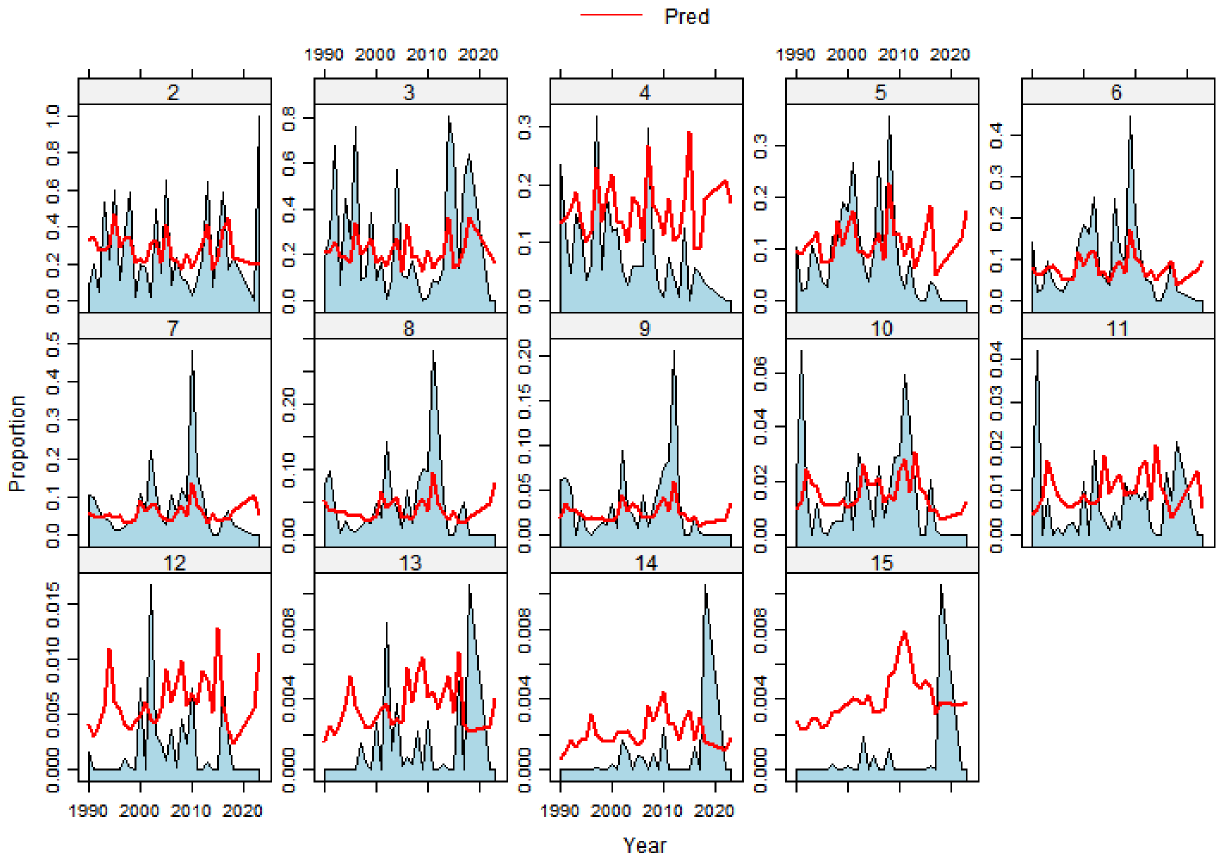

NYOHS Age Residuals By Age
Standardized Residual
Year
2
3
4
5
6
7
8
9
10
11
12
13
14
15
1990 1995 2000 2005


NYOHS Age Residuals By Year
Standardized Residual
Age
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006

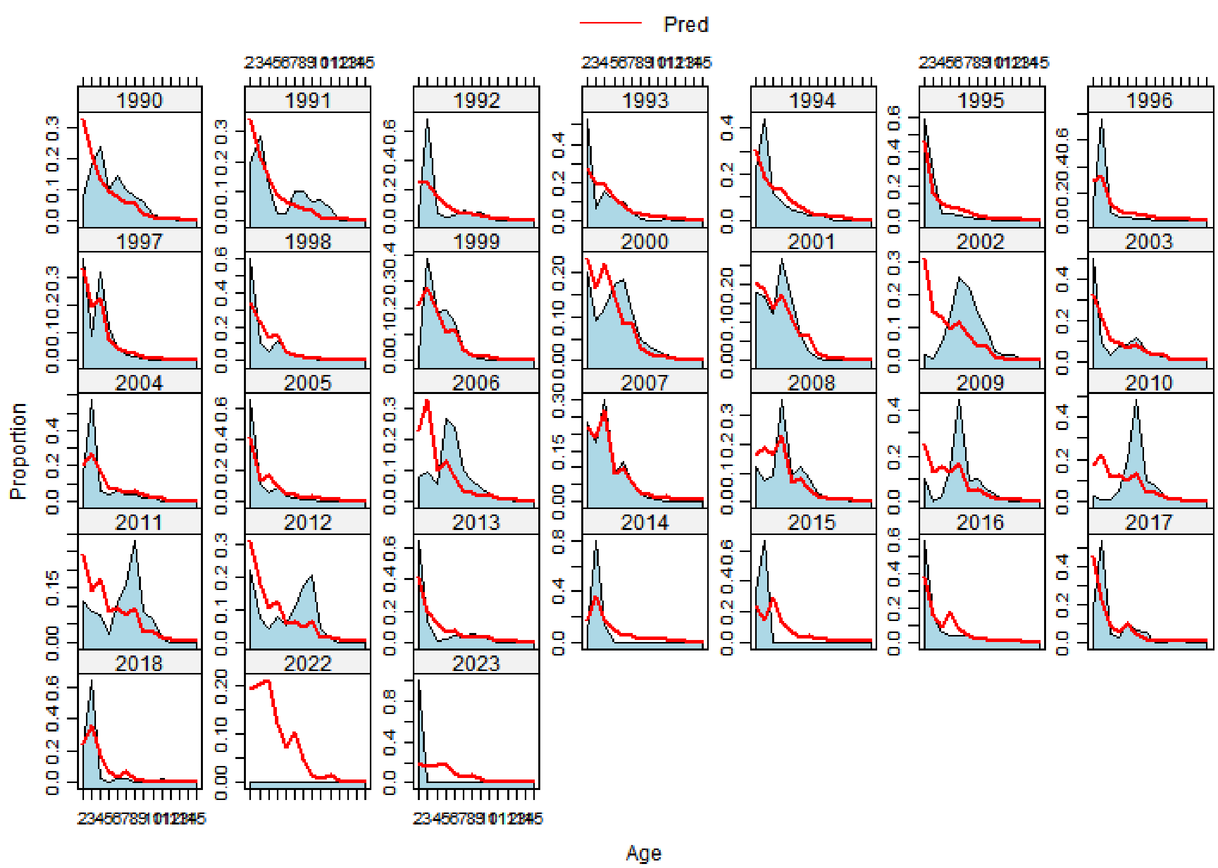

NYOHS Age Composition - Pearson Residuals (Solid = +, Hollow = -, Red > 3)
Age
2
4
6
8
10
12
14
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
Year


NYOHS Selectivity
Selectivity
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Age

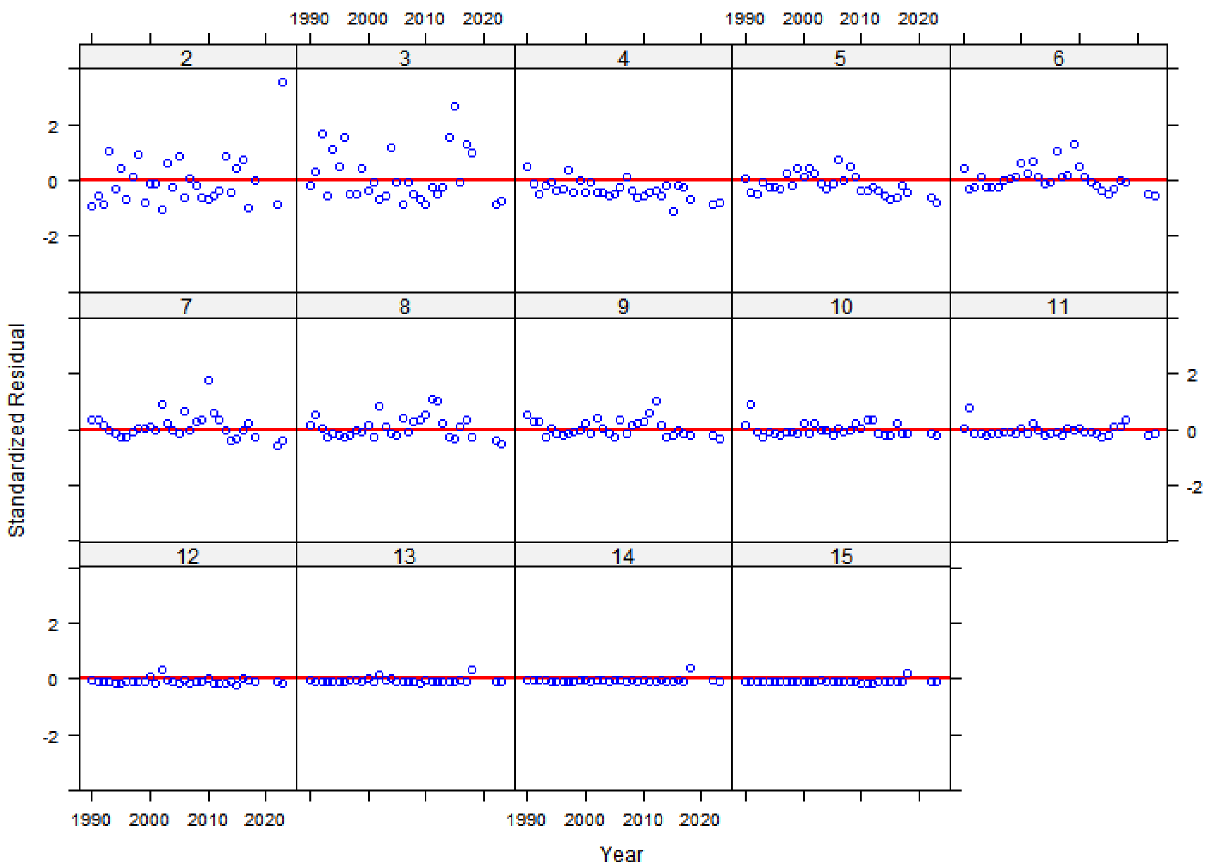
NJTrawl Age Composition By Age



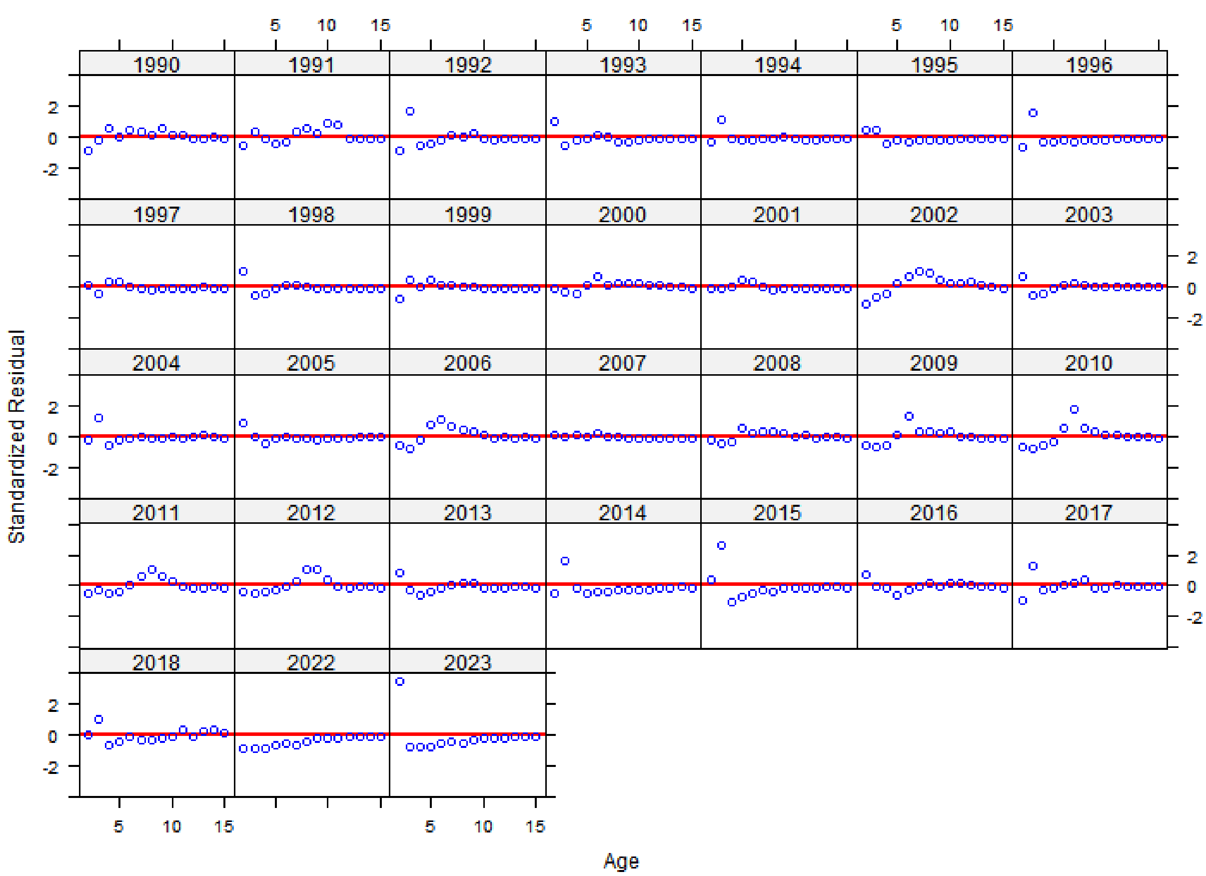
NJTrawl Age Composition By Year

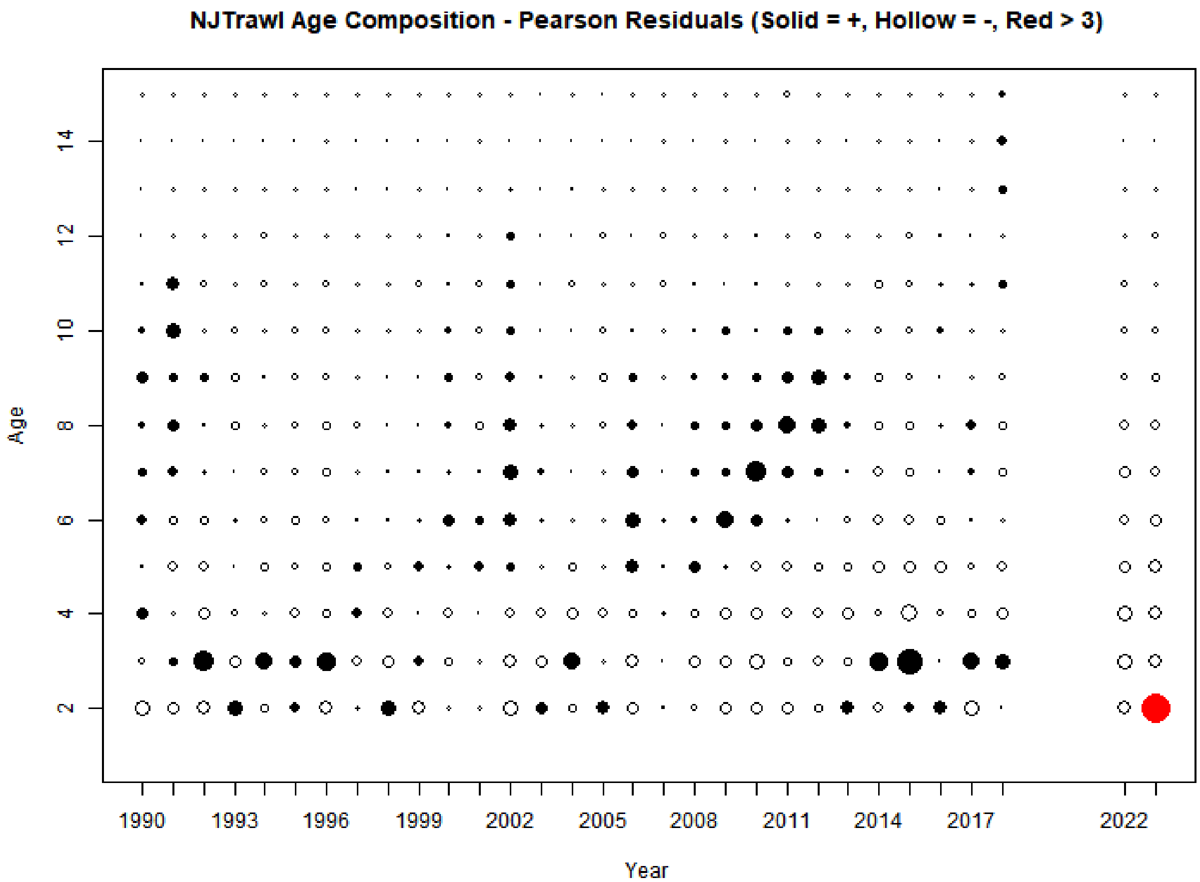


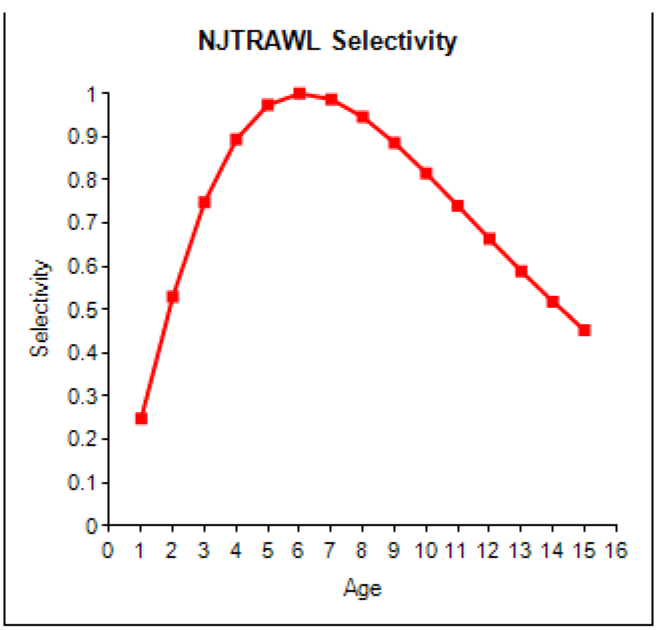
NJTrawl Age Residuals By Age

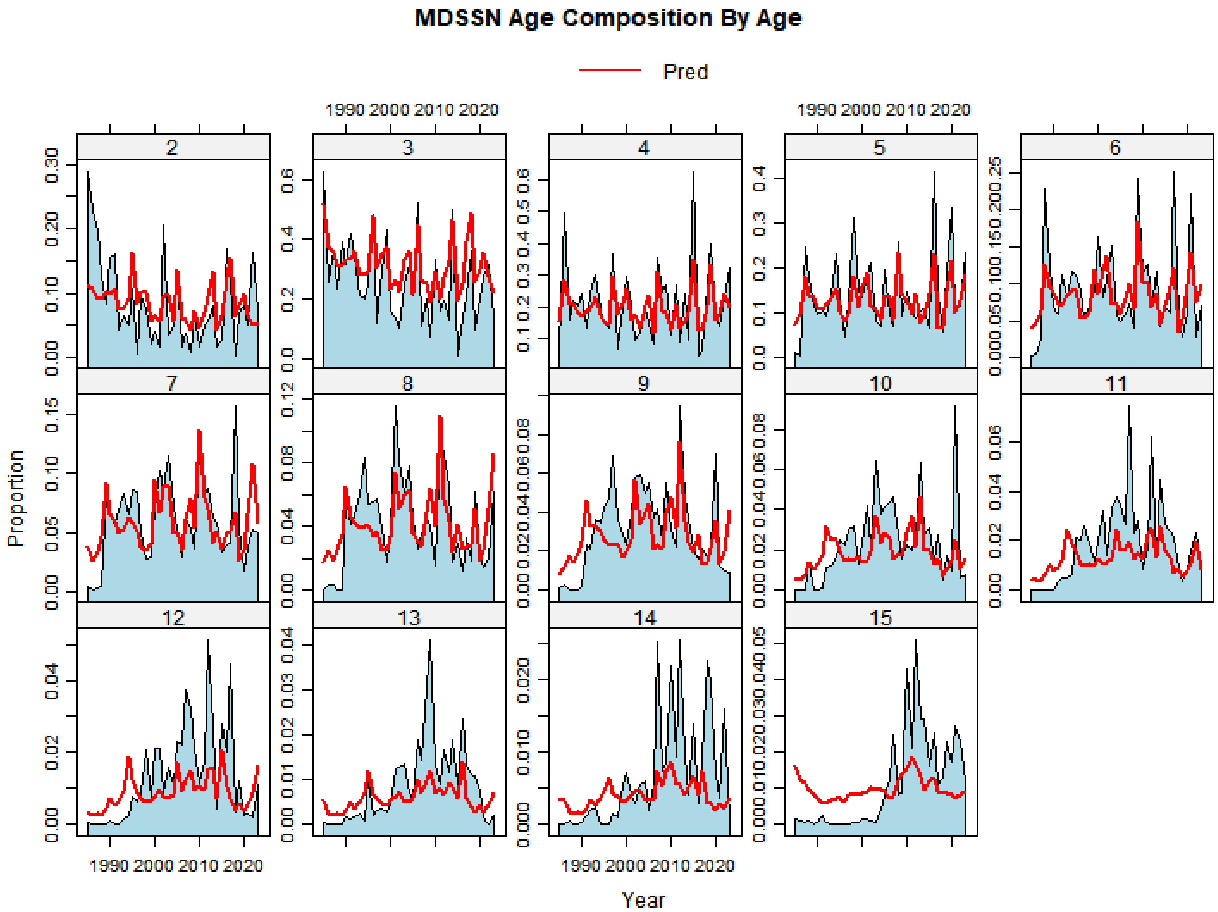


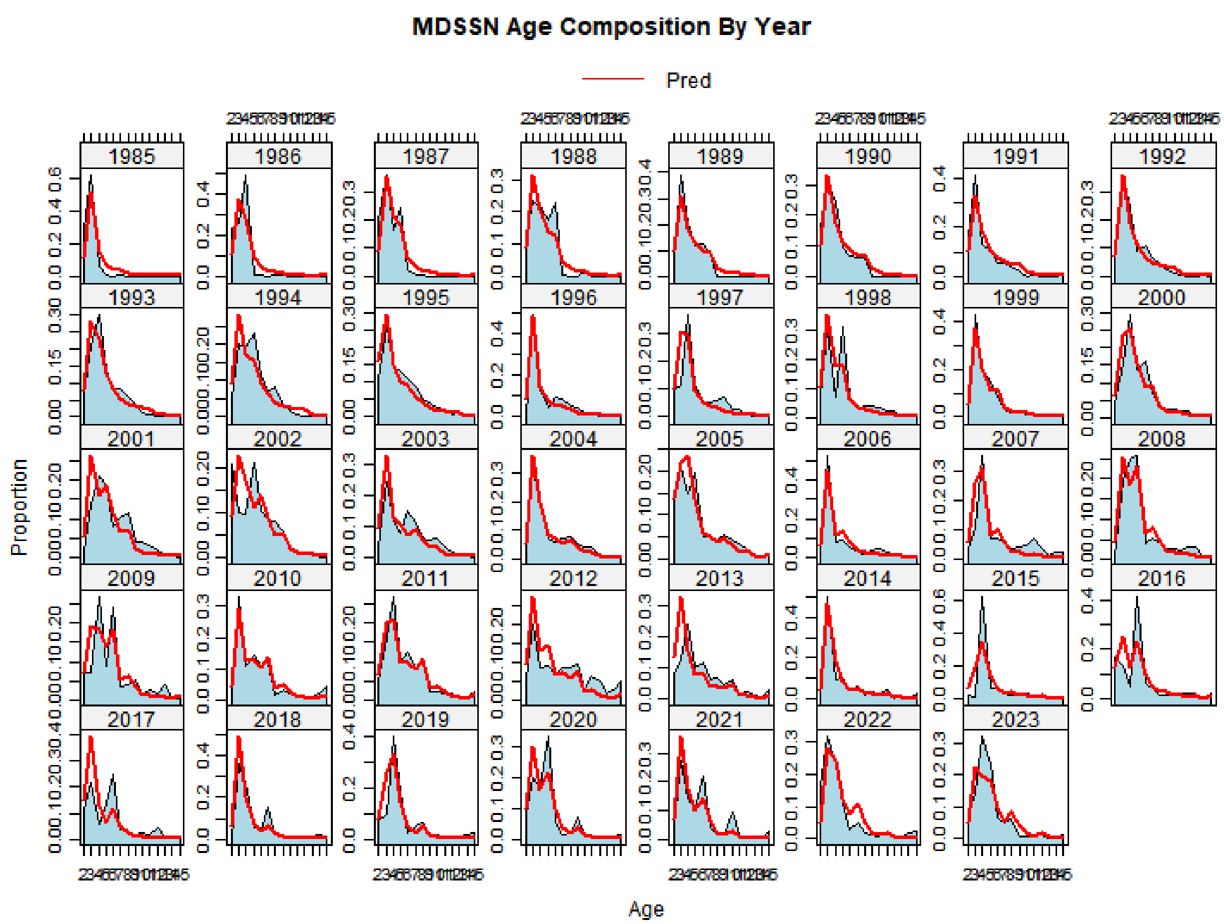
NJTrawl Age Residuals By Year

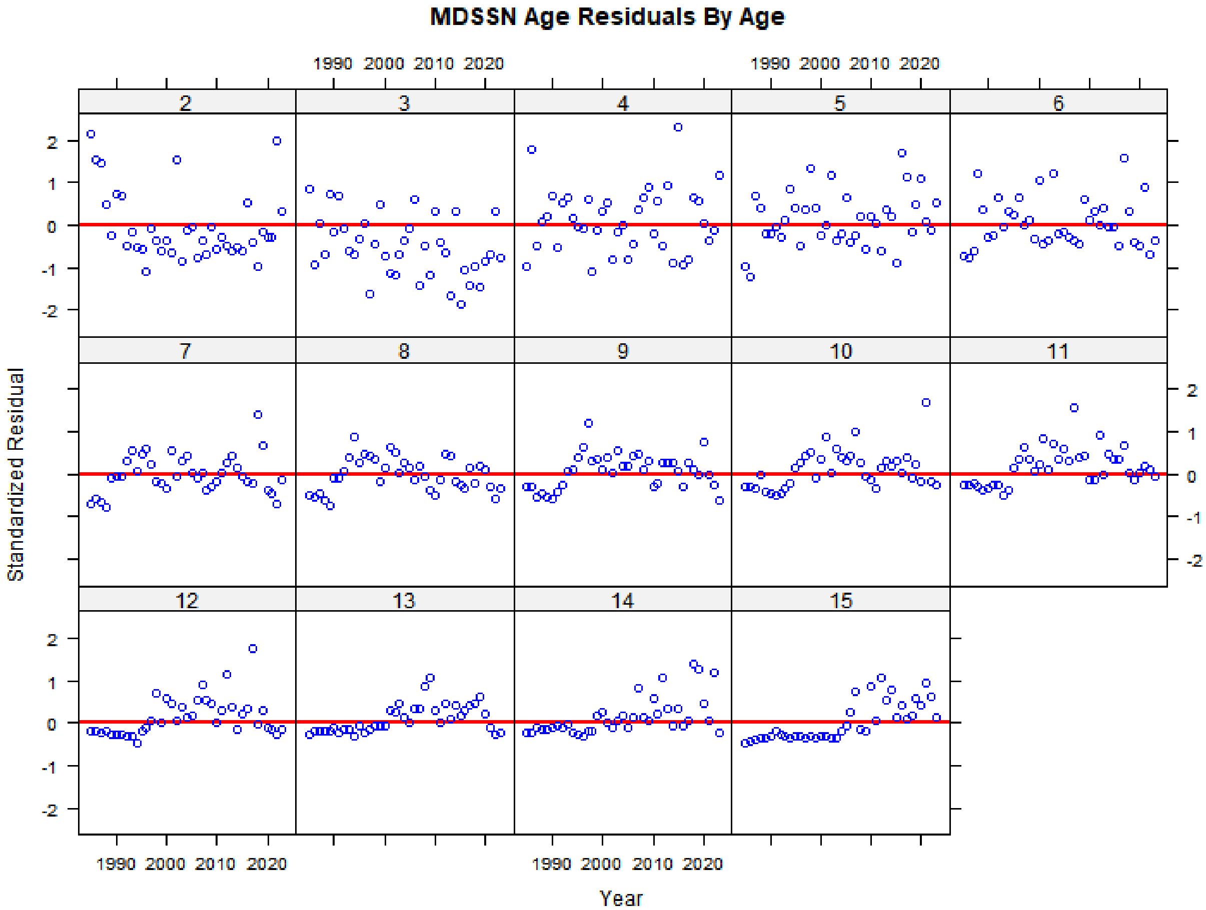


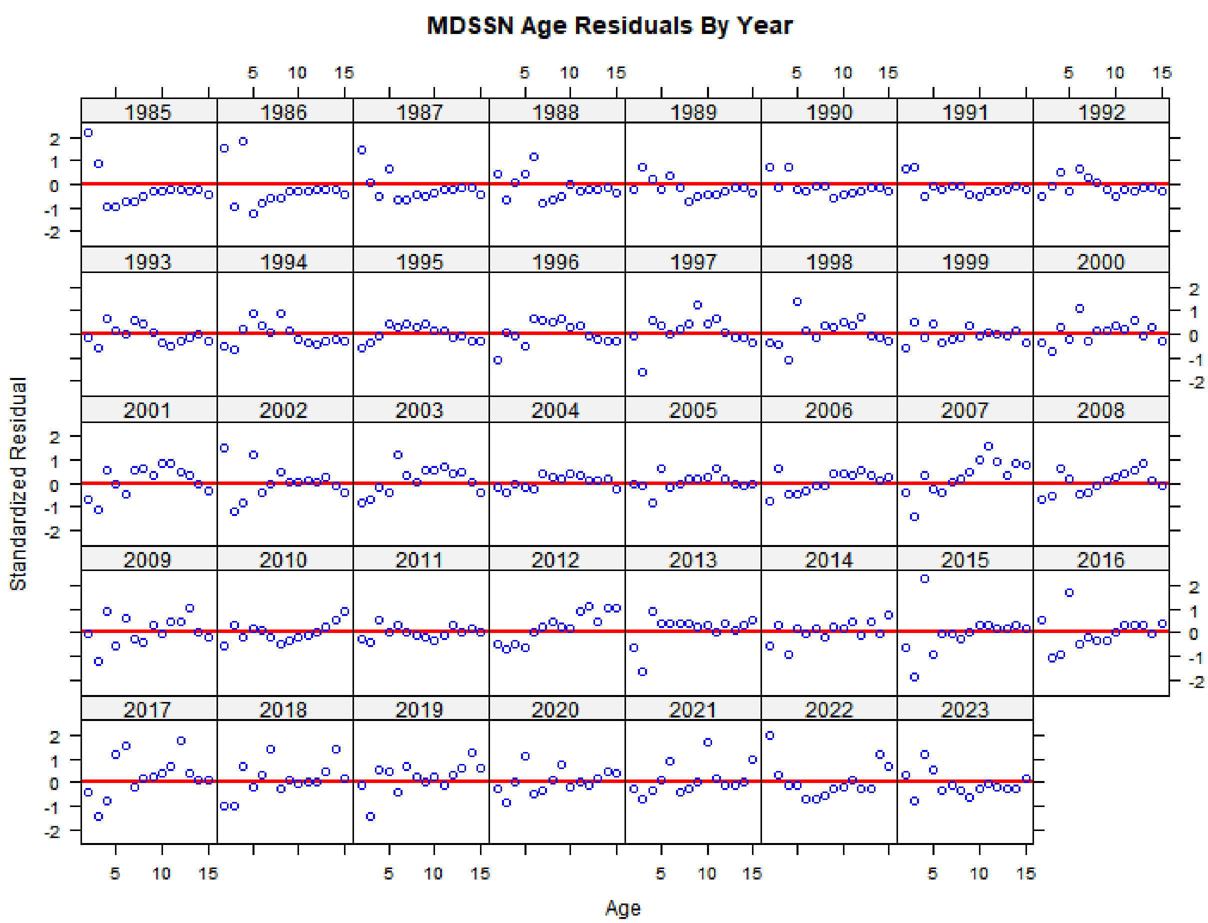

NJTrawl Age Composition - Pearson Residuals (Solid = +, Hollow = -, Red > 3)
Age
2
4
6
8
10
12
14
1990
1993
1996
1999
2002
2005
2008
2011
2014
2017
2022
Year


NJTRAWL Selectivity
Selectivity
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Age


MDSSN Age Composition By Age
Pred
2
3
4
5
6
7
8
9
10
11
12
13
14
15
1990 2000 2010 2020
Proportion
Year


MDSSN Age Composition By Year
Pred
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
Proportion
Age


MDSSN Age Residuals By Age
Standardized Residual
Year
2
3
4
5
6
7
8
9
10
11
12
13
14
15
1990 2000 2010 2020


MDSSN Age Residuals By Year
Standardized Residual
Age
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
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2011
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2013
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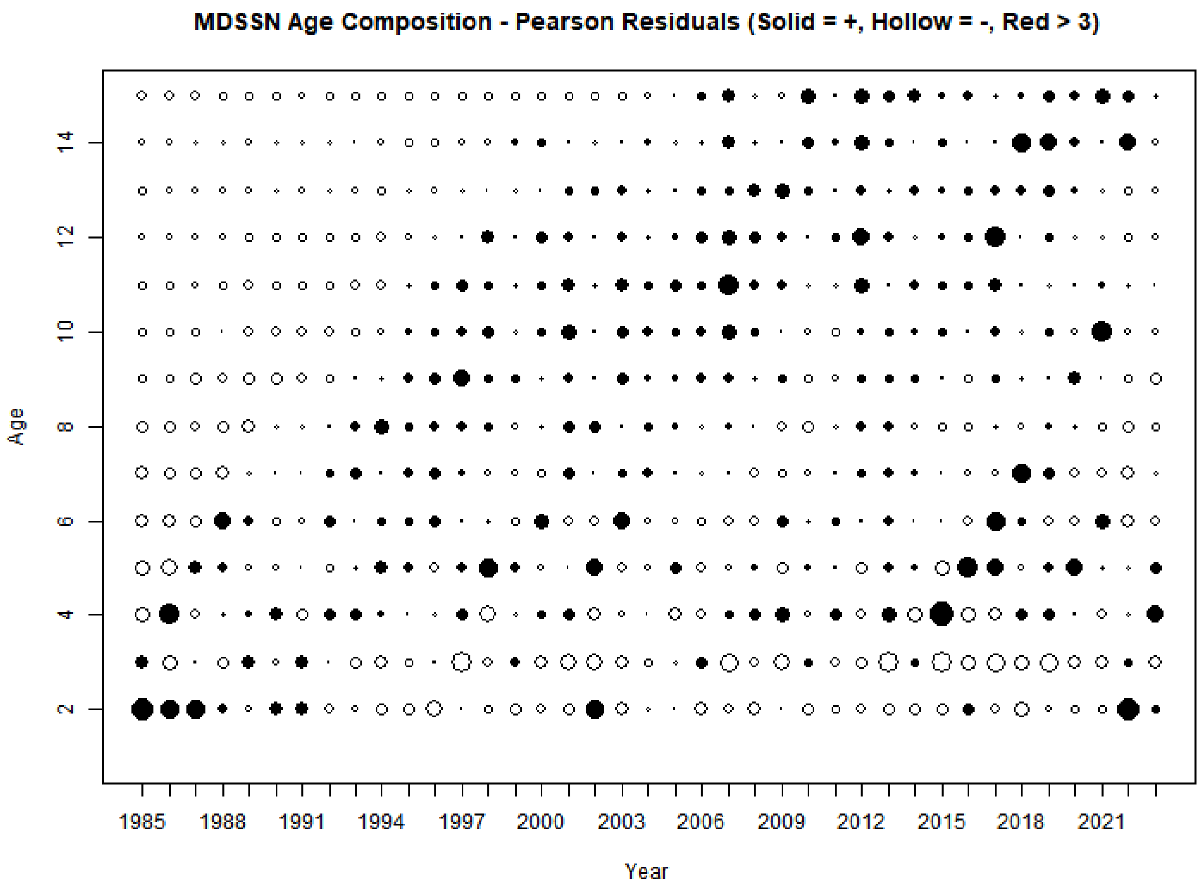
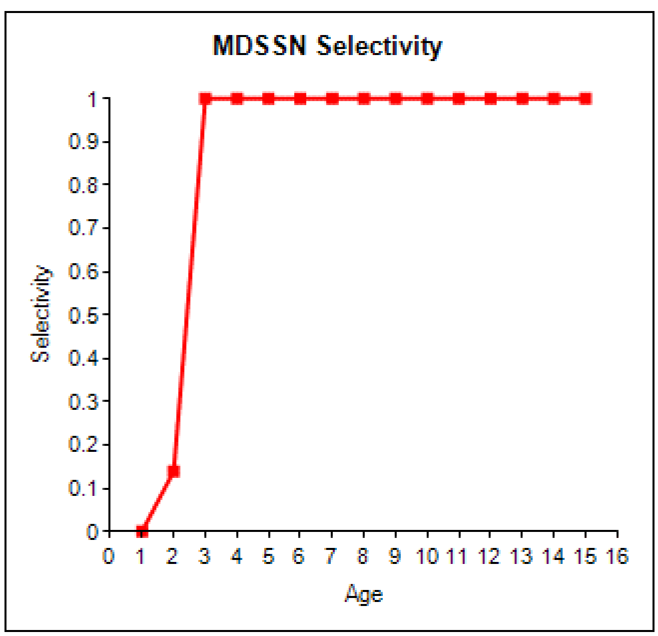
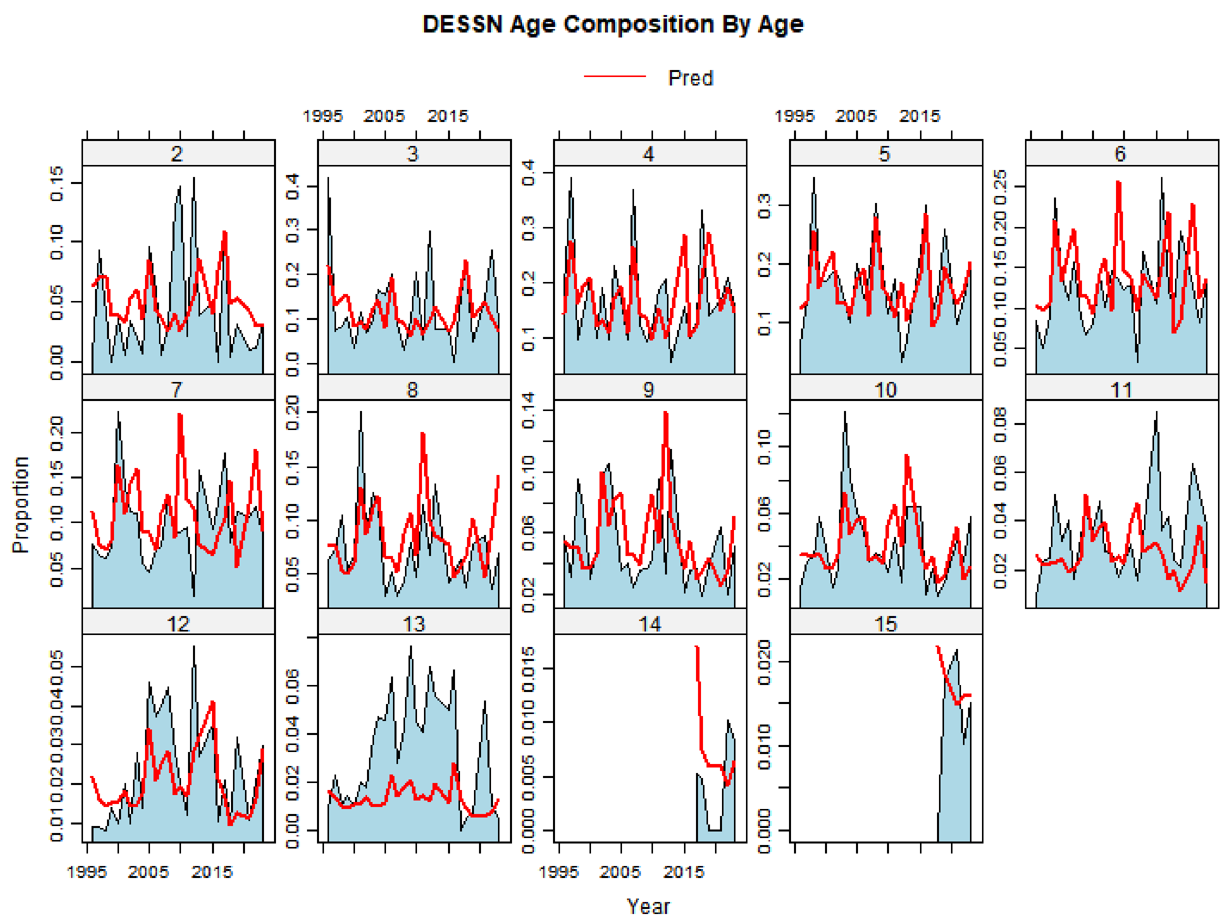
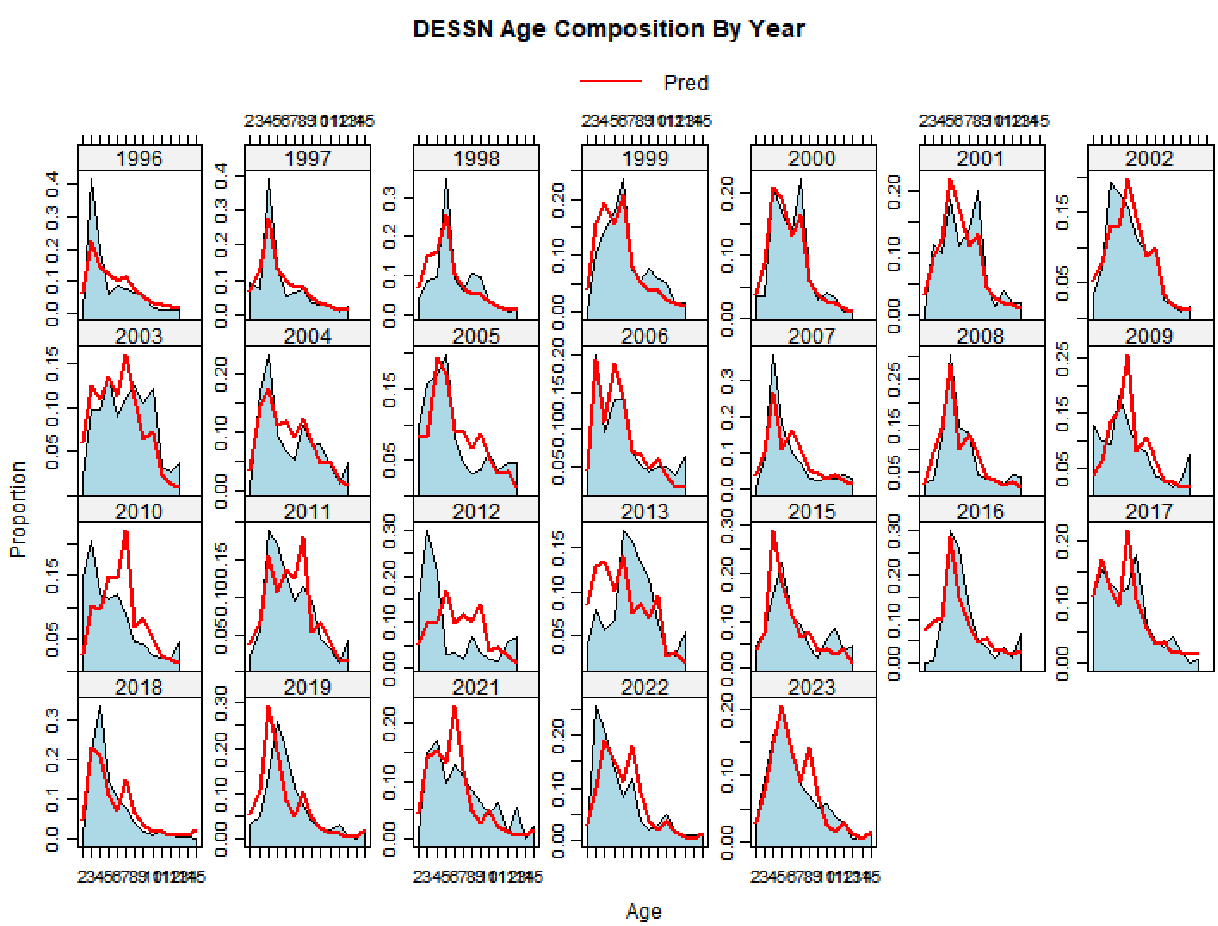
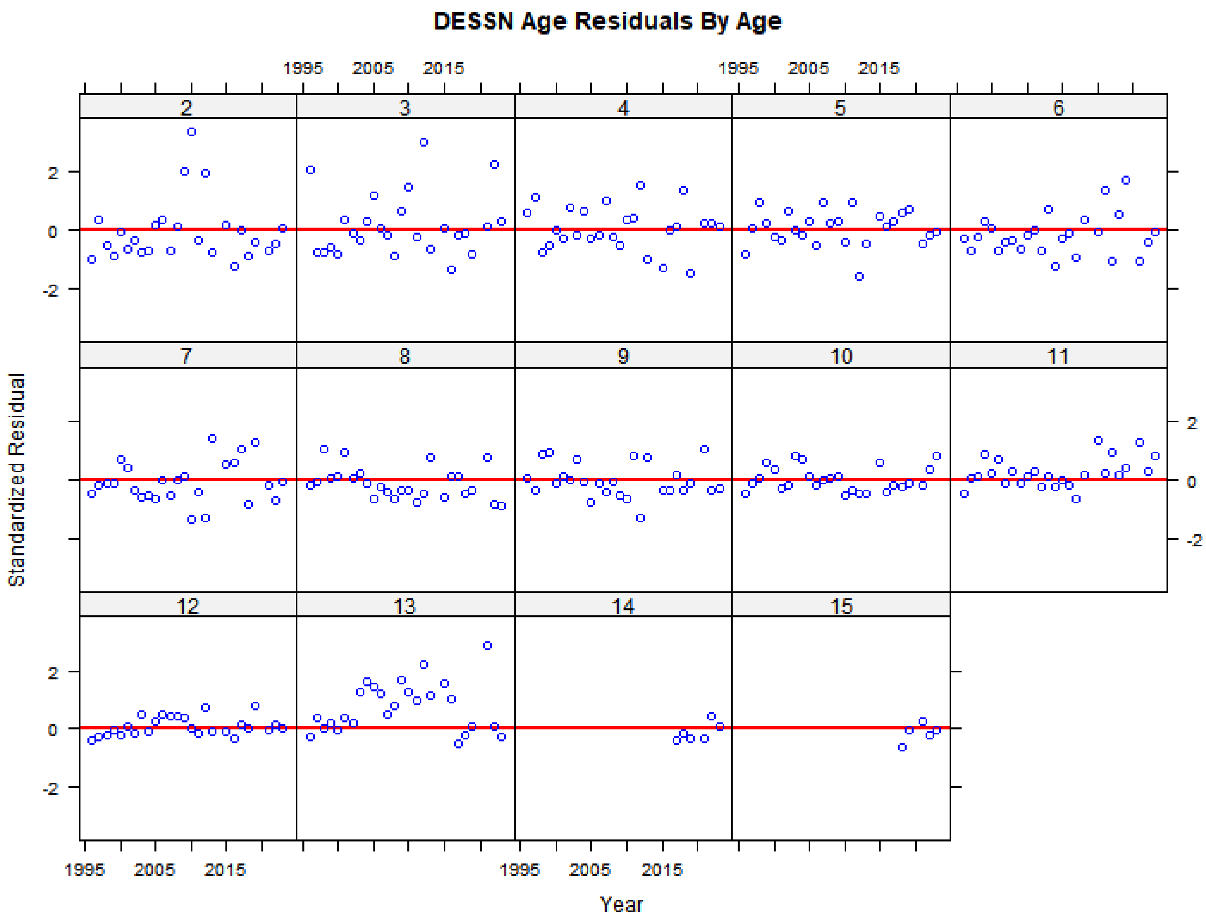
2015
2016
2017
2018
2019
2020
2021
2022
2023

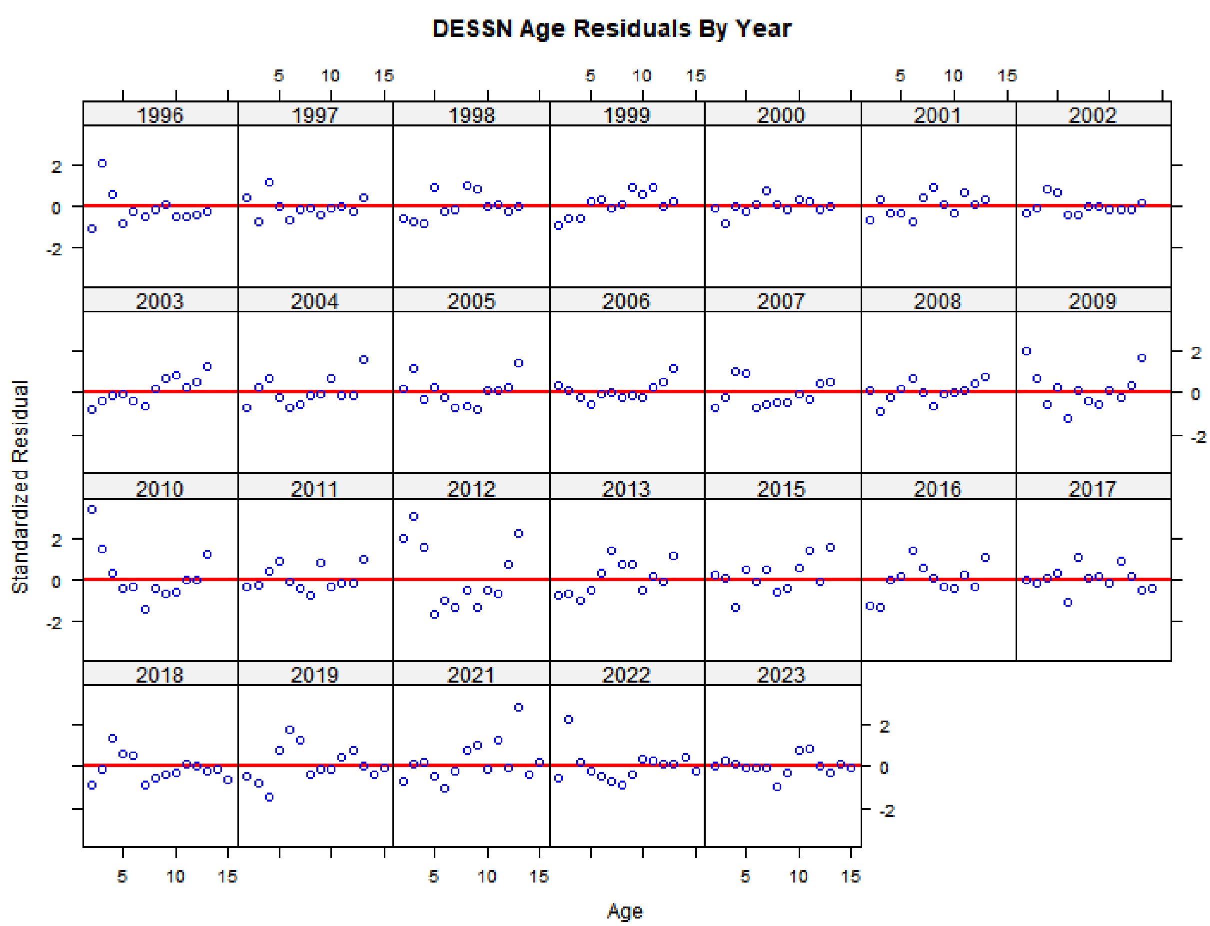

MDSSN Age Composition - Pearson Residuals (Solid = +, Hollow = -, Red > 3)
Age
2
4
6
8
10
12
14
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
2015
2018
2021
Year

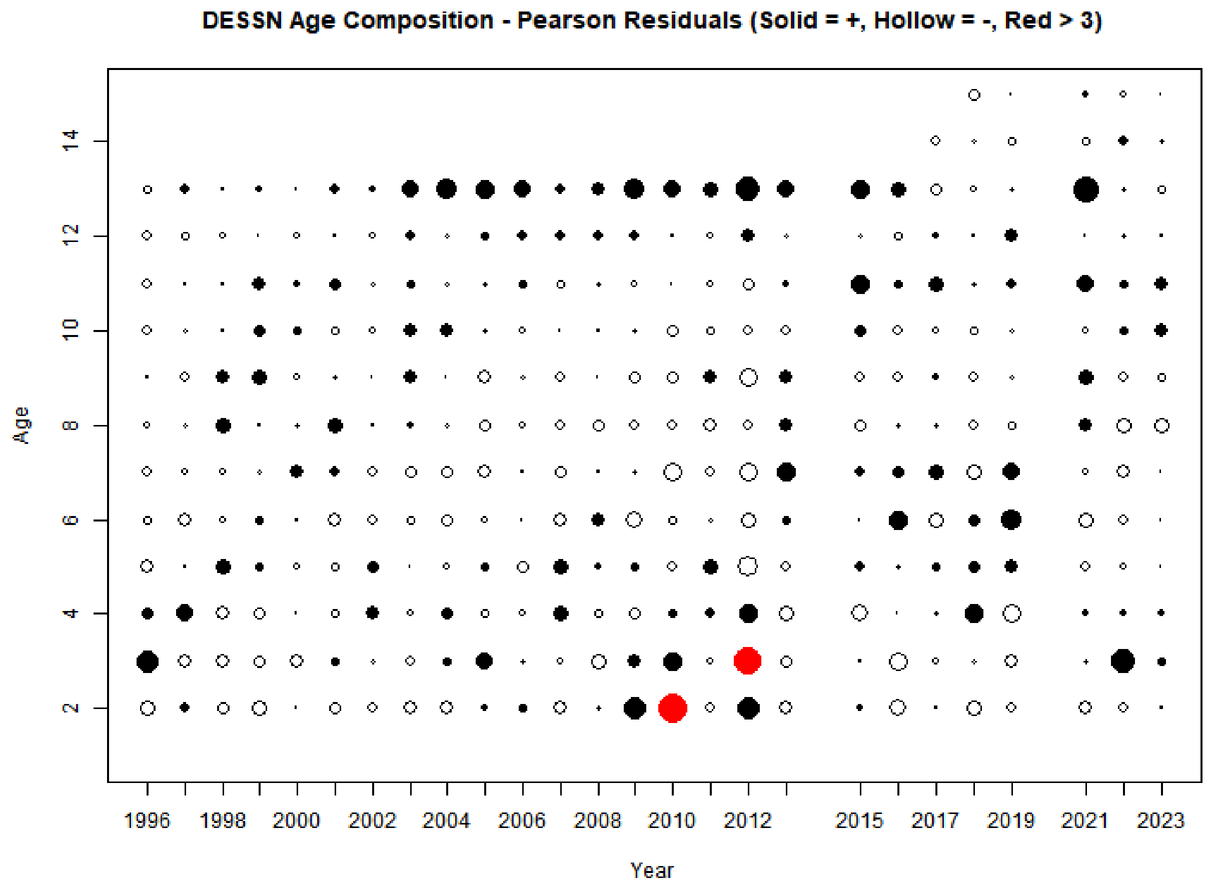

MDSSN Selectivity
Selectivity
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Age

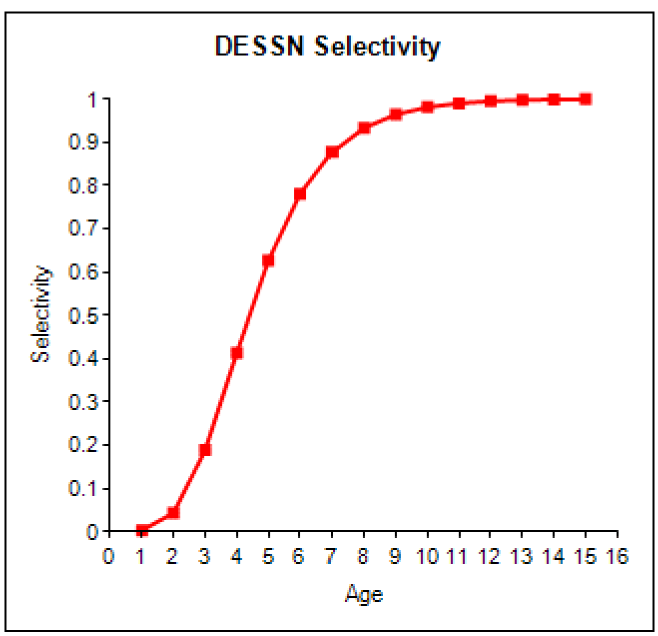

DESSN Age Composition By Age
Pred
Proportion
Year

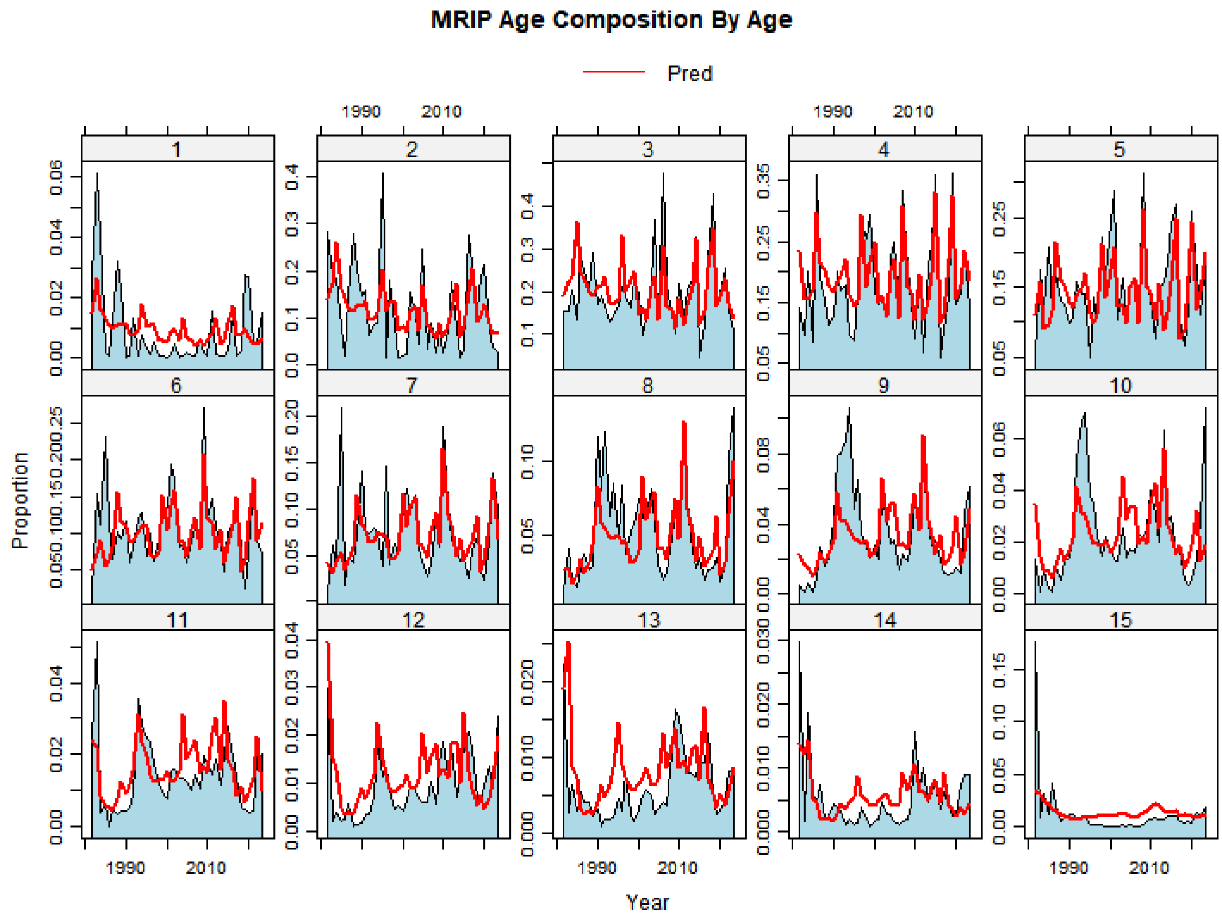

DESSN Age Composition By Year
Pred
Proportion
Age

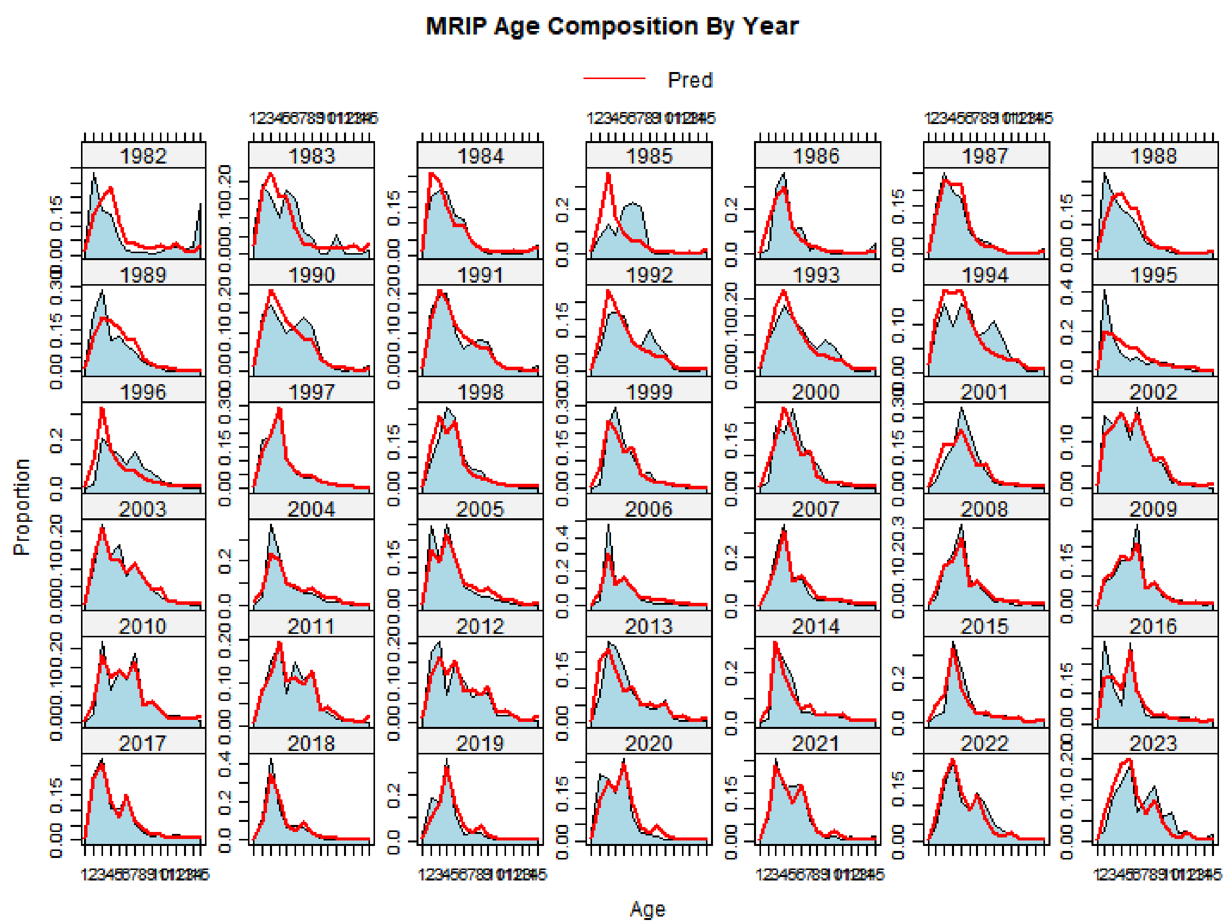

DESSN Age Residuals By Age
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Standardized Residual
Year
1995
2005
2015
2
0
-2

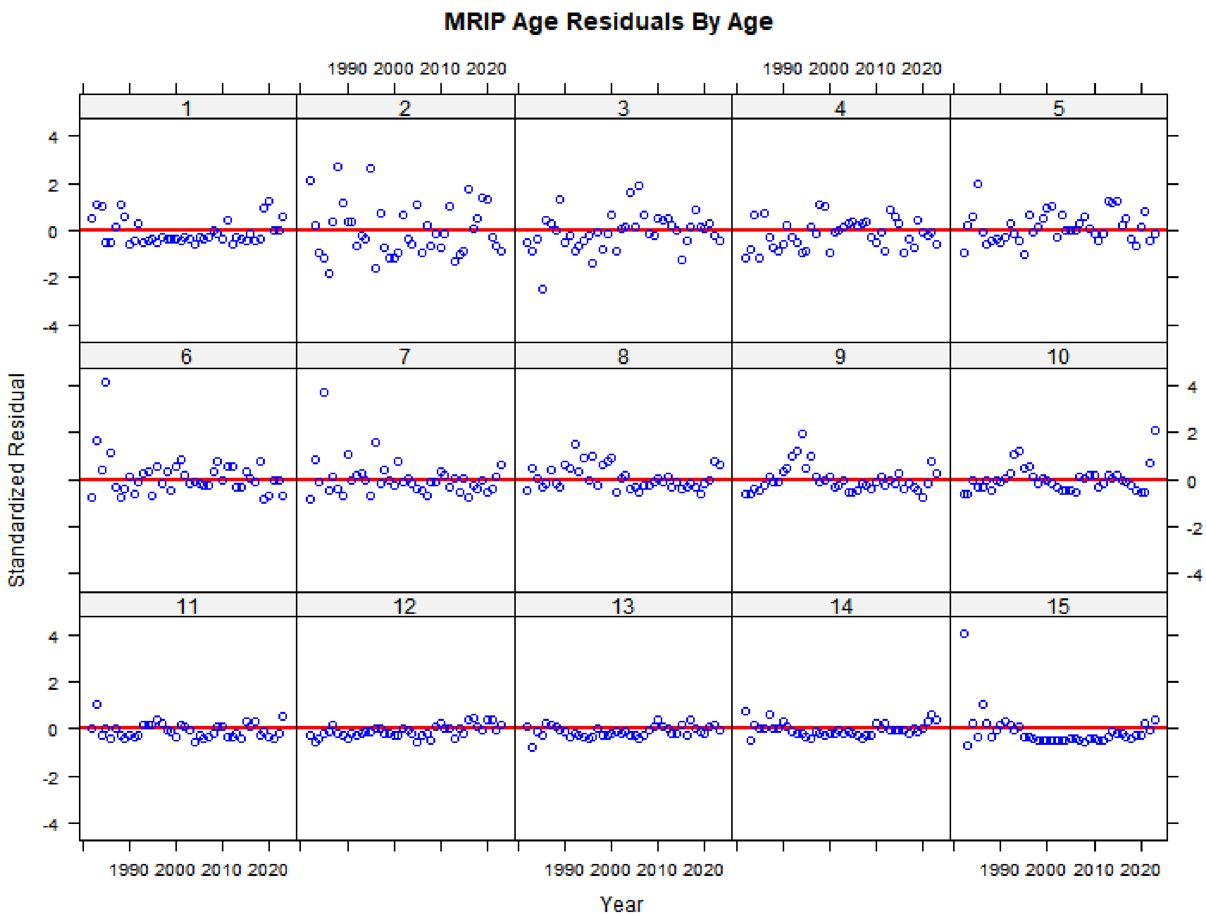

DESSN Age Residuals By Year
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2015
2016
2017
2018
2019
2021
2022
2023
Standardized Residual
Age
5
10
15
2
0
-2


DESSN Age Composition - Pearson Residuals (Solid = +, Hollow = -, Red > 3)
Age
Year
1996
1998
2000
2002
2004
2006
2008
2010
2012
2015
2017
2019
2021
2023
2
4
6
8
10
12
14

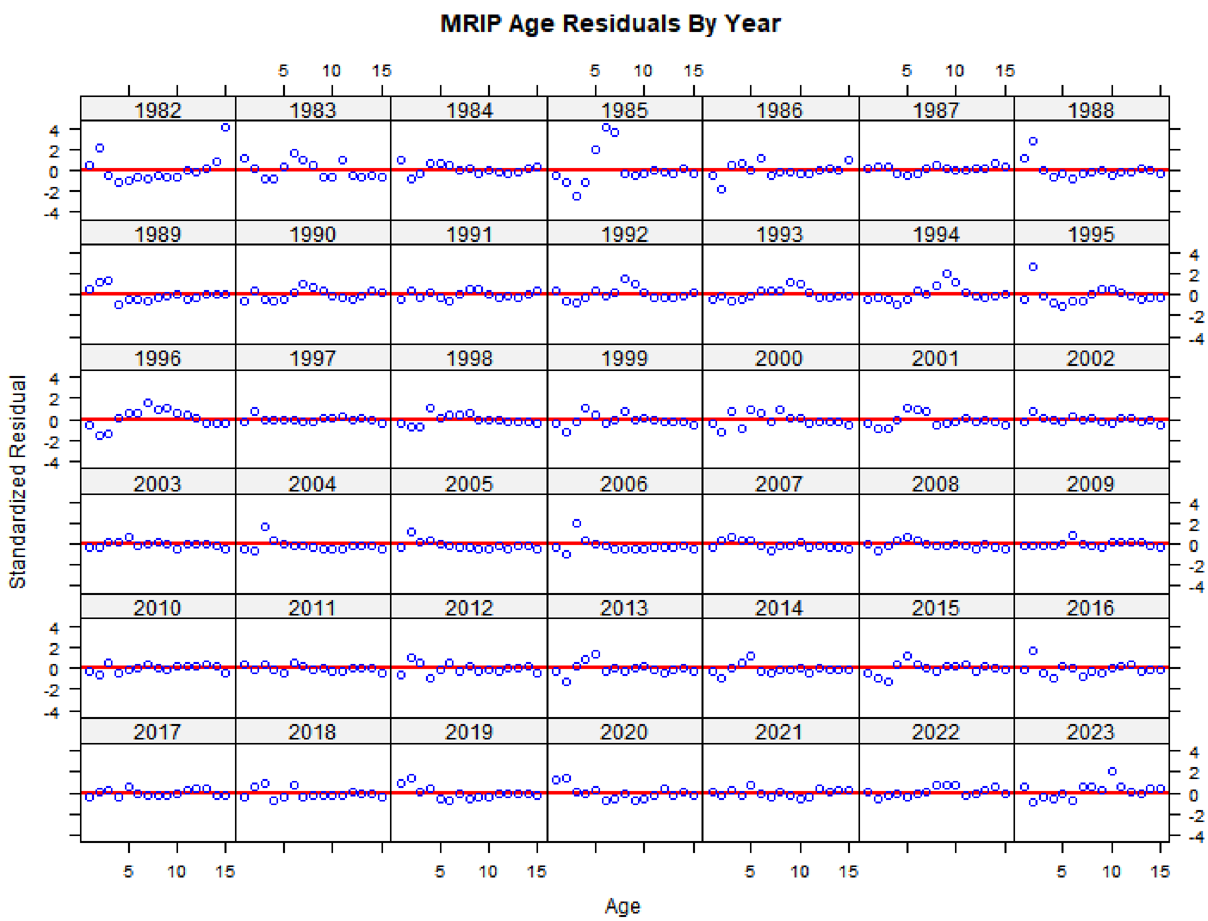

DESSN Selectivity
Selectivity
Age
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16


MRIP Age Composition By Age
Pred
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
1990
2010
Proportion
Year

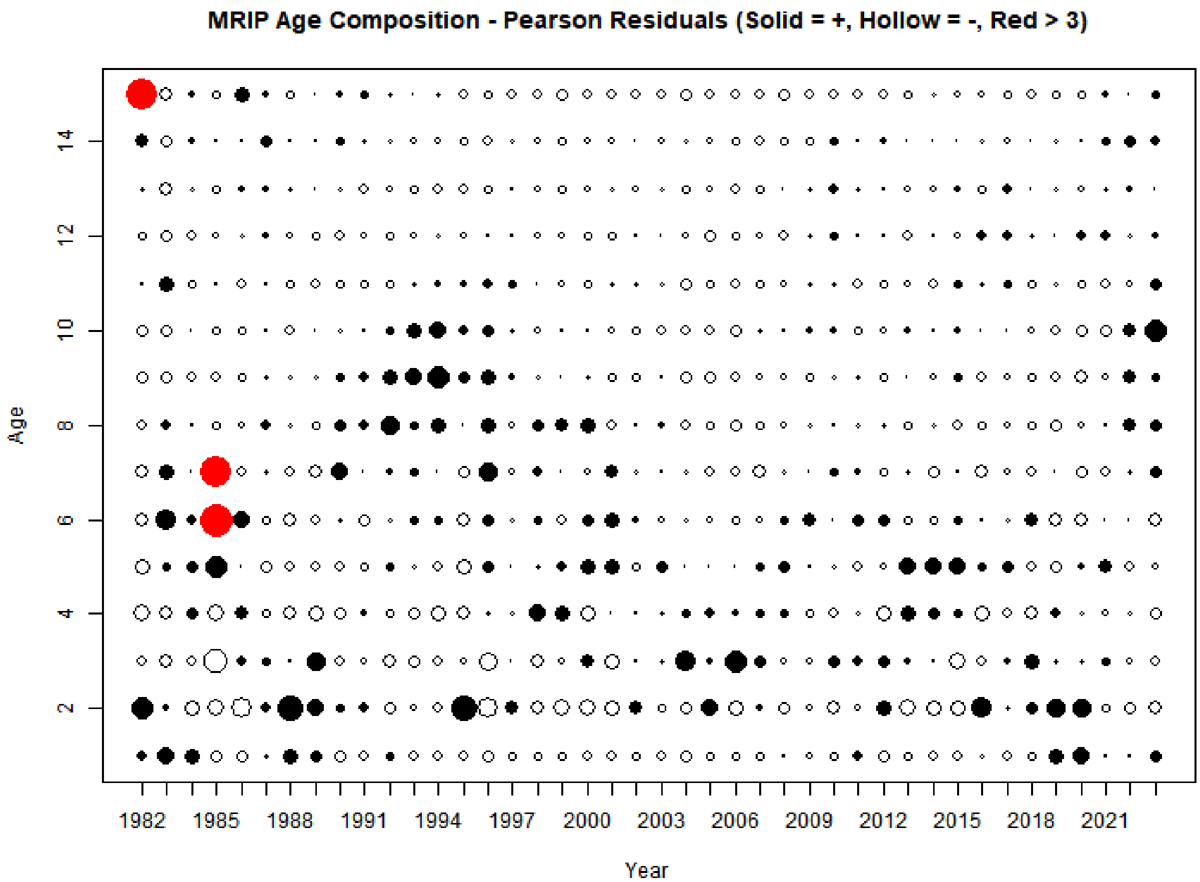

MRIP Age Composition By Year
Pred
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
Proportion
Age



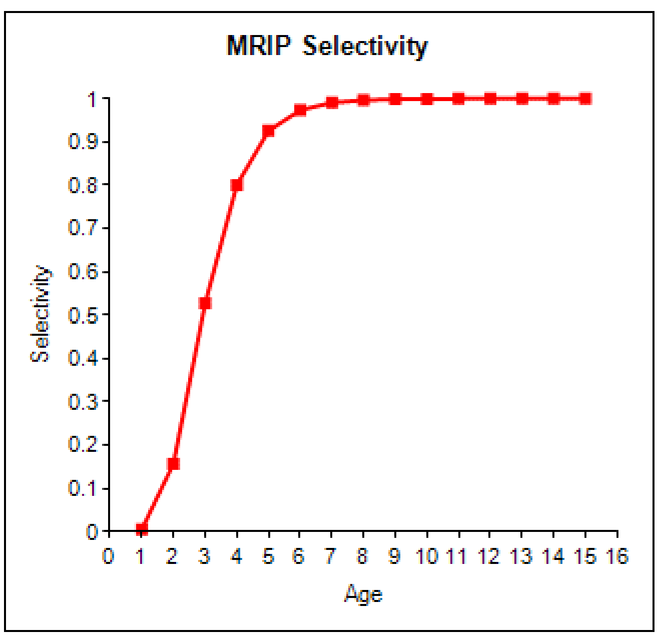
MRIP Age Residuals By Age
Standardized Residual
Year



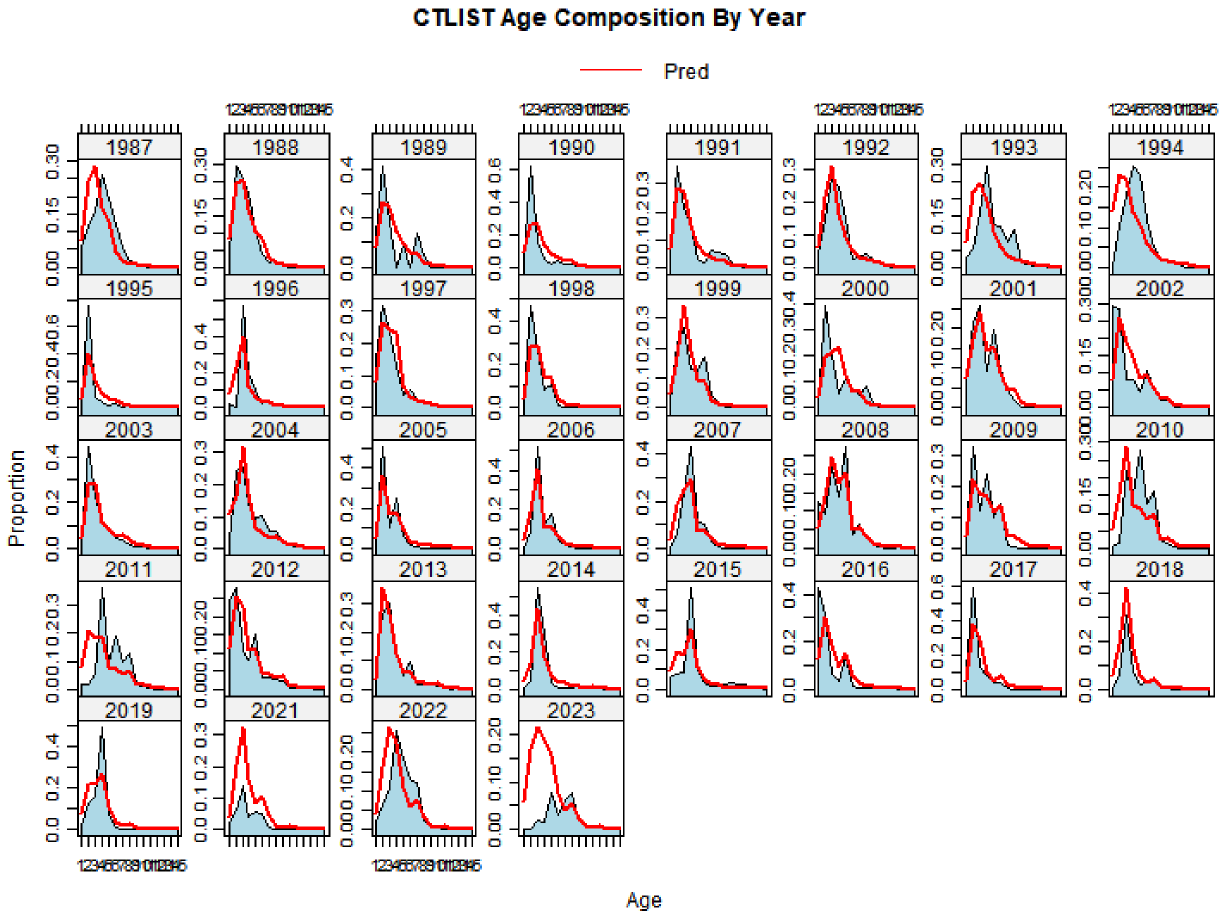
MRIP Age Residuals By Year
Standardized Residual
Age

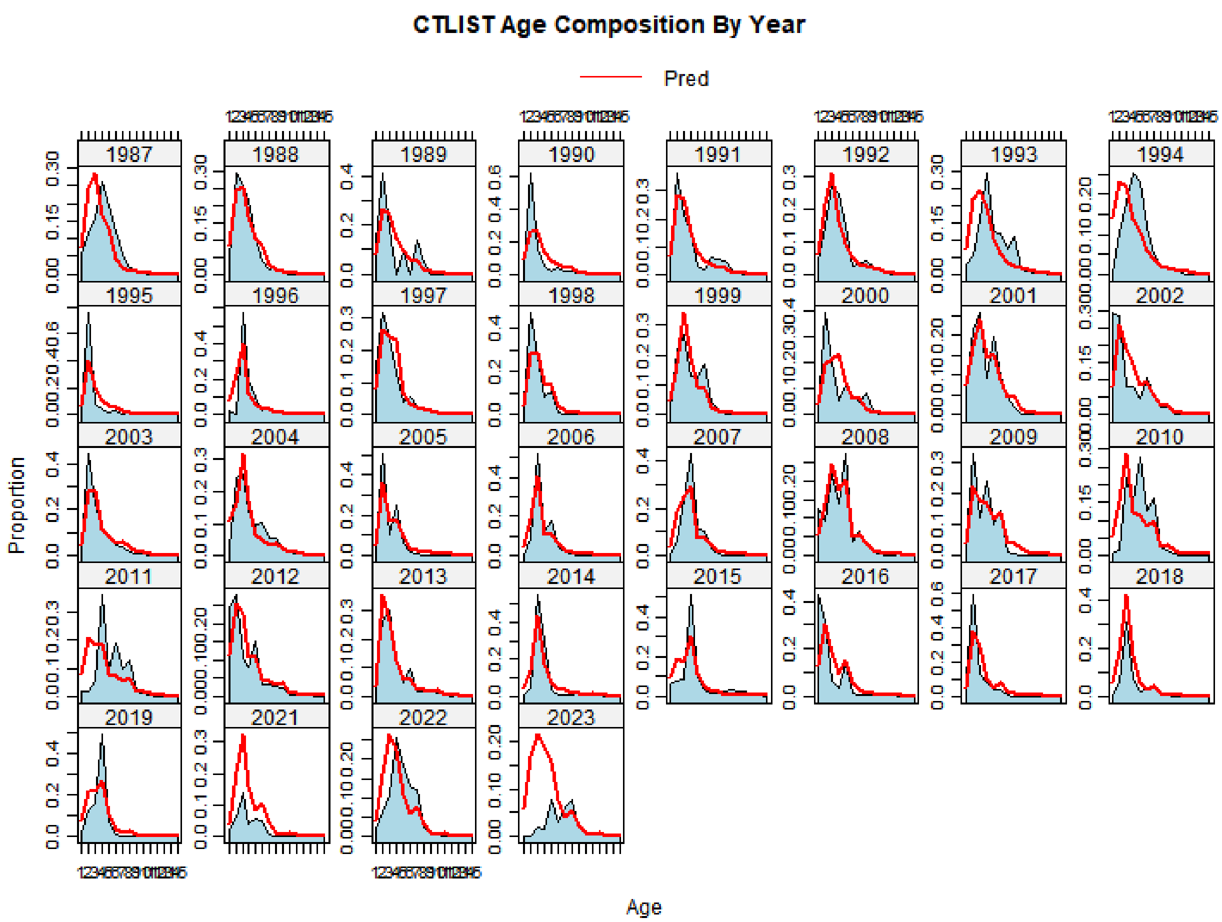


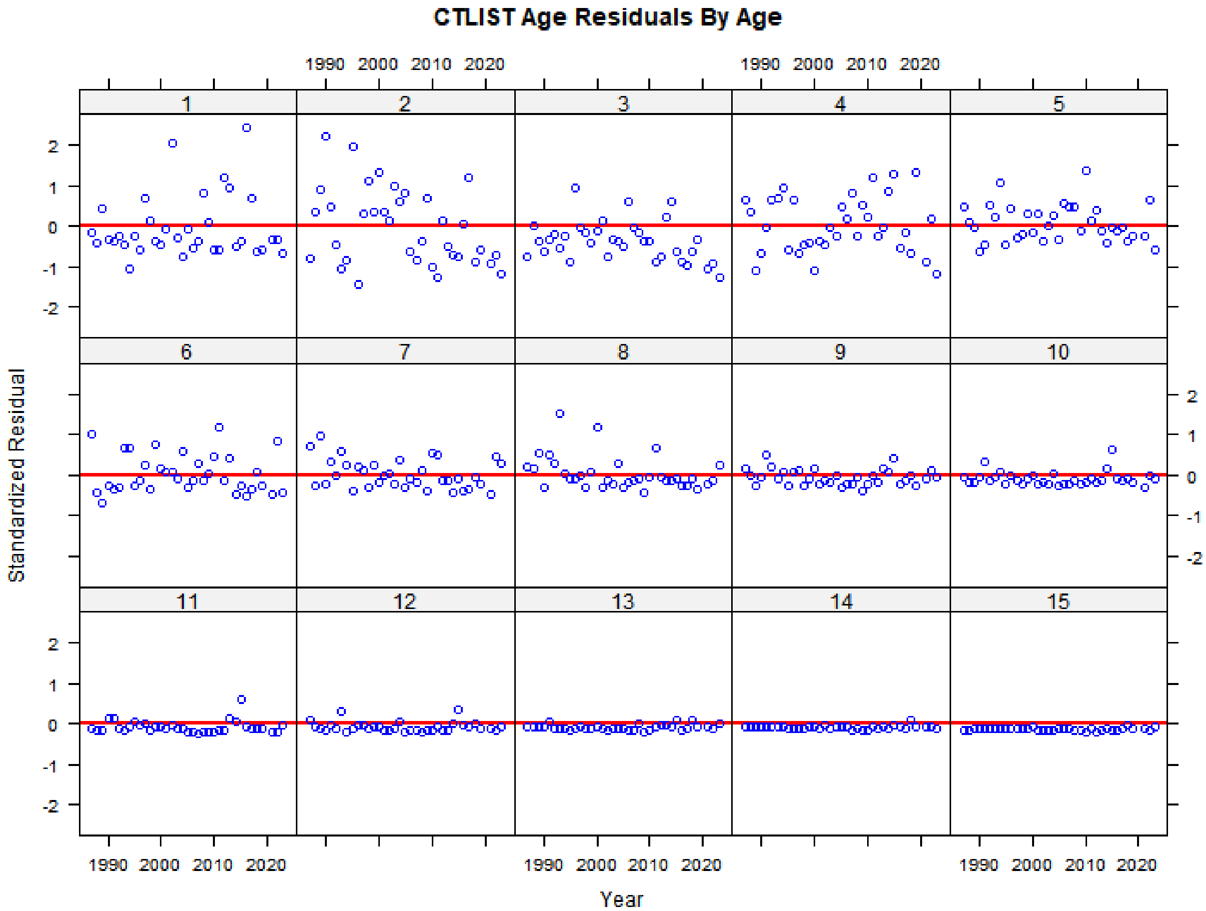
MRIP Age Composition - Pearson Residuals (Solid = +, Hollow = -, Red > 3)
Age
14
12
10
8
6
4
2
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
2015
2018
2021
Year

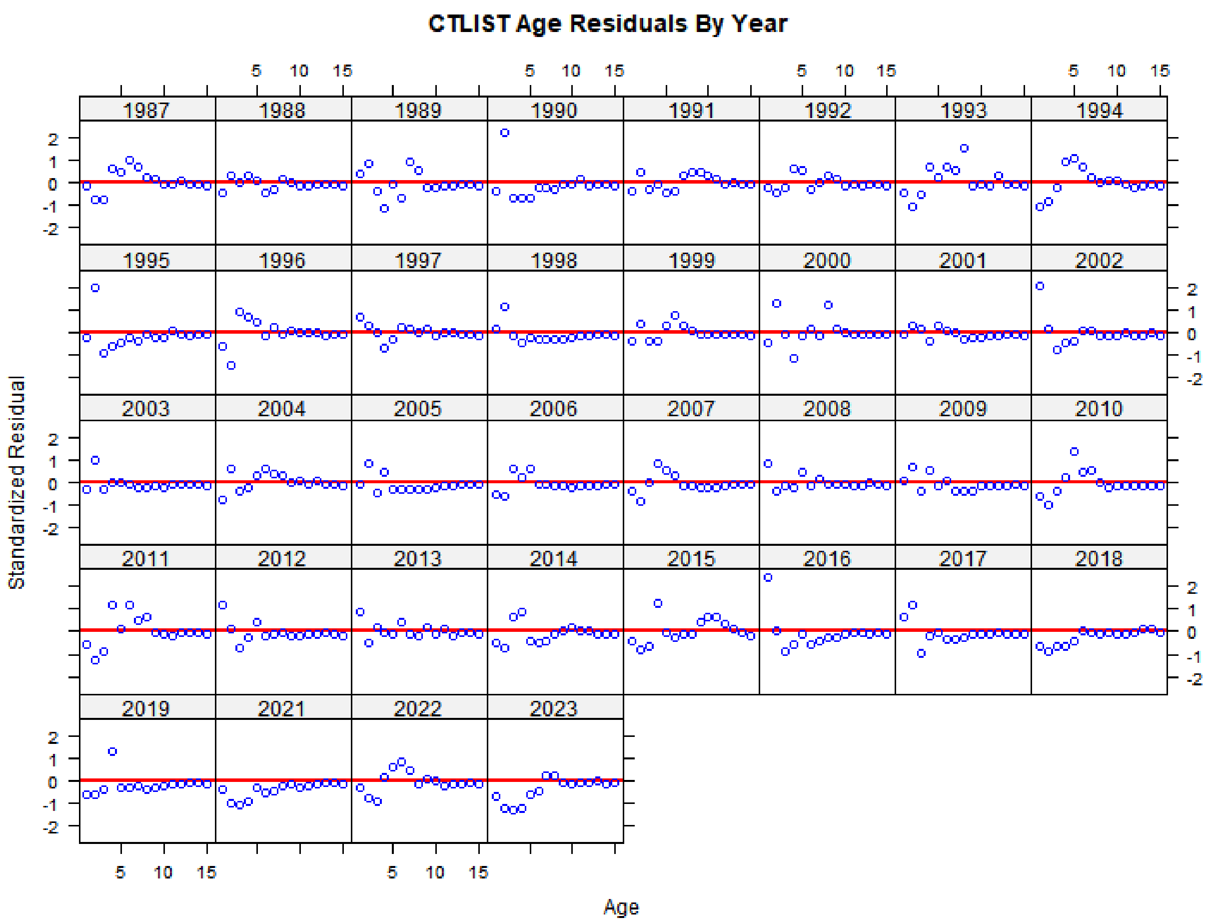


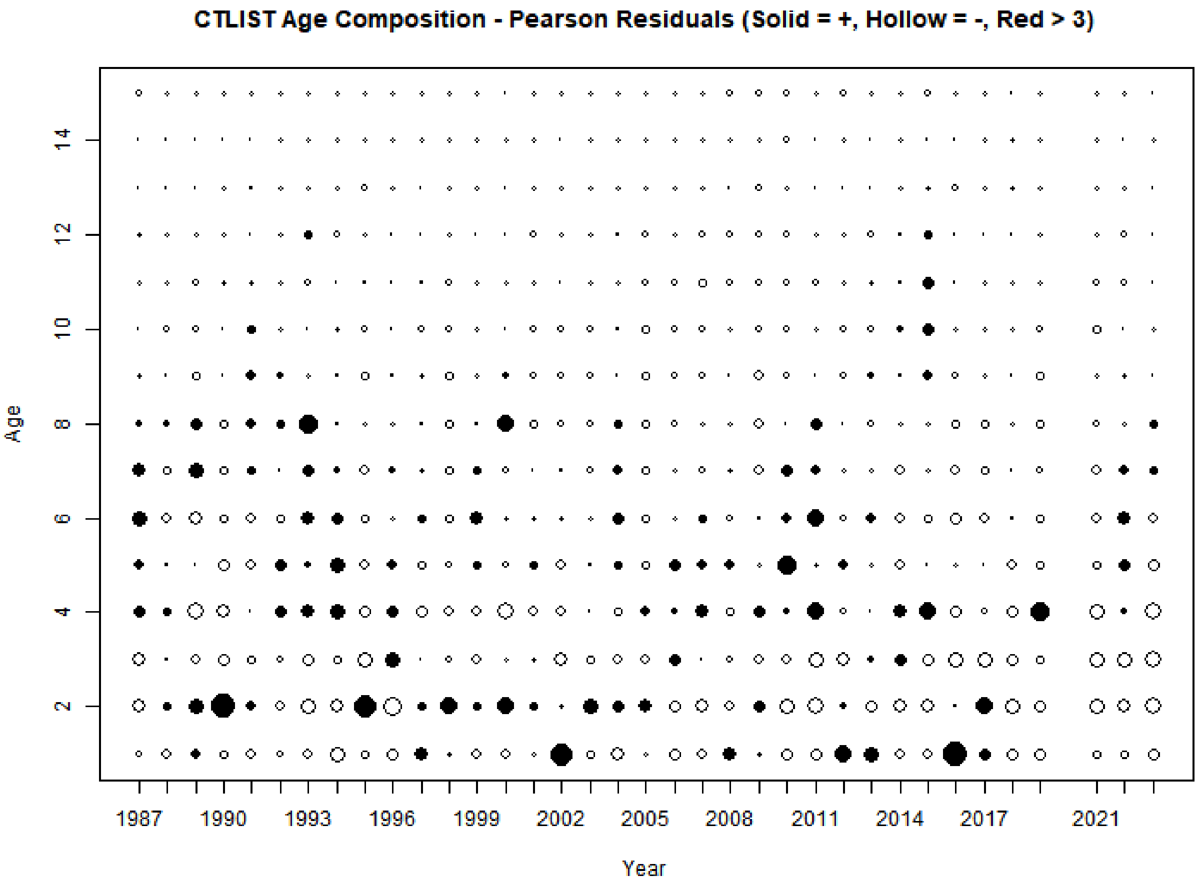
MRIP Selectivity
Selectivity
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Age


CTLIST Age Composition By Year
Pred
Proportion
Age
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2021
2022
2023

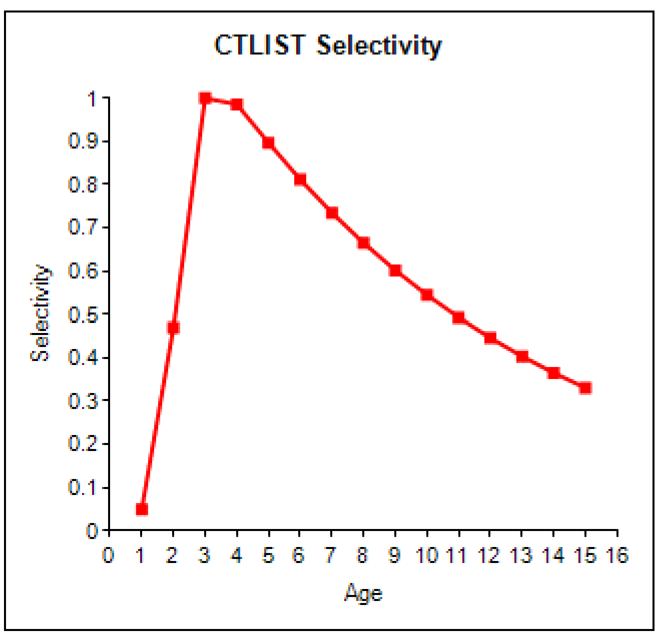

CTLIST Age Composition By Year
Pred
Proportion
Age
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2021
2022
2023


CTLIST Age Residuals By Age
Standardized Residual
Year


CTLIST Age Residuals By Year
Standardized Residual
Age

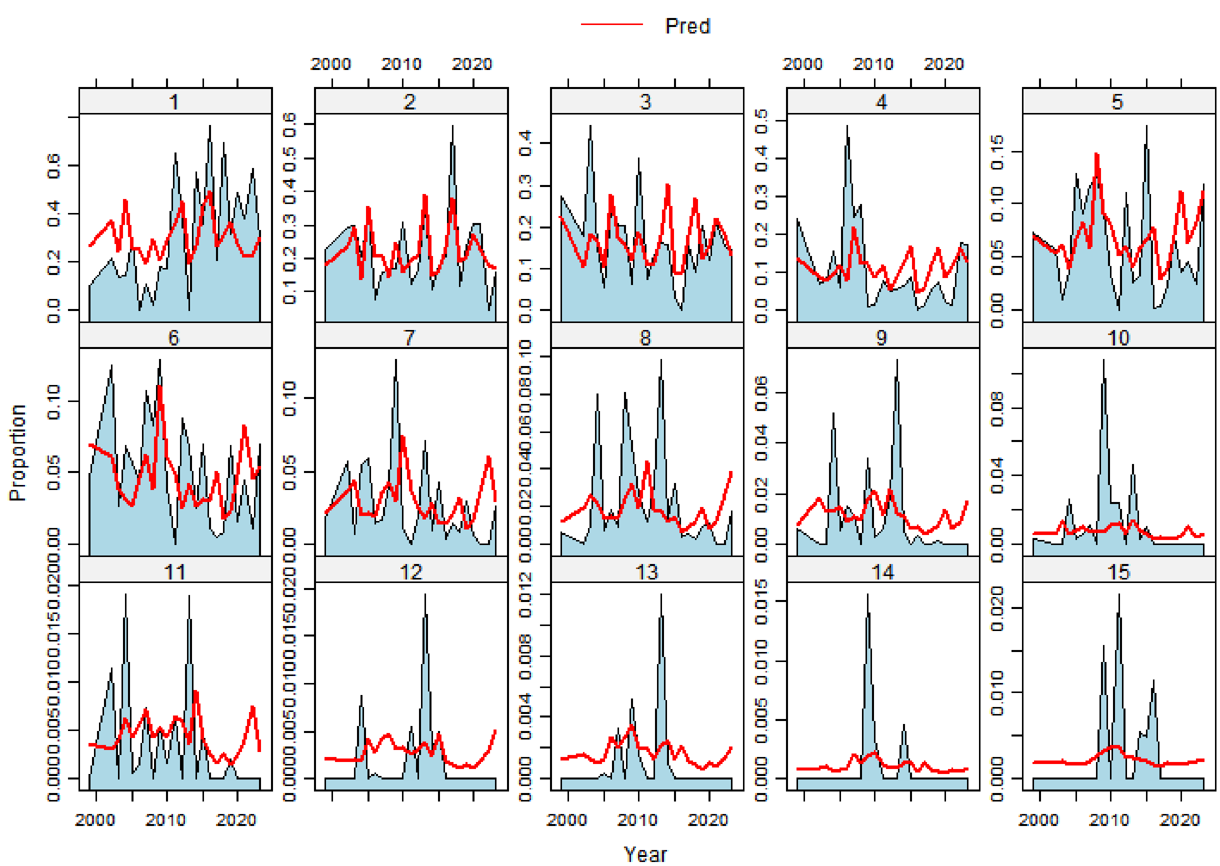


CTLIST Age Composition - Pearson Residuals (Solid = +, Hollow = -, Red > 3)
Age
Year
2
4
6
8
10
12
14
1987
1990
1993
1996
1999
2002
2005
2008
2011
2014
2017
2021

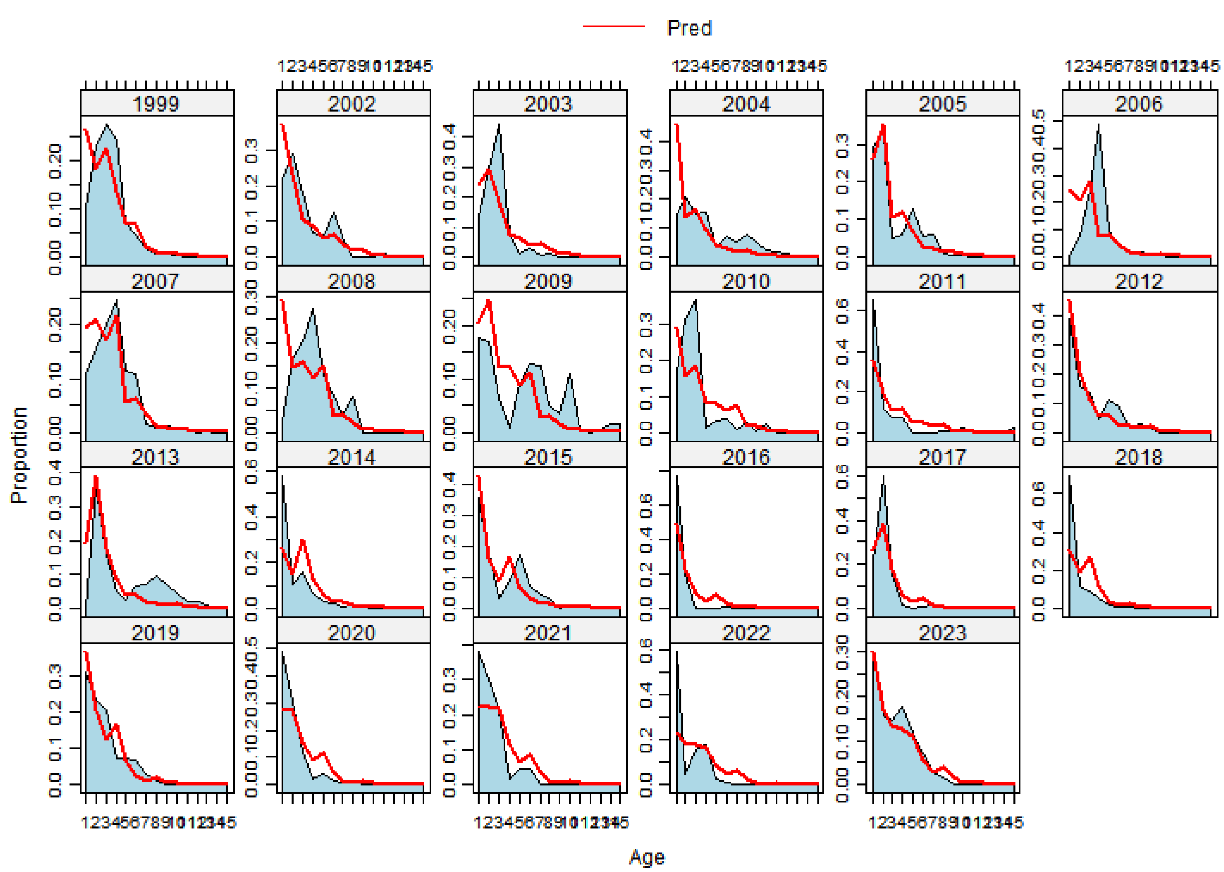


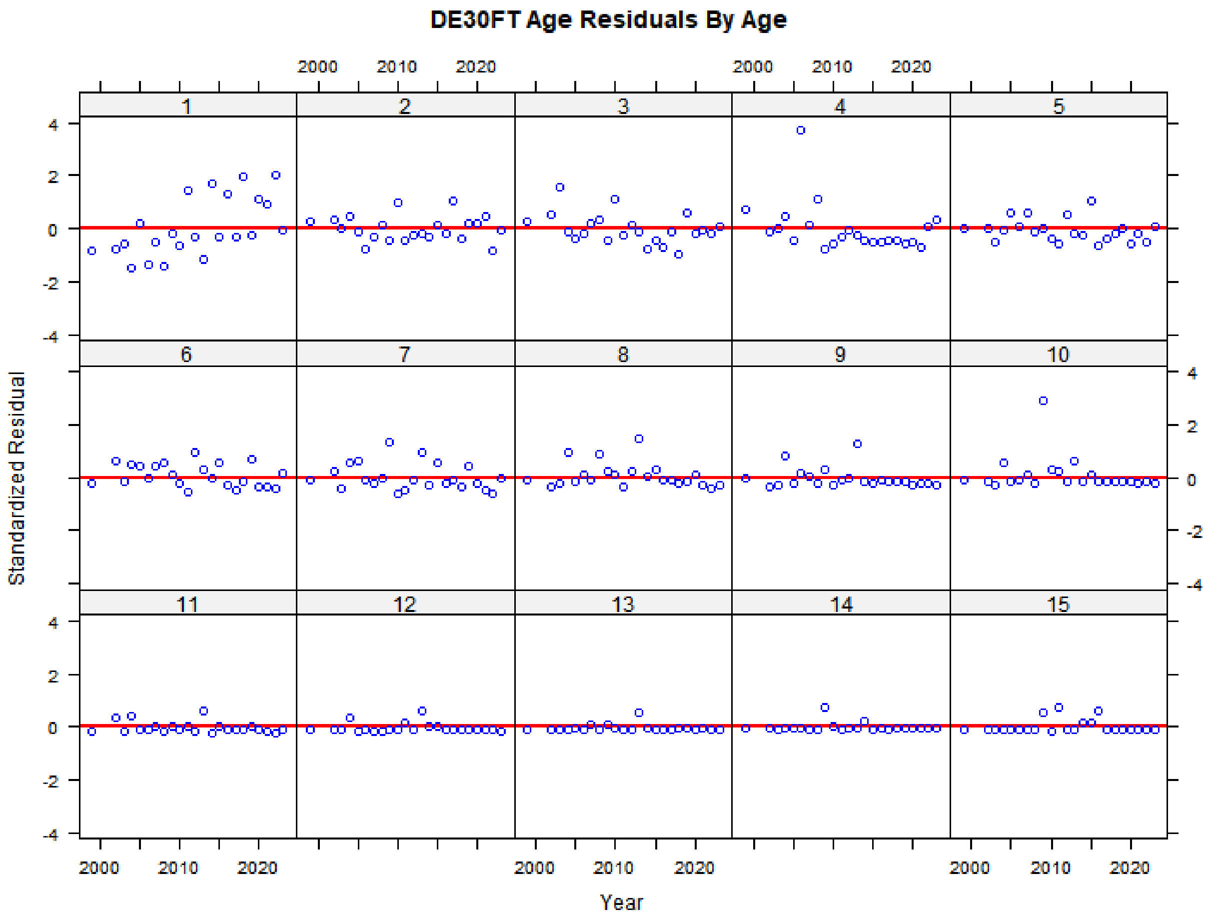
CTLIST Selectivity
Selectivity
Age
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

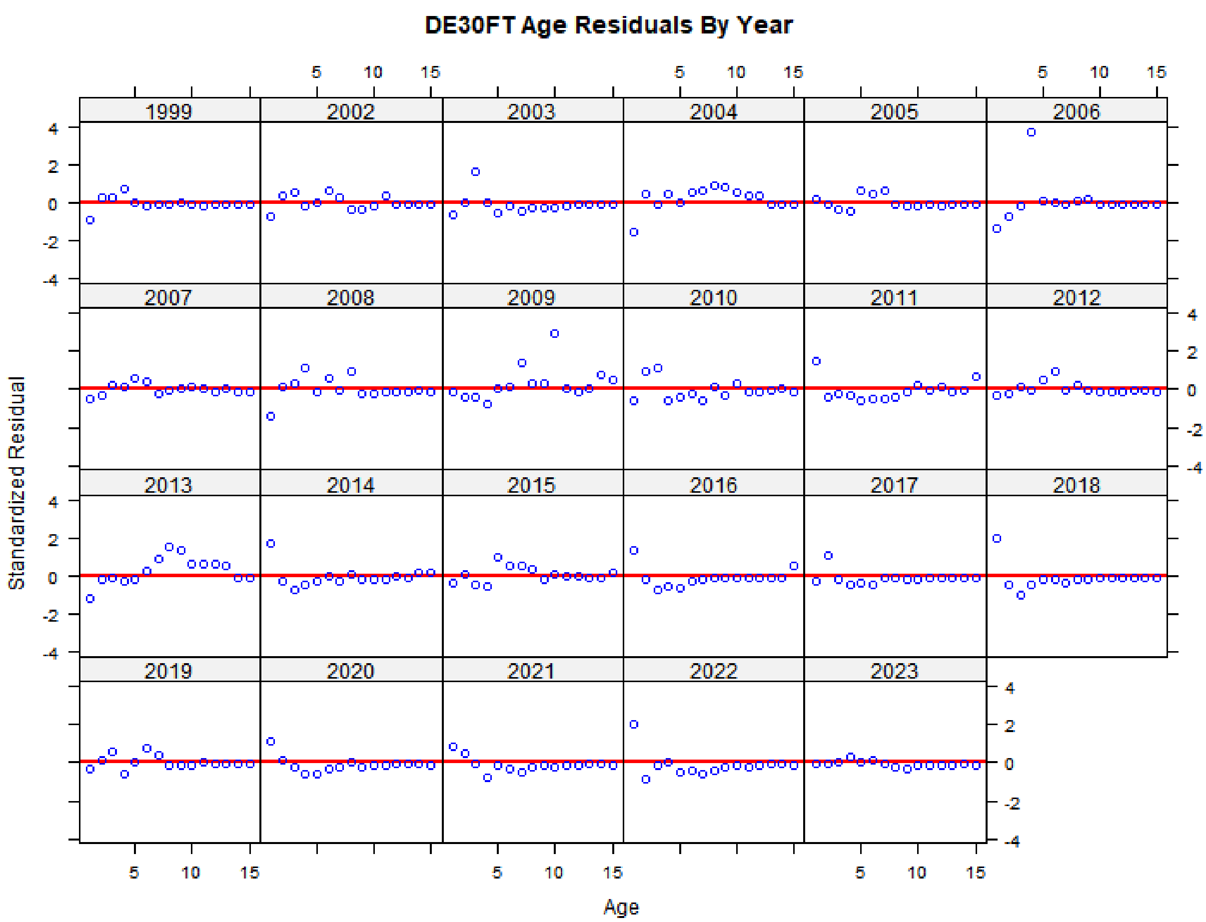
DE30FT Age Composition By Age

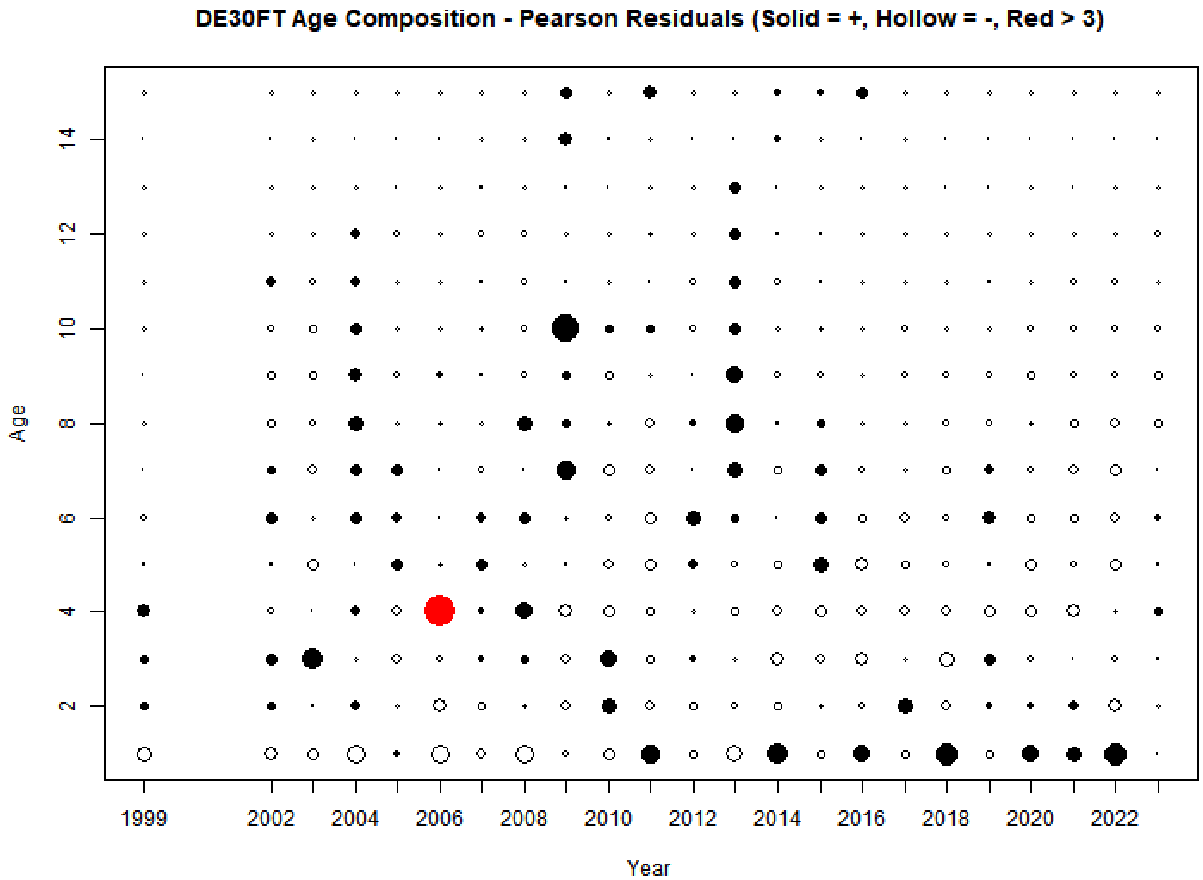


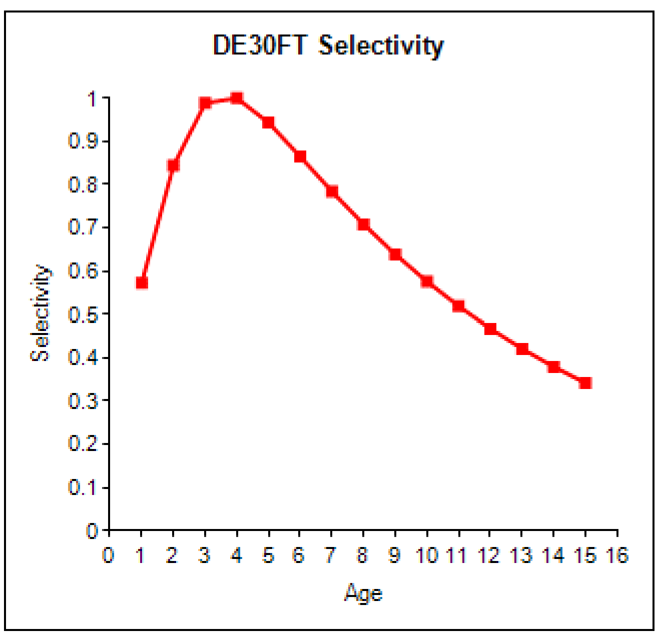
DE30FT Age Composition By Year

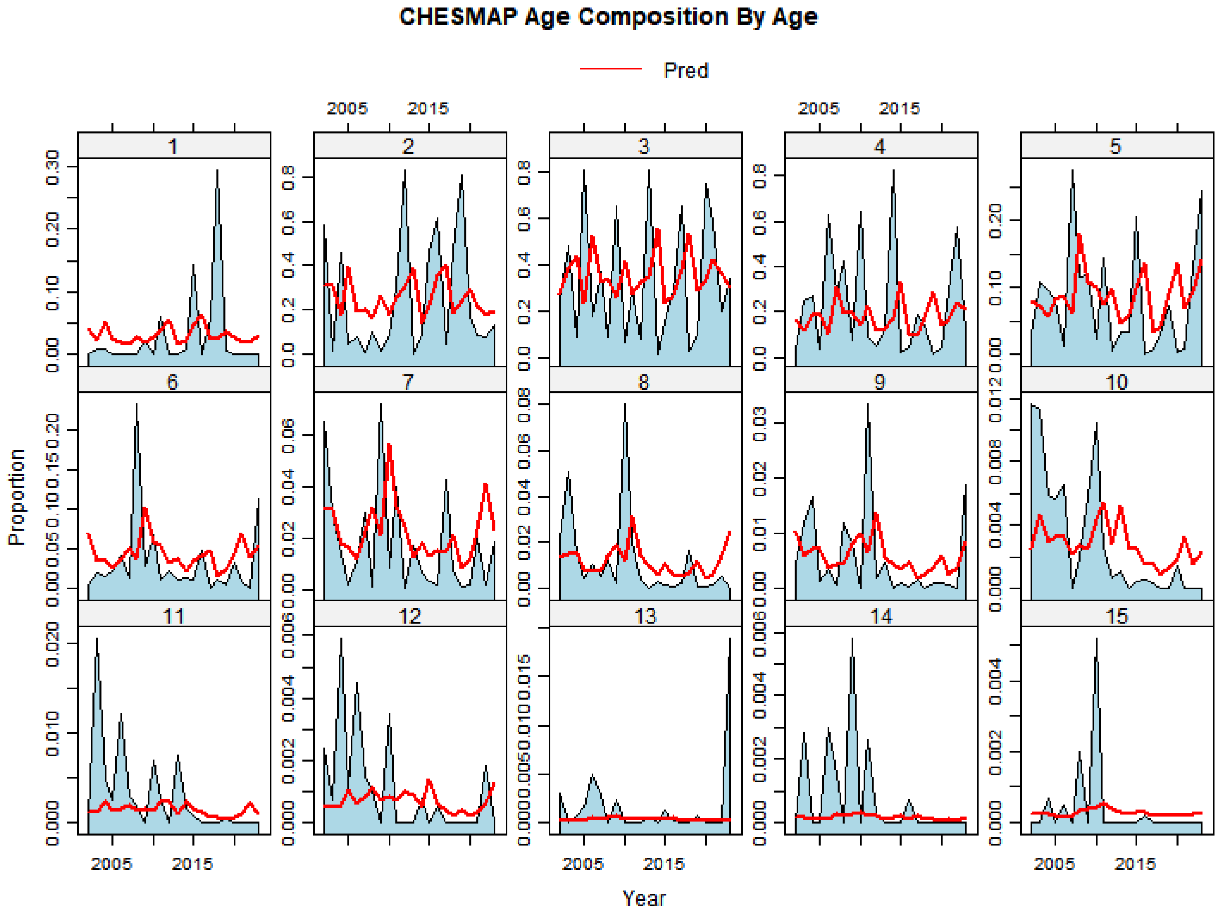


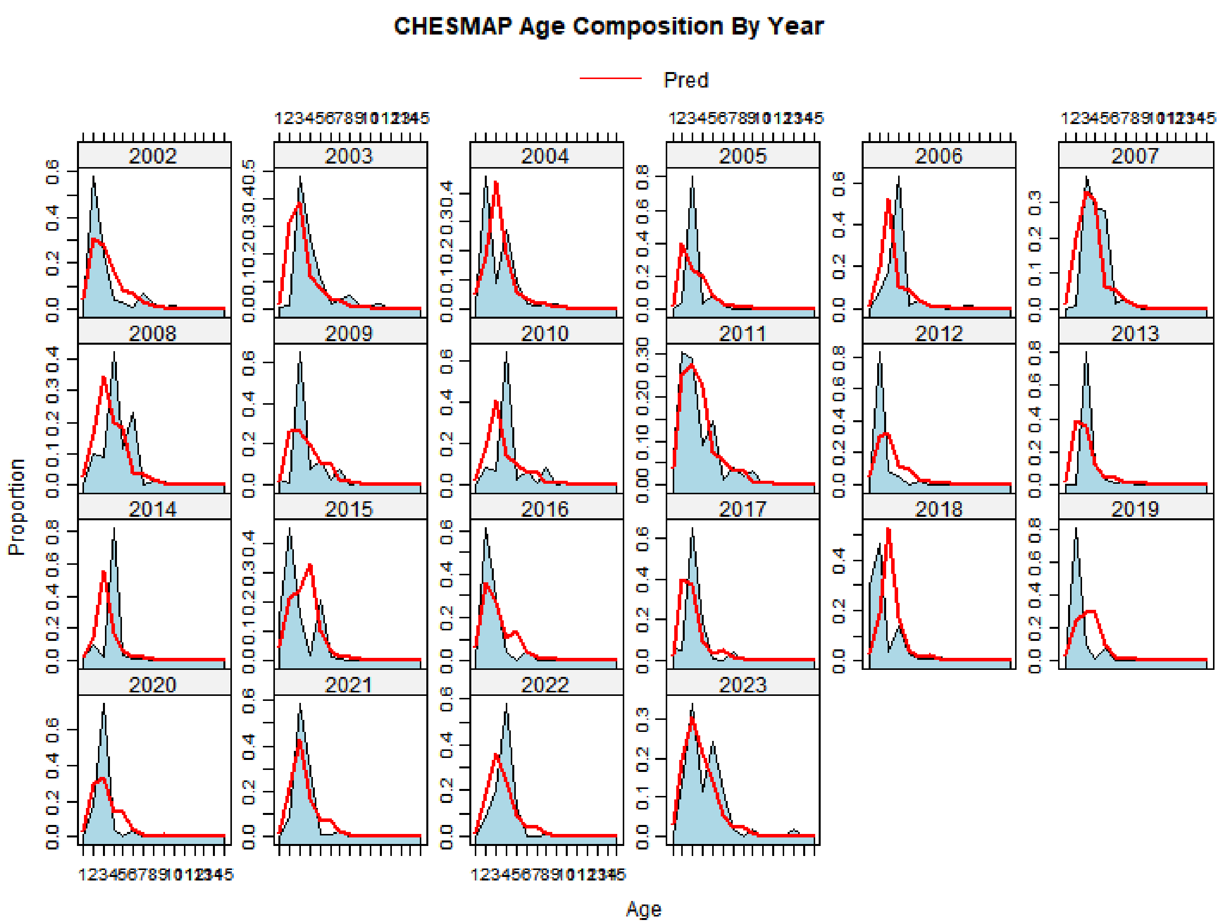

DE30FT Age Residuals By Age
Standardized Residual
Year


DE30FT Age Residuals By Year
Standardized Residual
Age

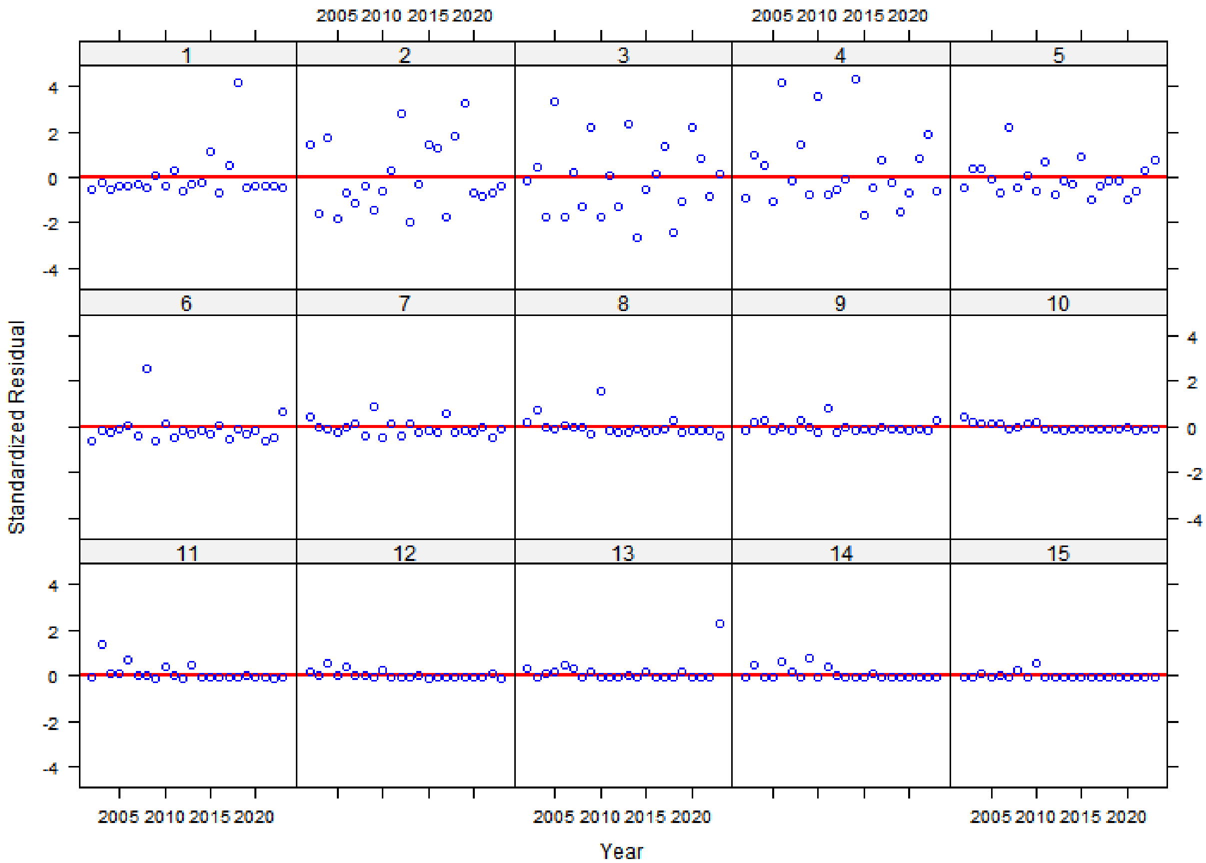

DE30FT Age Composition - Pearson Residuals (Solid = +, Hollow = -, Red > 3)
Age
2
4
6
8
10
12
14
1999
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Year


DE30FT Selectivity
Selectivity
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Age

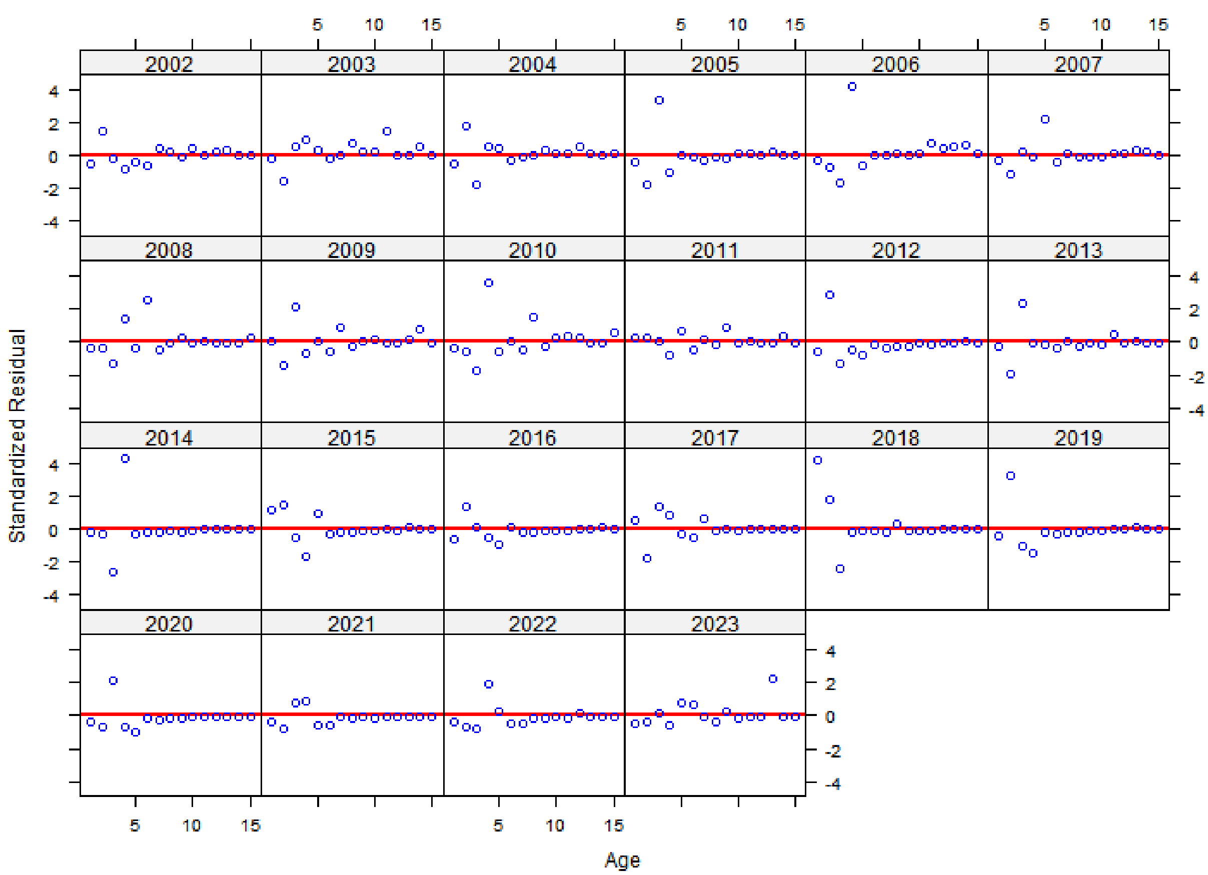

CHESMAP Age Composition By Age
Pred
Proportion
Year

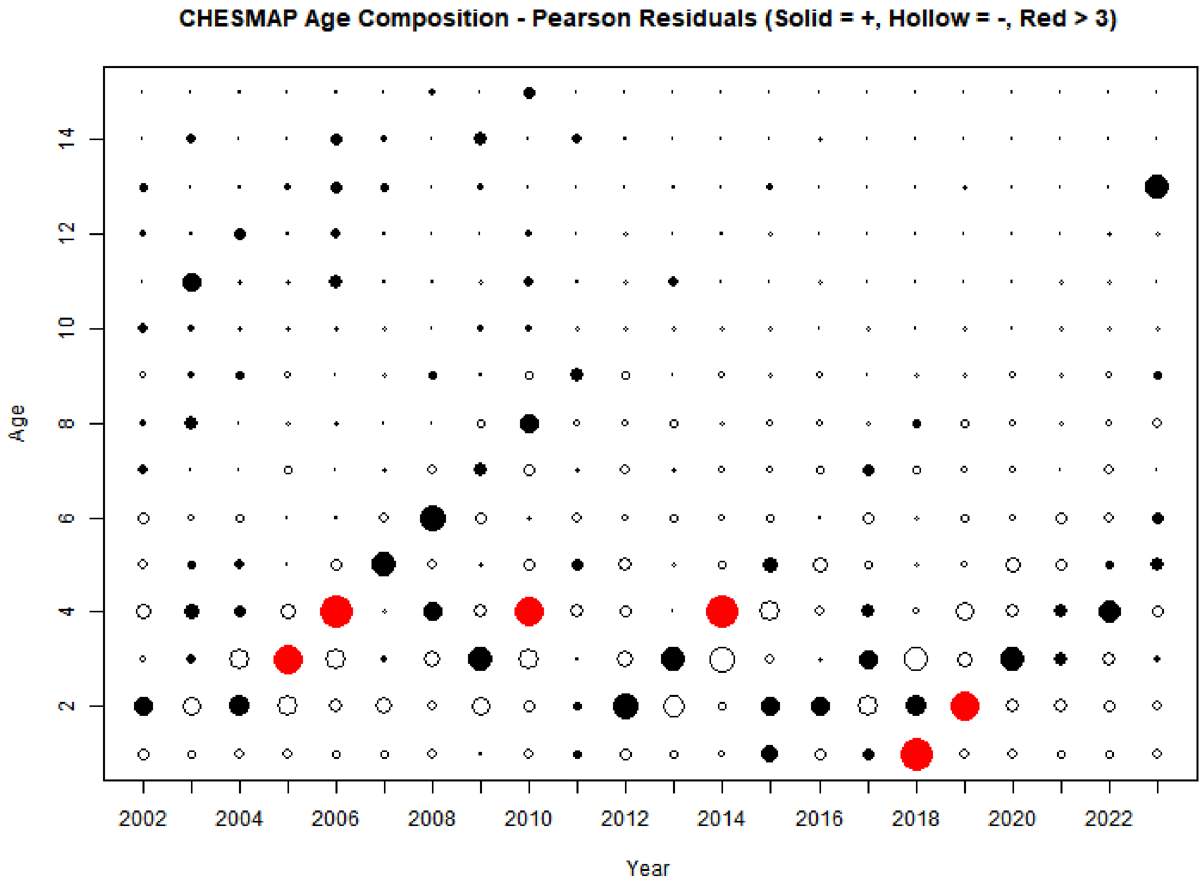

CHESMAP Age Composition By Year
Pred
Proportion
Age

CHESMAP Age Residuals By Age

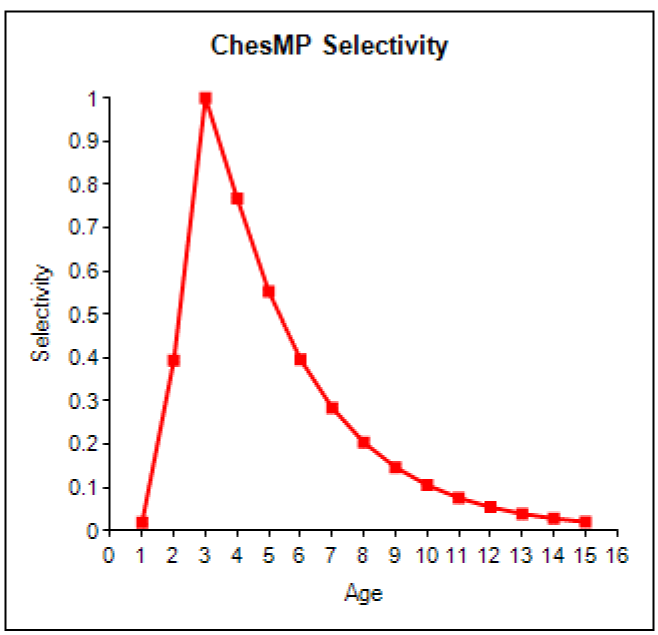


CHESMAP Age Residuals By Year





CHESMAP Age Composition - Pearson Residuals (Solid = +, Hollow = -, Red > 3)
Age
2
4
6
8
10
12
14
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Year



ChesMP Selectivity
Selectivity
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Age

Results and Projections

Table X2. Comparison of RMSE, CV weights and effective sample sizes from the 2018 benchmark and 2022 update assessments.

2024 Update Assessment

Index	n	RMSE	CV Weight	Effective Sample Size
NYYOY	38	1.00932	2.97	
NJYOY	40	1.01128	1.63	
MDYOY	12	1.0054	1.96	
compos	42	1.01242	1.00	
NYAge1	39	1.00882	1.19	
MDAge1	54	1.00057	3.25	
NYOHS	20	0.996985	2.55	21.34
NJTRAWL	31	0.999935	5.85	2.98
MDSSN	39	1.00736	2.40	15.57
DESSN	26	1.00552	1.42	19.45
MRIP	42	0.994992	2.27	27.47
CTLIST	36	1.00365	3.05	7.22
DE30FT	23	0.998003	0.85	5.62
ChesMP	22	0.995453	3.40	6.10

2022 Update

Index	n	RMSE	CV Weight	Effective Sample Size
NYYOY	36	0.990985	2.97	
NJYOY	38	1.00901	1.73	
MDYOY	12	1.00507	2.11	
compos	40	1.00575	0.96	
NYAge1	37	1.00193	1.19	
MDAge1	52	0.998121	3.25	
NYOHS	20	0.996071	2.65	21.80
NJTRAWL	29	1.00117	2.95	5.66
MDSSN	37	0.998646	2.50	14.95
DESSN	24	1.00934	1.17	18.55
MRIP	40	1.00898	2.27	29.64
CTLIST	34	0.996705	3.00	12.93
DE30FT	21	1.00132	0.85	5.81
ChesMP	17	1.00111	2.45	15.10

Table X3. Summary of likelihood component values.

	Likelihood Weight	RSS
Fleet 1 Total Catch:	2	0.231403
Fleet 2 Total Catch:	2	1.85817
Aggregate Abundance Indices		
NYYOY	1	30.7183
NJYOY	1	32.6827
MDYOY	1	10.5312
Composite	1	40.9288
NYAge1	1	34.4667
MDAge1	1	26.6986
Age Comp Abundance Indices		
NYOHS	1	18.9014
NJTrawl	1	6.55357
MDSSN	1	33.8027
DESSN	1	23.2213
MRIP	1	36.7523
CTLIST	1	29.0973
DE30FT	1	18.5411
CHESMAP	1	13.9466
Total RSS		358.932
No. of Obs		548
Conc. Likel.		-115.941
Age Composition Data		
Fleet 1 Age Comp	1	6468.26
Fleet 2 Age Comp	1	6799.73
NYOHS	1	711.306
NJTrawl	1	168.126
MDSSN	1	1241.94
DESSN	1	1159.93
MRIP	1	2483.06
CTLIST	1	463.211
DE30FT	1	241.603
CHESMAP	1	235.109
Recr Devs	1	41.5586
Total Likelihood		19825.3
AIC		40052.7

Table X4. Estimates of Bay and Ocean fully-recruited fishing mortality and total fully-recruited fishing mortality with associated standard errors.

	Bay			Ocean			Total		
	Fully-recruited			Fully-recruited			Fully-recruited		
Year	F	SD	CV	F	SD	CV	F	SD	CV
1982	0.057	0.014	0.240	0.179	0.004	0.020	0.180	0.029	0.161
1983	0.062	0.029	0.463	0.144	0.012	0.085	0.145	0.039	0.269
1984	0.060	0.008	0.128	0.060	0.004	0.062	0.074	0.014	0.190
1985	0.004	0.039	10.655	0.190	0.016	0.085	0.190	0.069	0.360
1986	0.006	0.013	2.250	0.051	0.004	0.076	0.052	0.013	0.256
1987	0.002	0.012	4.653	0.030	0.015	0.506	0.031	0.006	0.208
1988	0.005	0.001	0.132	0.036	0.005	0.131	0.036	0.007	0.207
1989	0.005	0.068	14.825	0.046	0.018	0.377	0.047	0.009	0.185
1990	0.040	0.002	0.049	0.063	0.004	0.061	0.064	0.011	0.174
1991	0.044	0.013	0.301	0.090	0.013	0.148	0.091	0.015	0.169
1992	0.049	0.001	0.013	0.109	0.003	0.028	0.110	0.018	0.166
1993	0.042	0.006	0.152	0.085	0.015	0.173	0.086	0.013	0.153
1994	0.055	0.001	0.018	0.111	0.004	0.037	0.113	0.016	0.145
1995	0.079	0.007	0.094	0.202	0.013	0.064	0.205	0.031	0.154
1996	0.057	0.001	0.018	0.234	0.007	0.029	0.261	0.036	0.137
1997	0.061	0.009	0.141	0.167	0.016	0.095	0.201	0.013	0.067
1998	0.053	0.005	0.101	0.181	0.005	0.026	0.209	0.014	0.068
1999	0.055	0.011	0.202	0.166	0.016	0.098	0.195	0.013	0.068
2000	0.059	0.007	0.120	0.162	0.007	0.041	0.194	0.013	0.066
2001	0.047	0.015	0.328	0.168	0.017	0.099	0.192	0.012	0.063
2002	0.051	0.005	0.101	0.181	0.006	0.031	0.208	0.013	0.061
2003	0.067	0.018	0.270	0.186	0.025	0.133	0.222	0.013	0.060
2004	0.065	0.004	0.061	0.213	0.009	0.040	0.248	0.017	0.068
2005	0.058	0.013	0.228	0.215	0.020	0.094	0.244	0.016	0.067
2006	0.079	0.005	0.059	0.248	0.006	0.025	0.290	0.018	0.064
2007	0.060	0.016	0.270	0.184	0.018	0.100	0.216	0.014	0.065
2008	0.052	0.006	0.123	0.203	0.009	0.045	0.229	0.016	0.068
2009	0.070	0.031	0.446	0.186	0.021	0.114	0.224	0.014	0.063
2010	0.074	0.004	0.049	0.224	0.007	0.031	0.264	0.017	0.065
2011	0.072	0.035	0.478	0.232	0.027	0.117	0.270	0.017	0.064
2012	0.084	0.003	0.040	0.224	0.005	0.024	0.269	0.018	0.068
2013	0.093	0.012	0.132	0.324	0.020	0.063	0.372	0.026	0.070
2014	0.107	0.003	0.026	0.233	0.004	0.017	0.294	0.022	0.075
2015	0.089	0.014	0.152	0.207	0.018	0.089	0.256	0.020	0.078
2016	0.120	0.003	0.023	0.229	0.004	0.017	0.299	0.024	0.081
2017	0.084	0.012	0.147	0.293	0.017	0.056	0.337	0.029	0.087
2018	0.071	0.003	0.047	0.209	0.003	0.015	0.246	0.022	0.090
2019	0.056	0.012	0.211	0.187	0.017	0.090	0.216	0.020	0.092
2020	0.052	0.002	0.047	0.103	0.003	0.033	0.151	0.018	0.122
2021	0.042	0.012	0.276	0.114	0.025	0.221	0.152	0.018	0.122
2022	0.041	0.003	0.071	0.170	0.006	0.038	0.207	0.027	0.131
2023	0.044	0.012	0.273	0.212	0.047	0.221	0.237	0.049	0.205

Table X4 cont.

Year	Recruitment	SD	CV
1982	37,364,100	3,561,750	0.095
1983	75,602,800	6,004,810	0.079
1984	62,859,700	4,971,380	0.079
1985	68,479,300	5,140,620	0.075
1986	67,611,600	5,071,660	0.075
1987	74,169,300	5,384,940	0.073
1988	93,300,800	6,426,560	0.069
1989	106,655,000	7,274,910	0.068
1990	130,941,000	8,472,950	0.065
1991	104,485,000	7,631,770	0.073
1992	108,762,000	8,080,020	0.074
1993	133,935,000	9,225,910	0.069
1994	285,297,000	14,524,200	0.051
1995	186,734,000	11,447,800	0.061
1996	234,018,000	13,186,100	0.056
1997	258,960,000	13,727,900	0.053
1998	148,052,000	9,929,320	0.067
1999	152,875,000	9,909,210	0.065
2000	124,486,000	8,956,900	0.072
2001	196,467,000	11,283,100	0.057
2002	221,336,000	11,926,200	0.054
2003	127,967,000	8,776,480	0.069
2004	304,432,000	13,794,500	0.045
2005	158,153,000	9,576,770	0.061
2006	135,236,000	8,615,300	0.064
2007	88,441,000	6,659,590	0.075
2008	126,912,000	8,010,310	0.063
2009	75,196,700	5,917,220	0.079
2010	96,903,000	6,899,820	0.071
2011	125,307,000	8,087,160	0.065
2012	192,360,000	10,784,700	0.056
2013	66,597,300	5,843,220	0.088
2014	82,938,200	6,642,880	0.080
2015	153,154,000	10,612,200	0.069
2016	228,067,000	15,322,400	0.067
2017	111,488,000	9,507,160	0.085
2018	130,105,000	11,341,500	0.087
2019	165,265,000	14,827,500	0.090
2020	120,143,000	12,559,800	0.105
2021	85,158,100	11,605,200	0.136
2022	76,967,300	10,874,800	0.141
2023	96,681,400	16,032,400	0.166

Catch Selectivity Parameters

Bay				Ocean			
	Estimate	SD	CV		Estimate	SD	CV
1982-1984				1982-1984			
α	-5.451	0.197	0.04	α	3.484	0.194	0.06
β	2.551	0.043	0.02	β	0.820	0.086	0.10
ϒ	0.830	0.020	0.02	1985-1989			
1985-1989				α	4.713	0.383	0.08
α	-3.922	0.496	0.13	β	0.473	0.051	0.11
β	2.292	0.090	0.04				
ϒ	0.958	0.013	0.01	1990-1996			
1990-1995				α	6.186	0.508	0.08
α	-2.060	0.101	0.05	β	0.345	0.034	0.10
β	4.468	0.188	0.04				
ϒ	0.816	0.033	0.04	1997-2019			
1996-2022				α	4.932	0.170	0.03
α	-1.783	0.059	0.03	β	0.450	0.022	0.05
β	3.710	0.085	0.02				
ϒ	0.953	0.010	0.01	2020-2022			
2023				α	-1.196	0.173	0.14
α	-1.985	0.318	0.16	β	4.656	0.722	0.16
β	3.801	0.377	0.10	ϒ	0.970	0.065	0.07
ϒ	0.888	0.054	0.06				
				2023			
				α	-1.160	0.179	0.15
				β	6.232	1.050	0.17
				ϒ	0.884	0.128	0.14

Survey Selectivity Parameters			
NYOHS	Estimate	SD	CV
α	-3.025	0.511	-0.17
β	2.620	0.154	0.06
ϒ	0.917	0.026	0.03
NJ Trawl			
α	1.43E+00	7.41E-01	0.52
β	2.34E-01	1.57E-01	0.67
MDSSN			
	0.14	0.02	0.14
DE SSN			
α	3.80E+00	2.44E-01	0.06
β	6.35E-01	8.62E-02	0.14
MRIP			
α	2.58E+00	7.63E-02	0.03
β	1.06E+00	6.42E-02	0.06
CTLIST			
α	-2.806	0.393	-0.14
β	2.163	0.160	0.07
ϒ	0.964	0.017	0.02
DE30FT			
α	-1.011	0.755	-0.75
β	1.445	1.173	0.81
ϒ	0.897	0.153	0.17
ChesMap			
α	-3.661	0.595	-0.16
β	2.281	0.138	0.06
ϒ	0.909	0.027	0.03

Catchability Coefficients			
Survey	Estimate	SD	CV
Y	1.28E-07	1.26E-08	0.10
ϒ	8.21E-09	4.98E-10	0.06
)Y	1.32E-07	2.06E-08	0.16
os	1.05E-06	4.65E-08	0.04
e1	2.45E-08	1.79E-09	0.07
;e1	8.07E-09	1.33E-09	0.16
IS	8.83E-08	8.15E-09	0.09
\WL	9.38E-08	2.74E-08	0.29
;N	7.70E-08	6.42E-09	0.08
N	4.26E-08	5.60E-09	0.13
	4.39E-08	2.97E-09	0.07
T	7.97E-09	7.41E-10	0.09
:T	2.66E-08	4.56E-09	0.17
MP	2.46E-06	4.39E-07	0.18

Table X5. Region-specific and total fishing mortality-at-age, 1982-2021

Bay Fishing Mortality-At-Age

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982	0.0001	0.0075	0.0574	0.0246	0.0098	0.0039	0.0015	0.0006	0.0002	0.0001	0.0000	0.0000	0.0000	0.0000	0.0012
1983	0.0001	0.0081	0.0620	0.0266	0.0105	0.0042	0.0017	0.0007	0.0003	0.0001	0.0000	0.0000	0.0000	0.0000	0.0013
1984	0.0001	0.0079	0.0605	0.0260	0.0103	0.0041	0.0016	0.0006	0.0003	0.0001	0.0000	0.0000	0.0000	0.0000	0.0013
1985	0.0000	0.0011	0.0037	0.0033	0.0028	0.0024	0.0020	0.0017	0.0014	0.0012	0.0010	0.0009	0.0007	0.0006	0.0005
1986	0.0001	0.0018	0.0060	0.0054	0.0046	0.0039	0.0033	0.0028	0.0024	0.0020	0.0017	0.0014	0.0012	0.0010	0.0009
1987	0.0000	0.0008	0.0025	0.0022	0.0019	0.0016	0.0014	0.0012	0.0010	0.0008	0.0007	0.0006	0.0005	0.0004	0.0004
1988	0.0000	0.0014	0.0046	0.0041	0.0035	0.0029	0.0025	0.0021	0.0018	0.0015	0.0013	0.0011	0.0009	0.0008	0.0007
1989	0.0000	0.0014	0.0046	0.0042	0.0035	0.0030	0.0025	0.0021	0.0018	0.0015	0.0013	0.0011	0.0009	0.0008	0.0007
1990	0.0002	0.0010	0.0053	0.0216	0.0402	0.0352	0.0249	0.0171	0.0117	0.0080	0.0055	0.0038	0.0026	0.0018	0.0012
1991	0.0002	0.0011	0.0058	0.0237	0.0440	0.0385	0.0273	0.0188	0.0129	0.0088	0.0060	0.0041	0.0028	0.0019	0.0013
1992	0.0002	0.0013	0.0065	0.0266	0.0494	0.0432	0.0307	0.0211	0.0144	0.0099	0.0067	0.0046	0.0032	0.0022	0.0015
1993	0.0002	0.0011	0.0055	0.0226	0.0419	0.0367	0.0260	0.0179	0.0122	0.0084	0.0057	0.0039	0.0027	0.0018	0.0013
1994	0.0003	0.0014	0.0072	0.0294	0.0546	0.0478	0.0339	0.0233	0.0159	0.0109	0.0075	0.0051	0.0035	0.0024	0.0016
1995	0.0004	0.0020	0.0105	0.0427	0.0792	0.0693	0.0492	0.0338	0.0231	0.0158	0.0108	0.0074	0.0051	0.0035	0.0024
1996	0.0007	0.0036	0.0162	0.0426	0.0568	0.0566	0.0528	0.0486	0.0448	0.0412	0.0379	0.0349	0.0321	0.0295	0.0271
1997	0.0008	0.0039	0.0175	0.0460	0.0614	0.0611	0.0570	0.0525	0.0484	0.0445	0.0409	0.0377	0.0346	0.0319	0.0293
1998	0.0007	0.0034	0.0152	0.0398	0.0532	0.0529	0.0494	0.0455	0.0419	0.0386	0.0355	0.0326	0.0300	0.0276	0.0254
1999	0.0007	0.0035	0.0157	0.0411	0.0548	0.0546	0.0509	0.0469	0.0432	0.0397	0.0366	0.0336	0.0309	0.0285	0.0262
2000	0.0007	0.0038	0.0167	0.0439	0.0586	0.0583	0.0544	0.0501	0.0461	0.0425	0.0391	0.0359	0.0331	0.0304	0.0280
2001	0.0006	0.0030	0.0133	0.0349	0.0466	0.0464	0.0433	0.0399	0.0368	0.0338	0.0311	0.0286	0.0263	0.0242	0.0223
2002	0.0006	0.0033	0.0146	0.0384	0.0512	0.0510	0.0476	0.0439	0.0404	0.0371	0.0342	0.0314	0.0289	0.0266	0.0245
2003	0.0008	0.0043	0.0191	0.0501	0.0668	0.0665	0.0621	0.0572	0.0527	0.0485	0.0446	0.0410	0.0377	0.0347	0.0319
2004	0.0008	0.0042	0.0187	0.0489	0.0652	0.0649	0.0606	0.0559	0.0514	0.0473	0.0435	0.0400	0.0368	0.0339	0.0312
2005	0.0007	0.0037	0.0165	0.0431	0.0575	0.0573	0.0534	0.0493	0.0454	0.0417	0.0384	0.0353	0.0325	0.0299	0.0275
2006	0.0010	0.0051	0.0226	0.0592	0.0790	0.0787	0.0734	0.0677	0.0623	0.0573	0.0527	0.0485	0.0446	0.0410	0.0377
2007	0.0007	0.0038	0.0171	0.0449	0.0599	0.0596	0.0556	0.0513	0.0472	0.0434	0.0399	0.0368	0.0338	0.0311	0.0286
2008	0.0006	0.0033	0.0149	0.0390	0.0521	0.0518	0.0484	0.0446	0.0410	0.0378	0.0347	0.0320	0.0294	0.0270	0.0249
2009	0.0009	0.0045	0.0200	0.0525	0.0700	0.0697	0.0650	0.0600	0.0552	0.0508	0.0467	0.0430	0.0395	0.0364	0.0335
2010	0.0009	0.0047	0.0212	0.0555	0.0741	0.0738	0.0688	0.0634	0.0584	0.0537	0.0494	0.0455	0.0418	0.0385	0.0354
2011	0.0009	0.0046	0.0207	0.0543	0.0725	0.0722	0.0673	0.0621	0.0571	0.0526	0.0483	0.0445	0.0409	0.0376	0.0346
2012	0.0010	0.0054	0.0240	0.0629	0.0840	0.0836	0.0780	0.0719	0.0662	0.0609	0.0560	0.0515	0.0474	0.0436	0.0401
2013	0.0011	0.0059	0.0265	0.0693	0.0926	0.0921	0.0859	0.0793	0.0729	0.0671	0.0617	0.0568	0.0522	0.0481	0.0442
2014	0.0013	0.0069	0.0307	0.0805	0.1075	0.1070	0.0998	0.0920	0.0847	0.0779	0.0717	0.0660	0.0607	0.0558	0.0513
2015	0.0011	0.0057	0.0255	0.0669	0.0893	0.0889	0.0829	0.0764	0.0703	0.0647	0.0595	0.0548	0.0504	0.0464	0.0426
2016	0.0015	0.0077	0.0344	0.0900	0.1202	0.1196	0.1116	0.1029	0.0947	0.0871	0.0801	0.0737	0.0678	0.0624	0.0574
2017	0.0010	0.0054	0.0241	0.0632	0.0844	0.0840	0.0784	0.0723	0.0665	0.0612	0.0563	0.0518	0.0477	0.0438	0.0403
2018	0.0009	0.0045	0.0202	0.0529	0.0706	0.0703	0.0656	0.0605	0.0557	0.0512	0.0471	0.0433	0.0399	0.0367	0.0337
2019	0.0007	0.0036	0.0159	0.0418	0.0557	0.0555	0.0518	0.0477	0.0439	0.0404	0.0372	0.0342	0.0315	0.0289	0.0266
2020	0.0006	0.0033	0.0148	0.0387	0.0517	0.0515	0.0480	0.0443	0.0407	0.0375	0.0345	0.0317	0.0292	0.0268	0.0247
2021	0.0005	0.0027	0.0119	0.0312	0.0417	0.0415	0.0387	0.0357	0.0329	0.0302	0.0278	0.0256	0.0235	0.0217	0.0199
2022	0.0005	0.0026	0.0116	0.0304	0.0406	0.0405	0.0377	0.0348	0.0320	0.0295	0.0271	0.0249	0.0229	0.0211	0.0194
2023	0.0005	0.0025	0.0127	0.0358	0.0440	0.0380	0.0308	0.0247	0.0198	0.0159	0.0127	0.0102	0.0082	0.0066	0.0053

Table X5 cont.

Ocean Fishing Mortality-At-Age

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982	0.0001	0.0058	0.0402	0.0933	0.1347	0.1580	0.1695	0.1747	0.1770	0.1781	0.1785	0.1787	0.1788	0.1788	0.1788
1983	0.0001	0.0047	0.0324	0.0751	0.1085	0.1273	0.1365	0.1408	0.1426	0.1435	0.1438	0.1440	0.1440	0.1441	0.1441
1984	0.0000	0.0020	0.0135	0.0313	0.0451	0.0530	0.0568	0.0586	0.0593	0.0597	0.0598	0.0599	0.0599	0.0599	0.0599
1985	0.0006	0.0048	0.0185	0.0434	0.0748	0.1055	0.1312	0.1507	0.1646	0.1740	0.1803	0.1843	0.1870	0.1887	0.1898
1986	0.0002	0.0013	0.0050	0.0118	0.0202	0.0286	0.0355	0.0408	0.0446	0.0471	0.0488	0.0499	0.0506	0.0511	0.0514
1987	0.0001	0.0008	0.0030	0.0069	0.0119	0.0168	0.0210	0.0241	0.0263	0.0278	0.0288	0.0294	0.0299	0.0301	0.0303
1988	0.0001	0.0009	0.0035	0.0081	0.0140	0.0197	0.0246	0.0282	0.0308	0.0326	0.0337	0.0345	0.0350	0.0353	0.0355
1989	0.0001	0.0012	0.0045	0.0106	0.0183	0.0258	0.0321	0.0369	0.0403	0.0426	0.0441	0.0451	0.0458	0.0462	0.0465
1990	0.0002	0.0010	0.0033	0.0079	0.0147	0.0227	0.0310	0.0387	0.0453	0.0506	0.0547	0.0579	0.0602	0.0619	0.0632
1991	0.0002	0.0014	0.0047	0.0113	0.0209	0.0324	0.0442	0.0551	0.0645	0.0721	0.0780	0.0824	0.0858	0.0882	0.0900
1992	0.0003	0.0017	0.0057	0.0136	0.0252	0.0391	0.0533	0.0665	0.0777	0.0869	0.0940	0.0994	0.1034	0.1064	0.1085
1993	0.0002	0.0013	0.0045	0.0107	0.0198	0.0307	0.0419	0.0522	0.0611	0.0682	0.0738	0.0781	0.0812	0.0836	0.0852
1994	0.0003	0.0017	0.0058	0.0139	0.0258	0.0400	0.0546	0.0681	0.0796	0.0890	0.0963	0.1018	0.1059	0.1090	0.1112
1995	0.0006	0.0031	0.0106	0.0253	0.0470	0.0728	0.0994	0.1240	0.1450	0.1620	0.1753	0.1854	0.1929	0.1984	0.2024
1996	0.0006	0.0036	0.0123	0.0293	0.0543	0.0843	0.1150	0.1434	0.1677	0.1874	0.2028	0.2145	0.2231	0.2295	0.2341
1997	0.0005	0.0042	0.0164	0.0389	0.0669	0.0943	0.1170	0.1340	0.1460	0.1541	0.1594	0.1629	0.1651	0.1665	0.1674
1998	0.0005	0.0045	0.0178	0.0421	0.0725	0.1022	0.1268	0.1452	0.1582	0.1670	0.1728	0.1765	0.1789	0.1804	0.1814
1999	0.0005	0.0041	0.0162	0.0385	0.0663	0.0934	0.1159	0.1328	0.1447	0.1527	0.1580	0.1614	0.1636	0.1650	0.1658
2000	0.0005	0.0040	0.0159	0.0377	0.0649	0.0914	0.1134	0.1299	0.1416	0.1494	0.1546	0.1579	0.1600	0.1614	0.1623
2001	0.0005	0.0042	0.0165	0.0391	0.0673	0.0948	0.1177	0.1348	0.1468	0.1550	0.1603	0.1638	0.1660	0.1674	0.1683
2002	0.0005	0.0045	0.0177	0.0420	0.0724	0.1020	0.1266	0.1450	0.1579	0.1667	0.1724	0.1762	0.1785	0.1801	0.1810
2003	0.0005	0.0046	0.0183	0.0433	0.0746	0.1050	0.1303	0.1493	0.1626	0.1716	0.1775	0.1814	0.1838	0.1854	0.1864
2004	0.0006	0.0053	0.0209	0.0495	0.0853	0.1202	0.1491	0.1708	0.1860	0.1964	0.2031	0.2075	0.2103	0.2121	0.2133
2005	0.0006	0.0053	0.0210	0.0498	0.0858	0.1209	0.1500	0.1718	0.1872	0.1975	0.2044	0.2088	0.2116	0.2134	0.2145
2006	0.0007	0.0062	0.0243	0.0575	0.0991	0.1396	0.1732	0.1985	0.2162	0.2282	0.2360	0.2411	0.2444	0.2465	0.2478
2007	0.0005	0.0046	0.0180	0.0427	0.0736	0.1037	0.1286	0.1473	0.1605	0.1694	0.1752	0.1790	0.1815	0.1830	0.1840
2008	0.0006	0.0050	0.0198	0.0471	0.0811	0.1142	0.1417	0.1623	0.1768	0.1866	0.1931	0.1972	0.1999	0.2016	0.2027
2009	0.0005	0.0046	0.0182	0.0431	0.0742	0.1046	0.1297	0.1486	0.1619	0.1709	0.1768	0.1806	0.1830	0.1846	0.1856
2010	0.0006	0.0056	0.0220	0.0521	0.0897	0.1264	0.1568	0.1796	0.1957	0.2065	0.2137	0.2183	0.2212	0.2231	0.2243
2011	0.0007	0.0058	0.0227	0.0538	0.0928	0.1306	0.1621	0.1857	0.2023	0.2135	0.2209	0.2256	0.2287	0.2306	0.2319
2012	0.0006	0.0056	0.0219	0.0519	0.0895	0.1260	0.1564	0.1791	0.1952	0.2060	0.2131	0.2177	0.2206	0.2225	0.2237
2013	0.0009	0.0081	0.0317	0.0752	0.1295	0.1824	0.2263	0.2593	0.2824	0.2981	0.3084	0.3150	0.3193	0.3220	0.3237
2014	0.0007	0.0058	0.0228	0.0542	0.0933	0.1315	0.1631	0.1869	0.2036	0.2148	0.2223	0.2271	0.2301	0.2321	0.2333
2015	0.0006	0.0051	0.0202	0.0480	0.0827	0.1165	0.1445	0.1656	0.1804	0.1903	0.1969	0.2012	0.2039	0.2056	0.2067
2016	0.0007	0.0057	0.0225	0.0532	0.0917	0.1292	0.1603	0.1836	0.2000	0.2111	0.2184	0.2231	0.2262	0.2281	0.2293
2017	0.0008	0.0073	0.0287	0.0680	0.1171	0.1649	0.2046	0.2344	0.2554	0.2695	0.2788	0.2848	0.2887	0.2912	0.2927
2018	0.0006	0.0052	0.0204	0.0484	0.0835	0.1175	0.1459	0.1671	0.1820	0.1921	0.1987	0.2030	0.2058	0.2075	0.2086
2019	0.0005	0.0047	0.0183	0.0435	0.0749	0.1055	0.1309	0.1500	0.1634	0.1724	0.1784	0.1822	0.1847	0.1863	0.1873
2020	0.0017	0.0052	0.0152	0.0380	0.0704	0.0941	0.1028	0.1034	0.1010	0.0979	0.0946	0.0914	0.0882	0.0852	0.0822
2021	0.0018	0.0057	0.0167	0.0417	0.0774	0.1034	0.1130	0.1136	0.1111	0.1076	0.1040	0.1004	0.0970	0.0936	0.0904
2022	0.0028	0.0086	0.0251	0.0625	0.1159	0.1549	0.1693	0.1702	0.1664	0.1612	0.1558	0.1504	0.1452	0.1402	0.1353
2023	0.0014	0.0039	0.0108	0.0287	0.0694	0.1360	0.1945	0.2124	0.2014	0.1808	0.1594	0.1397	0.1222	0.1068	0.0933

Table X5 cont.

Total Fishing Mortality-At-Age

	Age														
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982	0.0002	0.0133	0.0976	0.1179	0.1444	0.1619	0.1710	0.1753	0.1773	0.1782	0.1785	0.1787	0.1788	0.1788	0.1801
1983	0.0002	0.0127	0.0944	0.1018	0.1190	0.1315	0.1382	0.1414	0.1429	0.1436	0.1439	0.1440	0.1441	0.1441	0.1454
1984	0.0001	0.0098	0.0739	0.0572	0.0554	0.0570	0.0584	0.0592	0.0596	0.0598	0.0599	0.0599	0.0599	0.0600	0.0613
1985	0.0006	0.0059	0.0221	0.0467	0.0775	0.1078	0.1332	0.1524	0.1660	0.1752	0.1813	0.1852	0.1877	0.1893	0.1903
1986	0.0002	0.0031	0.0110	0.0171	0.0248	0.0324	0.0388	0.0436	0.0469	0.0491	0.0505	0.0514	0.0518	0.0521	0.0523
1987	0.0001	0.0015	0.0054	0.0092	0.0138	0.0185	0.0223	0.0252	0.0273	0.0286	0.0295	0.0300	0.0304	0.0306	0.0307
1988	0.0002	0.0023	0.0080	0.0122	0.0175	0.0227	0.0270	0.0303	0.0326	0.0341	0.0350	0.0356	0.0359	0.0361	0.0362
1989	0.0002	0.0026	0.0091	0.0148	0.0218	0.0288	0.0347	0.0390	0.0421	0.0441	0.0454	0.0462	0.0467	0.0470	0.0471
1990	0.0004	0.0020	0.0086	0.0295	0.0548	0.0579	0.0560	0.0558	0.0570	0.0586	0.0602	0.0616	0.0628	0.0637	0.0644
1991	0.0005	0.0025	0.0105	0.0350	0.0649	0.0709	0.0715	0.0739	0.0773	0.0808	0.0840	0.0866	0.0886	0.0902	0.0913
1992	0.0005	0.0029	0.0122	0.0402	0.0746	0.0823	0.0840	0.0875	0.0921	0.0967	0.1007	0.1040	0.1066	0.1085	0.1100
1993	0.0004	0.0024	0.0100	0.0332	0.0617	0.0673	0.0679	0.0701	0.0733	0.0766	0.0796	0.0820	0.0839	0.0854	0.0865
1994	0.0006	0.0031	0.0130	0.0433	0.0804	0.0878	0.0885	0.0914	0.0956	0.0999	0.1037	0.1069	0.1094	0.1113	0.1128
1995	0.0009	0.0051	0.0211	0.0680	0.1262	0.1422	0.1486	0.1578	0.1681	0.1779	0.1861	0.1928	0.1980	0.2019	0.2048
1996	0.0013	0.0072	0.0285	0.0718	0.1112	0.1408	0.1678	0.1921	0.2125	0.2286	0.2407	0.2493	0.2552	0.2590	0.2613
1997	0.0012	0.0081	0.0339	0.0848	0.1283	0.1554	0.1740	0.1866	0.1944	0.1986	0.2003	0.2005	0.1997	0.1983	0.1967
1998	0.0012	0.0079	0.0330	0.0820	0.1257	0.1551	0.1762	0.1908	0.2001	0.2055	0.2082	0.2091	0.2089	0.2080	0.2068
1999	0.0011	0.0076	0.0319	0.0796	0.1211	0.1480	0.1668	0.1797	0.1879	0.1924	0.1945	0.1950	0.1945	0.1934	0.1920
2000	0.0012	0.0078	0.0326	0.0815	0.1235	0.1497	0.1678	0.1801	0.1877	0.1919	0.1936	0.1938	0.1931	0.1918	0.1902
2001	0.0010	0.0072	0.0298	0.0740	0.1140	0.1413	0.1610	0.1747	0.1836	0.1888	0.1914	0.1924	0.1923	0.1916	0.1906
2002	0.0011	0.0078	0.0324	0.0804	0.1236	0.1530	0.1741	0.1888	0.1983	0.2038	0.2066	0.2076	0.2075	0.2067	0.2055
2003	0.0013	0.0089	0.0374	0.0933	0.1414	0.1715	0.1924	0.2065	0.2153	0.2201	0.2221	0.2224	0.2216	0.2201	0.2183
2004	0.0014	0.0095	0.0395	0.0984	0.1505	0.1851	0.2097	0.2266	0.2374	0.2436	0.2466	0.2475	0.2472	0.2460	0.2444
2005	0.0013	0.0090	0.0375	0.0929	0.1434	0.1782	0.2034	0.2211	0.2325	0.2393	0.2427	0.2441	0.2441	0.2433	0.2420
2006	0.0017	0.0112	0.0469	0.1167	0.1781	0.2183	0.2466	0.2661	0.2784	0.2854	0.2887	0.2896	0.2890	0.2875	0.2856
2007	0.0013	0.0084	0.0351	0.0876	0.1335	0.1633	0.1842	0.1986	0.2077	0.2128	0.2152	0.2158	0.2153	0.2141	0.2126
2008	0.0012	0.0084	0.0347	0.0861	0.1332	0.1660	0.1901	0.2069	0.2179	0.2244	0.2278	0.2292	0.2293	0.2287	0.2276
2009	0.0014	0.0091	0.0382	0.0956	0.1443	0.1743	0.1948	0.2086	0.2171	0.2217	0.2235	0.2236	0.2226	0.2210	0.2191
2010	0.0015	0.0103	0.0431	0.1076	0.1638	0.2001	0.2256	0.2431	0.2541	0.2602	0.2631	0.2637	0.2631	0.2616	0.2597
2011	0.0015	0.0104	0.0434	0.1081	0.1652	0.2028	0.2294	0.2478	0.2594	0.2660	0.2692	0.2701	0.2696	0.2683	0.2665
2012	0.0017	0.0109	0.0459	0.1148	0.1734	0.2096	0.2344	0.2510	0.2613	0.2668	0.2691	0.2692	0.2680	0.2661	0.2638
2013	0.0020	0.0140	0.0582	0.1445	0.2220	0.2745	0.3123	0.3385	0.3554	0.3652	0.3701	0.3718	0.3715	0.3701	0.3680
2014	0.0020	0.0127	0.0536	0.1347	0.2008	0.2385	0.2629	0.2789	0.2883	0.2928	0.2939	0.2930	0.2908	0.2879	0.2847
2015	0.0017	0.0109	0.0458	0.1149	0.1719	0.2053	0.2274	0.2420	0.2507	0.2551	0.2564	0.2559	0.2543	0.2520	0.2494
2016	0.0021	0.0134	0.0568	0.1433	0.2119	0.2488	0.2719	0.2865	0.2947	0.2982	0.2985	0.2969	0.2940	0.2905	0.2867
2017	0.0019	0.0127	0.0528	0.1312	0.2015	0.2490	0.2830	0.3067	0.3219	0.3307	0.3351	0.3366	0.3364	0.3350	0.3330
2018	0.0015	0.0097	0.0406	0.1014	0.1541	0.1879	0.2114	0.2276	0.2377	0.2433	0.2458	0.2464	0.2456	0.2442	0.2424
2019	0.0012	0.0082	0.0343	0.0852	0.1306	0.1610	0.1827	0.1977	0.2073	0.2128	0.2156	0.2164	0.2162	0.2152	0.2139
2020	0.0023	0.0085	0.0300	0.0767	0.1221	0.1456	0.1508	0.1476	0.1418	0.1354	0.1291	0.1231	0.1174	0.1120	0.1069
2021	0.0024	0.0084	0.0287	0.0730	0.1191	0.1450	0.1517	0.1493	0.1439	0.1379	0.1318	0.1260	0.1205	0.1153	0.1103
2022	0.0033	0.0112	0.0367	0.0930	0.1565	0.1954	0.2070	0.2050	0.1984	0.1907	0.1829	0.1754	0.1682	0.1613	0.1547
2023	0.0019	0.0065	0.0235	0.0645	0.1134	0.1740	0.2253	0.2371	0.2212	0.1967	0.1721	0.1499	0.1303	0.1133	0.0986

Table X6. Estimates of age-specific population abundance, 1982-2021

	Age																
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total	8+
1982	37,364,100	8,588,370	3,226,070	2,476,530	984,780	404,374	330,079	213,479	185,704	275,932	192,122	313,355	151,055	108,728	278,367	55,093,045	1,718,742
1983	75,602,800	12,068,000	4,293,690	1,865,850	1,582,410	663,821	284,418	239,450	154,199	133,873	198,742	138,323	225,568	108,728	278,367	97,838,239	1,477,250
1984	62,859,700	24,418,600	6,036,480	2,491,240	1,211,610	1,094,090	481,314	213,208	178,921	115,049	99,817	148,139	103,090	168,103	288,191	99,907,552	1,314,518
1985	68,479,300	20,303,500	12,250,200	3,574,720	1,691,400	892,742	854,611	390,767	172,963	145,090	93,277	80,920	120,090	83,569	369,578	109,502,727	1,456,254
1986	67,611,600	22,107,700	10,225,700	7,640,310	2,452,660	1,218,990	662,796	643,827	288,791	126,101	104,810	66,973	57,873	85,672	322,502	113,616,305	1,696,549
1987	74,169,300	21,836,200	11,165,400	6,448,960	5,399,460	1,863,340	975,896	548,761	530,513	237,174	103,335	85,769	54,759	47,295	333,442	123,799,604	1,941,048
1988	93,300,800	23,956,400	11,045,800	7,080,820	4,594,000	4,147,350	1,512,740	821,426	460,560	444,341	198,380	86,357	71,638	45,722	317,811	148,084,146	2,446,236
1989	106,655,000	30,134,800	12,109,200	6,987,030	5,028,780	3,515,920	3,352,810	1,267,300	685,903	383,703	369,638	164,873	71,731	59,485	301,786	171,087,958	3,304,418
1990	130,941,000	34,446,800	15,227,600	7,650,960	4,949,430	3,831,890	2,824,960	2,787,500	1,049,010	566,020	315,996	304,018	135,495	58,921	296,639	205,386,239	5,513,599
1991	104,485,000	42,283,100	17,416,500	9,626,300	5,340,420	3,648,980	2,990,600	2,299,140	2,268,960	852,882	459,454	256,089	246,034	109,526	286,987	192,569,972	6,779,072
1992	108,762,000	33,736,700	21,367,700	10,989,000	6,682,810	3,897,720	2,810,970	2,396,330	1,837,910	1,807,590	677,075	363,605	202,143	193,811	311,598	196,036,962	7,790,062
1993	133,935,000	35,115,100	17,041,600	13,459,400	7,589,240	4,830,600	2,968,700	2,224,620	1,889,700	1,442,670	1,412,390	526,927	282,048	156,400	389,927	223,264,322	8,324,682
1994	285,297,000	43,246,700	17,747,600	10,758,100	9,360,100	5,556,950	3,734,550	2,387,510	1,785,150	1,511,540	1,150,150	1,122,690	417,829	223,222	431,404	384,730,495	9,029,495
1995	186,734,000	92,108,400	21,841,600	11,169,900	7,406,490	6,726,490	4,209,160	2,942,140	1,875,510	1,396,460	1,177,330	892,402	868,332	322,356	503,596	340,174,166	9,978,126
1996	234,018,000	60,265,400	46,424,800	13,636,700	7,502,680	5,084,410	4,825,430	3,122,640	2,162,740	1,364,470	1,006,110	841,231	633,409	613,151	579,924	382,081,095	10,323,675
1997	258,960,000	75,495,500	30,311,800	28,770,400	9,124,160	5,228,440	3,652,350	3,511,810	2,218,020	1,505,120	934,388	680,720	564,275	422,380	791,697	422,171,060	10,628,410
1998	148,052,000	83,550,900	37,939,400	18,683,000	19,001,600	6,250,310	3,701,530	2,641,650	2,508,220	1,571,870	1,062,170	658,237	479,458	397,761	857,909	327,356,015	10,177,275
1999	152,875,000	47,770,300	41,994,900	23,406,800	12,374,800	13,050,100	4,426,050	2,671,330	1,878,780	1,767,290	1,101,560	742,368	459,644	334,876	878,539	305,732,337	9,834,387
2000	124,486,000	49,327,600	24,017,400	25,936,300	15,540,800	8,538,000	9,307,430	3,224,210	1,921,000	1,340,130	1,254,870	780,533	525,764	325,695	861,605	267,387,337	10,233,807
2001	196,467,000	40,166,100	24,796,600	14,822,600	17,186,200	10,697,600	6,078,890	6,773,450	2,317,780	1,370,470	952,107	889,963	553,441	373,069	844,523	324,289,793	14,074,803
2002	221,336,000	63,399,200	20,203,500	15,346,600	9,895,990	11,942,900	7,681,040	4,454,190	4,895,320	1,660,330	976,643	676,713	631,928	393,004	865,851	364,359,209	14,553,979
2003	127,967,000	71,418,000	31,870,300	12,472,000	10,180,700	6,810,750	8,475,350	5,554,690	3,174,080	3,455,590	1,165,570	683,709	473,270	442,005	881,917	285,024,931	15,830,831
2004	304,432,000	41,282,400	35,860,800	19,576,300	8,167,420	6,883,390	4,744,390	6,018,290	3,888,990	2,202,830	2,386,730	803,399	471,137	326,394	915,468	437,959,938	17,013,238
2005	158,153,000	98,204,900	20,717,200	21,979,700	12,755,300	5,471,910	4,730,500	3,311,210	4,129,550	2,639,810	1,486,030	1,605,270	539,860	316,713	836,755	336,877,708	14,865,198
2006	135,236,000	51,022,000	49,305,900	12,724,200	14,399,600	8,607,120	3,786,610	3,322,170	2,284,690	2,816,970	1,788,640	1,003,380	1,082,440	364,028	779,111	288,522,859	13,441,429
2007	88,441,000	43,613,400	25,560,400	29,999,900	8,139,960	9,384,600	5,722,040	2,546,890	2,191,350	1,488,530	1,822,530	1,153,420	646,466	697,828	739,045	222,147,359	11,286,059
2008	126,912,000	28,533,800	21,910,400	15,735,400	19,759,200	5,547,320	6,591,680	4,096,400	1,797,270	1,532,390	1,035,610	1,264,970	800,086	448,662	999,156	236,964,344	11,974,544
2009	75,196,700	40,947,600	14,335,200	13,493,800	10,379,600	13,470,000	3,885,600	4,691,510	2,866,800	1,244,090	1,053,860	709,776	865,771	547,530	992,185	184,680,022	12,971,522
2010	96,903,000	24,257,700	20,557,000	8,798,030	8,816,910	6,997,620	9,357,590	2,752,480	3,277,760	1,985,960	857,921	725,405	488,521	596,480	1,063,820	187,436,197	11,748,347
2011	125,307,000	31,255,000	12,163,300	12,554,200	5,679,980	5,829,110	4,737,180	6,427,480	1,857,870	2,188,230	1,317,670	567,614	479,621	323,219	1,101,440	211,788,914	14,263,144
2012	192,360,000	40,416,400	15,670,500	7,426,080	8,100,520	3,749,890	3,935,670	3,241,530	4,318,180	1,233,720	1,443,490	866,465	372,911	315,259	938,971	284,389,586	12,730,526
2013	66,597,300	62,036,200	20,253,000	9,543,610	4,759,560	5,304,120	2,514,580	2,679,760	2,170,600	2,861,980	813,181	949,314	569,765	245,504	828,725	182,127,199	11,118,829
2014	82,938,200	21,469,400	30,992,700	12,184,300	5,938,020	2,968,680	3,333,300	1,583,840	1,644,160	1,309,510	1,709,760	483,413	563,369	338,219	639,654	168,096,525	8,271,925
2015	153,154,000	26,739,200	10,739,800	18,731,000	7,655,810	3,783,210	1,934,150	2,205,700	1,031,450	1,060,750	841,052	1,096,820	310,403	362,540	632,440	230,278,325	7,541,155
2016	228,067,000	49,391,300	13,400,400	6,541,700	12,005,000	5,020,460	2,547,850	1,326,140	1,490,430	690,928	707,461	560,155	730,875	207,182	666,741	323,353,622	6,379,912
2017	111,488,000	73,518,300	24,689,800	8,072,670	4,075,320	7,564,400	3,237,260	1,670,930	857,067	955,370	441,338	451,755	358,299	468,845	564,197	238,413,551	5,767,801
2018	130,105,000	35,947,600	36,776,500	14,933,400	5,090,040	2,594,660	4,876,880	2,099,530	1,058,330	534,662	590,752	271,701	277,691	220,307	636,724	236,013,777	5,689,697
2019	165,265,000	41,967,500	18,035,800	22,516,400	9,701,210	3,398,080	1,778,200	3,397,620	1,439,300	718,223	360,807	397,648	182,792	186,956	578,611	269,924,147	7,261,957
2020	120,143,000	53,321,800	21,087,400	11,112,700	14,865,000	6,630,030	2,392,210	1,274,980	2,399,780	1,006,890	499,670	250,332	275,651	126,746	531,867	235,918,056	6,365,916
2021	85,158,100	38,720,900	26,784,800	13,048,600	7,399,390	10,246,600	4,740,090	1,770,770	946,785	1,792,490	756,905	377,985	190,510	210,977	508,908	192,653,810	6,555,330
2022	76,967,300	27,444,300	19,452,800	16,596,400	8,720,710	5,115,800	7,330,100	3,505,450	1,312,700	705,664	1,344,130	571,010	286,811	145,358	554,104	170,052,637	8,425,227
2023	96,681,400	24,782,200	13,749,300	11,957,000	10,872,400	5,807,770	3,479,720	5,129,420	2,458,020	926,552	501,940	963,536	412,419	208,649	515,022	178,445,348	11,115,558

Table X7. Estimates of female spawning stock biomass, 1982-2023.

	Age														
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
1982	0.0	0.0	0.0	142.0	365.4	409.4	891.1	825.6	886.1	2,010.4	1,860.7	3,105.7	1,861.0	1,496.7	4,454.6	18,308.5
1983	0.0	0.0	0.0	100.3	558.8	548.4	616.4	845.9	758.0	875.4	1,654.2	1,320.5	2,550.2	1,419.7	4,156.7	15,404.5
1984	0.0	0.0	0.0	147.0	457.3	926.4	1,270.7	742.6	950.2	728.9	747.4	1,603.8	1,194.6	2,238.1	4,503.3	15,510.3
1985	0.0	0.0	0.0	249.0	572.5	808.9	2,202.7	1,415.2	921.9	907.7	718.3	738.3	1,361.3	1,043.0	5,204.1	16,142.8
1986	0.0	0.0	0.0	627.8	910.6	953.3	1,486.0	2,205.4	1,310.8	687.1	723.5	561.0	547.9	905.0	3,673.1	14,591.5
1987	0.0	0.0	0.0	502.6	2,241.1	1,422.8	1,977.9	1,700.8	2,392.1	1,285.9	681.0	728.4	522.7	501.7	4,122.3	18,079.2
1988	0.0	0.0	0.0	539.9	2,179.3	4,058.2	3,481.6	2,472.2	1,964.7	2,169.3	1,430.1	768.1	703.3	495.5	3,938.9	24,201.0
1989	0.0	0.0	0.0	547.2	2,313.0	3,974.6	9,739.7	4,940.8	3,245.1	2,559.1	2,648.3	1,429.6	745.6	667.4	3,847.7	36,658.0
1990	0.0	0.0	0.0	576.5	1,917.6	3,789.9	7,889.0	11,043.2	5,091.2	2,950.0	2,195.9	2,522.9	1,232.7	595.9	3,228.6	43,033.1
1991	0.0	0.0	0.0	743.8	2,195.9	2,927.9	7,873.4	8,530.3	11,938.2	4,518.8	3,473.2	1,892.8	2,285.9	1,110.4	3,310.0	50,800.7
1992	0.0	0.0	0.0	801.6	2,934.7	3,582.7	7,148.7	9,008.8	10,071.3	12,053.6	5,293.0	3,859.0	2,274.1	2,521.3	5,053.7	64,602.5
1993	0.0	0.0	0.0	1,009.2	3,206.0	4,441.8	7,723.6	8,763.3	10,521.6	9,694.1	11,610.1	5,067.5	3,267.3	2,014.1	5,592.1	72,910.8
1994	0.0	0.0	0.0	871.8	4,062.9	4,995.6	9,846.1	9,439.7	9,804.0	9,698.6	9,538.2	10,651.2	4,569.9	2,734.1	5,963.6	82,175.8
1995	0.0	0.0	0.0	952.5	3,215.8	6,250.9	11,693.7	11,582.6	10,790.7	9,960.9	7,898.8	7,862.8	8,824.6	3,619.8	6,198.2	88,851.2
1996	0.0	0.0	0.0	1,151.4	3,648.4	5,508.0	15,383.4	13,936.6	13,051.0	10,128.6	8,165.6	7,118.3	6,641.2	7,095.5	7,619.0	99,447.0
1997	0.0	0.0	0.0	2,589.7	4,052.5	4,996.3	9,452.3	12,703.9	12,430.5	11,381.0	8,073.1	6,158.8	6,159.8	5,238.5	11,340.4	94,576.7
1998	0.0	0.0	0.0	1,164.0	7,251.0	4,927.2	9,343.1	9,508.8	13,039.2	9,375.6	7,609.6	5,883.8	4,769.0	4,503.7	10,724.9	88,099.9
1999	0.0	0.0	0.0	1,340.9	3,763.8	8,627.5	8,262.0	8,897.5	9,763.0	11,503.8	8,049.9	6,194.1	4,801.3	3,955.2	12,335.9	87,495.0
2000	0.0	0.0	0.0	1,464.5	4,678.3	5,864.2	18,622.0	9,967.9	10,295.7	8,240.1	10,237.9	7,178.6	5,829.2	4,189.1	13,283.0	99,850.5
2001	0.0	0.0	0.0	962.3	5,676.3	8,298.9	13,047.0	21,508.7	11,464.5	8,965.6	7,018.2	6,948.6	5,419.6	4,142.0	10,148.8	103,600.5
2002	0.0	0.0	0.0	895.4	3,387.6	9,359.6	17,321.8	15,302.2	23,150.9	10,313.1	7,564.8	5,789.9	6,254.2	4,519.6	11,802.3	115,661.3
2003	0.0	0.0	0.0	677.3	3,375.9	5,347.1	18,653.5	18,391.8	15,450.6	20,386.1	8,507.7	5,754.1	4,682.8	4,989.4	11,299.7	117,516.0
2004	0.0	0.0	0.0	1,047.1	2,860.8	5,294.6	10,524.9	19,693.5	18,573.9	12,893.9	16,680.8	6,435.4	4,483.7	3,520.5	11,205.9	113,215.0
2005	0.0	0.0	0.0	1,268.1	4,177.9	4,442.2	10,501.5	11,600.4	20,454.0	15,585.5	10,672.8	13,753.4	5,356.9	3,575.1	11,045.5	112,433.3
2006	0.0	0.0	0.0	683.1	4,453.6	6,112.7	7,928.6	11,163.5	11,942.5	17,109.8	12,906.5	8,250.7	10,961.6	4,179.1	10,355.2	106,046.9
2007	0.0	0.0	0.0	1,441.6	2,536.7	6,960.5	12,685.4	8,400.0	11,626.0	9,617.5	14,272.8	10,119.2	6,865.7	8,541.0	10,700.2	103,766.5
2008	0.0	0.0	0.0	843.1	6,187.0	4,587.4	16,830.6	14,265.2	9,304.3	10,356.3	8,083.4	11,082.9	8,434.5	5,409.3	13,700.9	109,084.9
2009	0.0	0.0	0.0	733.0	3,064.9	10,744.7	9,362.1	17,524.2	15,274.3	7,943.4	8,077.6	6,022.5	8,820.9	6,373.8	13,118.1	107,059.4
2010	0.0	0.0	0.0	476.2	2,659.8	5,480.1	21,359.5	9,252.0	16,413.7	12,616.6	6,529.6	5,911.7	4,827.8	6,743.9	13,722.0	105,992.8
2011	0.0	0.0	0.0	743.2	1,719.7	4,333.3	10,524.1	21,079.2	9,227.6	13,433.0	9,345.8	4,956.1	4,775.4	3,709.0	14,697.7	98,544.1
2012	0.0	0.0	0.0	457.1	2,786.5	2,903.9	9,091.2	11,653.4	21,759.0	8,190.9	10,984.5	7,636.2	3,989.1	3,815.7	13,325.2	96,592.6
2013	0.0	0.0	0.0	506.7	1,643.7	4,352.2	5,542.8	9,012.1	11,364.4	17,617.7	6,385.6	8,506.0	6,096.1	3,004.7	11,775.6	85,807.5
2014	0.0	0.0	0.0	597.5	1,884.5	2,267.1	7,644.9	5,265.4	8,726.4	8,859.6	13,111.7	4,846.8	6,593.1	4,569.5	10,466.8	74,833.3
2015	0.0	0.0	0.0	1,068.9	2,667.6	3,322.6	4,557.5	7,827.3	5,483.3	6,798.1	6,534.9	10,046.6	3,440.8	4,537.0	8,823.7	65,108.1
2016	0.0	0.0	0.0	313.4	3,963.2	4,235.7	6,478.9	4,984.0	8,107.3	4,924.4	5,826.7	5,326.4	8,533.0	2,756.8	10,642.6	66,092.4
2017	0.0	0.0	0.0	445.0	1,406.0	5,996.2	7,653.5	5,741.3	4,376.0	6,607.5	3,688.0	4,278.1	4,146.6	6,247.6	8,346.1	58,932.0
2018	0.0	0.0	0.0	801.6	1,649.1	2,287.1	10,427.1	7,096.9	5,954.6	3,760.5	5,238.2	2,950.9	3,245.4	2,813.7	10,386.1	56,611.0
2019	0.0	0.0	0.0	1,187.0	3,062.5	2,608.5	4,082.7	12,657.6	8,172.5	5,174.1	3,171.1	4,142.5	2,398.8	2,492.5	8,721.2	57,871.0
2020	0.0	0.0	0.0	680.4	4,646.6	4,701.2	5,561.3	4,953.1	13,133.7	7,331.8	4,506.5	2,664.9	3,362.3	1,653.9	7,747.4	60,943.1
2021	0.0	0.0	0.0	749.8	2,613.1	6,928.7	9,921.4	6,003.7	4,507.4	12,309.2	4,616.4	3,748.5	2,392.2	2,767.1	7,812.8	64,370.2
2022	0.0	0.0	0.0	1,088.0	3,150.1	4,703.4	16,627.5	11,287.4	6,904.6	4,338.2	11,170.6	5,171.3	3,409.7	1,836.5	8,349.5	78,036.8
2023	0.0	0.0	0.0	812.7	4,129.0	5,057.2	8,575.3	16,799.3	11,975.3	5,484.7	4,261.4	9,240.8	4,700.0	2,708.4	6,993.8	80,738.0

Table x8. Estimate of total female spawning stock biomass with associated standard errors and coefficients of variation.

Year	Total	SE	CV
1982	18,308.5	2,575.7	0.141
1983	15,404.4	2,285.6	0.148
1984	15,510.3	2,286.7	0.147
1985	16,142.8	2,221.6	0.138
1986	14,591.5	1,899.4	0.130
1987	18,079.2	2,093.3	0.116
1988	24,201.0	2,368.9	0.098
1989	36,658.0	3,084.6	0.084
1990	43,033.1	3,264.2	0.076
1991	50,800.7	3,659.9	0.072
1992	64,602.5	4,647.2	0.072
1993	72,910.7	5,027.9	0.069
1994	82,175.7	5,342.5	0.065
1995	88,851.2	5,491.2	0.062
1996	99,447.0	6,244.7	0.063
1997	94,576.7	6,356.5	0.067
1998	88,099.9	5,493.2	0.062
1999	87,495.0	5,457.6	0.062
2000	99,850.6	5,896.1	0.059
2001	103,601.0	5,575.4	0.054
2002	115,661.0	6,163.8	0.053
2003	117,516.0	6,258.5	0.053
2004	113,215.0	6,196.8	0.055
2005	112,433.0	6,387.2	0.057
2006	106,047.0	6,239.6	0.059
2007	103,766.0	6,304.1	0.061
2008	109,085.0	6,239.6	0.057
2009	107,059.0	5,976.9	0.056
2010	105,993.0	5,802.6	0.055
2011	98,544.2	5,661.3	0.057
2012	96,592.7	5,868.2	0.061
2013	85,807.5	5,684.1	0.066
2014	74,833.3	5,719.4	0.076
2015	65,108.1	5,188.6	0.080
2016	66,092.5	5,535.9	0.084
2017	58,932.0	5,264.8	0.089
2018	56,611.0	5,485.0	0.097
2019	57,871.0	5,674.1	0.098
2020	60,943.1	5,955.9	0.098
2021	64,370.1	6,342.3	0.099
2022	78,036.8	7,687.2	0.099
2023	80,738.0	8,574.5	0.106

Table x9 . Estimates of exploitable biomass, 1982-2021.

	Age															
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
1982	2,362	4,535	3,137	3,074	2,044	1,512	1,513	1,213	1,007	2,281	2,115	3,342	1,964	1,550	4,766	36,416
1983	8,730	3,227	3,330	2,280	3,023	1,873	1,069	1,218	910	949	1,811	1,465	2,653	1,493	4,432	38,463
1984	9,463	8,459	5,820	3,074	2,317	3,101	1,966	984	1,077	786	824	1,630	1,195	2,265	4,761	47,722
1985	1,333	7,769	9,815	5,987	3,186	2,764	3,487	2,056	1,070	1,030	780	767	1,478	1,105	5,573	48,199
1986	4,036	4,088	9,000	12,244	4,936	3,186	2,496	3,206	1,574	810	796	608	592	979	3,880	52,431
1987	6,954	7,169	10,010	10,557	13,226	4,965	3,275	2,374	2,801	1,409	711	747	534	506	4,345	69,583
1988	17,676	10,220	10,166	11,831	11,787	13,148	5,401	3,384	2,295	2,475	1,480	776	728	506	4,154	96,027
1989	7,235	15,286	12,759	10,943	12,378	13,218	15,578	6,620	3,655	2,588	2,620	1,507	773	678	4,062	109,900
1990	3,089	12,999	14,812	12,100	11,330	13,118	13,323	15,770	6,251	3,399	2,539	2,739	1,309	639	3,414	116,832
1991	12,105	11,471	18,662	15,141	12,377	9,959	12,836	12,099	14,079	5,087	3,453	2,012	2,358	1,133	3,510	136,281
1992	3,945	12,842	23,458	17,339	16,502	12,086	11,079	12,646	11,515	13,116	5,287	3,944	2,139	2,414	5,369	153,682
1993	2,421	9,681	16,202	21,731	17,548	15,321	12,460	12,172	12,056	10,772	12,447	5,403	3,478	2,126	5,927	159,745
1994	40,093	11,725	20,114	18,305	22,291	17,303	15,705	13,025	11,507	10,998	10,154	11,332	4,732	2,845	6,337	216,463
1995	27,000	37,753	26,004	21,440	18,325	21,695	18,265	16,230	12,592	10,839	8,889	8,683	9,399	3,868	6,647	247,630
1996	15,569	32,677	47,093	24,133	19,909	17,991	23,304	19,313	15,001	11,159	9,138	7,356	6,810	7,327	8,218	264,997
1997	13,833	22,242	33,740	54,711	23,297	17,928	16,490	19,989	15,343	12,737	8,935	6,647	6,287	5,408	12,153	269,739
1998	38,009	26,434	32,725	25,831	44,704	17,996	15,294	13,347	14,749	10,812	8,960	6,520	5,047	4,851	11,505	276,783
1999	100,633	28,302	38,824	30,769	21,768	31,013	13,935	12,975	11,448	12,931	8,610	6,461	4,933	4,022	13,213	339,836
2000	45,450	28,805	23,897	32,904	26,109	19,710	29,083	13,334	11,488	9,318	10,950	7,527	5,849	4,245	14,225	282,893
2001	22,583	15,061	19,462	20,566	30,765	26,999	20,610	29,932	13,187	10,199	7,602	7,981	5,844	4,532	10,869	246,193
2002	11,878	14,120	12,823	19,958	19,329	31,611	28,345	21,165	26,933	11,513	8,218	6,215	6,178	4,583	12,659	235,526
2003	7,044	19,164	17,745	15,193	18,556	17,989	30,555	25,928	18,352	22,769	9,343	6,320	4,888	5,270	12,135	231,250
2004	47,490	7,499	25,459	23,163	15,064	18,005	17,269	27,708	21,849	14,517	18,317	7,039	4,692	3,716	12,066	263,852
2005	12,025	33,303	12,707	25,798	22,487	15,330	17,056	16,000	23,717	17,464	11,567	14,519	5,453	3,672	11,890	242,988
2006	15,227	11,340	31,378	15,785	25,817	21,459	13,336	15,710	14,044	19,369	14,068	8,974	11,501	4,380	11,196	233,585
2007	4,169	12,550	15,277	30,785	13,706	23,020	19,878	11,512	13,305	10,788	15,203	10,748	6,912	8,717	11,485	208,051
2008	15,511	6,053	15,155	18,244	32,957	14,975	25,954	19,963	10,722	11,560	8,790	12,147	8,732	5,693	14,728	221,183
2009	11,915	14,775	9,760	16,340	17,199	35,742	15,337	25,259	17,638	8,947	8,990	6,621	9,140	6,710	14,089	218,462
2010	8,600	10,349	17,054	10,603	14,769	17,720	35,073	13,313	19,664	14,397	7,144	6,513	5,006	7,102	14,798	202,105
2011	16,177	9,015	10,378	16,467	9,538	14,431	17,530	30,082	10,737	15,046	10,436	5,371	4,886	3,858	15,861	189,813
2012	6,218	12,523	11,357	9,787	15,295	9,560	14,554	15,916	25,069	9,004	11,924	8,005	4,101	3,928	14,376	171,617
2013	7,437	12,283	13,748	11,308	9,267	14,789	9,224	12,999	13,614	20,157	7,133	9,228	6,400	3,173	12,837	163,596
2014	52,826	6,940	20,467	13,454	10,265	7,837	12,678	7,419	10,007	9,834	14,226	5,077	6,688	4,643	11,316	193,678
2015	13,568	10,080	7,640	22,282	13,642	10,742	7,237	10,885	6,269	7,777	7,305	10,783	3,705	4,891	9,506	146,310
2016	23,074	12,544	6,373	7,015	22,299	14,637	10,753	6,965	9,446	5,448	6,213	5,616	8,692	2,804	11,508	153,388
2017	13,968	21,001	16,669	8,990	7,190	20,181	12,606	8,392	5,325	7,431	4,122	4,704	4,339	6,619	9,067	150,603
2018	20,262	12,653	25,223	18,061	9,301	7,747	17,465	10,159	6,679	4,042	5,631	3,055	3,322	2,978	11,181	157,760
2019	19,932	15,522	14,792	26,185	16,593	8,726	6,862	16,756	9,086	5,812	3,463	4,459	2,503	2,607	9,362	162,658
2020	31,069	17,685	16,000	15,008	25,245	16,182	8,892	6,579	15,573	8,196	4,809	2,801	3,470	1,784	8,228	181,521
2021	5,006	15,333	19,463	16,221	14,317	24,114	15,832	8,503	5,653	13,509	5,613	4,078	2,467	2,900	8,300	161,310
2022	7,146	6,722	14,854	22,177	16,919	15,395	25,425	15,773	7,865	4,645	12,132	4,890	3,470	1,975	8,910	168,297
2023	29,847	7,714	11,042	17,548	23,209	17,115	14,489	24,463	13,889	6,375	4,478	9,885	4,935	2,846	7,421	195,258

Table X10. Reference points and probability of female spawning stock biomass being greater or equal to the SSB target and SSBthreshold over a ten-year projection under the current fully-recruited 2023 F, Ftarget and Fthreshold.

Reference Points

	SSB	F
Target	111064.0	0.193
Threshold	88851.2	0.235
Current	80738.0	0.237

	Current F		Ftarget		Fthreshold	
Year	Pr SSB>= SSBthreshold	Pr SSB>= SSBtarget	Pr SSB>= SSBthreshold	Pr SSB>= SSBtarget	Pr SSB>= SSBthreshold	Pr SSB>= SSBtarget
2023	0.111	0.000	0.114	0.000	0.109	0.000
2024	0.353	0.001	0.363	0.001	0.352	0.001
2025	0.430	0.004	0.607	0.012	0.432	0.004
2026	0.430	0.005	0.722	0.030	0.437	0.007
2027	0.356	0.004	0.767	0.046	0.388	0.005
2028	0.294	0.003	0.777	0.051	0.318	0.003
2029	0.247	0.002	0.774	0.057	0.269	0.003

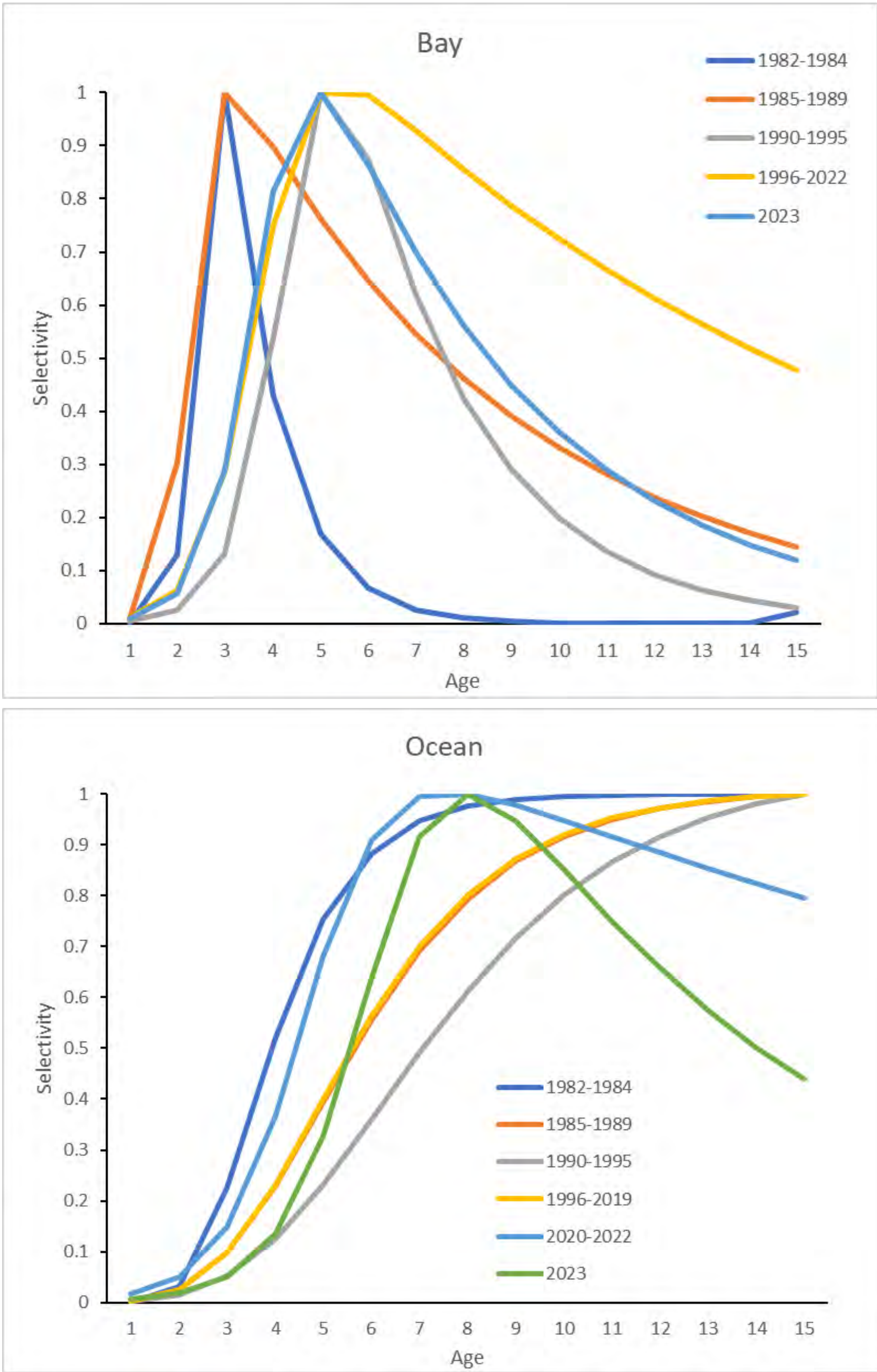


Figure 1. Estimates of selectivity patterns for the five Bay and Ocean time blocks.

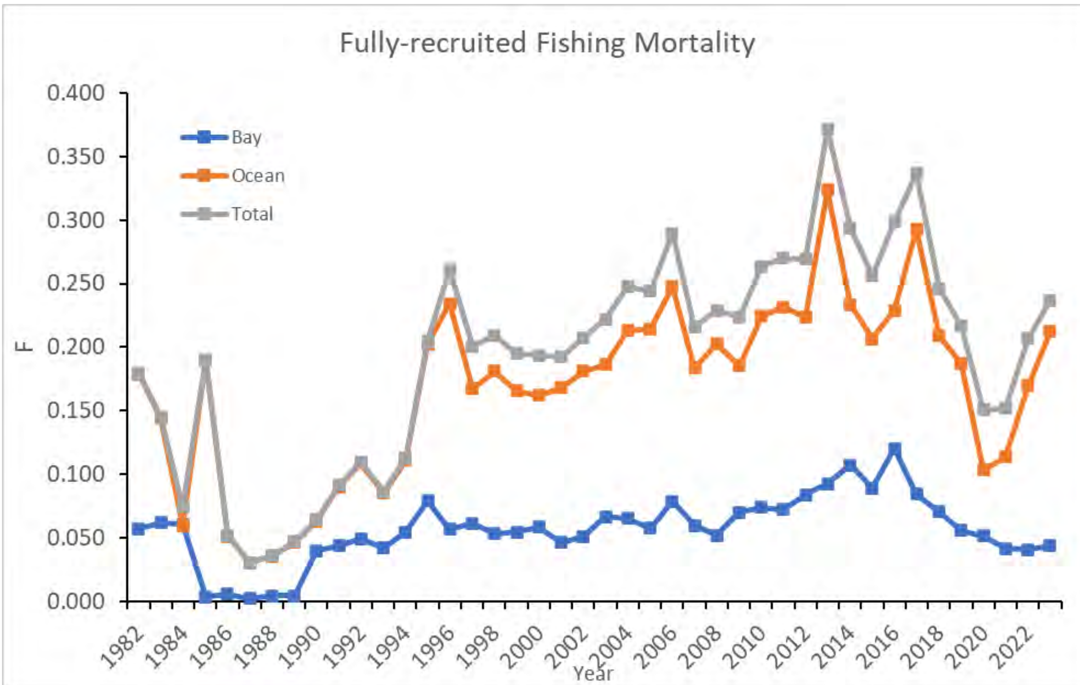


Figure 2. Estimates of region-specific and total fully-recruited fishing mortality in the Bay and Ocean, 1982-2023.

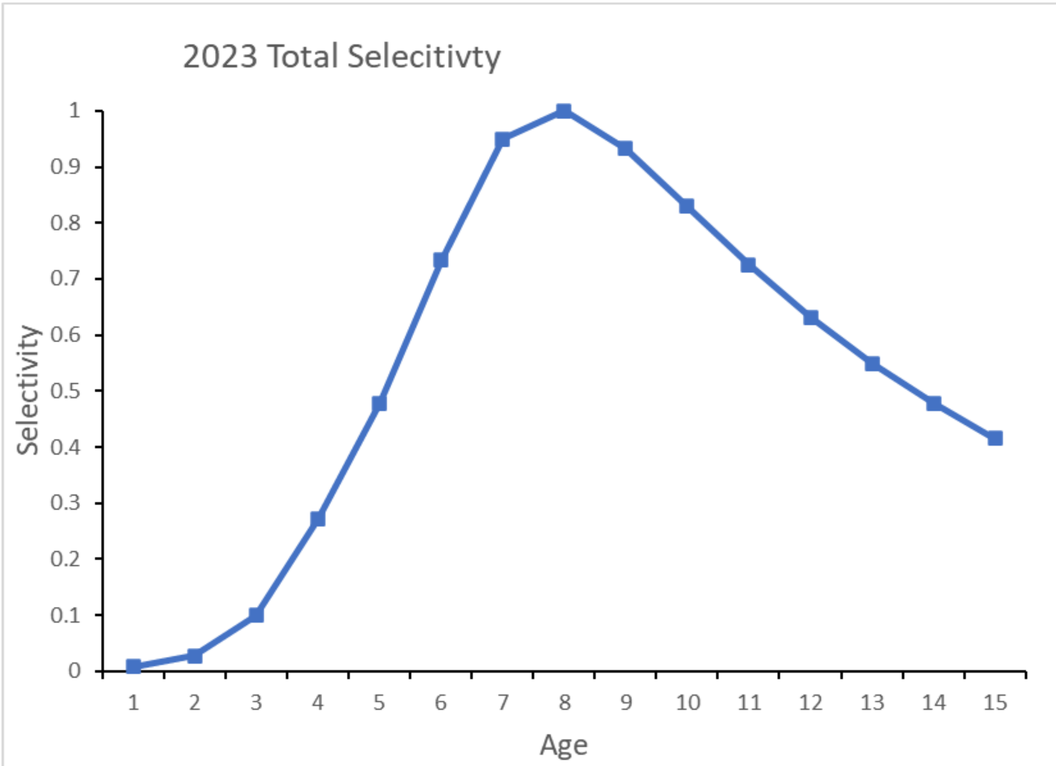


Figure 3. Total selectivity pattern for 2023 (Bay and Ocean combined) derived from total fishing mortality-at-age.

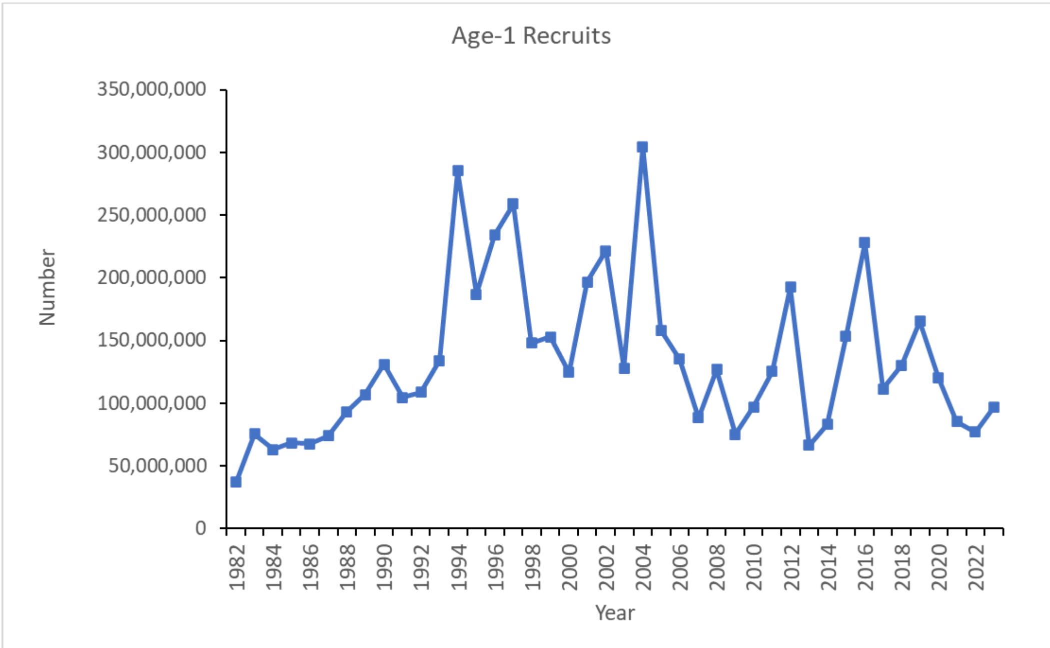


Figure 4. Estimates of recruit (age-1) abundance, 1982-2023.

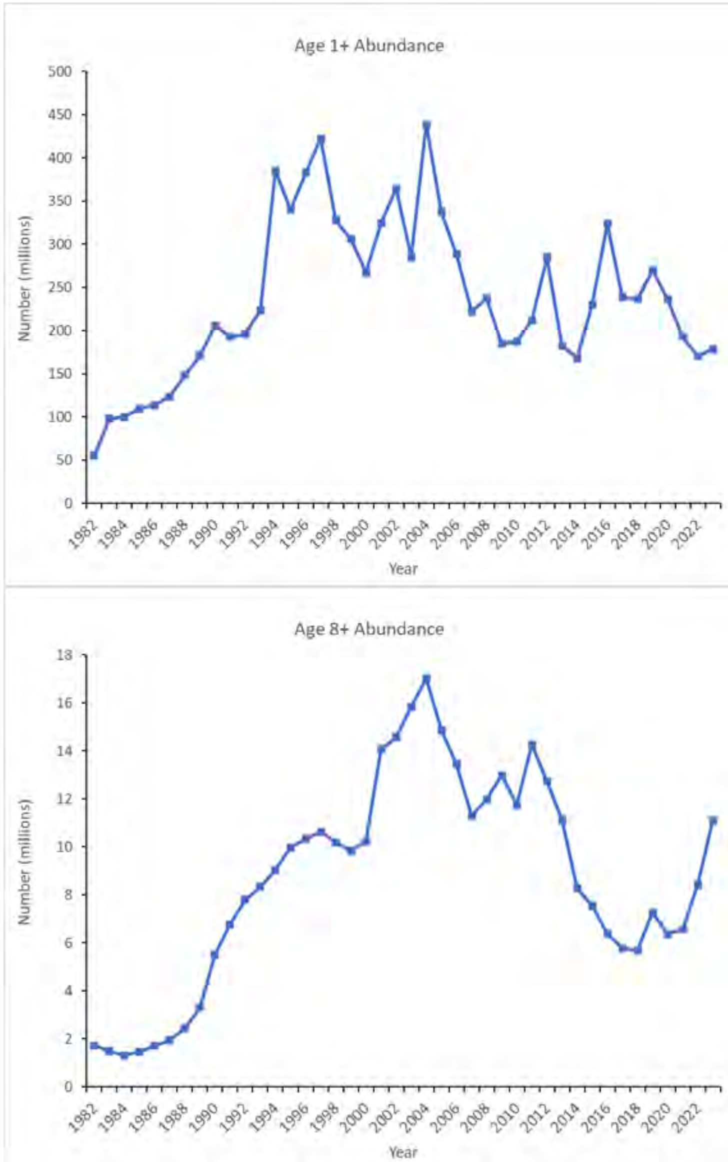
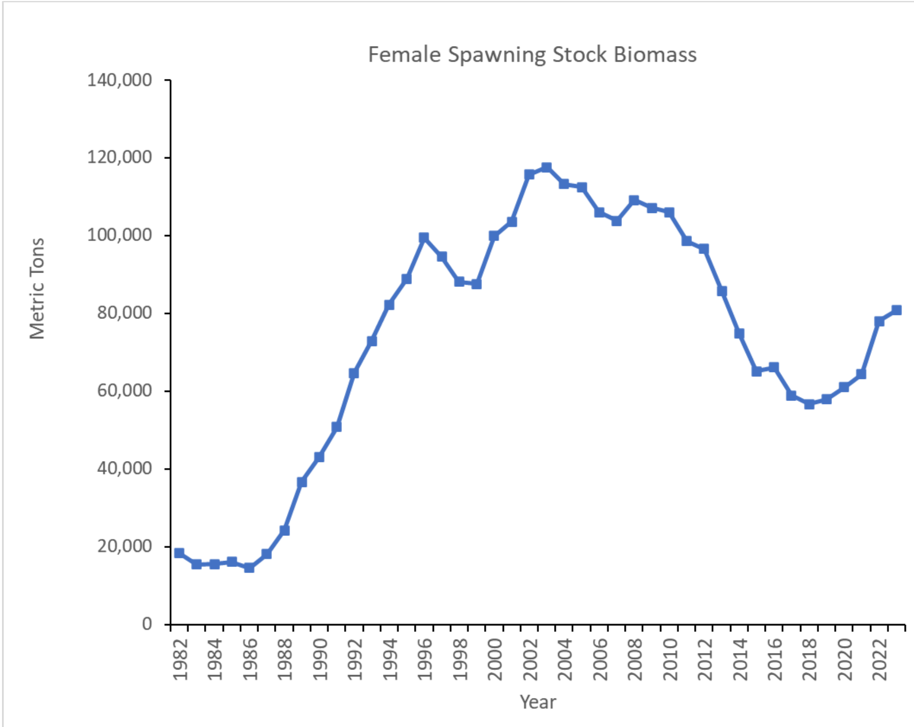


Figure 5. Estimates of total (top) and age-8 + (bottom) abundance from the updated stock assessment, 1982-2023.



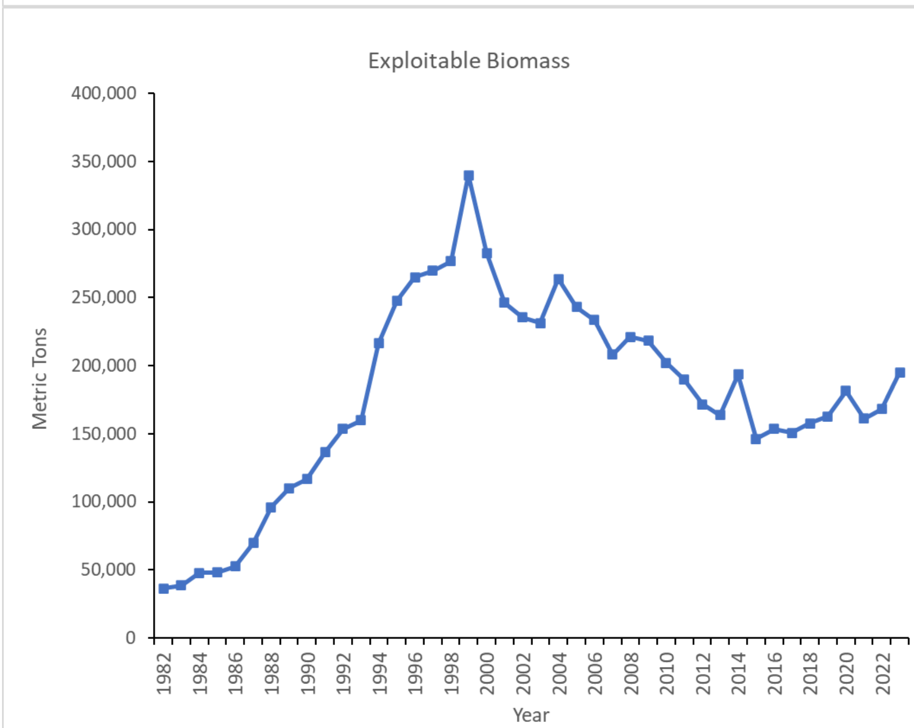


Figure 6. Estimates of female spawning stock biomass (top) and exploitable biomass (bottom), 1982-2023

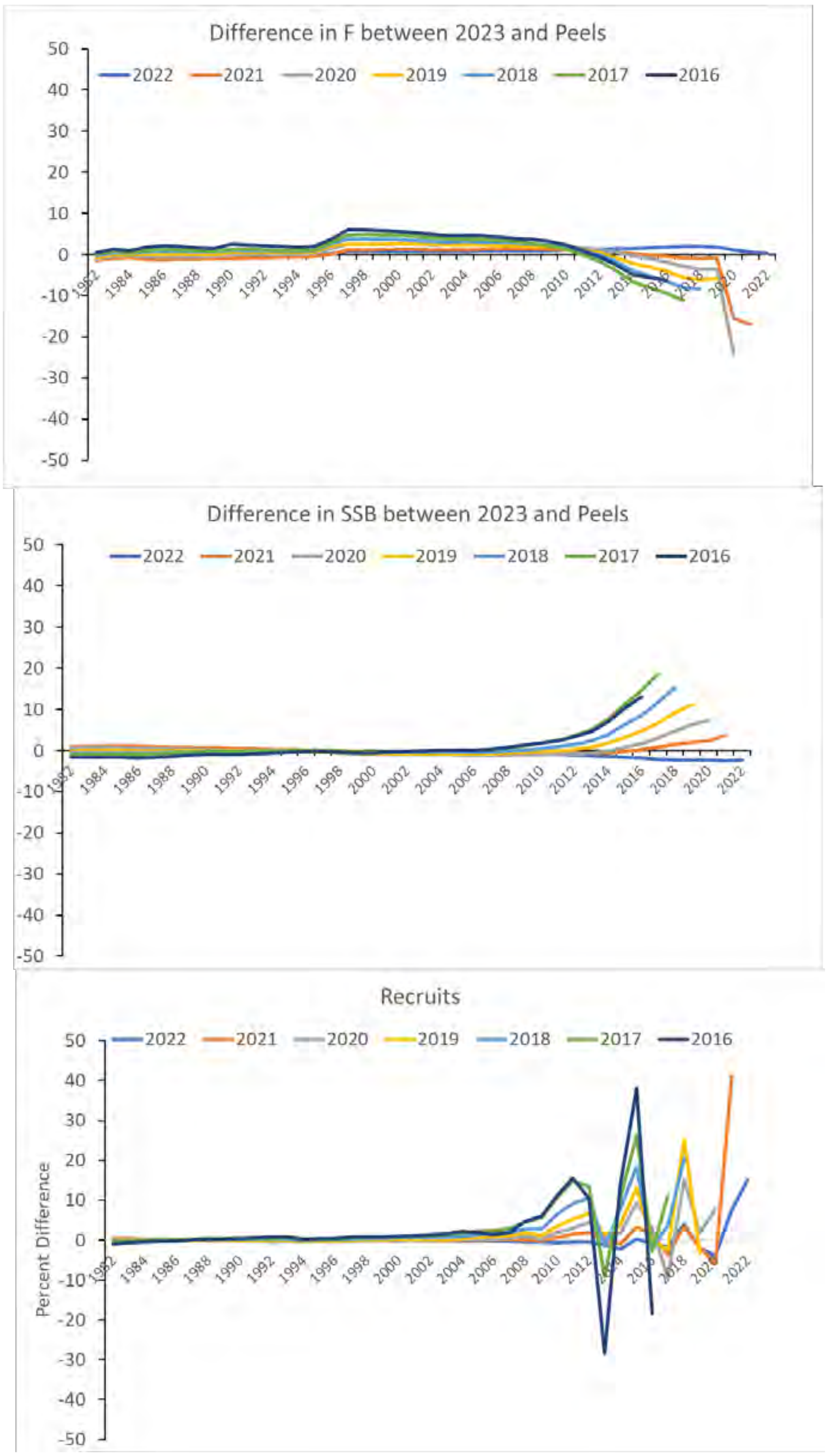


Figure 7. Retrospective plots of seven-year peels for fishing mortality, female spawning stock biomass and recruitment.

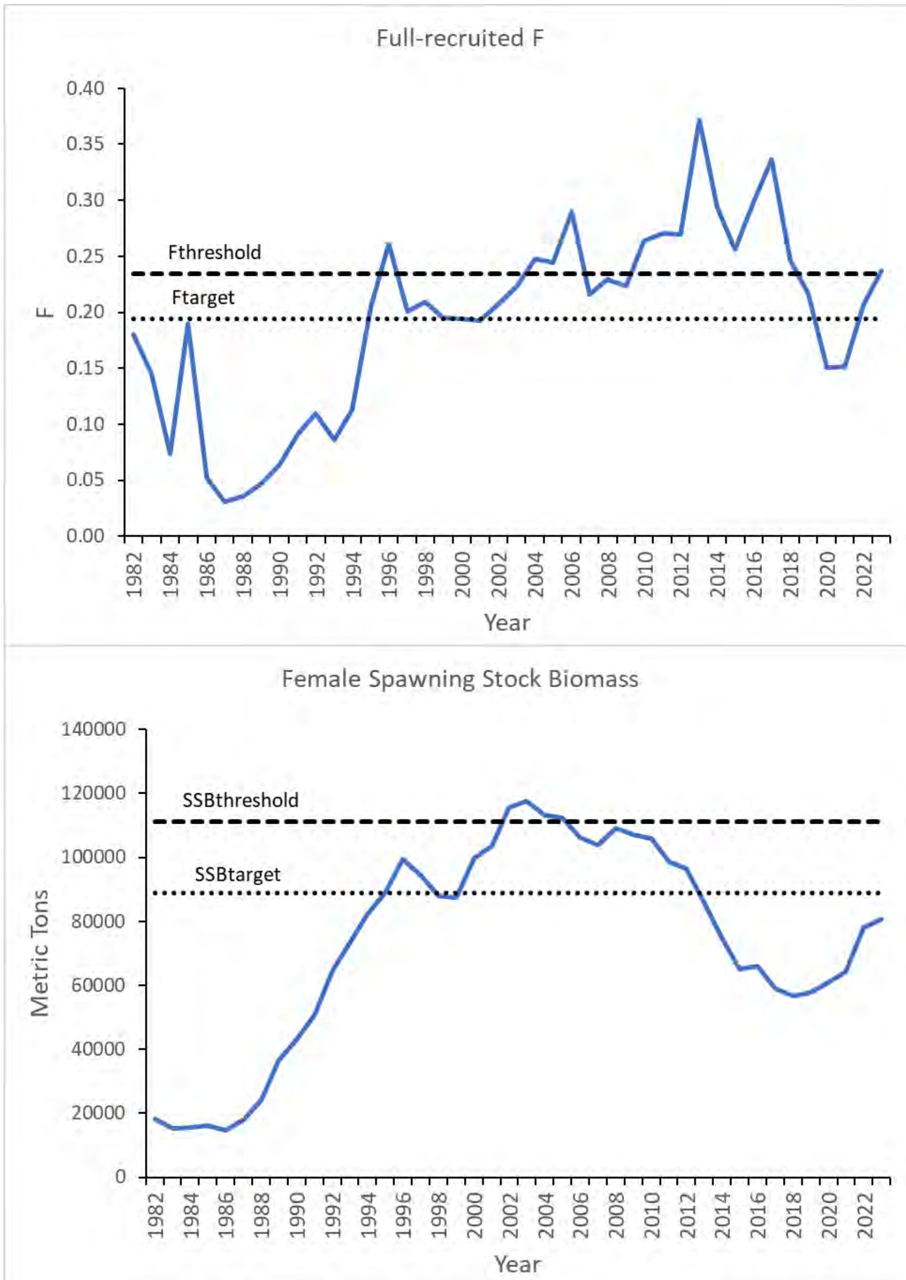


Figure 13. Comparison of SSB and F estimates to SSB and F reference points.

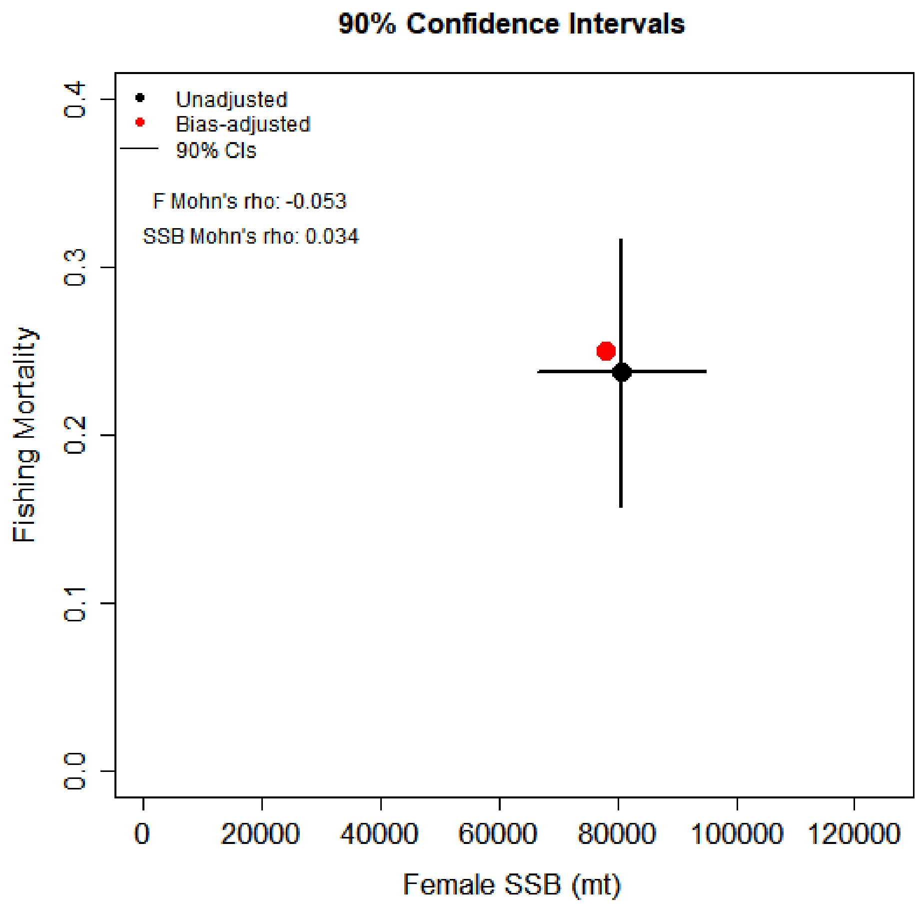


Figure 14. Plot comparing the 2023 bias-corrected F and female SSB values the uncorrected F and SSB estimates and their associated 90% confidence intervals. Because the retrospective adjusted values fall within the 90% confidence intervals, bias-correction is not needed.

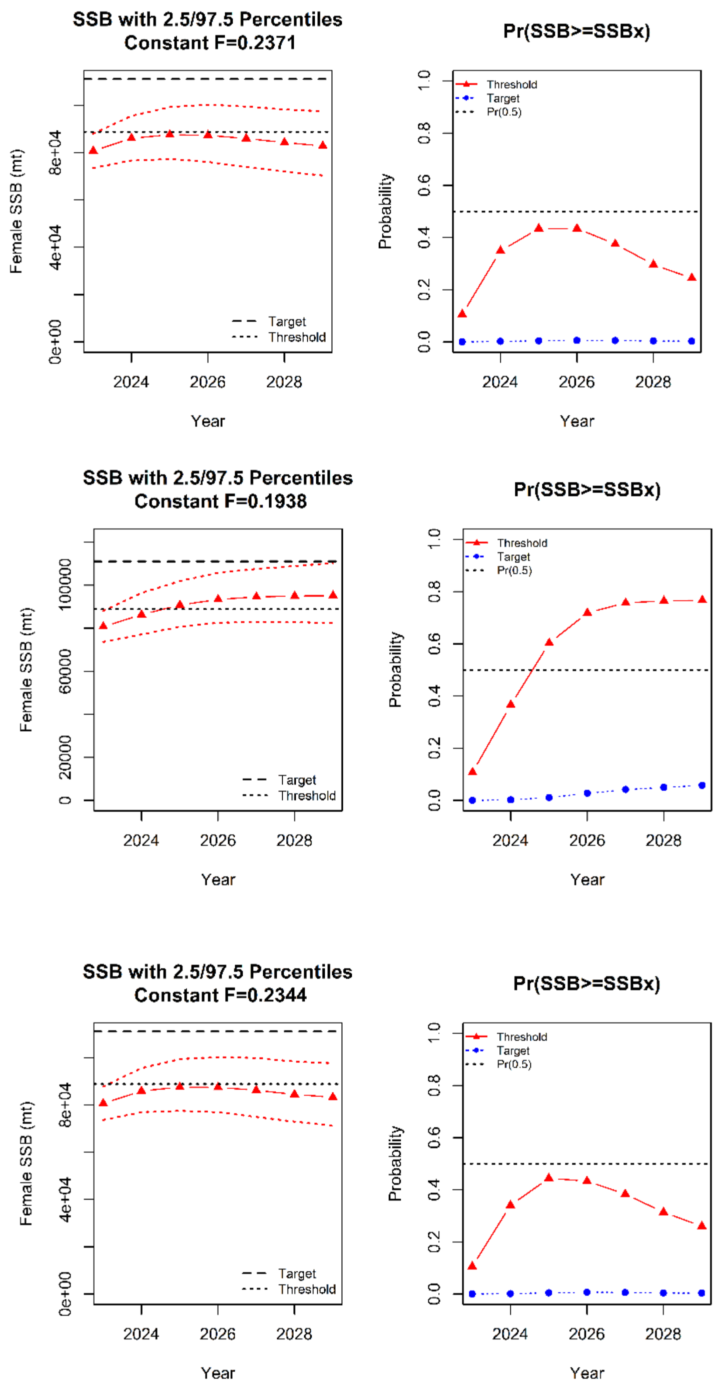


Figure 15. Projections of female spawning stock biomass through 2029 under current, target and threshold fishing mortality (left) and the probability of female SSB being above the target and threshold values of 111,064 and 88,851 metric tons, respectively, over time (right).

ASMFC Striped Bass - Estimating New Selectivity from the Two-Time Block 2024 Stock Assessment Update

Gary Nelson

2024-10-04

Method

1) Combine state ALK keys that have been expanded to the total number across each component (Rec Harvest, Rec Dead Releases, Comm Harvest). Dead Commercial Discards are included by using the ALK of the Comm Harvest.
2) Within an age, calculate the fraction that each length interval of each component comprises of the summed total of all components
3) Within an age, multiply step 2 fractions for each length interval of each component by the age-specific F
4) Apply the new slot to recreational harvest component, make lengths outside slot zero, but transfer F*0.09 to the Rec Dead Releases
5) Sum the age-specific Fs across components, standardize new F vector to one (F/max(F))

Load Functions

```
library(readxl)
library(writexl)
library(fishmethods)
library(kableExtra)
```

Constant_F_projection Code

```
Constant_F_Projections <-function(maxage=max_age,M=Nat_Mortality,sex=female_sex_fraction,
                          fmat=female_mature_fraction,Nages_base=N2024,
                          Nbias=N_bias,pF=F_fraction,pM=M_fraction,curwgt=average_wgt,
                          avgwgt=average_wgt,
                          cursel=select_current,avgselect=current_select,
                          recruits=recruits_series,
                          curyear=2024,recruit_start_year=2008,recruit_end_year=2023,
                          Fcur=F2024,FcurCV=F_current_CV,Fcur_bias=F_bias,
                          Fproj=F2024,
                          SSBtarget=SSB_target,SSBtargetCV=SSB_target_CV,
                          SSBthreshold=SSB_threshold,SSBthresholdCV=SSB_threshold_CV,
                          pyears=6,nsims=5000,usebias=1,
```

```
                        catch_current=pcatch){
if(usebias==1){
  Nages<-Nages_base
  F_base<-Fcur
}
if(usebias==2){
  Nages<-Nages_base
  Nages$N<-Nages$N*(1-Nbias)
  F_base<-Fcur*(1-F_bias)
}
if(length(Fproj)==1) F_p<-c(F_base,rep(Fproj,pyears-1))    #F to project
if(length(Fproj)>1){
  F_p<-c(F_base,Fproj)    #F to project
  if(length(F_p)!=pyears) stop("Number of pyears does not equal the number of Fs (Fcur+Fproj)")
}
F_CV<-FcurCV
F_SD<-F_base*F_CV
recruits_short<-recruits[recruits$year>=recruit_start_year &
                           recruits$year<=recruit_end_year,2]
N<-matrix(0,nrow=pyears,ncol=maxage)
SSB<-matrix(0,nrow=pyears,ncol=maxage)
catch<-matrix(0,nrow=pyears,ncol=maxage)
SSBout<-matrix(0,nrow=nsims,ncol=pyears)
catchout<-matrix(0,nrow=nsims,ncol=pyears)

#!!! Begin projections !!!#
for(nrep in 1:nsims){
  F_proj<-rnorm(length(F_p),mean=F_p,sd=F_p*F_CV)
  F_proj<-ifelse(F_proj<0,0,F_proj)
  # generate January 1 abundance and SSB estimates in current year
    for(a in 1:maxage){
    N[1,a]<-rnorm(1,mean=Nages[a,1],sd=Nages[a,2]*Nages[a,1])
    #calculate F given catch
    SSB[1,a]<-N[1,a]*exp(-(pF*cursel[a]*F_proj[1])-(M[a]*pM))*sex[a]*fmat[a]*
      curwgt[a]/1000 #metric tons
    }
  catch[1,1]<-catch_current

  for(i in 2:as.numeric(pyears)){
      for(a in 1:maxage){
        if(a==1) N[i,1]<-sample(recruits_short,1,replace=FALSE)
        if(a>1 & a<maxage) N[i,a]<-N[i-1,a-1]*exp(-F_proj[i-1]*avgselect[a-1]-M[a-1])
        if(a==maxage) N[i,a]<-N[i-1,a-1]*exp(-F_proj[i-1]*avgselect[a-1]-M[a-1])+
            N[i-1,a]*exp(-F_proj[i-1]*avgselect[a]-M[a]) #plus group calculation
        if(N[i,a]<0) N[i,a]<-0
        catch[i,a]<-(avgselect[a]*F_proj[i])/(avgselect[a]*F_proj[i]+M[a])*
          (1-exp(-(avgselect[a]*F_proj[i])-(M[a])))*N[i,a]
      }
      for(a in 1:maxage) SSB[i,a]<-N[i,a]*exp(-(pF*avgselect[a]*F_proj[i])-(M[a]*pM))*
          sex[a]*fmat[a]*avgwgt[a]/1000 #metric tons
    }

  SSBout[nrep,]<-rowSums(SSB)
```

```
  catchout[nrep,]<-rowSums(catch)
}
SSBprob_threshold<-NULL
for(i in 1:pyears) SSBprob_threshold[i]<-pgen(SSBout[,i],limit=SSBthreshold,
                          limSD=SSBthreshold*SSBthresholdCV,dist=1,comp=4)
#Plot results
SSBmed<-apply(SSBout,2,median)
SSBpercent<-apply(SSBout,2,function(x){quantile(x,prob=c(0.025,0.975))})
SSBmean<-apply(SSBout,2,mean)
SSBSE<-apply(SSBout,2,sd)
SSBLCI<-SSBmean-SSBSE*1.96
SSBUCI<-SSBmean+SSBSE*1.96
catchmed<-apply(catchout,2,median)
catchpercent<-apply(catchout,2,function(x){quantile(x,prob=c(0.025,0.975))})
catchmean<-apply(catchout,2,mean)
catchSE<-apply(catchout,2,sd)
catchLCI<-catchmean-catchSE*1.96
catchUCI<-catchmean+catchSE*1.96
SSBprob_target<-NULL
for(i in 1:pyears) SSBprob_target[i]<-pgen(SSBout[,i],limit=SSBtarget,
                                    limSD=SSBtarget*SSBtargetCV,dist=1,comp=4)

yrs<-seq(as.Date(paste(curyear,"/01/01",sep="")),by="1 year", length.out=pyears)
 outtables<-list(type="Constant_F_Projections",SSBthreshold=SSBthreshold,
          SSBtarget=SSBtarget,Fproj=Fproj,SSBmed=SSBmed,SSBpercentiles=SSBpercent,
          SSBmean=SSBmean,SSBSE=SSBSE,SSBLCI=SSBLCI,SSBUCI=SSBUCI,
          catchmed=catchmed, catchpercentiles=catchpercent,catchmean=catchmean,
          catchSE=catchSE,catchLCI=catchLCI,catchUCI=catchUCI,
          SSBprob_threshold=SSBprob_threshold,SSBprob_target=SSBprob_target,
          axis_yrs=yrs)
 return(outtables)
}
```

Plot Function

```
Plot_Projection_Results<-function(results=NULL,export_as_tif=FALSE,
                    tiff_attributes=list(name="C:/temp/outs.tif",width=16,height=12,
                                    zoom=12,pointsize=10,units="cm")){

    word.tif = function(filename="C:/Temp/Word_Figure_%03d.tif", zoom=12, width=16,
                        height=12, pointsize=10,units="cm", ...) {
      if (!grepl("[.]ti[f]+$", filename, ignore.case=TRUE))
      filename = paste0(filename,".tif")
      tiff(filename=filename, compression="lzw", res=96*zoom,
       width=width, height=height, units=units, pointsize=pointsize,...)}

  if(results$type=="Constant_Catch_Projections_1"){
    if(results$trajectory_target_label %in% c("Ftarget","Fthreshold")){
      if(export_as_tif==TRUE) word.tif(filename=tiff_attributes$name,
                                       width=tiff_attributes$width,
                                       height=tiff_attributes$height,
```

```
                                      zoom=tiff_attributes$zoom,
                                      pointsize=tiff_attributes$pointsize,
                                      units=tiff_attributes$units)

      par(mfrow=c(1,2),mai=c(0.8,0.8,0.6,0.6))
      plot(results$results$FM~results$results$year, main="",type="o",pch=16,
      ylim=c(min(results$results$FM),max(results$results$FM)*1.05),
      ylab="Fishing Mortality",xlab="Year")
      abline(h=results$trajectory_target,lty=3)
      temp<-paste(results$conditions[1]," = ",round(results$constant_catch,0),
                  " fish",sep="")
      mtext(text=temp,side=3,line=1,at=max(results$results$year)+2)
      text(x=results$results$year[2],y=results$trajectory_target*1.01,
           labels=results$trajectory_target_label,cex=0.7)
      plot(results$results$SSB~results$results$year, main="",type="o",pch=16,
           ylim=c(min(results$results$SSB),max(results$results$SSB)*1.05),
           ylab="Spawning Stock Biomass",xlab="Year")

    if(export_as_tif==TRUE) dev.off()
  }
  if(results$trajectory_target_label %in% c("SSBtarget","SSBthreshold")){
    if(export_as_tif==TRUE) word.tif(filename=tiff_attributes$name,
                                      width=tiff_attributes$width,
                                      height=tiff_attributes$height,
                                      zoom=tiff_attributes$zoom,
                                      pointsize=tiff_attributes$pointsize,
                                      units=tiff_attributes$units)

    par(mfrow=c(1,2),mai=c(0.8,0.8,0.6,0.6))
    plot(results$results$FM~results$results$year, main="",type="o",pch=16,
         ylim=c(min(results$results$FM),max(results$results$FM)*1.05),
         ylab="Fishing Mortality",xlab="Year")
    abline(h=results$trajectory_value,lty=3)
    temp<-paste(results$conditions[1]," = ",round(results$constant_catch,0),
                " fish",sep="")
    mtext(text=temp,side=3,line=1,at=max(results$results$year)+2)
      plot(results$results$SSB~results$results$year, main="",type="o",pch=16,
         ylim=c(min(results$results$SSB),max(results$results$SSB)*1.05),
         ylab="Spawning Stock Biomass",xlab="Year")
             abline(h=results$trajectory_target,lty=3)
          text(x=results$results$year[2],y=results$trajectory_target*1.01,
               labels=results$trajectory_target_label,cex=0.7)
   if(export_as_tif==TRUE) dev.off()
 }
}#Constant_Catch_Projections_1

if(results$type=="Constant_Catch_Projections_2"){
  if(export_as_tif==TRUE) word.tif(filename=tiff_attributes$name,
                                    width=tiff_attributes$width,
                                    height=tiff_attributes$height,
                                    zoom=tiff_attributes$zoom,
                                    pointsize=tiff_attributes$pointsize,
                                    units=tiff_attributes$units)
```

```
    par(mfrow=c(2,2),mai=c(0.7,0.7,0.5,0.4))
    plot(results$results$Fmed~results$results$year, main="",type="o",pch=16,
        ylim=c(0,max(results$results$F97_5)*1.10),ylab="Fishing Mortality",xlab="Years")
    lines(results$results$F2_5~results$results$year,lty=3,lwd=1.5)
    lines(results$results$F97_5~results$results$year,lty=3,lwd=1.5)
    abline(h=results$Ftarget,col="red",lwd=1.5)
    abline(h=results$Fthreshold,lty=2,col="blue",lwd=1.5)
    legend("bottomright",legend=c("Target","Threshold"),col=c("red","blue"),
           lty=c(1,2),bty="n",cex=0.7)
    mtext(text=paste("Constant Catch = ",round(results$results$catch[1],0),
                     " fish",sep=""),side=3,line=1, at=max(results$results$year)+2)

    plot(results$results$Prob_F_greater_Ftarget~results$results$year, main="",
         type="o",pch=16,
         ylim=c(0,1),ylab="Pr(F>Fx)",xlab="Year",col="red")
    lines(results$results$Prob_F_greater_Fthreshold~results$results$year,col="blue")
    points(results$results$Prob_F_greater_Fthreshold~results$results$year,
           col="blue",pch=16)
    legend("topleft",legend=c("F Target","F Threshold"),col=c("red","blue"),
           lty=c(1,2),pch=c(16,16),bty="n",cex=0.7,lwd=1.5)

    plot(results$results$SSBmed~results$results$year, main="",type="o",pch=16,
         ylim=c(min(results$results$SSB2_5,SSB_threshold)*0.95,
                max(results$results$SSB97_5,SSB_target)*1.10),
         ylab="Spawning Stock Biomass",
         xlab="Years")
    lines(results$results$SSB2_5~results$results$year,lty=3,lwd=1.5)
    lines(results$results$SSB97_5~results$results$year,lty=3,lwd=1.5)
    abline(h=results$SSBtarget,col="red",lwd=1.5)
    abline(h=results$SSBthreshold,col="blue",lty=2,lwd=1.5)
    legend("topleft",legend=c("SSB Target","SSB Threshold"),col=c("red","blue"),
           bty="n",pch=c(16,16),lty=c(1,2),cex=0.7)

    plot(results$results$Prob_SSB_less_SSBtarget~results$results$year, main="",
         type="o",pch=16,
         ylim=c(0,1),ylab="Pr(SSB<SSBx)",xlab="Year",col="red")
    lines(results$results$Prob_SSB_less_SSBthreshold~results$results$year,col="blue")
    points(results$results$Prob_SSB_less_SSBthreshold~results$results$year,
           col="blue",pch=16)
    legend("topright",legend=c("SSB Target","SSB Threshold"),col=c("red","blue"),
           bty="n",pch=c(16,NA),lty=c(1,1),cex=0.7)

    if(export_as_tif==TRUE) dev.off()
  }

  if(results$type=="Constant_F_Projections"){
    if(export_as_tif==TRUE) word.tif(filename=tiff_attributes$name,
                                     width=tiff_attributes$width,
                                     height=tiff_attributes$height,
                                     zoom=tiff_attributes$zoom,
                                     pointsize=tiff_attributes$pointsize,
                                     units=tiff_attributes$units)
```

```
    par(mfrow=c(1,2))
    if(length(results$Fproj)==1) mainlabel<-paste("SSB with 2.5/97.5 Percentiles","\n Constant F=",
                    round(results$Fproj,4),sep="")

    if(length(results$Fproj)>1){
        fslabels<-paste(as.character(round(results$Fproj,4)),collapse=" ")
        mainlabel<-paste("SSB with 2.5/97.5 Percentiles", "\n F=",fslabels,sep="")

    }

    plot(y=results$SSBmed,x=results$axis_yrs,type="b",col="red",

        main=mainlabel,

         xlab="Year",ylim=c(0,max(results$SSBpercent)*1.10),pch=17,
         ylab="Female SSB (mt)")
    lines(results$SSBpercent[1,]~results$axis_yrs,col="red",lty=3,lwd=1.5)
    lines(results$SSBpercent[2,]~results$axis_yrs,col="red",lty=3,lwd=1.5)
    abline(h=results$SSBthreshold,lty=3,lwd=1.5)
    abline(h=results$SSBtarget,lty=2,lwd=1.5)
    legend("bottomright",legend=c("Target","Threshold"),lwd=1.5,lty=c(2,3),bty="n",
          cex=0.8)
    plot(results$SSBprob_threshold~results$axis_yrs,type="b",col="red",
         main="Pr(SSB>=SSBx)",pch=17,
         xlab="Year",ylim=c(0,1),ylab="Probability")
    abline(h=0.5,lty=3,lwd=1.5)

    par(new=TRUE)
     plot(results$SSBprob_target~results$axis_yrs,type="b",col="blue",lty=3,pch=16,
         xlab="",ylim=c(0,1),ylab="")
    legend("topleft",legend=c("Threshold","Target","Pr(0.5)"),
          col=c("red","blue","black"),pch=c(17,16,NA),lty=c(1,3,3),bty="n",
          cex=0.7,lwd=1.5)
    if(export_as_tif==TRUE) dev.off()
  }#Constant F
}#function
```

Constant_Catch_Projections Function

```
Constant_Catch_Projections<-function(maxage=max_age,M=Nat_Mortality,
                  sex=female_sex_fraction,fmat=female_mature_fraction,
                  Nages_base=N_at_age_estimates,Nbias=N_bias,pF=F_fraction,
                  pM=M_fraction,curwgt=wgt_current,avgwgt=average_wgt,
                  cursel=select_current,avgselect=average_select,
                  recruits=recruits_series,curyear=2023,recruit_start_year=2008,
                  recruit_end_year=2023,Fcur=F_current,FcurCV1=F_current_CV,
                  Fcur_bias=F_bias,total_current_catch=sum(catch_at_age_current),
                  SSBthreshold=SSB_threshold, SSBthresholdCV=SSB_threshold_CV,
                  SSBtarget=SSB_target, SSBtargetCV=SSB_target_CV,
                  Ftarget=F_target, FtargetCV=F_target_CV,
                  Fthreshold=F_threshold,FthresholdCV=F_threshold_CV,
```

```
                  solve_catch=2,
                  objective_function_value_solve_catch_1=2,
                  pyears=7,nsims=5000,Nerr=1,Ferr=1,usebias=1,
                  rcentral=1){
pcatch<-NULL
if(usebias==1) {
  Fuse<-Fcur
  Nages<-Nages_base
}
if(usebias==2){
  Nages$N<-Nages_base$N*(1-Nbias)
  Fuse<-Fcur*(1-Fcur_bias)
}
recruits_short<-recruits[recruits$year>=recruit_start_year &
                           recruits$year<=recruit_end_year,2]
if(solve_catch==1){#solve for catch
  #storage matrices
  parm<-total_current_catch
  getsolution<-function(parm){
    N<-matrix(0,nrow=pyears,ncol=maxage)
    SSB<-matrix(0,nrow=pyears,ncol=maxage)
    prob<-matrix(0,nrow=pyears,ncol=1)
    SSBout<<-matrix(0,nrow=1,ncol=pyears)
    Fout<<-matrix(0,nrow=1,ncol=pyears)
    for(a in 1:maxage){
      N[1,a]<-Nages[a,1]
      Fran<-Fuse
      #SSB metric tons
      SSB[1,a]<-N[1,a]*exp(-(pF*cursel[a]*Fran)-(M[a]*pM))*sex[a]*fmat[a]*
        curwgt[a]/1000
    }
    Fout[1,1]<-Fran
    # January 1 abundance for years > current
    for(i in 2:as.numeric(pyears)){
      if(i==2){
        for(a in 1:maxage){
          if(a==1){
            if(rcentral==1) N[i,1]<-mean(recruits_short) else
              N[i,1]<-median(recruits_short)
          }
          if(a>1 & a<maxage) N[i,a]<-N[i-1,a-1]*exp(-Fout[1,i-1]*cursel[a-1]-M[a-1])
          if(a==maxage) N[i,a]<-N[i-1,a-1]*exp(-Fout[1,i-1]*cursel[a-1]-M[a-1])+
              N[i-1,a]*exp(-Fout[1,i-1]*cursel[a]-M[a]) #plus group calculation
          if(N[i,a]<0) N[i,a]<-0
        }
        # solve for F given total_current_catch
        Nin<-N[i,]
        solveF1<-function(x){
          for(a in 1:maxage){
            pcatch[a]<-(avgselect[a]*x)/(avgselect[a]*x+M[a])*
              (1-exp(-avgselect[a]*x-M[a]))*Nin[a]
          }
          (log(sum(pcatch))-log(parm))^2
```

```
      }
      outs<-optimize(solveF1,interval=c(0.001,2))
      Fout[1,i]<-outs$minimum
      for(a in 1:maxage) SSB[i,a]<-N[i,a]*exp(-(pF*avgselect[a]*Fout[1,i])-
                        (M[a]*pM))*sex[a]*fmat[a]*avgwgt[a]/1000 #metric tons
    }
    if(i>2){
      for(a in 1:maxage){
        if(a==1){
          if(rcentral==1) N[i,1]<-mean(recruits_short) else
            N[i,1]<-median(recruits_short)
        }
        if(a>1 & a<maxage) N[i,a]<-N[i-1,a-1]*exp(-Fout[1,i-1]*avgselect[a-1]-M[a-1])
        if(a==maxage) N[i,a]<-N[i-1,a-1]*exp(-Fout[1,i-1]*avgselect[a-1]-M[a-1])+
            N[i-1,a]*exp(-Fout[1,i-1]*avgselect[a]-M[a]) #plus group calculation
        if(N[i,a]<0) N[i,a]<-0
      }
      # solve for F given total_current_catch
      Nin<-N[i,]
      solveF1<-function(x){
        for(a in 1:maxage){
          pcatch[a]<-(avgselect[a]*x)/(avgselect[a]*x+M[a])*
            (1-exp(-avgselect[a]*x-M[a]))*Nin[a]
        }
        (log(sum(pcatch))-log(parm))^2
      }
      outs<-optimize(solveF1,interval=c(0.001,2))
      Fout[1,i]<-outs$minimum
      for(a in 1:maxage) SSB[i,a]<-N[i,a]*exp(-(pF*avgselect[a]*Fout[1,i])-
                         (M[a]*pM))*sex[a]*fmat[a]*avgwgt[a]/1000 #metric tons
    }
  }
  SSBout[1,]<<-rowSums(SSB)
  Fout2<<-Fout[1,]
  if(objective_function_value_solve_catch_1==1)
    return((Ftarget-Fout[1,pyears])^2)
  if(objective_function_value_solve_catch_1==2)
    return((Fthreshold-Fout[1,pyears])^2)
  if(objective_function_value_solve_catch_1==3)
    return((SSBtarget-SSBout[1,pyears])^2)
  if(objective_function_value_solve_catch_1==4)
    return((SSBthreshold-SSBout[1,pyears])^2)
}#getsolution
results<-optimize(getsolution,c(1,total_current_catch*10))
constcatch<-round(results$minimum,1)
labs<-NULL
if(objective_function_value_solve_catch_1==1) {outparm<-Ftarget;labs<-"Ftarget"}
if(objective_function_value_solve_catch_1==2)
  {outparm<-Fthreshold;labs<-"Fthreshold"}
if(objective_function_value_solve_catch_1==3)
  {outparm<-SSBtarget;labs<-"SSBtarget"}
if(objective_function_value_solve_catch_1==4)
  {outparm<-SSBthreshold;labs<-"SSBthreshold"}
```

```r
  dataset<-data.frame(year=c(curyear:c(curyear+pyears-1)),SSB=SSBout[1,],FM=Fout2)
  condata<-paste("Constant catch to obtain ",paste(labs," (",outparm,")",sep=""),
           " by year ",c(curyear+pyears-1),sep="")
  condata1<-paste("Recruit values from ",recruit_start_year,
                  " to ", recruit_end_year,sep="")
  condata2<-ifelse(usebias==1,"N & F not bias-corrected","N & F bias-corrected")
  condata3<-ifelse(rcentral==1,"Mean recruits used","Median recruits used")
  cons<-c(condata,condata1,condata2,condata3)


  outpt<-list(type="Constant_Catch_Projections_1",trajectory_target=outparm,
              trajectory_target_label=labs,conditions=cons,
              constant_catch=constcatch,results=dataset)
  return(outpt)
}#solve_catch==1

if(solve_catch==2){
  #storage matrices
  N<-matrix(0,nrow=pyears,ncol=maxage)
  SSB<-matrix(0,nrow=pyears,ncol=maxage)
  prob<-matrix(0,nrow=pyears,ncol=1)
  SSBout1<-matrix(0,nrow=nsims,ncol=pyears)
  Fout1<-matrix(0,nrow=nsims,ncol=pyears)

  for(nrep in 1:nsims){
    for(a in 1:maxage){
      if(Nerr==1) N[1,a]<-Nages[a,1]
      if(Nerr==2) N[1,a]<-rnorm(1,mean=Nages[a,1],sd=Nages[a,2]*Nages[a,1])

      if(Ferr==1) Fran<-Fuse
      if(Ferr==2) Fran<-rnorm(1,mean=Fuse,sd=Fuse*FcurCV)
      #calculate F given catch
      SSB[1,a]<-N[1,a]*exp(-(pF*cursel[a]*Fran)-(M[a]*pM))*sex[a]*fmat[a]*
        curwgt[a]/1000 #metric tons
    }
    Fout1[nrep,1]<-Fran
    # January 1 abundance for years > 2014
    for(i in 2:as.numeric(pyears)){
      if(i==2){
        for(a in 1:maxage){
          if(a==1){
            N[i,1]<-sample(recruits_short,1,replace=FALSE)
          }
          if(a>1 & a<maxage) N[i,a]<-N[i-1,a-1]*exp(-Fout1[nrep,i-1]*cursel[a-1]-M[a-1])
          if(a==maxage) N[i,a]<-N[i-1,a-1]*exp(-Fout1[nrep,i-1]*cursel[a-1]-M[a-1])+
              N[i-1,a]*exp(-Fout1[nrep,i-1]*cursel[a]-M[a]) #plus group calculation
          if(N[i,a]<0) N[i,a]<-0
        }
        # solve for F given total_current_catch
        Nin<-N[i,]
        solveF2<-function(x){
          for(a in 1:maxage){
            pcatch[a]<-(avgselect[a]*x)/(avgselect[a]*x+M[a])*(1-exp(-avgselect[a]*
```

```
                                x-M[a]))*Nin[a]
          }
          (log(sum(pcatch))-log(total_current_catch))^2
        }
        outs<-optimize(solveF2,interval=c(0.001,2))
        Fout1[nrep,i]<-outs$minimum
        for(a in 1:maxage) SSB[i,a]<-N[i,a]*exp(-(pF*avgselect[a]*Fout1[nrep,i])-
                    (M[a]*pM))*sex[a]*fmat[a]*avgwgt[a]/1000 #metric tons
      }
      if(i>2){
        for(a in 1:maxage){
          if(a==1){
            N[i,1]<-sample(recruits_short,1,replace=FALSE)
          }
          if(a>1 & a<maxage) N[i,a]<-N[i-1,a-1]*exp(-Fout1[nrep,i-1]*
                                              avgselect[a-1]-M[a-1])
          #plusgrp
          if(a==maxage) N[i,a]<-N[i-1,a-1]*exp(-Fout1[nrep,i-1]*avgselect[a-1]-
                        M[a-1])+N[i-1,a]*exp(-Fout1[nrep,i-1]*avgselect[a]-M[a])
          if(N[i,a]<0) N[i,a]<-0
        }
        # solve for F given total_current_catch
        Nin<-N[i,]
        outs<-optimize(solveF2,interval=c(0.001,2))
        Fout1[nrep,i]<-outs$minimum
        for(a in 1:maxage) SSB[i,a]<-N[i,a]*exp(-(pF*avgselect[a]*Fout1[nrep,i])-
                        (M[a]*pM))*sex[a]*fmat[a]*avgwgt[a]/1000 #metric tons
      }
    }
    SSBout1[nrep,]<-rowSums(SSB)
  }#nrep
  Fprob_target<-NULL
  for(i in 1:pyears) Fprob_target[i]<-pgen(Fout1[,i],limit=Ftarget,
                              limSD=Ftarget*FtargetCV,dist=1,comp=4)
  SSBprob_target<-NULL
  for(i in 1:pyears) SSBprob_target[i]<-pgen(SSBout1[,i],limit=SSBtarget,
                              limSD=SSBtarget*SSBtargetCV,dist=1,comp=2)

  Fprob_threshold<-NULL
  for(i in 1:pyears) Fprob_threshold[i]<-pgen(Fout1[,i],limit=Fthreshold,
                              limSD=Fthreshold*FthresholdCV,dist=1,comp=4)
  SSBprob_threshold<-NULL
  for(i in 1:pyears) SSBprob_threshold[i]<-pgen(SSBout1[,i],limit=SSBthreshold,
                              limSD=SSBthreshold*SSBthresholdCV,dist=1,comp=2)

  #Plot results
  SSBmed<-apply(SSBout1,2,median)
  SSBpercent<-as.data.frame(t(apply(SSBout1,2,function(x){quantile(x,
                                        prob=c(0.025,0.975))})))

  Fmed<-apply(Fout1,2,median)
  Fpercent<-as.data.frame(t(apply(Fout1,2,function(x){quantile(x,
                                        prob=c(0.025,0.975))})))
```

```
    dataout<-data.frame(year=c(curyear:(curyear+pyears-1)),
                        catch=total_current_catch,Fmed=Fmed,
                        F2_5=Fpercent[,1],F97_5=Fpercent[,2],
                        Prob_F_greater_Ftarget=Fprob_target,
                        Prob_F_greater_Fthreshold=Fprob_threshold,
                        SSBmed=SSBmed,SSB2_5=SSBpercent[,1],
                        SSB97_5=SSBpercent[,2],
                        Prob_SSB_less_SSBtarget=SSBprob_target,
                        Prob_SSB_less_SSBthreshold=SSBprob_threshold)

    if(Ferr==1) errorF<-"Off" else errorF<-"On"
    if(Nerr==1) errorN<-"Off" else errorN<-"On"
    if(usebias==1) bias_on<-"No" else bias_on<-"Yes"
    conout<-paste("F error: ",errorF,", N error: ",errorN,
                  ", F & N Bias-Corrected?: ",bias_on,sep="")
    outpt<-list(type="Constant_Catch_Projections_2",Ftarget=Ftarget,
                Fthreshold=Fthreshold,SSBtarget=SSBtarget,
                SSBthreshold=SSBthreshold,
                condition=conout,results=dataout)
    return(outpt)
  }#solve_catch==2
}#function
```

Data

```
maxage<-15
# Natural Mortality-at-age
Nat_Mortality<-M<-c(1.13,0.68,0.45,0.33,0.25,0.19,0.15,0.15,0.15,0.15,0.15,0.15,0.15,
                 0.15,0.15)

# Female Sex proportions-at-age
female_sex_fraction<-c(0.53,0.56,0.56,0.52,0.57,0.65,0.73,0.81,0.88,0.92,0.95,0.97,
                       1.00,1.00,1.00)

#Female maturity
female_mature_fraction<-c(0,0,0,0.09,0.32,0.45,0.84,0.89,1,1,1,1,1,1,1)

# Proportion F and M for SSB calculations
F_fraction<-0.1
M_fraction<-0.33
maxage<-max_age<-15


# SSB rivard wgts  #2024

# Average of 2019-2023
average_wgt<-c(0.170912897,0.417823556,0.927379714,1.458463863,2.071445994,2.897995624,
            3.990014283,5.182445546,6.319665235,7.741211998,9.069336065,10.90477891,
            13.0331813,13.87866685,15.67380948)
```

```r
# All recruits 1982-2023
recruits_series<-data.frame(year=1982:2023,
            recr=c(37364100,75602800,62859700,68479300,67611600,74169300,93300800,
                   106655000,130941000,104485000,108762000,133935000,285297000,
                   186734000,234018000,258960000,148052000,152875000,
                   124486000,196467000,221336000,127967000,304432000,158153000,
                   135236000,88441000,126912000,75196700,96903000,125307000,
                   192360000,66597300,82938200,153154000,228067000,111488000,
                   130105000,165265000,120143000,85158100,76967300,96681400))
```

Bay - New Selectivity

```r
dir<-getwd()
bayfile<-paste(dir,"/BAYALKS_2021.xlsx",sep="") # data 2021 only
MD_Bay_R_Har_2021 <-as.data.frame(read_xlsx(bayfile,sheet="MD Bay Rec Harvest"))
VA_Bay_R_Har_2021 <-as.data.frame(read_xlsx(bayfile,sheet="VA Bay Rec Harvest"))
MD_Bay_R_DR_2021 <-as.data.frame(read_xlsx(bayfile,sheet="MD Bay Rec Dead Rel"))
VA_Bay_R_DR_2021 <-as.data.frame(read_xlsx(bayfile,sheet="VA Bay Rec Dead Rel"))
MD_Bay_Comm_Har_2021 <-as.data.frame(read_xlsx(bayfile,sheet="MD Bay Comm Harvest"))
VA_Bay_Comm_Har_2021 <-as.data.frame(read_xlsx(bayfile,sheet="VA Bay Comm Harvest"))
PRFC_Comm_Har_2021 <-as.data.frame(read_xlsx(bayfile,sheet="PRFC Comm Harvest"))

bayfile<-paste(dir,"/BAYALKS_2020.xlsx",sep="") # data 2020 only
MD_Bay_R_Har_2020 <-as.data.frame(read_xlsx(bayfile,sheet="MD Bay Rec Harvest"))
VA_Bay_R_Har_2020 <-as.data.frame(read_xlsx(bayfile,sheet="VA Bay Rec Harvest"))
MD_Bay_R_DR_2020 <-as.data.frame(read_xlsx(bayfile,sheet="MD Bay Rec Dead Rel"))
VA_Bay_R_DR_2020 <-as.data.frame(read_xlsx(bayfile,sheet="VA Bay Rec Dead Rel"))
MD_Bay_Comm_Har_2020 <-as.data.frame(read_xlsx(bayfile,sheet="MD Bay Comm Harvest"))
VA_Bay_Comm_Har_2020 <-as.data.frame(read_xlsx(bayfile,sheet="VA Bay Comm Harvest"))
PRFC_Comm_Har_2020 <-as.data.frame(read_xlsx(bayfile,sheet="PRFC Comm Harvest"))

bayfile<-paste(dir,"/BAYALKS_2021.xlsx",sep="") # data 2021 only
MD_Bay_R_Har_2021 <-as.data.frame(read_xlsx(bayfile,sheet="MD Bay Rec Harvest"))
VA_Bay_R_Har_2021 <-as.data.frame(read_xlsx(bayfile,sheet="VA Bay Rec Harvest"))
MD_Bay_R_DR_2021 <-as.data.frame(read_xlsx(bayfile,sheet="MD Bay Rec Dead Rel"))
VA_Bay_R_DR_2021 <-as.data.frame(read_xlsx(bayfile,sheet="VA Bay Rec Dead Rel"))
MD_Bay_Comm_Har_2021 <-as.data.frame(read_xlsx(bayfile,sheet="MD Bay Comm Harvest"))
VA_Bay_Comm_Har_2021 <-as.data.frame(read_xlsx(bayfile,sheet="VA Bay Comm Harvest"))
PRFC_Comm_Har_2021 <-as.data.frame(read_xlsx(bayfile,sheet="PRFC Comm Harvest"))

bayfile<-paste(dir,"/BAYALKS_2022.xlsx",sep="") # data 2022 only
MD_Bay_R_Har_2022 <-as.data.frame(read_xlsx(bayfile,sheet="MD Bay Rec Harvest"))
VA_Bay_R_Har_2022 <-as.data.frame(read_xlsx(bayfile,sheet="VA Bay Rec Harvest"))
MD_Bay_R_DR_2022 <-as.data.frame(read_xlsx(bayfile,sheet="MD Bay Rec Dead Rel"))
VA_Bay_R_DR_2022 <-as.data.frame(read_xlsx(bayfile,sheet="VA Bay Rec Dead Rel"))
MD_Bay_Comm_Har_2022 <-as.data.frame(read_xlsx(bayfile,sheet="MD Bay Comm Harvest"))
VA_Bay_Comm_Har_2022 <-as.data.frame(read_xlsx(bayfile,sheet="VA Bay Comm Harvest"))
PRFC_Comm_Har_2022<-as.data.frame(read_xlsx(bayfile,sheet="PRFC Comm Harvest"))

Bay_Rec_Har<-MD_Bay_R_Har_2020[,c(2:16)]+VA_Bay_R_Har_2020[,c(2:16)]+
  MD_Bay_R_Har_2021[,c(2:16)]+ VA_Bay_R_Har_2021[,c(2:16)]+
```

```
  MD_Bay_R_Har_2022[,c(2:16)]+ VA_Bay_R_Har_2022[,c(2:16)]
Bay_Rec_Har[is.na(Bay_Rec_Har)]<-0

Bay_Comm_Har<-MD_Bay_Comm_Har_2020[,c(2:16)]+VA_Bay_Comm_Har_2020[,c(2:16)]+
  PRFC_Comm_Har_2020[,c(2:16)]+MD_Bay_Comm_Har_2021[,c(2:16)]+
  VA_Bay_Comm_Har_2021[,c(2:16)]+PRFC_Comm_Har_2021[,c(2:16)]+
  MD_Bay_Comm_Har_2022[,c(2:16)]+VA_Bay_Comm_Har_2022[,c(2:16)]+
  PRFC_Comm_Har_2022[,c(2:16)]
Bay_Comm_Har[is.na(Bay_Comm_Har)]<-0

Bay_Rec_Dead_Rel<-MD_Bay_R_DR_2020[,c(2:16)]+VA_Bay_R_DR_2020[,c(2:16)]+
  MD_Bay_R_DR_2021[,c(2:16)]+VA_Bay_R_DR_2021[,c(2:16)]+
  MD_Bay_R_DR_2022[,c(2:16)]+VA_Bay_R_DR_2022[,c(2:16)]
Bay_Rec_Dead_Rel[is.na(Bay_Rec_Dead_Rel)]<-0

#Comm Dead Discards
Bay_Comm_DD_2020<-c(0,58,1862,6633,17003,8297,2237,944,2775,736,160,39,13,23,427)
Bay_Comm_DD_2021<-c(0,201,7015,14559,15476,29719,5787,1421,1138,2102,155,0,112,0,157)
Bay_Comm_DD_2022<-c(0,12,2410,10018,7896,5568,9263,2878,565,523,1118,387,64,190,606)
Bay_Comm_DD<-Bay_Comm_DD_2020+Bay_Comm_DD_2021+Bay_Comm_DD_2022

#Don't have ALK for commercial discards
Bay_Comm_Dead_Dis<-as.matrix(Bay_Comm_Har)
for(cc in 1:ncol(Bay_Comm_Dead_Dis)){
  Bay_Comm_Dead_Dis[,cc]<-Bay_Comm_Dead_Dis[,cc]/sum(Bay_Comm_Dead_Dis[,cc])*
    Bay_Comm_DD[cc]
}
Bay_Comm_Dead_Dis[is.nan(Bay_Comm_Dead_Dis)]<-0

Bay_Rec_Har_Prop<-as.matrix(Bay_Rec_Har)
Bay_Rec_Har_Prop[is.nan(Bay_Rec_Har_Prop)]<-0
Bay_Rec_Dead_Rel_Prop<-as.matrix(Bay_Rec_Dead_Rel)
Bay_Rec_Dead_Rel[is.nan(Bay_Rec_Dead_Rel_Prop)]<-0
Bay_Comm_Har_Prop<-as.matrix(Bay_Comm_Har)
Bay_Comm_Har_Prop[is.nan(Bay_Comm_Har_Prop)]<-0
Bay_Comm_Dead_Dis_Prop<-as.matrix(Bay_Comm_Dead_Dis)
Bay_Comm_Dead_Dis_Prop[is.nan(Bay_Comm_Dead_Dis_Prop)]<-0


bayF2020<-c(0.00063,0.00331,0.01478,0.03872,0.05169,0.05146,0.048,0.04426,0.04074,
            0.03748,0.03448,0.03172,0.02918,0.02684,0.02469)

bayF2021<-c(0.000506789,0.00266759,0.011922,0.0312385,0.041701,0.0415123,0.038724,
            0.0357083,0.0328629,0.0302343,0.0278144,0.0255879,0.0235397,0.0216553,
            0.0199219)

bayF2022<-c(0.000493889,0.00259968,0.0116186,0.0304433,0.0406395,0.0404556,0.0377383,
            0.0347993,0.0320264,0.0294647,0.0271064,0.0249366,0.0229405,0.0211041,
            0.0194147)


bayFavg<-exp((log(bayF2020)+log(bayF2021)+log(bayF2022))/3)
```

```r
for(cc in 1:ncol(Bay_Comm_Dead_Dis)){
  coltotal<-sum(Bay_Rec_Har[,cc],Bay_Rec_Dead_Rel[,cc],Bay_Comm_Har[,cc],
                Bay_Comm_Dead_Dis[,cc])
  Bay_Rec_Har_Prop[,cc]<-Bay_Rec_Har[,cc]/coltotal*bayFavg[cc]
  Bay_Rec_Har_Prop[is.nan(Bay_Rec_Har_Prop)]<-0
  Bay_Rec_Dead_Rel_Prop[,cc]<-Bay_Rec_Dead_Rel[,cc]/coltotal*bayFavg[cc]
  Bay_Rec_Dead_Rel_Prop[is.nan(Bay_Rec_Dead_Rel_Prop)]<-0
  Bay_Comm_Har_Prop[,cc]<-Bay_Comm_Har[,cc]/coltotal*bayFavg[cc]
  Bay_Comm_Har_Prop[is.nan(Bay_Comm_Har_Prop)]<-0
  Bay_Comm_Dead_Dis_Prop[,cc]<-Bay_Comm_Dead_Dis[,cc]/coltotal*bayFavg[cc]
  Bay_Comm_Dead_Dis_Prop[is.nan(Bay_Comm_Dead_Dis_Prop)]<-0
}

#New Bay Regulations
new_Bay_slot<-c(19,24)

new_Bay_Rec_Har_Prop<-Bay_Rec_Har_Prop
new_Bay_Rec_Dead_Rel_Prop<-Bay_Rec_Dead_Rel_Prop

newbelow<-new_Bay_Rec_Har_Prop[1:c(new_Bay_slot[1]-1),]
newabove<-new_Bay_Rec_Har_Prop[c(new_Bay_slot[2]+1):nrow(Bay_Rec_Har_Prop),]

newbelow_adjusted<-newbelow*0.09
newabove_adjusted<-newabove*0.09

new_Bay_Rec_Har_Prop[1:c(new_Bay_slot[1]-1),]<-0
new_Bay_Rec_Har_Prop[c(new_Bay_slot[2]+1):nrow(Bay_Rec_Har_Prop),]<-0

#Add to Releases
new_Bay_Rec_Dead_Rel_Prop[1:c(new_Bay_slot[1]-1),]<-
  Bay_Rec_Dead_Rel_Prop[1:c(new_Bay_slot[1]-1),]+
  newbelow_adjusted
new_Bay_Rec_Dead_Rel_Prop[c(new_Bay_slot[2]+1):nrow(Bay_Rec_Dead_Rel_Prop),]<-
  new_Bay_Rec_Dead_Rel_Prop[c(new_Bay_slot[2]+1):nrow(Bay_Rec_Dead_Rel_Prop),]+
  newabove_adjusted

#Get New F trajectory
newBayF<-vector()
for(cc in 1:ncol(Bay_Comm_Har_Prop)){
newBayF[cc]<-sum(Bay_Comm_Har_Prop[,cc],Bay_Comm_Dead_Dis_Prop[,cc],
    new_Bay_Rec_Har_Prop[,cc],new_Bay_Rec_Dead_Rel_Prop[,cc])
}
newBayF[is.nan(newBayF)]<-0
new_bay_select<-newBayF/max(newBayF)
```

Coast - New Selectivity

```r
dir<-getwd()
#--------------------2020
cstfile<-paste(dir,"/CSTALKS_2020.xlsx",sep="")
ME_R_Har_2020 <-as.data.frame(read_xlsx(cstfile,sheet="ME Rec Harvest"))
```

```r
ME_R_Har_2020[is.na(ME_R_Har_2020)]<-0
NH_R_Har_2020 <-as.data.frame(read_xlsx(cstfile,sheet="NH Rec Harvest"))
NH_R_Har_2020[is.na(NH_R_Har_2020)]<-0
MA_R_Har_2020 <-as.data.frame(read_xlsx(cstfile,sheet="MA Rec Harvest"))
MA_R_Har_2020[is.na(MA_R_Har_2020)]<-0
RI_R_Har_2020 <-as.data.frame(read_xlsx(cstfile,sheet="RI Rec Harvest"))
RI_R_Har_2020[is.na(RI_R_Har_2020)]<-0
CT_R_Har_2020 <-as.data.frame(read_xlsx(cstfile,sheet="CT Rec Harvest"))
CT_R_Har_2020[is.na(CT_R_Har_2020)]<-0
NY_R_Har_2020 <-as.data.frame(read_xlsx(cstfile,sheet="NY Rec Harvest"))
NY_R_Har_2020[is.na(NY_R_Har_2020)]<-0
NJ_R_Har_2020 <-as.data.frame(read_xlsx(cstfile,sheet="NJ Rec Harvest"))
NJ_R_Har_2020[is.na(NJ_R_Har_2020)]<-0
DE_R_Har_2020 <-as.data.frame(read_xlsx(cstfile,sheet="DE Rec Harvest"))
DE_R_Har_2020[is.na(DE_R_Har_2020)]<-0
MD_R_Har_2020 <-as.data.frame(read_xlsx(cstfile,sheet="MD Ocean Rec Harvest"))
MD_R_Har_2020[is.na(MD_R_Har_2020)]<-0
VA_R_Har_2020 <-as.data.frame(read_xlsx(cstfile,sheet="VA Ocean Rec Harvest"))
VA_R_Har_2020[is.na(VA_R_Har_2020)]<-0

#rec releases
ME_R_Dead_Rel_2020 <-as.data.frame(read_xlsx(cstfile,sheet="ME Rec Dead Rel"))
ME_R_Dead_Rel_2020[is.na(ME_R_Dead_Rel_2020)]<-0
NH_R_Dead_Rel_2020 <-as.data.frame(read_xlsx(cstfile,sheet="NH Rec Dead Rel"))
NH_R_Dead_Rel_2020[is.na(NH_R_Dead_Rel_2020)]<-0
MA_R_Dead_Rel_2020 <-as.data.frame(read_xlsx(cstfile,sheet="MA Rec Dead Rel"))
MA_R_Dead_Rel_2020[is.na(MA_R_Dead_Rel_2020)]<-0
RI_R_Dead_Rel_2020 <-as.data.frame(read_xlsx(cstfile,sheet="RI Rec Dead Rel"))
RI_R_Dead_Rel_2020[is.na(RI_R_Dead_Rel_2020)]<-0
CT_R_Dead_Rel_2020 <-as.data.frame(read_xlsx(cstfile,sheet="CT Rec Dead Rel"))
CT_R_Dead_Rel_2020[is.na(CT_R_Dead_Rel_2020)]<-0
NY_R_Dead_Rel_2020 <-as.data.frame(read_xlsx(cstfile,sheet="NY Rec Dead Rel"))
NY_R_Dead_Rel_2020[is.na(NY_R_Dead_Rel_2020)]<-0
NJ_R_Dead_Rel_2020 <-as.data.frame(read_xlsx(cstfile,sheet="NJ Rec Dead Rel"))
NJ_R_Dead_Rel_2020[is.na(NJ_R_Dead_Rel_2020)]<-0
DE_R_Dead_Rel_2020 <-as.data.frame(read_xlsx(cstfile,sheet="DE Rec Dead Rel"))
DE_R_Dead_Rel_2020[is.na(DE_R_Dead_Rel_2020)]<-0
MD_R_Dead_Rel_2020 <-as.data.frame(read_xlsx(cstfile,sheet="MD Ocean Rec Dead Rel"))
MD_R_Dead_Rel_2020[is.na(MD_R_Dead_Rel_2020)]<-0
VA_R_Dead_Rel_2020 <-as.data.frame(read_xlsx(cstfile,sheet="VA Ocean Rec Dead Rel"))
VA_R_Dead_Rel_2020[is.na(VA_R_Dead_Rel_2020)]<-0
NC_R_Dead_Rel_2020 <-as.data.frame(read_xlsx(cstfile,sheet="NC Ocean Rec Dead Rel"))
NC_R_Dead_Rel_2020[is.na(NC_R_Dead_Rel_2020)]<-0

#com harvest
MA_R_Comm_Har_2020 <-as.data.frame(read_xlsx(cstfile,sheet="MA Comm Harvest"))
MA_R_Comm_Har_2020[is.na(MA_R_Comm_Har_2020)]<-0
RI_R_Comm_Har_2020 <-as.data.frame(read_xlsx(cstfile,sheet="RI Comm Harvest"))
RI_R_Comm_Har_2020[is.na(RI_R_Comm_Har_2020)]<-0
NY_R_Comm_Har_2020 <-as.data.frame(read_xlsx(cstfile,sheet="NY Comm Harvest"))
NY_R_Comm_Har_2020[is.na(NY_R_Comm_Har_2020)]<-0
DE_R_Comm_Har_2020 <-as.data.frame(read_xlsx(cstfile,sheet="DE Comm Harvest"))
DE_R_Comm_Har_2020[is.na(DE_R_Comm_Har_2020)]<-0
```

```r
MD_R_Comm_Har_2020 <-as.data.frame(read_xlsx(cstfile,sheet="MD Ocean Comm Harvest"))
MD_R_Comm_Har_2020[is.na(MD_R_Comm_Har_2020)]<-0
VA_R_Comm_Har_2020 <-as.data.frame(read_xlsx(cstfile,sheet="VA Ocean Comm Harvest"))
VA_R_Comm_Har_2020[is.na(VA_R_Comm_Har_2020)]<-0


#2021
cstfile<-paste(dir,"/CSTALKS_2021.xlsx",sep="")
ME_R_Har_2021 <-as.data.frame(read_xlsx(cstfile,sheet="ME Rec Harvest"))
ME_R_Har_2021[is.na(ME_R_Har_2021)]<-0
NH_R_Har_2021 <-as.data.frame(read_xlsx(cstfile,sheet="NH Rec Harvest"))
NH_R_Har_2021[is.na(NH_R_Har_2021)]<-0
MA_R_Har_2021 <-as.data.frame(read_xlsx(cstfile,sheet="MA Rec Harvest"))
MA_R_Har_2021[is.na(MA_R_Har_2021)]<-0
RI_R_Har_2021 <-as.data.frame(read_xlsx(cstfile,sheet="RI Rec Harvest"))
RI_R_Har_2021[is.na(RI_R_Har_2021)]<-0
CT_R_Har_2021 <-as.data.frame(read_xlsx(cstfile,sheet="CT Rec Harvest"))
CT_R_Har_2021[is.na(CT_R_Har_2021)]<-0
NY_R_Har_2021 <-as.data.frame(read_xlsx(cstfile,sheet="NY Rec Harvest"))
NY_R_Har_2021[is.na(NY_R_Har_2021)]<-0
NJ_R_Har_2021 <-as.data.frame(read_xlsx(cstfile,sheet="NJ Rec Harvest"))
NJ_R_Har_2021[is.na(NJ_R_Har_2021)]<-0
DE_R_Har_2021 <-as.data.frame(read_xlsx(cstfile,sheet="DE Rec Harvest"))
DE_R_Har_2021[is.na(DE_R_Har_2021)]<-0
MD_R_Har_2021 <-as.data.frame(read_xlsx(cstfile,sheet="MD Ocean Rec Harvest"))
MD_R_Har_2021[is.na(MD_R_Har_2021)]<-0
VA_R_Har_2021 <-as.data.frame(read_xlsx(cstfile,sheet="VA Ocean Rec Harvest"))
VA_R_Har_2021[is.na(VA_R_Har_2021)]<-0

#rec releases
ME_R_Dead_Rel_2021 <-as.data.frame(read_xlsx(cstfile,sheet="ME Rec Dead Rel"))
ME_R_Dead_Rel_2021[is.na(ME_R_Dead_Rel_2021)]<-0
NH_R_Dead_Rel_2021 <-as.data.frame(read_xlsx(cstfile,sheet="NH Rec Dead Rel"))
NH_R_Dead_Rel_2021[is.na(NH_R_Dead_Rel_2021)]<-0
MA_R_Dead_Rel_2021 <-as.data.frame(read_xlsx(cstfile,sheet="MA Rec Dead Rel"))
MA_R_Dead_Rel_2021[is.na(MA_R_Dead_Rel_2021)]<-0
RI_R_Dead_Rel_2021 <-as.data.frame(read_xlsx(cstfile,sheet="RI Rec Dead Rel"))
RI_R_Dead_Rel_2021[is.na(RI_R_Dead_Rel_2021)]<-0
CT_R_Dead_Rel_2021 <-as.data.frame(read_xlsx(cstfile,sheet="CT Rec Dead Rel"))
CT_R_Dead_Rel_2021[is.na(CT_R_Dead_Rel_2021)]<-0
NY_R_Dead_Rel_2021 <-as.data.frame(read_xlsx(cstfile,sheet="NY Rec Dead Rel"))
NY_R_Dead_Rel_2021[is.na(NY_R_Dead_Rel_2021)]<-0
NJ_R_Dead_Rel_2021 <-as.data.frame(read_xlsx(cstfile,sheet="NJ Rec Dead Rel"))
NJ_R_Dead_Rel_2021[is.na(NJ_R_Dead_Rel_2021)]<-0
DE_R_Dead_Rel_2021 <-as.data.frame(read_xlsx(cstfile,sheet="DE Rec Dead Rel"))
DE_R_Dead_Rel_2021[is.na(DE_R_Dead_Rel_2021)]<-0
MD_R_Dead_Rel_2021 <-as.data.frame(read_xlsx(cstfile,sheet="MD Ocean Rec Dead Rel"))
MD_R_Dead_Rel_2021[is.na(MD_R_Dead_Rel_2021)]<-0
VA_R_Dead_Rel_2021 <-as.data.frame(read_xlsx(cstfile,sheet="VA Ocean Rec Dead Rel"))
VA_R_Dead_Rel_2021[is.na(VA_R_Dead_Rel_2021)]<-0
NC_R_Dead_Rel_2021 <-as.data.frame(read_xlsx(cstfile,sheet="NC Ocean Rec Dead Rel"))
NC_R_Dead_Rel_2021[is.na(NC_R_Dead_Rel_2021)]<-0
```

```r
#com harvest
MA_R_Comm_Har_2021 <-as.data.frame(read_xlsx(cstfile,sheet="MA Comm Harvest"))
MA_R_Comm_Har_2021[is.na(MA_R_Comm_Har_2021)]<-0
RI_R_Comm_Har_2021 <-as.data.frame(read_xlsx(cstfile,sheet="RI Comm Harvest"))
RI_R_Comm_Har_2021[is.na(RI_R_Comm_Har_2021)]<-0
NY_R_Comm_Har_2021 <-as.data.frame(read_xlsx(cstfile,sheet="NY Comm Harvest"))
NY_R_Comm_Har_2021[is.na(NY_R_Comm_Har_2021)]<-0
DE_R_Comm_Har_2021 <-as.data.frame(read_xlsx(cstfile,sheet="DE Comm Harvest"))
DE_R_Comm_Har_2021[is.na(DE_R_Comm_Har_2021)]<-0
MD_R_Comm_Har_2021 <-as.data.frame(read_xlsx(cstfile,sheet="MD Ocean Comm Harvest"))
MD_R_Comm_Har_2021[is.na(MD_R_Comm_Har_2021)]<-0
VA_R_Comm_Har_2021 <-as.data.frame(read_xlsx(cstfile,sheet="VA Ocean Comm Harvest"))
VA_R_Comm_Har_2021[is.na(VA_R_Comm_Har_2021)]<-0

#2022

cstfile<-paste(dir,"/CSTALKS_2022.xlsx",sep="")
ME_R_Har_2022 <-as.data.frame(read_xlsx(cstfile,sheet="ME Rec Harvest"))
ME_R_Har_2022[is.na(ME_R_Har_2022)]<-0
NH_R_Har_2022 <-as.data.frame(read_xlsx(cstfile,sheet="NH Rec Harvest"))
NH_R_Har_2022[is.na(NH_R_Har_2022)]<-0
MA_R_Har_2022 <-as.data.frame(read_xlsx(cstfile,sheet="MA Rec Harvest"))
MA_R_Har_2022[is.na(MA_R_Har_2022)]<-0
RI_R_Har_2022 <-as.data.frame(read_xlsx(cstfile,sheet="RI Rec Harvest"))
RI_R_Har_2022[is.na(RI_R_Har_2022)]<-0
CT_R_Har_2022 <-as.data.frame(read_xlsx(cstfile,sheet="CT Rec Harvest"))
CT_R_Har_2022[is.na(CT_R_Har_2022)]<-0
NY_R_Har_2022 <-as.data.frame(read_xlsx(cstfile,sheet="NY Rec Harvest"))
NY_R_Har_2022[is.na(NY_R_Har_2022)]<-0
NJ_R_Har_2022 <-as.data.frame(read_xlsx(cstfile,sheet="NJ Rec Harvest"))
NJ_R_Har_2022[is.na(NJ_R_Har_2022)]<-0
DE_R_Har_2022 <-as.data.frame(read_xlsx(cstfile,sheet="DE Rec Harvest"))
DE_R_Har_2022[is.na(DE_R_Har_2022)]<-0
MD_R_Har_2022 <-as.data.frame(read_xlsx(cstfile,sheet="MD Ocean Rec Harvest"))
MD_R_Har_2022[is.na(MD_R_Har_2022)]<-0
VA_R_Har_2022 <-as.data.frame(read_xlsx(cstfile,sheet="VA Ocean Rec Harvest"))
VA_R_Har_2022[is.na(VA_R_Har_2022)]<-0

#rec releases
ME_R_Dead_Rel_2022 <-as.data.frame(read_xlsx(cstfile,sheet="ME Rec Dead Rel"))
ME_R_Dead_Rel_2022[is.na(ME_R_Dead_Rel_2022)]<-0
NH_R_Dead_Rel_2022 <-as.data.frame(read_xlsx(cstfile,sheet="NH Rec Dead Rel"))
NH_R_Dead_Rel_2022[is.na(NH_R_Dead_Rel_2022)]<-0
MA_R_Dead_Rel_2022 <-as.data.frame(read_xlsx(cstfile,sheet="MA Rec Dead Rel"))
MA_R_Dead_Rel_2022[is.na(MA_R_Dead_Rel_2022)]<-0
RI_R_Dead_Rel_2022 <-as.data.frame(read_xlsx(cstfile,sheet="RI Rec Dead Rel"))
RI_R_Dead_Rel_2022[is.na(RI_R_Dead_Rel_2022)]<-0
CT_R_Dead_Rel_2022 <-as.data.frame(read_xlsx(cstfile,sheet="CT Rec Dead Rel"))
CT_R_Dead_Rel_2022[is.na(CT_R_Dead_Rel_2022)]<-0
NY_R_Dead_Rel_2022 <-as.data.frame(read_xlsx(cstfile,sheet="NY Rec Dead Rel"))
NY_R_Dead_Rel_2022[is.na(NY_R_Dead_Rel_2022)]<-0
NJ_R_Dead_Rel_2022 <-as.data.frame(read_xlsx(cstfile,sheet="NJ Rec Dead Rel"))
NJ_R_Dead_Rel_2022[is.na(NJ_R_Dead_Rel_2022)]<-0
```

```r
DE_R_Dead_Rel_2022 <-as.data.frame(read_xlsx(cstfile,sheet="DE Rec Dead Rel"))
DE_R_Dead_Rel_2022[is.na(DE_R_Dead_Rel_2022)]<-0
MD_R_Dead_Rel_2022 <-as.data.frame(read_xlsx(cstfile,sheet="MD Ocean Rec Dead Rel"))
MD_R_Dead_Rel_2022[is.na(MD_R_Dead_Rel_2022)]<-0
VA_R_Dead_Rel_2022 <-as.data.frame(read_xlsx(cstfile,sheet="VA Ocean Rec Dead Rel"))
VA_R_Dead_Rel_2022[is.na(VA_R_Dead_Rel_2022)]<-0
NC_R_Dead_Rel_2022 <-as.data.frame(read_xlsx(cstfile,sheet="NC Ocean Rec Dead Rel"))
NC_R_Dead_Rel_2022[is.na(NC_R_Dead_Rel_2022)]<-0

#com harvest
MA_R_Comm_Har_2022 <-as.data.frame(read_xlsx(cstfile,sheet="MA Comm Harvest"))
MA_R_Comm_Har_2022[is.na(MA_R_Comm_Har_2022)]<-0
RI_R_Comm_Har_2022 <-as.data.frame(read_xlsx(cstfile,sheet="RI Comm Harvest"))
RI_R_Comm_Har_2022[is.na(RI_R_Comm_Har_2022)]<-0
NY_R_Comm_Har_2022 <-as.data.frame(read_xlsx(cstfile,sheet="NY Comm Harvest"))
NY_R_Comm_Har_2022[is.na(NY_R_Comm_Har_2022)]<-0
DE_R_Comm_Har_2022 <-as.data.frame(read_xlsx(cstfile,sheet="DE Comm Harvest"))
DE_R_Comm_Har_2022[is.na(DE_R_Comm_Har_2022)]<-0
MD_R_Comm_Har_2022 <-as.data.frame(read_xlsx(cstfile,sheet="MD Ocean Comm Harvest"))
MD_R_Comm_Har_2022[is.na(MD_R_Comm_Har_2022)]<-0
VA_R_Comm_Har_2022 <-as.data.frame(read_xlsx(cstfile,sheet="VA Ocean Comm Harvest"))
VA_R_Comm_Har_2022[is.na(VA_R_Comm_Har_2022)]<-0

CST_Rec_Har<-ME_R_Har_2021[,c(2:16)]+NH_R_Har_2021[,c(2:16)]+MA_R_Har_2021[,c(2:16)]+
  RI_R_Har_2021[,c(2:16)]+CT_R_Har_2021[,c(2:16)]+NY_R_Har_2021[,c(2:16)]+
  DE_R_Har_2021[,c(2:16)]+MD_R_Har_2021[,c(2:16)]+VA_R_Har_2021[,c(2:16)]+
  ME_R_Har_2020[,c(2:16)]+NH_R_Har_2020[,c(2:16)]+MA_R_Har_2020[,c(2:16)]+
  RI_R_Har_2020[,c(2:16)]+CT_R_Har_2020[,c(2:16)]+NY_R_Har_2020[,c(2:16)]+
  DE_R_Har_2020[,c(2:16)]+MD_R_Har_2020[,c(2:16)]+VA_R_Har_2020[,c(2:16)]+
  ME_R_Har_2022[,c(2:16)]+NH_R_Har_2022[,c(2:16)]+MA_R_Har_2022[,c(2:16)]+
  RI_R_Har_2022[,c(2:16)]+CT_R_Har_2022[,c(2:16)]+NY_R_Har_2022[,c(2:16)]+
  DE_R_Har_2022[,c(2:16)]+MD_R_Har_2022[,c(2:16)]+VA_R_Har_2022[,c(2:16)]

CST_Rec_Dead_Rel<-ME_R_Dead_Rel_2020[,c(2:16)]+NH_R_Dead_Rel_2020[,c(2:16)]+
  MA_R_Dead_Rel_2020[,c(2:16)]+RI_R_Dead_Rel_2020[,c(2:16)]+
  CT_R_Dead_Rel_2020[,c(2:16)]+NY_R_Dead_Rel_2020[,c(2:16)]+
  DE_R_Dead_Rel_2020[,c(2:16)]+MD_R_Dead_Rel_2020[,c(2:16)]+
  VA_R_Dead_Rel_2020[,c(2:16)]+NC_R_Dead_Rel_2020[,c(2:16)]+
  ME_R_Dead_Rel_2021[,c(2:16)]+NH_R_Dead_Rel_2021[,c(2:16)]+
  MA_R_Dead_Rel_2021[,c(2:16)]+RI_R_Dead_Rel_2021[,c(2:16)]+
  CT_R_Dead_Rel_2021[,c(2:16)]+NY_R_Dead_Rel_2021[,c(2:16)]+
  DE_R_Dead_Rel_2021[,c(2:16)]+MD_R_Dead_Rel_2021[,c(2:16)]+
  VA_R_Dead_Rel_2021[,c(2:16)]+NC_R_Dead_Rel_2021[,c(2:16)]+
  ME_R_Dead_Rel_2022[,c(2:16)]+NH_R_Dead_Rel_2022[,c(2:16)]+
  MA_R_Dead_Rel_2022[,c(2:16)]+RI_R_Dead_Rel_2022[,c(2:16)]+
  CT_R_Dead_Rel_2022[,c(2:16)]+NY_R_Dead_Rel_2022[,c(2:16)]+
  DE_R_Dead_Rel_2022[,c(2:16)]+MD_R_Dead_Rel_2022[,c(2:16)]+
  VA_R_Dead_Rel_2022[,c(2:16)]+NC_R_Dead_Rel_2022[,c(2:16)]

CST_Comm_Har<-MA_R_Comm_Har_2020[,c(2:16)]+RI_R_Comm_Har_2020[,c(2:16)]+
  NY_R_Comm_Har_2020[,c(2:16)]+DE_R_Comm_Har_2020[,c(2:16)]+
  MD_R_Comm_Har_2020[,c(2:16)]+VA_R_Comm_Har_2020[,c(2:16)]+
  MA_R_Comm_Har_2021[,c(2:16)]+RI_R_Comm_Har_2021[,c(2:16)]+
```

```r
  NY_R_Comm_Har_2021[,c(2:16)]+DE_R_Comm_Har_2021[,c(2:16)]+
  MD_R_Comm_Har_2021[,c(2:16)]+VA_R_Comm_Har_2021[,c(2:16)]+
  MA_R_Comm_Har_2022[,c(2:16)]+RI_R_Comm_Har_2022[,c(2:16)]+
  NY_R_Comm_Har_2022[,c(2:16)]+DE_R_Comm_Har_2022[,c(2:16)]+
  MD_R_Comm_Har_2022[,c(2:16)]+VA_R_Comm_Har_2022[,c(2:16)]

#Dead discards at age - from 2024 update
CST_Comm_DD_2020<-c(0,130,315,945,3810,4369,2443,1989,1378,576,419,928,321,550,984)
CST_Comm_DD_2021<-c(0,64,215,512,1408,3423,2060,1152,506,1360,334,146,65,117,281)
CST_Comm_DD_2022<-c(0,2,35,235,351,727,964,326,122,94,131,53,22,14,52)


CST_Comm_DD<-CST_Comm_DD_2020+CST_Comm_DD_2021+CST_Comm_DD_2022

CST_Comm_Dead_Dis<-as.matrix(CST_Comm_Har)
for(cc in 1:ncol(CST_Comm_Dead_Dis)){
  CST_Comm_Dead_Dis[,cc]<-CST_Comm_Dead_Dis[,cc]/sum(CST_Comm_Dead_Dis[,cc])*
    CST_Comm_DD[cc]
}
CST_Comm_Dead_Dis[is.nan(CST_Comm_Dead_Dis)]<-0

CST_Rec_Har_Prop<-as.matrix(CST_Rec_Har)
CST_Rec_Har_Prop[is.nan(CST_Rec_Har_Prop)]<-0
CST_Rec_Dead_Rel_Prop<-as.matrix(CST_Rec_Dead_Rel)
CST_Rec_Dead_Rel[is.nan(CST_Rec_Dead_Rel_Prop)]<-0
CST_Comm_Har_Prop<-as.matrix(CST_Comm_Har)
CST_Comm_Har_Prop[is.nan(CST_Comm_Har_Prop)]<-0

CST_Comm_Dead_Dis_Prop<-as.matrix(CST_Comm_Dead_Dis)
CST_Comm_Dead_Dis_Prop[is.nan(CST_Comm_Dead_Dis_Prop)]<-0

CSTF2020<-c(0.00168,0.0052,0.01522,0.03797,0.07037,0.0941,0.1028,0.10335,0.10103,
            0.0979,0.09462,0.09137,0.08821,0.08515,0.08219)

CSTF2021<-c(0.00184,0.00572,0.01673,0.04174,0.07736,0.10344,0.11301,0.11362,0.11107,
            0.10763,0.10402,0.10044,0.09697,0.09361,0.09036)

CSTF2022<-c(0.00276,0.00857,0.02505,0.06252,0.11586,0.15492,0.16926,0.17016,0.16635,
            0.16119,0.15578,0.15043,0.14523,0.14019,0.13533)

CSTFavg<-exp((log(CSTF2020)+log(CSTF2021)+log(CSTF2022))/3)


for(cc in 1:ncol(CST_Comm_Dead_Dis)){
  coltotal<-sum(CST_Rec_Har[,cc],CST_Rec_Dead_Rel[,cc],CST_Comm_Har[,cc],
              CST_Comm_Dead_Dis[,cc])
  CST_Rec_Har_Prop[,cc]<-CST_Rec_Har[,cc]/coltotal*CSTFavg[cc]
  CST_Rec_Har_Prop[is.nan(CST_Rec_Har_Prop)]<-0
  CST_Rec_Dead_Rel_Prop[,cc]<-CST_Rec_Dead_Rel[,cc]/coltotal*CSTFavg[cc]
  CST_Rec_Dead_Rel_Prop[is.nan(CST_Rec_Dead_Rel_Prop)]<-0
  CST_Comm_Har_Prop[,cc]<-CST_Comm_Har[,cc]/coltotal*CSTFavg[cc]
  CST_Comm_Har_Prop[is.nan(CST_Comm_Har_Prop)]<-0
  CST_Comm_Dead_Dis_Prop[,cc]<-CST_Comm_Dead_Dis[,cc]/coltotal*CSTFavg[cc]
```

```
  CST_Comm_Dead_Dis_Prop[is.nan(CST_Comm_Dead_Dis_Prop)]<-0
}

#New Regulations
cstslot<-c(28,31)

new_CST_Rec_Har_Prop<-CST_Rec_Har_Prop
new_CST_Rec_Dead_Rel_Prop<-CST_Rec_Dead_Rel_Prop

newbelow<-new_CST_Rec_Har_Prop[1:c(cstslot[1]-1),]
newabove<-new_CST_Rec_Har_Prop[c(cstslot[2]+1):nrow(CST_Rec_Har_Prop),]

newbelow_adjusted<-newbelow*0.09
newabove_adjusted<-newabove*0.09

new_CST_Rec_Har_Prop[1:c(cstslot[1]-1),]<-0
new_CST_Rec_Har_Prop[c(cstslot[2]+1):nrow(CST_Rec_Har_Prop),]<-0

#Add to Releases
new_CST_Rec_Dead_Rel_Prop[1:c(cstslot[1]-1),]<-
  CST_Rec_Dead_Rel_Prop[1:c(cstslot[1]-1),]+newbelow_adjusted
new_CST_Rec_Dead_Rel_Prop[c(cstslot[2]+1):nrow(CST_Rec_Dead_Rel_Prop),]<-
  new_CST_Rec_Dead_Rel_Prop[c(cstslot[2]+1):nrow(CST_Rec_Dead_Rel_Prop),]+
  newabove_adjusted

#Get New F trajectory
newCSTF<-vector()
for(cc in 1:ncol(CST_Comm_Har_Prop)){
  newCSTF[cc]<-sum(CST_Comm_Har_Prop[,cc],CST_Comm_Dead_Dis_Prop[,cc],
      new_CST_Rec_Har_Prop[,cc],new_CST_Rec_Dead_Rel_Prop[,cc])
}

newCSTF[is.nan(newCSTF)]<-0
new_CST_select<-newCSTF/max(newCSTF)
```

New combined Selectivity

```
# 2024 selectivity (from total F)
comb_select_2024<-newBayF+newCSTF
comb_select_2024<-comb_select_2024/max(comb_select_2024)
CombF<-CSTFavg+bayFavg #2020-2022
```

Calculate Numbers-at-age for 2024

```
#Jan-1
N2023<-data.frame(N=c(96681400,24782200,13749300,11957000,10872400,5807770,3479720,
                     5129420,2458020,926552,501940,963536,412419,208649,515022))
```

```r
catch_2023<-data.frame(removals=c(35504.03,111866.23,299326.95,799575.80,
                  1066841.90,567243.77,695959.36,1145467.72,357229.05,236550.82,
                  70131.97,73326.67,26013.12,19799.25,77273.11))

#Predict Age1 in 2024 from MD YOY Index for 2023
# All recruits 1982-2023
recruits_series<-data.frame(year=1982:2023,
            recr=c(37364100,75602800,62859700,68479300,67611600,74169300,93300800,
                   106655000,130941000,104485000,108762000,133935000,285297000,
                   186734000,234018000,258960000,148052000,152875000,
                   124486000,196467000,221336000,127967000,304432000,158153000,
                   135236000,88441000,126912000,75196700,96903000,125307000,
                   192360000,66597300,82938200,153154000,228067000,111488000,
                   130105000,165265000,120143000,85158100,76967300,96681400))
MDYOYlag<-c(0.59,3.57,0.61,1.64,0.91,1.34,1.46,0.73,4.87,1.03,1.52,2.34,13.97,6.40,
            4.41,17.61,3.91,5.50,5.34,7.42,12.57,2.20,10.83,4.85,6.91,
            1.78,5.12,1.26,3.92,2.54,9.57,0.49,3.42,4.06,10.67,1.25,5.88,6.96,1.95,
            1.12,1.65,1.78,0.57)

#Determine Age 1 versus MD YOY relationship
datar<-data.frame(year=1982:2024,age1=c(recruits_series$recr,NA),index=MDYOYlag)
tempdata<-datar[datar$year<2024,]
age1YOY_model<-lm(age1~index, data=tempdata)

# Predict age 1 for 2024
predicted_age1_2024<-as.numeric(predict(age1YOY_model,newdata=
                        data.frame(index=datar[datar$year==2024,3])))

N2024<-N2023
for(a in 1:maxage){
  if(a==1) N2024[1,1]<-predicted_age1_2024
  if(a>1 & a<maxage) N2024[a,1]<-N2023[a-1,1]*exp(-M[a-1])-catch_2023[a-1,1]*
       exp(-M[a-1]/2)
  if(a==maxage) N2024[a,1]<-N2023[a-1,1]*exp(-M[a-1])-catch_2023[a-1,1]*
      exp(-M[a-1]/2)+N2023[a,1]*exp(-M[a])-catch_2023[a,1]*exp(-M[a]/2)#plus group
   if(N2024[a,1]<0) N2024[a,1]<-0
}


N2024$CV<-c(0.166,0.141,0.137,0.107,0.098,0.102,0.107,0.107,0.121,0.135,
                0.149,0.149,0.171,0.193,0.247)
N2024
```

```
##              N    CV
## 1  80936272.2 0.166
## 2  31211128.4 0.141
## 3  12475460.6 0.137
## 4   8527923.3 0.107
## 5   7918215.8 0.098
## 6   7525949.0 0.102
## 7   4286952.3 0.107
## 8   2349351.0 0.107
## 9   3352232.5 0.121
```

```
## 10  1784220.5 0.135
## 11   578032.2 0.149
## 12   366959.3 0.149
## 13   761294.8 0.171
## 14   330838.8 0.193
## 15   532811.2 0.247
```

Reference Points

```
# Reference Points from one block model
SSB_threshold<-89213.4
SSB_threshold_CV<-0.062
SSB_target<-SSB_threshold*1.25
SSB_target_CV<-SSB_threshold_CV
F_threshold<-0.2064
F_threshold_CV<-0.133
F_target<-0.1707
F_target_CV<-0.133
SSB_2023<-86535.7
F_2023<-0.1828

Nbias<-c(0.052569183,0.018336967,0.022521635,0.0262269,0.027848943,0.035054616,
         0.047813092,0.053597387,0.051212845,0.048280795,0.044594976,
         0.040305708,0.035191998,0.029222708,0.010445624)#old

# Bias in F from retrospective analysis
F_bias<--0.053#old
```

Catch Number Scenarios

```
catch_scenario_1<-5862189
catch_scenario_2<-3890793
```

Projections: Catch Scenario 1 (High 2024 Catch)

Solve for F given total catch

```
   pcatch<-vector()
   solveF1<-function(x){
            for(a in 1:maxage){
              pcatch[a]<-(comb_select_2024[a]*x)/(comb_select_2024[a]*x+M[a])*
                (1-exp(-comb_select_2024[a]*x-M[a]))*N2024[a,1]
            }
            (log(sum(pcatch))-log(catch_scenario_1))^2
        }
```

```
    outs1<-optimize(solveF1,interval=c(0.00001,5))
    F2024_scen_1<-outs1$minimum
```

Projection to 2034 using F2024_scen_1 in year 1 and the same after 2024

```
cF_current_1<-Constant_F_Projections(maxage=max_age,M=Nat_Mortality,
                    sex=female_sex_fraction,
                    fmat=female_mature_fraction,Nages_base=N2024,
                    Nbias=N_bias,pF=F_fraction,pM=M_fraction,curwgt=average_wgt,
                    avgwgt=average_wgt,
                    cursel=comb_select_2024,avgselect=comb_select_2024,
                    recruits=recruits_series,
                    curyear=2024,recruit_start_year=2008,recruit_end_year=2023,
                    Fcur=F2024_scen_1,FcurCV=0.133,Fcur_bias=F_bias,
                    Fproj=F2024_scen_1,
                    SSBtarget=SSB_target,SSBtargetCV=SSB_target_CV,
                    SSBthreshold=SSB_threshold,SSBthresholdCV=SSB_threshold_CV,
                    pyears=11,nsims=5000,usebias=1,
                    catch_current=catch_scenario_1)
#cF_current_1
```

Projection F in year 1 is F2024_scen_1 and Ftarget thereafter

```
cF_target_1<-Constant_F_Projections(maxage=max_age,M=Nat_Mortality,
                    sex=female_sex_fraction,
                    fmat=female_mature_fraction,Nages_base=N2024,
                    Nbias=N_bias,pF=F_fraction,pM=M_fraction,curwgt=average_wgt,
                    avgwgt=average_wgt,
                    cursel=comb_select_2024,avgselect=comb_select_2024,
                    recruits=recruits_series,
                    curyear=2024,recruit_start_year=2008,recruit_end_year=2023,
                    Fcur=F2024_scen_1,FcurCV=0.133,Fcur_bias=F_bias,
                    Fproj=F_target,
                    SSBtarget=SSB_target,SSBtargetCV=SSB_target_CV,
                    SSBthreshold=SSB_threshold,SSBthresholdCV=SSB_threshold_CV,
                    pyears=11,nsims=5000,usebias=1,
                    catch_current=catch_scenario_1)
#cF_target_1
```

Solve for catch needed to achieve F target by 2025

```
ftarget_2025_1<-Constant_Catch_Projections(maxage=max_age,M=Nat_Mortality,
                    sex=female_sex_fraction,
                    fmat=female_mature_fraction,Nages_base=N2024,
                    Nbias=N_bias,pF=F_fraction,pM=M_fraction,curwgt=average_wgt,
                    avgwgt=average_wgt,cursel=comb_select_2024,
```

```
                        avgselect=comb_select_2024,recruits=recruits_series,
                        curyear=2024,recruit_start_year=2008,recruit_end_year=2023,
                        Fcur=F2024_scen_1,FcurCV1=F_target_CV,Fcur_bias=F_bias,
                        total_current_catch=catch_scenario_1,
                        SSBthreshold=SSB_threshold, SSBthresholdCV=SSB_threshold_CV,
                         SSBtarget=SSB_target, SSBtargetCV=SSB_target_CV,
                         Ftarget=F_target, FtargetCV=F_target_CV,
                         Fthreshold=F_threshold,FthresholdCV=F_threshold_CV,
                         solve_catch=1,
                         objective_function_value_solve_catch_1=1,
                         pyears=2,nsims=5000,Nerr=2,Ferr=2,usebias=1,
                         rcentral=1)
#ftarget_2025_1
```

Solve for F needed to achieve rebuilding with 50% probability of SSB being above SSBtarget by 2029

```
cF_Frebuild_1<-Constant_F_Projections(maxage=max_age,M=Nat_Mortality,
                    sex=female_sex_fraction,
                    fmat=female_mature_fraction,Nages_base=N2024,
                    Nbias=N_bias,pF=F_fraction,pM=M_fraction,curwgt=average_wgt,
                    avgwgt=average_wgt,
                    cursel=comb_select_2024,avgselect=comb_select_2024,
                    recruits=recruits_series,
                    curyear=2024,recruit_start_year=2008,recruit_end_year=2023,
                    Fcur=F2024_scen_1,FcurCV=0.133,Fcur_bias=F_bias,
                    Fproj=0.111,
                    SSBtarget=SSB_target,SSBtargetCV=SSB_target_CV,
                    SSBthreshold=SSB_threshold,SSBthresholdCV=SSB_threshold_CV,
                    pyears=6,nsims=10000,usebias=1,
                    catch_current=catch_scenario_1)
#cF_Frebuild_1
```

Projections: Catch Scenario 2 (Low 2024 Catch)

Solve for F given total catch

```
   pcatch<-vector()
   solveF1<-function(x){
            for(a in 1:maxage){
              pcatch[a]<-(comb_select_2024[a]*x)/(comb_select_2024[a]*x+M[a])*
                (1-exp(-comb_select_2024[a]*x-M[a]))*N2024[a,1]
            }
            (log(sum(pcatch))-log(catch_scenario_2))^2
        }

    outs2<-optimize(solveF1,interval=c(0.00001,5))
    F2024_scen_2<-outs2$minimum
```

Projection to 2034 using F2024 in year 1 and the same thereafter

```
cF_current_2<-Constant_F_Projections(maxage=max_age,M=Nat_Mortality,
                    sex=female_sex_fraction,
                    fmat=female_mature_fraction,Nages_base=N2024,
                    Nbias=N_bias,pF=F_fraction,pM=M_fraction,curwgt=average_wgt,
                    avgwgt=average_wgt,
                    cursel=comb_select_2024,avgselect=comb_select_2024,
                    recruits=recruits_series,
                    curyear=2024,recruit_start_year=2008,recruit_end_year=2023,
                    Fcur=F2024_scen_2,FcurCV=0.133,Fcur_bias=F_bias,
                    Fproj=F2024_scen_2,
                    SSBtarget=SSB_target,SSBtargetCV=SSB_target_CV,
                    SSBthreshold=SSB_threshold,SSBthresholdCV=SSB_threshold_CV,
                    pyears=11,nsims=5000,usebias=1,
                    catch_current=catch_scenario_1)
#cF_current_2
```

Projection constant F in year 1 and F target thereafter

```
cF_target_2<-Constant_F_Projections(maxage=max_age,M=Nat_Mortality,
                    sex=female_sex_fraction,
                    fmat=female_mature_fraction,Nages_base=N2024,
                    Nbias=N_bias,pF=F_fraction,pM=M_fraction,curwgt=average_wgt,
                    avgwgt=average_wgt,
                    cursel=comb_select_2024,avgselect=comb_select_2024,
                    recruits=recruits_series,
                    curyear=2024,recruit_start_year=2008,recruit_end_year=2023,
                    Fcur=F2024_scen_2,FcurCV=0.133,Fcur_bias=F_bias,
                    Fproj=F_target,
                    SSBtarget=SSB_target,SSBtargetCV=SSB_target_CV,
                    SSBthreshold=SSB_threshold,SSBthresholdCV=SSB_threshold_CV,
                    pyears=11,nsims=5000,usebias=1,
                    catch_current=catch_scenario_2)
#cF_target_2
```

Solve for catch needed to achieve F target by 2025

```
ftarget_2025_2<-Constant_Catch_Projections(maxage=max_age,M=Nat_Mortality,
                        sex=female_sex_fraction,
                        fmat=female_mature_fraction,Nages_base=N2024,
                        Nbias=N_bias,pF=F_fraction,pM=M_fraction,curwgt=average_wgt,
                        avgwgt=average_wgt,cursel=comb_select_2024,
                        avgselect=comb_select_2024,recruits=recruits_series,
                        curyear=2024,recruit_start_year=2008,recruit_end_year=2023,
                        Fcur=F2024_scen_2,FcurCV1=F_target_CV,Fcur_bias=F_bias,
                        total_current_catch=catch_scenario_2,
                        SSBthreshold=SSB_threshold, SSBthresholdCV=SSB_threshold_CV,
```

```
                            SSBtarget=SSB_target, SSBtargetCV=SSB_target_CV,
                            Ftarget=F_target, FtargetCV=F_target_CV,
                            Fthreshold=F_threshold,FthresholdCV=F_threshold_CV,
                            solve_catch=1,
                            objective_function_value_solve_catch_1=1,
                            pyears=2,nsims=5000,Nerr=2,Ferr=2,usebias=1,
                            rcentral=1)
#ftarget_2025_2
```

Solve for F needed to achieve rebuilding with 50% probability of SSB being above SSBtarget by 2029

```
cF_Frebuild_2<-Constant_F_Projections(maxage=max_age,M=Nat_Mortality,
                    sex=female_sex_fraction,
                    fmat=female_mature_fraction,Nages_base=N2024,
                    Nbias=N_bias,pF=F_fraction,pM=M_fraction,curwgt=average_wgt,
                    avgwgt=average_wgt,
                    cursel=comb_select_2024,avgselect=comb_select_2024,
                    recruits=recruits_series,
                    curyear=2024,recruit_start_year=2008,recruit_end_year=2023,
                    Fcur=F2024_scen_2,FcurCV=0.133,Fcur_bias=F_bias,
                    Fproj=0.126,
                    SSBtarget=SSB_target,SSBtargetCV=SSB_target_CV,
                    SSBthreshold=SSB_threshold,SSBthresholdCV=SSB_threshold_CV,
                    pyears=6,nsims=10000,usebias=1,
                    catch_current=catch_scenario_2)
#cF_Frebuild_2
```

```
F2024_scen_3 <- F2024_scen_2 * (1+0.387)

cF_2022pInc_2<-Constant_F_Projections(maxage=max_age,M=Nat_Mortality,
                    sex=female_sex_fraction,
                    fmat=female_mature_fraction,Nages_base=N2024,
                    Nbias=N_bias,pF=F_fraction,pM=M_fraction,curwgt=average_wgt,
                    avgwgt=average_wgt,
                    cursel=comb_select_2024,avgselect=comb_select_2024,
                    recruits=recruits_series,
                    curyear=2024,recruit_start_year=2008,recruit_end_year=2023,
                    Fcur=F2024_scen_2,FcurCV=0.133,Fcur_bias=F_bias,
                    Fproj=F2024_scen_3,
                    SSBtarget=SSB_target,SSBtargetCV=SSB_target_CV,
                    SSBthreshold=SSB_threshold,SSBthresholdCV=SSB_threshold_CV,
                    pyears=11,nsims=5000,usebias=1,
                    catch_current=catch_scenario_2)
#cF_2022pInc_2
```

```
F2024_scen_4 <- F2024_scen_2 * (1+0.172)

cF_2023pInc_2<-Constant_F_Projections(maxage=max_age,M=Nat_Mortality,
                    sex=female_sex_fraction,
                    fmat=female_mature_fraction,Nages_base=N2024,
```

```
                     Nbias=N_bias,pF=F_fraction,pM=M_fraction,curwgt=average_wgt,
                     avgwgt=average_wgt,
                     cursel=comb_select_2024,avgselect=comb_select_2024,
                     recruits=recruits_series,
                     curyear=2024,recruit_start_year=2008,recruit_end_year=2023,
                     Fcur=F2024_scen_2,FcurCV=0.133,Fcur_bias=F_bias,
                     Fproj=F2024_scen_4,
                     SSBtarget=SSB_target,SSBtargetCV=SSB_target_CV,
                     SSBthreshold=SSB_threshold,SSBthresholdCV=SSB_threshold_CV,
                     pyears=11,nsims=5000,usebias=1,
                     catch_current=catch_scenario_2)
#cF_2023pInc_2
```

Additional Projection with variable Fs

Altered Projection Code

```
varFs<-c(F2024_scen_4,0.126,0.126,0.126,0.126)
cf_scen_2_var_Fs2<-Constant_F_Projections(maxage=max_age,M=Nat_Mortality,
                     sex=female_sex_fraction,
                     fmat=female_mature_fraction,Nages_base=N2024,
                     Nbias=N_bias,pF=F_fraction,pM=M_fraction,curwgt=average_wgt,
                     avgwgt=average_wgt,
                     cursel=comb_select_2024,avgselect=comb_select_2024,
                     recruits=recruits_series,
                     curyear=2024,recruit_start_year=2008,recruit_end_year=2023,
                     Fcur=F2024_scen_2,FcurCV=0.133,Fcur_bias=F_bias,
                     Fproj=varFs,
                     SSBtarget=SSB_target,SSBtargetCV=SSB_target_CV,
                     SSBthreshold=SSB_threshold,SSBthresholdCV=SSB_threshold_CV,
                     pyears=6,nsims=5000,usebias=1,
                     catch_current=catch_scenario_2)
```

Tables

Table 1: 2024 Assessment Reference Points

SSB.Refs	SSB	F.Refs	F
Target	111,516.8	Target	0.1707
Threshold	89,213.4	Threshold	0.2064
2023	86,535.7	2023	0.1828

Table 2: Catch and 2024 F Estimates

Catch	Removals	F
Scenario 1	5,862,189	0.1950
Scenario 2	3,890,793	0.1264

Table 3: Projection Results using F2024 in All Years

	Scenario 1				Scenario 2			
Year	F	Catch	SSB.th.Pr	SSB.tar.Pr	F	Catch	SSB.th.Pr	SSB.tar.Pr
2024	0.195	5,862,189	0.325	0.001	0.126	5,862,189	0.370	0.001
2025	0.195	5,423,865	0.528	0.004	0.126	3,751,468	0.819	0.024
2026	0.195	5,134,366	0.599	0.006	0.126	3,658,378	0.969	0.134
2027	0.195	5,144,004	0.578	0.006	0.126	3,707,293	0.994	0.297
2028	0.195	5,318,206	0.458	0.003	0.126	3,873,952	0.998	0.434
2029	0.195	5,541,406	0.331	0.001	0.126	4,051,657	0.999	0.503
2030	0.195	5,684,011	0.238	0.001	0.126	4,198,552	0.999	0.561
2031	0.195	5,758,484	0.200	0.001	0.126	4,282,790	0.999	0.631
2032	0.195	5,825,179	0.186	0.001	0.126	4,339,902	0.999	0.676
2033	0.195	5,844,425	0.200	0.002	0.126	4,382,267	0.999	0.725
2034	0.195	5,862,793	0.217	0.003	0.126	4,425,940	0.999	0.763

Table 4: Projection Results for 2024 F and Ftarget

	Scenario 1				Scenario 2			
Year	F	Catch	SSB.th.Pr	SSB.tar.Pr	F	Catch	SSB.th.Pr	SSB.tar.Pr
2024	0.195	5,862,189	0.337	0.000	0.126	3,890,793	0.356	0.001
2025	0.171	4,782,921	0.545	0.004	0.171	4,977,582	0.792	0.020
2026	0.171	4,601,902	0.700	0.012	0.171	4,743,436	0.898	0.055
2027	0.171	4,636,210	0.761	0.020	0.171	4,743,985	0.923	0.074
2028	0.171	4,841,601	0.749	0.019	0.171	4,918,083	0.904	0.062
2029	0.171	5,061,695	0.691	0.015	0.171	5,085,327	0.853	0.041
2030	0.171	5,218,784	0.634	0.013	0.171	5,248,565	0.796	0.032
2031	0.171	5,288,331	0.607	0.016	0.171	5,332,686	0.755	0.032
2032	0.171	5,344,185	0.606	0.021	0.171	5,378,087	0.711	0.037
2033	0.171	5,363,981	0.611	0.037	0.171	5,390,770	0.692	0.049
2034	0.171	5,404,582	0.631	0.053	0.171	5,430,432	0.696	0.064

Table 5: Catch To Reach Ftarget by 2025

	Scenario 1		Scenario 2	
Year	F	Catch	F	Catch
2024	0.195	5,862,189	0.126	3,890,793
2025	0.171	4,786,429	0.171	4,983,814

Table 6: F needed to rebuild SSB by 2029

	Scenario 1				Scenario 2			
Year	F	Catch	SSB.th.Pr	SSB.tar.Pr	F	Catch	SSB.th.Pr	SSB.tar.Pr
2024	0.195	5,862,189	0.338	0.001	0.126	3,890,793	0.363	0.001
2025	0.111	3,171,196	0.563	0.004	0.126	3,735,471	0.810	0.024
2026	0.111	3,159,998	0.894	0.052	0.126	3,641,580	0.966	0.133
2027	0.111	3,249,542	0.980	0.196	0.126	3,700,575	0.993	0.304
2028	0.111	3,430,020	0.996	0.361	0.126	3,871,423	0.998	0.428
2029	0.111	3,629,865	0.999	0.517	0.126	4,052,648	0.999	0.504

Table 7: Projection Results if F Increases in 2025

	F Increases by Same Percent as in 2023				F Increases by Same Percent as in 2022			
Year	F	Catch	SSB.th.Pr	SSB.tar.Pr	F	Catch	SSB.th.Pr	SSB.tar.Pr
2024	0.126	3,890,793	0.365	0.001	0.126	3,890,793	0.368	0.001
2025	0.148	4,368,599	0.804	0.021	0.175	5,103,863	0.800	0.021
2026	0.148	4,207,073	0.938	0.087	0.175	4,853,542	0.888	0.051
2027	0.148	4,228,542	0.974	0.159	0.175	4,830,779	0.908	0.064
2028	0.148	4,410,957	0.979	0.192	0.175	5,016,984	0.876	0.050
2029	0.148	4,613,175	0.980	0.201	0.175	5,195,578	0.812	0.033
2030	0.148	4,747,809	0.975	0.195	0.175	5,344,763	0.733	0.022
2031	0.148	4,811,663	0.970	0.220	0.175	5,416,288	0.679	0.025
2032	0.148	4,853,165	0.962	0.249	0.175	5,451,445	0.623	0.028
2033	0.148	4,884,653	0.958	0.293	0.175	5,459,675	0.603	0.037
2034	0.148	4,937,977	0.957	0.334	0.175	5,492,176	0.599	0.047

Table 8: Projection results if F increases in 2025 only due to 2018 YC

	F = 0.126 after 2026			
Year	F	Catch	SSB.th.Pr	SSB.tar.Pr
2024	0.126	3,890,793	0.360	0.001
2025	0.148	4,361,188	0.808	0.022
2026	0.126	3,595,776	0.942	0.087
2027	0.126	3,678,054	0.988	0.230
2028	0.126	3,857,024	0.995	0.355
2029	0.126	4,054,539	0.998	0.416

Figures

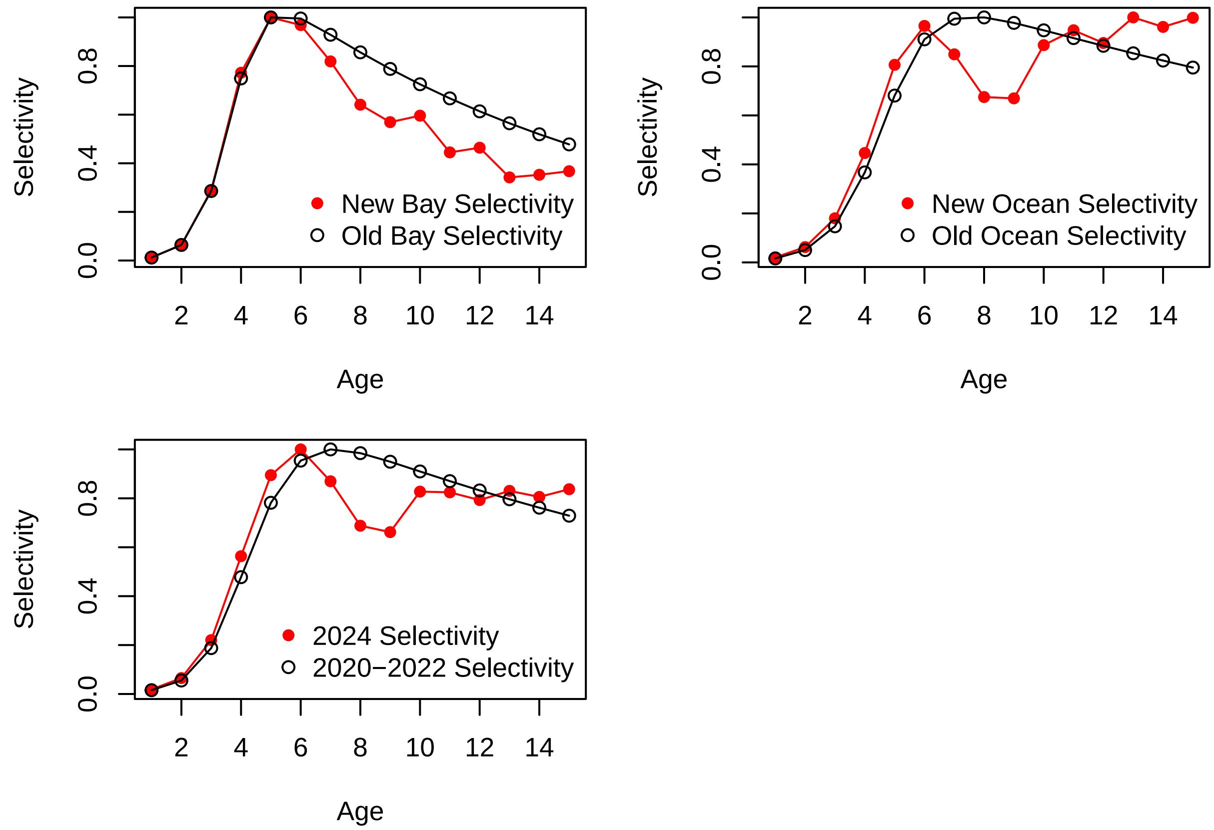


Figure 1. Plots of New Selectivities for Bay, Ocean and Combined.

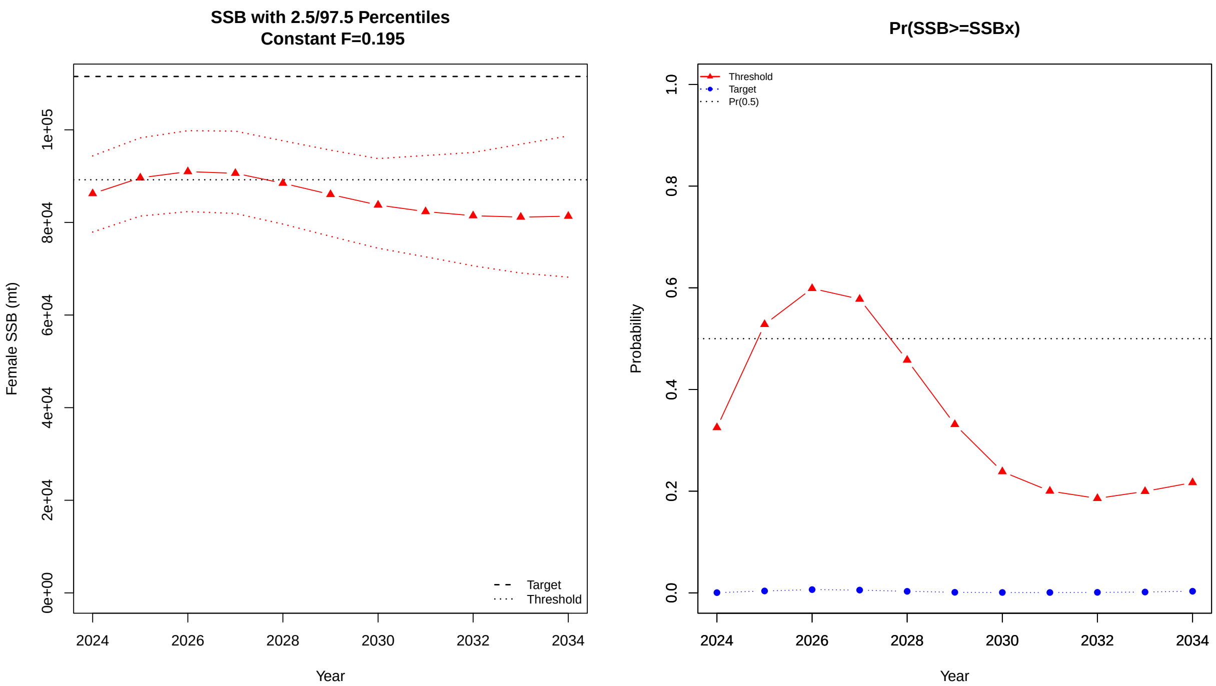


Figure 2. Projections of SSB and probabilities of SSB being >= SSB threshold and SSB target through 2034 under constant F=F2024 for catch scenario 1 .

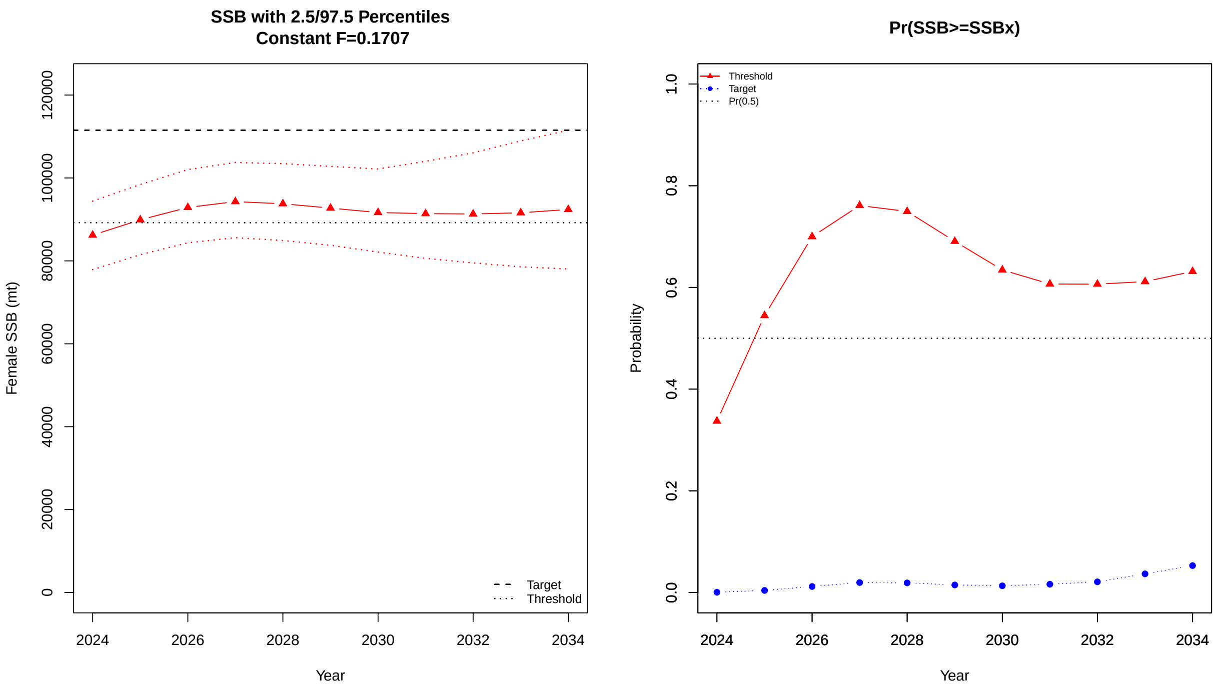


Figure 3. Projection through 2034 of SSB and probabilities of SSB being >= SSB threshold and SSB target under F2024 in 2024 and F-target thereafter for catch scenario 1 .

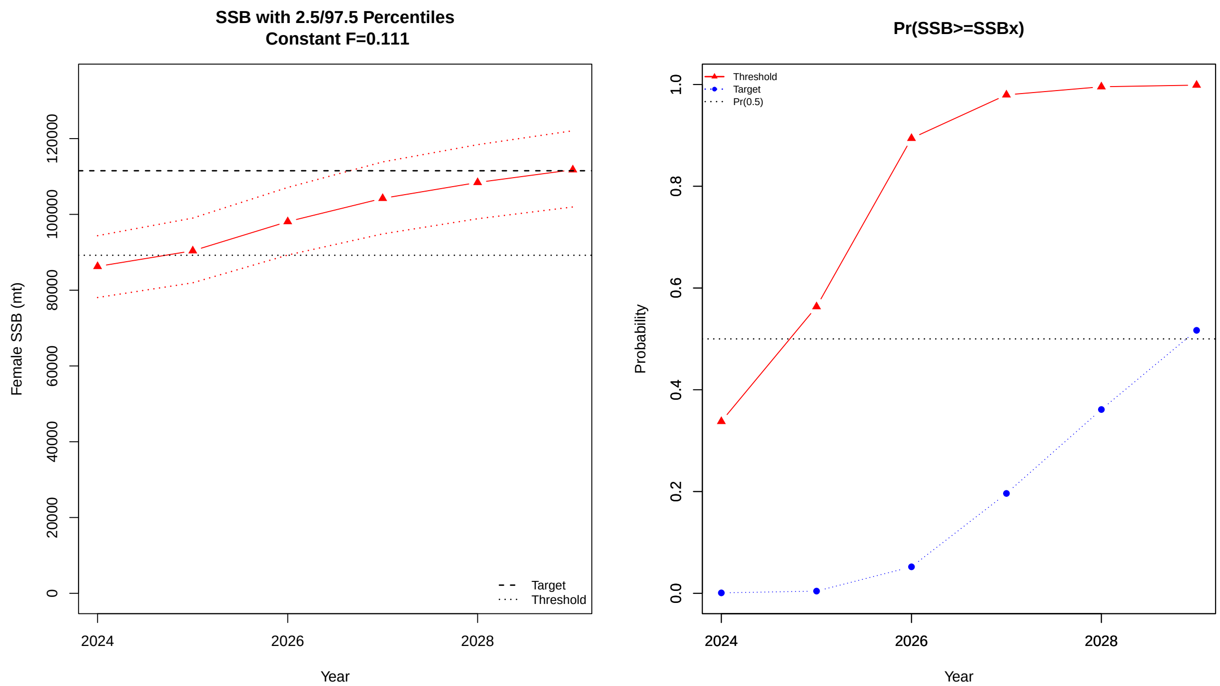


Figure 4. F needed to rebuild SSB with 50% probability that is SSB >= SSB target under catch scenario 1.

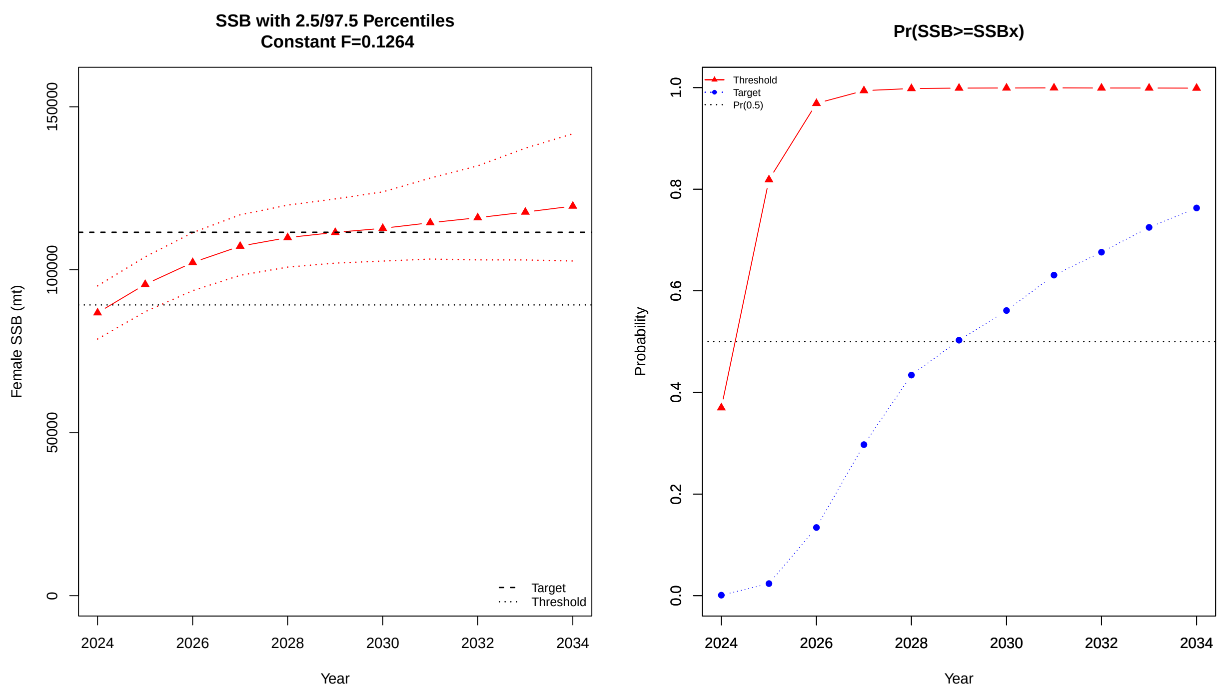


Figure 5. Projections of SSB and probabilities of SSB being >= SSB threshold and SSB target through 2034 under constant F=F2024 for catch scenario 2 .

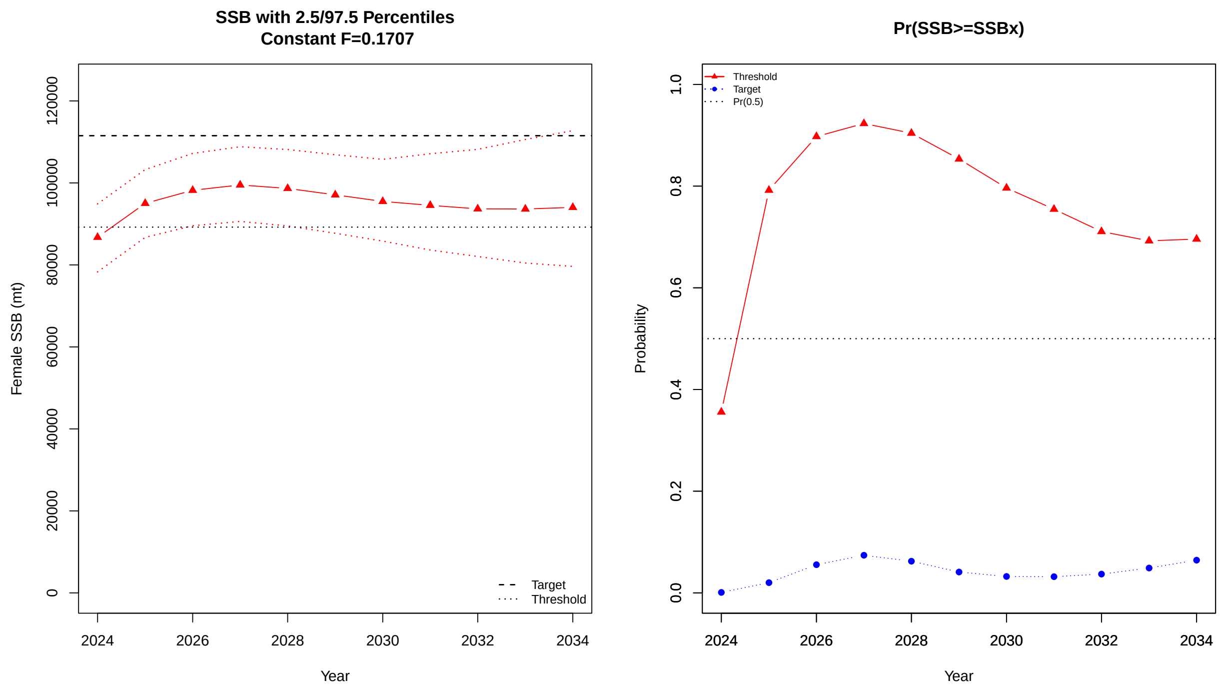


Figure 6. Projection through 2034 of SSB and probabilities of SSB being >= SSB threshold and SSB target under F2024 in 2024 and F-target thereafter for catch scenario 2.

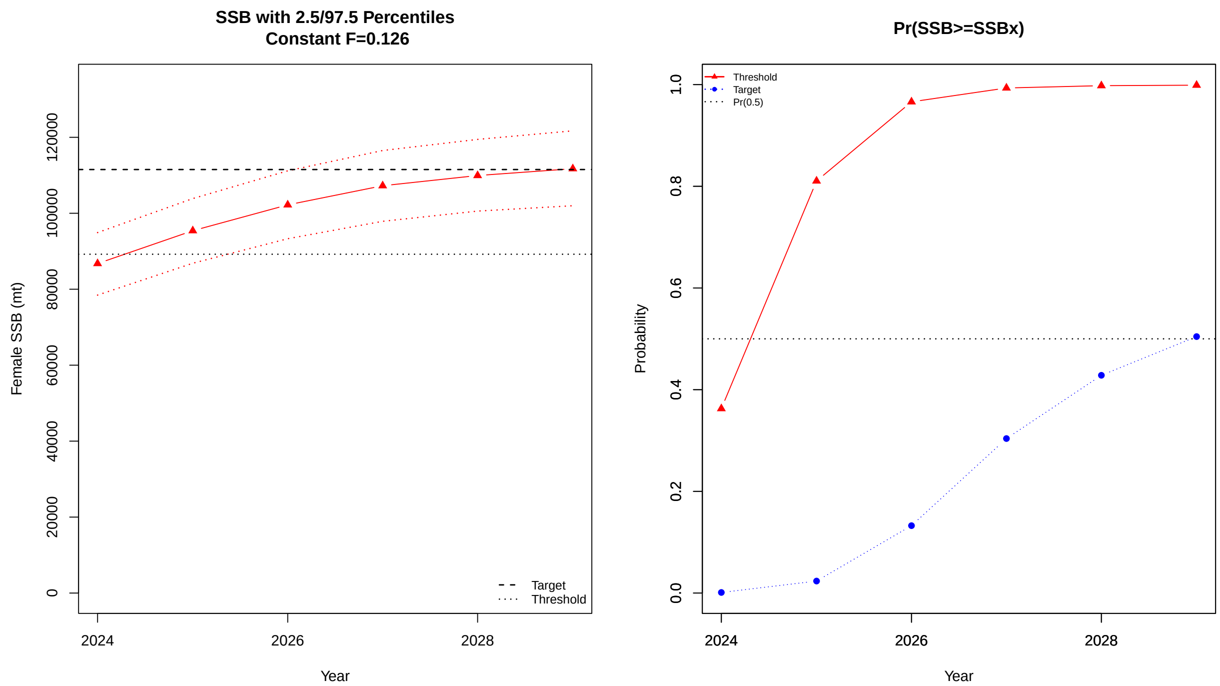


Figure 7. F needed to rebuild SSB with 50% probability that is SSB >= SSB target under catch scenario 2.

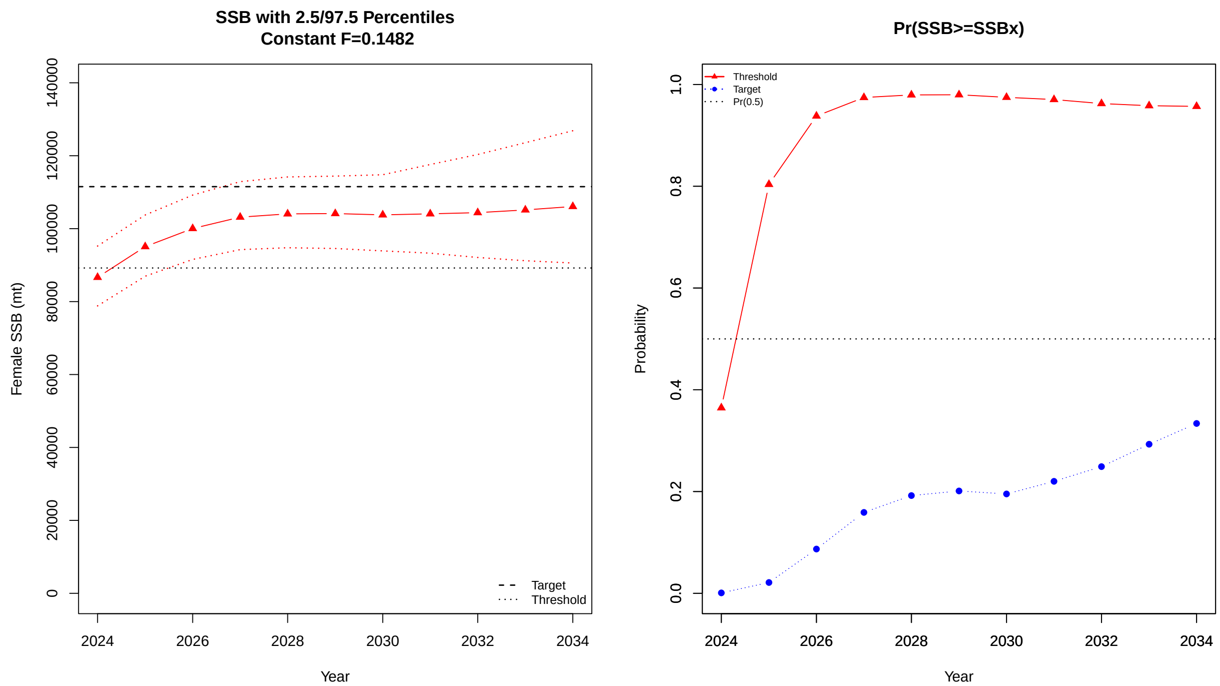


Figure 8. Constant F=F 2025, where F 2025 increases from F 2024 at the same rate seen from 2021 to 2023 under the 28-31" slot

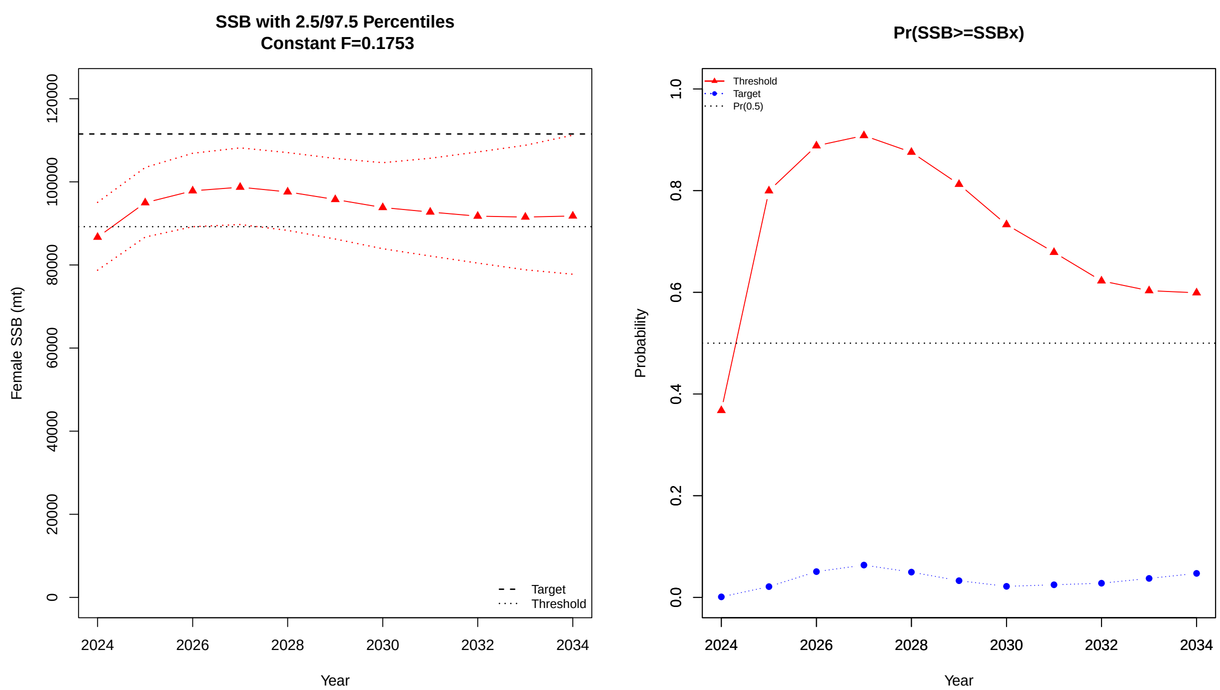


Figure 9. Constant F=F 2025, where F 2025 increases from F 2024 at the same rate seen from 2021 to 2022 when the 2015 year-class turned seven.

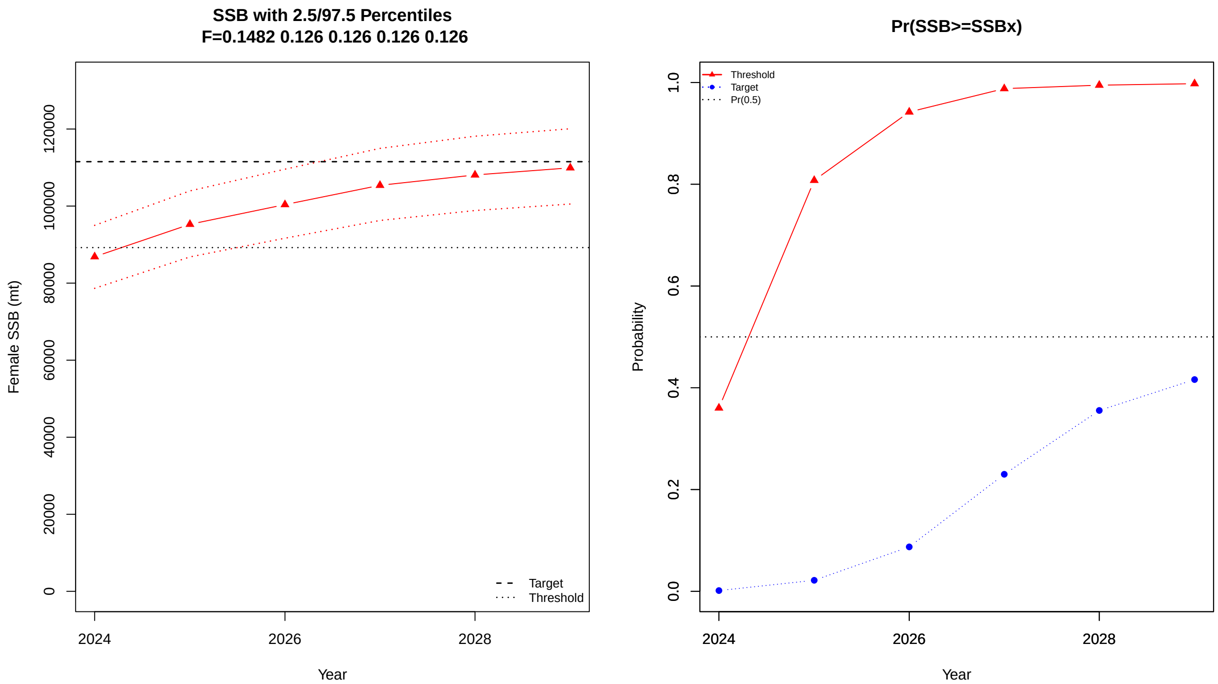


Figure 10. F increases in 2025 only as 2018 Year-class moves through slot. F after 2025 at F=F 2024=0.126