Atlantic States Marine Fisheries Commission

Atlantic Menhaden Management Board

August 2, 2017
11:30 a.m. – 5:45 p.m.
Alexandria, Virginia

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 *(R. Ballou)*	11:30 a.m.
2.	Board Consent • Approval of Agenda • Approval of Proceedings from May 2017	11:30 a.m.
3.	Public Comment	11:35 a.m.
4.	Review the 2017 Atlantic Menhaden Stock Assessment Update (*J. McNamee*)	11:45 a.m.
5.	Lunch Break (not provided)	12:30 p.m.
6.	Biological Ecological Reference Point Workgroup Report (*S. Madsen*) • Review of Hilborn, et al. (2017) Paper	1:30 p.m.
7.	Consider Draft Amendment 3 for Public Comment **Action** • Biological Ecological Reference Point Workgroup Report on Interim Reference Points (*K. Drew*) • Review of Management Issues and Alternatives (*M. Ware*) • Plan Development Team Report on NY Proposal to Recalibrate Landings (*M. Ware*) • Advisory Panel Report *(J. Kaelin*)	2:00 p.m.
8.	Set 2018 Atlantic Menhaden Specifications **Final Action** • Overview of Specification Process (*M. Ware*) • Technical Committee Report (*J. McNamee*) • Advisory Panel Report (*J. Kaelin*)	4:45 p.m.
9.	Update on 2017 Episodic Events Set Aside *(M. Ware)*	5:40 p.m.
10.	Other Business/Adjourn	5:45 p.m.

The meeting will be held at the Westin Alexandria, 400 Courthouse Square, Alexandria, VA; 703.253.8600

Vision: Sustainably Managing Atlantic Coastal Fisheries

MEETING OVERVIEW

Atlantic Menhaden Management Board Meeting
Wednesday – August 2, 2017
11:30 a.m. – 5:45 p.m.
Alexandria, Virginia

Chair: Robert Ballou (RI) Assumed Chairmanship: 05/16	Technical Committee Chair: Jason McNamee (RI)	Law Enforcement Committee Representative: Capt. Kersey (MD)
Vice Chair: Russ Allen (NJ)	Advisory Panel Chair: Jeff Kaelin (NJ)	Previous Board Meeting: May 9, 2017
Voting Members: ME, NH, MA, RI, CT, NY, NJ, PA, DE, MD, PRFC, VA, NC, SC, GA, FL, NMFS, USFWS (18 votes)		

2. Board Consent

- Approval of Agenda
- Approval of Proceedings from May 2017

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. 2017 Stock Assessment Update (11:45 a.m. – 12:30 p.m.)

Background

- The 2017 Stock Assessment Update was completed in June 2017 **(Briefing Materials)**.
- The TC met in Richmond, VA on June 15th to review a draft of the Stock Assessment Update and provide recommendations to the SASC.

Presentations

- Stock Assessment Update overview by J. McNamee

5. Lunch (12:30 – 1:30 p.m.)

6. BERP Workgroup Report on Hilborn et al., (2017) Paper (1:30-2:00 p.m.)

Background

- In April 2017, Hilborn et al. published a paper regarding harvest policies for forage fish.
- In May 2017, the Board tasked the BERP Workgroup with reviewing the Hilborn et al., (2017) paper given is potential application to the Amendment 3 process.
- The BERP Workgroup met via conference call on June 30th to discuss the Hilborn et al. (2017) paper and its application to menhaden management.

Presentations

- BERP Workgroup report by S. Madsen **(Briefing Materials)**

7. Draft Amendment 3 (2:00 – 4:45 p.m.) Action
Background • In February 2017, the Board tasked the PDT with developing Draft Amendment 3 in order to consider the adoption of ecological reference points and changes to the quota allocation method. • Since the Spring Board meeting, the PDT met via conference call on May 22nd, June 12th, and July 12th. • The Advisory Panel met via conference call on June 26th to provide feedback on the content of the Draft Amendment. • The BERP Workgroup met via conference call on May 19th and June 2nd to calculate interim reference point values.
Presentations • BERP Workgroup report on interim reference points by K. Drew **(Briefing Materials)** • Review of management issues and alternatives by M. Ware **(Briefing Materials)** • PDT report on NY proposal to recalibrate landings by M. Ware **(Briefing Materials)** • Advisory Panel report by J. Kaelin **(Briefing Materials)**
Board actions for consideration at this meeting • Approve Draft Amendment 3 for public comment.

8. 2018 Menhaden Specifications (4:45 – 5:40 p.m.) Final Action
Background • The Board sets an annual or multi-year TAC using the best available science. • The TC completed nine stock projection runs for the 2018 year based on recommendations from the Board. **(Briefing Materials)**
Presentations • Review of 2018 stock projections by J. McNamee
Board actions for consideration at this meeting • Approve fishery specifications for 2018.

9. 2017 Episodic Events Set Aside Program (5:40 – 5:45 p.m.)
Background • Roughly 4.4 million pounds were set aside for the episodic events program with the states of Maine, Rhode Island, and New York participating in the program. • On July 5th, harvest under the episodic events set aside was closed. • Total harvest under the program was roughly 4.6 million pounds, resulting in a 283,889 pound overage. **(Briefing Materials)**
Presentations • Summary of 2017 episodic events harvest by M. Ware

10. Other Business/Adjourn

DRAFT PROCEEDINGS OF THE

ATLANTIC STATES MARINE FISHERIES COMMISSION

ATLANTIC MENHADEN MANAGEMENT BOARD

The Westin Alexandria
Alexandria, Virginia
May 9, 2017

These minutes are draft and subject to approval by the Atlantic Menhaden 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 2016 by Consent** (Page 1).

3. **Move to implement a 1 million pound cap on New York's menhaden harvest under the episodic events program (**Page 27). Motion by Terry Stockwell; second by Cheri Patterson . Motion carried (Page 28).

4. **Move to accept the 2017 Fishery Management Plan Review and state compliance reports, and approve *de minimis* status for New Hampshire, Pennsylvania, South Carolina, Georgia, and Florida (Page 33).** Motion by Steve Heins; second by Cheri Patterson. Motion carried (Page 33).

5. **Motion to adjourn** by Consent (Page 33).

ATTENDANCE

Board Members

Terry Stockwell, ME, proxy for P. Keliher (AA)
Steve Train, ME (GA)
Sen. Joyce Maker, ME, proxy for Sen. Langley (LA)
Cheri Patterson, NH, proxy for D. Grout (AA)
G. Ritchie White, NH (GA)
Sen. David Watters, NH (LA)
Sarah Ferrara, MA, proxy for Rep. Peake (LA)
David Pierce, MA (AA)
Raymond Kane, MA (GA)
Eric Reid, RI, proxy for Sen. Sosnowski (LA)
Robert Ballou, RI, proxy for J. Coit (AA), Chair
David Borden, RI (GA)
Sen. Craig Miner, CT (LA)
Colleen Giannini, CT, proxy for M. Alexander (AA)
Steve Heins, NY, proxy for J. Gilmore (AA)
Emerson Hasbrouck, NY (GA)
John McMurray, NY, proxy for Sen. Boyle (LA)
Adam Nowalsky, NJ, proxy for Asm. Andrzejczak (LA)
Russ Allen, NJ, proxy for L. Herrighty (AA)
Loren Lustig, PA (GA)
Andy Shiels, PA, proxy for J. Arway (AA)
John Clark, DE, proxy for D. Saveikis (AA)
Craig Pugh, DE, proxy for Rep. Carson (LA)
Roy Miller, DE (GA)
Rachel Dean, MD (GA)
Dave Blazer, MD (AA)
Allison Colden, MD, proxy for Del. Stein (LA)
Rob O'Reilly, VA, proxy for J. Bull (AA)
Michelle Duval, NC, proxy for B. Davis (AA)
David Bush, NC, proxy for Rep. Steinburg (LA)
W. Douglas Brady, NC (GA)
Malcolm Rhodes, SC (GA)
Robert Boyles, Jr., SC (AA)
Patrick Geer, GA, proxy for Rep. Nimmer (LA)
Spud Woodward, GA (AA)
Jim Estes, FL, proxy for J. McCawley (AA)
Rep. Thad Altman, FL (LA)
Martin Gary, PRFC
Derek Orner, NMFS
Sherry White, USFWS

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

Ex-Officio Members

Jason McNamee, Technical Committee Chair

Staff

Bob Beal
Toni Kerns
Katie Drew
Shanna Madsen
Megan Ware

Guests

(Sign-In Not Distributed to Public)

Jeff Kaelin, Lunds Fisheries

The Atlantic Menhaden Management Board of the Atlantic States Marine Fisheries Commission convened in the Edison Ballroom of the Westin Hotel, Alexandria, Virginia, May 9, 2017, and was called to order at 3:45 o'clock p.m. by Chairman Robert Ballou.

CALL TO ORDER

CHAIRMAN ROBERT BALLOU: I would like to call this meeting of the Menhaden Management Board to order. My name is Bob Ballou; I have the honor of serving as Board Chair. Before we launch into our agenda, I need to note that we have a firm 5:45 deadline for concluding our meeting; that is because the Commission is hosting an awards event that begins promptly at 6:30.

APPROVAL OF AGENDA

CHAIRMAN BALLOU: We need to be just as prompt with our agenda, so we can get through everything by 5:45. Thank you for your help with that. Item 2 on the agenda is the agenda itself. Does anyone on the Board have any recommended modifications to the agenda? Seeing none; is there any objection to approving the agenda as proposed? Seeing no objections the agenda as proposed stands approved.

APPROVAL OF PROCEEDINGS

CHAIRMAN BALLOU: Item 2B are the meeting minutes from the Board's last meeting, which was held on February 1, 2017. Are there any recommended changes to the minutes? Seeing none; is there any objection to approving the minutes as proposed? Seeing none; the minutes stand approved by consent.

PUBLIC COMMENT

CHAIRMAN BALLOU: Item 3 is Public Comment.

This is an opportunity for anyone from the public who would like to comment on any issue that is not on today's agenda to do so. We rely upon a signup sheet; which I have here. There is no one on it. Is there anyone who intended to speak but did not sign up? Now would be your opportunity; please raise your hand.

CONSIDERATION OF THE HILBORN ET AL. 2017 PAPER FOR TECHNICAL REVIEW

CHAIRMAN BALLOU: Seeing no hands; I am going to move on to the next agenda item; which is Item 4, Board Consideration of the Hilborn et al. 2017 Paper.

First, I will note that in addition to the Hilborn paper the Board has also received a May 1, 2017 response to that paper from the Lenfest Forage Fish Task Force; and both documents are included in your meeting materials. Second, I will note that we have just 15 minutes set aside for this agenda item; so we are not anticipating an in-depth discussion of the documents at this point in time.

Rather, our intent today is to bring these two recently released documents with particular emphasis on the Hilborn Paper before the Board; and look to the Board for guidance on how you would like to proceed regarding their review and the potential incorporation of that review in the Amendment 3 process. Given the relevancy of the papers to the Draft Amendment, and given that they have not yet been subject to technical review by the Board's Technical Committee or the BERP Working Group, one suggestion would be for the Board to initiate a technical review via a tasking motion undertaken today; and then circle back to the issue at our next meeting with that technical review in hand. I know that Megan, our FMP coordinator and Jason McNamee to her right, have been discussing this matter. I would like to now look to either or both of them to offer their thoughts on how the Board might want to proceed on this issue. Megan.

MS. MEGAN WARE: I'll be very brief. When we received the Lenfest Forage Fish Report that was sent to the BERP for a technical review, and then the BERP came back with their review of that paper. One option for the Board is to pursue a similar avenue for the Hilborn paper, have the BERP read that over, provide their response and review of it at the August Board meeting.

CHAIRMAN BALLOU: With that; Board thoughts on this issue. Dr. Duval.

DR. MICHELLE DUVAL: I would actually like to go ahead and request that the BERP Work Group be tasked with the review of the Hilborn et al. Paper. You know in the same lens with which they reviewed the Lenfest Forage Fish Task Force Report for us a few years ago. I just don't think like it is going to be very productive for us to engage in much of a discussion today before we get that technical review. If that has to be in the form of a motion, I am willing to do that.

CHAIRMAN BALLOU: I don't think we need a motion; unless there are any objections. I will be looking for either concurrence on that or other thoughts on the matter. Robert, you had your hand up and then it went down.

MR. ROBERT H. BOYLES, JR.: Just to concur, Mr. Chairman, thank you.

CHAIRMAN BALLOU: Dr. Pierce.

DR. DAVID PIERCE: Yes I do concur, and I would like to highlight a couple of things relative to the paper that I suspect might come up whenever technical review is done by the BERP. For example, will this fishing forage species effect their predators? The authors of this paper, all seven of them, with Ray Hilborn being the first author; I assume, highlight that they're looking at rate of change.

That is significant when we're talking about rate of change, predator versus prey, and that needs to be looked at. In addition, it would be useful for there to be some reconciliation of what Ray Hilborn says in his recent text. He is the sole author with his wife, I believe, "Overfishing, What Everyone Needs to Know."

I've got great respect for Ray Hilborn; I read just about everything that he puts out. He has a chapter in his book; they have a chapter in their book that is basically questions and answers. One of the questions is, do forage fish need special protection? Basically the answer is, yes. I read this and I hear what he says, not too long ago.

Now I see this paper with these other co-authors; and I'm left wondering, has he changed his point of view? Has he been influenced by the other authors? What did the data really suggest to him? Again, he talks about rate of change. Again, I would like to see this review. I think it will be very useful.

CHAIRMAN BALLOU: Yes, John.

MR. JOHN G. McMURRAY: I don't have a problem with putting this in front of the Technical Committee. I think they need to take a close look at it. But to a lot of us who spend time on the water, some of the conclusions that the paper came up with seem unbelievable; particularly the idea that predators only feed on younger prey, and it uses the example of menhaden. Anybody who has spent any time in that fishery understands that aggregations of menhaden drive time and area specific bites.

Striped bass really do focus on adult menhaden. That is really just one example. I would have the Technical Committee really take a close look at those datasets, because something is amiss; the whole idea that predator abundance is not related to prey abundance, just from an on-the-water perspective, defies commonsense. I would like to see a more in-depth analysis of that. I hope you guys keep the common sense factor in mind when you do review it.

DR. DUVAL: Just to clarify, with regard to Mr. McMurray's comments. The request was to have the BERP Workgroup review it, rather than the TC. I just wanted to clarify that.

CHAIRMAN BALLOU: Anyone else on the Board wish to comment on this issue? Yes, Emerson.

MR. EMERSON C. HASBROUCK, JR.: Yes I concur that the paper should be reviewed, and that we should have that report back to us. But I would also request that during that review special attention be given to the last part of the paper; where the authors lay out what they conclude to be key factors that need to be included, when analyzing the impacts of fishing on forage fish. They lay out five or six key items that need to be addressed and included. Also, in terms of our review, I would like some comment about how will those key factors relate to where we're going with menhaden.

CHAIRMAN BALLOU: Good input; anyone else? Yes. Alison, you're new to the Board; welcome, thank you.

DR. ALLISON COLDEN: I heard in your opening statements that there are also public comments submitted in response to the Hilborn Paper. I am just wondering if the action that we are discussing also includes sending that response. I think the authors in that public comment indicated that there would be a peer reviewed response coming out following the public comment. I was just wondering if we were also considering sending the response to the paper to the BERP and or TC as well.

CHAIRMAN BALLOU: Yes, I believe you're referring to the Lenfest Task Force that did respond. That is in your meeting materials today; so we wanted to make sure it was before the Board, and that will be part of the review undertaken. It is essentially, they provided their response now we're looking to our own BERP Working Group to provide their response. Both will be essentially before the Board in August for your review and consideration. Next I have Rob O'Reilly.

MR. ROB O'REILLY: I guess my question is not to belabor the review, but in the paper there are several references besides Pikitch et al. in 2012, Curry is mentioned fairly frequently, Smith et al. I'm just wondering when this review takes place, and I don't know the answer here. Will you also look at some of these other papers? Is that part of the process?

CHAIRMAN BALLOU: I think the recommendation before the Board is to just review the Hilborn Paper. If you wish to expand on that you're welcome to, but I think right now that is the issue. Go ahead, Rob, follow.

MR. O'REILLY: I think this may be important to look at some of these other papers as well; the underpinnings for some of the premises that are here. I don't want to make it exhaustive, but maybe just to be able to look through them would be important. Get a sense of it.

CHAIRMAN BALLOU: That could be a pretty big lift, Rob. I mean, I very much respect your recommendation here.

MR. O'REILLY: I don't mind if they don't do it. I just was bringing it up. I mean that's fine; I'll stop.

CHAIRMAN BALLOU: Emerson, and then I would like to try to wrap this up.

MR. HASBROUCK: Thank you, Mr. Chairman for a second comment. In terms of review of the Lenfest response, if they're going to go forward with a peer review publication, relative to their response, I think it would be more appropriate to wait until that publication actually comes out; because what comes out of the peer review publication may be a little bit different than what they sent us as public comment.

CHAIRMAN BALLOU: That's an excellent point, and to clarify it I may have misspoken in response to Allison's question. The Lenfest response stands on its own. It's not going to be subject to further review. What's going to be subject to review is the Hilborn Paper and Lenfest has already responded to that.

As you say, Emerson, they may well pursue that further via peer reviewed paper; and if so we'll bring that back before the Board as well. We definitely don't want to get into the business of trying to referee all these different scientific perspectives; but given the relevancy of this Hilborn Paper in particular and of course the Lenfest response.

We just simply want to make sure they're part of the mix. I think with the benefit of a technical review by our BERP Working Group delivered for our August meeting, we should have, I think, a decent handle on this issue; and be able to hopefully engage in a more thorough discussion on it. If there is no other hands up, and I don't see any; I am inclined to move on to the next agenda item, with the understanding and concurrence of the Board that this will be moved to the BERP Working Group for a technical review and report back for our August meeting.

Thank you for a good discussion on that. With that we'll move on to Item 5, which is the BERP Working Group Progress Report. This is just a quick five-minute update on the status of the working group's efforts to develop ecosystem-based reference points for menhaden. I will turn to Shanna Madsen; our Commission's Fishery Science Coordinator for this review. Shanna, the floor is yours.

MS. SHANNA MADSEN: We're going to dive right in here to what should be a very familiar slide; because I show this to you guys every time I give you an update. Just looking at where we're at in 2017. Essentially, the BERP Work Group has a pretty full next few years coming up; to make sure that we are delivering our promise of ERPs by the 2019 timeframe.

In 2017, we've already completed one of these workshops, which I'll get into briefly on our next slide. We have two other in-person meetings scheduled; one to review another one of our modeling approaches, and we have various calls schedule throughout the rest of the year. We have a call coming up, actually in a few weeks.

We'll again be scheduling then a call to review the Hilborn Paper as the Board has just requested. Coming up in 2018, we will start our process of having our Data Workshop. Essentially we anticipate probably having two data workshops, due to the number of modeling approaches that we are considering; and the fact that these are multispecies models.

There is going to be a lot of data coming in. We're not just going to be vetting data for one species; we'll be vetting data for all of our predator species and all the other prey species that will be input into these models. Then in 2019, we will move into our assessment workshops. Again, we probably anticipate having about two assessment workshops.

That will have to take place prior to the 2019 peer review; where we anticipate all of our models going together as a package, along with a single species BAM model for review in 2019. We'll have those results for you, hopefully in 2020. Again, I just want to remind the Board that this is kind of the first time that we're attempting to do this level of modeling; to generate these ecosystem reference points.

It is a very ambitious timeline. We are cautiously confident in our ability to get these to you in 2019. We haven't experienced any hiccups yet; we are on track. But I will continue to keep the Board apprised of the situation as we move through the next few years. Our April modeling workshop that we just had a few weeks ago was focused on our multispecies statistical catch-at-age, you guys have all heard statistical catch-at-age modeling before.

This is the multispecies form of that. This catch-at-age model is actually being developed by our very own Jason McNamee. The Committee provided Jason with some suggestions for some modifications, some comments that they had, and from those recommendations the group will be putting together a subcommittee of people who work closely with our old MSVPA model to kind of look at some of the data inputs that we want to put into that multispecies-statistical-catch-at-age model

We were also updated on some of the outside modeling approaches that are in development; as well as heard some updates from a few of the other models that we considered in 2016. We also just held a call on April 24, so just a short time ago, with the Lenfest Forage Fish Task Force. The reason that we held this call is we wanted to ensure that the reference points that are being looked at in Amendment 3 are actually calculated and are congruent with all of the recommendations that Lenfest has in their paper.

We developed a list of questions that we distributed to the task force prior to that call; just so they understood the modeling questions that we would be looking at moving forward. We wanted to have a discussion later based off of their responses. For our near future plans, as I mentioned we're going to have a call; that will be on May 19. The group is going to review the recommendations the Task Force provided us on the previous call; and again look at some of the calculations that a few of our committee members have already been working on, just to make sure that the whole committee is onboard with the way that we've decided to move forward with these calculations.

We do anticipate that these calculated reference points will be available for Megan to place into Draft Amendment 3 for further review by the AP, I believe, later in June. These will be ready for August meeting week for the Board to look at as well. As a heads up, as I said earlier the BERP is also going to meet twice more in person this year. We're looking at a late summer in-person meeting to review a surplus production model that is in development outside of the work group.

At the end of the year the group is going to meet again in person; and that will sort of be our final decision workshop, I'm calling it, where we'll go through, we'll look at all of the modeling approaches that we've been considering over the past few years; and decide which of those will move forward into the peer review phase, as always, we will continue to keep you guys updated during our May and October meeting weeks. With that I will take any questions.

CHAIRMAN BALLOU: Questions for Shanna; Emerson.

MR. HASBROUCK: Thank you, Shanna for your presentation. I think it was your second or third slide that you had up there was relative to a recent conference call you had last week. Yes, I think it was that one, right. I'm just a little confused relative to the second bullet there.

Ensure control rules of Amendment 3 are congruent with the intention of the Lenfest Report, Pikitch et al. in 2012. Didn't either the Technical Committee or the Working Group determine that that paper was not relevant to what we are trying to do with menhaden management, menhaden ecosystem management?

MS. MADSEN: Yes, Emerson. From one of our earlier memos that we distributed to the Board after our review of the Lenfest Report, the BERP did find some issues with the paper. They did say that they believed that this would not be applicable to menhaden management. However, the Board did want to leave those reference points in Amendment 3 for consideration by the Board, as well as the public. That would be up to the Board to see how to move forward. The BERP is still working to make sure that the calculations that are done with those reference points are correctly done.

CHAIRMAN BALLOU: Emerson, do you have a follow up?

MR. HASBROUCK: Yes, thank you. Are those the only reference points that are going to be brought back to the Board; or there are other reference points that are being developed as well?

CHAIRMAN BALLOU: I'm going to let Megan take that.

MS. WARE: Hey Emerson, there are other options; and I'll be going through Draft Amendment 3, just after Shanna's finished. I'll be talking about the options that are in the document.

CHAIRMAN BALLOU: Other questions for Shanna on her update regarding the BERP Working Group? Seeing no hands; thank you, Shanna again for a great update.

UPDATE ON DRAFT AMENDMENT 3

CHAIRMAN BALLOU: We'll move on to Item 6 on the agenda; which is as Megan just indicated, an update on the development of Draft Amendment 3. I'll just give a couple words of intro here, before turning things over to Megan.

As everyone is aware, the Board moved to initiate the development of the draft amendment at our last meeting in February, and the target date for bringing the document before the Board for final review and approval as a draft; before going out to public comment, will be at our next meeting in August.

As such, today's meeting constitutes an interim stage in the process of developing the document. This mid-stream status affords the Board an excellent opportunity to review the progress made to date, consider some recommendations offered by the Board's Allocation Workgroup, and consider any other recommendations that anyone on the Board may wish to offer.

That is exactly what we plan to do over the next hour or so. As we engage, keep in mind that the draft amendment remains a work in progress, and no final decisions will be made on the issues and alternatives that will go out to public comment; until our August meeting. That said, the document is certainly taking shape; thanks to the excellent work being undertaken by Megan and the Plan Development Team.

As we engage in our discussion today and move into the final three-month phase of our draft plan development, I strongly encourage everyone on the Board to continue reviewing the issues and options set forth in the document; with a view to ensuring that they are presented and bounded in a way that gives the public a clear understanding of our current management program, and the alternatives being considered.

That clarity will really help to focus public comment; which no doubt will be significant, given the issues at hand. With that I am going to be turning things over to Megan for an update. Her update will wrap with a series of questions and Work Group recommendations; which will serve as the basis for our initial review and discussion today.

After we work through those issues, I will open the floor to any other comments or recommendations from the Board regarding the draft amendment, and if time allows, and I hope it does, I would also like to provide an opportunity for public comment. My goal today, with all of these issues is to seek consensus and call for motions and votes only if there are competing views among Board members. With that Megan, the floor is yours.

MS. WARE: I will be doing an update on Draft Amendment 3 today. I do just want to underline the disclaimer that this is a working document. I fully expect changes to continue to be made up until the August Board meeting. There are really two purposes of this review. The first is to provide an opportunity for the Board to kind of see progress thus far, and make any suggestions or modifications.

Then it's also an opportunity for the PDT to ask questions of the Board. As Bob alluded to, there are a series of questions that the PDT has for the Board; so we can get a bit more clarity moving forward. This is our timeline for Amendment 3. We are in the preparation of Draft Amendment 3 step, and we do expect that to take us to the August Board meeting. Hopefully at that point the Board will approve the document for public comment; which would make our public comment period likely from late August to potentially early October. Then the Board is scheduled to take final action in November. Just to kind of orient everyone to how Amendment 3 is organized, there are seven different chapters.

Chapter 1 is our introduction, so this states the problem that we're trying to address; and also provides a description of the resource fishery and habitat. The second chapter is our goals and objectives, so this outlines the purpose and need for action; as well as the reference points. Chapter 3 is our monitoring program.

This looks at things such as harvester reporting, as well as biological data collection. Chapter 4 is the management program. This is going to look at things such as allocation, episodic events, incidental catch, as well as any provisions that are under adaptive management. Chapter 5 is compliance, Chapter 6 is research needs, and then Chapter 7 is protected species.

Today I'm going to be focusing on Chapters 2, 3, and 4. However, if there are any comments or questions on the other chapters, I'm happy to answer those. Starting off with reference points, those are in Section 2.6.4. There are currently five different reference point options in the amendment.

Option A is our single species reference points. Then Options B, C, and D are all looking towards the menhaden specific BERP ERPs. But those interim ERPs are what differ. In Option B, it is the interim use of our current single species reference points. In Option C, it is the interim use of the 75 percent rule of thumb.

In Option D it is interim use of the Pikitch et al. reference points, and then Option E is kind of our combo option; which is the fishing mortality target, consistent with achieving 75 percent unfished biomass, and our 40 percent threshold. As Shanna just talked about for Option C, D, and E, the BERP working group is still working on the calculations for those reference points.

But we do fully intend to have those ahead of the August Board meeting, and included in a subsequent draft of the amendment. Section 3.1 is Commercial Reporting; and I did want to highlight this section, because there are some differences that may occur, depending on the allocation method that is chosen.

We would still have reduction reporting through the Captain's Daily Fishermen reports, and if a jurisdictional quota is implemented then states could maintain at a minimum their current monitoring system. However, if jurisdictional quotas are not implemented, we need some way to monitor landings in season so that we could follow things such as a fleet quota, or a regional quota, or a sector quota.

As Amendment 3 currently reads, states would work to report through SAFIS. There are a couple of reasons why the PDT is recommending SAFIS. First it allows us to monitor landings in near-real time. This will be particularly important if there are regional, fleet, sector or seasonal quotas.

Then it also is an established coast-wide program, which fulfills state and federal reporting requirements. If there are any concerns about SAFIS, now would definitely be a time to bring that up before the Board. If there are other suggestions on how to monitor quotas in season, the PDT is all ears. Section 4.3.1 is the TAC. We are using the same TAC setting method as Amendment 2, where the Board can set an annual or a multi-year TAC, and that can be done through the projection analysis or the ad hoc approach.

However, one of the new portions of this amendment is what we're calling the indecision clause. This is resulting from our healthy debate on the 2017 TAC. There are a couple reasons why we're putting this in. We need to specify what happens if the Board is unable to come to a decision on the TAC for a given year.

That is why we're putting this clause in. As it currently reads; if the Board is unable to approve a TAC for the subsequent fishing year by December 31, the TAC is set at one-half of the TAC from the previous year. I do want to note that this is definitely not a carrot approach; this is more of a stick approach, to getting the Board to a consensus.

The PDT did discuss keeping it at status quo, so if there is not a decision made, keeping the TAC from the previous year and moving it into the next year. However, there were a couple concerns that that might actually provide incentive to avoid a majority vote. For example, if the TAC is low and projections suggest that it could be increased; there may be some incentive to not have a majority vote to keep it low.

On the other end of the spectrum, if the TAC is high and projections suggest that there needs to be a decrease, there may be incentive to keep that TAC high, to not have to take that cut. That is how we ended up at one-half of the TAC. The PDT is all ears if you have another suggestion for what is a more appropriate level.

Moving on to Section 4.3.2, which is quota allocation. Just to orient everyone to how this is set up. There are three different tiers in this section. This is to try and accommodate the different combinations of allocation methods and timeframes that could be used. In Tier 1 we have our disposition quota, which is the bait versus reduction quota.

We also have fleet capacity quotas, seasonal quotas, allocation based on TAC level quotas, or none of the above. In Tier 2 we have our coastwide quota, our jurisdictional quotas, a fixed minimum quota, and then regional quotas. Then in Tier 3, we have our timeframes. Just to provide an example of how this would work.

For the Board to kind of choose the current management approach, the Board would choose none of the above in Tier 1. They would choose jurisdictional quota in Tier 2, and they would choose 2009 to 2011 in Tier 3. You have to choose an option in each tier to kind of create an allocation package.

Diving into these tiers a bit more, just to provide a bit of information on these different allocation methods, so the first one is our bait versus reduction, and there are two sub-options for how you split the quota between the two sectors. Sub-option 1 is 70 percent goes to the reduction fishery, and 30 percent goes to the bait fishery.

Sub-option 2 is that the split is based on historic landings, and preliminary allocation percentages for this option can be found in Table 1 of the amendment. Next is our fleet capacity quota. We have again two sub-options here; either a two-fleet or a three-fleet approach. Then there are also sub-options which look at whether that small capacity fleet can be managed under a soft quota. Just to provide a bit more context on that soft quota approach. The small capacity fleet is still allocated a portion of the quota; however their fishery would not close if that quota is met.

The intent of this is kind of to reflect the ebb and flow of bait landings. Where in some years they might be a little bit above that quota, in some years they might be a little bit below; but in the end it all kind of evens out. We also have seasonal quotas here, and I'm going to talk about this a little bit more; but kind of previewing a question I have for the Board is, if the Board is still interested in this option.

One of the things to consider is states have not submitted monthly landings. My sense is from some states that might be hard to get going back to 1985. If the Board would like to pursue this option, I probably will have to use ACCSP data to calculate those percentages. Then we have allocation based on a TAC level.

Under this option we have a baseline TAC of 212,500 metric tons. If the TAC is below this then we keep our current allocation method; if it is above it, then that difference is allocated to the reduction and the state bait fisheries in different percentages, where you have different sub-options there.

Next on to Tier 2, the first option is our coastwide quota. Our second option is jurisdictional quotas and percentages for those can be found in Table 7 of Amendment 3. Next we have our fixed minimum quota. In this case each state gets a fixed minimum amount of quota. We have sub-options for either 1 percent or half a percent, and again those allocation percentages can be found in Tables 8 and 9.

Then we have regional quotas, so we have three sub-options there. We have a two-region split between the Chesapeake Bay and everyone else, a three-region split between New England, the Mid-Atlantic states and the South Atlantic states, and then a four-region split between New England, the Mid-Atlantic states, the Chesapeake Bay states, and the South Atlantic.

Then finally Tier 3, these are our allocation timeframes. Just a reminder, they are 2009 - 2011, 2012-2016, 1985-2016, 1985-1995, and then a weighted allocation between 1985-1995, and 2012-2016. One thing I do want to note is that Florida did not collect gear-specific data prior to 1993.

What this means is for some of the older timeframes we're going to have to use data from 1993 and 1994 to kind of back calculate what those gear landings are for something like a fleet capacity allocation method. Then a question that's been brought up is do historic reduction landings from states which no longer have a reduction facility count towards the allocation percentages?

This will be one of the questions that I'm hoping to get an answer from the Board today. This is what the allocation section looks like, and I'm hoping people can't actually read this; because the point is that there may be too many options in this document. What we have here is our different tiers, we have different options, we have the sub-options and then we have the sub-sub-options. I think the concern of the PDT is that this number of options may hinder effective public comment; and it may also hinder resulting board action in November. Kind of one of the themes I'm hoping to get across today is how can we hone in on the number of management alternatives in this section? Section 4.3.3 is quota transfers. Quota transfers only apply if a regional or state-based quota is chosen.

The PDT did not feel it was appropriate for transfers between either the bait and reduction sector, or different fleets. There was a request at the February Board meeting that some guidance be provided on what happens if a state receives multiple requests at the same time. Amendment 3 recommends that if a state or a region receives multiple transfer requests, their transfers are considered in the order in which they were received.

We have four management alternatives here. Option A is kind of our status quo, so quota transfers would continue as they do now. Option B is our status quo, but it tries to build in some accountability measures, so that states aren't perpetually exceeding their quota; and then using transfers to try and address that issue.

This says if a state or region exceeds its quota by more than 5 percent in two years, it cannot receive a quota transfer in the third year. Option C is quota reconciliation; just a reminder of how this works. If the TAC is not exceeded then any state or region overages are forgiven. However, if the TAC is exceeded then any unused quota is pooled; and that is distributed to states or regions that had an overage.

Option D here again tries to build in some accountability measures. Under this option the amount of overages that is either forgiven or the amount that's distributed to states, is dependent on the number of previous years of overages. The more overages a state has had in consecutive years, the less amount of overage will be forgiven.

Section 4.3.4 is quota rollovers. The PDT has tried to tailor this so that quota rollovers will work under each allocation method. However, it is important to note that quota rollovers are not permitted if quota reconciliation from the previous slide is implemented. There are five different options for quota rollovers.

Option A is no quota rollovers, Option B is that 100 percent of unused quota can be rollover. Option C is 10 percent of total quota can be rollover. For an example, if I am a state and I have one million pounds, I could roll over 100,000 pounds of unused quota. Option D is obviously quite similar to that except 5 percent.

Then Option E is rollover of 50 percent unused quota. Another example, if I have 500,000 pounds of unused quota, I could roll over 250,000 pounds. Section 4.3.5 is incidental catch. The first thing that this section does is define a small-scale gear from a non-directed gear from a stationary multi-species gear.

I think one of the challenges with Amendment 2 has been that it is kind of unclear who can participate in the bycatch fishery. The PDT has tried to define these different gear categories, so that we can develop options that pertain to each of these categories. They are not exclusive, so some gear types do occur in multiple categories. We now have six options for incidental catch. To kind of separate them, Options A, B, and C do not include bycatch in the TAC. Options D, E, and F do include bycatch in the TAC. One of the pieces of feedback we had received from the Board was to develop options that do include bycatch in that TAC. Option A is a trip limit for non-directed gears. This would be kind of your true bycatch definition, where something like a pound net would be able to harvest menhaden after the directed fishery has been closed through a trip limit. Option B is probably closes to status quo; it is a trip limit for non-directed gears and small-scale gears; so here both pound nets and cast nets would be able to harvest.

Option C built on this by adding a cap and trigger. It sets the cap at 2 percent of the TAC, and if this cap is either exceeded by 10 percent in a given year or if it is exceeded two years in a row, then that would trigger management action. The Board would be triggered to consider ways to reduce bycatch in the menhaden fishery.

Option D is an incidental fishery set aside, so 2 percent of the TAC would be set aside for incidental catch; which occurs after the quota is met. Option E is a small-scale-fishery set aside, so this sets aside 1 percent of the TAC for small-scale gears; and these gears would harvest from this set aside throughout the year.

Then Option F is all catch is included in the TAC. Once the quota is met the fishery would close. Then 4.3.6 is episodic events. Currently as Amendment 3 is written, eligibility is for the states of Maine through New York. It is the same mandatory provisions as under Amendment 2, so harvest is restricted to state waters.

There is a trip limit, daily trip level reporting. However, the PDT has tried to provide greater guidance on ways for states to prove a high abundance of menhaden. Things such as surveys or landings reports, fish kills, we've tried to provide a bit more guidance to states in the application process.

There are three options here, 1 percent of the TAC is set aside for the episodic events program. Option B is an increase, so 3 percent of the TAC is set aside, and Option C is 0 percent of the TAC is set aside; so that would eliminate the episodic events program. Then 4.3.7 is the Chesapeake Bay cap.

Under Option A, this is our status quo, where the cap is set at roughly 87,000 metric tons. Then we have sub-options that allow for either a portion of rollover of that cap or no rollover. Option B would set the cap at 51,000 metric tons, which is roughly the five-year average. Again, we have options that allow for a rollover of a portion of that if it is unused, or no rollover.

Then Option C would remove the cap. That is Chapters 2 through 4 of Amendment 3. Kind of getting back to one of the messages or themes of this presentation, how can we hone in on the number of allocation methods?

REVIEW ALLOCATION WORKGROUP RECOMMENDATIONS

MS. WARE: The Allocation Workgroup met to review Amendment 3, and also to provide some recommendations to the Board on how we can try and hone in on some of these options.

There were four questions that were asked of the Allocation Workgroup, and I'm going to provide their responses. The first question is there any benefits or concerns for either the two-fleet or three-fleet allocation method. The recommendation of the Allocation Workgroup is that the Board maintains the two-fleet quota option, but removes the three-fleet option. The Allocation Workgroup felt that the two-fleet option is less complex, and still achieves the goals of the allocation method; which is to provide equitable access to the fishery for all gears, and also reduce the administrative burden on states. The second question asked of the Allocation Workgroup is should soft quotas be included as a management alternative. The Allocation Workgroup recommends that soft quotas be maintained as a management alternative for small-capacity fleets, but that the PDT further develops clear and up-front controls on this fleet.

The PDT has started to work on that. But this is something that we would continue to work on if the Board agrees with this recommendation. The third question is; is there a regional-allocation method which best reflects the menhaden fishery? The Allocation Workgroup recommends that the current regional allocation options be removed from Amendment 3, and that they be replaced with an option that establishes a regional quota for the New England states; but maintains jurisdictional quotas for the Mid-Atlantic and South Atlantic states.

Some of the members of the workgroup expressed concern that regional quotas could result in states being shut out of the fishery, due to the timing and the movement of menhaden. However, they did note the episodic nature of the New England fishery, and that may warrant a regional management approach.

Finally, the fourth question asked of the group was should historic reduction harvest from states which no longer have a reduction fishery be included in the landings used to calculate allocation percentages? The recommendation of the workgroup is that landings data prior to 2017 is not used in this amendment; 2007, my apologies. They pointed to a couple of things. They pointed to inconsistent reporting for several states prior to this date. They noted that this timeframe only includes one active reduction plan.

Many pointed to some of the management challenges that are occurring with summer flounder. As a result, they are recommending that the current allocation timeframes be replaced with the following; 2009-2011, which is our status quo, 2013-2016, which is four years under Amendment 2, 2007-2012, which is the six years before Amendment 2, 2012 -2016, which is the five most recent years of data, and 2007-2016, which is the most recent decade of data.

One of the last slides here, this is just kind of an FYI for the Board. New York did submit a proposal to recalibrate the menhaden landings, due to inconsistent or non-existing reporting. In the proposal they compare landings for 2013-2016 to 2009-2012; to scale their historic landings. The PDT is in the process of reviewing this proposal, and they will provide a recommendation to the Board in August.

PROVIDE GUIDANCE/ADDITIONAL INPUT TO THE PLAN DEVELOPMENT TEAM REGARDING MANAGEMENT OPTIONS

MS. WARE: Just to leave the Board off with some questions from the PDT. Again, how can we hone in on the number of management alternatives in this document? Should the three-fleet option be removed? Should soft quotas be included as an alternative? Is the Board still interested in seasonal quotas? Should the regional allocation options be replaced with an option that creates a New England regional quota, but maintain state quotas elsewhere, and what timeframe should be used for allocation?

CHAIRMAN BALLOU: Really excellent presentation. Here is what I would like to suggest. Instead of an open question period, as we typically do after a presentation like that. Let's work through the issues that were teed up by Megan's presentation; at least initially address any and all questions along the way. Once we get through those issues, we'll open the floor to any other suggestions, any other recommendations pertaining to anything in the document. But I just want to kind of manage the discussion here by staying as focused as we can. Issue Number 1, just drawing from this slide that Megan has left up, is the recommendation that the two-fleet option be maintained in the draft amendment, but the three-fleet option be removed. Are there any questions regarding this recommendation? Are there any thoughts regarding the working group's recommendation, which I just indicated? Dr. Pierce.

DR. PIERCE: Very well done presentation and the questions have been very succinctly listed for us. Should the three-fleet option be removed? I'm going to believe you in your presentation noted the benefits of going with the two-fleet instead of the three-fleet; but what I missed was the drawbacks. Did the group highlight any of the potential drawbacks if we go to two-fleet as opposed to three-fleet? I'm leaning towards the two-fleet, but again what are the specific drawbacks, if any?

MS. WARE: I don't think any drawbacks were discussed on the call, however you're just kind of outlining how the two-fleet versus three-fleet works. Two fleet is small versus large, so it's basically all gears separated from purse seines and pair trawls. The three-fleet option there is smaller gear, so things like cast nets, bait nets versus a medium fleet, which is something like pound nets versus the purse seines. I think it is more that the division between those different gear types.

DR. PIERCE: By going with the two-fleet as opposed to the three-fleet, we put in the mix the pound nets and cast nets. I am wrestling with that one. What is a gear that is capable of taking a "large amount of menhaden" versus a much smaller amount that one would expect to get with a cast net? I haven't yet been able to wrestle with that answer to that question. To what extent would we disadvantage the cast net fishermen as opposed to maybe not doing that?

CHAIRMAN BALLOU: I'll leave that as a comment. Good question and I think it was answered; any other questions, comments, Terry Stockwell.

MR. TERRY STOCKWELL: I am on the same thread. Megan, can you explain to me the difference between the two and the three-fleet, where cutoff would be. In a particular issue we discussed at the last meeting it was a difference in the size of the purse seiners; and the fact that actually the fish traps, at least in Maine, could have a fairly high catch. I'm not opposed to simplifying the document by going into a two-fleet component; I just want to make sure that the fishing effort is appropriately divided.

MS. WARE: In the two-fleet option it is basically purse seiners and pair trawls versus everything else; so your Maine purse seiners would be included in that large fleet. For the three-fleet option, the split for that large fleet is for purse seiners which have a capacity over the 120,000 pounds; so your Maine purse seiners would be in the medium fleet.

MR. STOCKWELL: To that point, thank you. In that case I am strongly in support of the three-fleet approach.

CHAIRMAN BALLOU: Okay, so we have a recommendation to just go with the two-fleet and not include the three as well, but we have at least one Board member, Terry Stockwell urging that it be kept in; that three-fleet option, so discussion on the issue, Rob O'Reilly.

MR. O'REILLY: Just a question. The fleet, whether two or three is part of that whether some of the gear types in the fleet, the small-based fleet would be soft caps and some would be soft quotas and some would be hard quotas. Is that part of what is also being asked?

MS. WARE: Yes, so those two issues are very much related. A sub-option of the fleet option is that that small capacity fleet be under a soft quota; so there is an option for it not to be under the soft quota, and an option for it to be under the soft quota. What you define as a small fleet will impact which gears might be subject to a soft quota.

CHAIRMAN BALLOU: I was hoping to reach consensus, and if we don't we can take a vote or we can just roll with what we've got. Again, the idea here is to try and give the PDT as much guidance as possible as they continue their work on this document; which will come back before the Board in August.

These issues could very well be brought back in August for further discussion, but at this point it is sort of an interim check; and this is one issue, and I'm looking for further guidance from the Board on how you would like to proceed on this. Emerson, did you have your hand up?

MR. HASBROUCK: Yes, thank you, Mr. Chairman and thank you, Megan for your excellent presentation. You were able to synthesize all those various options quite well. In looking in the document, under Table 2, which is the two-fleet option, there are different percentages there that are based on historical catch for different time periods.

Then for the three-fleet option it is allocations yet to be calculated. There is no direct comparison there currently, and even if there were, I know these percentages are based on reported landings; but is that subject to change by the Board in August, or even further down the road in October? If we want to change what those percentages are?

MS. WARE: The percentages in Table 2 are based on historic landings. Unless there is a change in historic landings, those percentages would not change, or unless the allocation timeframes are changed. They presumably would not change. But there is not an option in here yet that says 5 percent goes to small-fleet and 95 goes to large, and that not be based on an allocation timeframe. Did that answer your question?

MR. HASBROUCK: Yes it does, but what if we wanted to include a discussion about that; you know about having the distribution between fleets, whether it be two-fleets or three-fleets, be based on something other than historic landings over whatever time period we want to choose? Make it not based on historic landings.

MS. WARE: Yes, if the Board is interested in that that is important information for the PDT to know.

CHAIRMAN BALLOU: Let me just pick up on Emerson, your comment, because I think it's relevant to Terry's perspective; and that is right now in the document under Table 2, is a break out of what a two-capacity fleet allocation might look like; depending on the timeframe, and indeed there is a sort of hold under that for Table 3, allocations not yet calculated.

I think the challenge here is that it would be indeed a challenge to try to calculate allocations on a three-fleet basis; because now you're parsing the purse seine fleet. You're taking historically those purse seines able to harvest up to, I forget what the cut off is, 125,000 pounds; affording them an allocation in accordance with that middle fleet, medium-fleet category.

Then trying to go back and figure out how many purse seines that was capable of harvesting more than 125,000 pounds, putting them in the large fleet. I think if I'm not mistaken, and certainly anyone from the Working Group can speak up on this. That sense of trying to parse out the purse seine fleet into two different categories; based on historical timeframes, was going to be a huge challenge.

Why do it? Wouldn't it make more sense, and again I'm trying to paraphrase the Working Group recommendation, to just have the purse seine fleet in one category; purse seine and pair trawls, and all other gear types in the other? Terry, did you want to follow on that?

MR. STOCKWELL: Yes, thank you, Mr. Chairman. We entered into the development of this amendment with the understanding we were going to completely look at the reallocation from soup to nuts. By eliminating the medium capacity fleet, you are disenfranchising a complete gear type and region to start with.

I just don't think it is right at this point. We may find further down the road that it makes sense to merge the two, but right now the large purse seine effort and the small purse seine, they're two different fisheries; as different as between a medium vessel and a haul seine. They are two different fisheries.

Putting them in the same category, particularly as we go down soft quotas, time periods, I know it is a bucket load of work, and I appreciate all the hard work that the TCs and the Working Group is doing to develop this. But you lack the perspective of a historic fishery in this Working Group, to advocate for what last year in Maine was a significant fishery. I hate to see us go through the efforts to develop an action right now, and at the very beginning exclude a fishery. I am strongly in favor, at least at this point, of maintaining the three-fleet option.

CHAIRMAN BALLOU: Thank you, fair enough. What I'm going to pose to the Board is that there is now on the floor a strong recommendation for keeping both the two-fleet and three-fleet options in the document. I would like to have anyone speak to that in opposition. Is there anyone in opposition to keeping both in the document? Please raise your hand and speak to that. David.

MR. BORDEN: I'm not in opposition, I'm just trying to get my head around the issue, and that I understand Terry's point here. What is, if I can ask Megan a question? What portion, almost 95 percent of the allocation goes to a large capacity fleet, the way I understand it. Under the three-fleet option, what portion of the allocation goes to the medium-sized vessels?

MS. WARE: I don't know, because I haven't calculated it yet.

MR. BORDEN: Okay. As I said, I recognize the point that Terry is making, and I understand the logic. But I also, looking at this, I think it's going to pretty much complicate the document significantly if we have. One of the options would be to, instead of having a 25,000 pound trip limit per day on the small-capacity fleet to simply raise that to 125,000 pounds, so we would have two fleets, one would be a large capacity fleet, and the other would be a small capacity fleet. The small capacity fleet would have a higher trip limit. That should meet Terry's needs, and also simplify the document.

CHAIRMAN BALLOU: Duly noted. Are there other thoughts or suggestions on this issue? Emerson.

MR. HASBROUCK: Megan, I think it might be helpful sometime after this meeting, if you could send out to the Board members the summary slide that you had with the different actions under the various tiers. Because the question I have here relative to two fleets or three fleets is if we choose to just split the total allocation between the reduction fishery and the bait fishery, do we even get into a discussion about fleets? I can't recall from your summary.

CHAIRMAN BALLOU: The answer is no. Those are two different options under Tier 1. You would only be able to pick one. The Board would only be asked to pick one.

MR. HASBROUCK: Right, so if we chose the option of splitting the quota between the reduction fishery and the bait fishery, then we don't need to worry about two fleets or three fleets or four fleets or whatever.

CHAIRMAN BALLOU: Correct. I see no other hands, so I'm going to suggest, based on the discussion that has taken place today that both, two-fleet and three-fleet remain in the document for further development by the Plan Development Team. Is there any objection to that guidance moving forward?

Seeing none; we'll move on to the next issue, which is the recommendation that soft quotas be maintained as a management alternative as applied to the small-capacity fleet option. Are there questions on this issue, thoughts on the Working Group's recommendation that soft quotas be maintained? David Borden.

MR. BORDEN: Maybe two questions. One question is do all soft quotas count towards the overall TAC?

CHAIRMAN BALLOU: The answer is yes.

MR. BORDEN: Okay, so I'll pass on the second one.

CHAIRMAN BALLOU: Questions, thoughts on this issue, in particular the recommendation to keep soft quotas in the document; and again as applied to the small-capacity fleet option. Is the Board comfortable with that? Dr. Pierce.

DR. PIERCE: Yes, I'm very comfortable with that. I think it's a good concept and in light of the guidance you just provided, Mr. Chairman regarding the two-fleet and three-fleet option, it will provide for more, I wouldn't say a challenge, but it will be more informative for all of us; because the small-capacity fleet is defined in different ways, depending upon two or three fleets. That might influence our eventual decision about whether to go with the soft quota for the small-capacity fleet. I make that point, because I look at the two-fleet option and I see you know the drift gillnets and the weirs and the pound nets and the floating fish traps; and I'm thinking wouldn't that possibly result in a rather large amount of menhaden being landed? How do you justify a soft quota for those particular gear types? If it is only 5 percent of the total landings of the commercial fishery, then I suppose it is not a big deal. Again, I support the soft cap.

CHAIRMAN BALLOU: Any further thoughts on this issue? If not, since we have concurrence on keeping it in and moving forward, and as such we will now take on Issue 3, which is the question of whether the Board remains interested in including a set of alternatives pertaining to seasonal allocation. If I'm not mistaken, the Working Group's recommendation was to strike that set of options from the document.

We're looking for questions and/or comments on that recommendation. The issue is seasonal allocations. This would be a Tier 1 option, so it would be in lieu of that reduction bait breakout, in lieu of a fleet capacity, it would be just breaking out the entire fishery into seasons; and managing it accordingly. The Working Group's thoughts on that were no, it was essentially that it does not warrant remaining in the document, so thoughts on that. Rob O'Reilly.

MR. O'REILLY: I think that Megan outlined the problem that could exist with seasonal allocation when she gave her presentation. It could be haves and have not's, depending on the movement of the fish. I think it should be removed.

CHAIRMAN BALLOU: Thank you for that, Rob, is there anyone else on the Board wish to comment on this? Is the Board comfortable with this recommendation to remove it? It would certainly help pare down the options. It would be in keeping with the intent of this discussion. David Borden.

MR. BORDEN: I agree with Rob. I think it should be removed. I think it simplifies the document.

CHAIRMAN BALLOU: Any other thoughts? Seeing none; I think we have good guidance on this one, and we'll move on to the next issue; which is the recommendation that the current regional allocation options be removed from the amendment, and replaced with an option that considers a regional quota for the New England states, Maine through New York, and jurisdictional quotas for the Mid-Atlantic and South Atlantic states. Questions on this? Discussion? All right, Eric Reid.

MR. ERIC REID: I will be opposed to a regional quota in New England. Where we are in Rhode Island, typically we would have the last shot at any fishery. The perfect example is this year where there was no episodic event available to us, unless the quota was high enough that we all had a nice piece of the pie; but I would be opposed to a regional quota in New England.

CHAIRMAN BALLOU: Would you be opposed if that were the only region that had a quota, as a way of preserving access to the fishery for the New England region?

MR. REID: I'm opposed to a regional quota in New England.

CHAIRMAN BALLOU: Other thoughts on this. Dr. Pierce.

DR. PIERCE: I'll echo it, I'll echo Eric's perspective. I definitely do not want to see regional allocation options replaced. What we're doing right now in our individual states in New England, I can speak specific to Massachusetts. We've done quite a bit to figure out how to manage our individual quota.

We may eventually have to go in a completely different direction; depending upon what the final results are, relative to this addendum. But the regional allocation definitely would put my state in particular at a great disadvantage; relative to who gets what first, depending upon the movement of the fish and the seasonality of that movement. I would not support that regional allocation option.

CHAIRMAN BALLOU: We really have two issues that are sort of getting conflated here. One is right now the Draft Amendment under Option D, regional allocation has three sub-options. The first is a two-region split, Chesapeake Bay being one, and the rest of the coast being the other. Sub-Option 2 is a three-region split.

The first region is a New England region, the second is essentially a Mid-Atlantic and the third is a South Atlantic. The third sub-option is a four-region split; New England one, Mid-Atlantic, New York through Delaware being the second, Chesapeake Bay, Maryland through Virginia being the third, and South Atlantic being the fourth.

The question for the Board is; do you want to keep those regional allocation options, including all three sub-options in the document or not? If not, do you want to replace it with something else? I'm sort of hearing two different things. I'm hearing opposition to the regional allocation approach. I'm hearing particular opposition to a New England regional approach. I'm not sure. I'm just trying to get a clear read from the Board on how they want to proceed on this issue. Rob O'Reilly.

MR. O'REILLY: I'll just mention what the Allocation Work Group talked about concerning regions that it would break down to states within the region, trying to make sure that they didn't go over a quota; and that could be somewhat of a complication. I know that was stated on the Allocation Working Group.

CHAIRMAN BALLOU: Let me pose the question this way. Is there any opposition on the part of the Board to removing regional allocation in its entirety? I'll just stop there. Is there any opposition to that? Does the Board support removing regional allocation as a component of this amendment? Let me go to Steve Train first.

MR. STEPHEN R.TRAIN: While I can see the merit to removing it, no knowing what we're going to get for a choice in the end makes me wish we could keep it in there a little bit longer. I mean with what we landed in Maine last year, and the way things are changing; having an allocation that is greater than having Terry and Pat begging and borrowing from the other states to get quota, would be better for us now. Can we do away with regional, yes? But not knowing what we're going to get instead of it, makes me want to be able to keep the option in it for now.

CHAIRMAN BALLOU: Understood. Cheri.

MS. CHERI PATTERSON: I agree. I think we need to maintain the regional option, because these fish are moving. We are seeing more and more episodic events further north; and those need to be considered if the population continues to expand.

CHAIRMAN BALLOU: Yes, Senator Watters.

SENATOR DAVID H. WATTERS: Just a follow up on what Cheri said. It is hard to separate this from the next issue of the timeframes, kind of a question to Megan. If we are seeing a shift of the biomass towards the north because of climate, do those timeframes really adequately reflect what might be projected there from, so that whatever we do in the regions, if we have timeframes that are based on historic landings that really don't reflect where the fish are going? I think that would be difficult.

MS. WARE: Yes it's a tough question. I'm going to throw it back to the Board. I mean I think it is up to the Board to make a policy decision on the timeframes, and whether the Board is interested in using historic timeframes or pursuing the allocation workgroup's recommendation to go from 2007 forward. I mean that is the next discussion we're going to have.

CHAIRMAN BALLOU: Dr. Pierce.

DR. PIERCE: Yes, I'm very much influenced by Option C in the list of options. Jurisdiction allocation with minimum based allocations, I suspect that that option and one of those sub-options, one or two, would actually be of benefit to the state of Maine and to other states. I know it will be to the state of Maine that is the last in line, so to speak, with menhaden.

With the regional allocation that would include, what is it Connecticut through Maine that potentially would put Maine at a disadvantage; regional allocation in the interest of shortening the document and making it easy to understand, and certainly supportable by me.

Regional allocation Option D, I still think we could delete that and go with Options A, B, and C. That should do the trick, but again I'll defer to the state of Maine. If Maine's representatives really feel that Option D needs to be kept in there then I'll support that. But I really do think it's unnecessary.

CHAIRMAN BALLOU: Then again, just to remind the Board. We will be coming back to this for really a final review as a draft for public comment in August. We will have another chance at this issue. It's just to try to aid in the further development of the document, particularly with regard to the analysis of these options that we're really trying to address today. David Borden.

MR. BORDEN: Yes, Mr. Chairman, a question for you. Does this require more? If we leave it in until the next meeting, when we review more details, does it require any more work on the part of staff?

MS. WARE: It depends if we change the timeframes or not.

MR. BORDEN: It may make some sense just to leave it in and then take this up at the next meeting, and make a formal decision on it. People can think on it and so forth.

CHAIRMAN BALLOU: I think that is a really good fallback suggestion on these kinds, given the discussion we've just had. Just as a reminder, this is a Tier 2 issues, and I think as the Board becomes more fluent in the development and the nature of the amendment, the notion of first you don't even get to this issue of regional allocation until you've gone through a Tier 1 selection process.

I think what I'm urging everyone to do is sort of go back home, really try to digest this document as best you can. Think through the sequencing, if you will, of the decision making process that is going to unfold. Think about the public, in terms of trying to make sure they can be guided through the process of assessing the options in a way that is clear and straightforward.

Perhaps when we return in August there will be some clear thinking on what combinations we want to keep in, and which we might want to remove. I get the sense that maybe for many of you, you're just getting more and more familiar, but aren't at the point yet where you're ready to strike a wholesale some of these options.

That's the sense I'm getting, but if I'm wrong correct me. If there is certainly any specific recommendations to for example take out any of the specific sub-options under regional allocation. Now is the time to speak, otherwise maybe we'll just keep things together. David Blazer.

MR. DAVID BLAZER: In the spirit of cooperation, trying to trim down a little bit of the document. I think we could eliminate Sub-option 1, which divides the regional allocation for Chesapeake Bay and everybody else. I think we're supportive of eliminating that option.

CHAIRMAN BALLOU: Is there any objection to removing that so that we would be left with two sub-options, one would be a three-region split, the other would be a four-region split. We would remove, as Commissioner Blazer just suggested, the two-region split separating out Chesapeake Bay. Is there any objection to trimming the document just a bit in that way? Seeing no objection; thank you for that suggestion and we'll convey that to the PDT, other thoughts on this issue; Rob O'Reilly.

MR. O'REILLY: Not on the region, but we had also delved into the timeframe.

CHAIRMAN BALLOU: That's next.

MR. O'REILLY: Okay. Too early to comment?

CHAIRMAN BALLOU: You might be only five seconds early, but let me just make sure we've wrapped on that. Have we wrapped on the issue of regional allocation; or does anyone have anything else? Dr. Rhodes.

DR. MALCOLM RHODES: Just one quick question. We would remove Chesapeake Bay, but we would still have the catch cap in the earlier part of the document.

CHAIRMAN BALLOU: Correct.

DR. RHODES: All right, perfect, thank you.

CHAIRMAN BALLOU: Good question, I was thinking the same thing, so if the Chesapeake Bay cap portion remains, this just has to do with this sub-option; any other discussion on this issue? Seeing none; and Rob, I'll give you first crack at this. We're up to Issue, actually the last issue if you will on the list of issues to be considered; at least from the Working Group's perspective and that is the issue of Allocation Timeframes.

The issue has two components. One is the question of whether reduction landings from states which no longer have a reduction fishery, should be included in the calculations. The other is the question of which set of timeframe options should be included in the amendment, and used to flesh out the allocation percentages for every alternative that involves jurisdictional allocations. I just want to make sure the Board is clear.

These timeframes would be used in multiple ways throughout the document, on each and every occasion where there needs to be an allocation based on historical timeframes. You can see right now in the document in the tables that have been developed that were presented and are in your meeting materials, how things would play out with regard to the current four alternatives that are in the document.

In addition to status quo there are four alternatives in the document. You also have a Working Group recommendation to replace those with four different alternatives. I know Megan had put that slide up, but there it is right there. Right at the bottom of the slide is the focus of the discussion I would now like to undertake, and that is current timeframes versus proposed new timeframes; questions, discussion on this, I'll go to Rob O'Reilly first.

MR. O'REILLY: I'm well aware that Robert Boyles and you have hosted about maybe nine, it seems like nine Allocation Workgroup conference calls, and so we have discussed this. I think in the document that has been prepared, the Draft Amendment 3. It is pretty clear that there are some problems with the historic information; not only the lack of data back in time, but also the fact that the last factory or reduction facility other than Omega Protein, was around until about 2007. We talked about that.

We talked about the data deficiencies, and I think one of the recommendations and there are other folks on the Working Group, so if I get anything wrong let me know. But one of the ideas was there was a comment that 2013-2016, the second option was actually going to be almost a continuation of what had happened; even though it followed Amendment 2.

Certainly that was born out that the proportion of harvest after Amendment 2 is there. The 2012, the fourth item was because with Amendment 2, the Board was just short of having any final data, and it seemed like that could be included. Then of course the 2007 goes back to the fact that that is where there is only one reduction facility; and that is Omega Protein.

I would recommend, and other Working Group members can chime in, with the proposed timeframes are really more suitable. I know that it would be a struggle to try and recreate the past data. That is one reason. The second reason owes to the reduction class.

CHAIRMAN BALLOU: Just to help ensure that the discussion that ensues now is well informed. At the end of the Working Group memo, which is just a short, two-page memo in your meeting materials, is a third page, essentially. That is Table 1, and it shows the state-by-state allocation percentages for the time periods recommended by the Allocation Working Group. That would be the set of allocation timeframes on the right, on the slide that's up there now. In your Draft Amendment, I think its Table 7. Does that sound right? Table 7 in the Draft Amendment is the percentages that correspond to the current timeframes on the left side.

You can do your compare and contrast, or however you want to look at it, by comparing those two tables that are in your meeting materials. I just want to make sure that this discussion is focused on those tables; because they bear the fruit, if you will, of how things would play out regarding the Board's decision on how to move forward. David.

MR. DAVID BUSH: Just a quick question. Just to kind of get a sense of how the regulatory process has impacted the fisheries, now understanding that these things change from state-to-state, year-to-year a lot of changes. But I guess what I'm wondering is, and the reason why I'm asking, over the past few years with a couple of huge cuts, there are some significant cuts.

Is there any sense that that has caused any shift in any of the other fisheries, certain smaller fisheries, maybe no longer found it practical to fish during those years, and if so, we've sort of set it up to almost shape the plan and determine who's going to get the fish afterwards.

CHAIRMAN BALLOU: Is that a question or a comment? If it's a comment –

MR. BUSH: It's a question. I guess I'm looking for a sense of whether or not the recent regulatory changes have had any impacts in where these fish are landed, or if it is completely and totally just up to where the fish are?

CHAIRMAN BALLOU: I think the best way to answer that is to call your attention to Table 1, at the end of the Working Group document. That shows the percentages that would be applicable for each of the timeframes, one being the status quo timeframe, the other being that period of time since the adoption of Amendment 2, which for the first time put menhaden under quota management. Then you have some other combinations there.

I think really the best way to answer your question, David, is to just point to that table; and you can see whether there are any impacts that you can discern or not. I think that is the best way to answer that question, so I'll leave it there. Megan, did you have anything else on it? Okay. I'm trying to do my best to answer questions, and I keep forgetting I've got my expert right here to my right. Cheri.

MS. PATTERSON: Some states actually had decent fisheries or decent landing back in the late eighties early nineties, New Hampshire being one of them. I would of course be more leaning towards the current timeframe; so that we actually can show that we did have viable landings that can be attributed, because if we go with the proposed timeframes, we have 0 percent.

CHAIRMAN BALLOU: Understood, additional thoughts on this. David Borden.

MR. BORDEN: I'm actually opposed to the proposed timeframes of the Working Group. I just remind everybody that the state of Rhode Island, under the existing allocation got 66,000 pounds. If you went back over the timeframe of 1985-2015, there are periods there when I worked for the state of Rhode Island that we landed 25 million pounds. There is an enormous difference. Part of the reason we're doing this whole addendum is because when the allocations were made, they simply excluded those long term timeframes. I would also remind everybody that when we went to public hearing, at least at two of the hearings there was almost unanimous agreement on the part of the public to include a longer timeframe. I'm opposed to taking out the long timeframe. I think it should be included for the public process.

CHAIRMAN BALLOU: Let me remind the Board that this is a two-part question. One is whether we keep the timeframes or not, and David and Cheri have just spoken in favor of supporting the current timeframes that do stretch back. The other is should reduction landings from states that no longer have reduction fisheries be included in those timeframes; those calculations or not? Again, a two-part question there, and I think we are looking for Board guidance on both issues. Dr. Pierce.

DR. PIERCE: I will reflect on your suggestion earlier on, Mr. Chairman that it is a tiered approach, and we need to focus on that as we get ready for the next meeting. With that said. I do favor the current timeframes, if for no other reason then again; it does include a longer time period.

I'll specifically reference Table 2 in the document; where consistent with what you said these timeframes will be carried through the entire document, all the different options, and that Table 2 reference is large-capacity versus small-capacity fleets. Depending upon the years you pick, the small-capacity fleet does get maybe twice what it otherwise would get. I'm influenced by Table 2, and as a consequence of that I would prefer to leave in the longer time span that includes the 1984 and later.

CHAIRMAN BALLOU: If you don't mind, I'm going to now challenge everyone on the Part 2 of that and that is which approach do you favor; a time series that includes reduction landings from states that no longer have reduction fisheries or a timeframe that essentially cuts them out? There is good historical information, as I understand it, on the purse seine fisheries. This would be for states like North Carolina and others that once had reduction fisheries, but no longer do; should those landings be included in the long time series that you're supporting, or not?

DR. PIERCE: I would not include them.

CHAIRMAN BALLOU: Thank you. I appreciate that and I would like to again ask every Board member as you comment to speak to that second part of the issue as well. Thoughts on the issue, there seems to be more support for keeping the current timeframes than replacing them, and I'm still waiting for more input on the question of whether historical reduction landings from states that no longer have reduction fisheries should be retained or not. Emerson.

MR. HASBROUCK: I have a question, and then I guess a comment or two comments. In terms of what timeframe should be used for allocation, we have current and proposed. Is that for all references in this document to timeframe? That would include again, going back to a Tier 1 choice; the allocation between the bait fishery and the reduction fishery. Okay.

In terms then of what timeframes to use, I'm not opposed to keeping the current timeframes, except that I would like to include 2013 through 2016. I don't know what the easiest way to do that is if we just change 2009 to 2012? But then that doesn't reflect, I'm going to say status quo or what the current allocation is based on. Then, in terms of your question about do we include states that used to have a reduction fishery? I would say yes, if we're going to go back to the 1950s and look at historic landings back to the 1950s when New York had a reduction fishery.

CHAIRMAN BALLOU: We're not going that far back, at least as proposed. We're only going back as 1985.

MR. HASBROUCK: I said that somewhat tongue in cheek.

CHAIRMAN BALLOU: I'm sorry; I didn't pick up on that. Robert Boyles.

MR. BOYLES: Looking for wisdom here on how to split the baby. Many of you who I have spoken to over the years about allocation, know that I favor kind of a weighted approach, because we all want what we want. I make a note that South Carolina has a history of a reduction fishery; and yet we made a policy decision many, many years ago to effectively abandon that fishery.

It is why I like the weighted allocation. There are some of us who like more contemporary timeframes, and yet some of us like a longer time series. What I look at in terms of a weighted allocation, and why I favor it, is that you weight it both equally and you split the baby that way. I'm not quite sure where we're going to go.

I'm interested in final disposition of this, of course; I hope in November, and hope we can come to some consensus on how to best address it, but it's why I think I like the weighted allocation. You look at a long time series and you give that half, and you look at a more contemporary time series, and you give that half and you split the baby that way.

CHAIRMAN BALLOU: Robert, I'm not going to let you off the hook. Do you, in supporting that weighted allocation, which would in part rely upon the '85-'95 period, during which there were reduction fisheries in some states that no longer exist. Would you support keeping those landings in, or removing them?

MR. BOYLES: I would remove them.

CHAIRMAN BALLOU: Dr. Duval.

DR. DUVAL: Well I am going to agree and disagree with my neighbor to the south here. I also like keeping the weighted allocation in there; because I think it helps to bracket what the capacity was in different areas of the coast at different times. I think just because some states like North Carolina no longer have a reduction fishery.

Due to legislative action, it is highly unlikely that we will probably ever have a reduction fishery again. That doesn't mean that there is not the capacity there to harvest more. That is one of the reasons why I like the weighted allocation, and I would probably favor keeping those reduction landings in there. But you know that's me.

CHAIRMAN BALLOU: Terry Stockwell.

MR. STOCKWELL: I think we're all going to cherry pick what our favorite allocation is, I mean depending upon where we live and when we had our fisheries. Certainly there is from the northern perspective there is some wisdom for me to be in favor of a longer time series. I could also say a weighted allocation if they looked at this last year.

I am personally hoping we don't use timeframes at all as we move forward for the final decision. But I mean, tongue in cheek, Mr. Chairman. If we're going to go back and looking at old rendering plants, my hometown had three of them back in the 1800s.

CHAIRMAN BALLOU: Wisdom of the Board on this one. I am trying to discern and think about all the comments that have been offered, and is there a common thread here? I would really like to get maybe another comment or two from folks who have been thinking about this; and have a recommendation for a way forward.

Again, thinking about the fact that we have status quo in four alternatives under current timeframes; which we can keep. It seems like there are more board members in support of keeping that. I frankly don't know if I've heard too many if anyone suggest replacing. Then I definitely sense a mixed feeling on the issue of whether historic reduction landings from states that no longer have reduction fisheries should be kept in or not.

Maybe a little bit more discussion on that second point in particular, with my sense anyway from my perch here that the consensus that seems to be emerging is to stay with the current timeframes on the left of that slide; but again, looking for more clarity on that second part of the question. Roy Miller.

MR. ROY W. MILLER: Speaking from the perspective of a state that once had a reduction fishery, and like Emerson, I would have to go back to the '50s and '60s. I don't feel like it's appropriate for us to consider the landings from those old reduction fisheries. That infrastructure that supported those fisheries no longer exists; the dock space, the fleets, everything. All of that is ancient history. I think it would be prudent to just eliminate these reduction fisheries that occurred before '85, and subsequent to '85.

CHAIRMAN BALLOU: Understood, thank you, Roy, I appreciate that. Robert.

MR. BOYLES: You know we made this decision to pursue ecosystem reference points, recognizing it was going to be very difficult for us to move forward. We are diligently working in that direction, and at the same time trying to grasp this apple with this question of allocation. I think it just strikes me, I'll follow up on Roy's comment and Terry's somewhat tongue in cheek comment; but it's a true statement.

I mean we have had capacity in these communities for generations. You've heard me say before, the communities are important. But I look at the same time that we are trying to move this ecosystem, this fishery forward. I think it's important that we recognize the capacity that we have now; with respect to reduction, and recognize that we've got terrific demands on bait. I would say for the purpose of keeping the orders of the day, Mr. Chairman that we keep the current timeframes but not include those historical capacities in the reduction fishery.

CHAIRMAN BALLOU: Here is my suggested way forward, because I do think that we do need to move on. If we keep the current timeframes, as I think there is pretty good consensus to do. By and large the work's already been done on the two ways of looking at those. You can go into your document after you get home and see more of what I'm referring to; if you don't know what I mean. Each option has sort of with reduction included, without reduction included.

My sense from what I'm hearing, and I think the direction that I'm inclined to offer the PDT, based on this Board discussion, is that the Board's preference is to use the current timeframes without including the reduction landings from states that no longer have reduction fisheries; but we'll keep that dataset sort of in our back pocket or off to the side, however you might want to refer to it, to be potentially brought back at our August meeting. If anyone felt so strongly that it needed to be.

But at least for the purposes of further refining the document, we would focus on just that one approach. Is there any objection to doing that from the standpoint of furthering the development of this document? No final decisions are being made right now; but it is more about giving the PDT the guidance they need, and Megan of course in her lead role here, to really further work on this. Is the Board comfortable with that approach? Is there any objection to that approach? Steve Train.

MR. TRAIN: The only thing that makes me uncomfortable is the fish were harvested; someone in the state landed the fish, and then because they chose to sell it to a reduction plant that is no longer there, we're not going to count it anymore. That doesn't make sense to me. It would have been sold somewhere else if the reduction plant wasn't there. It was landings that belong to the history of that state, and I have trouble pulling it out.

CHAIRMAN BALLOU: Do you have an objection to the approach I recommended, which is sort of well, let's put it this way, Steve. We can keep the document just as it is right now, and each option has two alternatives; one with reduction landings in, one with reduction landings out. I hear you saying that is your preference; to keep it that way. Is that what I hear?

MR. TRAIN: Yes, and the reason I spoke up is you said you were going to work forward in one direction; but keep the records of the other. I had a problem with that.

CHAIRMAN BALLOU: I'm going to try and broker this by just suggesting, because I really think it's important to kind of keep everything together as much as possible; even though I saw some heads nodding as I was trying to offer a way forward that was a more refined way. In fairness to Commissioner Train, and others who have spoken on this issue, let's keep everything in.

But let's vow to really roll up our sleeves and look at this document between now and August; in the sense of coming back at our meeting in August with a clear sense as to how you think this should go out for public comment. I think we've come a long way today in this discussion and our understanding of the issues and the options.

August is only three months away, it's not that far. I would just suggest that might be the best way forward. I sort of feel like on the one hand

I should offer some leadership here, and perhaps make some calls; but on the other hand I don't want to make a call that might disadvantage or be perceived as disadvantaging certain states and certain interests. Does that sound like a better way forward, to keep it together with both options, both approaches in? I don't see too many heads nodding, I see one affirmative. This is a tough issue. I am really looking for consensus here. I don't want to put this to a vote.

In August we might put it to a vote, in fact we will. In August we're going to be voting on these issues. Maybe that's the way to really think about it. We need to really come to a resolution on these issues at our August meeting. We're kicking the can down the road a little bit here today, which is okay; because we're in mid-stream.

We don't need to make a final call on what goes out for public comment. But in August we will. Fair enough, I think we've had a good robust discussion on these issues. I'm not planning to further it anymore, unless anybody wants to. Megan, do you have any? No reactions, I didn't get any elbows or anything on that one.

I guess I'm okay with that suggestion. I think it is the best way to kind of keep this process together. Just know that August is going to be a good meeting. It's going to be a good meeting in August. We are going to really try to and get this thing; come to terms with it. All right with that the clock is ticking. Dr. Pierce.

DR. PIERCE: Yes, before you go on to the next agenda item. I would suggest that we could actually remove 4.3.1.2 the indecision clause. I know it is a stick. Last time around, we had a problem setting the quota for the year; but that I think was kind of a unique situation. The nature of the motions that were made, we boxed ourselves in. But then at the next meeting through your leadership skills, we ended up coming to agreement; and we set ourselves a TAC. I don't think that's needed.

CHAIRMAN BALLOU: Thoughts on that indecision clause and whether or not it needs to be kept in or not. By the way, I wasn't planning to move on to the next agenda item, I was planning to open the floor to additional comments; as Dr. Pierce took full advantage of, on other items that we haven't yet discussed. On this issue of the indecision clause, and the carrot/stick approach if you will, more of a stick I think, to get the Board to make a decision. Is that needed? Should that be kept in the document? David Borden.

MR. BORDEN: Question then, if we take it out then what happens if we don't make a decision?

MS. WARE: That's a great question. That's why we put it in. We need to specify what happens if the Board does not provide, or is not able to come to a consensus; because we were pretty close to that.

MR. BORDEN: I was going to suggest that with all due respect to the PDT, I thought as Megan characterized it carrot and stick. I was going to suggest that we use the Danvers half-long that's a carrot, a very short carrot, approach. Maybe we should pick a range of percentages there. Leave it in, but have a different range. Instead of having it be 50 percent, maybe have it be 75 percent or 90 percent. It wouldn't trouble me at all to say that the quota stays the same, or it gets reduced, and have some different percentages there.

CHAIRMAN BALLOU: Does that sound like a fair approach? David.

MR. BUSH: I certainly agree, and as a military guy I am all for accountability measures. I am uncomfortable with putting those accountability measures on the stakeholders though.

CHAIRMAN BALLOU: Further comments on this issue? We've had a suggestion to keep it in, but perhaps not make it quite so onerous with that half-cut; maybe something a little bit less onerous. I see a few heads nodding, so why don't we take that as the guidance we'll offer back to the PDT to keep this in; but not make that stick quite so heavy and dangerous. Okay, other comments or other recommendations on any other issues that Megan addressed, having to do with the draft amendment? Emerson.

MR. HASBROUCK: Megan, in your presentation a couple of times you referenced 212,500 metric tons as a trigger, I think, for different things to occur. What does that 212,500 metric tons derive from?

MS. WARE: Those are the average coastwide landings from 2009-2011.

CHAIRMAN BALLOU: I believe it was the first TAC established, wasn't it?

MS. WARE: That was what the Amendment 2 was based on, and then we took a 20 percent reduction from that.

CHAIRMAN BALLOU: I saw Dr. Duval next.

DR. DUVAL: I was actually going to go back and Megan had brought up an allocation, so if an eventual allocation method is implemented that does not have a jurisdictional component, the requirement to report landings via SAFIS. I understand that the intent is to try to provide real time monitoring; but I have concerns about this, based on North Carolina's statutory requirements that our dealers report to us.

Right now we use federal, so in order to track our quota monitored species, which we do on a daily basis for summer flounder and black sea bass. We have a dealer permit, it requires submission of a quota monitoring report; not trip ticket reports to us daily, which we can't require daily submission of trip tickets by statute.

You know we're looking to try to modify that. I think my point is that if the amendment specifies the frequency and required data elements, in terms of real-time reporting that the states ought to be allowed to submit those data and to meet those requirements; I guess is what I'm saying, and not necessarily dictate that you have to be reporting directly to SAFIS, because we're going to run into some problems with that in North Carolina.

MS. WARE: Michelle, maybe in response, where would you be submitting those reports to? What I'm trying to avoid is have the FMP Coordinator be kind of a receiver of states landings on a weekly basis. I think that that is kind of an onerous position to put the Coordinator in, so I'm just trying to put it all in some place where people could check it; and all the states could be submitting to one place.

DR. DUVAL: You know perhaps that's something that we're going to have to discuss offline. But again I raised the statutory issues that we have in North Carolina that data be submitted to us first. If we can perhaps work to try to develop an alternative that would both meet our statutory requirements, as well as not having dealers submitting information directly to the FMP Coordinator; you know we might have to find some work-around for the division submitting data to SAFIS on behalf of those dealers. That might be an alternative.

CHAIRMAN BALLOU: Rob O'Reilly.

MR. O'REILLY: Pretty much the same situation in Virginia, and so we all will have to have a conversation about how to accomplish this if it doesn't go jurisdictional. We've had mandatory reporting on the harvester basis since 1993. As with Michelle, the data comes to VMRC, so we would definitely have to work something out if it ends up that we don't go jurisdictional.

CHAIRMAN BALLOU: Any other comments or thoughts from the Board? Eric, on any issue, the floor is open right now.

MR. REID: The 212,500 tons that Emerson referenced earlier are those percentages of allocation at that amount fixed? I'm looking at 4.3.2 Tier 1, Option E, Sub-options 1 and 2. If the 212,500 tons is subject to a reallocation that is one thing; but if our current allotments are fixed in at that number, I would like to see that entire section removed.

CHAIRMAN BALLOU: We had this discussion at the last meeting. There were some recommendations to remove that and the consensus was to keep it in. I know Rob has been a strong proponent of that option, and I'll let Rob speak to it.

MR. O'REILLY: It used to be Option H, now it's Option E. This was proposed in Maine, and the idea is that again we came relatively close to having a 10 percent increase; and then everyone knows the story of how we came back with the increase that we had. We are relatively close still, to 212,500 metric tons.

The only idea there is that there would not be fixed percentages associated, once that 212,500 is reached or is attained. They would variable, and I think in the document it has two different percentages where the bait would receive a larger share; you know up to 70 percent, I think is what the document has.

That was the basis for that back in Maine. It remains the same. I think that last time around Nichola asked it to be removed, based on the public comment; and I had a few things to say about that which I won't say today again. But really, the public comment at that time was really not looking at our process to the direct way. That is why that option is in there, Eric, and I don't know whether that helps you or not.

CHAIRMAN BALLOU: Eric, a follow up?

MR. REID: Yes, it absolutely helps me, Rob. It tells me that I don't like it and you do, so it is going to stay in the document for now; that's what it tells me. Okay, can I keep going?

CHAIRMAN BALLOU: Please.

MR. REID: Are you good with that Rob? I'm looking in the draft document on Pages 53 and 54. It is minimum quota plus additional quota. I don't know how much work it is. Right now the numbers that I see are 0.5 percent and 1 percent. Just for reference, I would be fine if 0.5 percent were dropped out of the document. But I would like to see some analysis at least 2 percent, and if it is not too much of a pain in the neck, 1.5 as well.

That would be my request. If we have the capability at some point to say, okay we have the analysis at 1 percent and we have the analysis at 2 percent; can we do something in the middle, or can we just extrapolate the numbers? The numbers don't extrapolate very well in my mind; but at least they're close enough for me to make a decision. I guess that's my request. Can we do a table at 2 percent without too much trouble?

CHAIRMAN BALLOU: The answer is yes, it can be done. If there is no opposition on the part of the Board to add another sub-option, having to do with minimum jurisdictional quotas, and that would be in addition to the 0.5 percent; although I know you recommended taking it out. But one thought is to keep that in, keep the 1 percent, and then add a new 2 percent option. Does that sound fair?

MR. REID: Yes, I'm fine with that. Like I said, I can't extrapolate 0.5 to 1. You can't just multiply them times 2. I would like to see what 2 percent looks like plus the addition, 2 plus X for lack of a better term; and if I could have that I would appreciate it.

CHAIRMAN BALLOU: Okay, duly noted, other suggestions? We are running late. We've got a couple more agenda items here, but this is obviously a very important issue. David Borden.

MR. BORDEN: Just for my own edification, on the quota rollover and specifically the option to roll over 100 percent of the quota and 50 percent. I'm struggling with that a little bit, because I can't think of another example of where the system, the management system in any area has allowed the rollover of up to 100 percent of the quota.

I mean I've listened to a lot of different discussions at council meetings and commission meetings about rollovers. Generally the scientist's voice a lot of concerns, because you're a whole year later, you've had natural mortality on the stock and a whole bunch of other variables that can't be calculated. What is the scientific advice on 100 percent rollovers?

MS. WARE: The TC has not reviewed this document, so I can't really provide scientific advice from them. But we got those five options from Board input; based on the PID. If the Board would like to reconsider the options that are in there that would be useful information.

MR. BORDEN: Yes, my preference here would be to have the technical people specifically review that issue of the rollover, and whether or not it creates problems from a technical perspective.

CHAIRMAN BALLOU: Duly noted. Are there any other, suggestions, comments, recommendations from the Board on this issue? Seeing none; I had hoped to get some public input, but we're really running late. We've got a couple of other, three other actually, important issues. I don't think we'll take too much time. But we're well aware of the clock and the need to break in either four minutes or at some point soon thereafter. We're going to move on, is there any objection to moving on? Seeing none; we'll move on to Item 7 on the agenda, which is New York Participation in Episodic Event Program. This issue was addressed in part by the Board last year, but may need to be readdressed this year to lend clarification to the issue. I'll let Megan summarize it, and set the stage for the Board's consideration.

NEW YORK PARTICIPATION IN EPISODIC EVENTS PROGRAM

MS. WARE: Just to briefly review the Episodic Events Program and what it would look like in 2017. In May of 2016 the Board passed the motion to extend the Episodic Events Program until Amendment 3 is implemented. We do have the Episodic Events Program for this year. The set-aside is roughly 4.4 million pounds; and that reflects the 200,000 metric ton TAC that has been specified for this year.

In May of 2016, the Board also approved New York as an eligible state to harvest under the Episodic Events Program, so as a result for 2017, the states of Maine through New York can harvest from the set-aside; pending they meet the mandatory provisions. The Board also capped New York at one million pounds for 2016. There is currently no cap on New York's harvest for 2017.

CHAIRMAN BALLOU: That's where things stand. If the Board were to take no further action, New York is eligible to participate in the program; that may be a signal, in 2017, and is not subject to a cap. If the Board wanted to change that scenario in any way, action would be needed today. Does anyone have any recommendations or thoughts? Terry.

MR. STOCKWELL: Déjà vu from a year ago. I'll keep this quick. **I am going to move that New York harvest is capped at one million pounds for 2017.**

CHAIRMAN BALLOU: Under the Episodic Event Program.

MR. STOCKWELL: **Under the Episodic Event Program.**

CHAIRMAN BALLOU: Is there a second to that; seconded by Cheri? Moved by Terry Stockwell, seconded by Cheri, to re-impose the one million pound cap on New York's participation in the Episodic Even Program for 2017 is there discussion on the motion, Steve Heins.

MR. STEVE HEINS: Probably that's a wise move on the part of the Board, because as of today our directed fisheries closed and you can walk across the water on the backs of the menhaden; they're so thick in New York. We need this Episodic Events just to try to at least forestall fish kills. We're going to have them. It's just maybe we can put them off for a few weeks.

CHAIRMAN BALLOU: Further discussion on the motion, Eric Reid.

MR. REID: I just have a question. How much tonnage or poundage did New York harvest last year?

CHAIRMAN BALLOU: Megan is looking into that and while she's looking into it, any other questions or comments on the motion? Seeing none; we'll wait for the answer to that and then we'll take a vote. Steve.

MR. HEINS: If you don't need an exact number, I think we were around (struck from the record due to confidentiality) of the Episodic.

MS. WARE: I don't have your episodic number actually, because I believe it is confidential; but total state landings were roughly 1.4 million, so that is bycatch, episodic, directed.

CHAIRMAN BALLOU: Do you want to just let your comment stand, Steve?

MR. HEINS: Well, I know that we didn't hit the one million mark; but that was because we had reached a point where we believed we had gotten out of the woods. Then in November we had (struck from the record due to confidentiality). I can't really judge this anymore.

MR. REID: I would like you to give a million pounds to Rhode Island of Episodic Event, but I don't think that's going to happen. No, I'm fine. If Rhode Island is going to be out of the fishery because Episodic Event gets used up again; that would be unfortunate for the state of Rhode Island. That's all I'm going to say.

CHAIRMAN BALLOU: Other comments? Robert Boyles.

MR. BOYLES: Mr. Chairman, parliamentary inquiry. I would like unanimous consent to strike Mr. Heins comments from the record; on the basis of information from staff.

CHAIRMAN BALLOU: Given the potential confidentiality?

MR. BOYLES: Yes.

CHAIRMAN BALLOU: Is there any objection to striking those comments from the record to protect any potential violation of confidentiality? Seeing no objections those comments will be struck. Thank you for that suggestion. Other comments on the motion, seeing none; is the Board ready for the question? If so, all in favor of the motion, I'm sorry, 15 second caucus.

Okay I'm going to call the question. **All in favor please raise your hand, 18 in favor, opposed, null votes, and abstentions. The motion passes 18 to 0.**

PROVIDE GUIDANCE TO THE TECHNICAL COMMITTEE REGARDING STOCK PROJECTIONS

CHAIRMAN BALLOU: And we're on to Item 8; which is to Provide Guidance to the Technical Committee Regarding Stock Projections. This is a prelude to setting the TAC for 2018; which will be on our agenda for our next meeting in August. I believe our TC Chair, Jason McNamee has a presentation, so at this point I will turn it over to Jason.

MR. JASON McNAMEE: We at the Technical Committee were sitting around chatting, and we said do you know what the Board hasn't heard from us in about three months, projection methodology. Let's do that again. I've got a quick presentation. This will help support the addendum. Kristen, if you want to jump right to Slide 4, we can skip some of that early stuff.

REVIEW STOCK PROJECTION METHODOLOGY

MR. McNAMEE: I'm just going to give you a whirlwind tour. The projection methodology has not changed the past several times that you've seen it. Monte Carlo bootstrap runs of 2015, the approved assessment, the base run of that approved assessment was used for the basis of the projections. They were run under various scenarios for a total of five years since that terminal year. Starting conditions include initial numbers-at-age, which were the estimated numbers-at-age for Year 2014 from BAM, for each of the Monte Carlo bootstrap runs. Monte Carlo bootstrap runs, it's just an iteration of the model. Certain elements of the model have a little perturbation to their starting values, and you end up with about a thousand different versions of the world. They're all very close but slightly different, and that's where you kind of determine your variability in your estimates. The numbers-at-age after that initial year, a fancy equation to look at here, the important element there is that Z parameter up in the air there. What that is is age and year specific total mortality.

What that consists of is it's the addition of the natural mortality for each age for that year, plus the fishing mortality that takes into account the selectivity by age. The natural mortality for each of the projections was a vector from each of the Monte Carlo bootstraps; the selectivity again also a vector from each of the Monte Carlo bootstraps.

In this case the northern and the southern fishery selectivities, they're the values from the last time period; so there are a couple of blocks in the BAM model, and we're just grabbing the last blocks of the estimate from the last period of time. Then fishing mortality is estimated to match the annual landings that are estimated.

These landings, where do those come from? Those are calculated using the Baranov Catch Equation and the weight of the landings. There is recruitment in there. This is an important one to think about. Recruitment is projected without an underlying stock recruitment function, so there is no Beverton Holt or Ricker model in here.

What we're doing is taking median recruitment level, and that's the median from each of the 1,000 bootstrap runs. Then the way we get variability in there is there is a deviation vector in there; and so there is this vector, it's the length and it is the number of years that you're looking at. We have a median recruitment level, and then each year is a deviation away from that median. That is where your uncertainty comes from.

Those are selected randomly with replacement from each of the runs. All right, so we do all that stuff and we get some outputs. These are relevant outputs for you folks. They include fecundity, so remember that that is what we use as the biomass metric for menhaden. It produces fishing mortality, recruitment and landings.

Those are the model outputs that you get from the projections. Fecundity is calculated as the number of fish in each age times the reproductive vector at that age. We know a little bit about, or a lot about the fecundity of menhaden. That's all taken into account here. We use a 50/50 sex ratio, the maturity as we understand it for menhaden, mash that up all together and that's how we come up with the fecundity estimate. A couple of caveats for you, we did not include structural uncertainty in the projections.

This is model uncertainty is another way that people characterize it. There are lots of uncertainties that are accounted for; but this is not one of them. The projections are conditional on a set of functional forms. These are things like the selectivity function, which is a curve and recruitment as I've described.

The fisheries were assumed to continue at the current proportions of allocation; meaning bait and reduction using the current selectivities. The selectivity aspect of that is the important part. New management regulations that alter the proportions or the selectivities, would likely affect the projection results. Just be aware of that. If future recruitment is characterized by long periods of large or small year classes that is also going to impact the projections. You know when we end up at Year 5, and the answer is different than what we projected. There are a number of reasons why that is.

Additionally, because we're using the Baranov Catch Equation, it is assuming mortality occurs throughout the year. Again, if seasonal closures and things like that go in that is going to affect the outcomes of reality versus the projections. All right, just a couple of slides here, we can think back. This is what you had asked us for last time we did projections for you.

Current TAC is not the current TAC now, it is the current TAC back when we did these; but that was like a status quo projection you asked for. Then we did a series that were fairly simple, they were just increases from that TAC and then that was projected forward. Then you did a series where you were thinking more about risk; and you asked for three different levels of these risk probabilities of being at or below the F target.

In summary, we are performing, and by "we" I mean Amy Schuler who's in the back there. We're performing new projections based on previous guidance from the Board; and as outlined in the presentation. We added in some new scenarios that include interim ecological reference points as requested.

As Shanna already noted, we conferred with the folks at Lenfest to make sure that we were interpreting their intent, so we're all on the same page there and we don't bring something forward that then someone might come back and say no that's not what we meant by that. We've done that homework. We are on track, I have completion in August. That's right, right? Yes. We're on track with the work. That's it; any questions?

CHAIRMAN BALLOU: Questions for Jason? Adam.

MR. ADAM NOWALSKY: Did I understand correctly that you're going to apply those same projections, the 5 percent increase, the 10 percent increase, the 50 percent probability, the 55 percent probability. Was that what I heard or did I mishear that?

MR. McNAMEE: That is not what I showed. I just wanted to show you the types of things that we have done for projections in the past as an example. I'm not actually entirely sure the exact ones that we're doing, and so Megan or Bob, if you have a better idea.

CHAIRMAN BALLOU: The issue I think for the Board, is the Board comfortable asking that those same projections be run again? Yes, it would be repeating the same, whatever it was seven runs I think, there is more actually when you add in some of the additional ERP type approaches. But is that what the Board would like to see again?

In the same way you saw it last year and use that as the basis for your deliberations on setting the TAC for 2018, or would you recommend doing something different, either reducing those options or changing them that is the issue before the Board today. I guess the question is if we don't have any recommendations to change anything, we'll run the same projections in the same way that they were run last year; and you'll get a report on those at your August meeting. This is the time to recommend any changes. If you don't have any recommended changes, you will see those same projections done in the same way. It must be getting late, because I don't see any movement, anybody shifting; except I see one hand up in the back. Rob.

MR. O'REILLY: Yes, I support moving ahead with those same runs. The second thing is, I will ask one question and I know it's late. What really determines the risk against the target F, and is there any uncertainty there in the risk? Bog you down, kind of curious.

MR. McNAMEE: What determines that is, so I had mentioned we do these Monte Carlo bootstraps, so you end up with these variations of the universe as you move forward; and they're different from each other. What you do in the end is you kind of bound all of the different projections.

That's what determines that envelop of uncertainty around some median value or something like that. If you picked it to be right at the median it would be 50 percent probability, and then you move up and down from there. It is all of the uncertainties coming out of the bootstrap on the elements in the projections that we put those perturbations on.

CHAIRMAN BALLOU: Any other question, comments, is there any opposition to tasking the TC with running the same projections that they ran last year in the ways just described? Seeing none; I'll take that as Board support for a repeat, and we'll look forward to the results that we'll see in August. Is there anything else on this issue?

CONSIDER APPROVAL OF THE 2017 FMP REVIEW AND STATE COMPLIANCE REPORTS

CHAIRMAN BALLOU: Okay so on to our final issue. Consider Approval of the 2017 FMP Review and State Compliance Reports**.** States were required to submit their compliance plans by April 1, the PRT reviewed those plans and reported out via the FMP Review, which is in your meeting materials; so Megan, I think has a brief summary report. Megan.

MS. WARE: We're going to go right to Slide 4 to just kind of get to the meat of the FMP Review. For 2016 our TAC was 414.2 million pounds. Overall I would say landings were down from 2015. Our directed harvest, which excludes bycatch, was 396.15 million pounds; so that's 4.4 percent under the TAC and a 3.6 percent decrease from 2015.

Bycatch was 2.18 million pounds, which is a 63 percent decrease from 2015; but it's important to note that those landings do not count towards the TAC. Total harvest including bycatch, directed harvest, and the Episodic Events Program was 398 million pounds, which is a 4.5 percent decrease from 2015.

We can also look at the landings by the different sectors. Looking at bait harvest it is roughly 95.4 million pounds, which is a 5.6 percent decrease from 2015, and a 10.1 percent decrease from the previous five-year average. The states of New Jersey, Virginia, Maryland, Maine and Massachusetts landed the largest shares.

Reduction harvest was 302.9 million pounds, which is a 4.2 percent decrease from 2015, and a 6 percent decrease from the previous five-year average. In terms of the Chesapeake Bay reduction fishery cap, landings were less than 45,000 metric tons; which is well below the cap. This means for 2017 our cap will be the full 87,000 metric tons plus the almost 11,000 metric ton rollover. This is one of the figures in the FMP review, which shows reduction landings in blue and bait landings in red. It is important to note that there are two different Y axes here, so reduction landings are still higher than bait landings. But overall we've seen a slight decline in reduction landings over the years, while we've seen a slight increase in bait landings. This is Table 1 in the FMP review; and I recommend looking at it in the printed document, because it is much easier to see.

But it shows average bycatch landings by state and gear type from 2013-2016. The predominant gears include pound nets and anchored or staked gillnets; and the states of Maryland and Virginia contribute the most to total bycatch landings. We can also look at the number of bycatch trips that were taken in 2016.

There were a total of 1,908 bycatch trips taken in 2016. This is significantly lower from the 4,668 trips taken in 2015. The majority of these trips did land less than 1,000 pounds. In terms of the Episodic Events Set-Aside Program, the states of Maine, Rhode Island and New York participated in the program; 3.8 million pounds were harvested in 2016, which is a much greater value than has ever been harvested under the program.

Ninety-two percent of the set-aside was used, but the remaining unused set-aside was reallocated to the states on November 1st. Table 3, this is quota performance, and I definitely recommend looking at this in the FMP review. But what it shows here is on a state-by-state basis the transfers that took place, what the total quota was, in terms of what a state was allocated, plus or minus transfers and then the redistribution of unused set-aside.

Then it shows what total landings were and if there were any overages. We had one state with an overage; that was Florida. It is only 4,000 pounds though. Then the final column there is 2017 quotas. This is based on the 200,000 metric ton TAC, as well as any overages that took place in 2016.

Non de minimis states are required to conduct biological monitoring based on their landings, as well as the geographic region. This is Table 6 in the FMP Review; it shows the number of ten fish samples that were required, and then the ones that were carried out by each state. All states did meet the biological sampling requirements.

In terms of de minimis, the states of New Hampshire, Pennsylvania, South Carolina, Georgia, and Florida have requested de minimis status for 2017. All states qualified, because they do not have a reduction fishery and the bait landings in the two most recent years of data did not exceed 1 percent of coastwide bait landings.

The PRT recommends that the Board accept the 2017 FMP Review, de minimis status for the five states there, and then also notes that jurisdictions which repeatedly or grossly exceed their quota, should consider implementing more frequent reporting to avoid these overages.

CHAIRMAN BALLOU: Questions for Megan on her report? Dr. Duval.

DR. DUVAL: Not a question, just a comment. Megan, I believe you received information last week correcting North Carolina's 2016 landings. They are roughly about half of the 800,000 pounds that was shown up on the screen. We had a coding error with landings from a particular dealer, so that has since been corrected.

CHAIRMAN BALLOU: Any other questions? **If not I would entertain a motion to accept the 2017 Fishery Management Plan Review, and approve de minimis request for the states of New Hampshire, Pennsylvania, South Carolina, Georgia and Florida. Moved by Steve Heins, do we have a second?** Seconded by Cheri Patterson, is there any discussion on the motion?

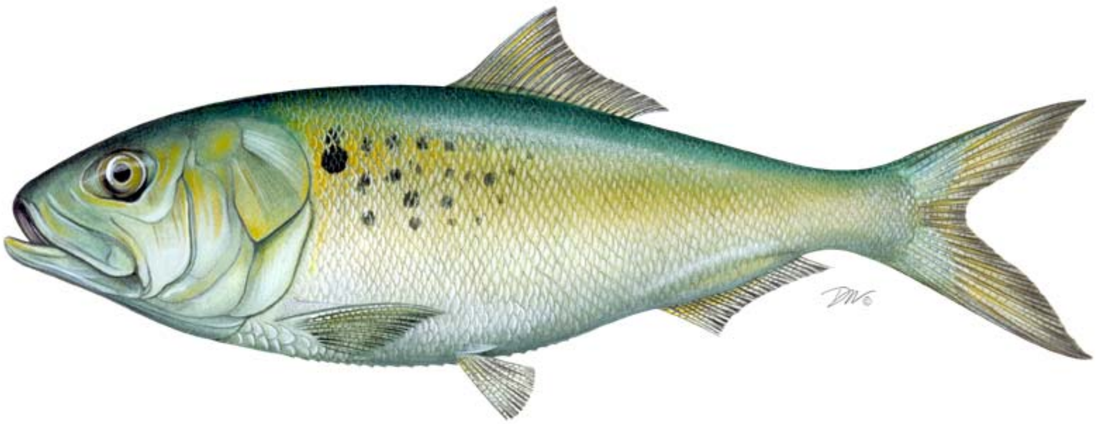
Is there a need to caucus? Seeing no indication, is the Board ready for the vote? **If so, all in favor raise your hand, 18 in favor and that's unanimous**, so I think we are at the last item; which is Other Business.

Other Business/Adjourn

CHAIRMAN BALLOU: Is there any other business to come before the Board? Seeing none; is there any opposition to adjourning? Seeing none; we are adjourned. Thank you very much.

(Whereupon, the meeting was adjourned at 6:05 o'clock p.m., May 9, 2017.)

Atlantic Menhaden Stock Assessment Update



August 2017

Vision: Sustainably Managing Atlantic Coastal Fisheries

Atlantic States Marine Fisheries Commission

2017 Atlantic Menhaden Stock Assessment Update

Prepared by the
ASMFC Atlantic Menhaden Stock Assessment Subcommittee

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Executive Summary

The purpose of this assessment was to update the 2015 Atlantic menhaden benchmark stock assessment (SEDAR 2015) with recent data from 2014-2016. No changes in structure or parameterization were made to the base model run. Additional sensitivity analyses were conducted.

Landings

The Atlantic menhaden commercial fishery has two major components, a purse-seine reduction sector that harvests fish for fish meal and oil and a bait sector that supplies bait to other commercial and recreational fisheries. The first coastwide total allowable catch (TAC) on Atlantic menhaden was implemented in 2013 and since then reduction landings have ranged from 131,000 mt in 2013 to 143,500 mt in 2015. In 2016, reduction landings were 137,400 mt and accounted for approximately 76% of coastwide landings. Landings in the reduction fishery are currently at their lowest levels in the time series because only one plant remains in operation along the coast. In contrast, bait landings have increased in recent years as demand has grown because of recent limitations in other species used as bait (e.g., Atlantic herring), peaking in 2012 at 63,700 mt. In 2016, bait landings were 43,100 mt and comprised 24% of coastwide landings.

Indices of Relative Abundance

<u>Young of the Year (YOY) Index</u>

The YOY index developed from 16 fishery-independent surveys shows the largest recruitments occurred during the 1970s and 1980s. Recruitment has since been lower with notable year classes in 2005, 2010, and 2016.

<u>Age-1+ Indices</u>

Two coastwide indices of adult abundance were developed from nine fishery independent survey data sets spanning the coast from New England to Georgia. In the most recent years, the northern adult index indicated an increase in abundance for ages-2+, while the southern adult index for the assessment indicated a slightly decreasing abundance for age-1.

Fishing Mortality

Highly variable fishing mortalities were noted throughout the entire time series. Fishing mortality rate was reported as the geometric mean fishing mortality rate of ages-2 to -4. In the most recent decade, the geometric mean fishing mortality rate has ranged between 0.31 and 0.58. The geometric mean fishing mortality rate for 2016 was 0.51. Adding data from 2014-2016 to the assessment model resulted in higher fishing mortality rates for the entire time series compared to the 2015 benchmark assessment, although the trend remained largely the same. These changes also affected the reference points, which are calculated as the median (target) and maximum (threshold) for the 1960-2012 time series.

Biomass

Biomass has fluctuated with time from an estimated high of over 2,288,000 mt in 1958 to a low of 567,000 mt in 2000. Biomass was estimated to have been largest during the late-1950s, with lows occurring during the mid-1990s to mid-2000s. Biomass was estimated to have been relatively stable through much of the 1970s and 1980s. The oldest age classes comprise the smallest proportion of the population, but that proportion has increased in recent years. Biomass is likely increasing at a faster rate than abundance because of the increase in the number of older fish at age and an increase in weight at age.

Fecundity

Population fecundity (i.e., Total Egg Production) was the measure of reproductive output used. Population fecundity (*FEC*, number of maturing ova) was highest in the early 1960s, early 1970s, and during the present decade and has generally been higher with older age classes making up a larger proportion of the *FEC.*

Stock Status

The current benchmarks for Atlantic menhaden are $F_{36\%}$, $F_{21\%}$, $FEC_{36\%}$, *and* $FEC_{21\%}$, which were calculated using the methods from the 2015 benchmark stock assessment. The benchmarks are calculated through spawner-per-recruit analysis using the mean values of any time-varying components (i.e., growth, maturity). Based on the current adopted benchmarks, **the Atlantic menhaden stock status is not overfished and overfishing is not occurring**. In addition, the stock is currently below the current fishing mortality target and below the current *FEC* target. The 2015 benchmark reference points for Atlantic menhaden were $F_{38\%}$, $F_{57\%}$, $FEC_{38\%}$, and $FEC_{57\%}$. Because this stock assessment update resulted in higher fishing mortality values throughout the time series due to the additional three years of data, the maximum and median *F* values were estimated higher compared to the 2015 benchmark.

Table of Contents

List of Tables

List of Figures

Introduction

The purpose of this assessment was to update the 2015 Atlantic menhaden (*Brevoortia tyrannus*) benchmark stock assessment (SEDAR 2015) with recent data from 2014-2016. No changes in structure or parameterization were made to the base model run. Corrections made to data inputs were minor and are described in the body of this report. The 2015 benchmark stock assessment for Atlantic menhaden was initiated by the Atlantic States Marine Fisheries Commission (ASMFC or Commission) Atlantic Menhaden Management Board (Board), prepared by the ASMFC Atlantic Menhaden Stock Assessment Subcommittee (SAS), and reviewed and approved by the ASMFC Atlantic Menhaden Technical Committee (TC) as part of the interstate fisheries management process.

1.0 Regulatory History

The first coastwide fishery management plan (FMP) for Atlantic menhaden was passed in 1981 (ASMFC 1981). The 1981 FMP did not recommend or require specific management actions, but provided a suite of options should they be needed. After the FMP was approved, a combination of additional state restrictions, establishment of local land use rules, and changing economic conditions resulted in the closure of most reduction plants north of Virginia (ASMFC 1992). In 1988, ASMFC concluded that the 1981 FMP had become obsolete and initiated a revision to the plan.

The 1992 Plan Revision included a suite of objectives to improve data collection and promote awareness of the fishery and its research needs (ASMFC 1992). Under this revision, the menhaden program was directed by the Board, which at the time was composed of up to five state directors, up to five industry representatives, one representative from the National Marine Fisheries Service, and one representative from the National Fish Meal and Oil Association.

Representation on the Board was revised in 2001 to include three representatives from each state in the management unit, including the state fisheries director, a legislator, and a governor's appointee. The reformatted Board has passed two amendments and six addenda to the 1992 FMP revision.

Amendment 1, passed in 2001, provided specific biological, social/economic, ecological, and management objectives for Atlantic menhaden. No recreational or commercial management measures were implemented as a result of Amendment 1.

Addendum I (2004) addressed biological reference points for menhaden, specified the frequency of stock assessments to be every three years, and updated the habitat section of the FMP.

Addendum II (2005) instituted a harvest cap on the reduction fishery in the Chesapeake Bay. This cap, based on average landings from 2000-2004 (see technical Addendum I), was established for the 2006 through 2010 fishing seasons. Addendum II also outlined a series of research priorities to examine the possibility of localized depletion of Atlantic menhaden in the Chesapeake Bay. They included: determining menhaden abundance in Chesapeake Bay; determining estimates of removal of menhaden by predators; exchanging of menhaden between bay and coastal systems; and conducting larval studies.

Addendum III (2006) revised the Chesapeake Bay Reduction Fishery Cap to 109,020 metric tons, which is an average of landings from 2001-2005. Implementation of the cap remained for the 2006 through 2010 fishing seasons. Addendum III also allowed a harvest underage in one year to be added to the next year's quota. As a result, the maximum cap in a given year was extended to 122,740 metric tons.

Addendum IV (2009) extended the Chesapeake Bay harvest cap three additional years (2011-2013) at the same levels as established in Addendum III.

Addendum V (2011) established a new F threshold and target rate based on maximum spawning potential (MSP) with the goal of increasing abundance, spawning stock biomass, and menhaden availability as a forage species.

Amendment 2, approved in December 2012, established a 170,800 metric ton (mt) total allowable catch (TAC) for the commercial fishery beginning in 2013. This TAC represented a 20% reduction from average landings between 2009 and 2011. The 2009-2011 time period was also used to allocate the TAC among the jurisdictions. The Amendment also established requirements for timely reporting and required states to be accountable for their respective quotas by paying back any overages the following year. The amendment included provisions that allow for the transfer of quota between jurisdictions and a bycatch allowance of 6,000 pounds per trip for non-directed fisheries that operate after a jurisdiction's quota has been landed. Further, it reduced the Chesapeake Bay reduction fishery harvest cap by 20% to 87,216 metric tons.

At its May 2015 meeting, the Board established an 187,880 mt TAC for the 2015 and 2016 fishing years. This represented a 10% increase from the 2013 and 2014 TAC. In October 2016, the Board approved a TAC of 200,000 mt for the 2017 fishing year, representing a 6.45% increase from the 2015 and 2016 fishing years.

In August 2016, the Board approved Addendum I which added flexibility to the current bycatch provision by allowing two licensed individuals to harvest up to 12,000 pounds of menhaden bycatch when working together from the same vessel using stationary multi-species gear. The intent of this Addendum was to accommodate cooperative fishing practices which traditionally take place in the Chesapeake Bay.

Amendment 3 to the Atlantic Menhaden FMP is currently under development, initiated in 2015 to address several concerns in the fishery including the adoption of ecological reference points (ERPs) and a new quota allocation scheme. The ERPs are meant to account for changes in the abundance of prey and predator species when setting overfished and overfishing thresholds for menhaden. The Board reviewed public input in February 2017 and provided guidance on management options to include in Amendment 3. Under the current timeline, the Board will consider final action on Draft Amendment 3 at the end of 2017.

In May 2013, the Board approved Technical Addendum I which established an episodic events set aside program. This program set aside 1% of the coastwide TAC for the New England States (ME, NH, MA, RI, CT) to harvest Atlantic menhaden when they occur in higher abundance than normal. In order to participate in the program, a state must reach its individual quota prior to September 1 before harvesting from the set aside. At its October 2013 meeting, the Board extended the episodic event set aside program through 2015, adding a re-allocation provision that re-allocated unused set aside as of October 31 to the coastwide states based on the same allocation percentages included in Amendment 2. At its May 2016 meeting, the Board again extended the episodic events program until final action on Amendment 3 and added New York as an eligible state to harvest under the program.

2.0 Life History

2.1 Stock Definition

Atlantic menhaden are considered a single stock. Historically there was considerable debate relative to stock structure of Atlantic menhaden on the US East Coast, with a northern and southern stock hypothesized based on meristics and morphometrics (Sutherland 1963; June 1965). Based on size-frequency information and tagging studies (Nicholson 1972 and 1978; Dryfoos et al. 1973), the Atlantic menhaden resource is believed to consist of a single unit stock or population. Recent genetic studies (Anderson 2007; Lynch et al. 2010) support the single stock hypothesis.

2.2 Age

In 1955, the NOAA Laboratory at Beaufort, NC, began monitoring the Atlantic menhaden purse-seine fishery for size and age composition of the catch (June and Reintjes 1959). From the outset, scales were selected as the ageing tool of choice for Atlantic menhaden due to ease of processing and reading and an age validation study confirming reliable age marks on scales (June and Roithmayer 1960). During the early decades of the Menhaden Program at the Beaufort Laboratory, scales from individual menhaden specimens were read multiple times by several readers. Since the early 1970s, only a single reader was retained on staff to age menhaden scales.

To address future plans for states to age Atlantic menhaden scales and the research recommendation to conduct an ageing workshop, the ASMFC organized and held a workshop in 2015 (ASMFC 2015). An exchange of scale samples took place and was followed with an in-person workshop to discuss the results. Depsite the fact that most participating agers were new to ageing Atlantic menhaden or had never aged the species, agreement between readers was on average 73% and increased to 95% within one year. False annuli, poor storage of samples, and damaged scales were common issues identified at the workshop. Atlantic menhaden scales were also examined at ASMFC's 2017 Quality Assurance/Quality Control Fish Ageing Workshop (ASMFC 2017). Average percent error between agers along the Atlantic coast was 15%, although many readers had no previous experiencing ageing Atlantic menhaden. When considering readers with experience ageing this species, average exact agreement was 43%, although it increased to 88% within one year.

2.3 Growth

Catch in numbers by year, season, and fishing area was developed for weighting corresponding sampled weights of Atlantic menhaden. This was then used to calculate the mean weight at age for fish from 1955-2016, which was used in the stock assessment for matching to landings. These "weighted" mean weights increased during the 1960s, declined dramatically during the 1970s, and remained low during most of the 1980s. Increasing mean weights were estimated during the 1990s followed by declines in mean weight to the present. Weighting by catch in numbers by year, season, and fishing area was also applied to calculate average fork lengths (mm) by age and year.

An overall regression of weight (W in g) on fork length (FL in mm) for port samples of Atlantic menhaden was fit based on the natural logarithm transformation:

$$\ln W = a + b \ln FL$$

and was corrected for transformation bias (root MSE) when retransformed back to the form:

$$W = a(FL)^b.$$

As in previous menhaden assessments, regressions of fork length (mm) on age (yr) were based on the von Bertalanffy growth curve:

$$FL = L_\infty(1 - \exp(-K(\text{age} - t_0))).$$

Von Bertalanffy fits were made with the size at age data aligned by cohort (year class). Because of concerns that density-dependent growth is a characteristic of the cohort, cohort-based analyses were thought to be a better approach.

Annual estimates of length at age for the population were bias-corrected using methods in Schueller et al. (2014). Specifically, the methods correct for the absence of samples at the youngest, smallest and largest, oldest sizes and ages. The correction was done on the cohort-based annually estimated growth curves with a minimum size of 100 mm FL (unless samples had a larger minimum size) and the maximum size was set at the 99.95% size for encountered fish rounded to the nearest whole number ending in 0 or 5. In a few cases, t_0 was fixed at the uncorrected value. The reference age selected was age-2 as that age reflects the full distribution of sizes at the age. The corrected values of L_∞ and K were within the observed range of uncorrected values (Table 2.3.1). The growth curve parameters vary year to year and are influenced by both density dependent processes and the fact that each cohort experiences a different set of conditions leading to differing growth.

Annual estimates of fork length-at-age were interpolated from the annual, cohort-based von Bertalanffy growth fits with a bias correction in order to represent the population or start of the fishing year (March 1) for use in estimating population fecundity (Table 2.3.2). Annual estimates of length-at-age were interpolated based on the non-biased corrected von Bertalanffy estimates to represent the fishery or middle of the fishing year (September 1), and converted to weight-at-age (Eq. 2) for use in the statistical catch-at-age models when comparing model estimated catch to observed catch (Table 2.3.3).

2.4 Maturity

For the 2015 benchmark stock assessment, data from the NEAMAP Southern New England/Mid-Atlantic Neashore Trawl Survey were analyzed to evaluate maturity at age. Based on the analysis and discussions among the SAS during the 2015 SEDAR benchmark assessment, it was determined that maturity is a length-based process as opposed to an age-based process. A logistic regression was fit to the maturity and length data from the commercial reduction fishery database. Fish were coded as immature or mature, as in the analysis completed on the NEAMAP data. Because the growth of Atlantic menhaden varies greatly among years, the SAS determined that maturity must also vary among years. Thus, the time-varying lengths at age for the population were used along with the logistic regression to provide time-varying maturity at age for 1955-2016 for the assessment update. Because the commercial reduction fishery had more years of data and a larger sample size, the maturity based on those data were used in the final base run model.

2.5 Fecundity

Often reproductive capacity of a stock is modeled using female weight-at-age, primarily because of lack of fecundity data. To the extent that egg production is not linearly related to female weight, indices of egg production (fecundity) are considered better measures of reproductive output of a stock of a given size and age structure. Additionally, fecundity better emphasizes the important contribution of older and larger individuals to population egg production. Thus, in the 2015 benchmark stock assessment and this update, modeling increases in egg production with size is preferable to female biomass as a measure of reproductive ability of the stock.

Atlantic menhaden are relatively prolific spawners. Predicted fecundities are:

$$\text{number of maturing ova} = 2563 * e^{0.015*FL}$$

according to the equation derived by Lewis et al. (1987). Annual fecundity at age was calculated using the Lewis et al. (1987) equation as well as the bias corrected, cohort based estimates of length at age for the population at the beginning of the fishing year (March 1; Table 2.5.1).

2.6 Natural Mortality

Atlantic menhaden are vulnerable to multiple sources of natural mortality (*M*) throughout their range including, but not limited to, predation, pollution, habitat degradation, toxic algal blooms, and hypoxia. Estimating the relative contribution and magnitude of these mortality sources continues to be a challenge for stock assessments especially for a short-lived forage fish like Atlantic menhaden. For the 2015 benchmark assessment, the SAS explored several methods for estimating *M* and endorsed the use of an age-varying but time-invariant approach using the methods of Lorenzen (1996) scaled to tagging estimates of natural mortality for ages 4-6. Refer to the 2015 SEDAR benchmark stock assessment report for a more detailed discussion of methods the SAS evaluated and reasoning for rejecting or accepting various methods.

2.7 Migration

There have been several studies examining Atlantic menhaden migration patterns (Roithmayr 1963; Dryfoos et al. 1973; Nicholson 1978; ASMFC 2004b). Adults begin migrating inshore and north in early spring following the end of the major spawning season off the Carolinas during December-February. The oldest and largest fish migrate farthest, reaching southern New England by May and the Gulf of Maine by June. Fish begin migrating south from northern areas to the Carolinas in late fall. Adults that remain in the south Atlantic region for spring and summer migrate south later in the year, reaching northern Florida by fall. During November and December, most of the adult population that summered north of Chesapeake Bay moves south of the Virginia and North Carolina capes. After winter dispersal along the south Atlantic coast, adults again begin migrating north in early spring.

3.0 Fishery-Dependent Data Sources

3.1 Commercial Reduction Fishery

SEDAR 2015 provides a description of the history of the reduction fishery for Atlantic menhaden. Briefly, coastwide participation and landings for this fishery have expanded and contracted over the years, but only one reduction factory on the US East Coast exists today – Omega Protein Inc. in Reedville, VA, which fishes with approximately seven vessels. Most of their fishing activity takes place in the Virginia portion of the Chesapeake Bay and Virginia's ocean waters, although fleets travel along the US East Coast seasonally.

3.1.1 Selectivity Time Blocks or Breaks in the BAM Model

When addressing selectivity in the reduction fishery and potential time blocks or breaks, the SAS considered residual patterns in the age composition data and major changes within the fishery. With regard to the latter, the SAS adopted three time blocks for the reduction fishery in the northern region (defined as waters north of Machipongo Inlet, VA): 1955-1969, 1970-1993, and 1994-2016. The SAS also adopted three time blocks for the reduction fishery in the southern region (defined as waters south of Machipongo Inlet, VA, including Chesapeake Bay): 1955-1971, 1972-2004, and 2005-2016. These time blocks are related to changes in the reduction fishery and are decribed in detail in SEDAR 2015. In both regions, the introduction of selectivity time blocks noticeably improved the residual pattern apparent in the age composition data.

3.1.2 Data Collection and Survey Methods

Fishery-dependent data for the Atlantic menhaden purse-seine reduction fishery have been maintained by the Beaufort Laboratory of the National Marine Fisheries Service since 1955 and they consist of three major data sets: 1) fishery landings or catch records, 2) port samples for age and size composition of the catch, and 3) daily logbooks, or Captains Daily Fishing Reports (CDFRs). Detailed landings data for the reduction purse-seine fishery are available 1940-2016. The biostatistical data, or port samples, for length and weight at age are available from 1955 through 2016, and represent one of the longest and most complete time series of fishery data sets in the nation. The CDFRs itemize purse-seine set locations and estimated at-sea catches; vessel compliance is 100%. CDFR data for the Atlantic menhaden fleet are available for 1985-2016. Biological sampling for the menhaden purse-seine fishery is conducted over its entire range of the fishery, both temporally and geographically (Chester 1984; Chester and Waters 1985).

Historically, daily vessel unloads were reported weekly or monthly during the fishing year. In recent years (since about 2005) individual vessel unloads are available daily via email from the clerical staff at the fish factory. Landings are provided in thousands of standard fish (1,000 standard fish = 670 lbs), which are converted to kilograms.

3.1.3 Commercial Reduction Landings

Landings and nominal fishing effort (vessel-weeks, measured as number of weeks a vessel unloaded at least one time during the fishing year) are available since 1940 (Table 3.1.3.1). Landings rose during the 1940s, peaked during the late 1950s (>600,000 mt for five of six years; record landings of 715,200 mt in 1956), and then declined to low levels during the 1960s (from 578,600 mt in 1961 to 162,300 mt in 1969). During the 1970s the stock rebuilt (landings rose from 250,300 mt in 1971 to 375,700 mt in 1979) and then maintained intermediate levels during the 1980s. Landings during the 1990s declined from 401,100 mt in 1990 to 171,200 mt in 1999.

By 1998, the fishery had contracted to only two factories, one in Virginia and one in North Carolina. Landings dipped to 167,300 mt in 2000, rose to 233,600 mt in 2001, and then stabilized until the North Carolina reduction plant closed in 2005, leaving the sole plant along the Atlantic coast in Virginia. Between 2006 and 2012, reduction landings averaged 162,100 mt. The first coastwide TAC on Atlantic menhaden was implemented in 2013 and since that time, reduction landings have ranged from 131,000 mt in 2013 to 143,500 mt in 2015. In 2016, reduction landings were 137,400 mt and accounted for approximately 76% of coastwide landings.

3.1.4 Commercial Reduction Catch at Age - Methods and Intensity

Detailed sampling of the reduction fishery allows landings in biomass to be converted to landings in numbers at age. For each port/week/area caught, biostatistical sampling provides an estimate of mean weight and the age distribution of fish caught. Hence, dividing landings for that port/week/area caught by the mean weight of fish allows the numbers of fish landed to be estimated. The age proportion then allows for estimation of fish landed. Developing the catch matrix at the port/week/area caught level of stratification provides for considerably greater precision than is typical for most assessments.

Catch At Age in Recent Years

Since 2012, approximately 1,190 10-fish samples have been collected from the reduction fishery. Over the past three years, age-2 Atlantic menhaden have comprised on average 51% of the total numbers of fish landed in the north and 55% of the total numbers of fish landed in the south.

Landings, Removals by Areas, and the Beaufort Assessment Model (BAM)

In the SEDAR 2015 benchmark assessment, the Atlantic menhaden fishery is addressed in terms of a northern and a southern fishery versus solely as a reduction and a bait fishery as in the 2010 assessement (ASMFC 2010). To this end, this benchmark assessment incorporates "fleets-as-areas" components where both the bait and reduction fisheries are divided into northern and southern regions (Tables 3.1.4.1 – 3.1.4.2). By consensus, the SAS divided the northern and southern fisheries using a line that runs due east from Great Machipongo Inlet on the Eastern Shore of Virginia. Historically and for statistical reporting purposes, this has been the dividing line for the Mid-Atlantic and Chesapeake Bay areas for the Menhaden Program at the Beaufort Laboratory (June and Reintjes 1959). Nicholson (1971) noted that "Similarities in age and size composition of the catches, time and duration of fishing, and range of vessels from home port tended to set each area apart." Through about the 1970s, reduction vessels from menhaden plants in New Jersey and Delaware rarely fished below this line; conversely, reduction vessels from Chesapeake Bay rarely fished north of this line. Thus, it is a convenient line of demarcation to sort port samples and landings data for the fleet-as-areas model. Moreover, empirical data for mean lengths of port sampled fish indicated appreciable size differences between areas north and south of this line.

Landings for the bait fleets were uncomplicated as these vessels typically operate over a much smaller geographic range than the reduction fleet; therefore, it was assumed that bait removals came from the state in which the fish were landed.

3.1.5 Potential Biases, Uncertainty, and Measures of Precision

The topics and data derivations for this section are unchanged and assumed the same as in the benchmark stock assessment (SEDAR 2015).

3.2 Commercial Bait Fishery

3.2.1 Data Collection Methods

Atlantic menhaden are harvested for bait in almost all Atlantic Coast states and are used for bait in commercial (e.g., American lobster and blue crab) and sport fisheries (e.g., striped bass and bluefish). Bait harvest comes from directed bait fisheries, primarily small purse seines, pound nets, gill nets, and cast nets. Menhaden are also landed as bycatch in various food-fish fisheries, such as pound nets, haul seines, and trawls. Systems for reporting bait landings have historically been incomplete because of the nature of the fishery and its unregulated marketing. Data limitations also exist because menhaden taken as bycatch in other commercial fisheries are often reported as "bait" together with other fish species. Additionally, menhaden harvested for personal bait use or sold "over-the-side" likely go unreported. As a result, the TC has determined that even though bait landing records date back to 1955, the most reliable bait landings are available since 1985 because of recent improvements made to harvester and dealer reporting programs.

Despite problems associated with estimating menhaden bait landings, data collection has improved in many areas. Some states license directed bait fisheries and require detailed landings records. More recently, harvest data reporting requirements changed through the implementation of Amendment 2 to the Atlantic Menhaden FMP because of the need for states to monitor in-season harvest relative to their newly implemented state specific quotas. Beginning in 2013, several states went from monthly reporting to weekly or daily reporting to avoid exceeding their allocated quota.

Bait landings from 1985-2016 were compiled using state-specific landing records by gear type and represent the most accurate dataset (Table 3.2.1.1). Bait landings from 1955-1984 were compiled using the Atlantic Coastal Cooperative Statistics Program’s (ACCSP) data warehouse, which houses historical data but is admittedly incomplete. More specifically, purse seine bait landings from 1955-1984 were not included because bait/reduction disposition is not available prior to 1985 so all the purse seine landings during this time period were included in the reduction landings even though a fraction of those landings may have been for bait purposes. Therefore, bait landings data from 1955-1984 are only from pound nets and “other” gears.

3.2.2 Commercial Bait Landings

Coastwide bait landings of Atlantic menhaden have generally increased from 1985 through 2016 (Figure 3.2.2.1). During 1985 to 1997 bait landings averaged 28,000 mt, with a high of 43,800 mt landed in 1988 and a low of 21,600 mt landed in 1986. Between 1998 and 2005, bait landings were fairly stable around 35,500 mt and then generally increased through 2016, peaking in 2012 at 63,700 mt. In 2016, bait landings were 43,100 mt and comprised 24% of coastwide landings.

Changes from the 2015 SEDAR Benchmark Assessment

Historic bait landings for several states have been updated from the 2015 SEDAR benchmark assessment to reflect the best available data. Prompted by incomplete or non-existent reporting in the past, several states, such as New York, have sought out historic landing reports to fill data gaps and better reflect the historic bait fishery. In addition, Florida reduction landings from 1985-1987 and Maine internal water processing landings through 1993 have been removed from the bait landings to avoid double counting in both the bait and reduction fleets. Florida reduction landings and Maine internal water processing landings are included in the reduction fleet. As a part of Amendment 3, all states have reviewed and approved their menhaden landings from 1985-2016.

3.2.3 Commercial Bait Catch-at-Age

Because of the limited age composition data, characterizing the age distribution of the removals by the bait fishery has been done at the region/year level, rather than port/week/area fished used for the reduction fishery. Four regions are defined as follows: (1) New England (Connecticut and north); (2) Mid-Atlantic (coastal Maryland, and Delaware through New York); (3) Chesapeake Bay (including coastal waters of Virginia); and (4) South Atlantic (North Carolina to Florida). Separate catch-at-age matrices were constructed for the northern and southern bait fisheries where the northern region included (1) and (2), while the southern region included (3) and (4). When the number of samples for a given region and year was less than 50, data were pooled across the years available and substituted for that year as described in SEDAR 2015. The resultant northern and southern catch-at-age matrices for the bait fishery are shown in Tables 3.2.3.1 and 3.2.3.2.

3.2.4 Potential biases, Uncertainty, and Measures of Precision

The topics and data derivations for this section are unchanged and assumed the same as in the benchmark stock assessment (SEDAR 2015).

3.3 Recreational Fishery

3.3.1 Data Collection Methods

The Marine Recreational Fisheries Statistics Survey (MRFSS, 1981-2003) and the Marine Recreational Information Program (MRIP, 2004-2016) data sets were used to derive a time series of recreational landings of Atlantic menhaden. Estimated recreational catches are reported as number/weight of fish harvested (Type A+B1) and number of fish released alive (Type B2).

3.3.2 Recreational Landings

The recreational landings estimates of Atlantic menhaden for the two assessment regions were combined with the bait landings and are shown in Tables 3.2.3.1 and 3.2.3.2. These estimates include an assumed 50% mortality of released fish (A+B1+0.5*B2), the same value used in the 2010 and 2015 benchmark assessments. The average recreational landings in the past ten years was estimated at 130 mt in the north and 380 mt in the south, representing less than 1% of total (combined bait and reduction) landings. Landings were highly variable with an increasing trend in recent years in both regions.

3.3.3 Recreational Discards/Bycatch

To determine total harvest, an estimate of release mortality to apply to the B2 caught fish is necessary. Under the assumption that many of these recreationally caught fish were caught by cast net, the judgment of the data workshop participants was that a 50% release mortality rate was a reasonable value.

3.3.4 Recreational Catch-at-Age

Insufficient biological samples were available to develop a recreational catch-at-age matrix. As in the 2010 and 2015 benchmarks, recreational landings were combined with bait landings, and the bait catch-at-age matrix was expanded to reflect these additional landings in numbers applied regionally and then combined.

3.3.5 Potential biases, Uncertainty, and Measures of Precision

The MRFSS/MRIP provides estimates of PSE (proportional standard error) as a measure of precision. The PSE values associated with MRFSS/MRIP estimates for Atlantic menhaden were substantial (>50%) in most years. Potential biases are unknown.

4.0 Indices of Abundance

4.1 Fishery-Dependent Indices

For the 2015 benchmark stock assessment, four fishery-dependent datasets (MA pound net, NJ gillnet, MD pound net, and PRFC pound net) were used to create state-specific indices of relative abundance. The fishery-dependent (FD) datasets revealed that FD indices had significant positive correlations with fishery-independent (FI) indices, within their respective regions. The FD data sets lacked both age and length data and because the FI datasets had longer time series and were generally of a higher quality (i.e., fewer issues of concern; e.g., one data set was one permit holder), all FD indices were removed from consideration in assessment models and were not updated for this report.

4.2 Fishery-Independent Indices

For more information on criteria used to determine which FI data sets should be developed into indices of abundance, see SEDAR 2015. For this update report, the SAS added the most recent years' data to the indices developed previously. All surveys were standardized using a generalized linear model (GLM) and the same methods as SEDAR 2015. Information on the surveys used in index development and differences in the GLM standardization from the benchmark can be found in Appendix A.

4.2.1 Coastwide Indices

YOY Index (1959-2016)

Sixteen fishery-independent young-of-the-year (YOY) survey data sets were used to create a coastwide index of recruitment for use in the base run of the Atlantic menhaden assessment model. The individual indices were combined using hierarchical modeling as described in Conn (2010). The resultant YOY index shows the largest recruitments occurring during the 1970s and 1980s (Figure 6.1.13; Table 4.2.1.1). Recruitment has since been lower but with increases in recruitment in the last three years. The CV for the index ranged from 0.37 to 1.04. This index was used to inform annual recruitment deviations in the model along with the catch at age data.

Age-1+ Indices

Two coastwide indices of adult abundance were developed from nine FI surveys. A northern adult index (NAD) was created using the method of Conn (2010) that included VIMS, CHESMAP, CHESFIMS, NJ, CT, and DE 16- and 30-ft trawls for the years 1980-2016 (Figure 6.1.14). A southern adult index (SAD) was created using the method of Conn (2010) that included the SEAMAP trawl survey and the GA trawl survey for the years 1990-2016 (Figure 6.1.15).

The NAD adult index for the assessment indicates an increase in abundance in the most recent years, while the SAD adult index for the assessment indicates a slightly decreasing abundance in the most recent years (Table 4.2.1.1). The CV associated with the SAD index ranged from 0.40 to 0.71, and the CV associated with the NAD index ranged from 0.29 to 0.88.

The length compositions for each of the adult indices were combined across surveys. Raw lengths in 10-mm bins from each survey by year were summed and then divided by the total number of length samples for that year. Length compositions with sample sizes over 100 (number of sets, trawls, etc.) were available continuously for 1990-2016 for the SAD and for 1988-2016 for the NAD and were used to determine selectivity of the respective indices.

5.0 Assessment Model

The base run from the 2015 benchmark assessment was updated. A statistical catch-at-age approach was used based on the Beaufort Assessment Model (BAM). A thorough description of the BAM model was provided in SEDAR 2015.

5.1 Beaufort Assessment Model (BAM)

BAM is a forward-projecting statistical catch-at-age model. The essence of such a model is to simulate a population that is projected forward in time like the population being assessed. Aspects of the fishing process (e.g., gear selectivity) are also simulated. Quantities to be estimated are systematically varied from starting values until the simulated population's characteristics match available data on the real population as closely as possible. Such data include total catch by year, observed age composition by year, observed indices of abundance, and observed length composition by year. The BAM was the forward-projecting age-structured model used in the previous Atlantic menhaden benchmark assessment (SEDAR 2015) and is being updated here.

Treatment of Indices

The two adult indices, SAD and NAD, were included in the base run of the BAM along with length compositions because they were deemed as accurate representations of the population over time and best available science. Age-specific selectivity schedules were estimated for each of these indices by fitting to length composition data sampled during the surveys. The SAD index selectivity was estimated as a double logistic because large fish were absent from the length samples. The NAD index selectivity was estimated as logistic because many of these surveys captured some of the largest individuals sampled by either FI or FD gears. The level of error in each index was based on the precision surrounding the annual values produced by the hierarchical method used to standardize and combine the component indices. In the BAM model, the estimates of the product of total numbers of fish at the appropriate time of the year

(May 15 for SAD and September 1 for NAD), a single catchability parameter, and the selectivity schedule were fit to the index value in that same year for each respective index. The error in both of these abundance indices was assumed to follow a lognormal distribution.

In the model the recruitment, or juvenile abundance index (JAI), was treated as an age-0 CPUE recruitment index, by fitting the product of the model estimated annual age-0 numbers part way through the year (June 1) and a constant catchability parameter to the computed index values. The catchability parameter for this index was blocked in order to accommodate data streams contributing to the index. Therefore, two constant catchability parameters were estimated for this index, one for 1959-1986 and one for 1987-2016. This allowed for changing spatial coverage in the index (the spatial coverage changes as survey time series were added) as well as changes due to habitat with increasing spatial coverage of the index. The error in the JAI index was assumed to follow a lognormal distribution.

Parameterization

The major characteristics of the model formulation were as follows:

- *Start year and terminal year:* The start year of the model was 1955, and the terminal year of the model was 2016.
- *Ages:* The model included ages 0 to 6 with age-6 being treated as a plus group.
- *Natural mortality*: The age-specific natural mortality rate was assumed constant. A Lorenzen curve was scaled such that the mortality of the older ages was that estimated in a tagging study.
- *Stock dynamics*: The standard Baranov catch equation was applied. This assumes exponential decay in cohort size because of fishing and natural mortality processes.
- *Sex ratio:* The ratio of males to females was fixed in the model at 1:1 because of the 251,330 fish sampled from the reduction fishery from 1955-1970, 49% were male and 51% were female.
- *Maturity and Fecundity*: The percent of females mature and fecundity were age and time varying, but fixed in the model. Both fecundity and maturity were based on length at age for the population at the start of the fishing year. Annual, cohort-based von Bertalanffy growth parameters (L_∞, K, and t_0) were estimated with a bias correction using the fishery data. These annual growth parameters were then used to estimate mean lengths at age over time. Female fecundity at age for each year was fixed in the model and was based on a function of mean length by age for the population (Lewis and Roithmayr 1981). Lengths were also used in an estimated logistic regression function for determining maturity each year, which was fixed in the model.
- *Weights at age:* The weight-at-age during spawning and during the middle of the fishery were input into the model and were based on the overall estimates of the parameters for the weight-length equation.
- *Recruitment:* Spawning was assumed to occur on March 1 in the model; hence the spawning time in months was 0.0, as March 1 was the start date for the model. Recruitment to age-0 was estimated in the assessment model for each year with a set of annual deviation parameters, conditioned about a median recruitment, which was

estimated in log-space. The steepness value was fixed at 0.99, which allowed for the estimation of a median recruitment and estimated deviations with time. Estimated deviations were informed by age composition data and a recruitment index.

- *Fishing*: Four fisheries were explicitly modeled. Southern and northern fleets of both the reduction fishery and the bait fishery were explicitly modeled to account for differences in selectivity due to size and age based migratory patterns. Being such a small proportion of the landings in each year, recreational landings were combined with the bait fishery landings. Fishing mortality rates were estimated for each year for each fishery by estimating a mean log fishing mortality rate and annual deviations.
- *Selectivity functions – indices:* Selectivity for the recruitment index was 1.0 for age-0 and 0.0 for all other ages. Selectivities for the NAD and SAD indices were age-varying, but constant with time. The NAD index selectivity was estimated as a flat-topped logistic function, while the SAD index selectivity was estimated as a double logistic or dome-shaped function.
- *Selectivity functions - fishery*: Selectivity for each of the fishery fleets was estimated using a functional form of dome-shaped selectivity. Specifically, the selectivity for each fleet was estimated as a four parameter double logistic. Selectivity was dome-shaped for each fishery for all years 1955-2016. Selectivity for both the northern and southern commercial reduction fisheries was time-varying using time blocks. For the southern fleet, selectivity was blocked as follows 1955-1971, 1972-2004, and 2005-2016. For the northern fleet, selectivity was blocked as follows 1955-1969, 1970-1993, and 1994-2016. Time blocks were based on the contraction and changes in the fishery over time. Selectivity for the bait fishery was constant throughout the time series.
- *Discards*: Discards of Atlantic menhaden were believed to be negligible and were therefore ignored in the assessment model.
- *Abundance indices*: The model used three indices of abundance that were each modeled separately: a recruitment (age-0) index series (1959-2016; JAI), a southern adult index series (1990-2016; SAD), and a northern adult index series (1980-2016; NAD). Each index represents a composite of multiple survey datasets that were standardized/combined using the hierarchical method of Conn (2010).
- *Ageing uncertainty*: Ageing uncertainty was not included in the base run of the assessment.
- *Fitting criterion*: The fitting criterion was a total likelihood approach in which catch, the observed age compositions from each fishery, the observed length compositions from each index, and the patterns of the abundance indices were fit based on the assumed statistical error distribution and the level of assumed or measured error.
- *Biological benchmarks*: Current interim benchmarks adopted for Atlantic menhaden are SPR based benchmarks and were calculated as they were in the 2015 benchmark stock assessment.

Weighting of Likelihoods

The likelihood components in the BAM model include northern and southern reduction landings, northern and southern bait landings, northern and southern reduction catch-at-age, northern and southern bait catch-at-age, the NAD index, the SAD index, a recruitment index, NAD length compositions, and SAD length compositions. For each of these components, a statistical error distribution was assumed as follows:

Likelihood Component	Error Distribution	Error Levels
N & S reduction landings	Lognormal	Constant CV = 0.03
N & S bait landings	Lognormal	Constant CV = 0.15 (1955-1984) and Constant CV = 0.05 (1985-2016)
N & S reduction catch at age	Multinomial	Annual number of trips sampled
N & S bait catch at age	Multinomial	Annual number of trips sampled
NAD length compositions	Multinomial	Annual number of sampling events
SAD length compositions	Multinomial	Annual number of sampling events
NAD index	Lognormal	Annual CV values from 0.29 to 0.88
SAD index	Lognormal	Annual CV values from 0.40 to 0.71
Recruitment index (JAI)	Lognormal	Annual CV values from 0.37 to 1.04

In addition to these components, the likelihood also contained some penalty terms and prior probability distributions. The penalties were on recruitment deviations and the deviations in the initial age structure from equilibrium. The priors were on the two parameters of the descending limb of the double logistic selectivity for the SAD index and the A_{50} of the descending limb of the southern commercial reduction fishery selectivity.

Iterative reweighting was used to weight the data components as they were weighted in SEDAR 40 (Francis 2011). Iterative reweighting was completed such that the standard deviation of the normalized residuals for each data component was near the value from the benchmark assessment (SEDAR 2015).

Estimating Precision

The BAM model was implemented using the AD Model Builder software, which allowed for easy calculation of the inverse Hessian matrix, which provides approximate precision of estimated parameters. However, in this case where some key values were fixed (e.g., natural mortality), it is believed that precision measures from the inverse Hessian matrix are underestimates of the true precision. Instead, the BAM model employed a parametric Monte Carlo bootstrap (MCB) procedure in which the input data sources were re-sampled using the measured or assumed statistical distribution and error levels provided, as described in SEDAR 2015.

Sensitivity Analyses

A total of 15 sensitivity runs were completed with the BAM model. These sensitivity runs represent those involving input data, those involving changes to the model configuration, and those included as part of the retrospective analyses. Some of these runs were completed in order to explore the differences between the benchmark and update assessments.

Sensitivity to Input Data

Four sensitivity runs were conducted to examine various effects to changes in the input data. These runs are related to uncertainty in index choice or life history values. The following is a list of these sensitivity runs:

Run Number	Sensitivity Examined
am-090	Excluded the NAD index and NAD length compositions
am-091	Upper CI from Lorenzen for M
am-092	Lower CI from Lorenzen for M
am-100	Uncorrected bait landings, as used in the 2015 benchmark stock assessment

Sensitivity to Model Configuration

Five sensitivity runs were conducted to examine the effects of various model configurations. In particular, this set of runs was completed to try to assess the differences that occurred between the benchmark and update stock assessments. These runs are related to recruitment index catchability and catchability of the NAD index. The following is a list of these sensitivity runs:

Run Number	Sensitivity Examined
am-093	One estimated catchability for the recruitment index
am-076	Fixed catchability for the NAD index (fixed at benchmark assessment value)
am-101	Two catchabilities estimated for NAD index (1980-1989; 1990-2016)
am-102	Two catchabilities estimated for NAD index (1980-1995; 1996-2016)
am-103	Two catchabilities estimated for NAD index (1980-2006; 2007-2016)

Retrospective Analyses

Retrospective analyses were completed by running the BAM model in a series of runs sequentially omitting years 2016 to 2011, as indicated below:

Run Number	Sensitivity Examined
am-094	Retrospective analysis with modeling ending in 2015
am-095	Retrospective analysis with modeling ending in 2014
am-096	Retrospective analysis with modeling ending in 2013
am-097	Retrospective analysis with modeling ending in 2012
am-098	Retrospective analysis with modeling ending in 2011
am-099	Retrospective analysis with modeling ending in 2010

Uncertainty analyses

Uncertainty was examined in our results in two distinct ways: sensitivity runs and by using a Monte Carlo boostrap (MCB) procedure. This parametric bootstrap procedure was run for 1,500 iterations. For some iterations, the model did not converge; where this was true, then that particular iteration was not included in the results. In addition, some iterations estimated fairly high values for R_0 or other parameters. Thus, some additional runs were excluded. In the end, about 13% of runs did not converge or were excluded for unrealistic parameter estimates.

Reference Point Estimation – Parameterization, Uncertainty, and Sensitivity Analysis

Fishing mortality reference points for Atlantic menhaden were calculated using the same methods as the benchmark assessment (SEDAR 2015). The threshold and limit are the maximum and median geometric mean fishing mortality rates, respectively, during the years 1960-2012. The resultant reference points are $F_{36\%}$ (target) and $F_{21\%}$ (limit) based on SPR, which are a change from the 2015 benchmark stock assessment values of $F_{57\%}$ and $F_{38\%}$. These changes are due to adding additional years of data to the model. Population fecundity (*FEC*, number of maturing or ripe eggs) is the other reference point and is a measure of reproductive capacity. The reference points for reproductive output include $FEC_{36\%}$ (target) and $FEC_{21\%}$ (limit). All benchmark calculations were based upon landings weighted selectivity across all fleets and areas, *M*-at-age (which was constant), mean maturity at age, a 1:1 sex ratio, and mean fecundity-at-age from the model inputs. All means are across the time series of 1955 to 2013. Also included was the $F_{X\%}$ of the current fishing mortality rate and a plot of the biomass over time divided by the biomass at $F = 0$. Uncertainty in the benchmark estimates was provided by the bootstrap runs. For each run, the current reference points were calculated and a distribution of the benchmarks was provided.

6.0 Model Results

6.1 Goodness of Fit

Observed and model predicted removals for the northern and southern reduction and bait fisheries (1955–2016; Figures 6.1.1-6.1.4) were compared for the base model run. Reduction fishery removals, which are known fairly precisely, fit very well, as do bait fishery removals. Patterns in the annual comparisons of observed and predicted proportions of catch-at-age for the northern and southern reduction and bait fisheries (Figures 6.1.5-6.1.8) indicate a good overall model fit to the observed data. The bubble plots for the northern and southern reduction and bait fisheries (Figures 6.1.9-6.1.12) indicate that the model fit does fairly well at estimating catch-at-age during the time series. There is no patterning observed in the bubble plot that caused concern.

Observed and predicted coastwide recruitment indices were compared for the base model run (1959–2016; Figure 6.1.13). The residual pattern suggests that the recruitment index data did not fit well for relatively large year classes, especially those that occurred in the 1970s and 1980s. Visual examination of the fit suggests that the overall pattern fit reasonably well for the most recent time period with the BAM model capturing some of the lows and highs observed in the index values.

The observed and predicted NAD index (1980–2016; Figure 6.1.14) and SAD index (1990-2016; Figure 6.1.15) values fit well. The general patterns are captured. However, the model has a difficult time fitting estimates to the highest observed values in the 1980s and 2010s for the

NAD and in 1990, 2006, 2009, and 2011 for the SAD. Patterns in the annual comparisons of observed and predicted proportion NAD and SAD measurements at length for the NAD and SAD indices (Figures 6.1.16-6.1.17) indicate good fit to the observed data in some years, but problems in fitting to data in other years. Given the nature of these indices as a conglomeration of data from different state fishery-independent data sources, changing patterns in the data are expected, yet are difficult to discern with model specifications. Therefore, although the fits to the data could be better, the SAS only used the length data to get an idea of ages represented by each index, nothing more. Some of the problems include an accumulation of predicted values at larger lengths for the NAD index, a mismatch in size for given years for the SAD index, and bi-modality in the NAD index, all of which would be difficult to capture by addressing them with selectivity within the model. The bubble plots for the NAD and SAD index length compositions (Figures 6.1.18-6.1.19) show patterns, as would be expected from the annual length composition plots and are similar to the plots from the benchmark assessment.

6.2 Parameter Estimates

6.2.1 Selectivities and Catchability

Fishery removals were related to an overall level of fishing mortality and the selectivity (or availability) of Atlantic menhaden to the fishery. Model estimates of selectivity for the reduction and bait fisheries are shown graphically in Figures 6.2.1.1-6.2.1.8. Selectivity parameters were estimated for each fishery and time period as four-parameter, double-logistic models with the parameters being the ascending slope and A_{50} and the descending slope and A_{50} (Table 6.2.1.1).

Selectivity for the NAD index was estimated as a two-parameter logistic function as shown in Figure 6.2.1.9 and Table 6.2.1.1. Selectivity for the NAD index was used to fit the NAD length composition data and represents the ages of fish that were captured by the NAD index.

Selectivity for the SAD index was estimated as a four-parameter, double-logistic function as shown in Figure 6.2.1.10 and Table 6.2.1.1. Selectivity for the SAD index was used to fit the SAD length composition data and represents the ages of fish that were captured by the SAD index.

The base BAM model estimated a single, constant catchability parameter for the NAD and SAD abundance indices, reflecting the assumption that expected catchability for these indices is believed to be constant through time. This is a good assumption for the NAD and SAD fishery-independent indices since they are based on consistent, scientific survey collections, albeit the surveys are a mix of state surveys and do not target menhaden and because the indices used to create the NAD and SAD were standardized to account for catchability differences. Log-catchability was estimated as 0.81 (2.25 back transformed) for the NAD index with a 0.20 SE, while the log-catchability of the SAD index was -1.54 (0.21 back transformed) with a 0.08 SE. The addition of the 2014-2016 NAD index data points resulted in a large difference in the estimation of the NAD index catchability parameter when compared to the benchmark assessment. The three points had high leverage with the resultant catchability change resulting in scale differences between this update assessment and the benchmark assessment. Some sensitivity runs were included to demonstrate the impact (see below).

The base BAM model estimated two constant catchability parameters for the recruitment index using two time blocks: 1959-1986 and 1987-2016. The time blocks represent a change in the combined spatial extent of the component seine surveys that comprise the index, with the addition of several state fishery-independent surveys after 1987. Log-catchability was estimated as -2.31 (0.10 back transformed) for the first time period with a SE of 0.06, while the log-catchability of the second time period was -2.79 (0.06 back transformed) with a SE of 0.04.

6.2.2 Fishing Mortality Rates

Highly variable fishing mortalities were noted throughout the entire time series and dependent upon the fishing. The highest fishing mortalities for the commercial reduction fishery in the north were in the 1950s (Figure 6.2.2.1), while the highest fishing mortality rates for the commercial reduction fishery in the south were during the 1970s to 2000s (Figure 6.2.2.2). The highest fishing mortalities for the commercial bait fishery in the north were in the 1950s and 1990s (Figure 6.2.2.3), while the highest fishing mortality rates for the commercial bait fishery in the south were during the late 1990s and 2000s (Figure 6.2.2.4).

Fishing mortality rate over time was reported as the geometric mean fishing mortality rate of ages-2 to -4 (Table 6.2.2.1; Figure 6.2.2.5). In the most recent decade, the geometric mean fishing mortality rate has ranged between 0.31 and 0.58. The geometric mean fishing mortality rate for 2016 is 0.51. The fishing mortality rate for this update assessment is higher than the fishing mortality rate from the benchmark assessment (Figure 7.2.1.3). The scale of the fishing mortality rate is different and the trend deviates in some years. To look at the difference in the scale and trend of the fishing mortality rate, the SAS and TC ran sensitivity runs (see below).

6.2.3 Abundance, Fecundity, Biomass, and Recruitment Estimates

The base BAM model estimated population numbers-at-age (ages 0-6+) for 1955–2016 (Figure 6.2.3.1 and Table 6.2.3.1). From these estimates, along with growth and reproductive data, different estimates of reproductive capacity were computed. Population fecundity (i.e., Total Egg Production) was the measure of reproductive output used as in the benchmark assessment. Population fecundity (*FEC*, number of maturing ova) was highest in the early 1960s, early 1970s, and during the more recent years and has generally been higher with older age classes making up a larger proportion of the *FEC* (Figure 6.2.3.2 and Table 6.2.3.2). Fecundity for this update assessment is lower than the fecundity from the benchmark assessment (Figure 7.2.1.4). The scale of the fecundity is different and the trend deviates in some years. To look at the difference in the scale and trend of the fecundity, the SAS and TC ran sensitivity runs (see below).

Biomass has fluctuated with time from an estimated high of over 2,288,000 mt in 1958 to a low of 567,000 mt in 2000 (Figures 6.2.3.3-6.2.3.4; Table 6.2.3.3). Biomass was estimated to have been largest during the late-1950s, with lows occurring during the 1960s and mid-1990s to mid-2000s, and was relatively stable through much of the 1970s, 1980s, and 2010s. Biomass is likely increasing at a faster rate than abundance because of the increase in the number of older fish at age, which weigh more than younger individuals.

Age-0 recruits of Atlantic menhaden (Figure 6.2.3.5 and Table 6.2.3.1) were highest during the 1970s and 1980s. An extremely large year class was also predicted for 1958. More recently, larger year-classes have also been estimated in 2005, 2010, and 2016. The annual estimated recruitment values relative to the median are shown in Figure 6.2.3.6. The only recruitment parameter estimated in the model was log of R_0, which was estimated at 2.62 with a standard deviation of 0.024. The log of R_0 was estimated at a lower value with the addition of the 2014-2016 data points when compared to the benchmark stock assessment. This seemed to be related to the leverage of the 2014-2016 NAD index points and increased estimate of catchability. To explore this, the SAS and TC ran additional sensitivity runs (see below).

6.3 Weighting of the Data Components

The likelihood components of NAD index, SAD index, recruitment index, SAD length compositions, NAD length compositions, northern commercial reduction fishery age compositions, southern commercial reduction fishery age compositions, northern bait fishery age compositions, and southern bait fishery age compositions were all weighted such that the weights for this update were similar to the weights from the benchmark assessment (Francis 2011; SEDAR 2015).

6.4 Sensitivity Analyses

6.4.1 Alternate model runs

The results of the sensitivity runs suggest that the base BAM model trends and stock status are somewhat robust to model choices made in the base run and data choices made by the SAS (Figures 6.4.1.1-6.4.1.11).

Sensitivity runs were completed to evaluate model robustness to decisions related to natural mortality, *M*. Fishing mortality rate varied overall for this series of runs with an increase and a decrease in *M*. Biomass and recruitment were greatly influenced by *M* with increased (upper) *M* values causing dramatically increased biomass and recruitment, which is to be expected. Only the scale of *M* was explored; time-varying *M* was not explored as a sensitivity run. Natural mortality likely varies with time given that Atlantic menhaden are a forage species and that the environment is dynamic.

Some sensitivity runs were completed to look at the effects of index choice and parameterization on model outcomes. The largest differences in model outcomes were for those runs that excluded the NAD index, had catchability fixed for the NAD index, or estimated two catchability parameters for the NAD index. When the NAD index was removed from the model, the biomass and fecundity from the 1990s forward increased dramatically and recruitment increased, while the *F* decreased. In short, the removal of the NAD index resulted in a larger population. With a loss of the NAD index, the model also lost its one logistic selectivity. The estimation of two catchabilities for the NAD index resulted in a much different scale when the break years were 2006/2007. This suggests the potential for exploring the catchability of the NAD index in the next benchmark assessment. These runs provide insight into the changes that occurred between the benchmark and update assessment. Sensitivity runs and restrospective analysis (see below) suggested that the model is sensitive to the NAD index, and in particular to the addition of three most recent data points (2014-2016). This update leads to a change in the index catchability and higher fishing mortality for most of the time series. The 2015 benchmark assessment was also sensitive to the NAD index. Thus, the NAD index is critical to determining the scaling and trend in the stock assessment, as are the decisions surrounding the configuration of the NAD index within the stock assessment model. These runs suggest further exploration of the NAD index and its components during the next assessment.

Removal of time blocks on catchability for the recruitment index had very little influence on estimates of fishing mortality, especially in the most recent time period. With one constant catchability for the recruitment index, the biomass and fecundity in the 1970s was much higher than the base run. However, both the biomass and fecundity from 1990 to the present are similar to the base run. The fit to the recruitment index was different from the base run with a poorer fit for the sensitivity run. This was expected as the additional catchability parameter would allow for better fit to the recruitment index. Overall, the behaviors observed from the sensitivity run with one catchability were as expected.

In general, a common trend in the results from 1955-2016 were seen in many of the sensitivity runs. Some sensitivity runs resulted in differing year-to-year values depending upon the data sources used and modeling choices that were made, which was expected. Some sensitivity runs did change the overall scale of the assessment. For example, changes to natural mortality scaled other model components, which is a typical stock assessment result. Overall, the final stock status was the same across all sensitivity runs except the run with lower natural mortality.

The sensitivity runs when compared to the MCB runs discussed below are generally within the bounds of uncertainty explored for this assessment. Likelihood values, SDNRs, and some of the estimated parameters (Tables 6.4.1.1-6.4.1.3) can be compared below. The output distributions from the estimated parameters from the MCBs are fairly smooth distributions, which suggests that these runs are simply the bounds on the uncertainty of the assessment given the assumptions and data inputs.

6.4.2 Retrospective Analyses

The retrospective was run peeling off data back to 2010 (Figures 6.4.2.1-6.4.2.11; Tables 6. 4.2.1-6.4.2.3). The fits to the indices remained consistently good with the removal of years of data. The retrospective exhibits very little change for the first of the two years peel (2015-2014). For the years before 2014, geometric mean fishing mortality for ages-2 to -4 was under predicted. Biomass and fecundity exhibit similar behaviors for the retrospective analysis as the fishing mortality rate did. However, biomass and fecundity were over predicted in the years before 2014.

There are always trade-offs in fitting data components, and those tradeoffs change with time; these trade-offs have an impact on the appearance of retrospective analyses. For example, the second catchability parameter estimated for the JAI index is consistently estimated, but the catchability for the other indices and R_0 are changing with respect to the number of years of data included (Table 6.4.2.3). Patterns in retrospective analysis can emerge from data trade-offs; the addition of data in a data space with no historical information can create patterns where parameter estimates are influenced and the fit to the indices is influenced.

The stock status outcome did not vary in this set of retrospective model runs. In particular, the ratio of geometric mean fishing mortality at ages-2 to -4 to the benchmarks in the terminal year showed no variation in stock status (Figures 6.4.2.8-6.4.2.9), nor did the ratio of *FEC* to the *FEC* benchmarks in the terminal year (Figures 6.4.2.10-6.4.2.11).

6.5 Uncertainty Analysis

Uncertainty was examined in our results in two distinct ways: sensitivity runs and by using a MCB procedure. This parametric bootstrap procedure was run for 1,500 iterations. For some iterations, the model did not converge; where this was true, then that particular iteration was not included in the results. In addition, some iterations estimated fairly high values for R_0 or other parameters. Thus, some additional runs were excluded. In the end, about 13% of runs did not converge or were excluded for unrealistic parameter estimates.

The resulting estimates from the MCB runs have been summarized in Figures 6.5.1-6.5.4, showing the 95% confidence region. In general, the MCB results are not symmetrical distributions about the base run results because some of the uncertainty specifications were not symmetrical. Uncertainty was large in some years, especially for biomass and fecundity. The uncertainty explored with the retrospective analysis was within the bounds of the uncertainty from the MCB runs.

7.0 Stock Status

7.1 Current Overfishing, Overfished/Depleted Definitions

The current overfishing definition is a fecundity-per-recruit threshold based on a historical performance reference point. The threshold and target were calculated, as in the benchmark assessment, as the maximum and median geometric mean fishing mortality rate for ages-2 to -4 during 1960-2012 (a period deemed sustainable). The resulting reference points for this update are a threshold of $F_{21\%}$ and a target of $F_{36\%}$. *F*-based reference points should be compared to the geometric mean fishing mortality rate for ages-2 to -4. The resultant fecundity-based overfished definition is a threshold of $FEC_{21\%}$ and a target of $FEC_{36\%}$.

The maximum spawning potential (MSP) or spawner per recruit (SPR) based reference points are intended to be interim reference points while the ASMFC’s Multispecies Technical Committee develops ecological-based reference points (ERP). The ERPs will take time to develop because of the complexity of modeling the predator-prey relationships for marine species that rely on Atlantic menhaden for forage (e.g., striped bass, bluefish, and weakfish). In either case (biological or ecological reference points), the intent is to manage Atlantic menhaden at sustainable levels to support fisheries and meet predator demands by maintaining sufficient reproductive capacity to prevent stock depletion and protect against recruitment failure.

7.2 Stock Status Determination

7.2.1 Overfished and Overfishing Status

Benchmarks for Atlantic menhaden are $F_{36\%}$, $F_{21\%}$, $FEC_{36\%}$, and $FEC_{21\%}$. The benchmarks are calculated through spawner-per-recruit analysis using the mean values of any time-varying components (i.e., growth, maturity) as in the benchmark assessment (SEDAR 2015) and geometric mean fishing mortality rate at ages-2 to -4 for each year (Figure 7.2.1.1). The base BAM model benchmark estimates and terminal year stock status are indicated in Table 7.2.1.1 Based on the current adopted benchmarks, **the Atlantic menhaden stock status is not overfished and overfishing is not occurring**. In addition, the current stock is below the current fishing mortality target and below the current *FEC* target (Figure 7.2.1.2).

The stock status for this update assessment is the same as the status from the benchmark assessment (Figures 7.2.1.3 and 7.1.2.4). Because the assessment update resulted in generally higher fishing mortality values throughout the time series, the maximum and median *F* values were estimated higher than the 2015 benchmark and the resulting reference points were different from the 2015 reference points of $F_{38\%}$, $F_{57\%}$, $FEC_{38\%}$, and $FEC_{57\%}$. While the scale is different and the trend deviates in some years, during the last decade the stock status for both fishing mortality rate and fecundity has been similar. Sensitivity runs indicate that the scale and trend differences are related to the NAD index and its model configuration. However, additional analyses should be undertaken during the next benchmark assessment to address this topic.

7.2.2 Uncertainty

The MCB runs and sensitivity runs support the stock status determination using the benchmarks. For each MCB run, the benchmarks were calculated. The entire time series of estimates of the geometric mean fishing mortality at ages-2 to -4 over $F_{21\%}$ and $F_{36\%}$ are shown in Figures 7.2.2.1 and 7.2.2.2, which include the 95% confidence intervals for the MCB runs. The entire time series of estimates of fecundity over $FEC_{21\%}$ and $FEC_{36\%}$ are shown in Figures 7.2.2.3 and 7.2.2.4, which also include the 95% confidence intervals for the MCB runs. In addition, the retrospective runs are within the bounds of the MCB runs in Figures 7.2.2.1 – 7.2.2.4. Phase plots of base run and each MCB run versus the threshold and target benchmarks are shown in Figures 7.2.2.5 and 7.2.2.6, respectively. Densities and cumulative probability densities for each of the benchmarks are shown in Figures 7.2.2.7 -7.2.2.8. In addition, each of the sensitivity and retrospective runs, as well as most of the MCB runs, indicated the same stock status as the base run, except the lower natural mortality run, and most of the MCB runs (Tables 7.2.2.1-7.2.2.2). The history of fishing mortality rates in these figures suggests that overfishing likely occurred in the 1950s, but generally, overfishing is unlikely to be occurring at present. The history of fecundity over the time series suggests that the population was overfished as recent as the late 1990s to mid 2000s, but is not currently overfished.

The uncertainty in the terminal year stock status indicators were expressed using the results of the bootstrap runs of the base BAM model and sensitivity runs. The results indicate that the fecundity estimates for the terminal year are generally above the threshold with 5% of runs falling below 1.0 for $FEC_{21\%}$, while 61% of runs fell below 1.0 for $FEC_{36\%}$. The results for the 2016 fishing mortality rate suggests that the base run estimate is below the target and threshold with none of the bootstrap runs exceeding the threshold values in the terminal year and 10% of the boostrap runs exceeding the target values in the terminal year.

7.3 Plan for Development of Ecological Reference Points

In the *Ecological Reference Points for Atlantic Menhaden* report, the Biological Ecological Reference Points (BERP) Workgroup (WG) presented a suite of preliminary ecological reference point (ERP) models and ecosystem monitoring approaches for feedback as part of the 2015 Benchmark Stock Assessment for Atlantic Menhaden (SEDAR 2015, Appendix E). The BERP WG recommended the use of facilitated workshops to develop specific ecosystem and fisheries objectives to drive further development of ERPs for Atlantic menhaden. This Ecosystem Management Objectives Workshop (EMOW) contained a broad range of representation including Commissioners, stakeholder representatives, and technical representatives to provide various perspectives on Atlantic menhaden management. The EMOW identified potential ecosystem goals and objectives that were reviewed and approved by the Board. The WG then assessed the ability of each preliminary ERP model to address EMOW-identified management objectives and performance measures, and selected models accordingly.

Currently, the WG is thoroughly evaluating this suite of novel multispecies models to ensure they are able to generate ERPs which meet as many management objectives as possible. Some of the models under consideration are a Bayesian surplus production model with time-varying population growth rate which estimates the trend in total Atlantic menhaden stock biomass and fishery exploitation rate by allowing the population growth rate to fluctuate annually in response to changing environmental conditions. This approach produces dynamic, maximum sustainable yield-based ecological reference points that implicitly account for the forage services menhaden provide. Another production model that is up for consideration is a Steele-Henderson model. This type of Steele-Henderson modeling permits non-fisheries (predation and environmental) effects to be quantified and incorporated into the single species stock assessments, allowing fixed and non-equilibrium (time-varying) ecological overfishing thresholds to be established. This approach is not intended to replace more complex multispecies ecosystem assessment models, but rather to expand the scope of the single species assessments to include the separate and joint effects of fishing, predation and environmental effects at the fish community level. Finally, a multispecies statistical catch-at-age modeling framework is being considered. This model uses standard statistical catch-at-age techniques and single species models are linked using trophic calculations to provide a predator-prey feedback between the population models. The statistical framework is believed to be an improvement from the existing MSVPA because using statistical techniques may help to estimate many of the model parameters while incorporating the inherent uncertainty in the data. An external model being considered is an Ecopath with Ecosystem model, however the application of this model is for strategic planning (to explore tradeoffs) not tactical (e.g., quota setting) advice. The model is flexible and able to explore additional menhaden relevant scenarios, ERPs, and questions. This model could be used to evaluate the other models being developed.

Once these models are fully vetted, the WG will select which models will go to peer-review in 2019 along with the single-species BAM model, which has traditionally been used for menhaden management. This is an ambitious timeline, since all models will need to be evaluated in the same timeframe as a single species assessment. Additionally, the WG recommends conducting a Management Strategy Evaluation (MSE) for Atlantic menhaden during which single-species forage services reference points would be tested relative to traditional reference points and the management goals for the stock.

8.0 Research and Modeling Recommendations for Benchmark

Many of the research and modeling recommendations from the last benchmark stock assessment remain relevant for this update stock assessment. Research recommendations are broken down into two categories: data and modeling. While all recommendations are high priority, the first recommendation is the highest priority. Each category is further broken down into recommendations that can be completed in the short term and recommendations that will require long term commitment. Notes have been added for this report regarding work that has been addressed or initiated since SEDAR 2015.

<u>Annual Data Collection</u>
Short term (next 3-6 years):

1. Continue current level of sampling from bait fisheries, particularly in the Mid-Atlantic and New England. Analyze sampling adequacy of the reduction fishery and effectively sample areas outside of that fishery (e.g., work with industry and states to collect age structure data and biological data outside the range of the fishery). **NOTE**: Work to assess the sampling adequacy of the bait and reduction fisheries has been initiated by Genevieve Nesslage's research group at the University of Maryland Center for Environmental Science.
2. Ageing:
    a. Conduct ageing validation study (e.g., scale : otolith comparison), making sure to sample older age classes. Use archived scales to do radio isotope analysis.
    b. Ageing precision: conduct an ageing workshop to assess precision and error among readers (currently planned for January 2015). **NOTE**: A workshop was completed and described in ASMFC 2015 and Atlantic menhaden scales have been added to the annual ASMFC QA/QC Fish Ageing Workshop (ASMFC 2017) to address an ongoing need for information on ageing precision and error.
3. Conduct a comprehensive fecundity study. **NOTE**: This work has been initiated and is ongoing with Rob Latour's research group at Virginia Institute of Marine Science.
4. Place observers on boats to collect at-sea samples from purse-seine sets, or collect samples at dockside during vessel pump-out operations (as opposed to current top of hold sampling) to address sampling adequacy.

5. Investigate relationship between fish size and school size in order to address selectivity (specifically addressing fisher behavior related to harvest of specific school sizes).
6. Investigate relationship between fish size and distance from shore (addressing selectivity).
7. Evaluate alternative fleet configurations for the removal and catch-at-age data.

Long term (6+ years):

1. Develop a menhaden specific coastwide fishery-independent index of adult abundance at age. One possible methodology is an air spotter survey complemented with ground truthing for biological information (e.g., size and age composition). In all cases, a sound statistical design is essential (involving statisticians in the development and review of the design; some trial surveys may be necessary). **[Highest Priority] NOTE:** Design of a winter pelagic survey of adult Atlantic menhaden in the Mid-Atlantic has been initiated by Genevieve Nesslage's research group at the University of Maryland Center for Environmental Science.
2. Conduct studies on spatial and temporal dynamics of spawning (how often, how much of the year, batch spawning, etc.)
3. Conduct studies on productivity of estuarine environments related to recruitment. **NOTE**: Anstead et al. 2016 and 2017 used otolith chemistry to evaluate the proportional contribution of each nursery area along the US Atlantic coast for recruits for 2010-2012.
4. Investigation of environmental covariates related to recruitment. **NOTE**: Buchheister et al. 2016 evaluated coast wide recruitment patters from 1959-2013 and found the Atlantic Multidecal Oscillation was the best predictor of regional recruitment. Simpson et al. 2016 evaluated several environmental covariates for an effect on larval survival and found temperature had the greatest effect on early life survival which was more related to recruitment than larval supply.

<u>Assessment Methodology</u>

Short term (3-6 year):

1. Conduct management strategy evaluation (MSE). **[Highest Priority] NOTE:** This work has been initiated and is ongoing with Amy Schueller's research group at the Southeast Fisheries Science Center in Beaufort, North Carolina.
2. Conduct multi-objective decision analysis (MODA). **[Highest Priority] NOTE:** This will be addressed through the ongoing BERP WG activities.
3. Continue to develop an integrated length and age based model (e.g., SS3).
4. Continue to improve methods for incorporation of natural mortality (e.g., multi-species statistical catch-at-age model). **NOTE**: This work will be addressed by McNamee's doctoral thesis (*in prep*) and through current BERP WG activities.
5. During the next benchmark stock assessment process (scheduled for 2019), the SAS recommends that the following items be considered during modeling workshops:
    a. Re-examine the methodology and surveys used for the development of the NAD index.
    b. Explore the likelihood component for the length composition data.

c. Examine the age composition of the bait fishery.

Long term (6+ years):

1. Develop a seasonal spatially-explicit model, once sufficient age-specific data on movement rates of menhaden are available.

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10.0 Tables

Table 2.3.1 The estimated annual, cohort-based von Bertalanffy growth curves with the bias correction as detailed in Schueller et al. (2014). Those t_0 values with a * indicated values were fixed at the non-bias corrected values. 2012 and 2013 did not converge.

		Bias corrected values		
	n	L_∞	K	t_0
1947	28	380.7	0.23	0.00
1948	101	335.2	0.69	0.00
1949	355	322.8	0.75	-0.71
1950	1202	342.2	0.39	-0.25
1951	6574	344.7	0.42	0.00
1952	3596	354.8	0.34	-1.02*
1953	9362	356.5	0.39	-0.58
1954	9216	366.1	0.39	-0.43
1955	18271	544.9	0.15	-1.13
1956	20357	393.0	0.28	-0.68
1957	9581	487.3	0.17	-1.37
1958	34120	459.1	0.19	-0.85
1959	6880	443.7	0.21	-1.30*
1960	9016	374.6	0.33	-0.63
1961	8220	334.6	0.39	-0.74
1962	11242	349.6	0.35	-0.88
1963	9324	368.6	0.32	-0.95
1964	17597	469.8	0.23	-1.01*
1965	17274	627.4	0.14	-1.17*
1966	25575	440.1	0.29	-0.76*
1967	13397	675.2	0.12	-1.50*
1968	9459	620.2	0.13	-1.50*
1969	11442	503.3	0.25	-0.84*
1970	4373	392.2	0.45	-0.36*
1971	7721	539.8	0.15	-1.36
1972	6292	327.1	0.54	-0.11
1973	6366	401.5	0.27	-0.72*
1974	6796	562.3	0.13	-1.29
1975	8832	426.5	0.19	-0.95*
1976	6814	537.4	0.13	-1.06
1977	7168	592.9	0.12	-1.05
1978	5200	480.4	0.14	-1.34
1979	9437	565.5	0.10	-1.47*
1980	7302	393.7	0.22	-0.84
1981	13566	472.5	0.16	-1.10
1982	6564	429.1	0.22	-0.70*
1983	9446	541.3	0.12	-1.31
1984	10173	427.9	0.19	-0.98
1985	8361	544.8	0.13	-1.15
1986	6350	397.8	0.21	-0.92
1987	4215	420.2	0.21	-0.76*

		Bias corrected values		
	n	L_∞	*K*	t_0
1988	9608	384.6	0.29	-0.59
1989	3806	332.8	0.40	-0.56
1990	5668	393.6	0.26	-0.79*
1991	7743	461.4	0.20	-1.25
1992	5775	626.9	0.13	-1.01
1993	3567	417.4	0.27	-0.82*
1994	5693	405.2	0.35	-0.25
1995	3201	414.8	0.34	-0.16*
1996	3329	455.6	0.23	-0.46
1997	3364	396.3	0.30	-0.46*
1998	4574	426.3	0.24	-1.09*
1999	3797	392.5	0.41	-0.26*
2000	2182	325.7	0.62	0.00
2001	3377	295.2	0.59	-0.47
2002	4238	363.0	0.35	-0.63
2003	3326	376.3	0.30	-0.83*
2004	2293	367.3	0.36	-0.25*
2005	4356	296.1	0.60	-0.19
2006	4009	302.2	0.55	-0.38
2007	1875	296.3	0.57	-0.43
2008	3544	402.5	0.22	-1.46*
2009	3325	292.1	0.58	-0.46
2010	4171	302.7	0.48	-0.68
2011	3676	301.6	0.47	-0.72

Table 2.3.2 Fork length (mm) at age on March 1 (beginning of fishing year) estimated from year class von Bertalanffy growth parameters with a bias correction. Shaded cells are the average from the three preceding estimated years.

Year	1	2	3	4	5	6+
1955	155.1	226.3	263.8	280.2	298.5	320.7
1956	151.5	222.7	268.3	290.0	302.3	312.7
1957	147.3	207.3	268.6	296.8	308.6	316.8
1958	157.6	207.3	255.2	299.8	316.1	321.9
1959	138.7	207.7	252.7	296.3	321.1	329.2
1960	169.9	195.2	250.3	287.0	331.6	335.5
1961	156.4	221.8	241.8	286.3	312.9	361.8
1962	164.5	218.1	263.8	280.1	316.9	332.4
1963	169.1	219.5	262.3	297.9	311.7	342.8
1964	171.7	222.7	256.6	294.0	325.5	337.7
1965	171.0	225.8	260.3	281.8	316.8	347.9
1966	162.1	231.2	265.0	286.8	298.9	333.1
1967	175.4	222.0	279.3	293.4	305.4	310.4
1968	168.7	241.8	274.3	317.7	314.1	318.5
1969	174.3	223.7	291.6	319.8	348.3	329.0
1970	184.5	229.5	272.8	328.8	359.5	372.8
1971	179.4	254.5	277.8	316.5	356.8	394.0
1972	161.6	256.5	309.1	320.1	355.5	377.7
1973	147.3	214.6	305.7	351.8	357.2	390.2
1974	149.9	222.3	260.2	337.1	385.1	389.8
1975	141.0	209.8	266.1	299.4	357.0	411.0
1976	132.1	190.9	255.4	291.5	333.1	369.8
1977	127.7	183.1	234.9	290.2	306.4	362.1
1978	129.1	178.4	225.2	273.6	316.7	315.1
1979	134.4	181.5	222.8	260.0	307.8	336.9
1980	128.2	179.6	228.1	261.7	288.8	337.9
1981	131.0	171.4	218.9	269.3	295.8	312.6
1982	136.4	182.9	210.3	253.1	305.9	325.7
1983	132.1	186.6	224.5	245.4	282.8	338.4
1984	134.6	190.0	229.4	257.9	277.0	308.6
1985	131.4	182.0	236.6	265.7	284.7	305.5
1986	129.3	181.5	223.9	274.2	296.7	306.2
1987	133.8	178.5	223.1	260.9	304.4	323.0
1988	130.1	184.7	221.9	257.7	293.6	328.7
1989	140.4	185.0	225.7	260.1	286.4	322.5
1990	154.9	200.9	229.6	258.9	293.8	310.3
1991	147.9	213.8	246.5	265.7	285.6	323.5
1992	163.6	204.7	253.2	280.7	294.9	307.2
1993	143.2	216.4	248.4	279.6	306.5	318.7
1994	162.2	201.7	259.8	282.0	297.2	325.9
1995	142.8	222.6	253.2	295.5	307.8	309.0
1996	134.3	219.7	268.7	298.4	324.9	327.6
1997	131.9	214.7	274.1	303.9	338.2	349.1
1998	141.7	199.5	272.1	312.6	330.7	373.1

Year	1	2	3	4	5	6+
1999	169.9	208.2	252.9	313.0	339.7	351.2
2000	158.2	225.2	257.4	295.2	342.2	358.9
2001	150.1	237.0	268.6	293.7	328.6	363.1
2002	170.9	231.1	289.3	302.6	320.5	355.1
2003	156.7	226.2	274.7	324.0	329.3	340.3
2004	158.1	217.0	256.9	298.2	347.1	350.2
2005	134.0	214.3	259.7	273.9	310.9	362.3
2006	151.6	204.8	256.1	289.9	283.4	317.7
2007	160.5	216.9	254.2	287.1	311.3	288.6
2008	164.8	220.3	252.6	288.5	310.1	326.4
2009	165.5	221.9	254.8	272.3	312.4	327.1
2010	166.4	211.3	254.2	274.8	283.0	329.1
2011	168.1	221.4	248.3	272.5	286.4	288.9
2012	167.0	219.6	252.4	278.1	282.8	293.0
2013	167.2	217.4	251.3	269.8	302.2	288.7
2014	167.2	219.5	248.9	271.0	279.6	321.6
2015	167.2	219.5	250.9	268.6	283.1	285.1
2016	167.2	219.5	250.9	269.8	281.0	290.6

Table 2.3.3 Weight (g) at age on September 1 (middle of fishing year) estimated from overall weight-length parameters and annual lengths at age. Shaded cells are the average from the three preceding estimated years.

Year	0	1	2	3	4	5	6+
1955	36.7	126.2	279.1	397.5	459.9	533.3	622.6
1956	25.3	105.8	269.1	431.5	502.2	563.4	606.7
1957	43.2	94.0	232.5	410.6	545.5	586.4	634.6
1958	24.0	110.2	227.0	368.9	530.1	622.7	651.3
1959	62.8	77.5	230.6	367.0	494.1	622.4	672.2
1960	35.3	132.3	189.8	363.2	488.8	599.3	690.3
1961	51.6	118.9	254.9	328.0	489.7	585.0	683.1
1962	57.5	128.0	265.9	396.4	471.3	600.8	656.5
1963	62.0	140.9	248.2	407.2	542.2	606.4	693.4
1964	63.7	142.7	266.4	360.2	520.9	682.4	726.0
1965	52.8	143.7	270.0	377.5	450.9	604.4	810.9
1966	65.6	121.0	280.1	392.7	462.8	518.8	662.5
1967	63.8	158.4	251.0	426.5	496.4	523.7	567.4
1968	73.0	124.8	307.7	411.7	565.3	577.8	565.3
1969	75.6	138.4	243.6	452.7	587.6	687.3	638.9
1970	55.7	177.6	258.8	404.1	575.4	766.0	789.5
1971	48.4	167.4	344.6	411.4	603.0	671.5	937.8
1972	24.8	125.4	339.9	511.8	588.8	834.8	743.4
1973	40.5	118.0	263.8	486.2	658.5	783.1	1093.6
1974	28.6	104.0	266.0	414.5	591.5	777.6	986.9
1975	27.1	84.2	213.8	377.5	556.6	661.3	870.0
1976	18.0	67.4	186.2	328.0	445.9	679.7	705.5
1977	21.2	64.2	145.2	294.9	430.8	484.3	781.1
1978	28.9	68.1	157.4	240.2	393.5	516.1	504.9
1979	25.3	67.8	161.4	262.4	341.6	475.4	583.3
1980	22.1	55.7	141.2	269.1	361.0	441.2	539.7
1981	20.8	69.0	117.5	230.4	373.8	444.8	534.0
1982	24.9	71.9	159.3	202.1	325.7	466.2	511.8
1983	30.6	69.9	171.6	260.0	306.0	420.0	543.2
1984	23.8	67.7	157.8	279.9	354.8	425.0	508.6
1985	21.9	67.5	138.9	262.0	378.1	436.1	554.5
1986	25.5	65.9	150.3	228.9	367.8	458.8	502.1
1987	25.9	73.7	149.9	243.7	330.5	466.1	521.5
1988	27.3	69.0	160.6	243.7	333.8	437.1	552.5
1989	41.2	93.2	150.8	252.2	332.5	413.4	543.4
1990	37.5	114.7	207.7	246.0	334.3	409.3	479.9
1991	52.5	94.0	228.2	315.9	341.6	401.8	472.1
1992	30.1	128.3	192.9	327.1	401.2	429.6	454.3
1993	51.0	95.3	247.2	298.8	400.7	462.7	506.4
1994	25.2	122.8	218.5	358.6	397.3	451.5	504.8
1995	23.5	118.6	243.0	351.9	449.3	481.7	484.8
1996	18.2	98.5	286.6	366.4	473.6	517.7	550.5
1997	29.7	88.3	243.1	435.1	477.0	574.9	567.0
1998	61.1	94.7	227.0	388.4	541.6	568.5	654.4

Year	0	1	2	3	4	5	6+
1999	40.3	134.7	219.5	363.3	507.8	610.8	640.7
2000	28.2	136.2	261.3	357.0	471.4	596.4	653.6
2001	55.4	128.0	291.6	400.2	484.6	548.7	658.6
2002	37.8	145.9	289.3	426.1	535.1	592.5	600.9
2003	48.1	116.9	262.8	414.7	523.7	656.8	678.6
2004	24.8	114.4	242.1	345.9	494.5	588.5	761.4
2005	35.3	88.3	224.0	350.8	397.0	540.9	629.6
2006	43.6	114.2	199.2	334.7	430.7	426.2	566.7
2007	53.7	129.6	233.0	303.1	432.7	484.5	442.5
2008	59.7	134.8	252.5	328.1	384.1	512.8	519.3
2009	53.4	117.6	245.6	347.3	392.2	441.6	575.2
2010	57.7	134.6	215.1	331.7	409.4	432.1	480.5
2011	56.9	132.7	241.5	324.0	389.7	447.2	455.8
2012	56.9	128.1	239.1	320.4	433.7	426.1	469.2
2013	56.9	128.1	231.8	328.5	371.1	537.1	448.1
2014	56.9	128.1	231.8	324.3	394.4	401.3	630.4
2015	56.9	128.1	231.8	324.3	399.2	439.6	418.9
2016	56.9	128.1	231.8	324.3	399.2	457.1	469.5

Table 2.5.1 Fecundity (number of ova) at age on March 1 (beginning of fishing year) estimated from annual lengths.

Year	1	2	3	4	5	6+
1955	26267	76356	134072	171499	225574	314702
1956	24883	72366	143502	198473	238833	279006
1957	23368	57467	144117	219979	262471	296958
1958	27254	57476	117858	230192	293759	320304
1959	20527	57823	113474	218295	316474	357302
1960	32777	47911	109417	189742	370470	392930
1961	26775	71349	96300	187906	279836	583275
1962	30235	67500	134037	171141	297215	375348
1963	32403	68920	131049	223455	274818	438442
1964	33692	72330	120396	210941	338151	405941
1965	33326	75794	127224	175648	296815	473099
1966	29143	82221	136478	189256	226831	379233
1967	35572	71658	169108	209101	250238	269709
1968	32194	96373	156906	300776	284953	304553
1969	35028	73488	203311	310553	476360	356683
1970	40785	80098	153362	355629	562879	687690
1971	37767	116588	165349	295467	540609	944933
1972	28938	120135	264616	312075	530105	739806
1973	23352	64090	251253	501646	544506	892560
1974	24271	71970	126973	402194	826354	886857
1975	21245	59625	138682	228571	542898	1219898
1976	18604	44895	118252	203248	378919	657341
1977	17400	39935	86830	199236	253960	585202
1978	17768	37208	75112	155318	296465	289161
1979	19244	39023	72427	126644	259346	401304
1980	17524	37913	78409	129836	195075	407546
1981	18298	33502	68360	145595	216542	278839
1982	19817	39834	60076	114123	252076	339017
1983	18579	42124	74366	101690	178182	410168
1984	19306	44310	79989	122730	163410	262470
1985	18410	39323	89194	137999	183470	250572
1986	17838	39010	73718	156641	219434	253334
1987	19072	37306	72816	128431	246471	325540
1988	18035	40898	71494	122319	209725	354998
1989	21041	41123	75715	126859	188243	323439
1990	26177	52198	80213	124490	210324	269352
1991	23564	63325	103370	137864	185986	328444
1992	29834	55250	114350	172802	213846	257181
1993	21955	65819	106374	169801	254310	305240
1994	29190	52835	126214	176012	221209	340065
1995	21827	72214	114326	215661	259222	264026
1996	19204	69223	144185	225319	335133	349075
1997	18541	64206	156512	244434	409063	481664
1998	21465	51057	151852	278590	365730	690935
1999	32798	58256	113812	280572	418758	497451

Year	1	2	3	4	5	6+
2000	27487	75179	121790	214629	434711	558555
2001	24369	89659	144090	209972	354575	594044
2002	33274	82031	196498	240004	313961	527521
2003	26878	76273	157805	330756	358097	422592
2004	27465	66446	120859	224531	467296	490110
2005	19130	63834	126059	156028	271539	587754
2006	24912	55360	119383	198305	179784	300837
2007	28460	66301	116016	190006	273240	194493
2008	30382	69774	113395	194201	268277	342797
2009	30670	71500	117175	152188	277993	346570
2010	31077	61013	116070	158122	178830	356863
2011	31910	70991	106252	152698	188034	195368
2012	31398	69046	112949	166207	178345	207843
2013	31475	66874	111211	146641	238433	194730
2014	31475	68970	107228	149274	169818	318982
2015	31475	68970	110463	144125	179031	184421
2016	31475	68970	110463	146669	173416	200300

Table 3.1.3.1 Total menhaden reduction landings (1000s mt) 1940-2016, divided into northern and southern reduction landings.

Year	Landings (1000 t)	Northern landings (1000 t)	Southern landings (1000 t)
1940	217.7		
1941	277.9		
1942	167.2		
1943	237.2		
1944	257.9		
1945	295.9		
1946	362.4		
1947	378.3		
1948	346.5		
1949	363.8		
1950	297.2		
1951	361.4		
1952	409.9		
1953	593.2		
1954	608.1		
1955	644.5	402.7	241.7
1956	715.2	478.9	236.4
1957	605.6	389.8	215.8
1958	512.4	248.3	264.0
1959	662.2	318.4	343.7
1960	532.2	323.9	208.4
1961	578.6	334.8	243.9
1962	540.7	321.4	219.3
1963	348.4	147.5	200.9
1964	270.4	50.6	219.8
1965	274.6	58.0	216.6
1966	220.7	7.9	212.8
1967	194.4	17.2	177.2
1968	235.9	33.1	202.8
1969	162.3	15.4	146.9
1970	259.4	15.8	243.6
1971	250.3	33.4	216.9
1972	365.9	69.1	296.8
1973	346.9	90.7	256.2
1974	292.2	77.9	214.3
1975	250.2	48.4	201.8

Year	Landings (1000 t)	Northern landings (1000 t)	Southern landings (1000 t)
1976	340.5	86.8	253.7
1977	341.2	53.3	287.8
1978	344.1	63.5	280.5
1979	375.7	70.2	305.6
1980	401.5	83.0	318.5
1981	381.3	68.1	313.2
1982	382.5	35.1	347.4
1983	418.6	39.4	379.3
1984	326.3	35.0	291.3
1985	306.7	111.3	195.4
1986	238.0	42.6	195.4
1987	326.9	83.0	243.9
1988	309.3	73.6	235.6
1989	322.0	98.8	223.2
1990	401.1	144.1	257.1
1991	381.4	104.6	276.9
1992	297.6	99.1	198.5
1993	320.6	58.4	262.2
1994	260.0	33.4	226.6
1995	339.9	96.3	243.6
1996	292.9	61.6	231.4
1997	259.1	25.2	234.0
1998	245.9	12.3	233.6
1999	171.2	8.4	162.8
2000	167.3	43.2	124.1
2001	233.6	39.6	193.9
2002	174.1	27.2	146.9
2003	166.1	4.1	162.0
2004	178.5	25.9	152.6
2005	152.9	15.4	137.5
2006	157.4	60.1	97.2
2007	174.5	36.6	137.8
2008	141.1	39.3	101.8
2009	143.8	18.7	125.1
2010	183.1	28.7	154.4
2011	174.0	29.6	144.5
2012	160.6	23.9	136.7
2013	131.0	32.7	98.3
2014	131.1	29.9	101.2
2015	143.5	28.8	114.7
2016	137.4	45.0	92.4

Table 3.1.4.1 Catch-at-age for the northern commercial reduction fishery from 1955-2016.

Year	0	1	2	3	4	5	6+
1955	0.000	0.015	0.471	0.217	0.253	0.032	0.012
1956	0.000	0.133	0.555	0.195	0.025	0.072	0.020
1957	0.000	0.270	0.610	0.051	0.033	0.017	0.020
1958	0.000	0.025	0.908	0.042	0.010	0.008	0.009
1959	0.000	0.531	0.291	0.159	0.009	0.004	0.007
1960	0.000	0.009	0.892	0.037	0.049	0.009	0.004
1961	0.000	0.003	0.160	0.803	0.012	0.018	0.003
1962	0.000	0.015	0.245	0.218	0.457	0.033	0.032
1963	0.000	0.296	0.438	0.095	0.068	0.080	0.023
1964	0.000	0.034	0.357	0.345	0.128	0.065	0.072
1965	0.000	0.160	0.370	0.373	0.071	0.013	0.014
1966	0.000	0.201	0.467	0.212	0.100	0.009	0.012
1967	0.000	0.055	0.296	0.567	0.072	0.009	0.000
1968	0.000	0.007	0.479	0.388	0.116	0.009	0.001
1969	0.000	0.001	0.251	0.594	0.149	0.005	0.000
1970	0.000	0.150	0.793	0.050	0.007	0.000	0.000
1971	0.000	0.126	0.288	0.433	0.137	0.017	0.000
1972	0.000	0.169	0.286	0.452	0.085	0.008	0.000
1973	0.000	0.021	0.821	0.133	0.024	0.001	0.000
1974	0.000	0.028	0.844	0.117	0.006	0.004	0.000
1975	0.000	0.000	0.798	0.175	0.025	0.001	0.000
1976	0.000	0.092	0.823	0.071	0.013	0.000	0.000
1977	0.000	0.022	0.567	0.326	0.079	0.006	0.001
1978	0.000	0.000	0.298	0.567	0.120	0.015	0.000
1979	0.000	0.007	0.579	0.332	0.076	0.006	0.000
1980	0.000	0.002	0.237	0.462	0.243	0.051	0.004
1981	0.000	0.001	0.357	0.357	0.210	0.070	0.006
1982	0.000	0.042	0.393	0.473	0.063	0.025	0.004
1983	0.000	0.012	0.826	0.120	0.037	0.005	0.000
1984	0.000	0.024	0.343	0.506	0.097	0.029	0.001
1985	0.000	0.020	0.760	0.089	0.111	0.017	0.003
1986	0.000	0.010	0.795	0.107	0.050	0.031	0.006
1987	0.000	0.005	0.652	0.277	0.058	0.006	0.002
1988	0.000	0.000	0.225	0.486	0.260	0.026	0.003
1989	0.000	0.081	0.623	0.173	0.097	0.025	0.000
1990	0.000	0.011	0.788	0.134	0.049	0.018	0.001
1991	0.000	0.085	0.430	0.385	0.072	0.023	0.005
1992	0.000	0.058	0.687	0.107	0.118	0.026	0.004
1993	0.000	0.045	0.675	0.226	0.036	0.017	0.002
1994	0.000	0.017	0.420	0.333	0.183	0.047	0.000
1995	0.000	0.020	0.567	0.329	0.079	0.006	0.000
1996	0.000	0.000	0.579	0.320	0.092	0.008	0.000
1997	0.000	0.000	0.495	0.293	0.158	0.055	0.000
1998	0.000	0.000	0.657	0.281	0.062	0.000	0.000
1999	0.000	0.000	0.389	0.428	0.168	0.015	0.000
2000	0.000	0.005	0.559	0.406	0.019	0.011	0.000

Year	0	1	2	3	4	5	6+
2001	0.000	0.000	0.150	0.796	0.055	0.000	0.000
2002	0.000	0.040	0.347	0.491	0.120	0.002	0.000
2003	0.000	0.000	0.474	0.378	0.139	0.010	0.000
2004	0.000	0.004	0.615	0.320	0.061	0.000	0.000
2005	0.000	0.000	0.219	0.605	0.174	0.002	0.000
2006	0.000	0.022	0.456	0.422	0.099	0.001	0.000
2007	0.000	0.022	0.761	0.174	0.041	0.002	0.000
2008	0.000	0.002	0.216	0.668	0.106	0.008	0.000
2009	0.000	0.123	0.299	0.463	0.102	0.013	0.000
2010	0.000	0.000	0.456	0.348	0.193	0.003	0.000
2011	0.000	0.058	0.726	0.190	0.023	0.003	0.000
2012	0.000	0.001	0.778	0.192	0.029	0.000	0.000
2013	0.000	0.028	0.724	0.233	0.015	0.000	0.000
2014	0.000	0.085	0.518	0.274	0.119	0.004	0.000
2015	0.000	0.006	0.593	0.362	0.038	0.000	0.000
2016	0.000	0.075	0.413	0.481	0.031	0.000	0.000

Table 3.1.4.2 Catch-at-age for the southern commercial reduction fishery from 1955-2016.

Year	0	1	2	3	4	5	6+
1955	0.374	0.323	0.269	0.016	0.016	0.002	0.000
1956	0.017	0.885	0.049	0.018	0.004	0.022	0.004
1957	0.151	0.598	0.217	0.010	0.011	0.007	0.006
1958	0.059	0.466	0.443	0.018	0.005	0.005	0.004
1959	0.003	0.855	0.099	0.034	0.005	0.002	0.002
1960	0.052	0.192	0.701	0.018	0.025	0.008	0.004
1961	0.000	0.538	0.217	0.234	0.004	0.007	0.000
1962	0.040	0.387	0.491	0.033	0.044	0.003	0.002
1963	0.079	0.460	0.386	0.059	0.007	0.008	0.002
1964	0.187	0.433	0.349	0.028	0.002	0.000	0.000
1965	0.184	0.528	0.269	0.018	0.001	0.000	0.000
1966	0.265	0.414	0.299	0.020	0.001	0.000	0.000
1967	0.007	0.663	0.269	0.057	0.003	0.000	0.000
1968	0.143	0.349	0.468	0.037	0.003	0.000	0.000
1969	0.188	0.442	0.330	0.038	0.002	0.000	0.000
1970	0.016	0.650	0.309	0.022	0.003	0.000	0.000
1971	0.083	0.288	0.569	0.054	0.005	0.001	0.000
1972	0.033	0.618	0.285	0.061	0.003	0.000	0.000
1973	0.036	0.372	0.591	0.001	0.000	0.000	0.000
1974	0.196	0.388	0.413	0.003	0.000	0.000	0.000
1975	0.154	0.371	0.469	0.006	0.001	0.000	0.000
1976	0.101	0.572	0.324	0.003	0.000	0.000	0.000
1977	0.140	0.289	0.567	0.003	0.000	0.000	0.000
1978	0.158	0.230	0.558	0.050	0.003	0.000	0.000
1979	0.413	0.172	0.403	0.012	0.001	0.000	0.000
1980	0.028	0.476	0.452	0.038	0.004	0.001	0.000
1981	0.316	0.186	0.460	0.038	0.000	0.000	0.000
1982	0.038	0.306	0.558	0.096	0.001	0.000	0.000
1983	0.279	0.148	0.547	0.016	0.008	0.001	0.000
1984	0.396	0.311	0.244	0.040	0.007	0.002	0.000
1985	0.235	0.394	0.364	0.006	0.000	0.000	0.000
1986	0.056	0.126	0.797	0.019	0.002	0.001	0.000
1987	0.022	0.253	0.691	0.031	0.003	0.000	0.000
1988	0.175	0.146	0.573	0.099	0.006	0.001	0.000
1989	0.069	0.514	0.402	0.014	0.001	0.000	0.000
1990	0.190	0.078	0.697	0.023	0.010	0.002	0.000
1991	0.317	0.360	0.281	0.038	0.004	0.001	0.000
1992	0.243	0.428	0.313	0.014	0.002	0.000	0.000
1993	0.049	0.266	0.608	0.074	0.003	0.000	0.000
1994	0.064	0.197	0.609	0.094	0.035	0.002	0.000
1995	0.044	0.408	0.366	0.150	0.031	0.002	0.000
1996	0.036	0.226	0.630	0.092	0.015	0.001	0.000
1997	0.027	0.260	0.423	0.236	0.047	0.007	0.001
1998	0.073	0.187	0.535	0.123	0.073	0.009	0.001
1999	0.188	0.292	0.428	0.069	0.020	0.003	0.000
2000	0.140	0.205	0.510	0.127	0.016	0.002	0.000

Year	0	1	2	3	4	5	6+
2001	0.039	0.073	0.604	0.265	0.018	0.001	0.000
2002	0.242	0.284	0.321	0.140	0.012	0.000	0.000
2003	0.088	0.185	0.643	0.073	0.010	0.001	0.000
2004	0.020	0.234	0.670	0.060	0.015	0.001	0.000
2005	0.020	0.131	0.618	0.210	0.018	0.003	0.000
2006	0.016	0.525	0.378	0.072	0.008	0.000	0.000
2007	0.001	0.306	0.631	0.054	0.008	0.000	0.000
2008	0.017	0.115	0.812	0.053	0.003	0.000	0.000
2009	0.007	0.515	0.311	0.147	0.019	0.001	0.000
2010	0.017	0.447	0.494	0.034	0.008	0.000	0.000
2011	0.000	0.477	0.467	0.048	0.007	0.002	0.000
2012	0.007	0.183	0.789	0.020	0.001	0.000	0.000
2013	0.043	0.457	0.388	0.095	0.016	0.000	0.000
2014	0.007	0.482	0.377	0.106	0.026	0.002	0.000
2015	0.000	0.141	0.759	0.092	0.009	0.000	0.000
2016	0.022	0.303	0.509	0.160	0.006	0.000	0.000

Table 3.2.1.1 Atlantic menhaden historical bait landings from 1950-1984 and recent bait landings (1000 mt) from 1985-2016.

Year	Historic Bait (1000 mt)	Year	Recent Bait (1000 mt)
1950	11.3	1985	26.6
1951	20.4	1986	21.6
1952	14.2	1987	25.5
1953	25.8	1988	43.8
1954	19.3	1989	31.5
1955	14.6	1990	28.1
1956	23.3	1991	29.7
1957	24.7	1992	33.8
1958	14.7	1993	23.4
1959	20.6	1994	25.6
1960	19.4	1995	28.4
1961	25.1	1996	21.7
1962	26.6	1997	24.2
1963	24.4	1998	38.4
1964	20.2	1999	34.8
1965	23.6	2000	33.5
1966	13.7	2001	35.3
1967	11.6	2002	36.2
1968	9.5	2003	33.2
1969	10.6	2004	34.0
1970	21.6	2005	38.4
1971	13.5	2006	27.2
1972	10.3	2007	42.1
1973	14.8	2008	47.6
1974	14.5	2009	39.2
1975	21.7	2010	42.7
1976	19.6	2011	52.6
1977	23.1	2012	63.7
1978	25.9	2013	37.0
1979	13	2014	41.6
1980	26.2	2015	45.8
1981	22.4	2016	43.1
1982	19.9		
1983	19.1		
1984	14.3		

Table 3.2.3.1 Catch-at-age for the northern commercial bait fishery (includes small amount of recreational catch).

Year	0	1	2	3	4	5	6+
1985	0.000	0.000	0.671	0.180	0.117	0.025	0.006
1986	0.000	0.000	0.088	0.624	0.259	0.027	0.003
1987	0.000	0.000	0.087	0.624	0.259	0.027	0.003
1988	0.000	0.000	0.074	0.632	0.264	0.027	0.003
1989	0.000	0.000	0.083	0.627	0.261	0.027	0.003
1990	0.000	0.000	0.119	0.605	0.247	0.026	0.003
1991	0.000	0.000	0.153	0.584	0.234	0.026	0.003
1992	0.000	0.000	0.180	0.567	0.224	0.026	0.003
1993	0.000	0.000	0.215	0.546	0.211	0.025	0.003
1994	0.000	0.000	0.107	0.498	0.343	0.048	0.004
1995	0.000	0.000	0.086	0.478	0.434	0.002	0.000
1996	0.000	0.000	0.437	0.439	0.118	0.005	0.000
1997	0.000	0.000	0.152	0.326	0.388	0.116	0.018
1998	0.004	0.000	0.109	0.399	0.396	0.078	0.013
1999	0.005	0.000	0.149	0.483	0.311	0.041	0.010
2000	0.000	0.004	0.410	0.322	0.228	0.029	0.007
2001	0.000	0.000	0.113	0.734	0.135	0.014	0.004
2002	0.000	0.000	0.058	0.568	0.318	0.055	0.000
2003	0.000	0.000	0.127	0.666	0.197	0.010	0.000
2004	0.000	0.000	0.252	0.523	0.198	0.025	0.003
2005	0.000	0.000	0.227	0.538	0.207	0.025	0.003
2006	0.000	0.004	0.269	0.575	0.144	0.008	0.000
2007	0.000	0.000	0.386	0.495	0.110	0.008	0.002
2008	0.000	0.000	0.246	0.608	0.132	0.014	0.000
2009	0.000	0.000	0.181	0.616	0.185	0.017	0.000
2010	0.000	0.000	0.365	0.393	0.216	0.024	0.002
2011	0.000	0.000	0.142	0.488	0.325	0.044	0.000
2012	0.000	0.000	0.392	0.473	0.125	0.008	0.002
2013	0.000	0.000	0.254	0.563	0.157	0.026	0.000
2014	0.000	0.000	0.059	0.642	0.270	0.027	0.002
2015	0.000	0.000	0.059	0.642	0.270	0.027	0.002
2016	0.000	0.000	0.078	0.709	0.175	0.039	0.000

Table 3.2.3.2 Catch-at-age for the southern commercial bait fishery (includes small amount of recreational catch).

Year	0	1	2	3	4	5	6
1985	0.003	0.176	0.611	0.172	0.034	0.003	0.000
1986	0.003	0.148	0.644	0.172	0.030	0.003	0.000
1987	0.003	0.133	0.678	0.153	0.031	0.003	0.000
1988	0.003	0.161	0.616	0.180	0.035	0.003	0.000
1989	0.003	0.148	0.652	0.164	0.030	0.003	0.000
1990	0.005	0.320	0.532	0.118	0.022	0.002	0.000
1991	0.002	0.246	0.607	0.120	0.022	0.002	0.000
1992	0.005	0.320	0.532	0.118	0.022	0.002	0.000
1993	0.010	0.397	0.418	0.144	0.029	0.003	0.000
1994	0.003	0.198	0.622	0.147	0.027	0.003	0.000
1995	0.000	0.392	0.374	0.218	0.017	0.000	0.000
1996	0.001	0.049	0.738	0.179	0.033	0.000	0.000
1997	0.000	0.083	0.521	0.303	0.074	0.012	0.006
1998	0.039	0.067	0.534	0.237	0.108	0.012	0.003
1999	0.000	0.053	0.722	0.169	0.049	0.006	0.000
2000	0.008	0.234	0.639	0.118	0.001	0.000	0.000
2001	0.003	0.061	0.685	0.235	0.014	0.003	0.000
2002	0.000	0.041	0.255	0.504	0.178	0.020	0.002
2003	0.006	0.099	0.752	0.130	0.013	0.000	0.000
2004	0.000	0.068	0.736	0.163	0.030	0.003	0.000
2005	0.000	0.015	0.528	0.430	0.024	0.003	0.000
2006	0.000	0.290	0.485	0.201	0.024	0.000	0.000
2007	0.000	0.273	0.688	0.028	0.011	0.000	0.000
2008	0.000	0.039	0.865	0.080	0.013	0.003	0.000
2009	0.004	0.264	0.414	0.288	0.030	0.000	0.000
2010	0.000	0.367	0.545	0.065	0.023	0.000	0.000
2011	0.000	0.391	0.514	0.080	0.015	0.000	0.000
2012	0.000	0.089	0.892	0.018	0.000	0.000	0.000
2013	0.009	0.612	0.284	0.091	0.003	0.000	0.000
2014	0.000	0.523	0.328	0.090	0.058	0.000	0.000
2015	0.000	0.248	0.702	0.050	0.000	0.000	0.000
2016	0.000	0.283	0.437	0.264	0.016	0.000	0.000

Table 4.2.1.1 Values for each index used in the assessment and the associated CV values included in the stock assessment. Each index is scaled to its mean value.

Year	YOY index	CV	SAD index	CV	NAD index	CV
1959	0.69	0.93				
1960	0.33	0.92				
1961	0.31	0.94				
1962	1.67	0.86				
1963	1.02	1.04				
1964	0.16	0.98				
1965	0.43	0.88				
1966	0.61	0.95				
1967	0.81	0.98				
1968	0.58	0.81				
1969	0.64	0.75				
1970	0.40	0.87				
1971	1.64	0.74				
1972	2.06	0.70				
1973	1.50	0.86				
1974	2.19	0.81				
1975	2.99	0.82				
1976	3.46	0.80				
1977	2.91	0.82				
1978	1.58	0.82				
1979	2.46	0.80				
1980	1.57	0.63			0.67	0.71
1981	2.38	0.68			0.41	0.80
1982	2.23	0.65			2.33	0.64
1983	1.16	0.69			0.85	0.68
1984	0.91	0.73			0.37	0.88
1985	1.71	0.52			0.67	0.74
1986	1.07	0.56			3.73	0.62
1987	0.43	0.55			3.45	0.63
1988	1.34	0.50			1.70	0.37
1989	1.34	0.44			1.07	0.39
1990	1.57	0.43	3.34	0.64	0.54	0.37
1991	1.14	0.43	1.08	0.52	0.65	0.36
1992	0.71	0.43	0.69	0.58	0.61	0.34
1993	0.16	0.48	0.47	0.58	0.53	0.42
1994	0.58	0.44	0.44	0.61	0.27	0.42
1995	0.36	0.41	0.14	0.45	0.48	0.37
1996	0.31	0.40	0.72	0.47	0.22	0.40
1997	0.54	0.39	0.48	0.53	0.18	0.36
1998	0.55	0.43	0.56	0.59	0.14	0.39

Year	YOY index	CV	SAD index	CV	NAD index	CV
1999	0.80	0.46	0.47	0.58	0.36	0.34
2000	0.71	0.41	0.77	0.71	0.25	0.34
2001	0.41	0.40	0.61	0.59	0.27	0.42
2002	0.96	0.41	0.66	0.57	0.54	0.36
2003	0.50	0.39	0.60	0.65	0.21	0.32
2004	0.63	0.39	0.45	0.48	0.31	0.34
2005	0.83	0.38	1.21	0.45	0.66	0.34
2006	0.38	0.38	3.72	0.45	0.74	0.31
2007	0.58	0.39	0.26	0.48	1.18	0.29
2008	0.41	0.37	0.44	0.46	1.20	0.44
2009	0.34	0.38	2.73	0.55	1.07	0.35
2010	0.63	0.39	0.66	0.42	0.94	0.31
2011	0.35	0.38	2.94	0.41	1.63	0.33
2012	0.24	0.37	1.00	0.41	1.42	0.31
2013	0.24	0.37	0.77	0.41	1.21	0.33
2014	0.49	0.37	0.66	0.48	2.44	0.31
2015	0.41	0.41	0.69	0.40	1.24	0.33
2016	0.62	0.42	0.42	0.55	2.50	0.34

Table 6.2.1.1 Selectivity slope and A_{50} of the ascending and descending limbs with associated SE for the bait and reduction fisheries, and the NAD and SAD indices.

			Ascending Limb				Descending Limb			
Fishery/Index	**Region**	**Period**	**Slope**	**SE**	**A50**	**SE**	**Slope**	**SE**	**A50**	**SE**
Reduction	North	1955-1969	3.63	0.18	2.32	0.10	1.67	4.17	3.81	3.14
Reduction	North	1969-1993	5.31	0.93	2.13	0.10	1.49	1.91	2.83	1.23
Reduction	North	1994-2016	5.19	2.13	2.21	0.14	0.54	0.42	1.50	0.04
Reduction	South	1955-1971	3.92	0.24	1.15	0.05	2.08	1.25	1.75	0.02
Reduction	South	1972-2004	2.16	0.15	3.33	0.18	4.36	0.87	-1.00	0.003
Reduction	South	2005-2016	4.80	1.88	1.36	0.15	1.44	0.85	1.50	0.001
Bait	North	1955-2016	5.71	2.23	2.47	0.21	4.27	3.29	2.19	0.46
Bait	South	1955-2016	36.21	28306	1.08	62.8	0.67	1.16	2.98	6.28
NAD	North		2.42	5318	2.09	20.56	NA	NA	NA	NA
SAD	South		35.0	0.016	0.13	0.033	4.08	0.04	1.75	0.02

Table 6.2.2.1 Fishing mortality rate at age estimates from 1955-2016.

Ages	0	1	2	3	4	5	6+
1955	0.006	0.210	1.137	2.992	2.953	2.522	1.596
1956	0.011	0.369	3.167	10.457	10.710	9.069	5.718
1957	0.008	0.287	2.502	8.348	8.535	7.081	4.437
1958	0.008	0.276	1.358	3.259	3.160	2.696	1.707
1959	0.008	0.262	1.772	5.148	5.183	4.433	2.805
1960	0.003	0.087	0.502	1.372	1.361	1.142	0.719
1961	0.005	0.179	0.601	0.880	0.735	0.608	0.383
1962	0.009	0.301	1.078	1.765	1.537	1.276	0.804
1963	0.010	0.325	1.252	2.189	1.948	1.586	0.994
1964	0.011	0.349	1.076	1.281	0.956	0.703	0.430
1965	0.013	0.424	1.337	1.537	1.137	0.868	0.538
1966	0.014	0.465	1.229	0.836	0.354	0.181	0.101
1967	0.009	0.294	0.828	0.707	0.411	0.279	0.169
1968	0.009	0.302	0.834	0.741	0.447	0.326	0.201
1969	0.008	0.262	0.705	0.509	0.241	0.148	0.088
1970	0.010	0.329	0.922	0.644	0.274	0.123	0.051
1971	0.009	0.283	0.792	0.635	0.309	0.144	0.053
1972	0.036	0.309	2.318	1.498	0.619	0.350	0.130
1973	0.021	0.187	1.664	1.714	1.085	0.612	0.222
1974	0.017	0.155	1.371	1.358	0.841	0.481	0.177
1975	0.016	0.145	1.202	0.987	0.544	0.311	0.121
1976	0.016	0.139	1.215	1.162	0.706	0.408	0.153
1977	0.015	0.129	1.012	0.713	0.337	0.193	0.076
1978	0.014	0.129	1.007	0.695	0.322	0.187	0.075
1979	0.016	0.144	1.093	0.728	0.315	0.181	0.068
1980	0.023	0.205	1.595	1.101	0.507	0.296	0.117
1981	0.019	0.168	1.330	0.976	0.479	0.277	0.107
1982	0.023	0.206	1.506	0.844	0.281	0.156	0.063
1983	0.026	0.224	1.636	0.921	0.307	0.170	0.067
1984	0.028	0.244	1.798	1.052	0.377	0.209	0.082
1985	0.011	0.105	1.096	1.491	1.082	0.582	0.207
1986	0.008	0.068	0.545	0.468	0.266	0.129	0.045
1987	0.011	0.097	0.767	0.578	0.291	0.159	0.059
1988	0.017	0.156	1.208	0.827	0.382	0.204	0.080
1989	0.023	0.205	1.733	1.573	0.929	0.502	0.185
1990	0.013	0.119	1.237	1.853	1.387	0.687	0.229
1991	0.017	0.153	1.329	1.417	0.917	0.459	0.157
1992	0.012	0.111	1.063	1.449	1.052	0.500	0.164
1993	0.016	0.137	1.092	0.980	0.572	0.261	0.086
1994	0.015	0.129	0.972	0.774	0.396	0.184	0.100
1995	0.031	0.278	2.280	2.201	1.257	0.733	0.455
1996	0.019	0.174	1.539	2.152	1.506	0.707	0.384

Ages	0	1	2	3	4	5	6+
1997	0.025	0.226	1.743	1.520	0.853	0.362	0.182
1998	0.027	0.244	1.830	1.450	0.769	0.288	0.128
1999	0.018	0.167	1.287	1.117	0.646	0.235	0.100
2000	0.011	0.100	0.920	1.252	0.871	0.435	0.246
2001	0.016	0.140	1.120	0.996	0.555	0.293	0.171
2002	0.016	0.142	1.133	0.923	0.492	0.254	0.146
2003	0.017	0.156	1.165	0.709	0.290	0.123	0.061
2004	0.011	0.097	0.792	0.751	0.446	0.218	0.121
2005	0.001	0.114	0.708	0.641	0.381	0.166	0.082
2006	0.001	0.071	0.543	0.803	0.566	0.314	0.187
2007	0.001	0.070	0.466	0.606	0.422	0.184	0.093
2008	0.001	0.060	0.411	0.533	0.372	0.165	0.084
2009	0.001	0.077	0.474	0.473	0.295	0.118	0.055
2010	0.001	0.097	0.591	0.657	0.428	0.167	0.076
2011	0.001	0.086	0.549	0.721	0.509	0.192	0.084
2012	0.001	0.058	0.387	0.619	0.474	0.157	0.059
2013	0.000	0.051	0.327	0.379	0.251	0.111	0.057
2014	0.001	0.066	0.422	0.454	0.293	0.129	0.065
2015	0.001	0.076	0.489	0.579	0.392	0.159	0.075
2016	0.001	0.062	0.436	0.654	0.478	0.210	0.107

Table 6.2.3.1 Numbers at age in billions of fish estimated from the base run of the BAM model for 1955-2016.

Ages	0	1	2	3	4	5	6+
1955	26.735	4.348	2.744	0.540	0.000	0.000	0.000
1956	28.328	8.668	1.553	0.460	0.015	0.000	0.000
1957	13.599	9.142	2.640	0.034	0.000	0.000	0.000
1958	79.353	4.400	3.021	0.113	0.000	0.000	0.000
1959	11.646	25.675	1.470	0.405	0.002	0.000	0.000
1960	10.263	3.770	8.701	0.130	0.001	0.000	0.000
1961	10.195	3.340	1.522	2.749	0.019	0.000	0.000
1962	11.644	3.308	1.230	0.436	0.645	0.005	0.000
1963	8.836	3.764	1.078	0.218	0.042	0.082	0.001
1964	8.499	2.855	1.198	0.161	0.014	0.004	0.010
1965	7.807	2.744	0.887	0.213	0.025	0.003	0.005
1966	11.312	2.515	0.791	0.122	0.026	0.005	0.003
1967	6.542	3.639	0.695	0.121	0.030	0.011	0.004
1968	8.446	2.116	1.195	0.159	0.034	0.012	0.007
1969	11.488	2.730	0.689	0.271	0.043	0.013	0.009
1970	5.429	3.718	0.926	0.178	0.092	0.020	0.012
1971	15.225	1.754	1.179	0.192	0.053	0.042	0.018
1972	12.029	4.925	0.582	0.279	0.058	0.023	0.032
1973	12.452	3.788	1.592	0.030	0.035	0.018	0.027
1974	19.646	3.978	1.384	0.157	0.003	0.007	0.020
1975	30.335	6.299	1.500	0.184	0.023	0.001	0.013
1976	25.286	9.740	2.401	0.235	0.039	0.008	0.007
1977	24.619	8.123	3.734	0.372	0.042	0.011	0.007
1978	20.840	7.917	3.144	0.709	0.103	0.018	0.010
1979	37.572	6.702	3.066	0.600	0.200	0.044	0.014
1980	22.123	12.059	2.556	0.537	0.164	0.087	0.031
1981	25.994	7.054	4.328	0.271	0.101	0.059	0.056
1982	14.911	8.322	2.626	0.597	0.058	0.037	0.058
1983	29.858	4.752	2.982	0.304	0.145	0.026	0.053
1984	32.063	9.496	1.672	0.303	0.068	0.064	0.044
1985	25.474	10.174	3.275	0.145	0.060	0.028	0.056
1986	16.898	8.217	4.034	0.571	0.018	0.012	0.038
1987	11.039	5.471	3.382	1.221	0.202	0.008	0.029
1988	25.323	3.562	2.186	0.820	0.387	0.090	0.021
1989	15.925	8.119	1.342	0.341	0.203	0.157	0.057
1990	18.112	5.078	2.912	0.124	0.040	0.048	0.087
1991	14.965	5.832	1.986	0.441	0.011	0.006	0.057
1992	15.980	4.799	2.204	0.274	0.060	0.003	0.033
1993	6.622	5.150	1.892	0.397	0.036	0.013	0.018
1994	13.688	2.127	1.978	0.331	0.084	0.012	0.016
1995	10.592	4.402	0.824	0.391	0.086	0.034	0.015

Ages	0	1	2	3	4	5	6+
1996	11.178	3.350	1.468	0.044	0.024	0.015	0.016
1997	9.913	3.577	1.240	0.164	0.003	0.003	0.011
1998	9.354	3.154	1.256	0.113	0.020	0.001	0.007
1999	9.796	2.970	1.089	0.105	0.015	0.006	0.004
2000	6.730	3.138	1.107	0.157	0.019	0.005	0.005
2001	6.825	2.172	1.250	0.230	0.025	0.005	0.004
2002	13.005	2.193	0.832	0.213	0.048	0.009	0.004
2003	10.276	4.177	0.837	0.140	0.048	0.017	0.006
2004	11.003	3.296	1.574	0.136	0.039	0.021	0.013
2005	16.032	3.552	1.318	0.372	0.036	0.015	0.018
2006	9.593	5.225	1.397	0.339	0.111	0.015	0.018
2007	9.756	3.128	2.143	0.423	0.086	0.037	0.016
2008	12.369	3.181	1.285	0.702	0.131	0.033	0.028
2009	9.561	4.033	1.319	0.445	0.233	0.054	0.033
2010	18.654	3.117	1.644	0.429	0.157	0.103	0.048
2011	11.411	6.081	1.246	0.475	0.126	0.061	0.081
2012	8.517	3.720	2.457	0.376	0.131	0.045	0.076
2013	9.936	2.777	1.546	0.872	0.114	0.048	0.068
2014	10.791	3.240	1.163	0.582	0.338	0.053	0.066
2015	8.781	3.519	1.336	0.398	0.209	0.150	0.066
2016	13.363	2.863	1.436	0.428	0.126	0.084	0.116

Table 6.2.3.2 Fecundity at age in billions of eggs during 1955-2016.

Ages	0	1	2	3	4	5	6+
1955	0	3997	73328	33639	6	0	0
1956	0	6470	37082	31334	1490	0	0
1957	0	5341	37163	2339	1	0	0
1958	0	4796	42541	5989	1	0	0
1959	0	7905	20820	20472	263	0	0
1960	0	8650	72952	6279	124	2	0
1961	0	3577	35282	109844	1722	28	0
1962	0	5501	25313	27155	53504	785	13
1963	0	7929	23408	13305	4665	11211	202
1964	0	7214	28587	8816	1430	604	2120
1965	0	6401	23197	12471	2153	465	1248
1966	0	3664	24386	7805	2404	541	515
1967	0	11002	16444	9909	3055	1341	528
1968	0	4427	47781	11941	5017	1657	1061
1969	0	7651	16953	26979	6633	3052	1552
1970	0	18198	27062	13081	16370	5618	3999
1971	0	6624	61831	15251	7722	11250	8288
1972	0	7126	31830	36484	8984	6109	11893
1973	0	2211	29076	3723	8832	5018	12191
1974	0	2897	32878	9196	613	2923	8691
1975	0	2677	23259	11962	2590	212	7813
1976	0	2718	16169	12529	3851	1497	2423
1977	0	1413	17150	12589	4065	1426	2078
1978	0	1407	11114	18367	7680	2594	1395
1979	0	1935	13161	14333	11650	5700	2906
1980	0	2113	9691	15145	9889	8297	6287
1981	0	1291	10876	5738	6976	6226	7751
1982	0	2474	12030	9330	2930	4637	9863
1983	0	1324	16332	7688	6276	2239	10889
1984	0	2750	10745	8857	3822	4982	5712
1985	0	1873	14167	5096	3886	2483	6987
1986	0	1466	17309	14321	1384	1311	4742
1987	0	1565	11985	29796	11951	1024	4687
1988	0	642	10729	19058	21558	9235	3752
1989	0	3417	6898	8903	11838	14494	9143
1990	0	4653	31159	3625	2289	4909	11573
1991	0	3436	35208	19615	711	541	9402
1992	0	7874	27394	13968	5070	273	4146
1993	0	2261	36742	18390	3000	1580	2729
1994	0	3105	21942	19238	7200	1339	2741
1995	0	1921	19633	19877	9128	4331	1986
1996	0	965	32003	3014	2728	2447	2758

Ages	0	1	2	3	4	5	6+
1997	0	995	22684	12350	350	660	2656
1998	0	1354	12509	8169	2803	134	2436
1999	0	6819	15854	5331	2086	1173	1038
2000	0	3450	28708	8697	2049	1017	1402
2001	0	1588	44837	15755	2610	859	1267
2002	0	5107	25590	20510	5713	1360	1165
2003	0	4491	22357	10599	7914	3130	1360
2004	0	3621	31381	7499	4328	4974	3215
2005	0	1019	23972	21593	2726	1992	5164
2006	0	3905	17782	18410	10774	1289	2625
2007	0	4006	42630	22109	7994	5060	1486
2008	0	5316	28684	35443	12430	4446	4745
2009	0	6804	30650	23450	16859	7370	5712
2010	0	5812	26584	22392	11892	8954	8596
2011	0	12612	28746	21970	9115	5595	7714
2012	0	7008	53446	18876	10425	3884	7766
2013	0	5245	31008	42647	7965	5709	6467
2014	0	6120	24064	27462	23931	4446	10294
2015	0	6645	27645	19350	14312	13270	6000
2016	0	5406	29713	20790	8793	7212	11571

Table 6.2.3.3 Biomass of Atlantic menhaden (1000s mt) by age from 1959 to 2016.

Year	0	1	2	3	4	5	6+	Total
1955	745.9	271.7	566.6	181.0	0.0	0.0	0.0	1765
1956	603.4	503.6	304.8	162.8	6.9	0.0	0.0	1582
1957	477.3	485.4	413.4	12.1	0.0	0.0	0.0	1388
1958	1491.8	289.0	473.1	34.1	0.0	0.0	0.0	2288
1959	521.7	1127.1	231.5	118.7	1.2	0.0	0.0	2000
1960	262.7	314.4	1125.9	37.0	0.6	0.0	0.0	1741
1961	346.6	214.4	294.7	699.5	8.1	0.1	0.0	1564
1962	462.3	249.1	225.9	146.1	261.4	3.2	0.0	1348
1963	377.3	309.4	202.1	71.9	20.8	46.9	0.7	1029
1964	345.9	246.4	235.0	49.5	6.5	2.3	7.7	893
1965	270.9	233.5	181.9	68.5	10.5	1.9	4.2	771
1966	446.8	180.6	174.8	41.4	11.3	2.4	1.9	859
1967	287.2	335.5	135.3	48.5	14.0	5.8	2.2	828
1968	416.4	172.4	304.3	60.2	20.4	6.8	4.3	985
1969	548.0	247.1	137.2	124.7	26.4	10.4	5.9	1099
1970	174.3	402.3	199.8	66.3	62.0	17.8	11.7	934
1971	570.9	173.6	352.8	75.9	31.5	36.3	20.9	1262
1972	141.9	350.7	178.7	154.3	35.6	19.9	33.6	915
1973	287.6	201.1	277.9	16.0	29.4	16.1	31.6	860
1974	457.8	223.2	270.4	50.6	2.2	7.9	22.6	1035
1975	515.7	291.0	243.8	63.3	11.5	0.7	17.5	1143
1976	391.9	366.2	289.3	71.3	17.8	5.5	7.2	1149
1977	389.0	274.6	394.4	86.3	18.9	6.1	6.5	1176
1978	431.4	277.1	305.6	144.1	38.8	10.6	5.7	1213
1979	680.0	266.1	315.2	117.8	64.1	24.3	10.5	1478
1980	349.5	412.4	254.1	113.5	53.6	38.8	22.7	1245
1981	517.3	258.9	370.9	50.3	36.1	28.3	32.2	1294
1982	217.7	346.2	276.5	97.8	17.0	19.9	38.0	1013
1983	603.1	178.7	334.6	61.2	38.7	10.8	39.2	1266
1984	545.1	378.9	198.7	65.4	21.4	24.9	24.2	1258
1985	428.0	376.4	339.6	34.4	20.6	11.9	30.1	1241
1986	297.4	289.2	414.7	114.2	7.0	5.9	20.3	1149
1987	161.2	214.5	329.7	241.2	65.6	4.4	18.3	1035
1988	433.0	127.5	237.2	159.2	120.7	42.3	14.2	1134
1989	390.2	370.2	146.5	69.8	65.1	68.4	35.8	1146
1990	420.2	316.4	412.6	26.8	12.6	22.5	48.7	1260
1991	576.1	313.8	342.5	119.4	3.8	2.6	36.6	1395
1992	346.8	355.1	331.4	80.9	24.7	1.2	17.7	1158
1993	210.6	249.8	339.1	110.2	14.7	6.8	11.0	942
1994	169.7	153.2	284.0	105.9	34.9	6.0	10.6	764
1995	90.0	211.7	161.4	115.1	41.5	18.4	8.4	647
1996	133.0	132.6	276.2	15.6	12.1	9.5	10.5	590

Year	0	1	2	3	4	5	6+	Total
1997	154.6	133.8	216.8	62.3	1.5	2.4	9.0	580
1998	392.9	147.9	174.0	41.9	11.7	0.5	7.1	776
1999	177.3	247.7	172.8	30.9	8.7	4.2	3.5	645
2000	66.6	208.7	225.2	48.7	9.3	3.6	4.5	567
2001	234.1	122.5	298.8	81.8	12.0	3.3	3.9	756
2002	339.4	186.2	183.5	95.7	24.9	5.4	3.8	839
2003	308.3	269.4	172.8	53.3	30.8	11.8	4.8	851
2004	113.3	218.8	284.8	42.1	19.2	17.0	10.8	706
2005	258.1	139.6	229.1	118.9	13.8	8.4	16.1	784
2006	237.9	303.6	210.5	103.5	50.1	6.2	10.6	922
2007	282.0	217.7	386.9	126.3	37.6	21.2	7.0	1079
2008	541.8	241.1	243.6	205.5	58.2	18.7	18.2	1327
2009	297.3	309.4	256.0	133.7	86.5	30.7	21.8	1135
2010	690.2	243.1	273.4	127.9	59.8	43.3	32.5	1470
2011	422.2	490.1	240.2	131.7	46.7	26.4	36.0	1393
2012	291.3	293.9	461.2	109.5	51.8	18.8	35.7	1262
2013	339.8	220.3	281.3	250.9	41.2	24.9	30.2	1189
2014	369.1	257.0	218.1	162.5	123.3	21.3	41.4	1193
2015	300.3	279.0	250.5	114.0	74.3	62.8	28.5	1109
2016	457.0	227.0	269.3	122.5	45.5	34.4	52.6	1208

Table 6.4.1.1 Likelihood components for the base run and all sensitivity runs.

Run	total	unwgt	cRn L	cRs L	cBn L	cBs L	SAD lenc	NAD lenc	cRn agec	cRs agec	cBn agec	cBs agec	SAD	NAD	JAI	priors	SRfit
Base run	-4314	-4299	0.14	1.46	0.05	0.07	-1470	-1348	-605	-548	-295	-303	57.9	67.6	143.0	-11.3	-7.4
Am-076	-4286	-4281	0.07	0.62	0.02	0.03	-1471	-1346	-607	-546	-295	-303	47.7	96.7	142.1	1.6	-8.3
Am-089	-3129	-3113	0.02	0.10	0.00	0.01	-1471	0	-610	-546	-296	-309	60.1	0.0	58.4	-11.3	-7.1
Am-090	-4298	-4282	0.15	0.76	0.10	0.06	-1470	-1348	-604	-545	-292	-305	50.5	81.4	148.7	-11.3	-7.3
Am-091	-4312	-4299	0.13	1.94	0.05	0.08	-1470	-1346	-604	-548	-294	-302	63.3	67.1	131.1	-11.3	-6.4
Am-092	-4289	-4272	0.12	1.62	0.06	0.08	-1470	-1347	-602	-544	-295	-303	57.9	73.0	156.3	-11.3	-8.5
Am-100	-4286	-4281	0.07	0.62	0.02	0.03	-1471	-1346	-607	-546	-295	-303	47.65	96.73	142.07	1.56	-8.3
Am-101	-3129	-3113	0.02	0.10	0.00	0.01	-1471	0	-610	-546	-296	-309	60.11	0.0	58.4	-11.3	-7.1
Am-102	-4298	-4282	0.15	0.76	0.10	0.06	-1470	-1348	-604	-545	-292	-305	50.54	81.4	148.7	-11.3	-7.3
Am-103	-4312	-4299	0.13	1.94	0.05	0.08	-1470	-1346	-604	-548	-294	-302	63.29	67.1	131.1	-11.3	-6.4

Table 6.4.1.2 Standard deviation of the normalized residuals for the base run and each sensitivity run.

Run	SAD lenc	NAD lenc	cRn agec	cRs agec	cBn agec	cBs agec	SAD	NAD	JAI
Base run	0.35	0.41	1.08	1.28	1.18	1.15	2.11	1.94	2.24
Am-076	0.37	0.35	1.06	1.32	1.07	1.13	1.91	2.32	2.23
Am-089	0.26		1.03	1.33	0.96	0.98	2.15		1.43
Am-090	0.37	0.36	1.12	1.34	1.13	1.13	1.97	2.13	2.28
Am-091	0.34	0.41	1.10	1.27	1.23	1.17	2.21	1.93	2.15
Am-092	0.35	0.41	1.08	1.32	1.17	1.14	2.11	2.01	2.33
Am-100	0.37	0.35	1.06	1.32	1.07	1.13	1.91	2.32	2.23
Am-101	0.26	0.21	1.03	1.33	0.96	0.98	2.15	5.03	1.43
Am-102	0.37	0.36	1.12	1.34	1.13	1.13	1.97	2.13	2.28
Am-103	0.34	0.41	1.1	1.27	1.23	1.17	2.21	1.93	2.15

Table 6.4.1.3 Estimated R_0 and index catchabilities (q) from each of the sensitivity runs.

Run	R_0	q NAD	*q2 NAD*	q SAD	q_1 JAI	q_2 JAI
Base run	13.78	2.25		0.21	0.10	0.06
Am-076	16.65	0.58		0.19	0.08	0.05
Am-089	22.83			0.10	0.07	0.03
Am-090	63.33	6.79		0.10	0.03	0.02
Am-091	6.85	2.10		0.31	0.18	0.12
Am-092	14.35	2.21		0.22	0.07	
Am-100	13.82	2.25		0.21	0.1	0.06
Am-101	14.1	3.19	1.42	0.2	0.1	0.06
Am-102	13.48	2.58	2.98	0.22	0.1	0.06
Am-103	33.9	0.04	0.18	0.11	0.03	0.03

Table 6.4.2.1 Likelihood components for the base run and retrospective analyses.

Run	total	unwgt	cRn L	cRs L	cBn L	cBs L	SAD lenc	NAD lenc	cRn agec	cRs agec	cBn agec	cBs agec	SAD	NAD	JAI	priors	SRfit
Base run	-4314	-4299	0.14	1.46	0.05	0.07	-1470	-1348	-605	-548	-295	-303	57.9	67.6	143.0	-11.3	-7.4
End year 2015	-4195	-4181	0.11	1.19	0.03	0.05	-1416	-1300	-595	-536	-288	-292	56.4	63.1	126.8	-11.3	-6.4
End year 2014	-4059	-4046	0.10	1.10	0.03	0.05	-1362	-1253	-584	-528	-280	-282	57.2	64.3	120.9	-11.3	-5.6
End year 2013	-3942	-3928	0.06	0.66	0.01	0.03	-1309	-1206	-575	-517	-271	-275	55.0	65.2	105.5	-11.3	-4.9
End year 2012	-3811	-3798	0.06	0.58	0.01	0.02	-1255	-1160	-565	-509	-262	-270	51.9	68.3	102.8	-11.3	-5.0
End year 2011	-3674	-3659	0.05	0.53	0.01	0.02	-1201	-1114	-553	-497	-253	-259	53.0	68.0	95.9	-11.3	-5.7
End year 2010	-3561	-3547	0.03	0.28	0.00	0.01	-1149	-1068	-545	-484	-243	-249	44.1	64.1	82.5	-11.3	-4.7

Table 6.4.2.2 Standard deviation of the normalized residuals for the base run and each retrospective run.

Run	SAD lenc	NAD lenc	cRn agec	cRs agec	cBn agec	cBs agec	SAD	NAD	JAI
Base run	0.35	0.41	1.08	1.28	1.18	1.15	2.11	1.94	2.24
Retrospective 2015	0.36	0.38	1.09	1.30	1.14	1.16	2.12	1.90	2.13
Retrospective 2014	0.34	0.38	1.10	1.30	1.14	1.17	2.18	1.94	2.10
Retrospective 2013	0.33	0.36	1.09	1.34	1.09	1.09	2.19	1.99	1.98
Retrospective 2012	0.33	0.35	1.09	1.34	1.10	1.01	2.17	2.07	1.97
Retrospective 2011	0.33	0.35	1.10	1.36	1.09	1.00	2.25	2.09	1.92
Retrospective 2010	0.29	0.35	1.12	1.40	1.05	1.00	2.10	2.07	1.80

Table 6.4.2.3 Estimated R_0 and index catchabilities (q) from the retrospective analysis.

Run	R_0	q NAD	q SAD	q_1 JAI	q_2 JAI
Base run	13.78	2.25	0.21	0.10	0.06
Retrospective 2015	14.08	1.72	0.21	0.10	0.06
Retrospective 2014	14.29	1.56	0.21	0.09	0.06
Retrospective 2013	15.67	0.77	0.19	0.08	0.06
Retrospective 2012	16.24	0.64	0.18	0.08	0.06
Retrospective 2011	16.74	0.61	0.17	0.08	0.05
Retrospective 2010	19.15	0.31	0.14	0.07	0.05

Table 7.2.1.1 Fishing mortality and fecundity benchmarks (targets and thresholds) along with terminal year values from the base run of the BAM. Fecundity (FEC) is in billions of eggs.

Reference Points	Benchmark	Current value
$F_{21\%\ (threshold)}$	1.85	0.51
$F_{36\%\ (target)}$	0.80	0.51
$FEC_{21\%\ (threshold)}$	57,295	83,486
$FEC_{36\%\ (target)}$	99,467	83,486

Table 7.2.2.1 Benchmarks calculated for the base run and each sensitivity run along with the 2016 values relative to the benchmark values. Values with a dash (–) indicate an extreme scenario that hit a bound on the maximum level of F.

Run	$F_{21\%}$	$F_{36\%}$	$FEC_{21\%}$	$FEC_{36\%}$	$F_{2016}/F_{21\%}$	$F_{2016}/F_{36\%}$	$FEC_{2016}/FEC_{21\%}$	$FEC_{2016}/FEC_{36\%}$
Base run	1.85	0.80	57295	99467	0.28	0.64	1.46	0.84
Am-076	1.56	0.74	69203	120183	0.19	0.41	2.16	1.25
Am-089	1.63	0.82	94892	164784	0.12	0.23	2.32	1.33
Am-090	-	4.18	-	69829	-	0.13	-	1.29
Am-091	0.91	0.51	93196	161886	0.58	1.05	0.90	0.52
Am-092	1.84	0.80	59670	103555	0.30	0.69	1.32	0.76
Am-100	1.85	0.81	57443	99725	0.28	0.64	1.46	0.84
Am-101	1.68	0.76	58614	101784	0.26	0.57	1.75	1.01
Am-102	1.93	0.81	56046	97269	0.30	0.70	1.34	0.77
Am-103	1.64	0.82	140904	244652	0.09	0.18	1.88	1.08

Table 7.2.2.2 Benchmarks calculated for the base run and each retrospective run.

Run	$F_{21\%}$	$F_{36\%}$	$FEC_{21\%}$	$FEC_{36\%}$
Base run	1.85	0.80	57295	99467
Retrospective 2015	1.58	0.72	58539	101622
Retrospective 2014	1.51	0.70	59411	103141
Retrospective 2013	1.54	0.73	65141	113104
Retrospective 2012	1.54	0.74	67485	117189
Retrospective 2011	1.57	0.78	69580	120834
Retrospective 2010	1.57	0.79	79593	138203

12.0 Figures

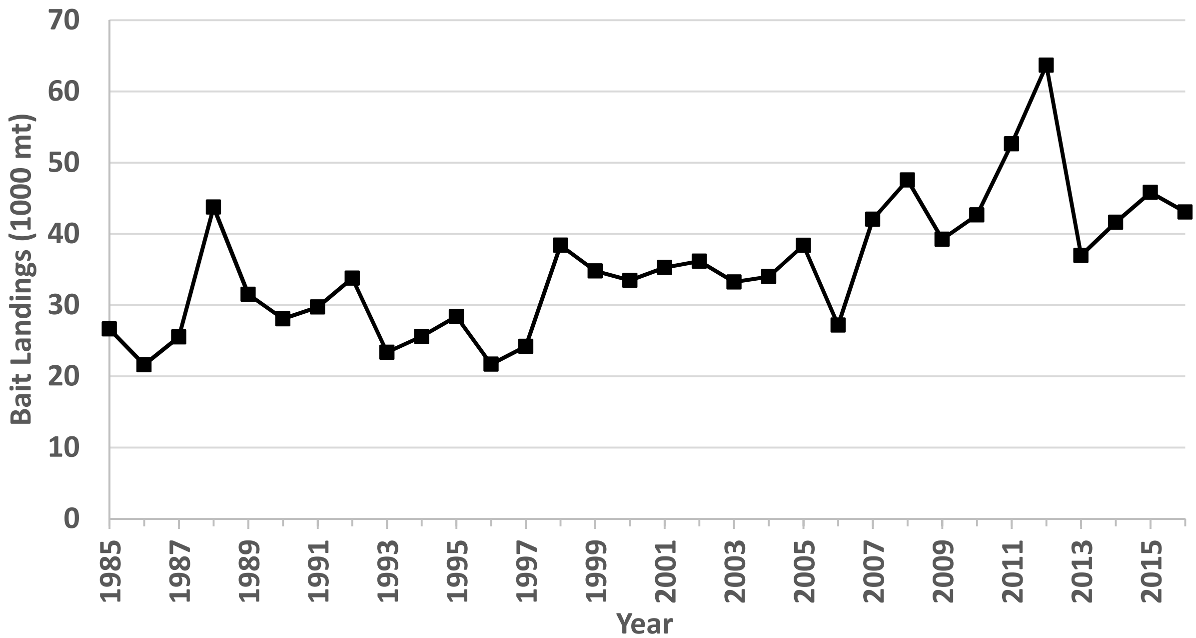


Figure 3.2.2.1. Atlantic menhaden bait landings (1000s mt) from 1985 to 2016.

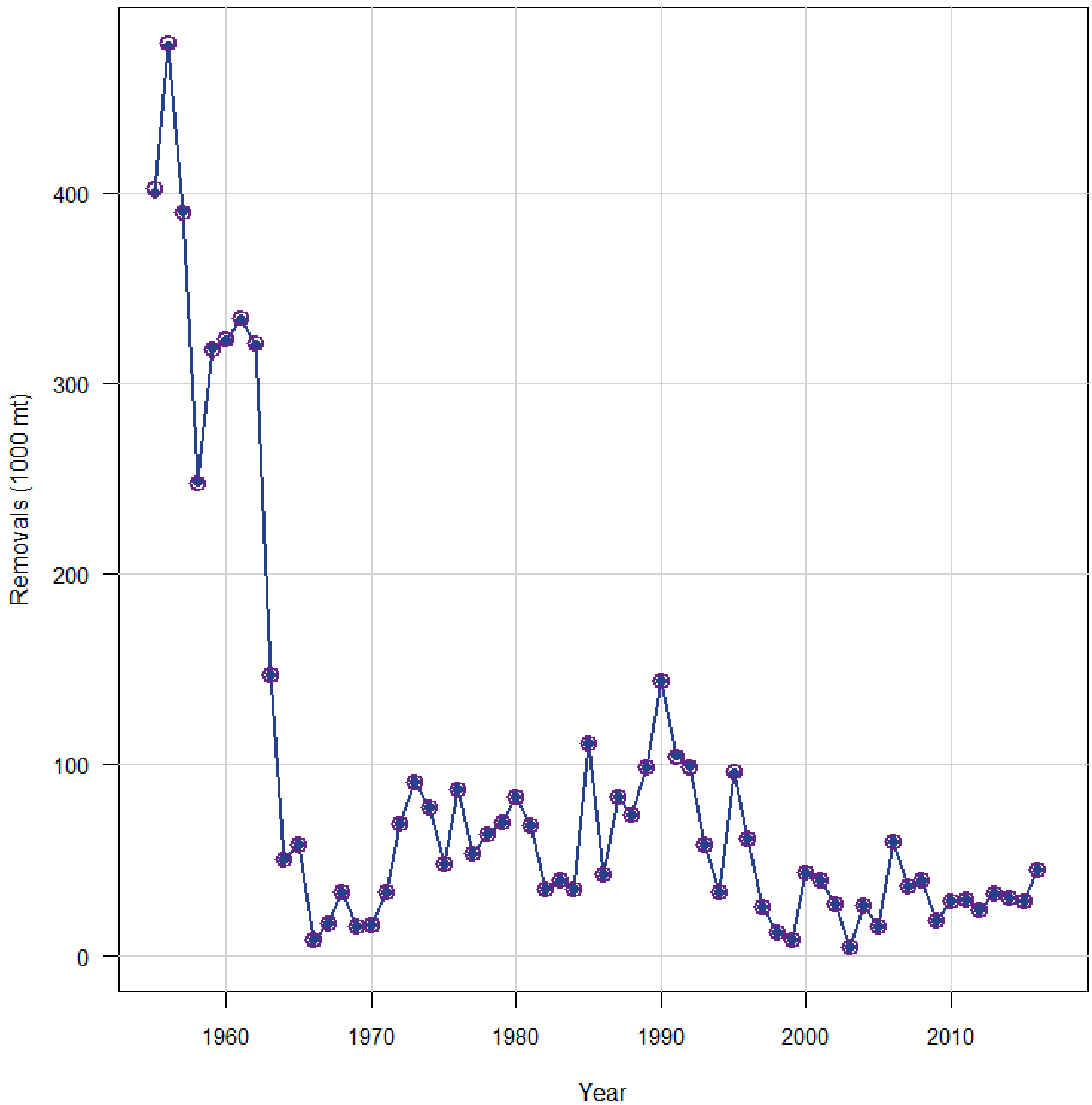


Figure 6.1.1. Observed and predicted removals of Atlantic menhaden from 1955-2016 from north of Virginia Eastern Shore by the commercial reduction fishery.

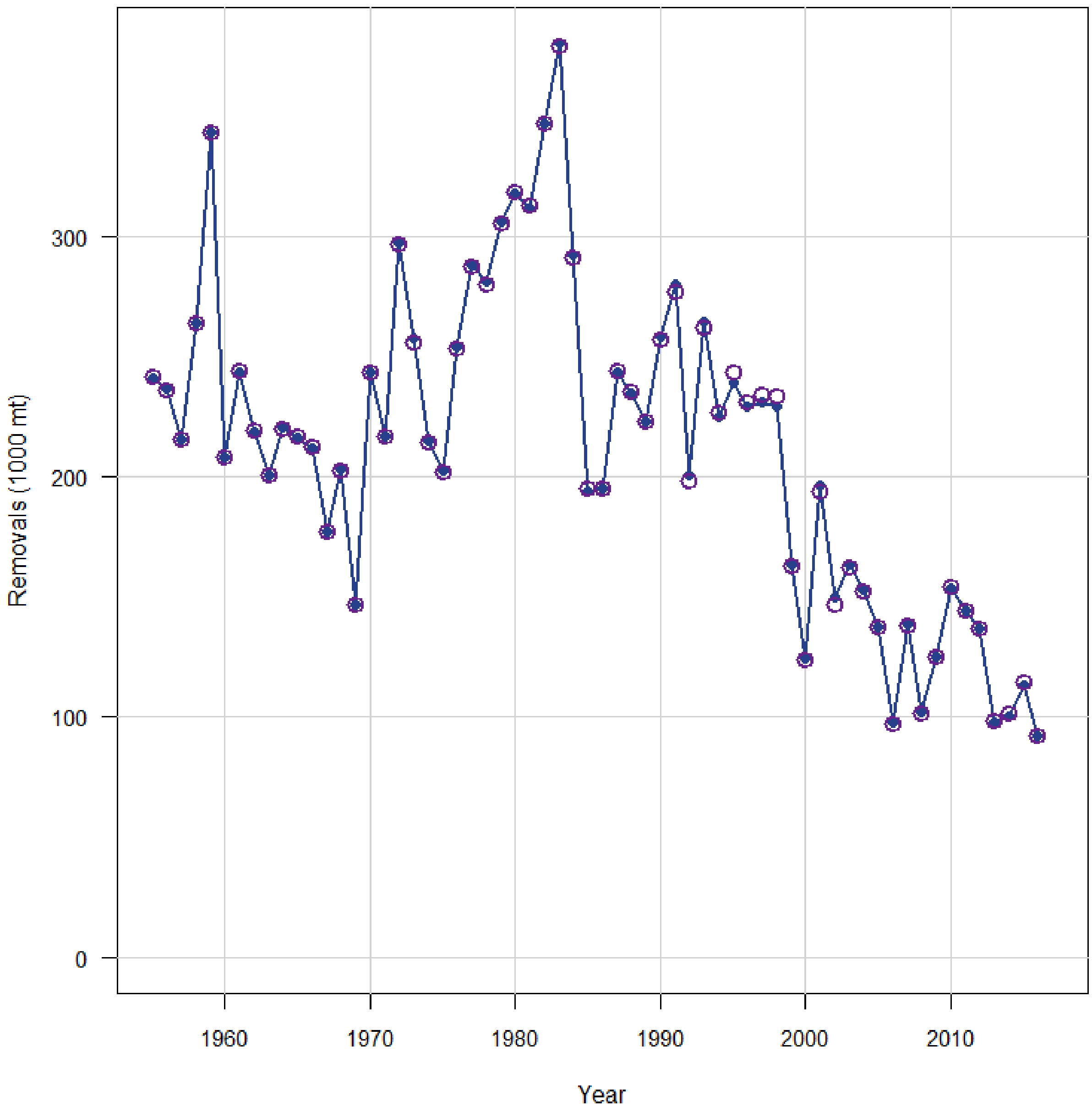


Figure 6.1.2. Observed and predicted removals of Atlantic menhaden from 1955-2016 from Virginia Eastern Shore and south by the commercial reduction fishery.

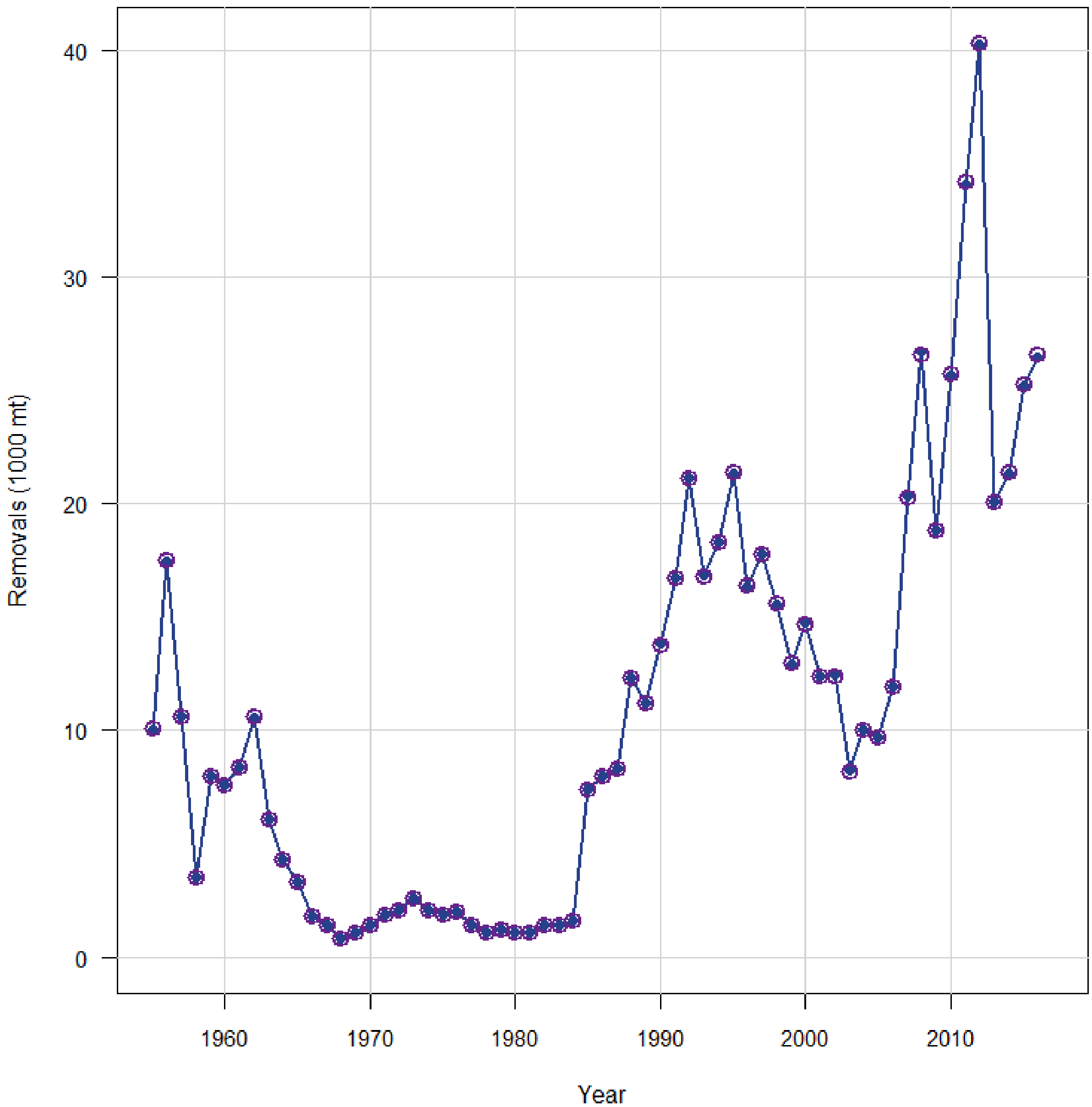


Figure 6.1.3. Observed and predicted removals of Atlantic menhaden from 1955-2016 from north of Virginia Eastern Shore by the commercial bait fishery.

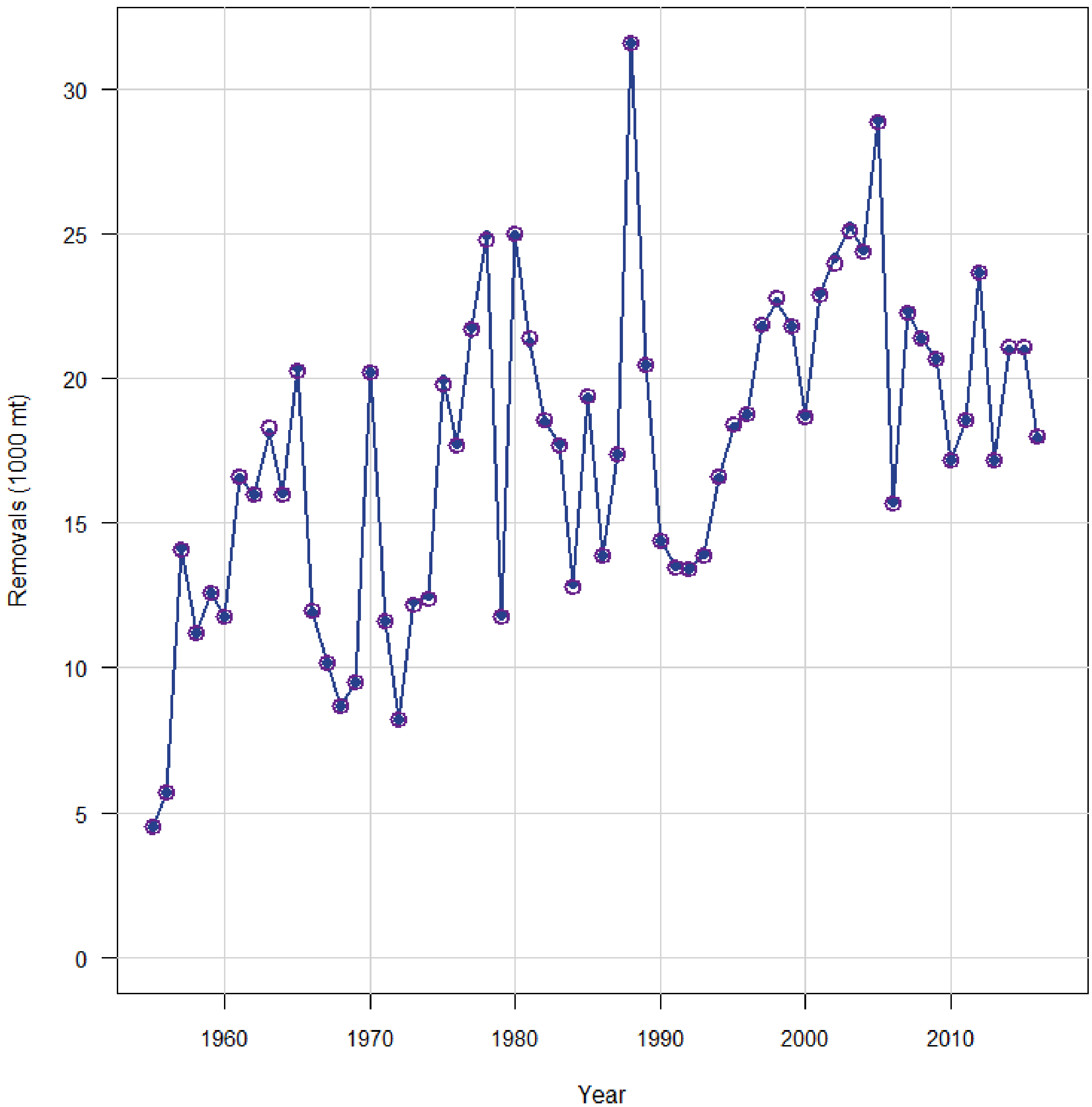


Figure 6.1.4. Observed and predicted removals of Atlantic menhaden from 1955-2016 from Virginia Eastern Shore and south by the commercial bait fishery.

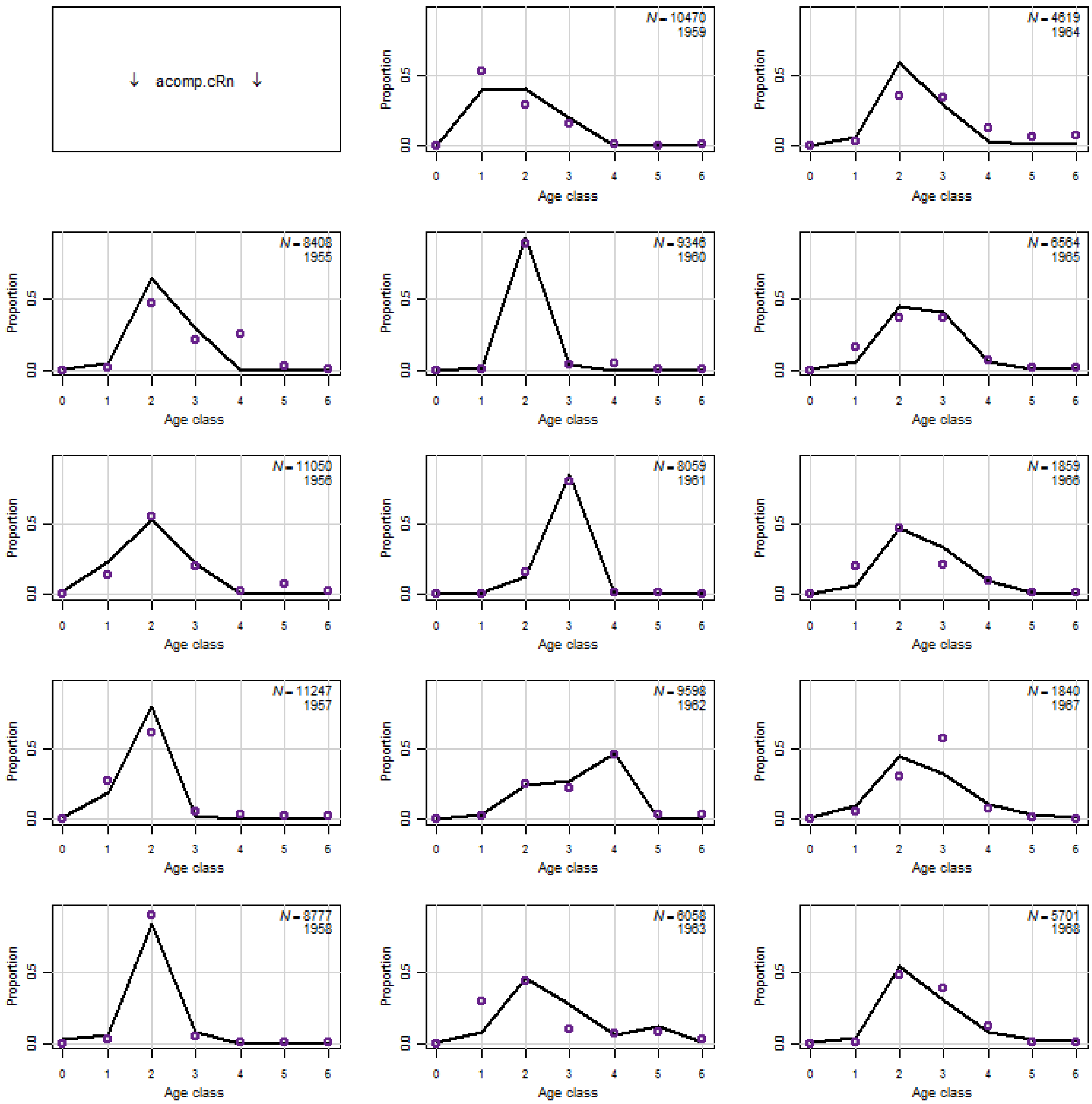
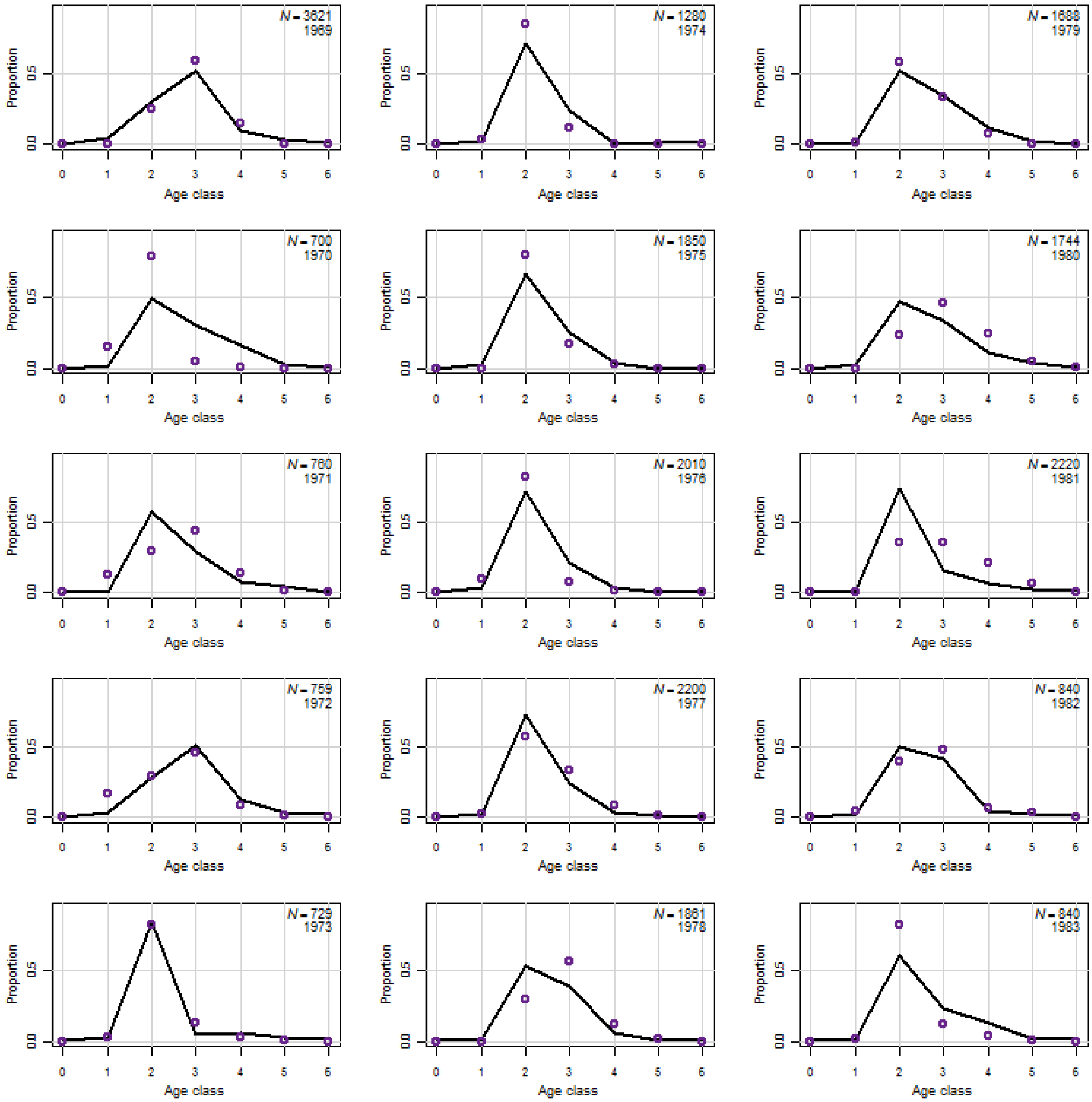


Figure 6.1.5. Annual observed and predicted catch-at-age of Atlantic menhaden from 1955-2016 from north of Virginia Eastern Shore by the commercial reduction fishery.



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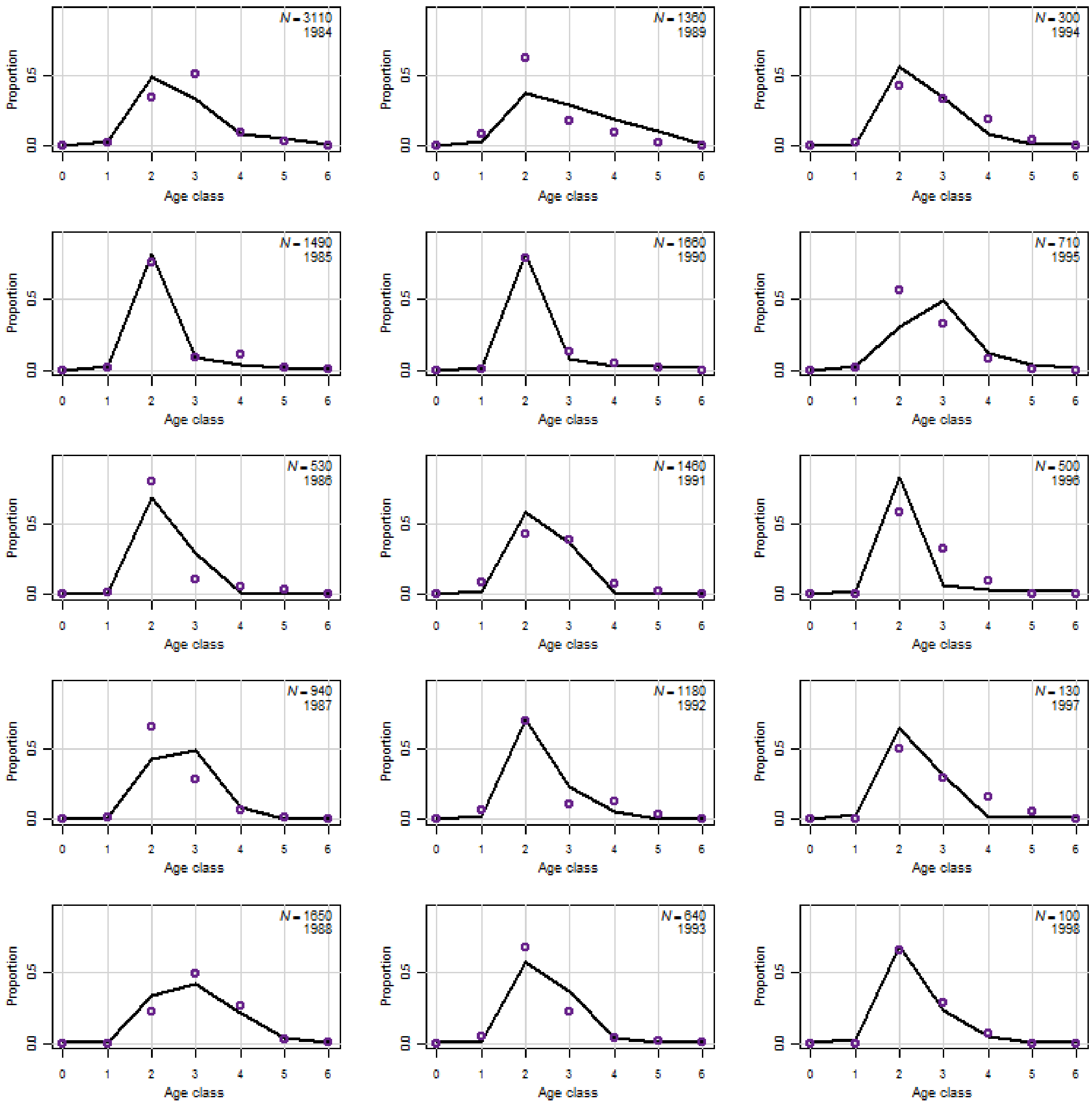

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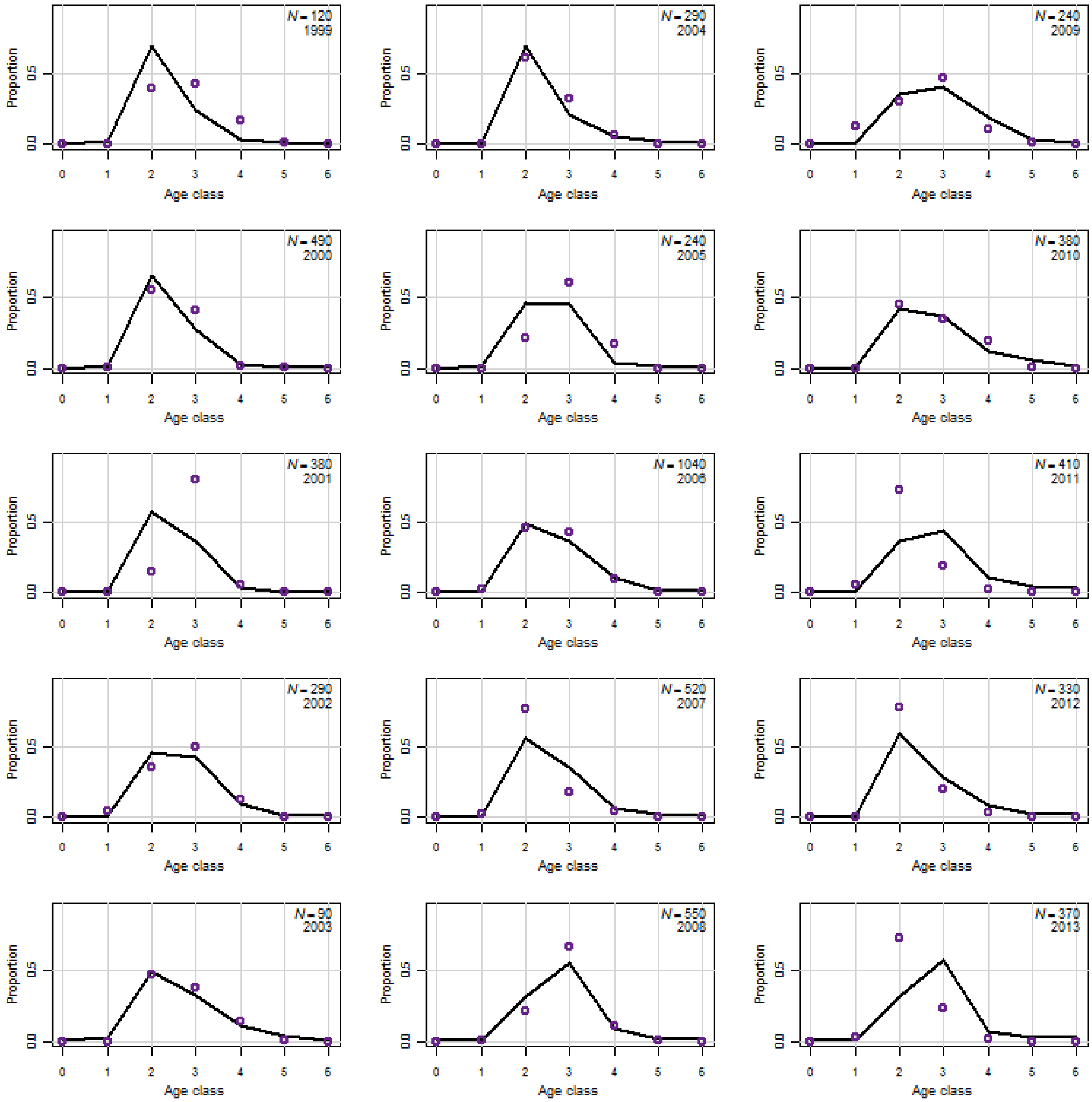

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Figure 6.1.5. ***Continued*.**

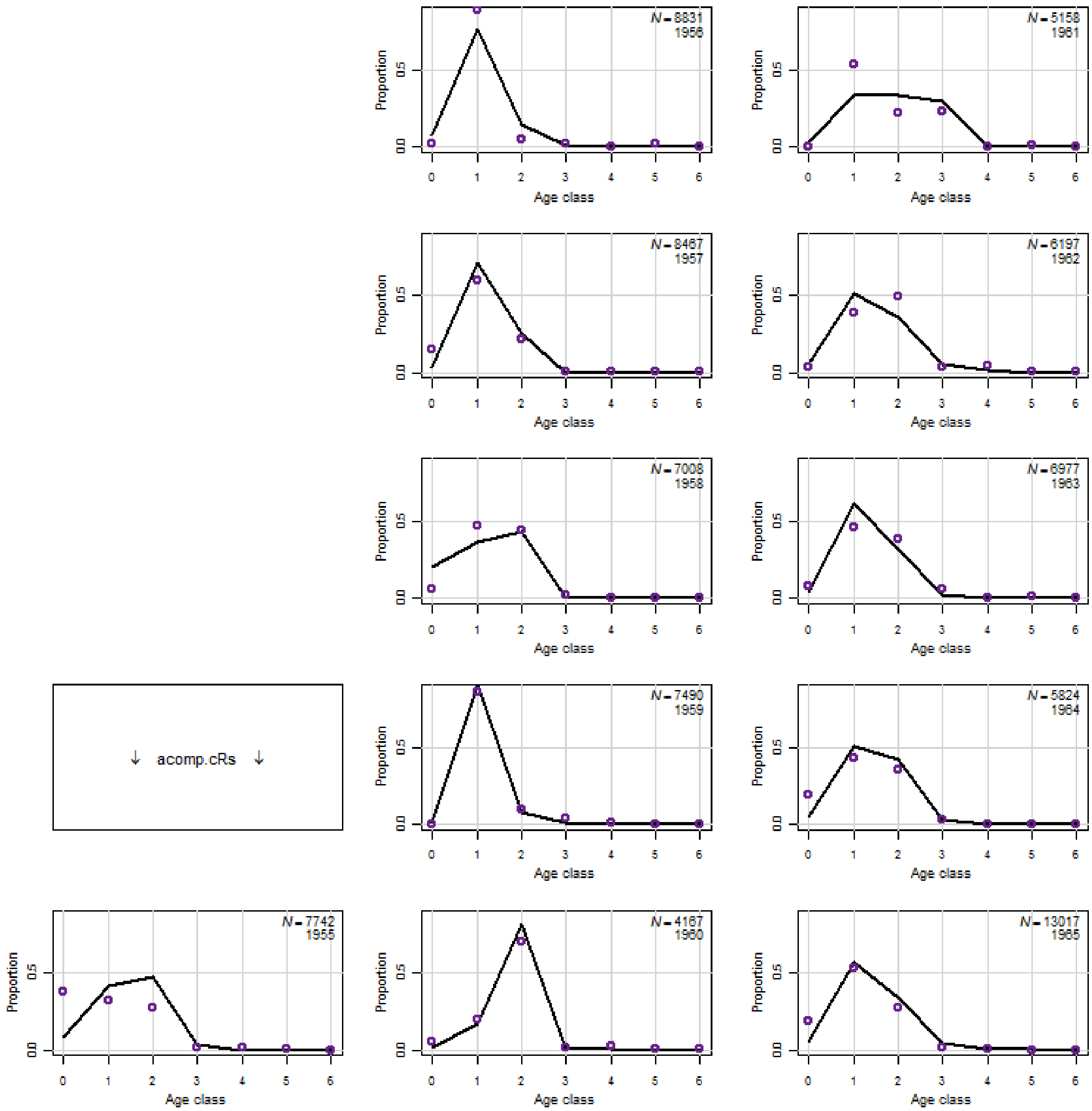
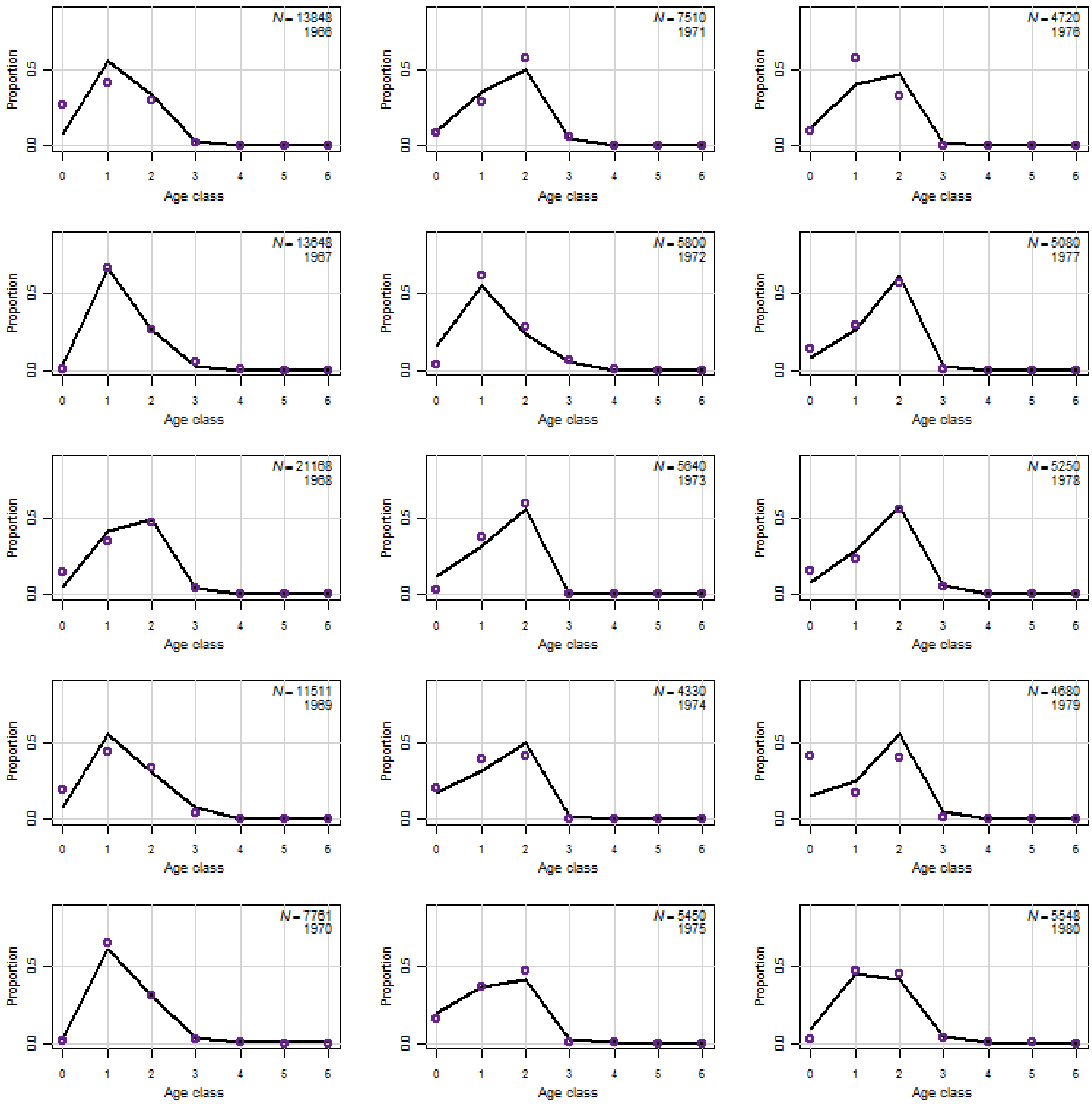


Figure 6.1.6. Annual observed and predicted catch-at-age of Atlantic menhaden from 1955-2016 from Virginia Eastern Shore and south by the commercial reduction fishery.



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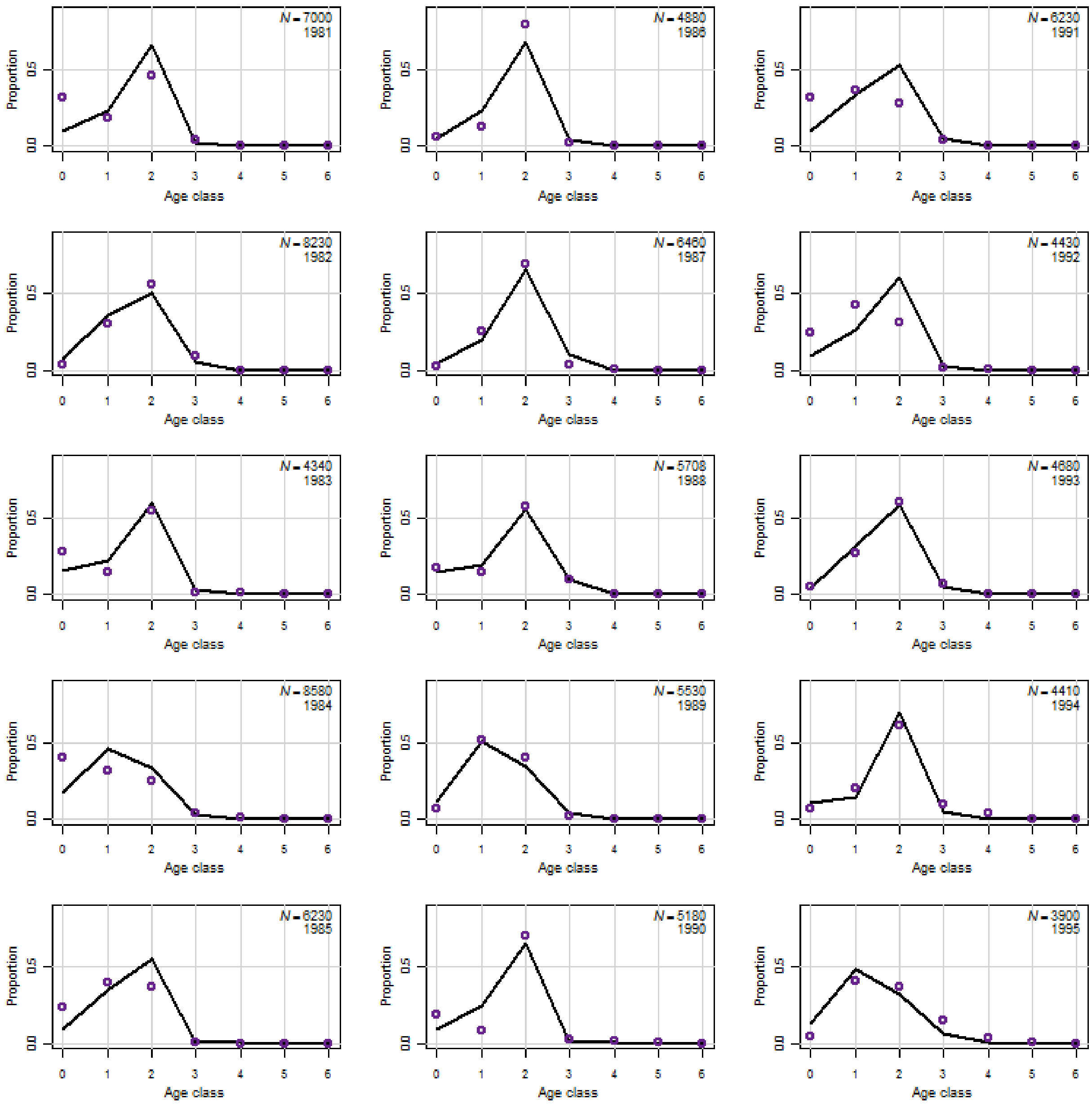

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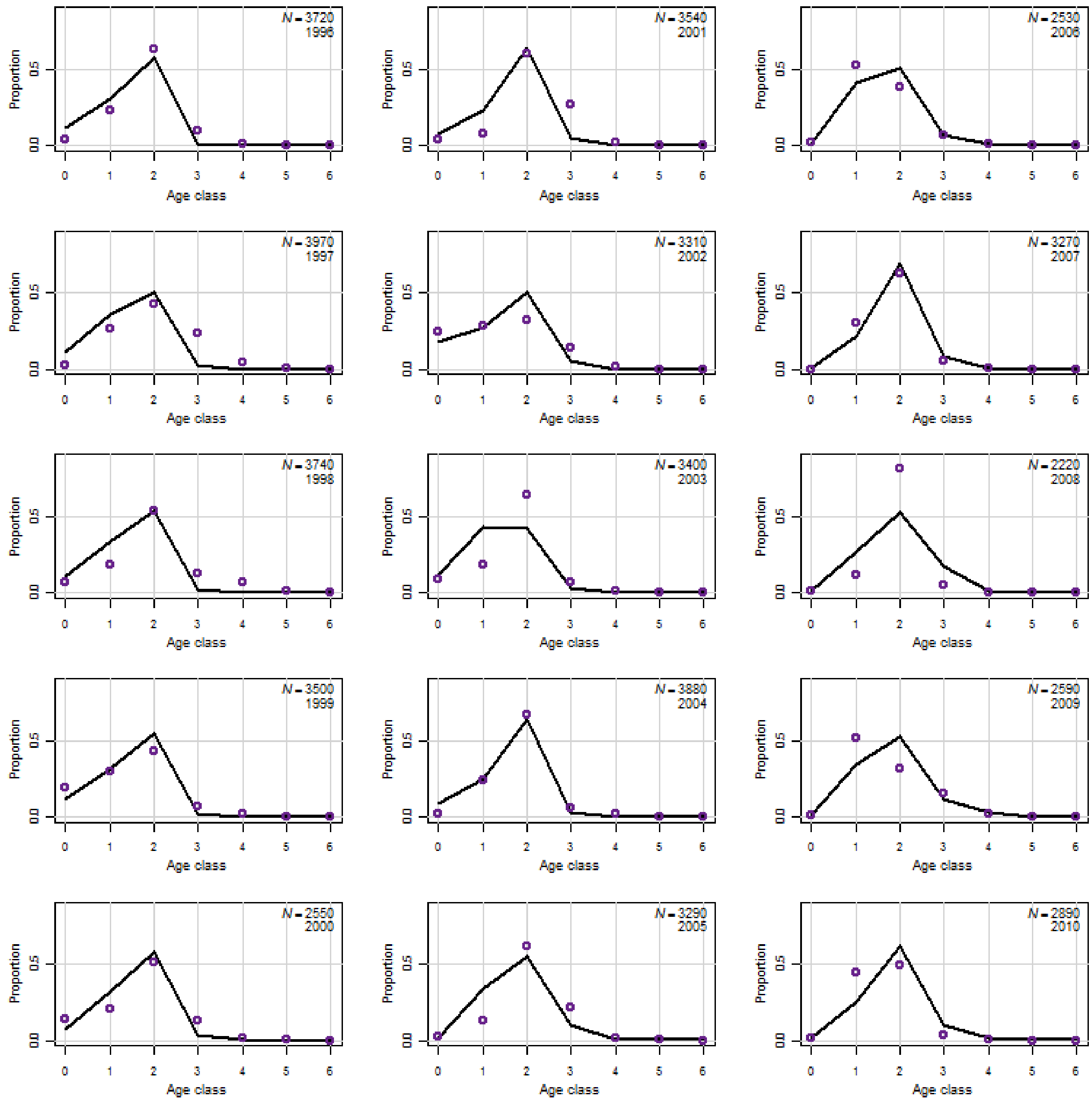

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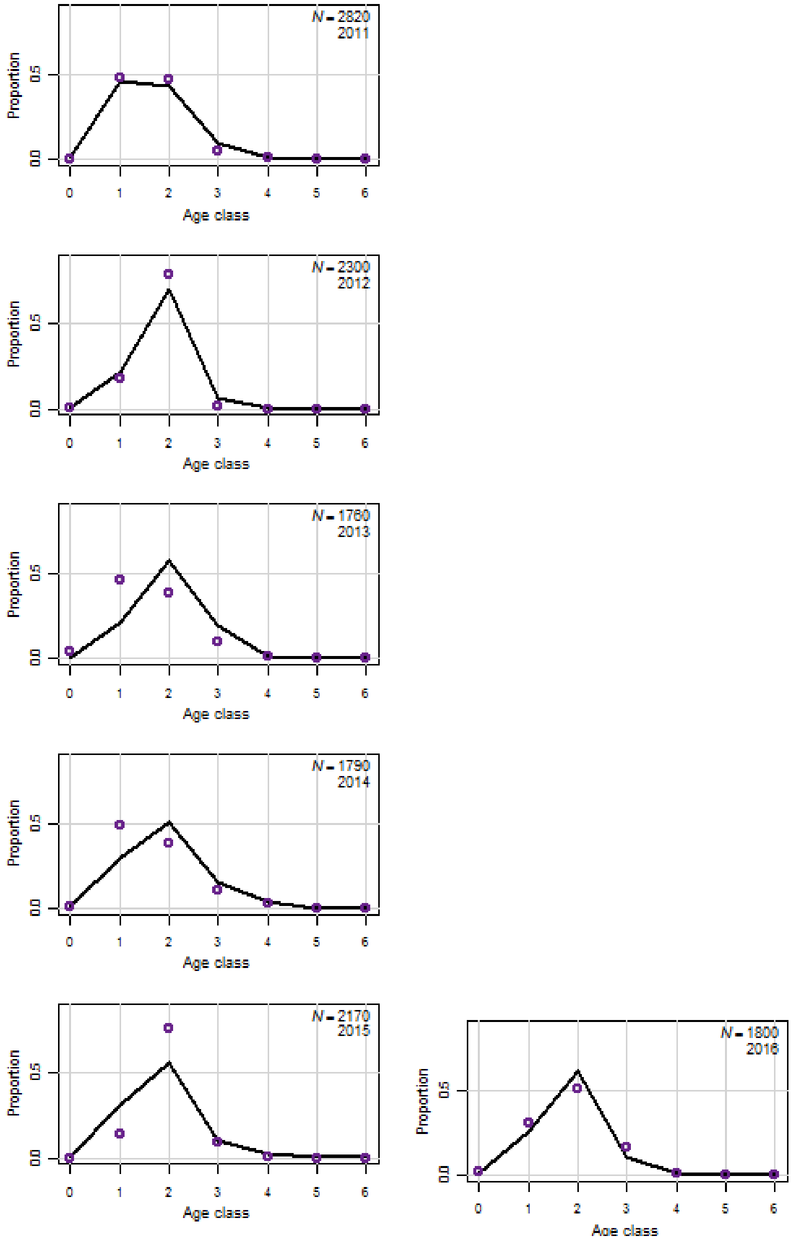

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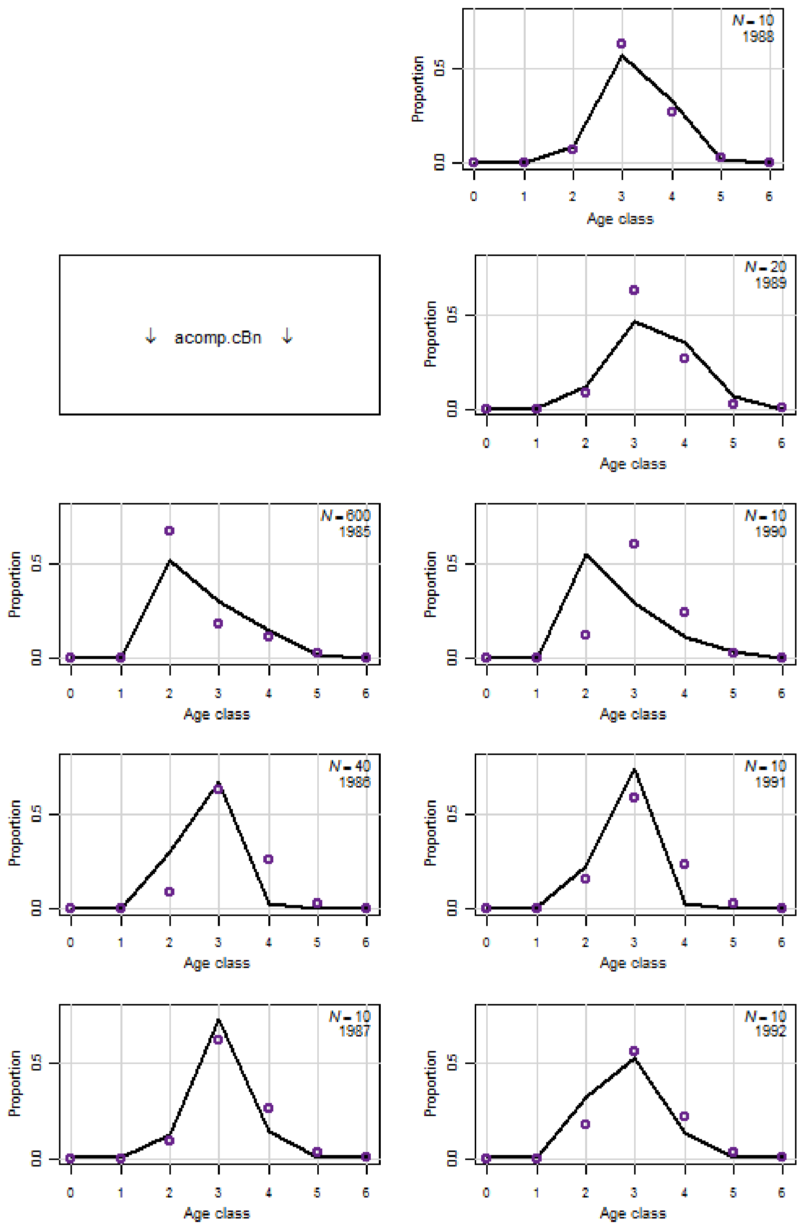
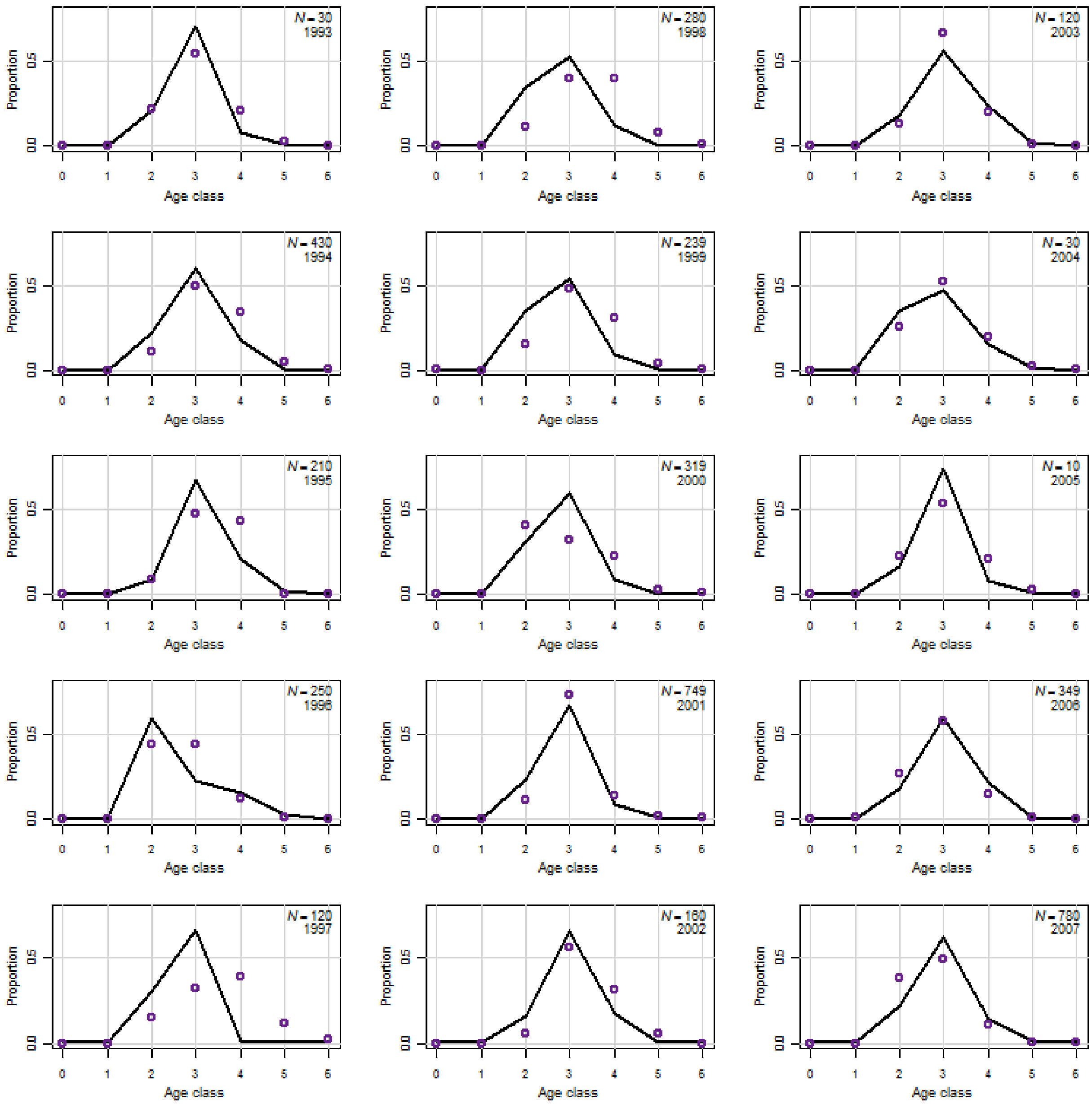


Figure 6.1.7. Annual observed and predicted catch-at-age of Atlantic menhaden from 1985-2016 from north of Virginia Eastern Shore by the commercial bait fishery.



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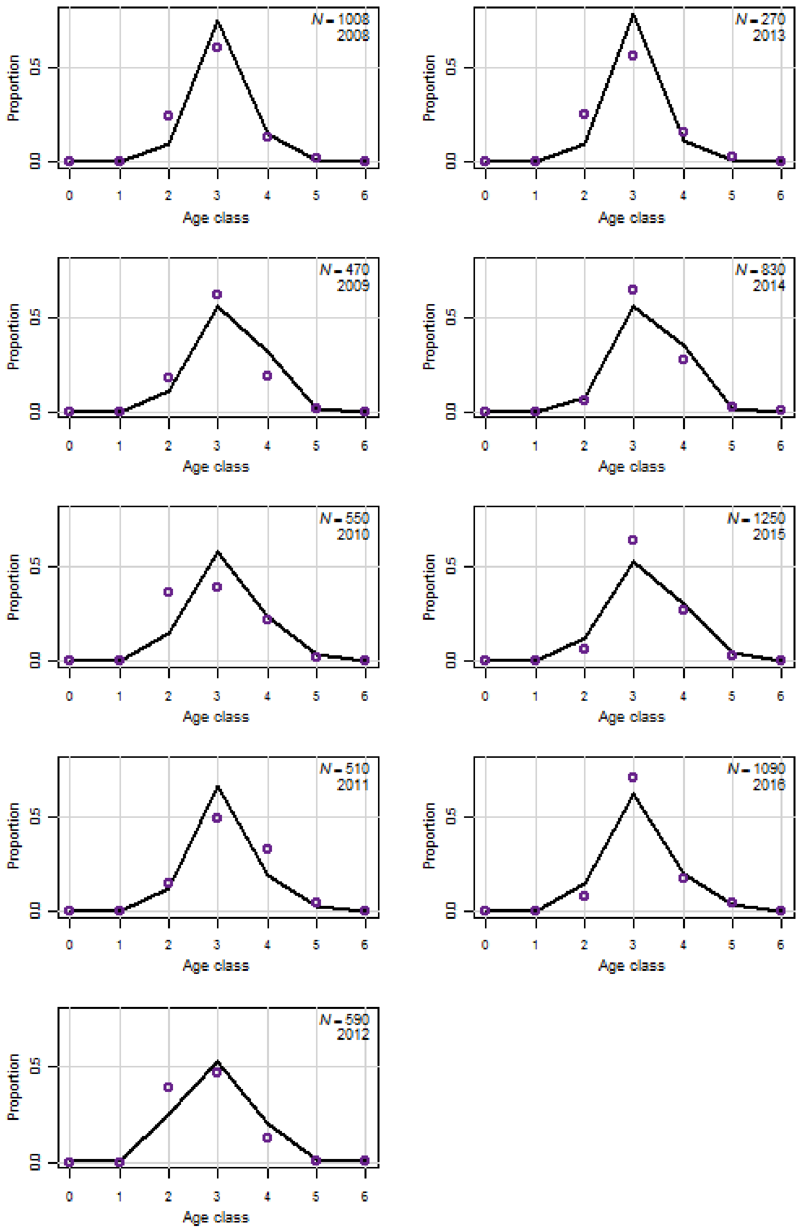

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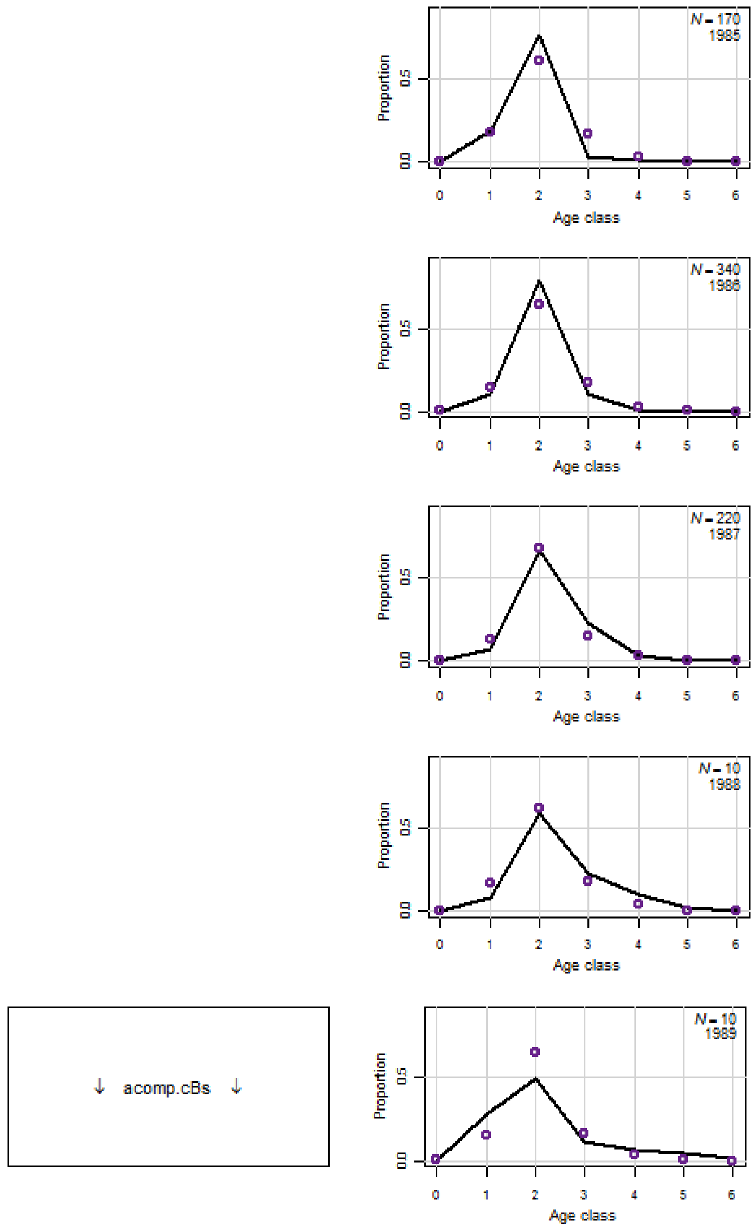
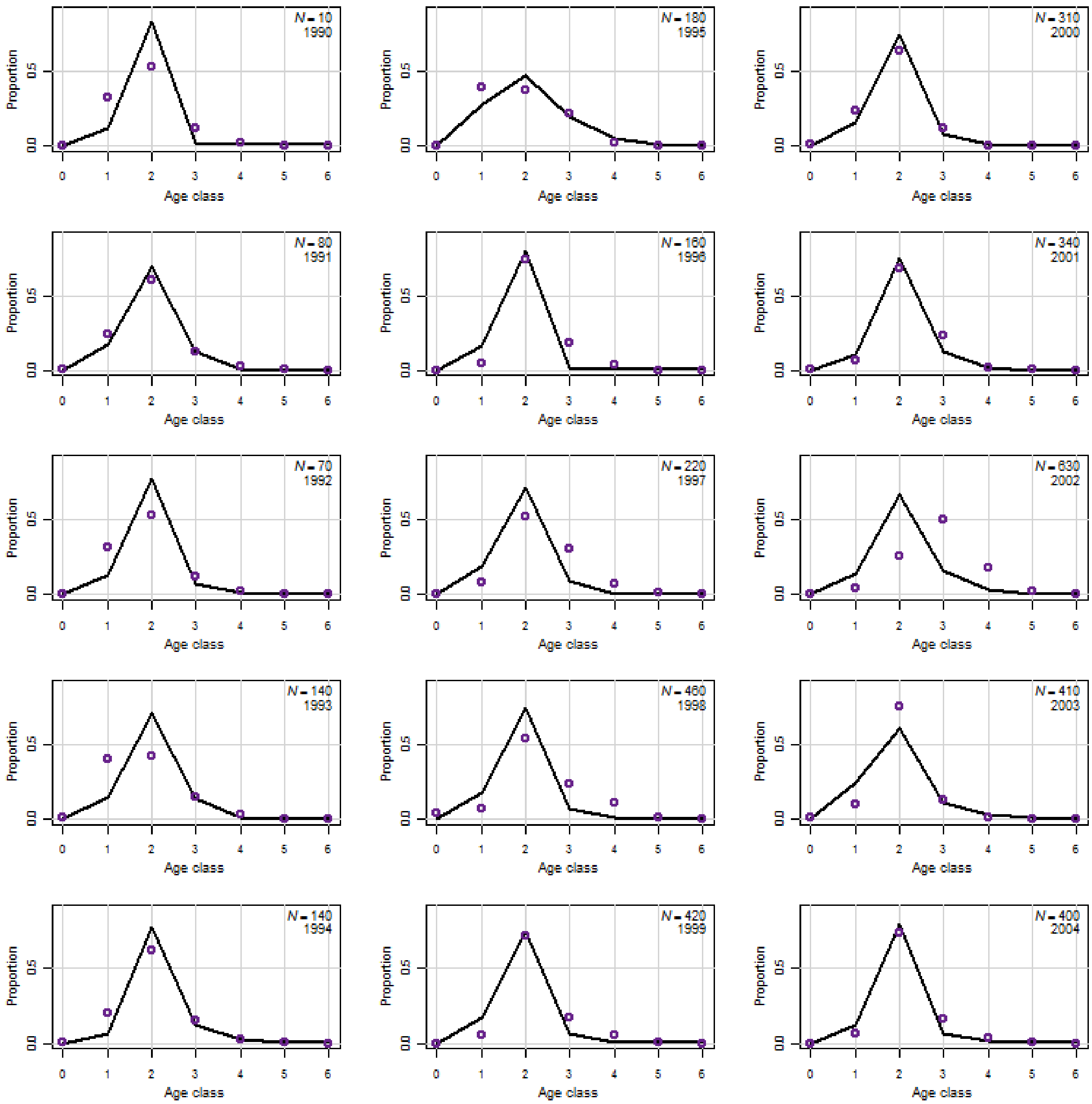


Figure 6.1.8. Annual observed and predicted catch-at-age of Atlantic menhaden from 1985-2016 from Virginia Eastern Shore and south by the commercial bait fishery.



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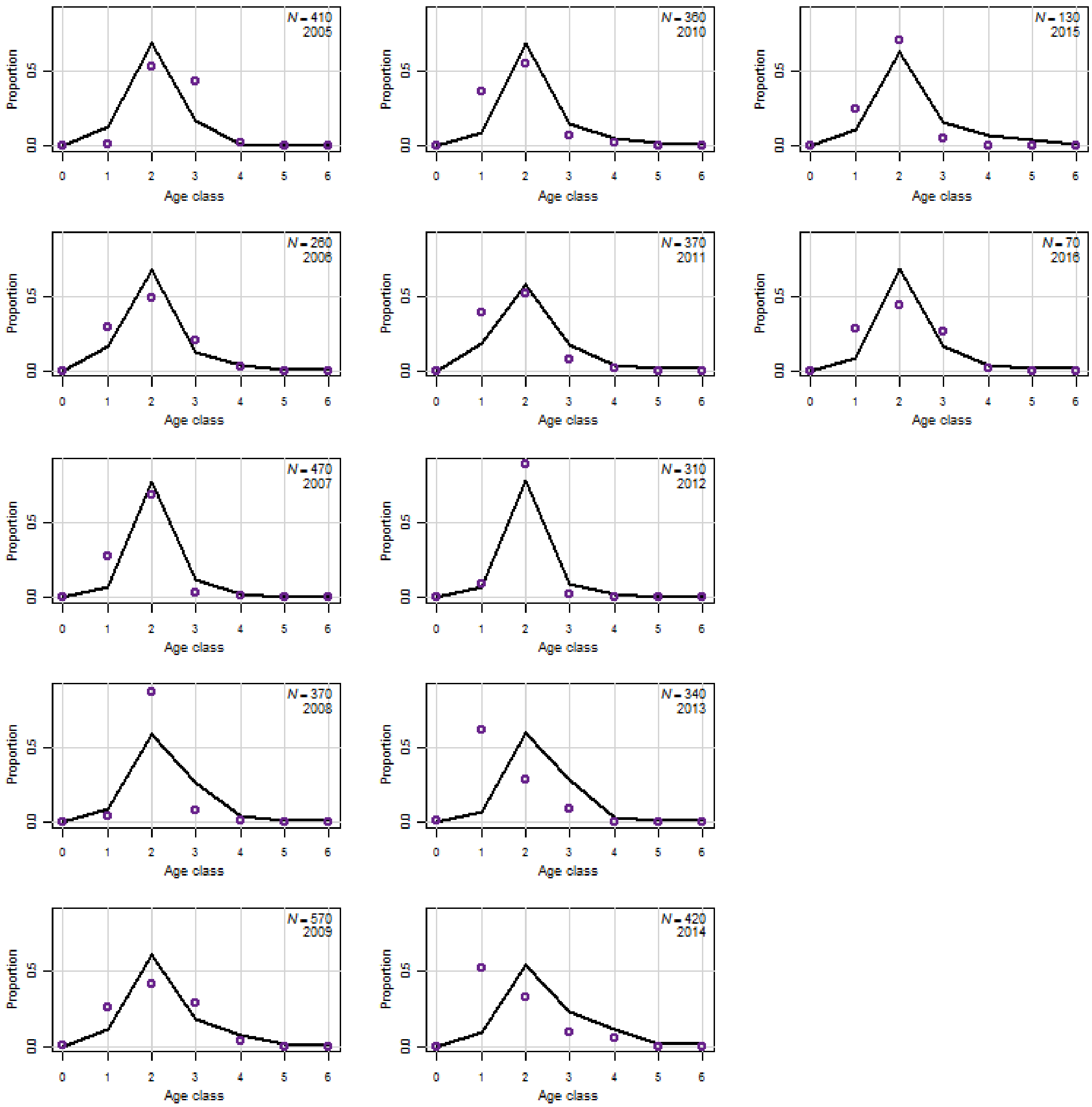

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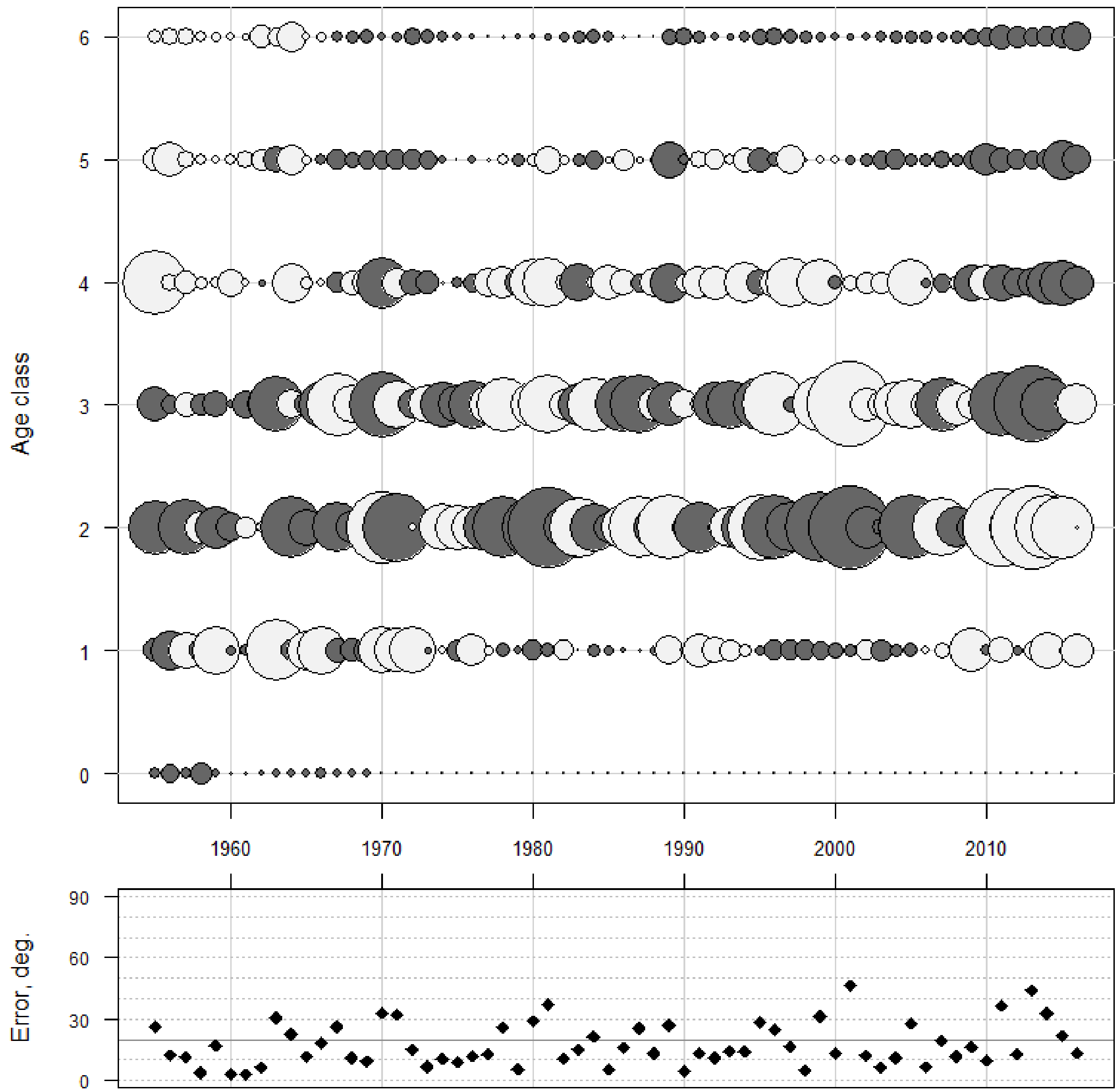
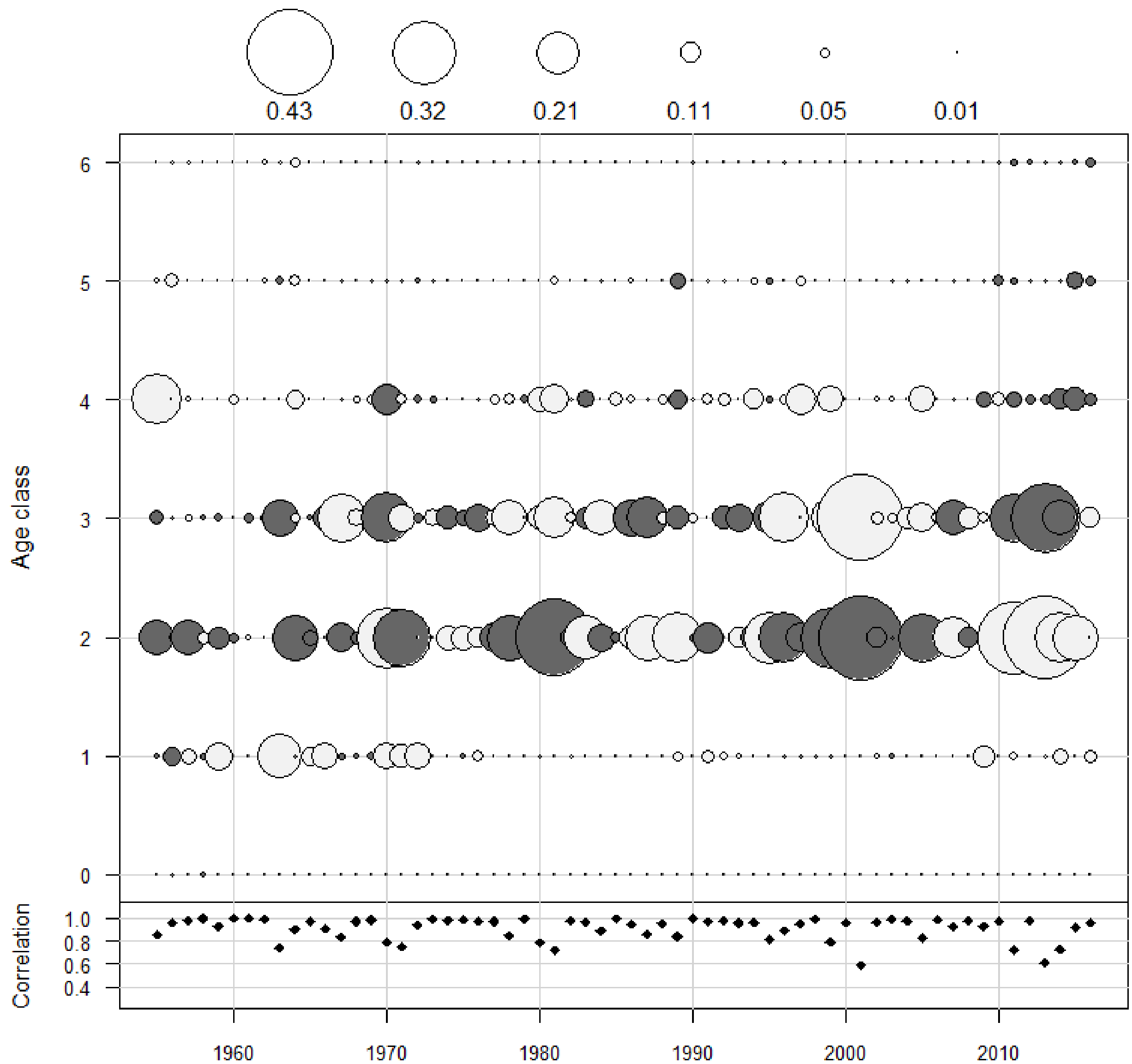


Figure 6.1.9. Relative (above) and absolute (next page) bubble plots of the residuals of the predicted catch-at-age for Atlantic menhaden from 1955-2016 from north of Virginia Eastern Shore by the commercial reduction fishery. The error degrees in the upper panel represents a composite fit by year across ages, while in the lower plot contains correlations between years.



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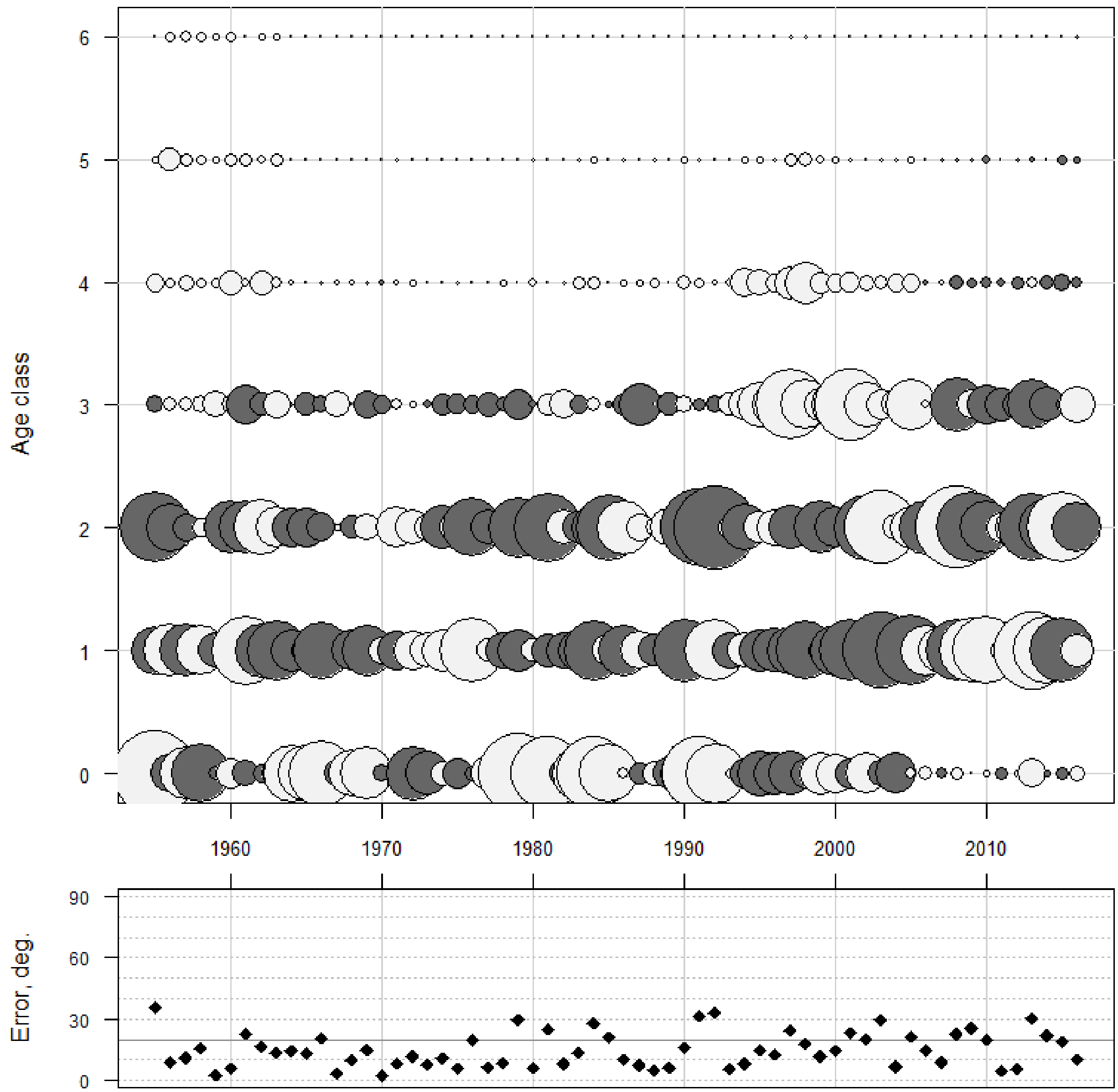
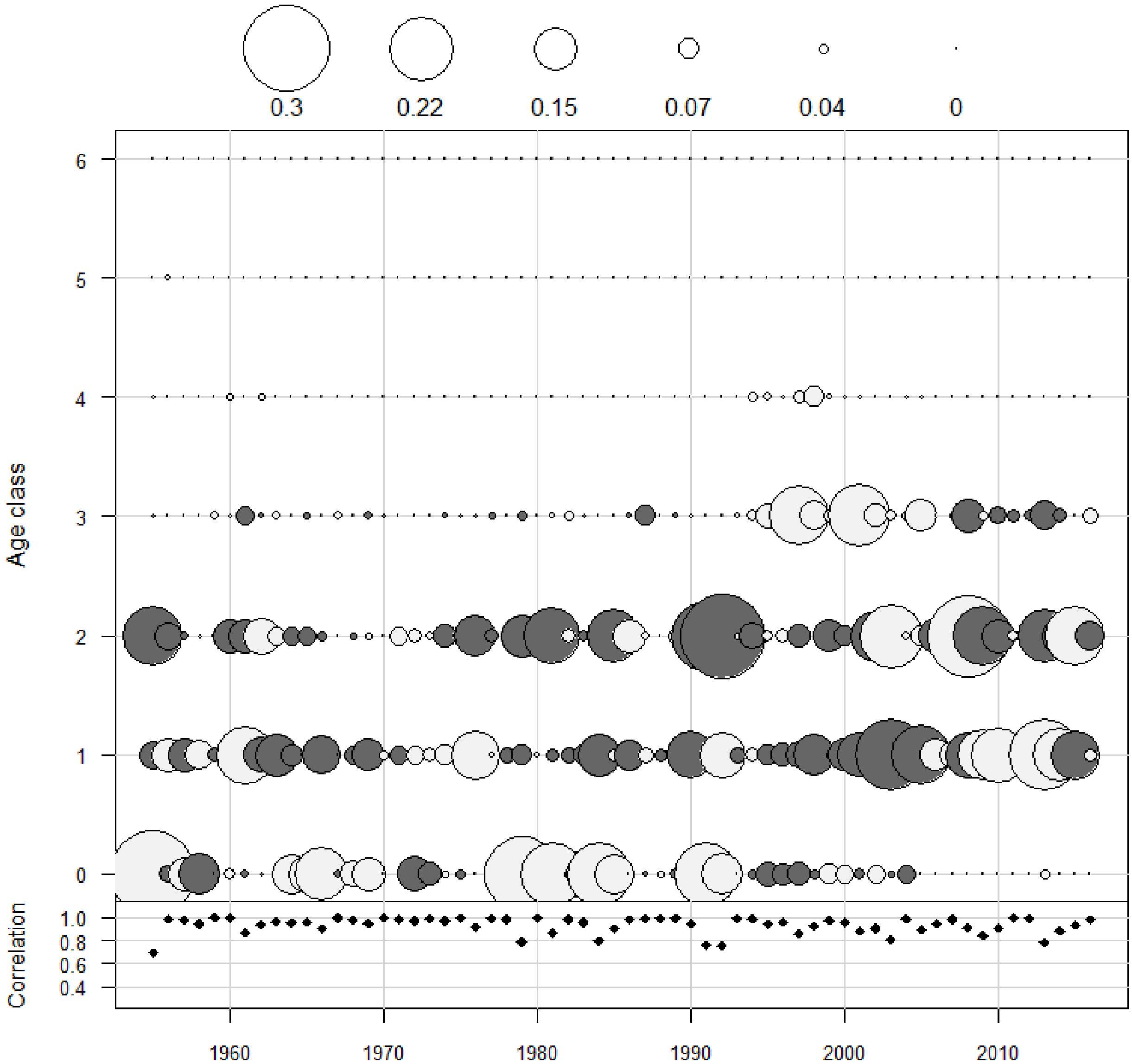


Figure 6.1.10. Relative (above) and absolute (next page) bubble plots of the residuals of the predicted catch-at-age for Atlantic menhaden from 1955-2016 from Virginia Eastern Shore and south by the commercial reduction fishery. The error degrees in the upper panel represents a composite fit by year across ages, while in the lower plot contains correlations between years.



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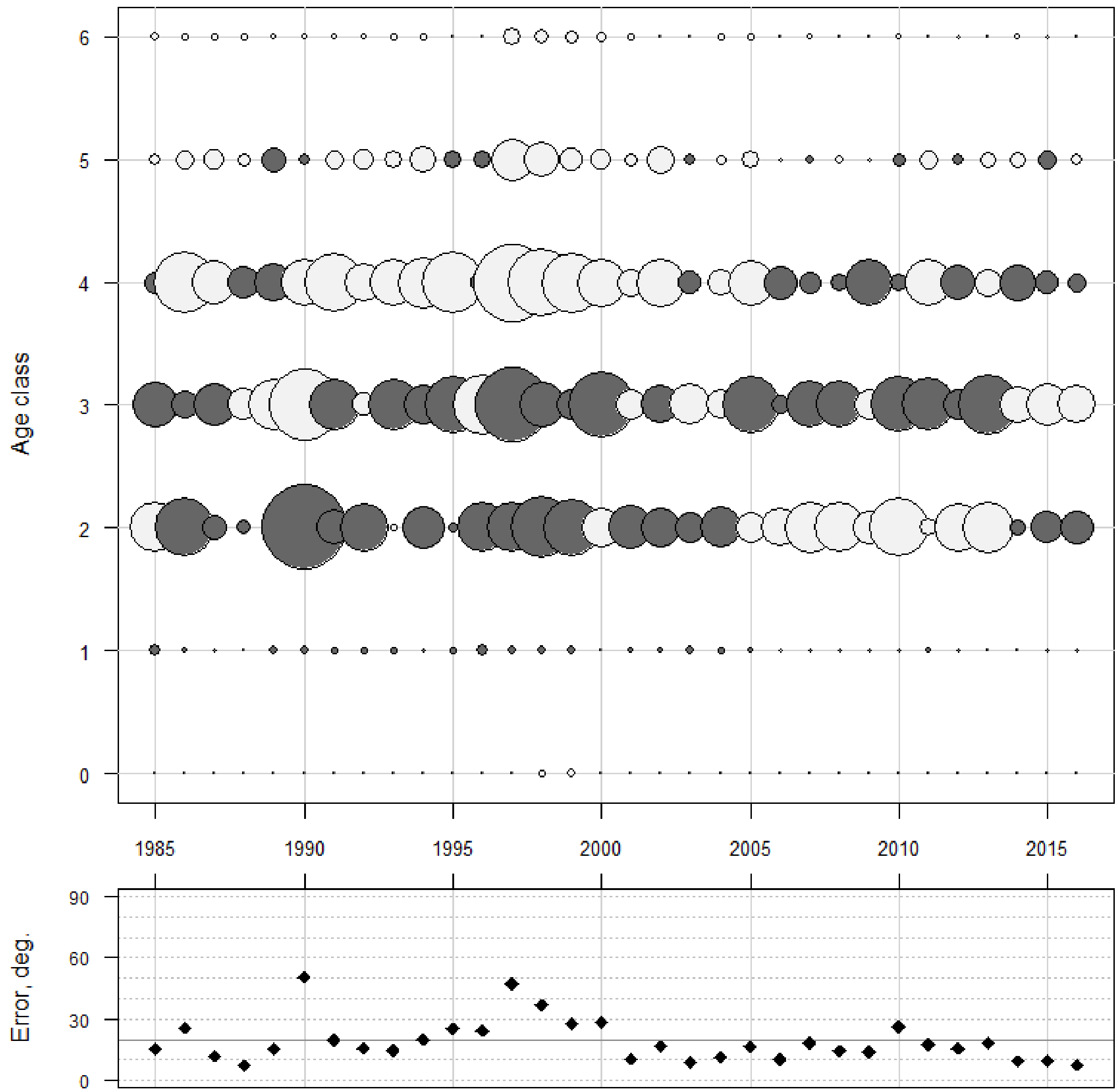
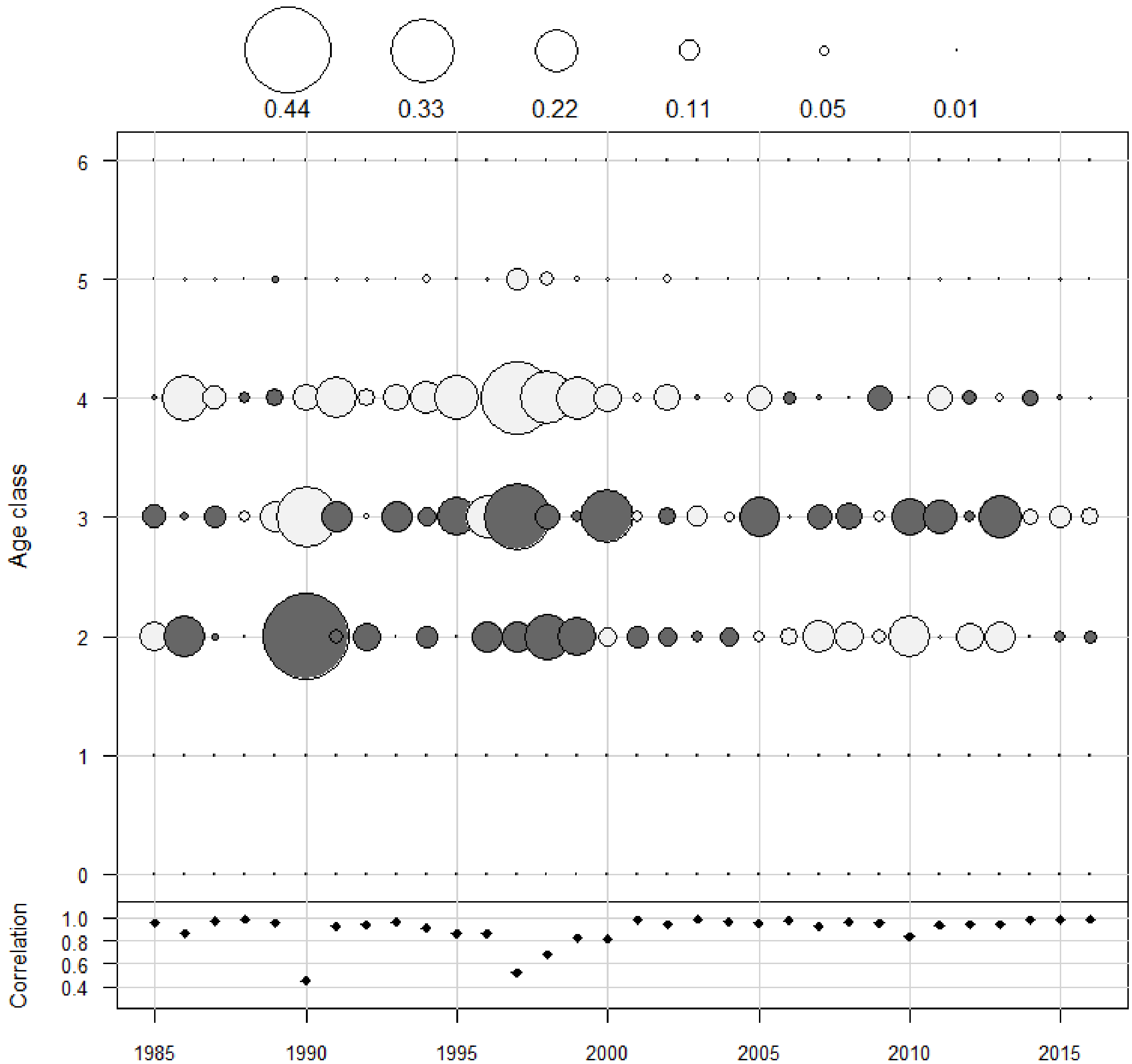


Figure 6.1.11. Relative (above) and absolute (next page) bubble plots of the residuals of the predicted catch-at-age for Atlantic menhaden from 1985-2016 from north of Virginia Eastern Shore by the commercial bait fishery. The error degrees in the upper panel represents a composite fit by year across ages, while in the lower plot contains correlations between years.



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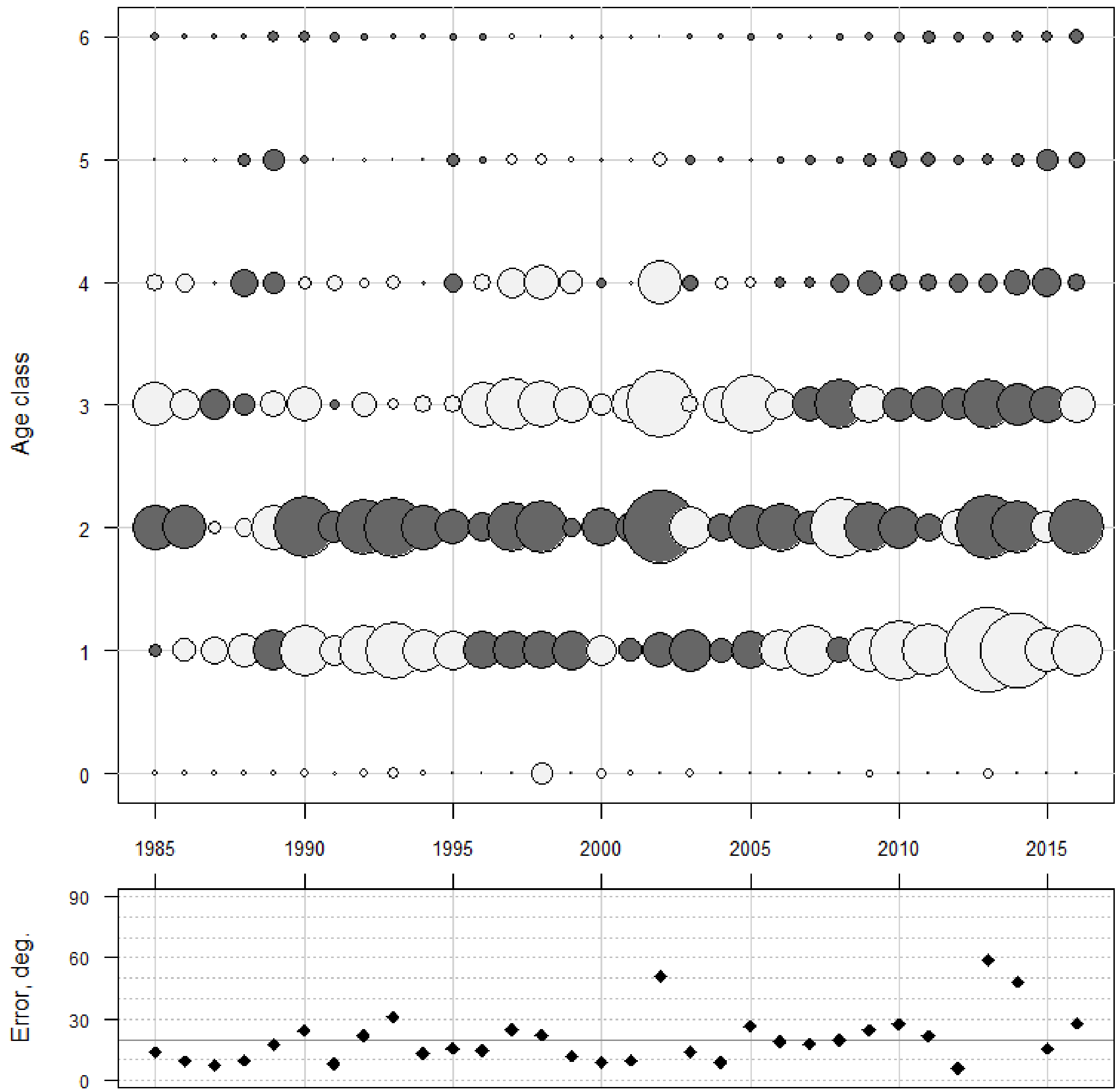
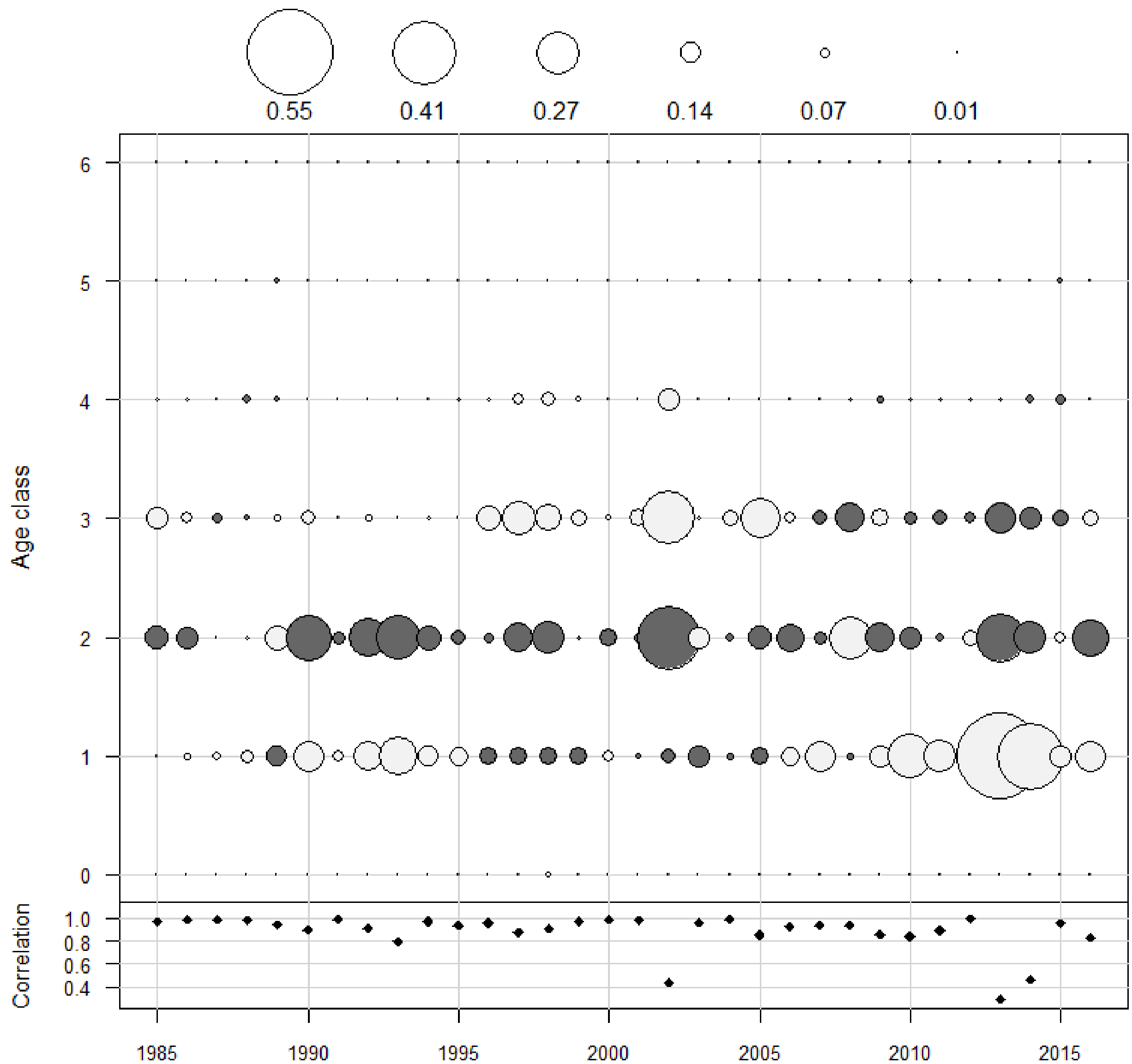


Figure 6.1.12. Relative (above) and absolute (next page) bubble plots of the residuals of the predicted catch-at-age for Atlantic menhaden from 1985-2016 from Virginia Eastern Shore and south by the commercial bait fishery. The error degrees in the upper panel represents a composite fit by year across ages, while in the lower plot contains correlations between years.



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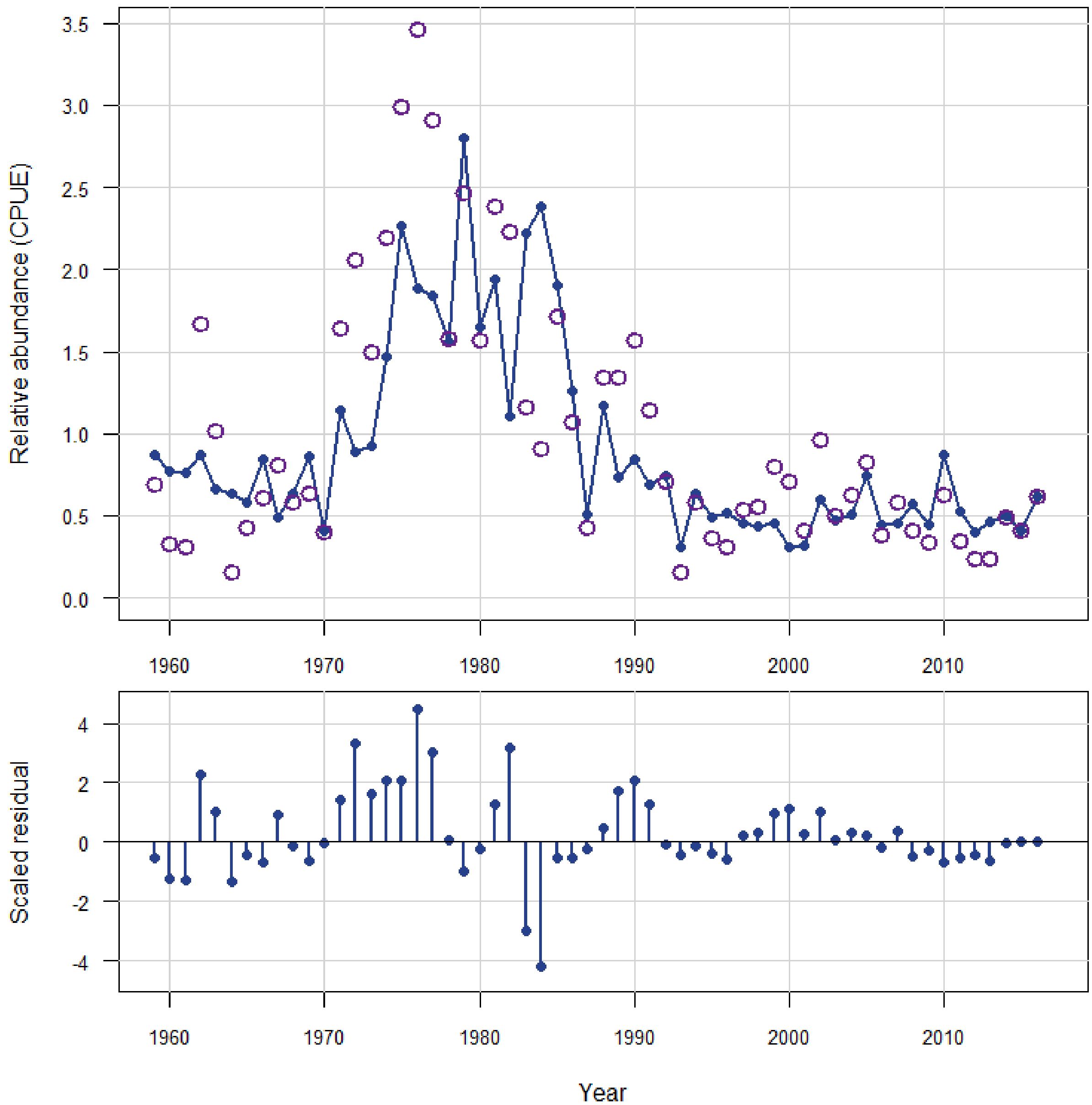


Figure 6.1.13. The observed and predicted recruitment index for 1959-2016 comprised of a series of state surveys.

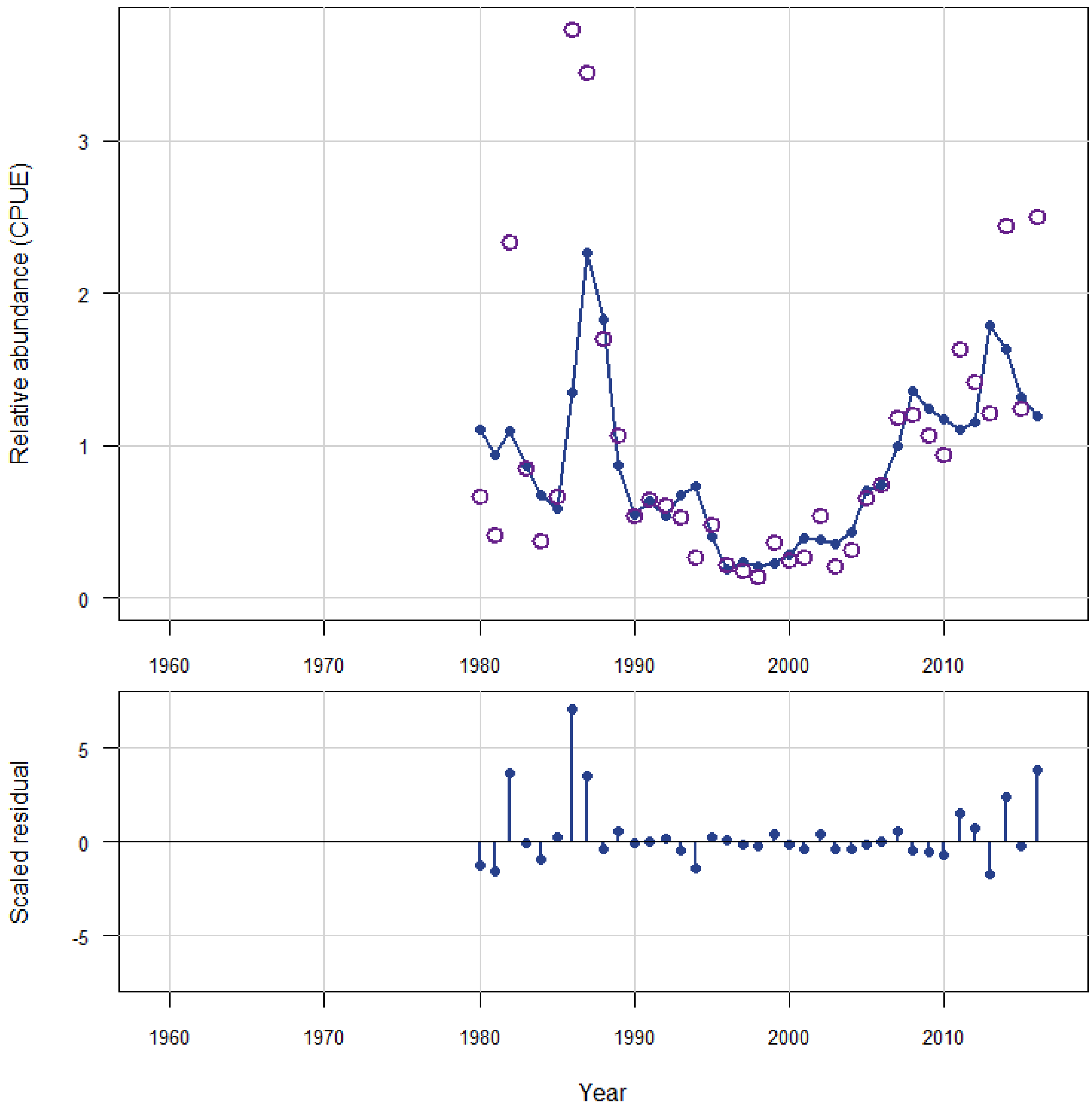


Figure 6.1.14. The observed and predicted NAD index for 1980-2016 comprised of a series of state trawl surveys in the northern region.

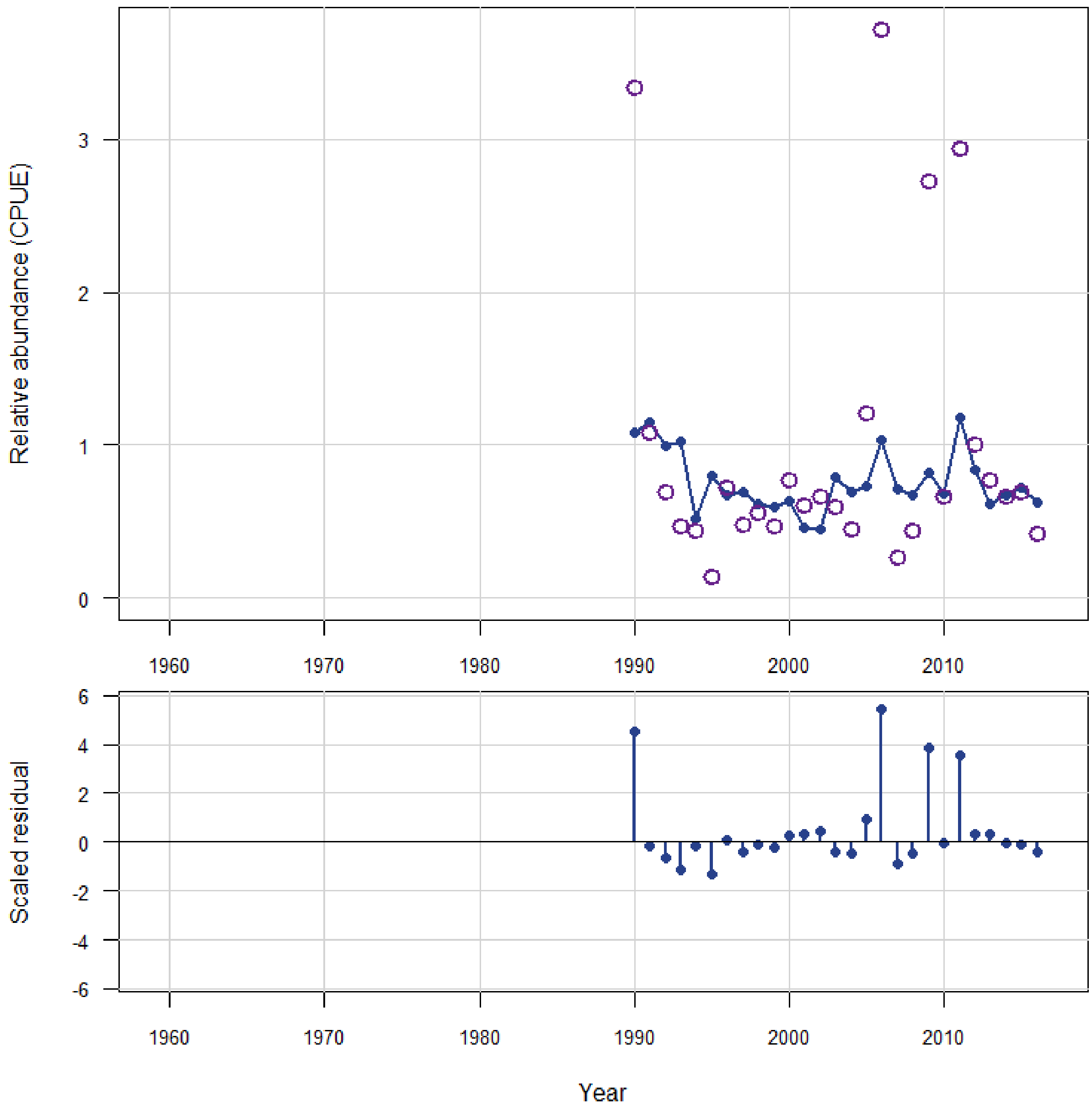


Figure 6.1.15. The observed and predicted SAD index for 1990-2016 comprised of two state trawl surveys in the southern region.

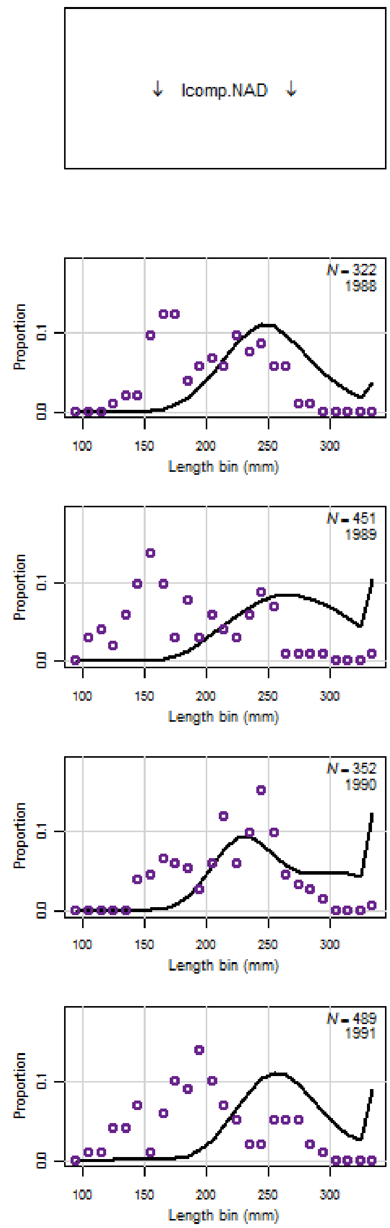
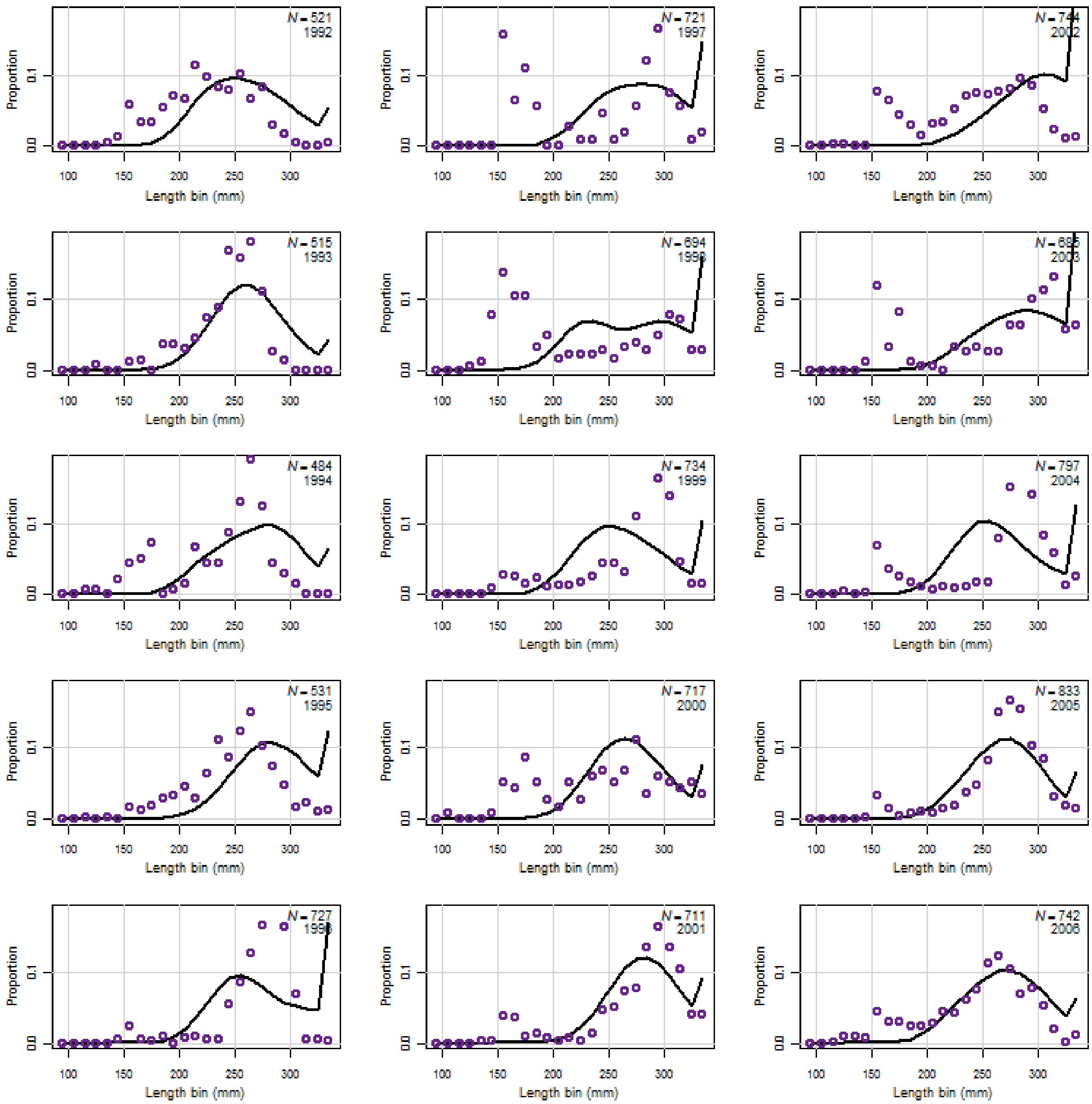


Figure 6.1.16. Annual observed and predicted length measurements of Atlantic menhaden from 1986-2016 for the NAD index.



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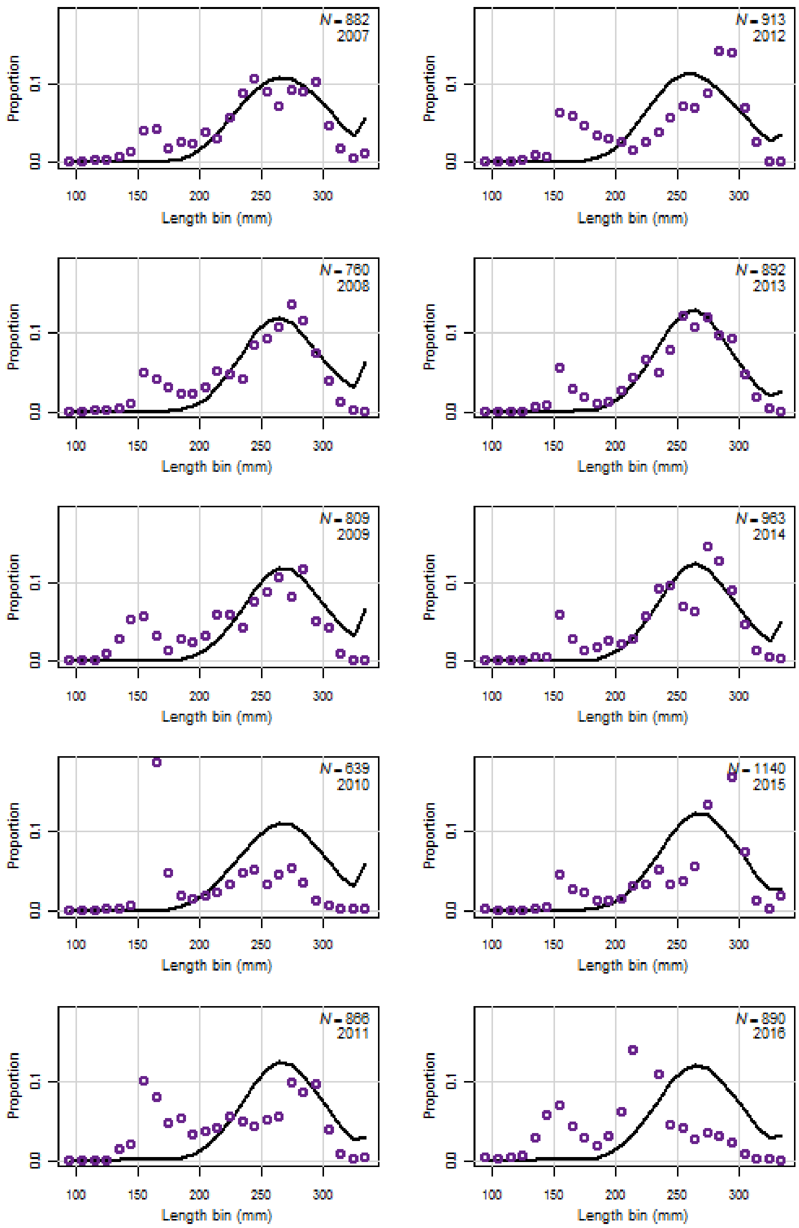


Figure 6.1.16. *Continued.*

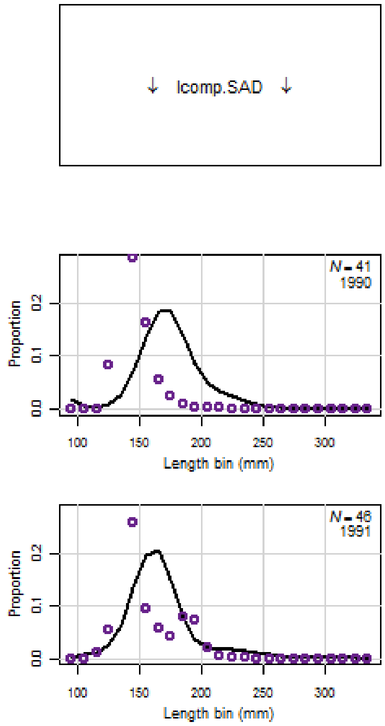
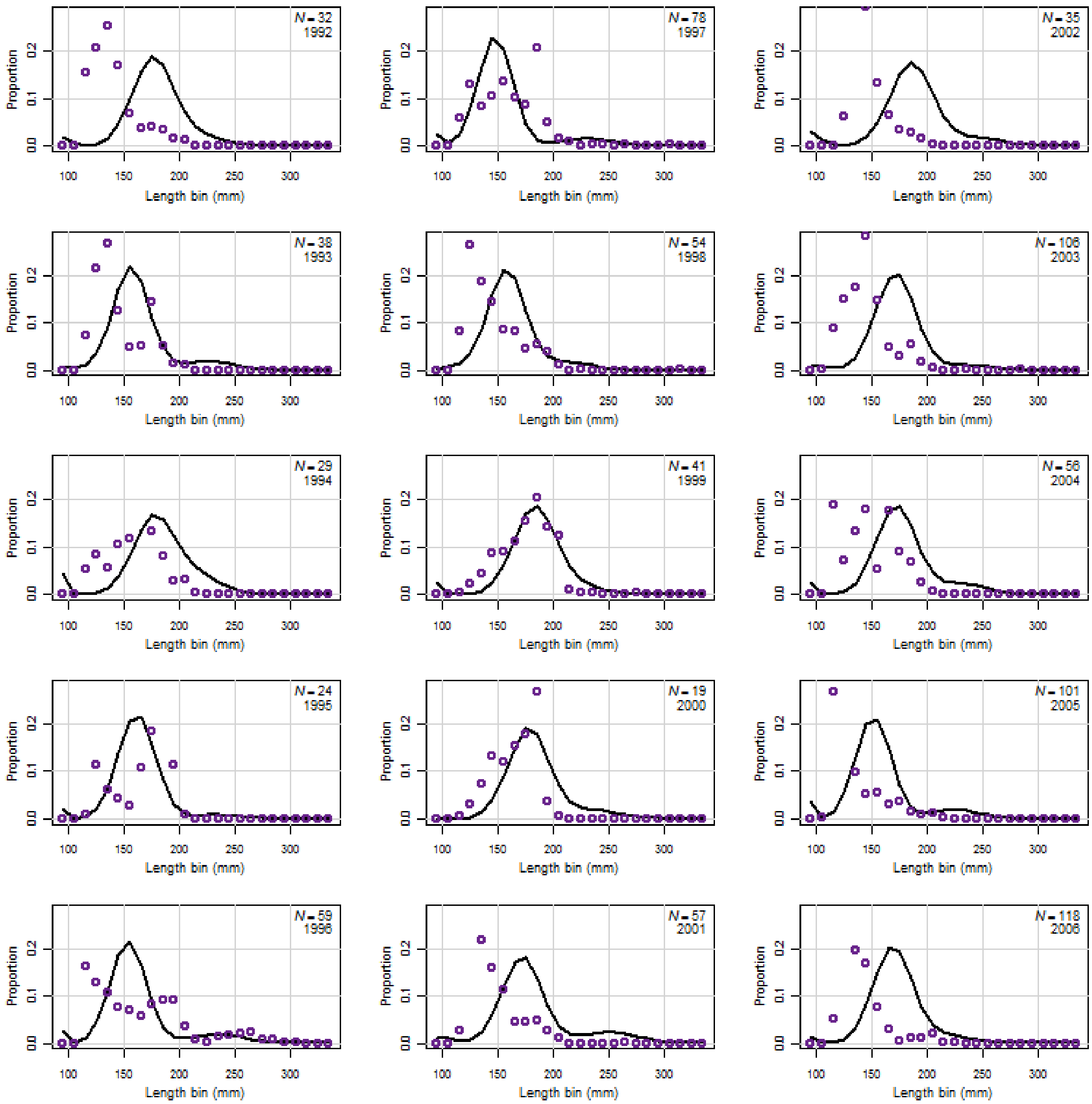


Figure 6.1.17. Annual observed and predicted length measurements of Atlantic menhaden from 1990-2016 for the SAD index.



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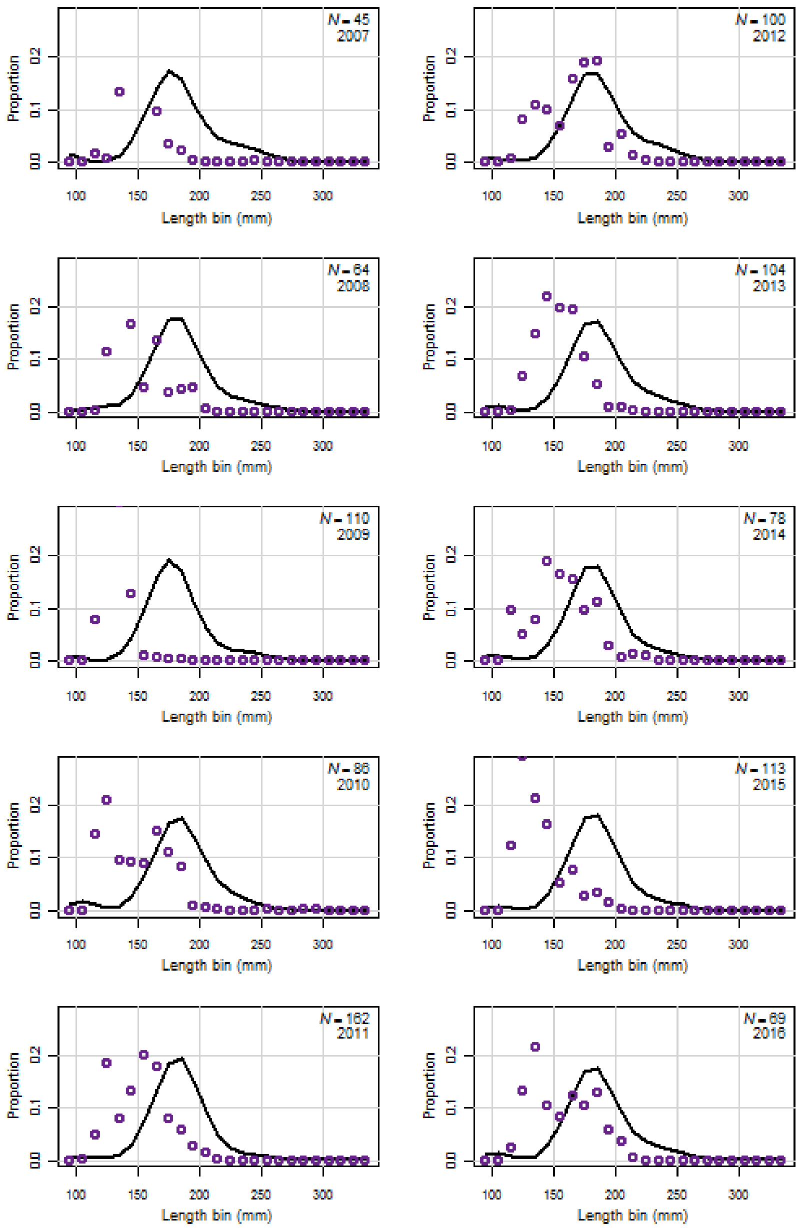

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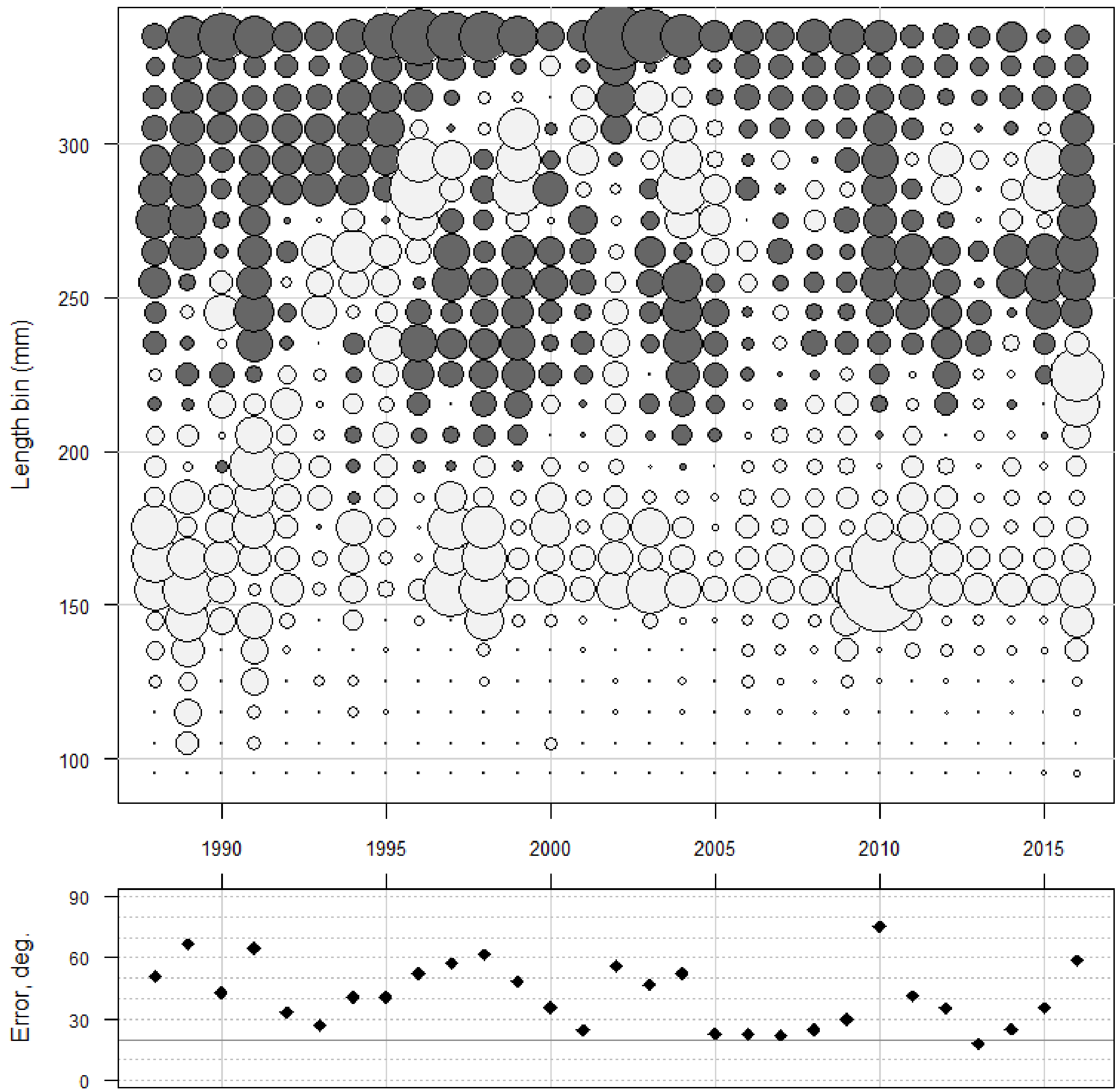


Figure 6.1.18. Relative (above) and absolute (next page) bubble plots of the residuals of the predicted lengths for Atlantic menhaden from 1986-2016 from the NAD. The error degrees in the upper panel represents a composite fit by year across lengths, while in the lower plot contains correlations between years.

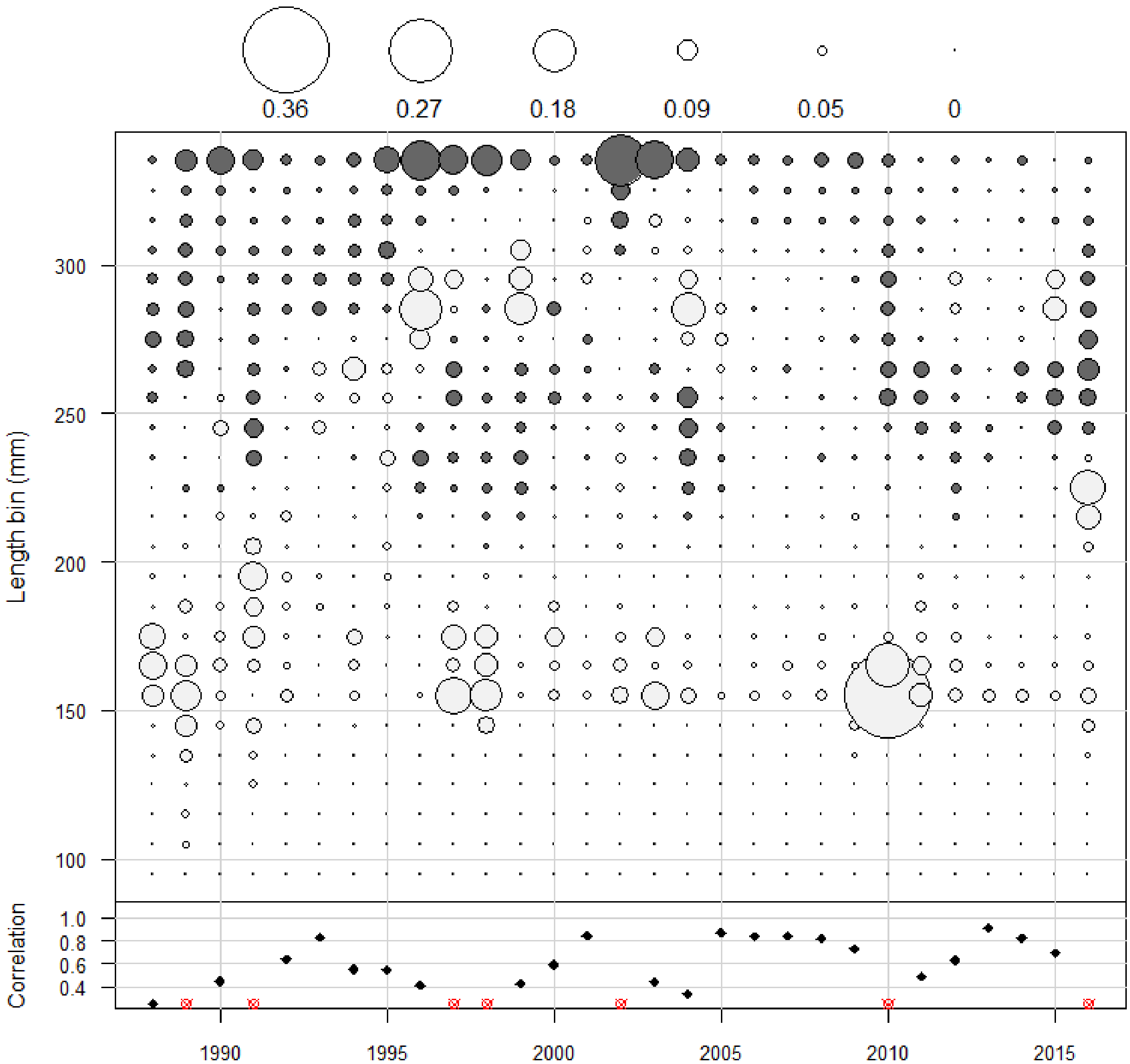


Figure 6.1.18. ***Continued.***

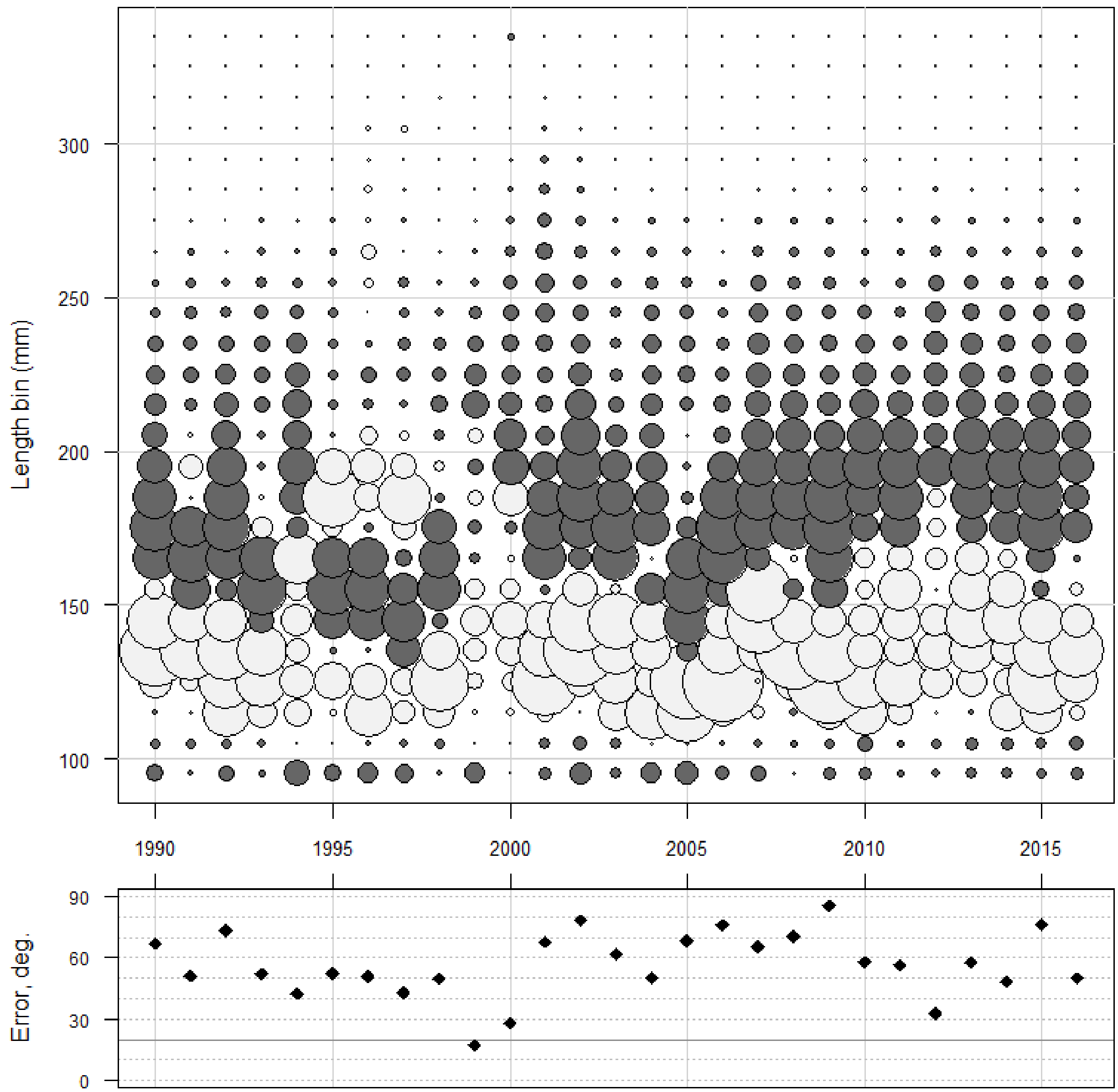


Figure 6.1.19. Relative (above) and absolute (next page) bubble plots of the residuals of the predicted lengths for Atlantic menhaden from 1990-2016 from the SAD. The error degrees in the upper panel represents a composite fit by year across lengths, while in the lower plot contains correlations between years.

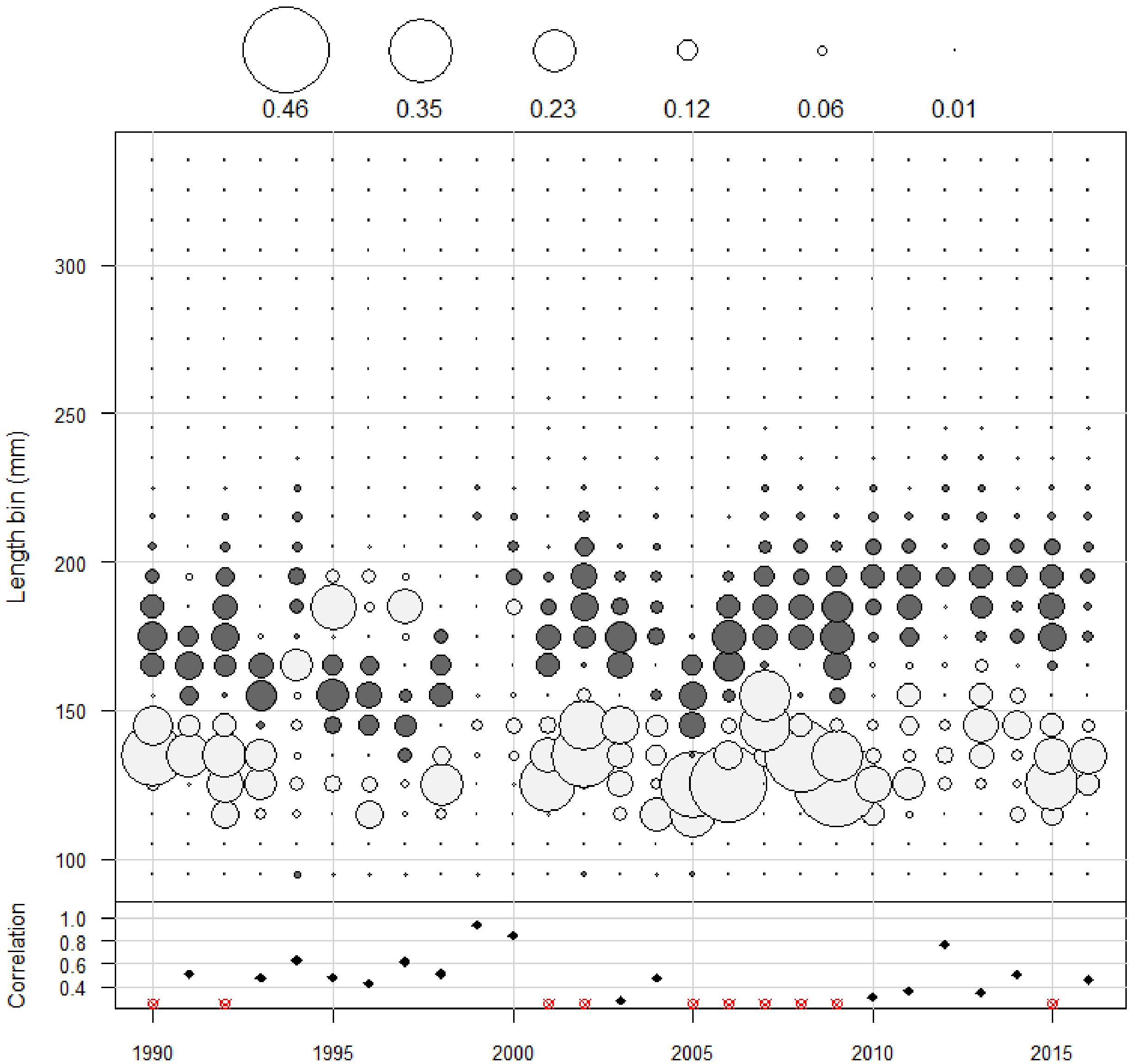


Figure 6.1.19. ***Continued.***

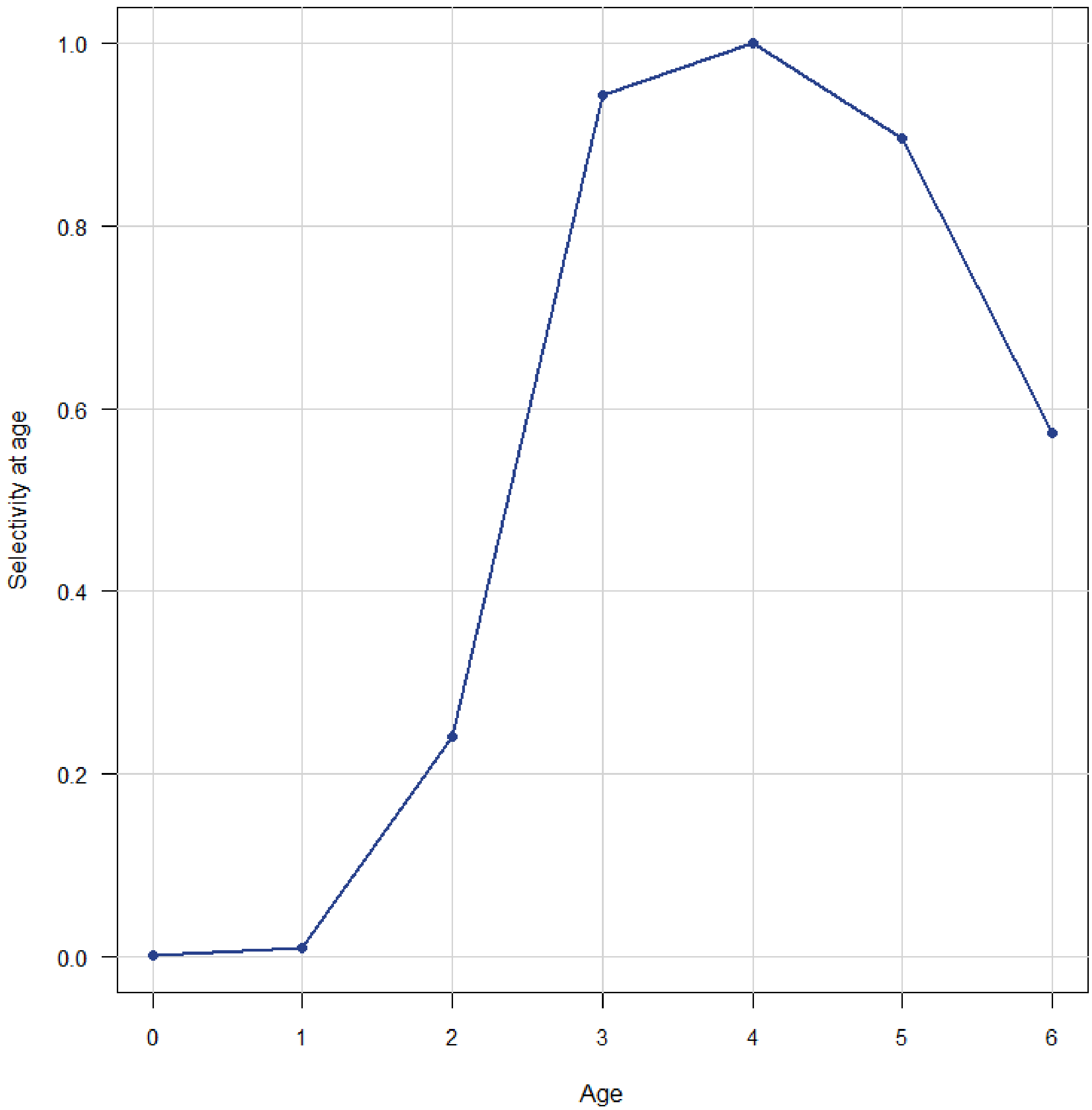


Figure 6.2.1.1. Selectivity for the northern commercial reduction fleet for 1955-1969.

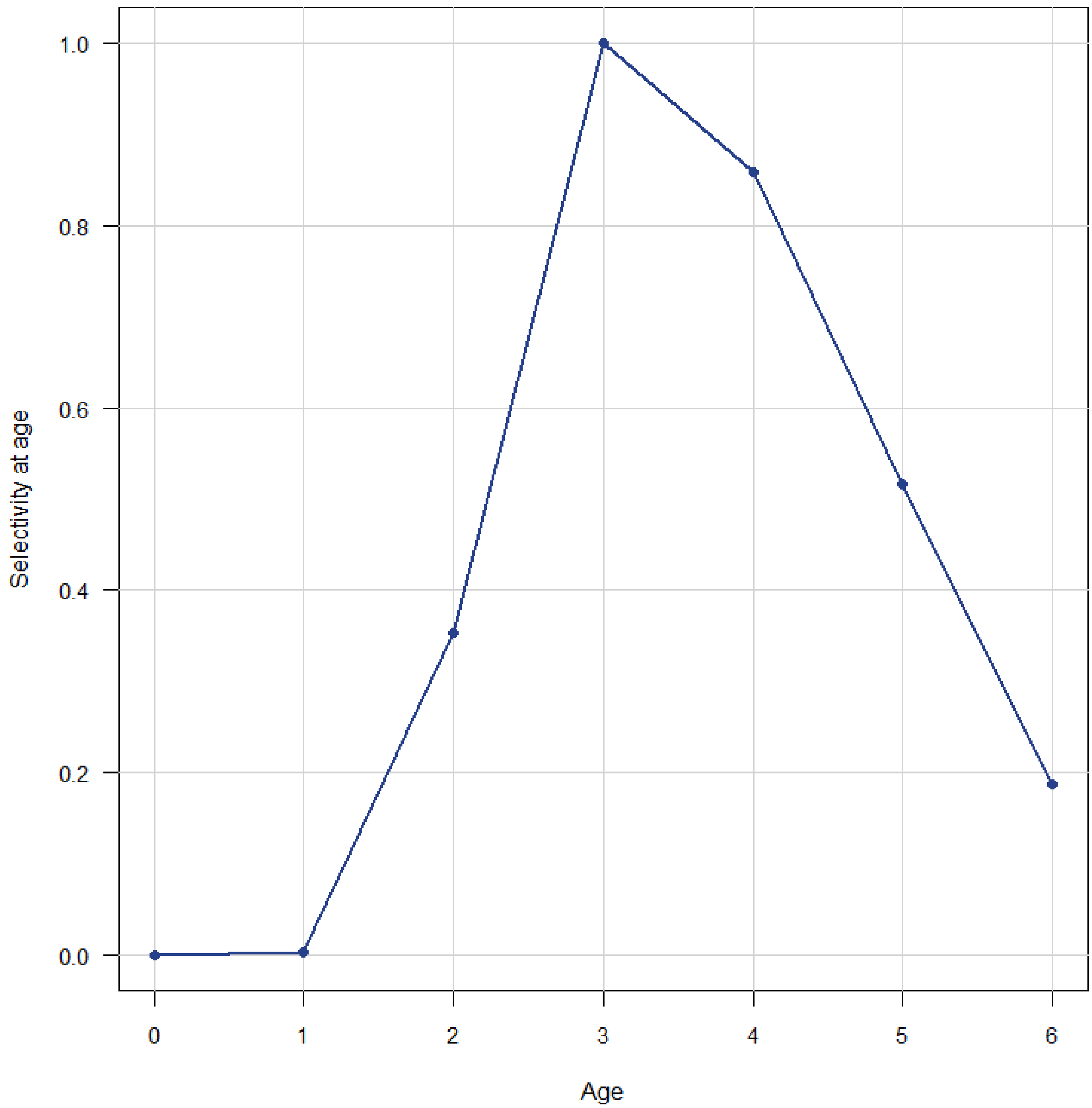


Figure 6.2.1.2. Selectivity for the northern commercial reduction fleet for 1970-1993.

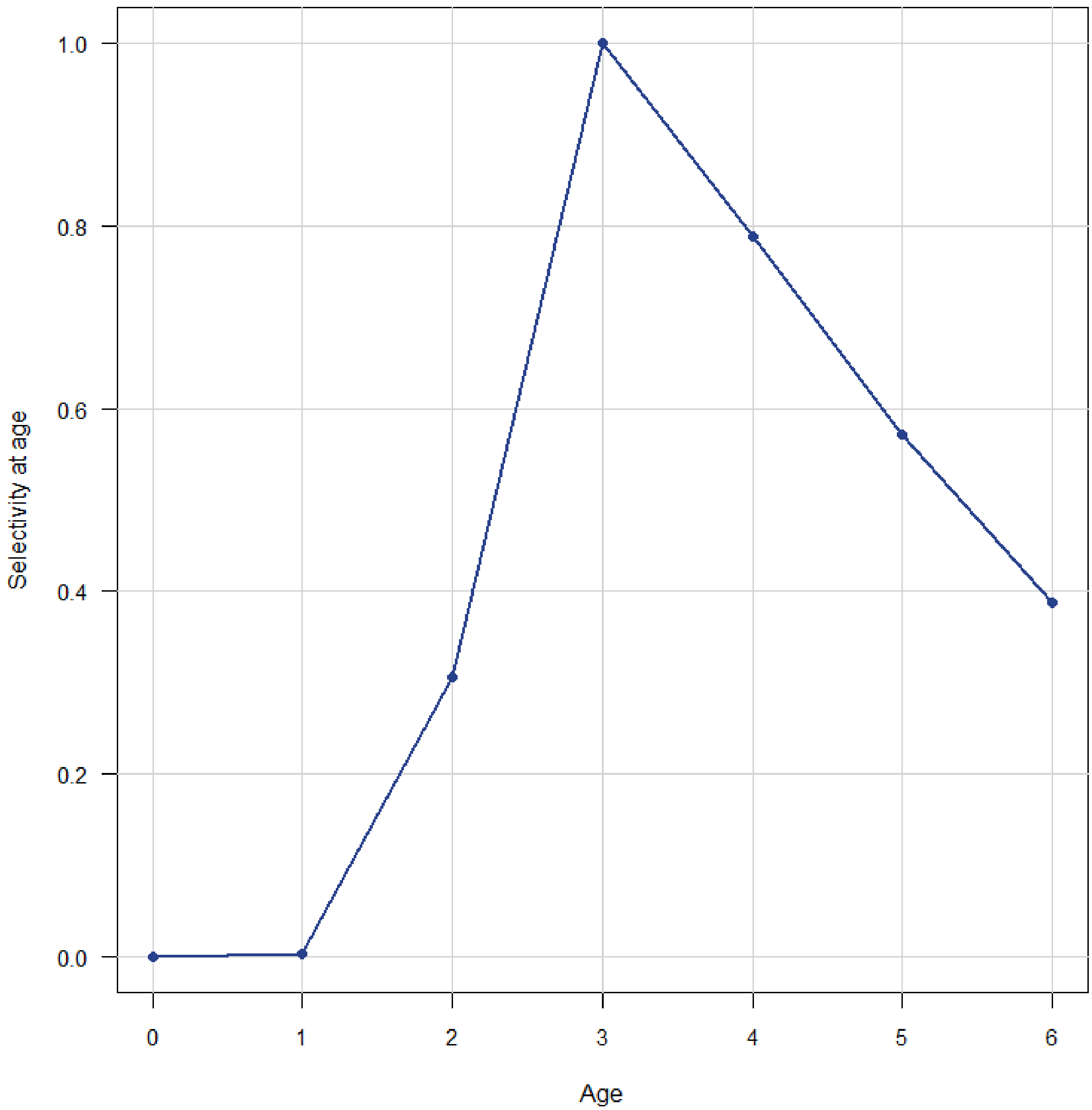


Figure 6.2.1.3. Selectivity for the northern commercial reduction fleet for 1994-2016.

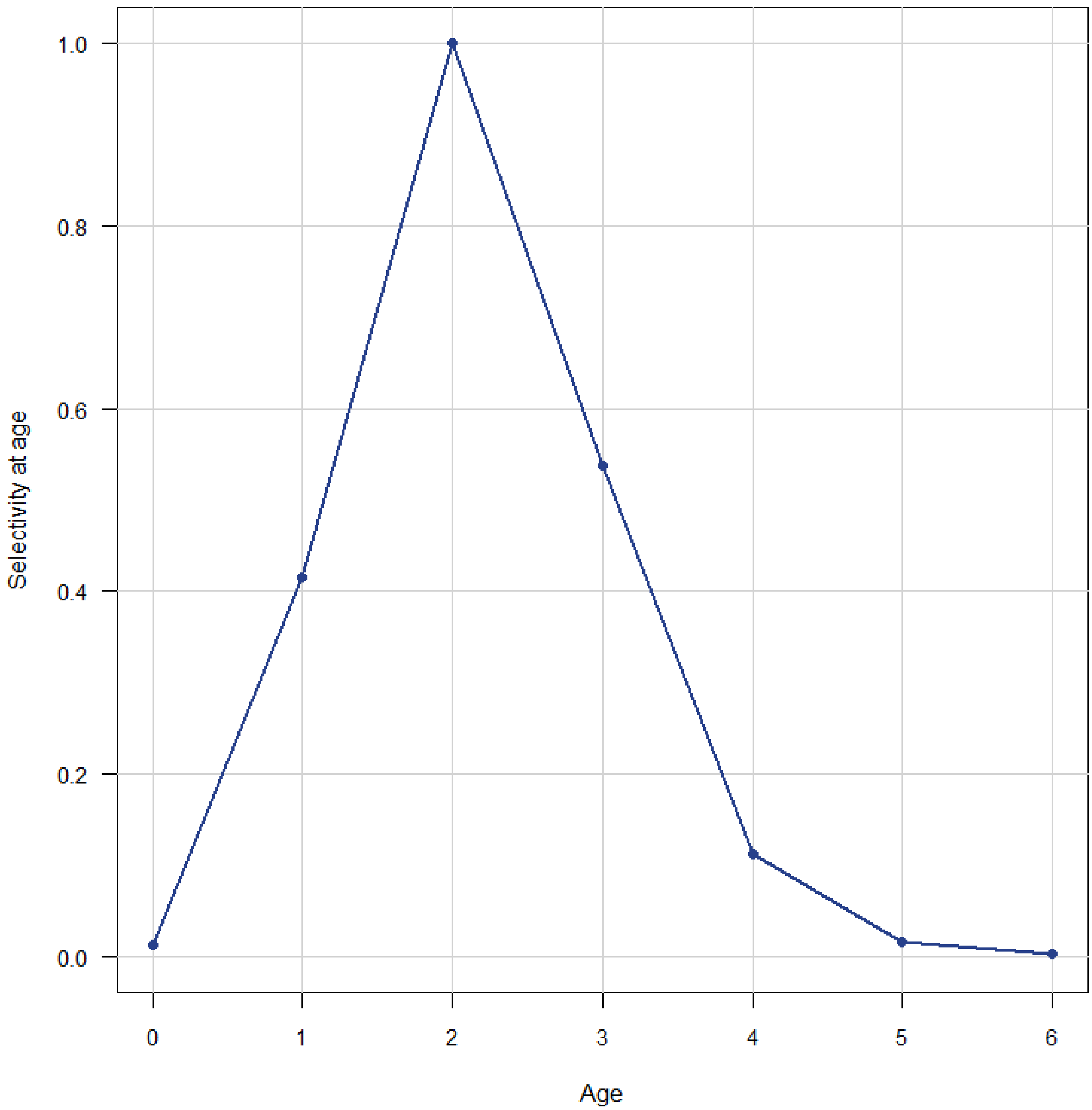


Figure 6.2.1.4. Selectivity for the southern commercial reduction fleet for 1955-1971.

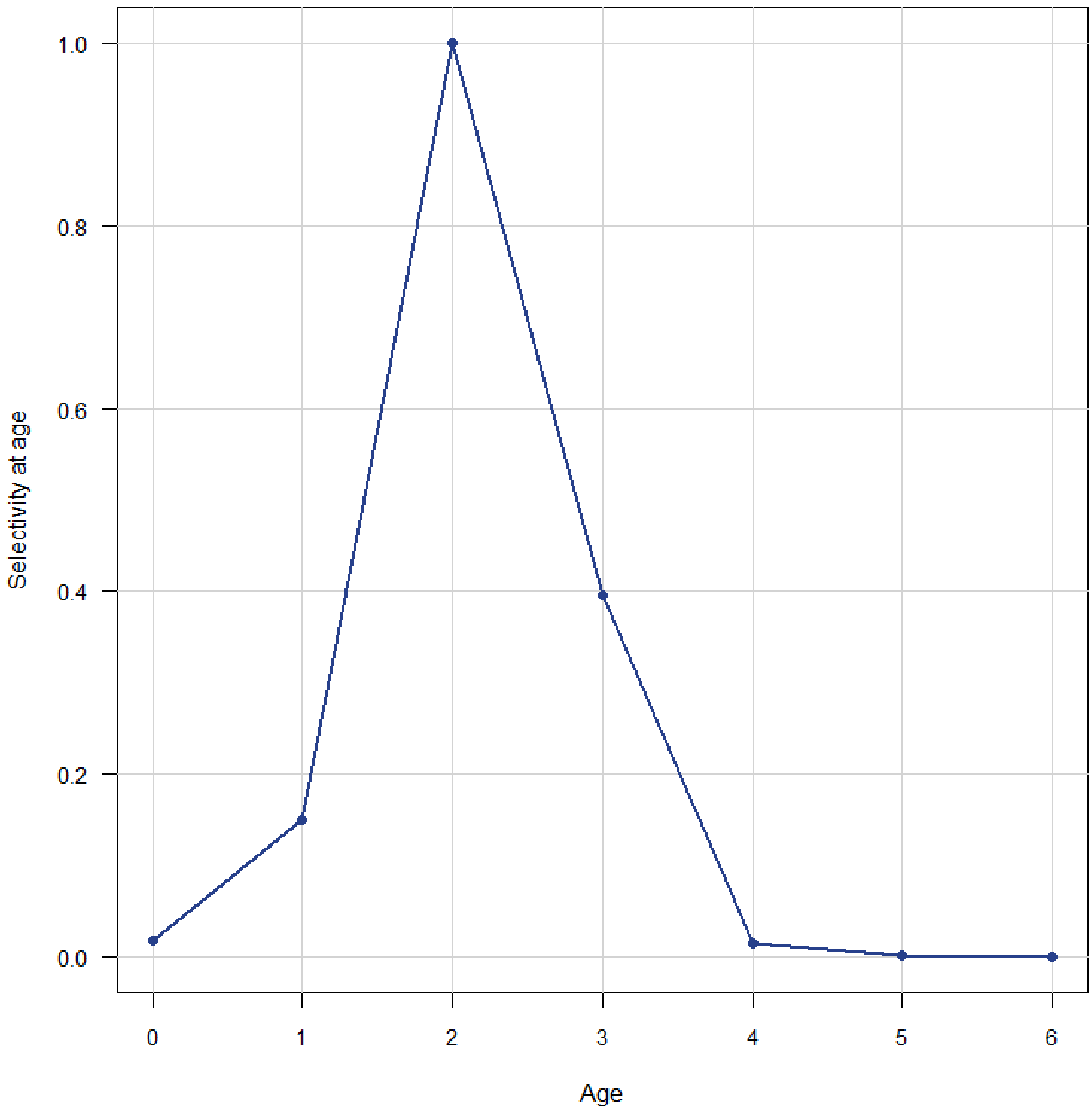


Figure 6.2.1.5. Selectivity for the southern commercial reduction fleet for 1972-2004.

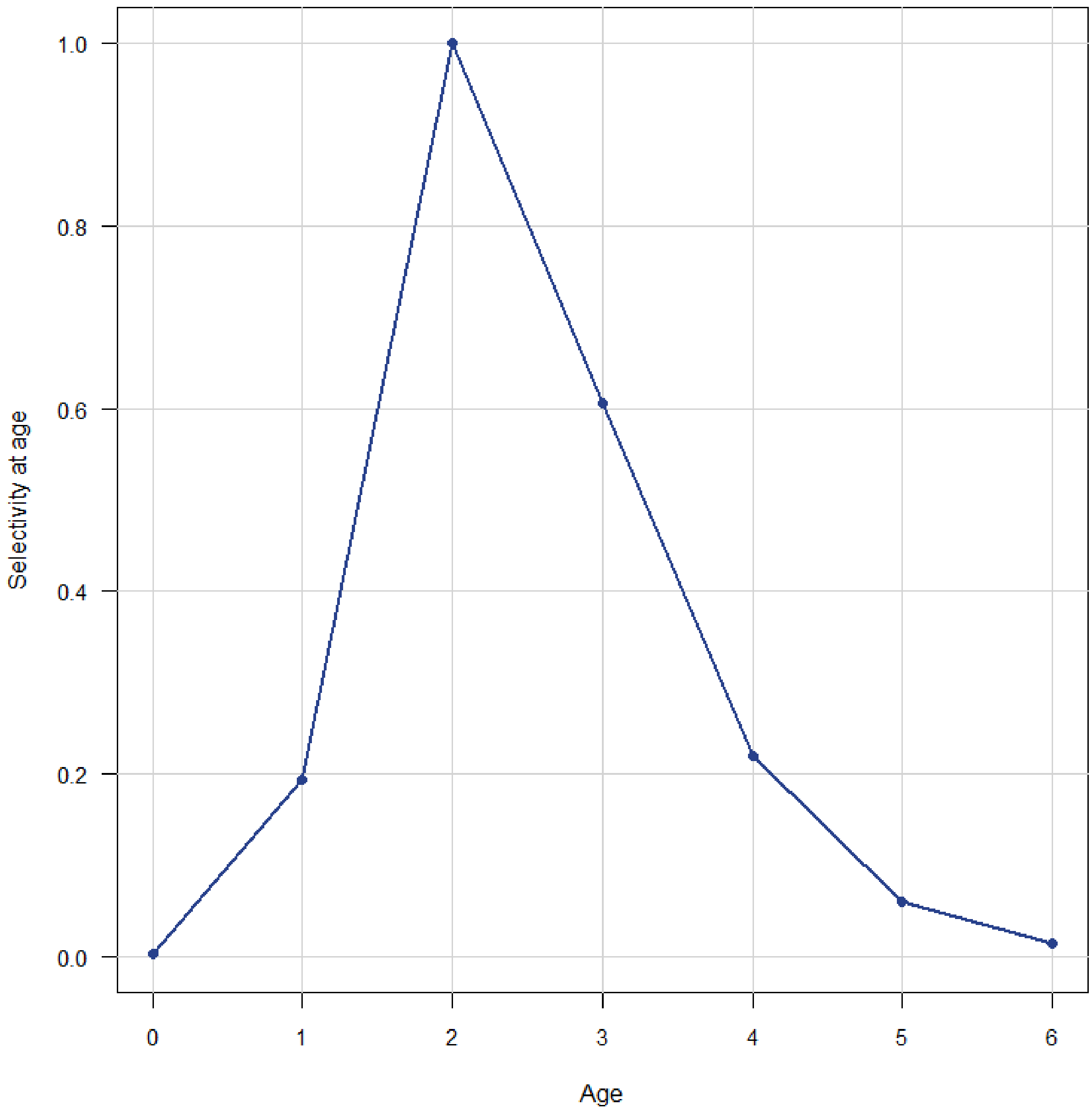


Figure 6.2.1.6. Selectivity for the southern commercial reduction fleet for 2005-2016.

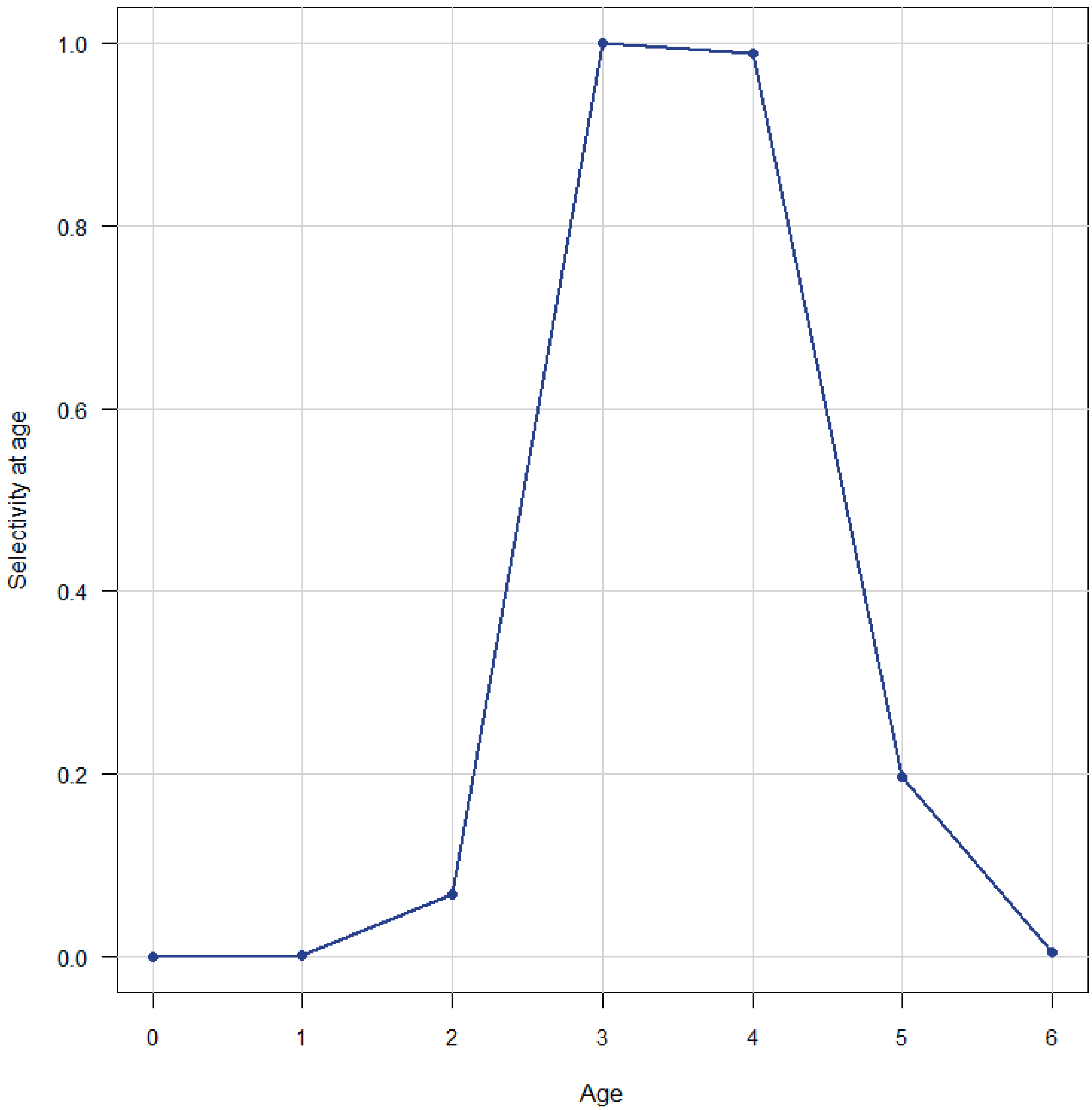


Figure 6.2.1.7. Selectivity for the northern commercial bait fleet for 1955-2016.

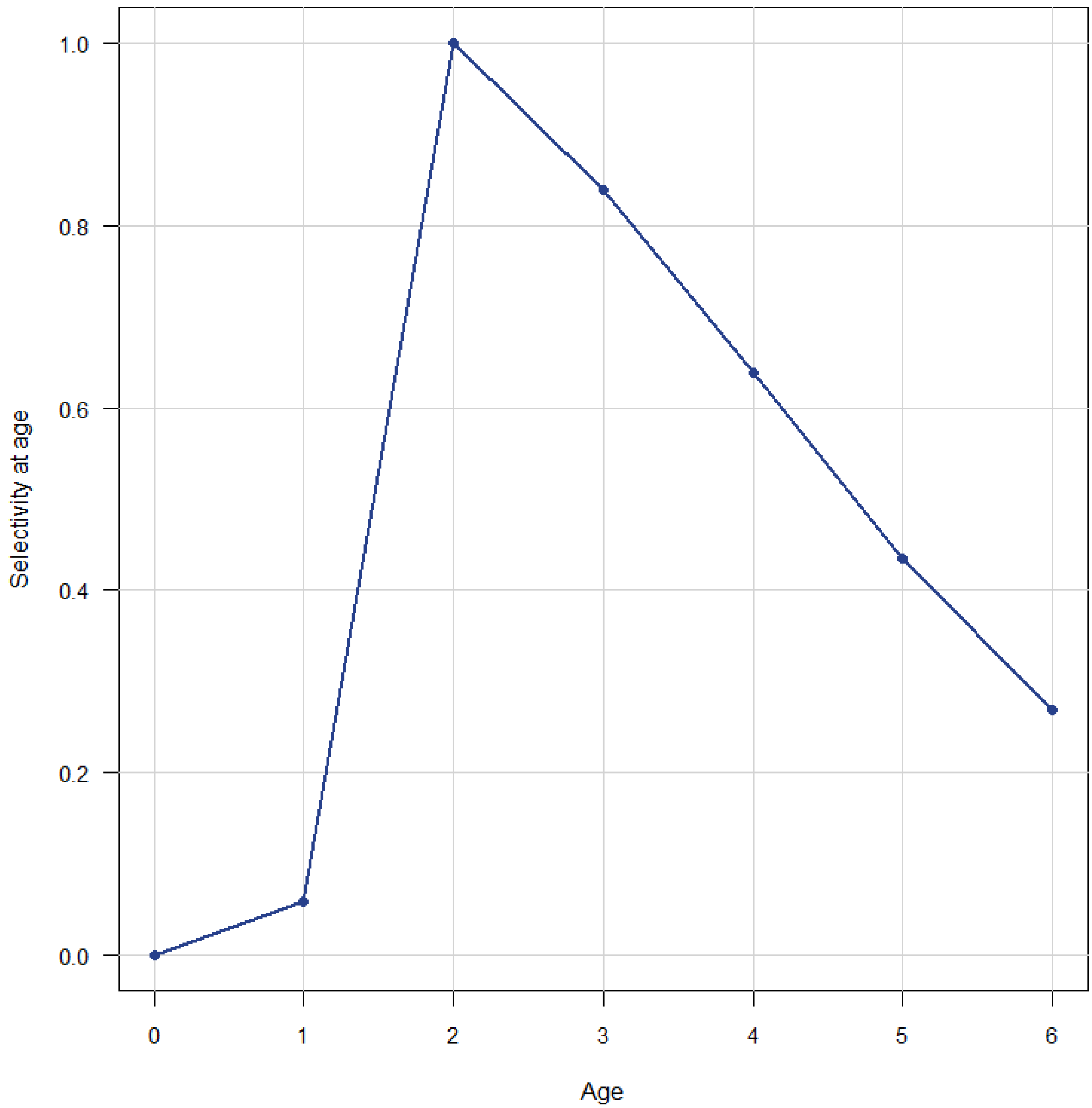


Figure 6.2.1.8. Selectivity for the southern commercial bait fleet for 1955-2016.

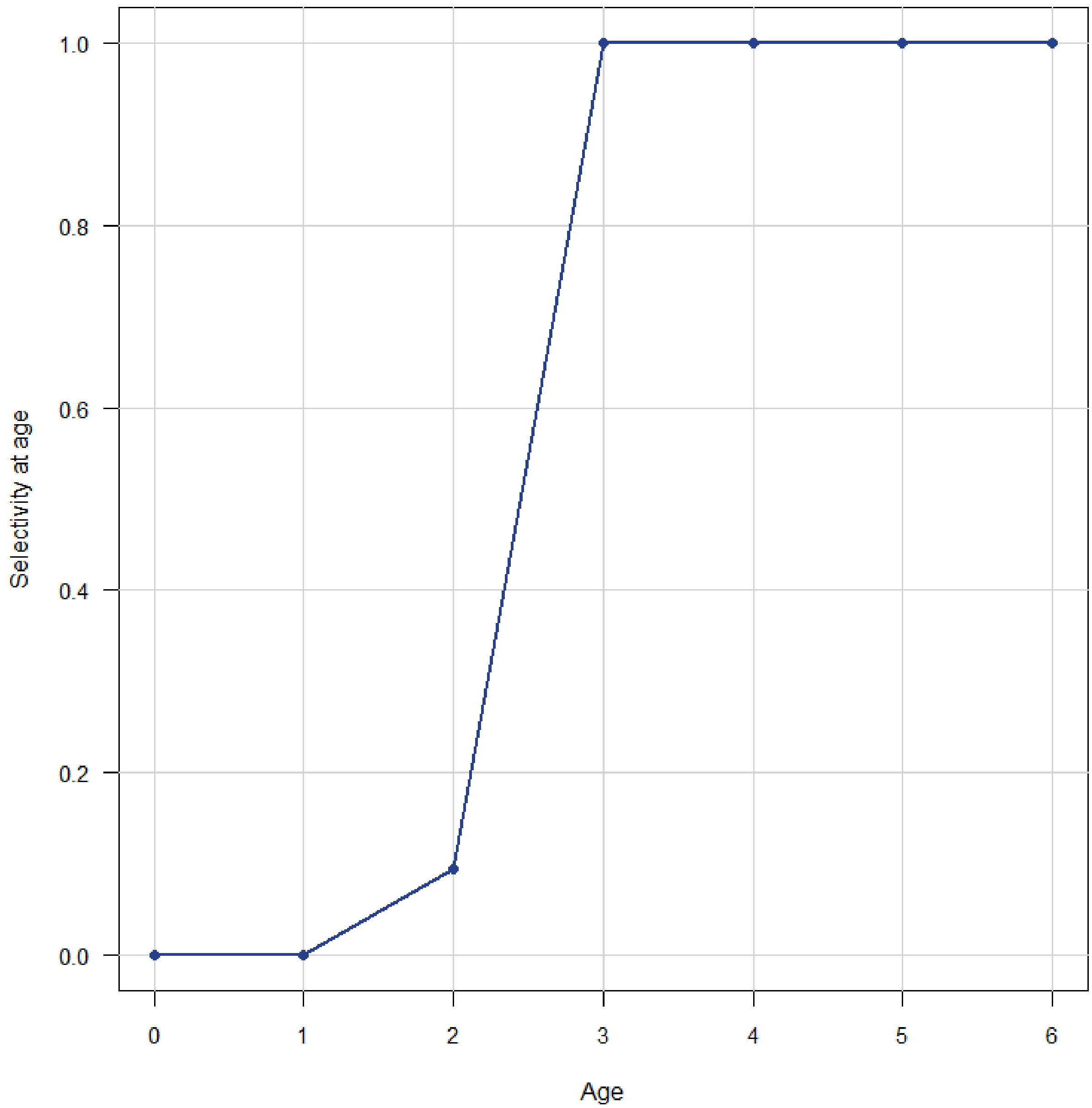


Figure 6.2.1.9. Selectivity for the NAD index for 1980-2016.

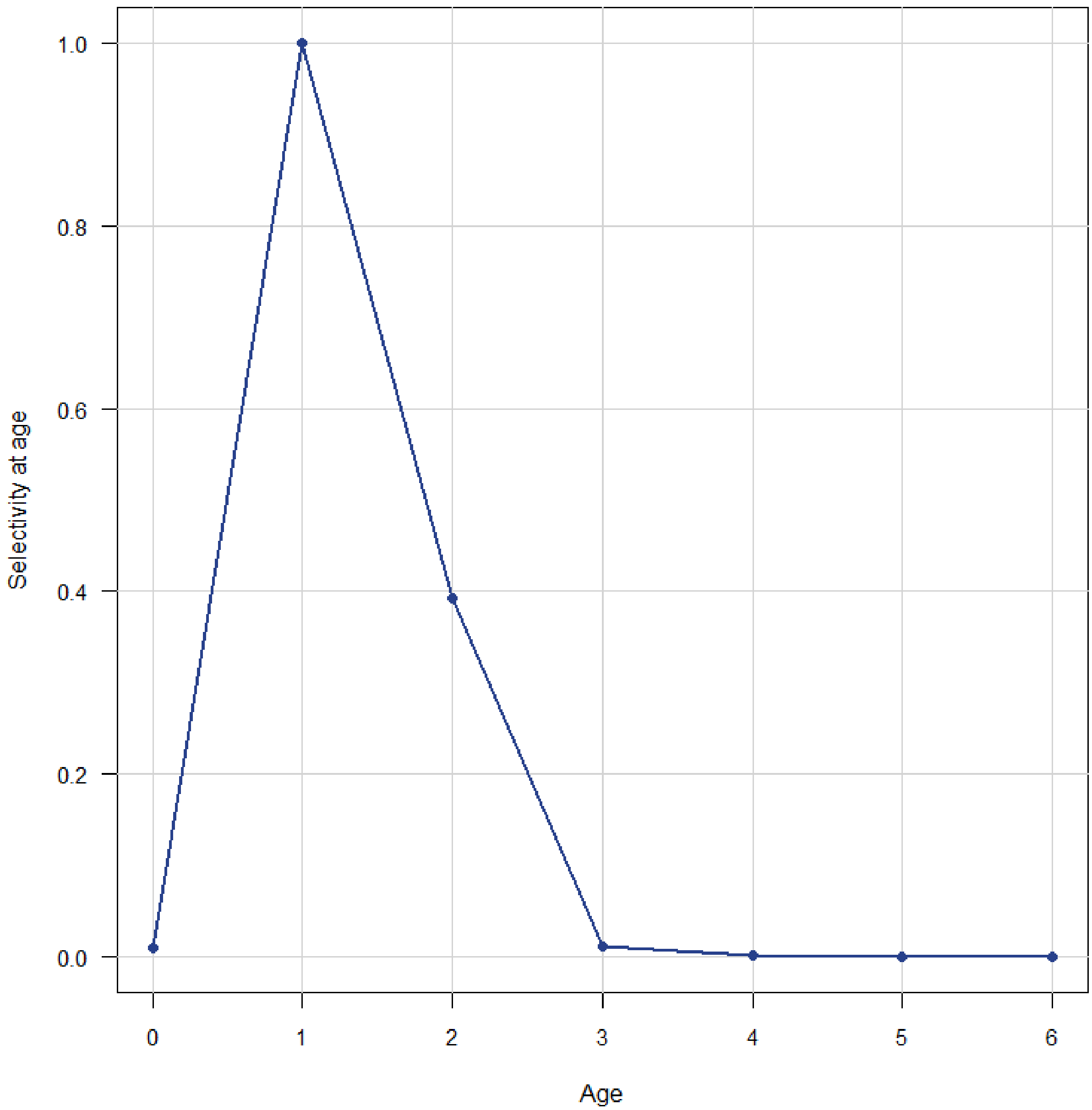


Figure 6.2.1.10. Selectivity for the SAD index for 1990-2016.

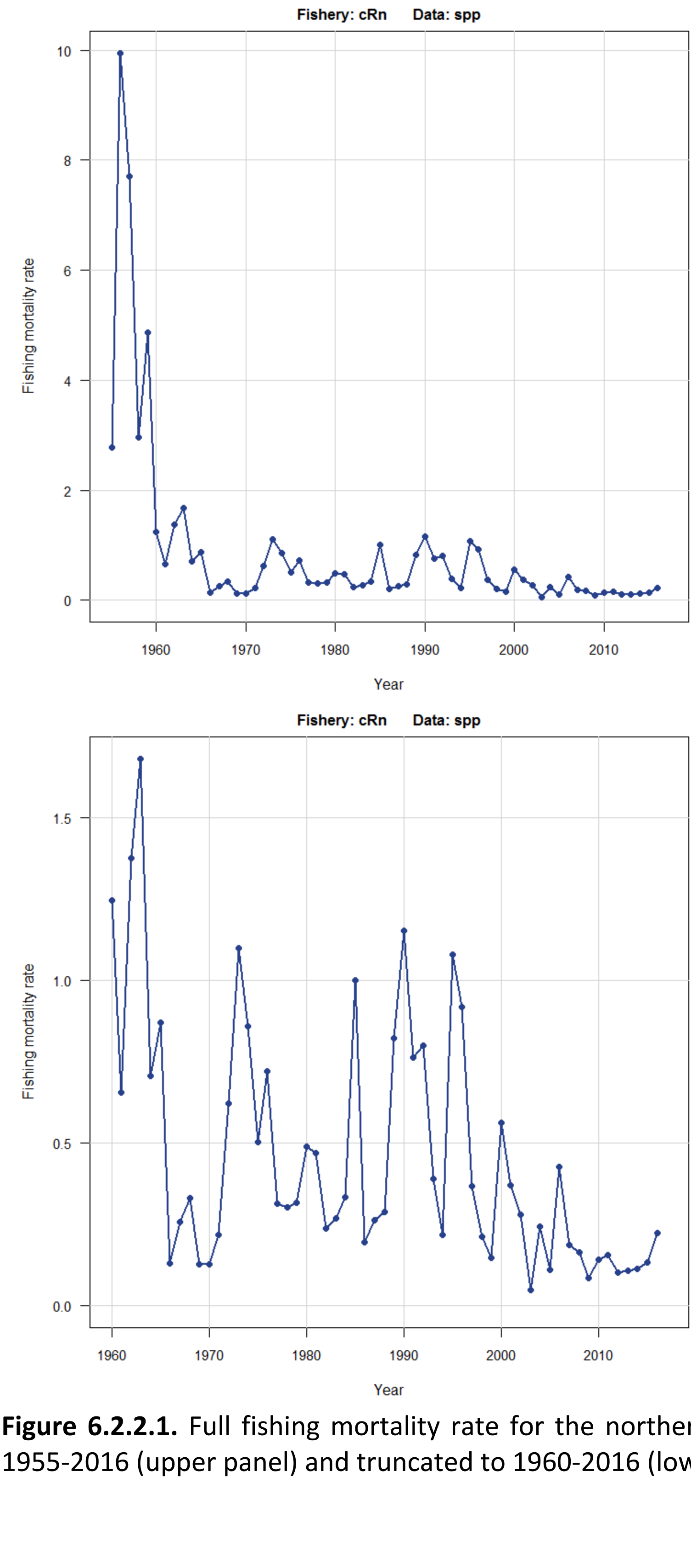


Figure 6.2.2.1. Full fishing mortality rate for the northern commercial reduction fishery from 1955-2016 (upper panel) and truncated to 1960-2016 (lower panel).

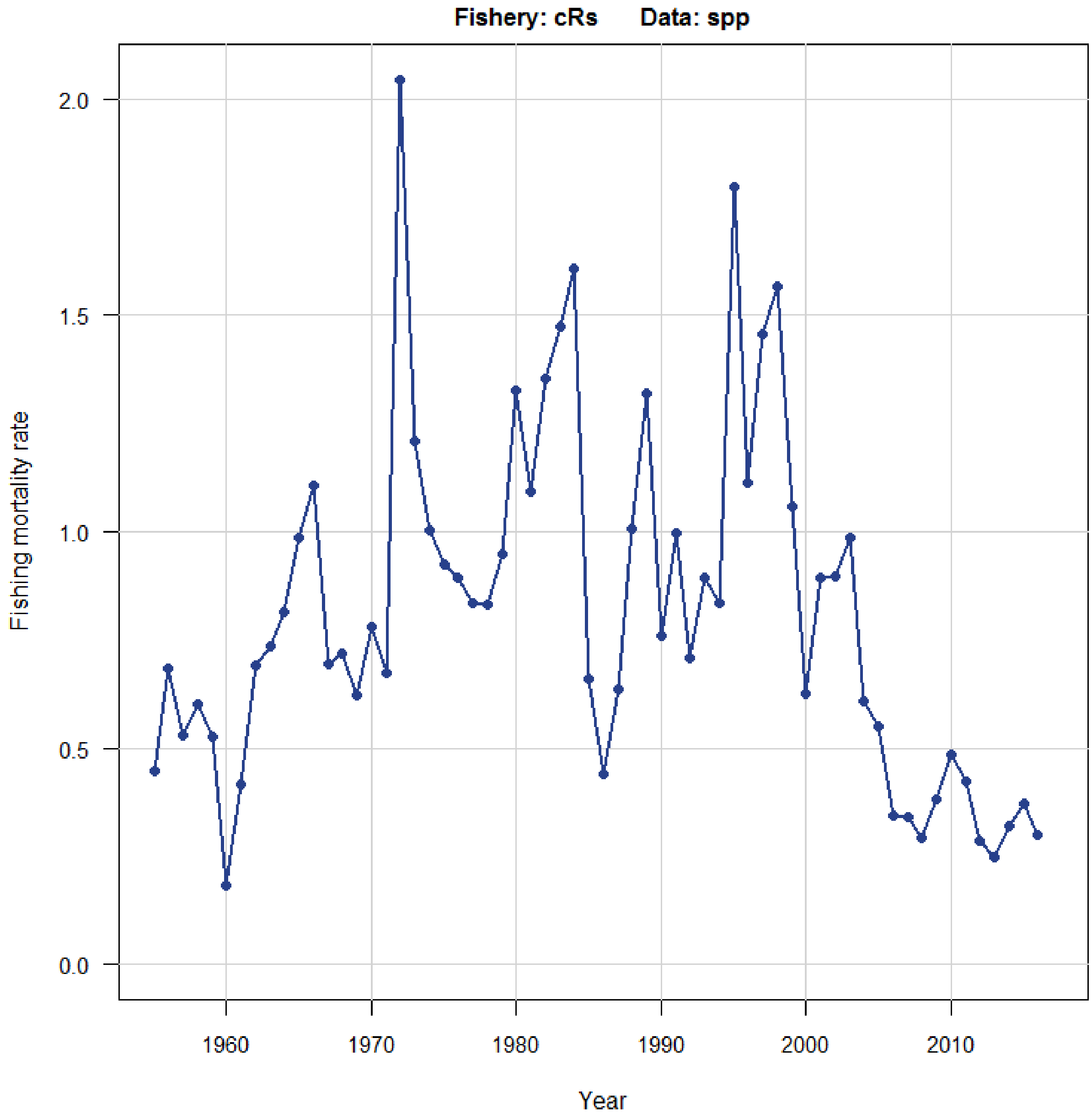


Figure 6.2.2.2. Full fishing mortality rate for the southern commercial reduction fishery from 1955-2016.

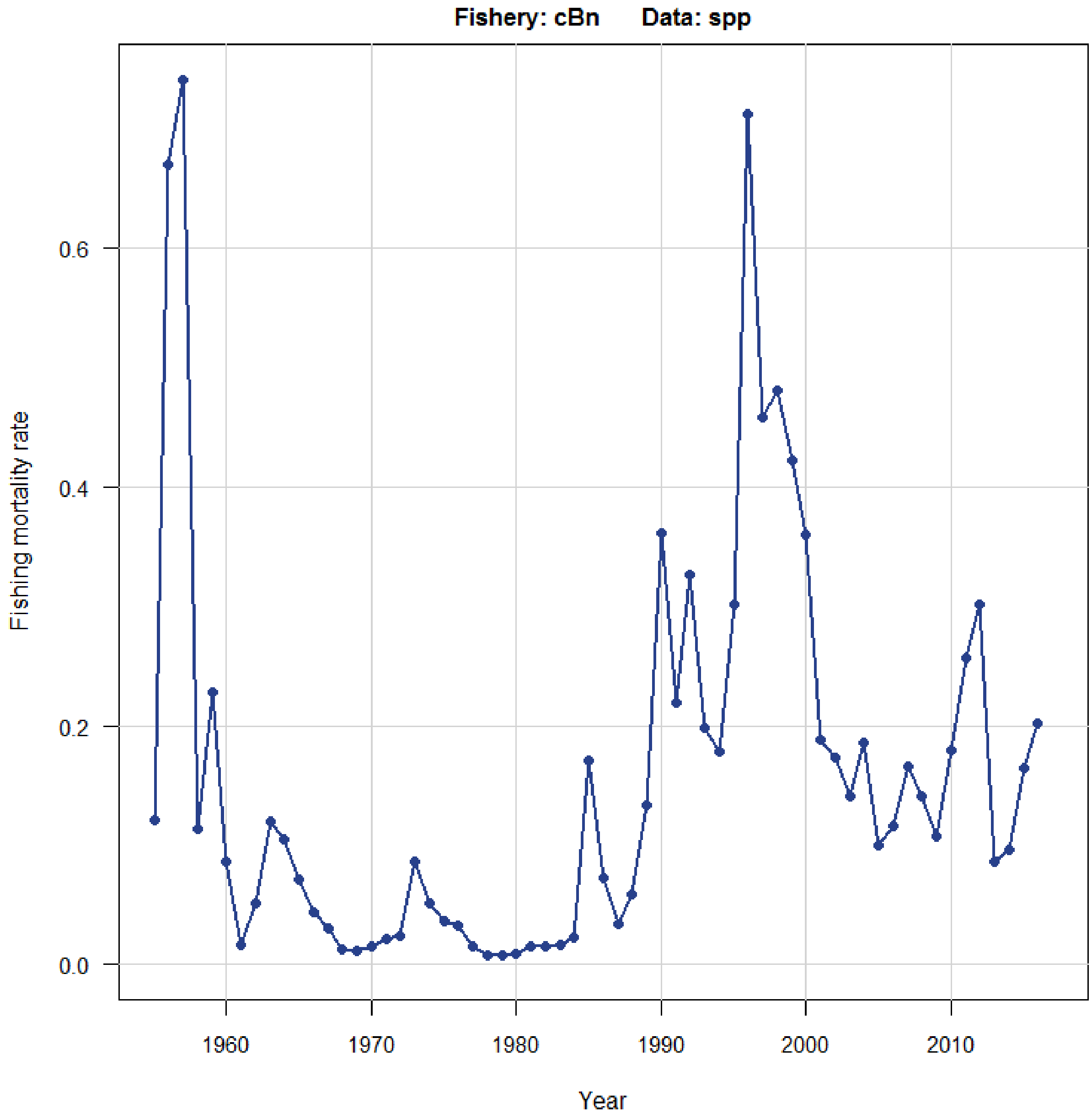


Figure 6.2.2.3. Full fishing mortality rate for the northern commercial bait fishery from 1955-2016.

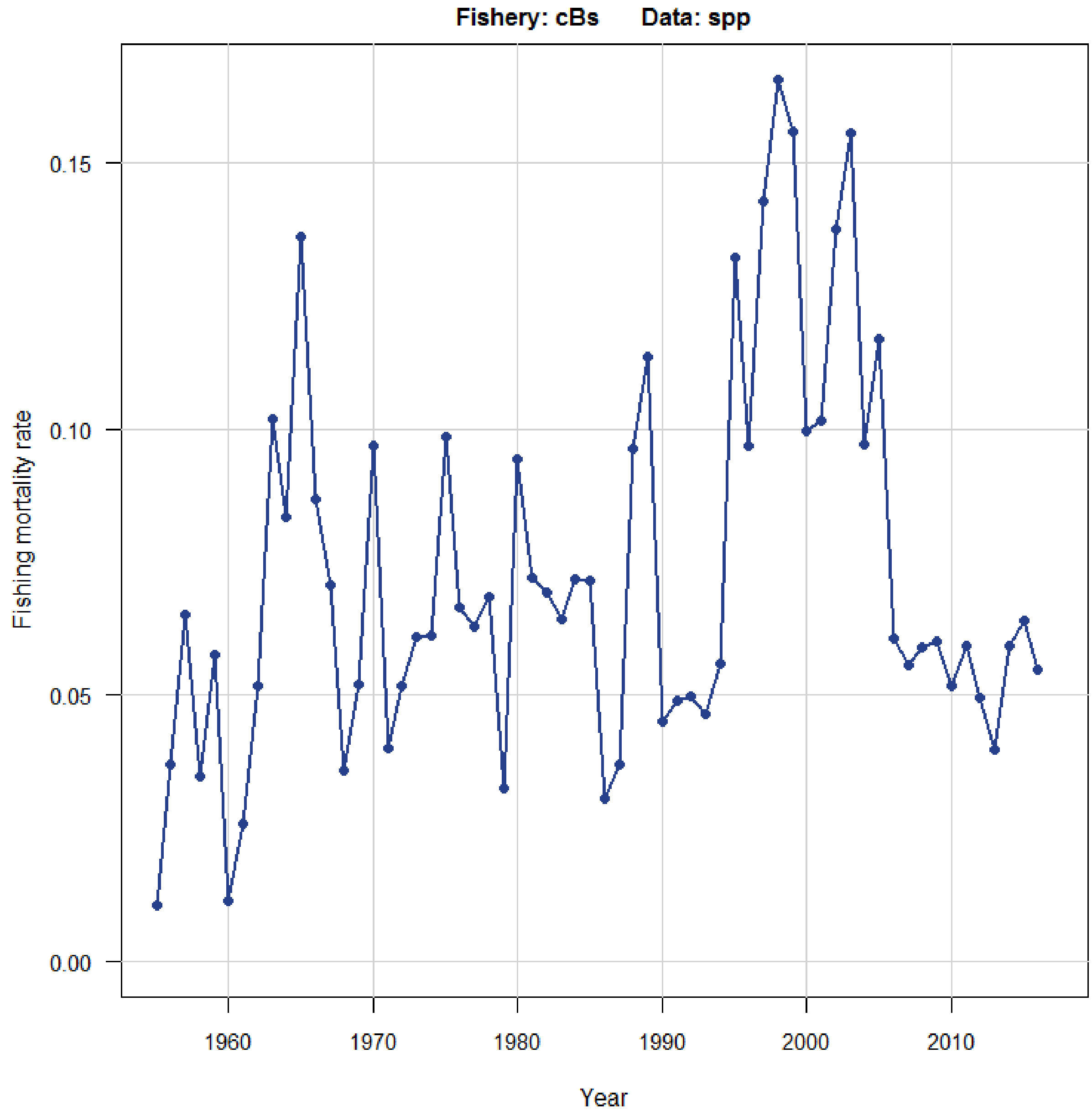


Figure 6.2.2.4. Full fishing mortality rate for the southern commercial bait fishery from 1955-2016.

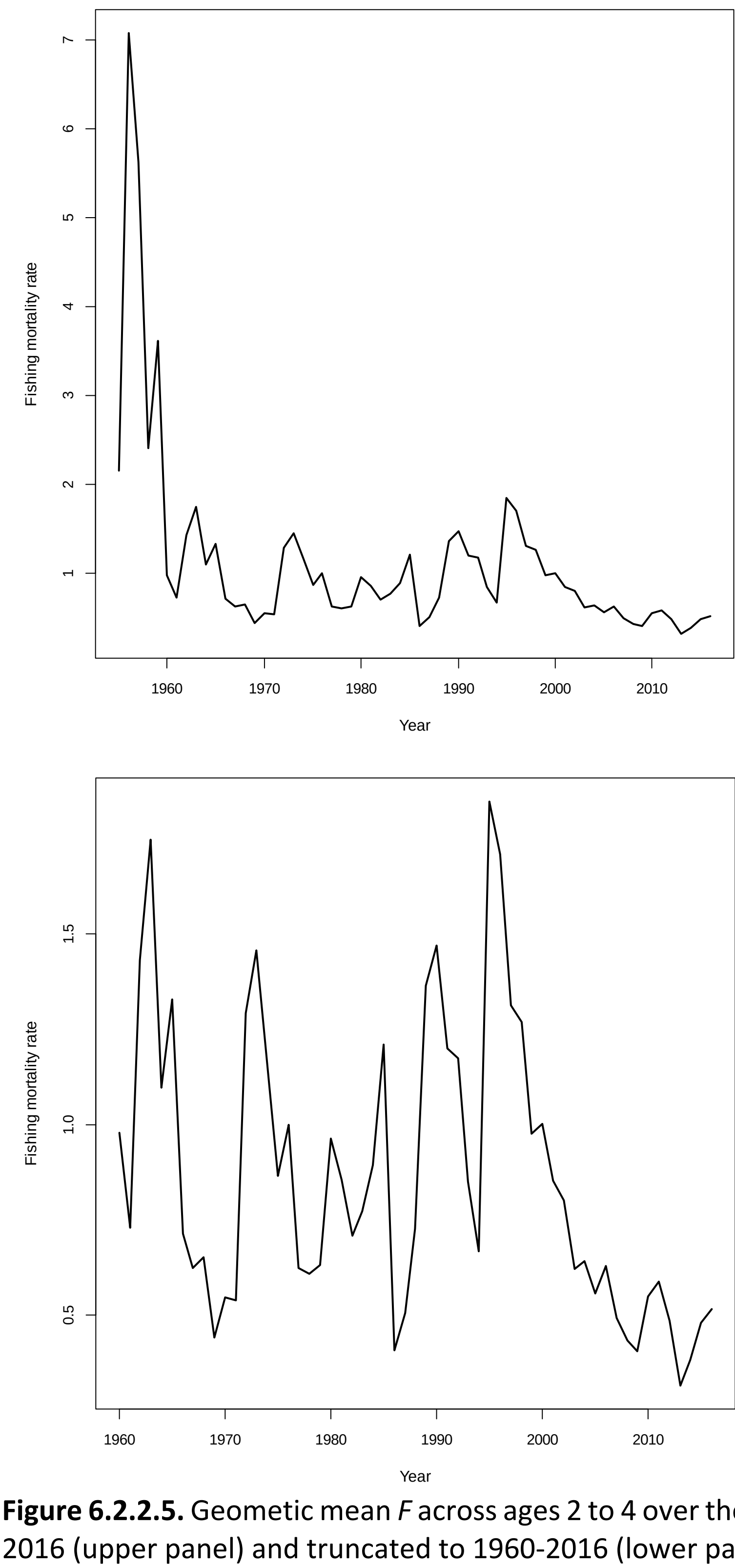


Figure 6.2.2.5. Geometic mean *F* across ages 2 to 4 over the time course of the fishery from 1955-2016 (upper panel) and truncated to 1960-2016 (lower panel).

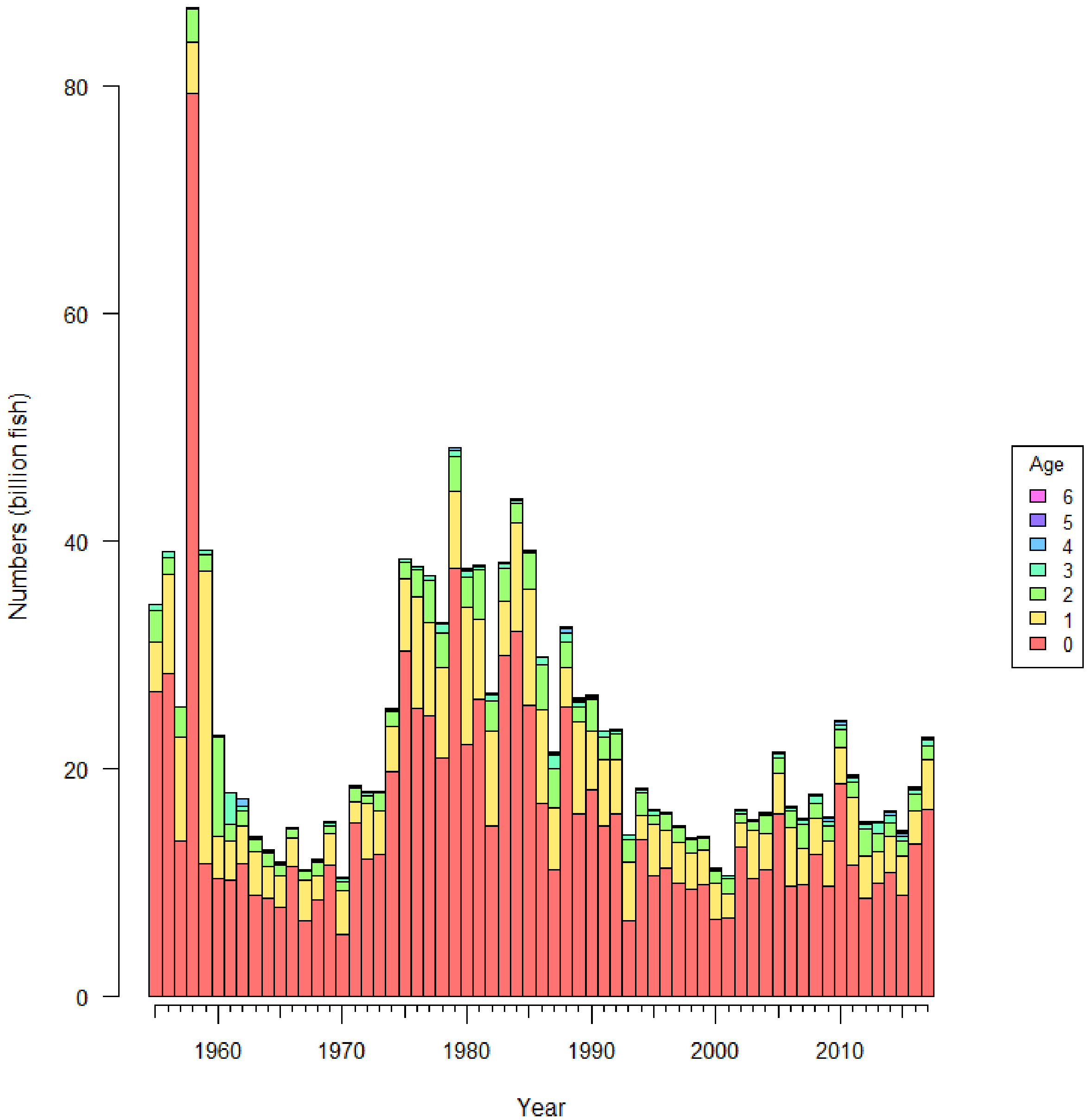


Figure 6.2.3.1. Numbers at age (above) and proportion of numbers at age (next page) estimated from the base run of the BAM for ages 0-6+ during the time period 1955-2016.

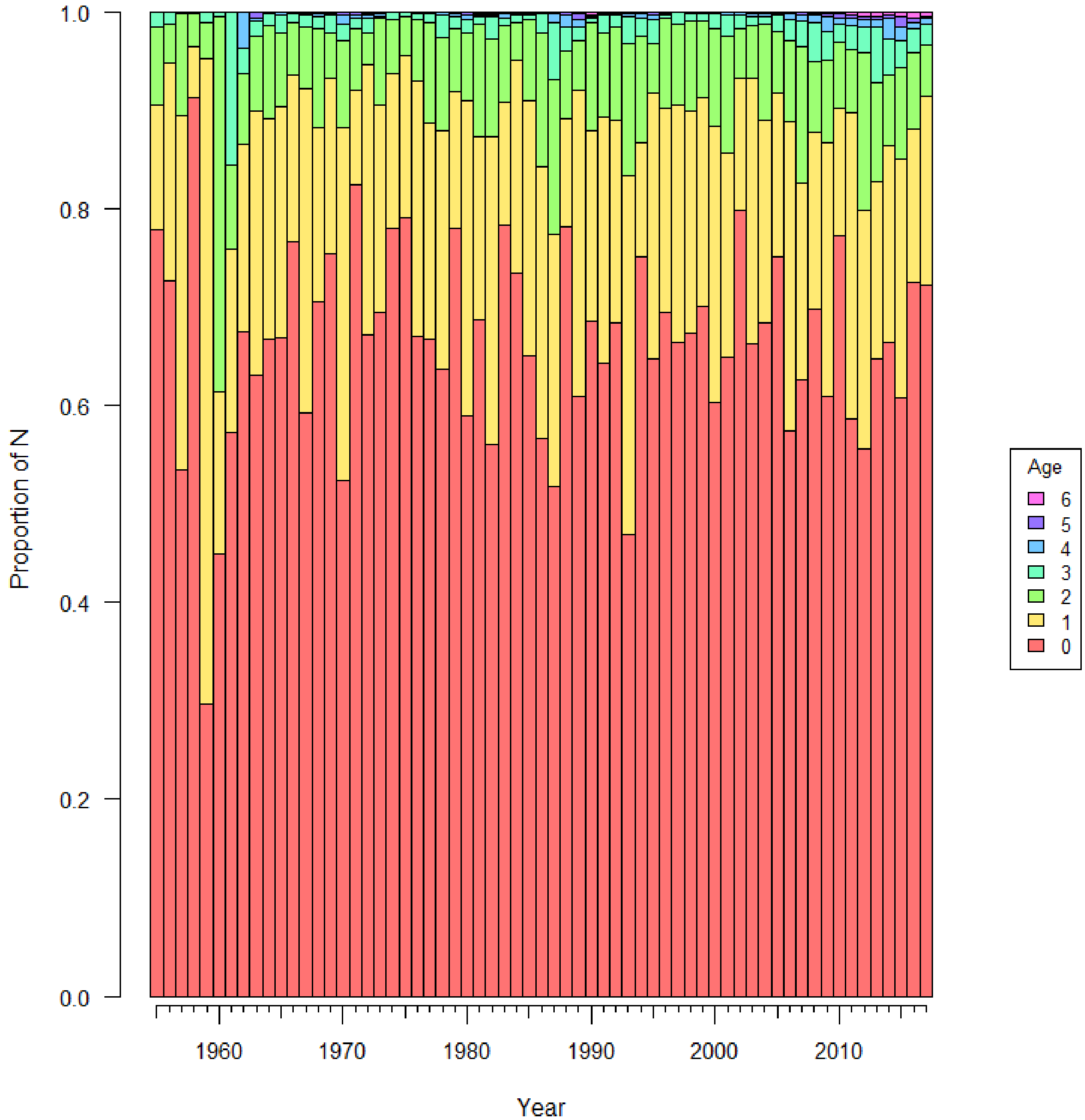


Figure 6.2.3.1. ***Continued.***

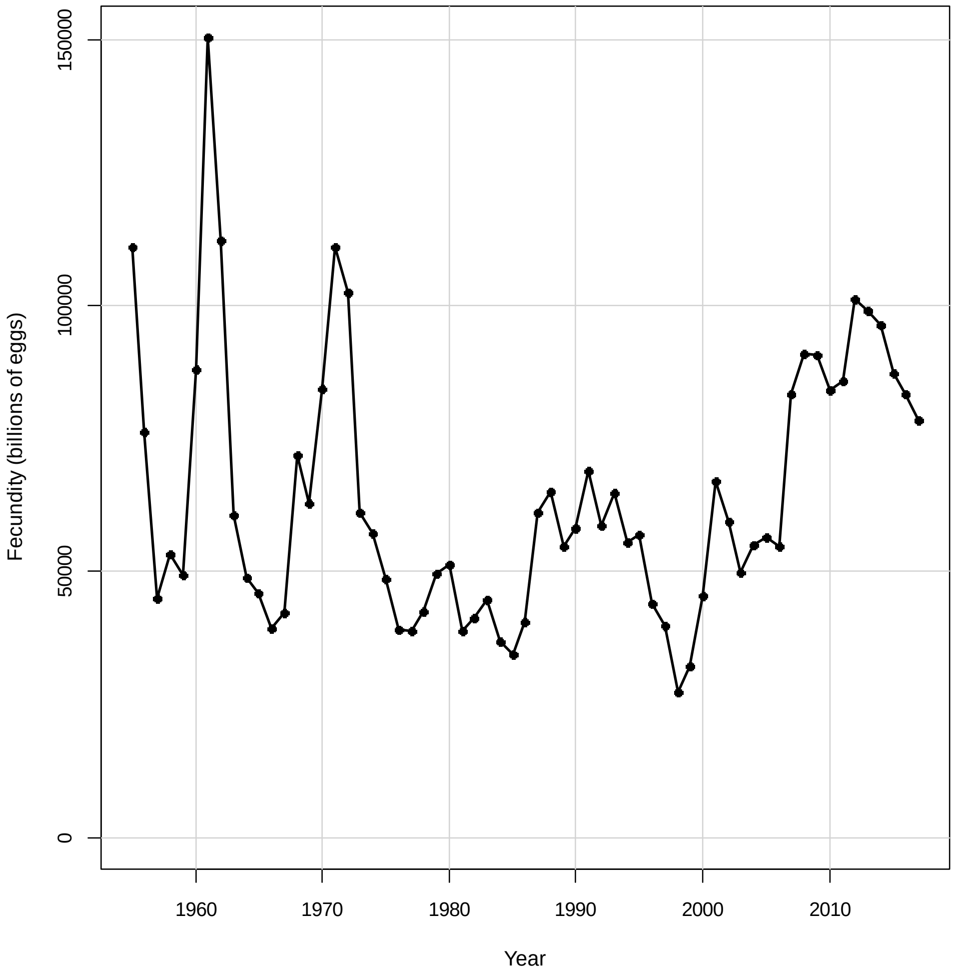


Figure 6.2.3.2. Fecundity in billions of eggs from 1955-2017, with the last year being a projection based on 2016 mortality.

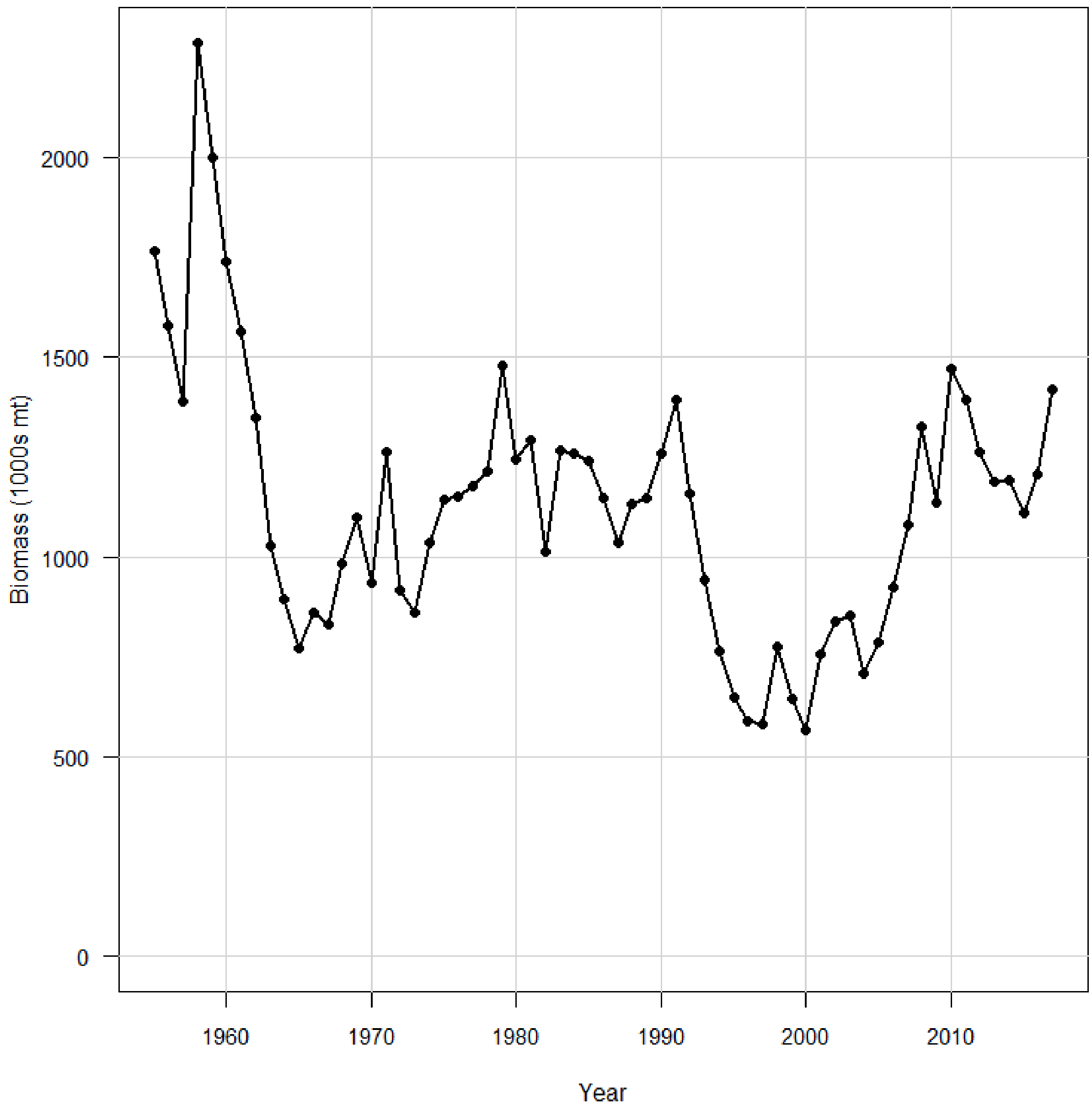


Figure 6.2.3.3. Biomass (above) and proportion of biomass at age (next page) over time as predicted from the base run of the BAM for Atlantic menhaden, with the last year being a projection based on 2016 mortality.

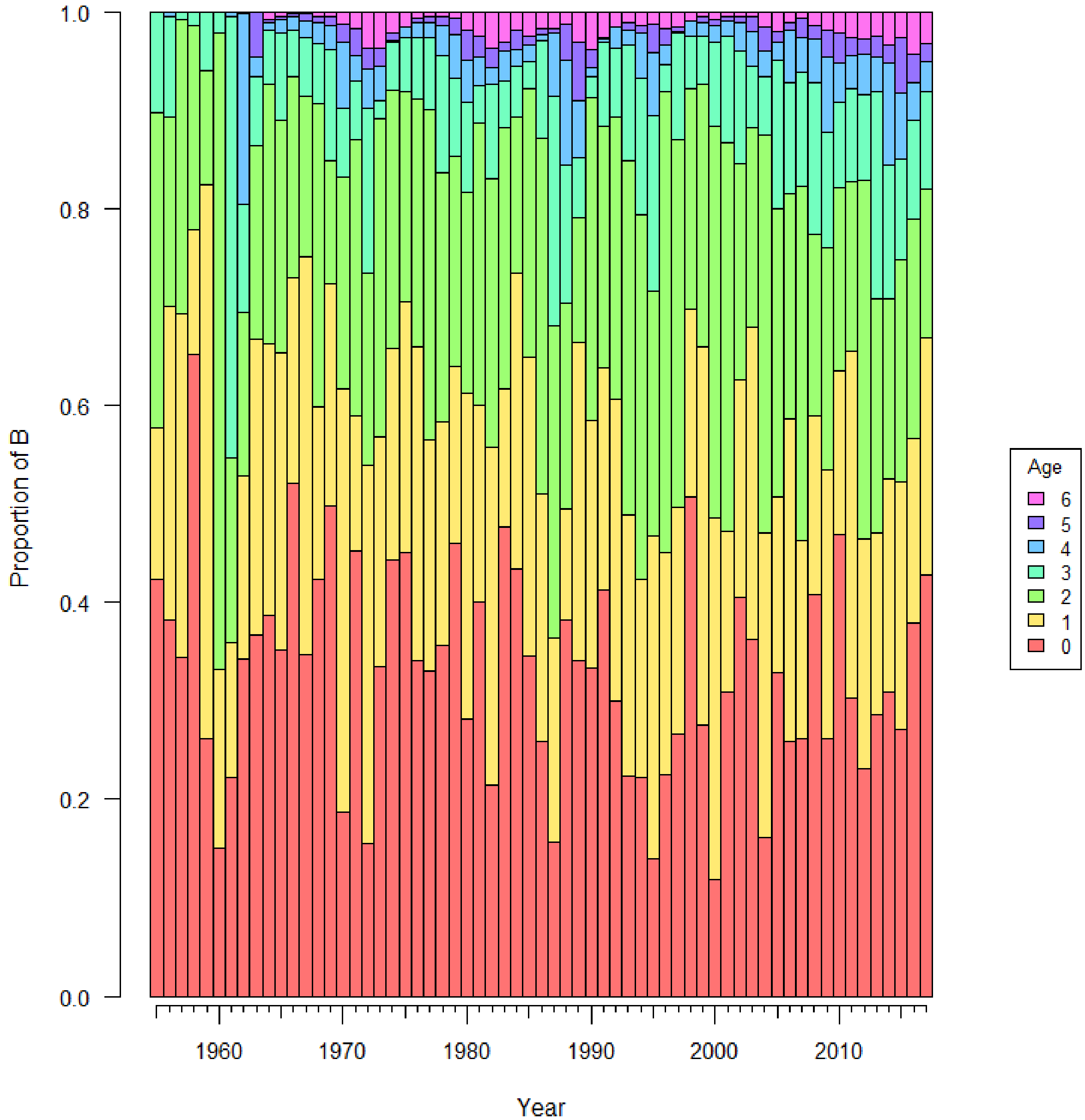


Figure 6.2.3.3. *Continued.*

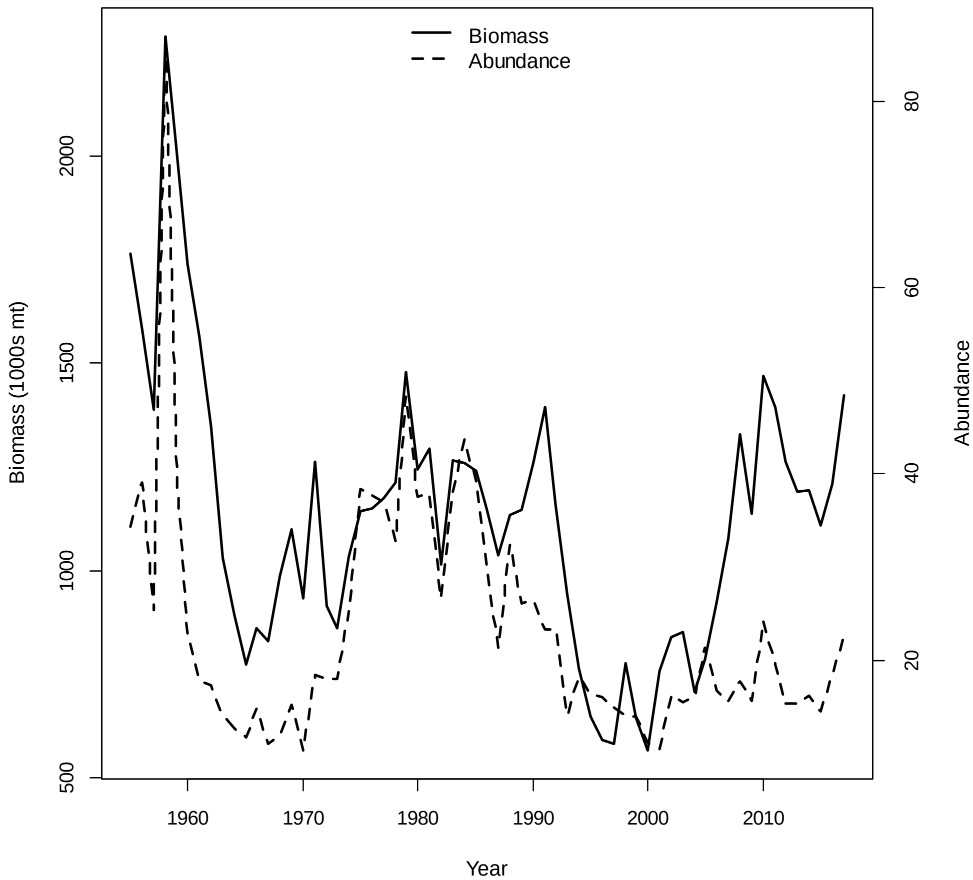


Figure 6.2.3.4. Biomass (1000s mt) and abundance over time for Atlantic menhaden from 1959-2016.

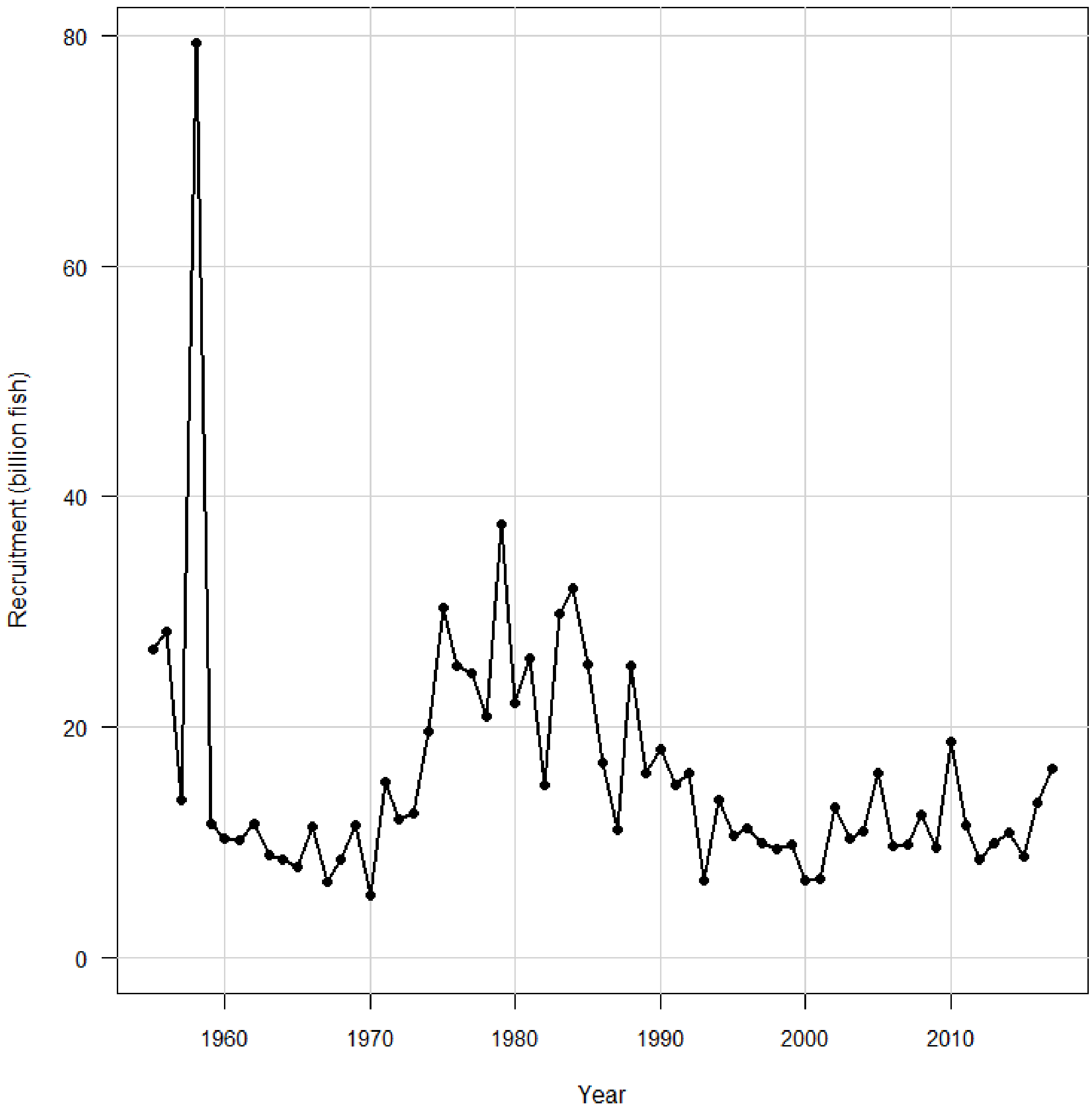


Figure 6.2.3.5. Number of recruits in billions of fish predicted from the base run of BAM for 1955-2017, with the last year being a projection based on 2016 mortality.

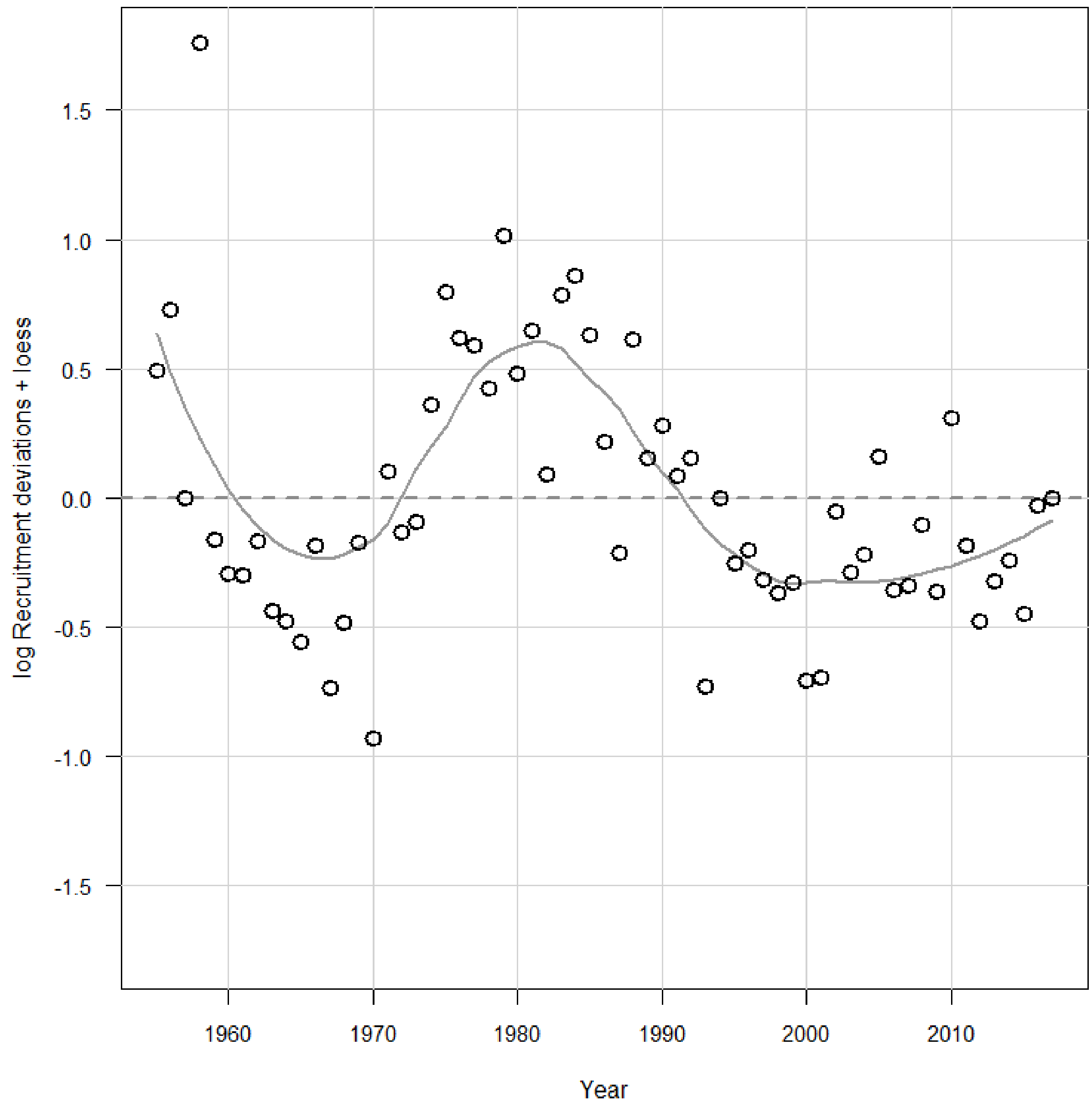


Figure 6.2.3.6. Deviations in log recruitment from 1955-2017 with a loess smoother, with the last year being a projection based on 2016 mortality.

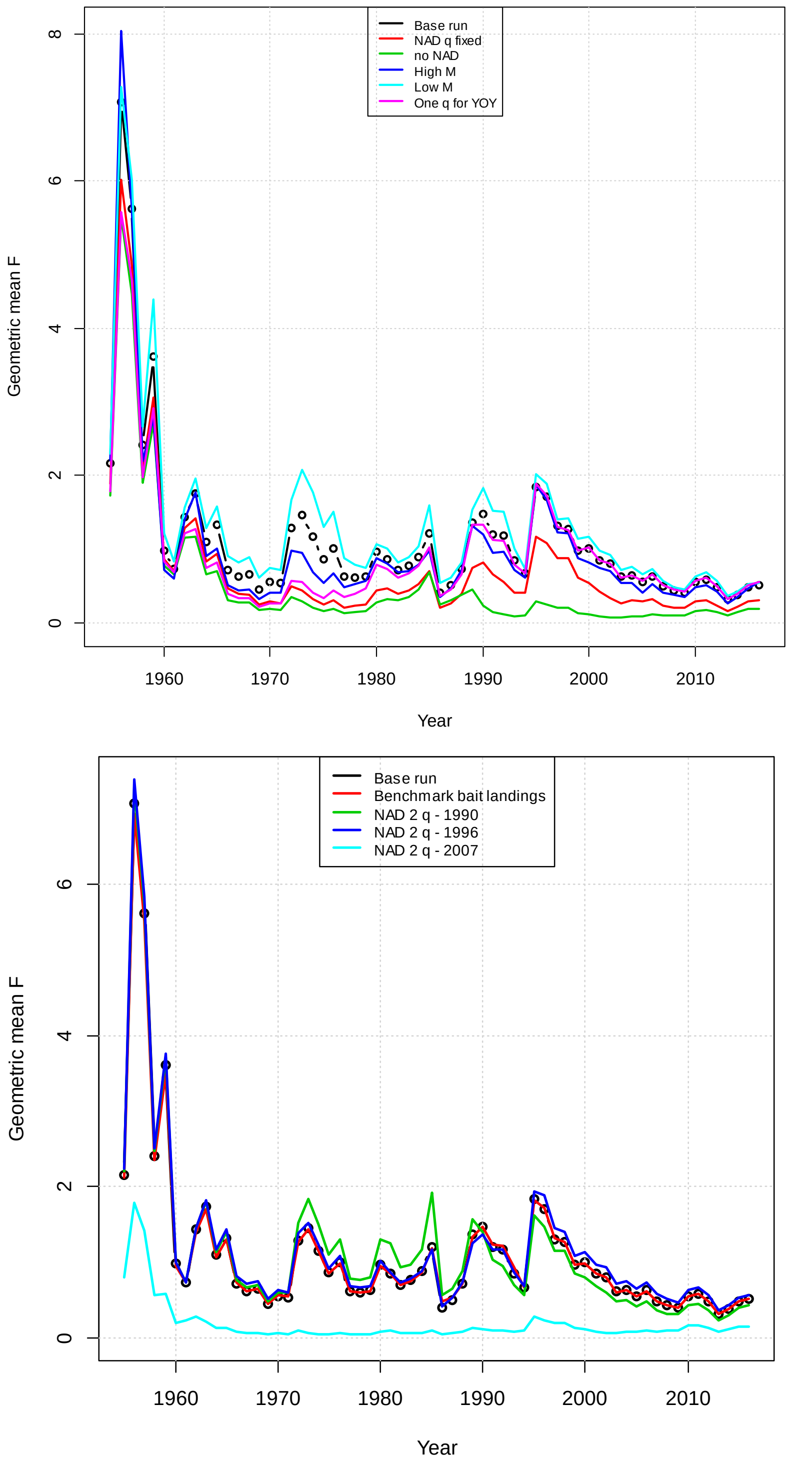


Figure 6.4.1.1 Geometric mean of *F* for sensitivity runs considering differences in growth and life history parameters and differences in indices and catchability in the assessment model.

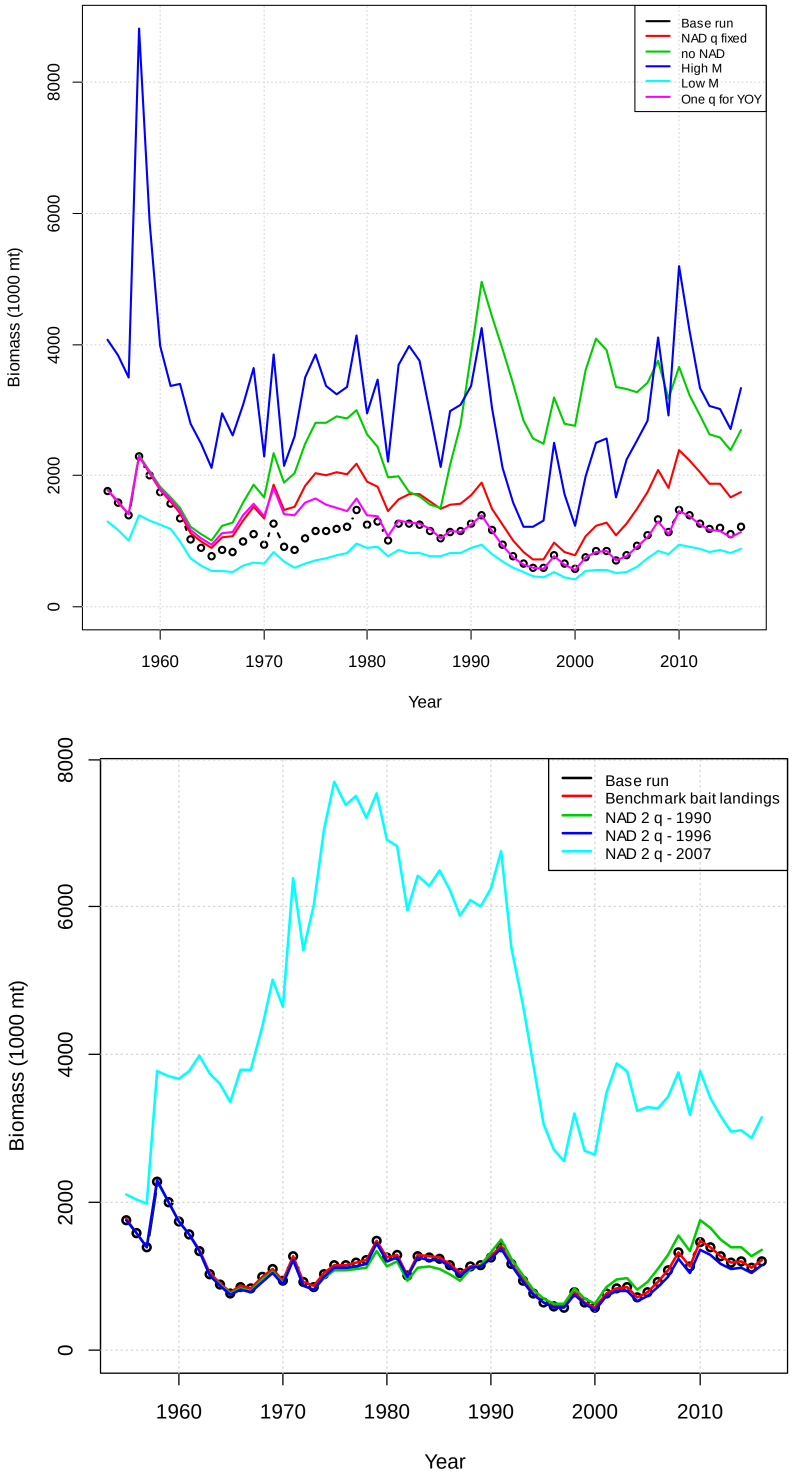


Figure 6.4.1.2 Age-1+ biomass in 1000 mt for sensitivity runs considering differences in growth and life history parameters and differences in indices and catchability in the assessment model.

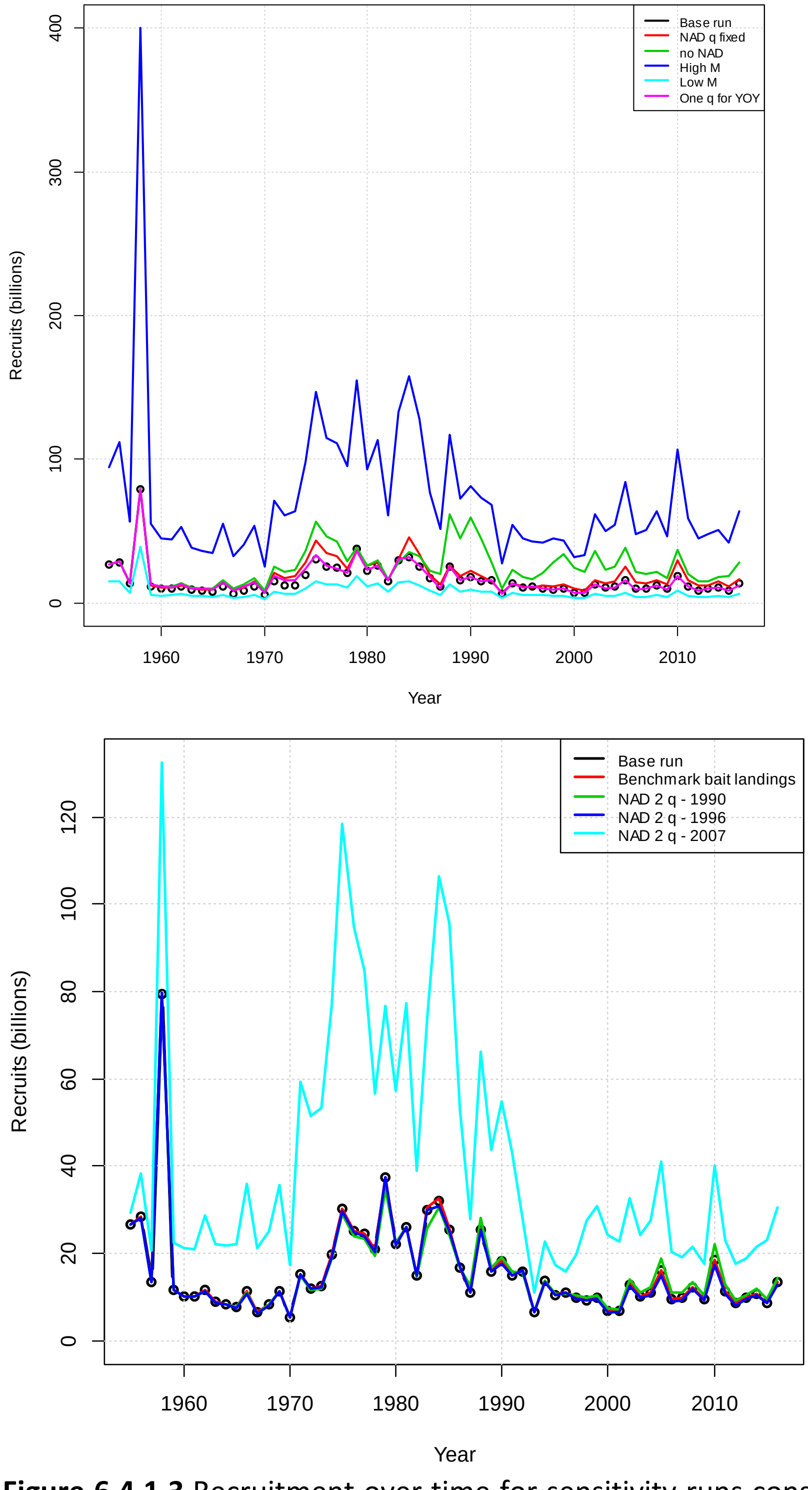


Figure 6.4.1.3 Recruitment over time for sensitivity runs considering differences in growth and life history parameters and differences in indices and catchability in the assessment model.

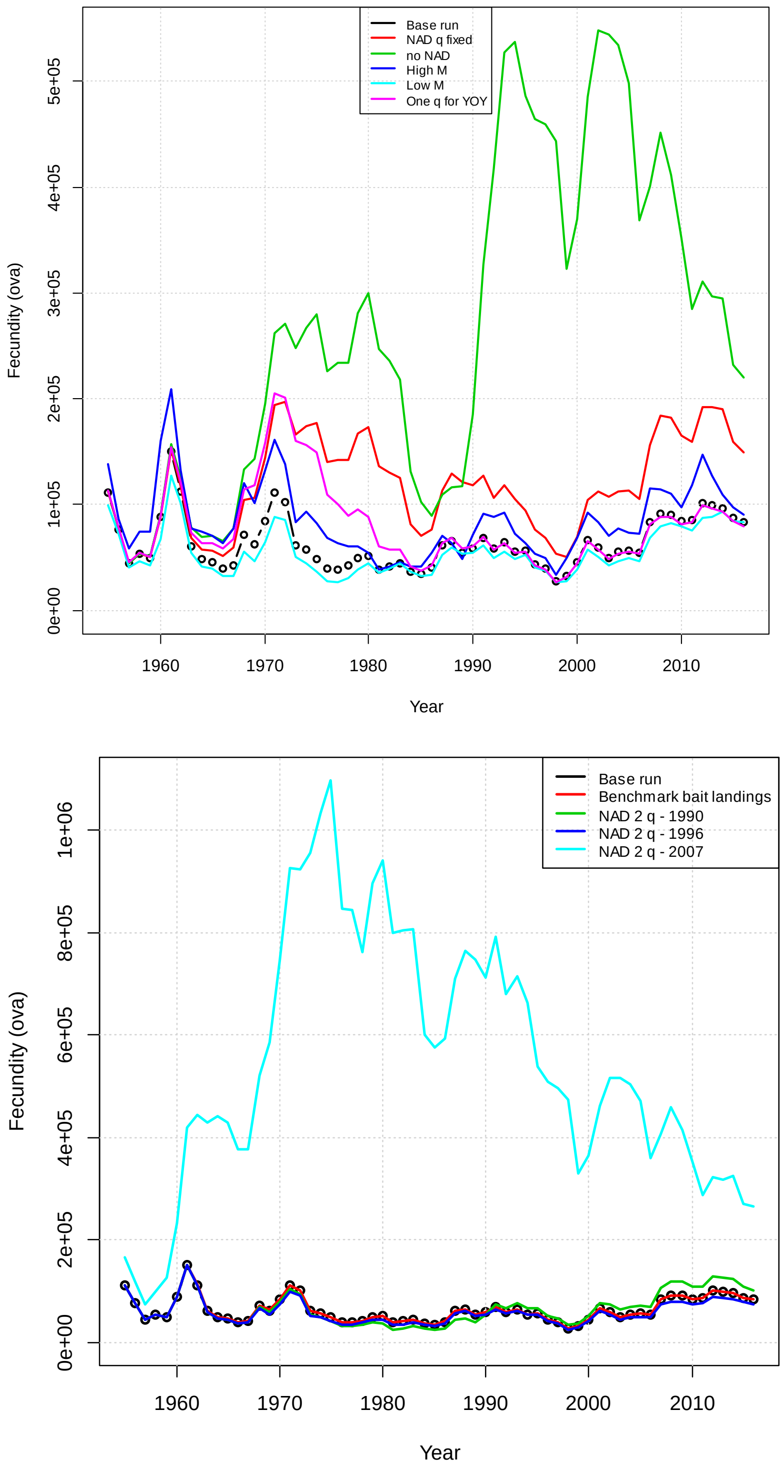


Figure 6.4.1.4 Fecundity over time for sensitivity runs considering differences in growth and life history parameters and differences in indices and catchability in the assessment model.

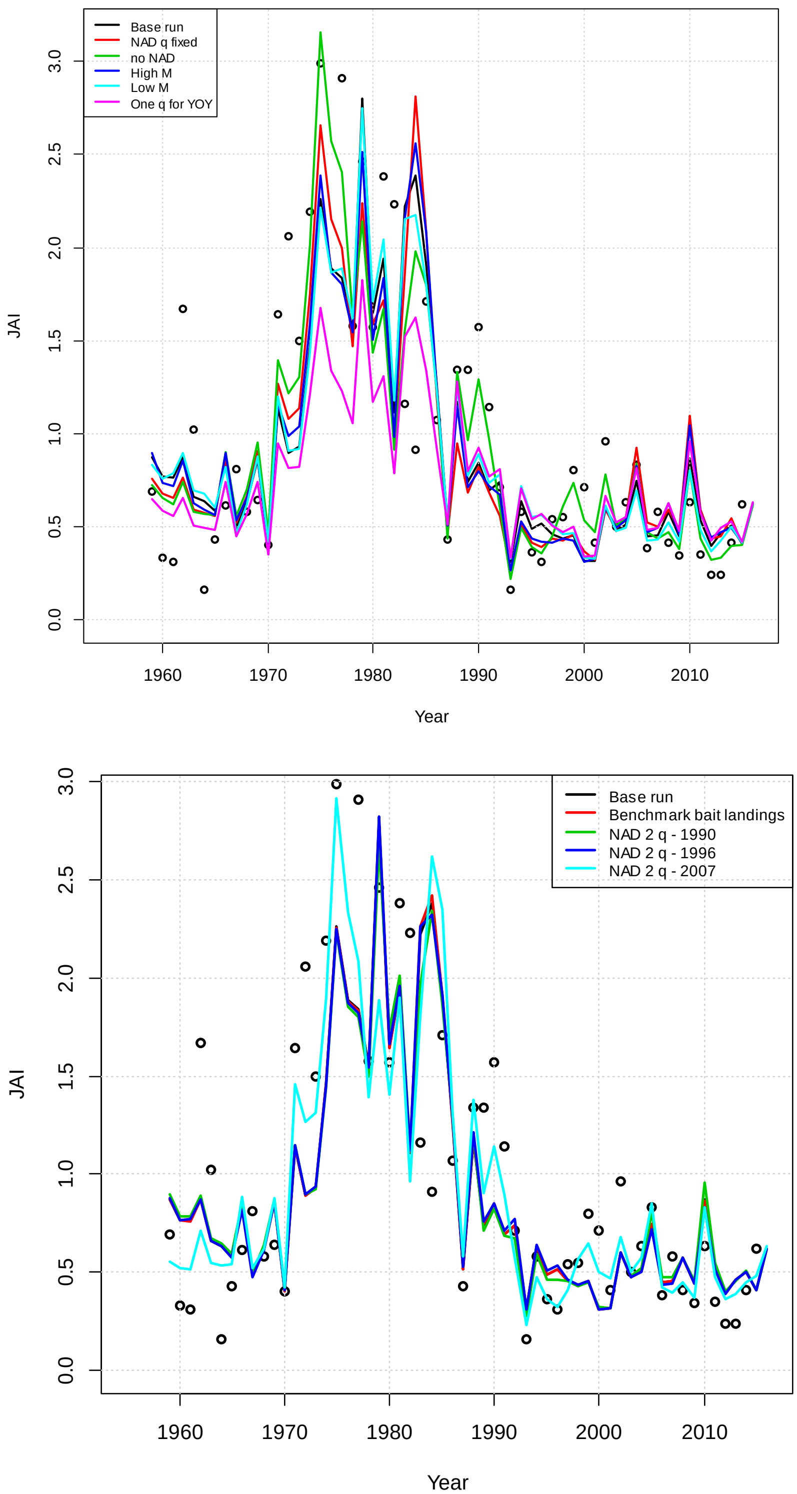
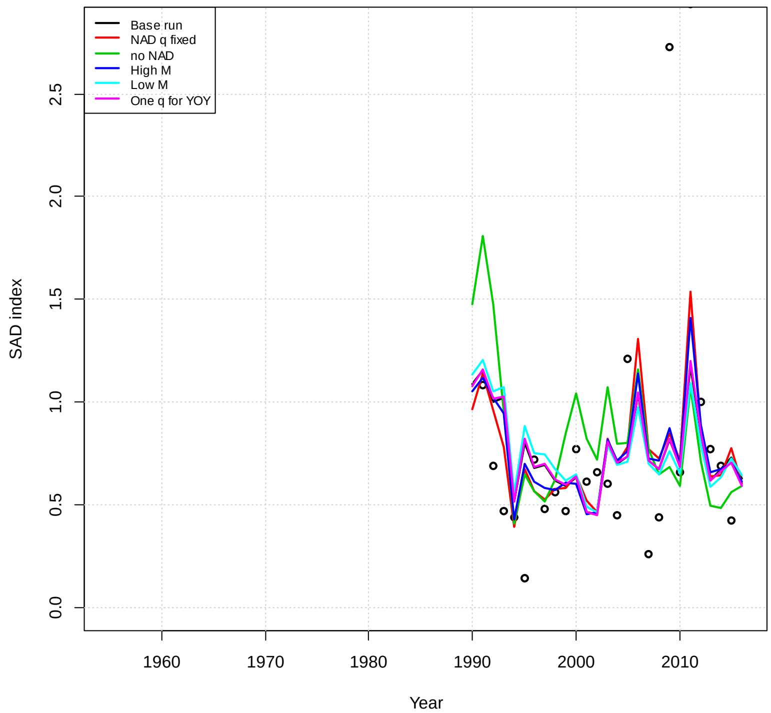


Figure 6.4.1.5 Fit to the recruitment index for sensitivity runs considering differences in growth and life history parameters and differences in indices and catchability in the assessment model.



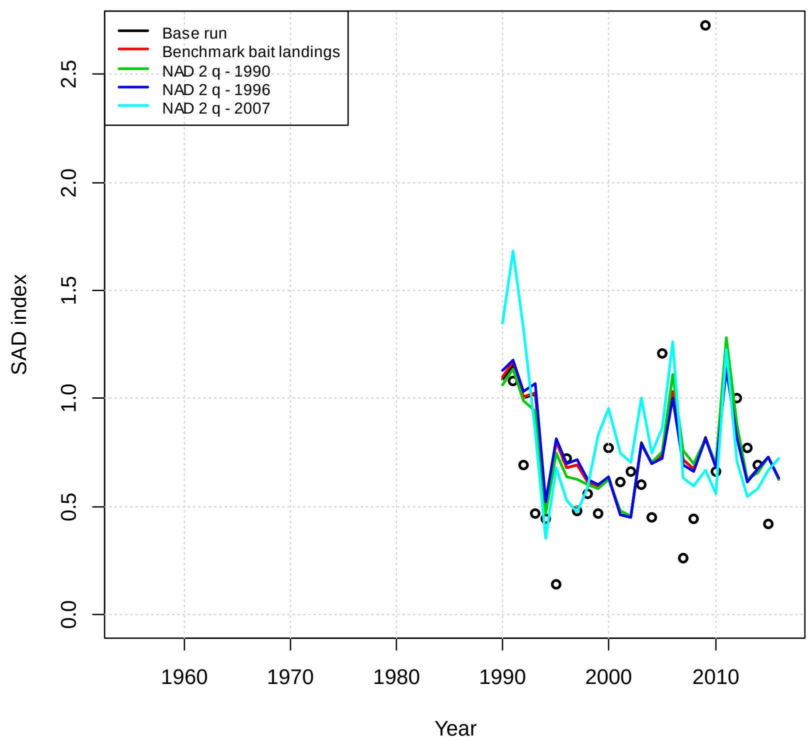
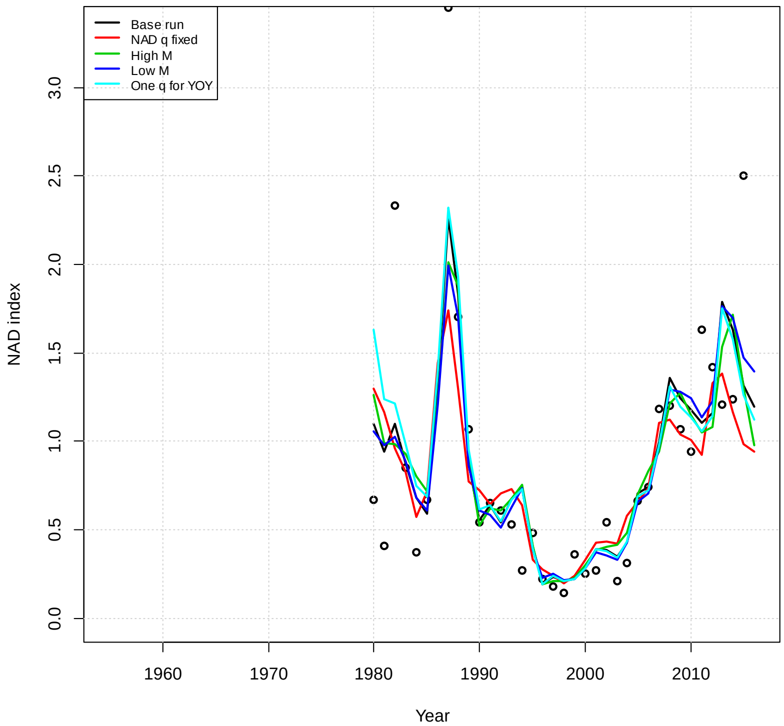


Figure 6.4.1.6 Fit to the SAD index for sensitivity runs considering differences in growth and life history parameters and differences in indices and catchability in the assessment model.



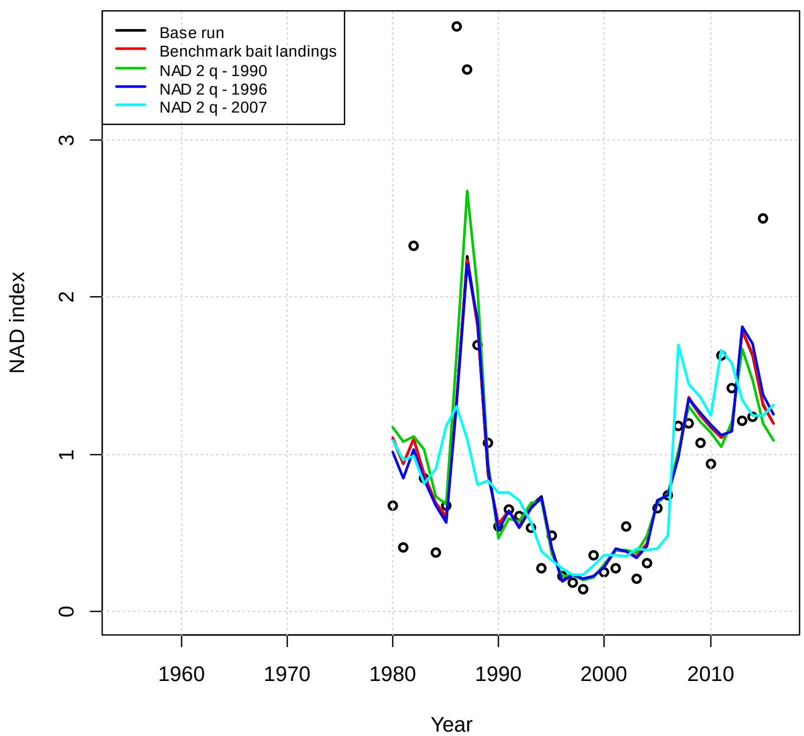


Figure 6.4.1.7 Fit to the NAD index for sensitivity runs considering differences in growth and life history parameters and differences in indices and catchability in the assessment model.

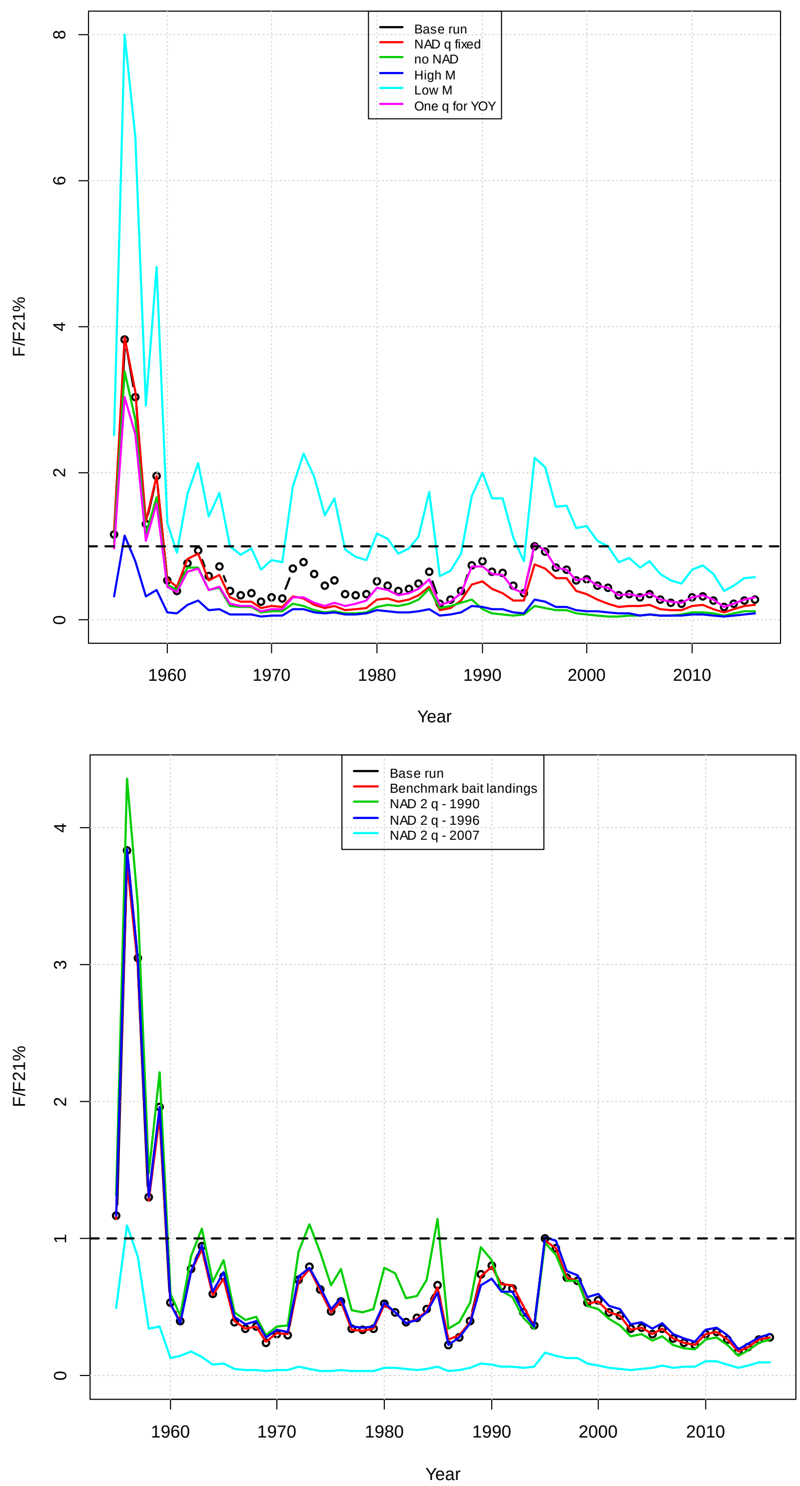
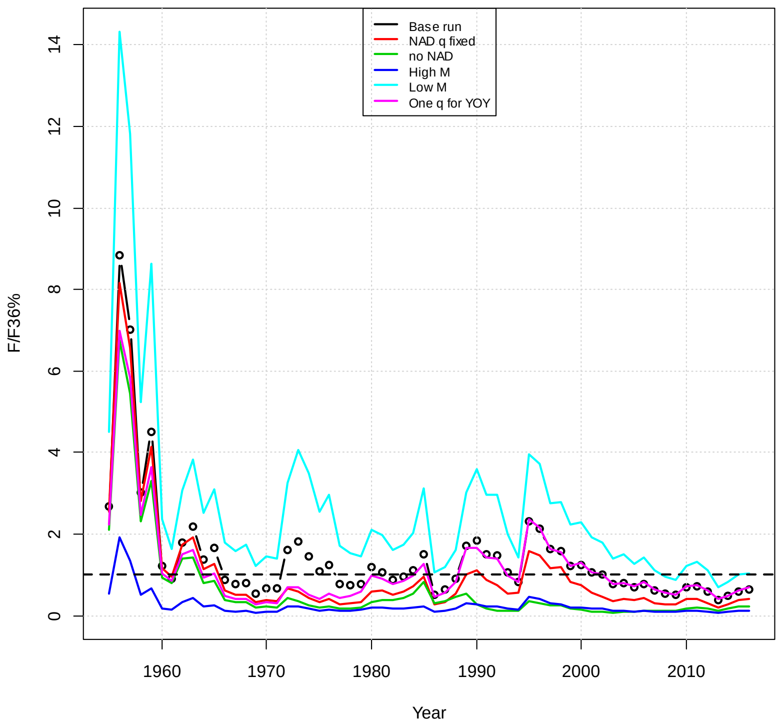


Figure 6.4.1.8 Full *F* over $F_{21\%}$ for sensitivity runs considering differences in growth and life history parameters and differences in indices and catchability in the assessment model.



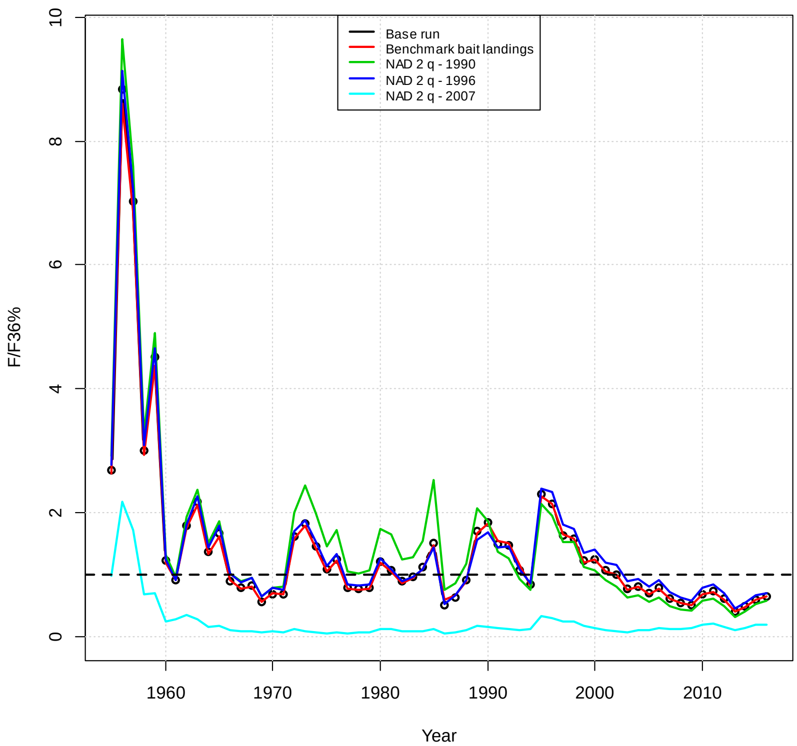


Figure 6.4.1.9 Full *F* over $F_{36\%}$ for sensitivity runs considering differences in growth and life history parameters and differences in indices and catchability in the assessment model.

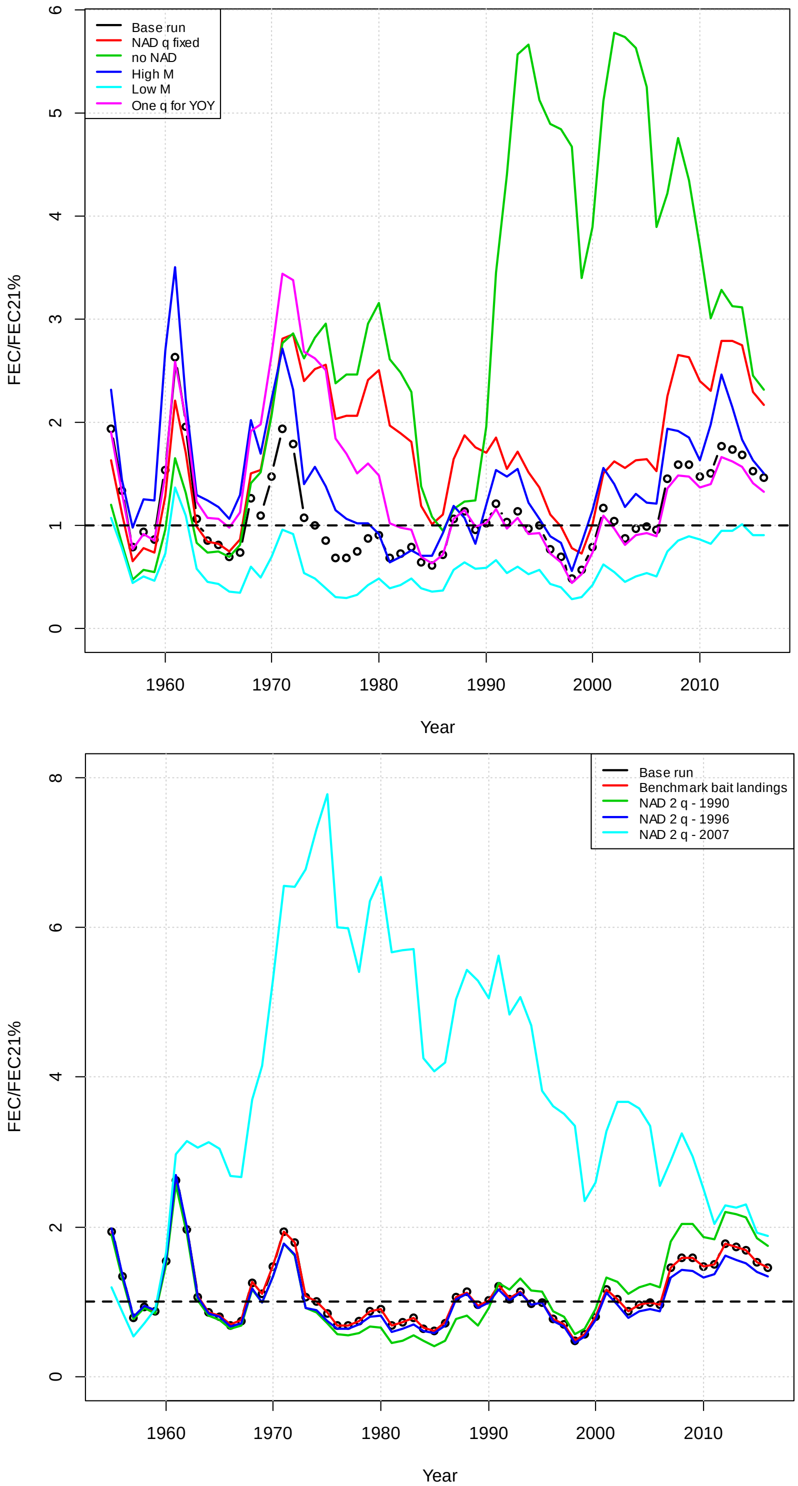
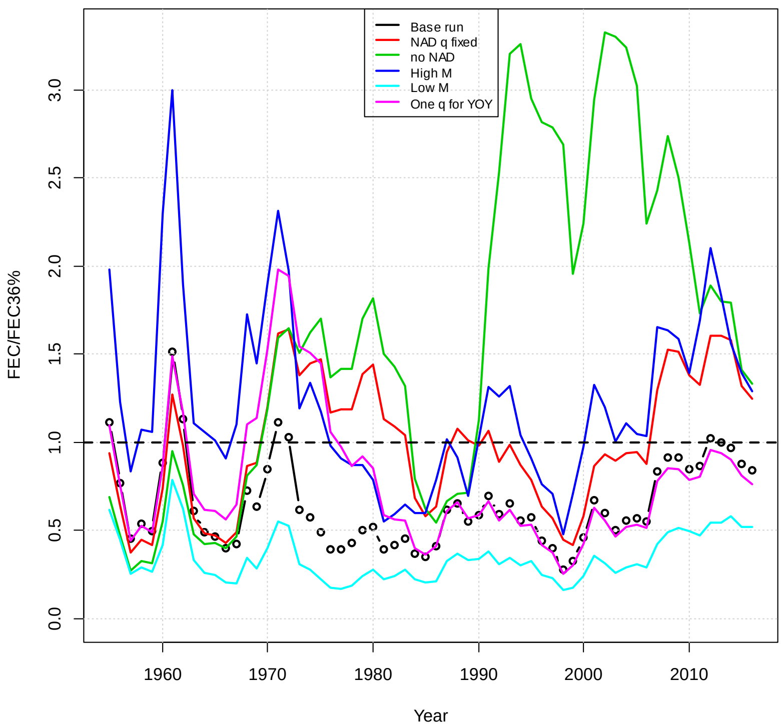


Figure 6.4.1.10 Fecundity over $FEC_{21\%}$ for sensitivity runs considering differences in growth and life history parameters and differences in indices and catchability in the assessment model.



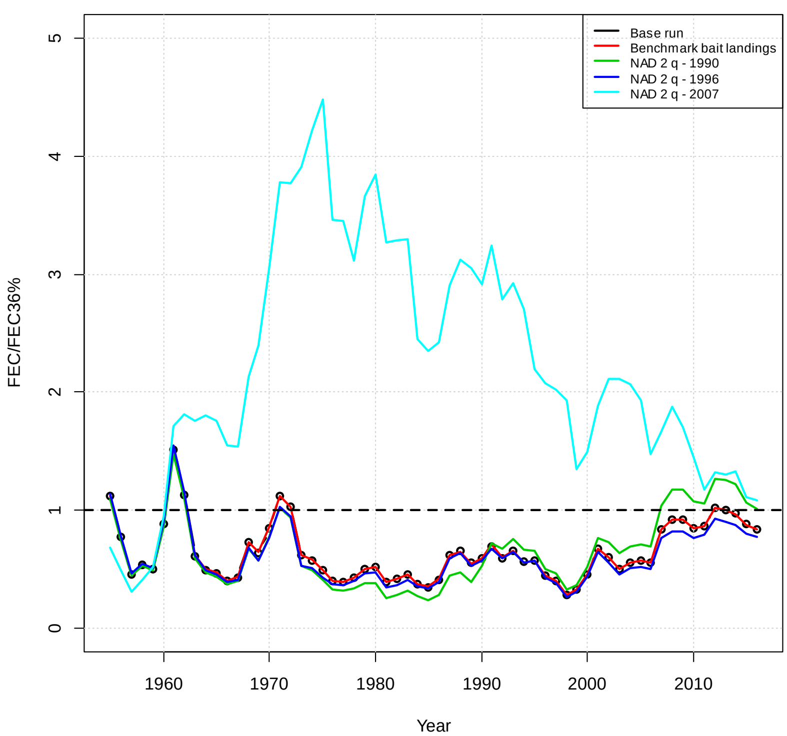


Figure 6.4.1.11 Fecundity over $FEC_{36\%}$ for sensitivity runs considering differences in growth and life history parameters and differences in indices and catchability in the assessment model.

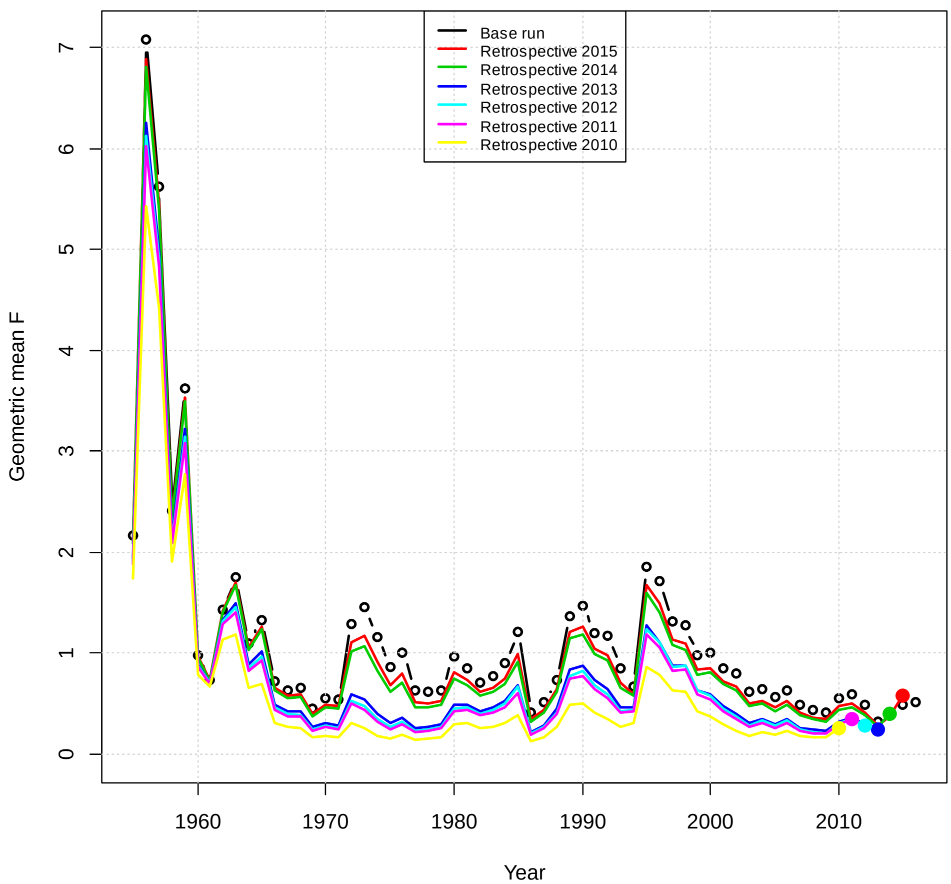


Figure 6.4.2.1 Fishing mortality over time for the retrospective analysis of the assessment model.

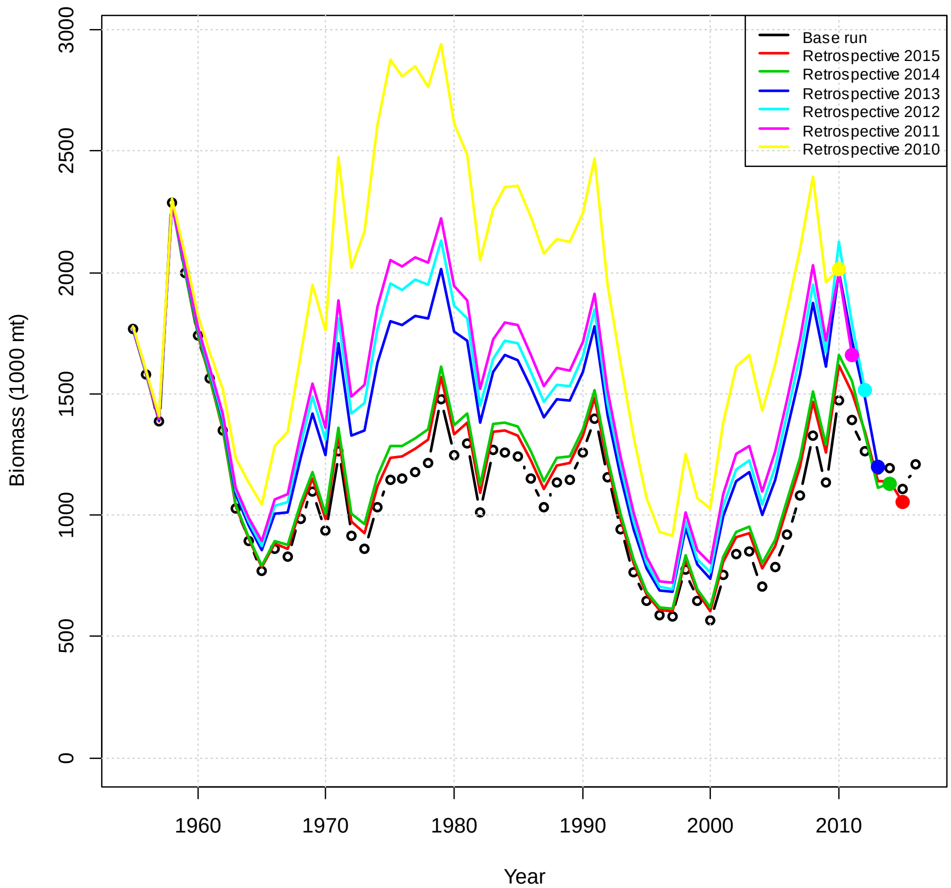


Figure 6.4.2.2 Age-1+ biomass in 1000s mt over time for the retrospective analysis of the assessment model.

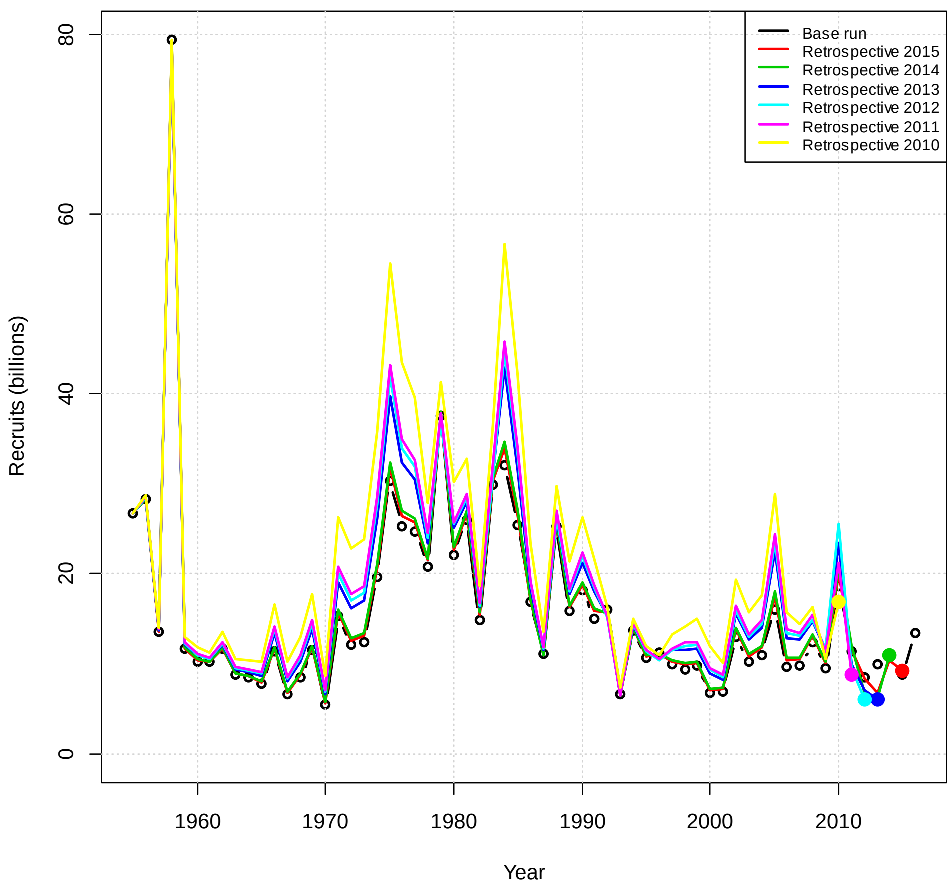


Figure 6.4.2.3 Recruitment over time for the retrospective analysis of the assessment model.

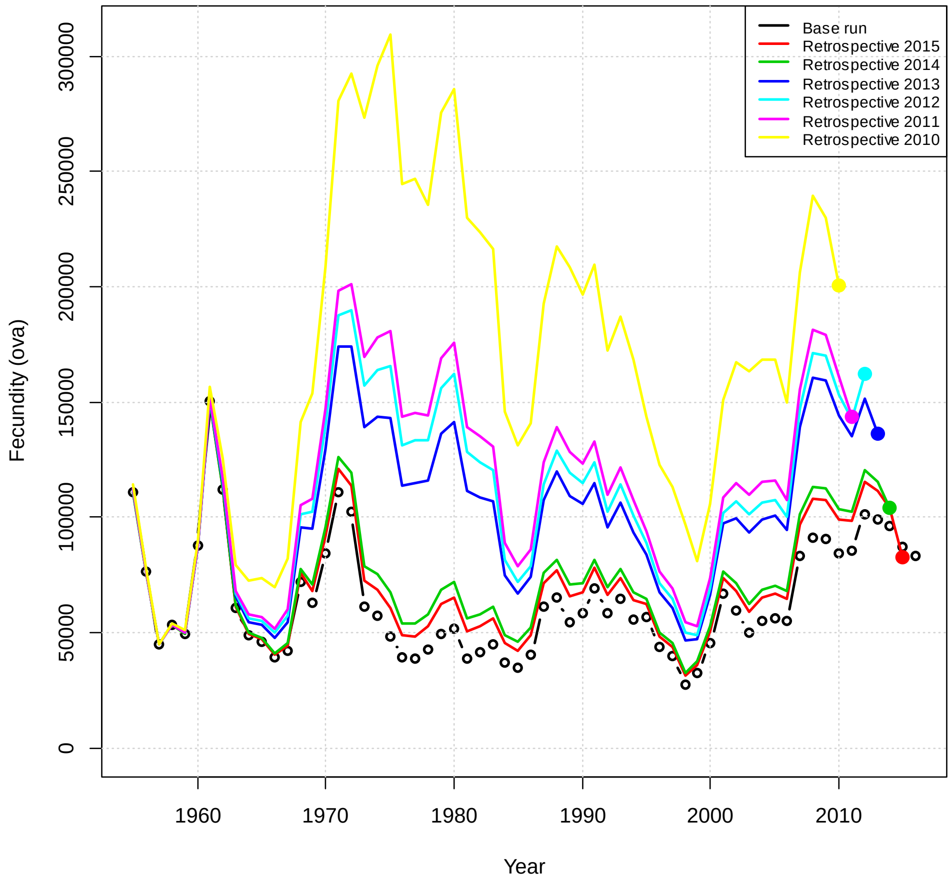


Figure 6.4.2.4 Fecundity over time for the retrospective analysis of the assessment model.

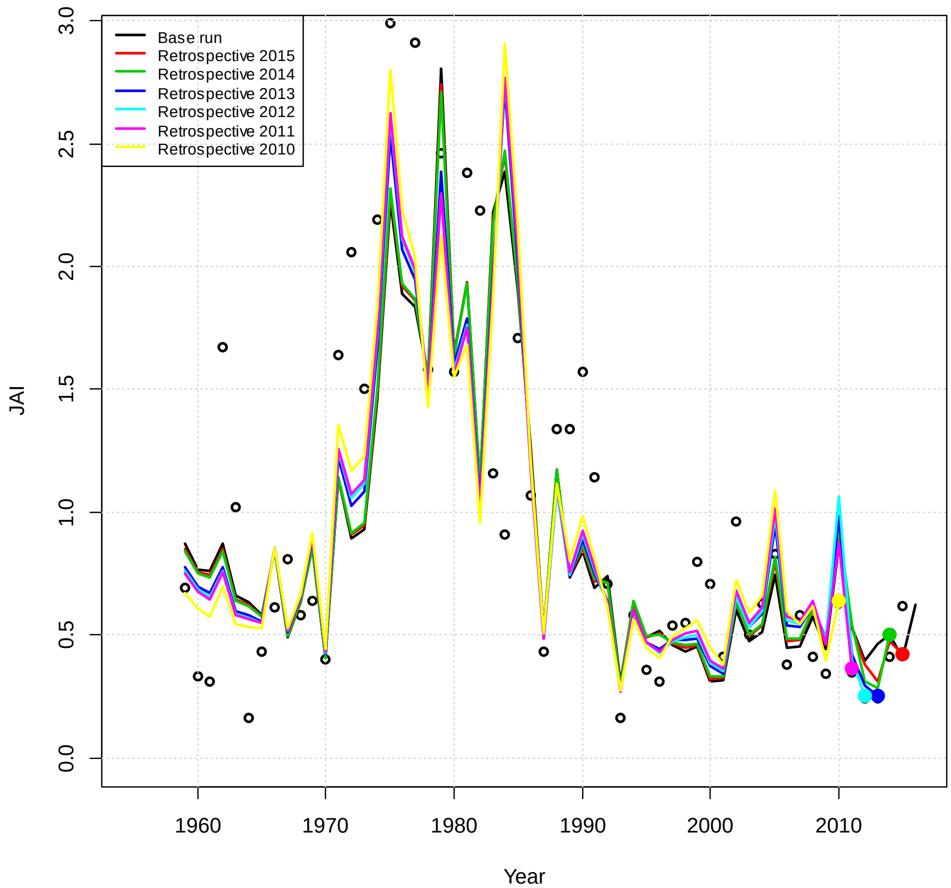


Figure 6.4.2.5 Fit to the JAI index over time for the retrospective analysis of the assessment model.

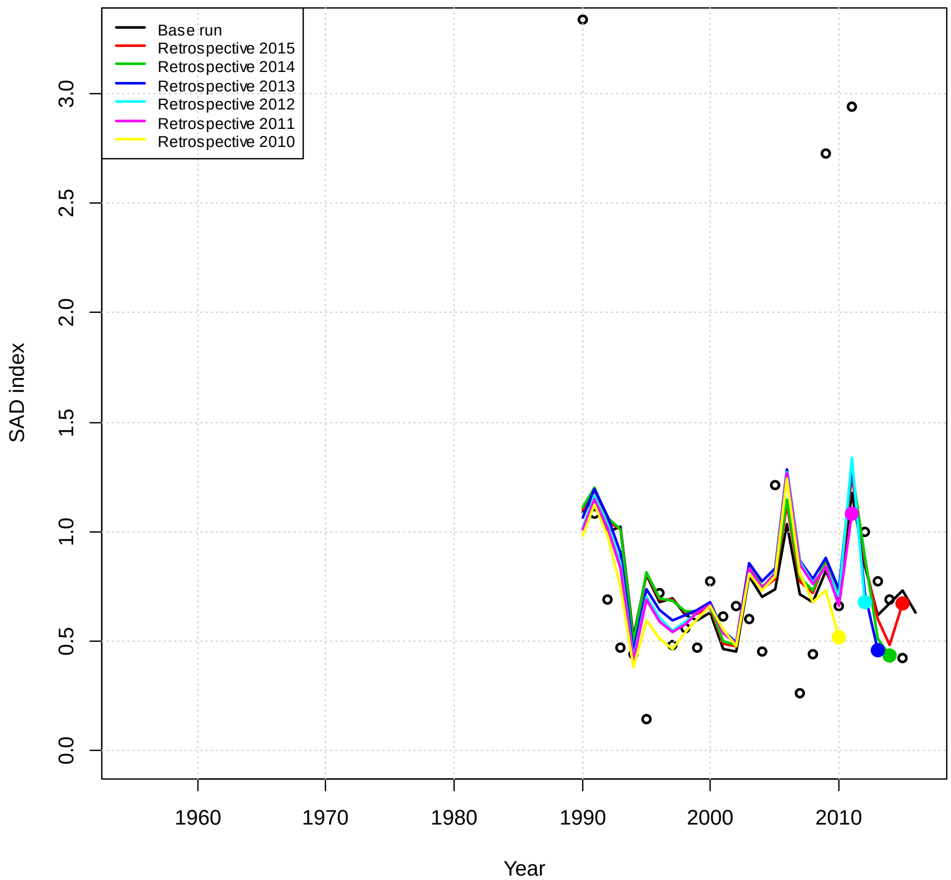


Figure 6.4.2.6 Fit to the SAD index over time for the retrospective analysis of the assessment model.

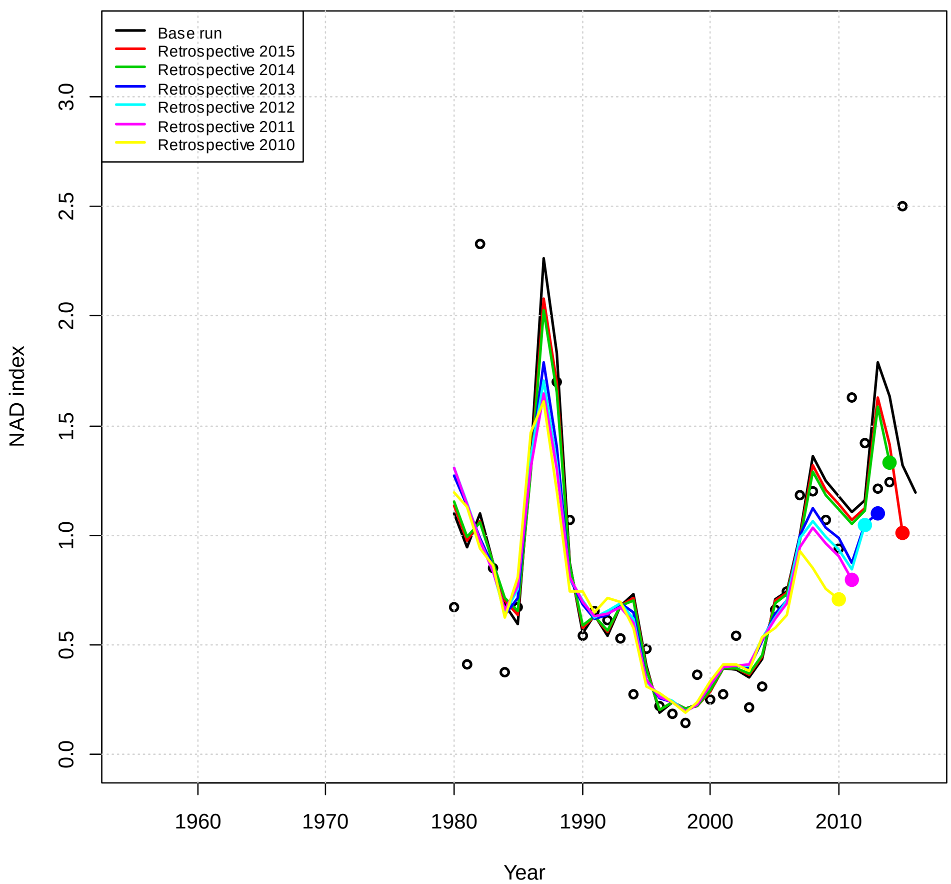


Figure 6.4.2.7 Fit to the NAD index over time for the retrospective analysis of the assessment model.

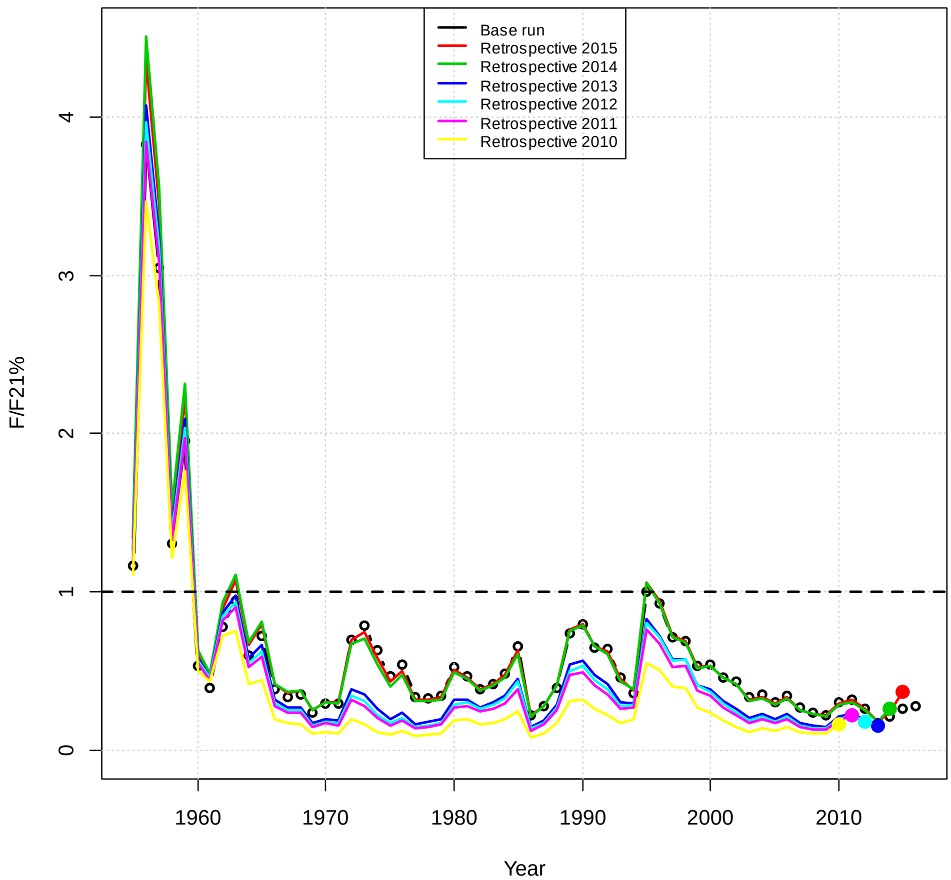


Figure 6.4.2.8 Fishing mortality rate over $F_{21\%}$ for the retrospective analysis of the assessment model.

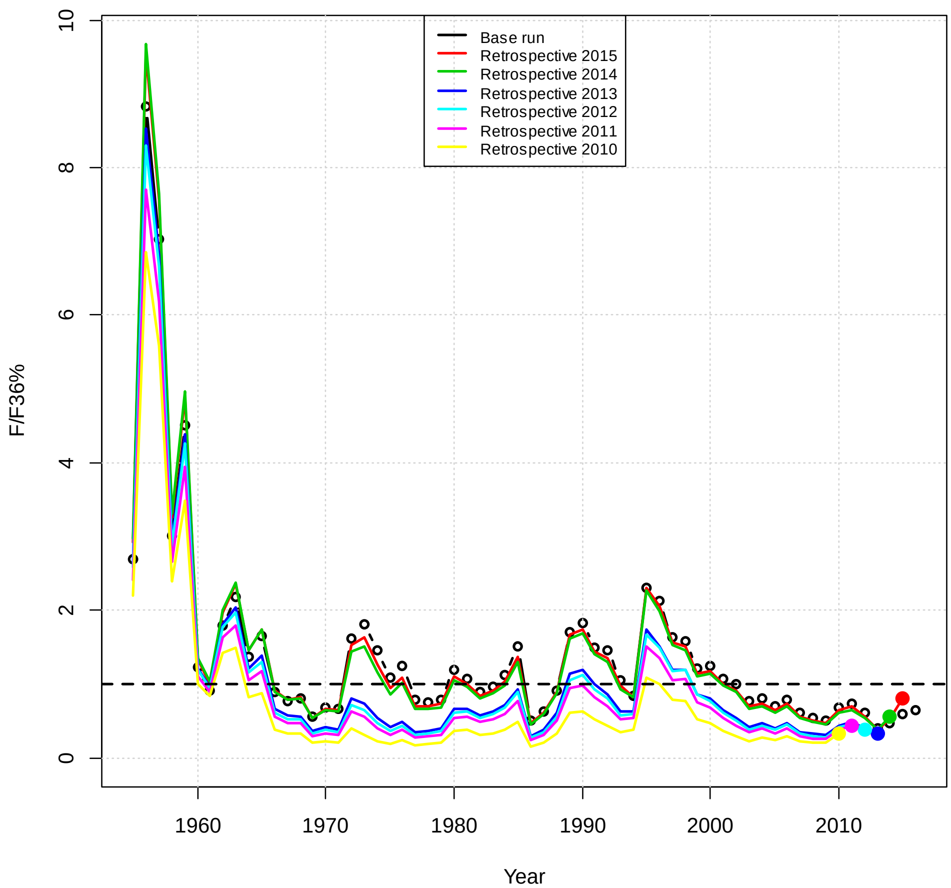


Figure 6.4.2.9 Fishing mortality rate over $F_{36\%}$ for the retrospective analysis of the assessment model.

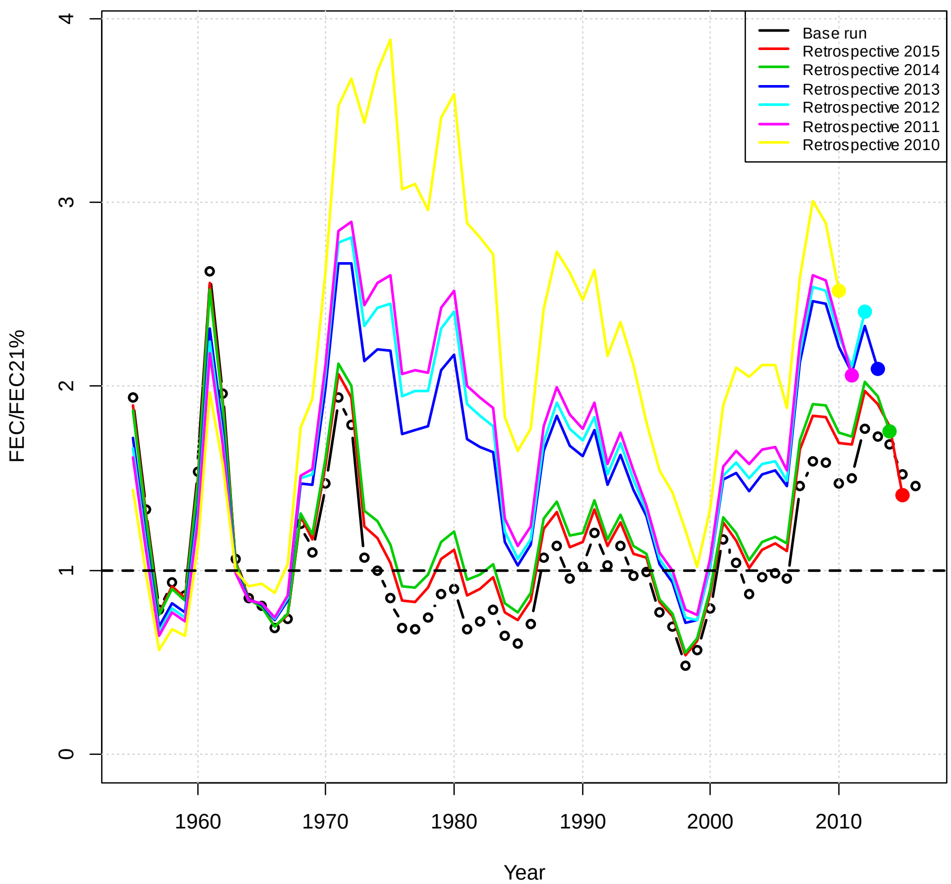


Figure 6.4.2.10 Fecundity over *$FEC_{21\%}$* for the retrospective analysis of the assessment model.

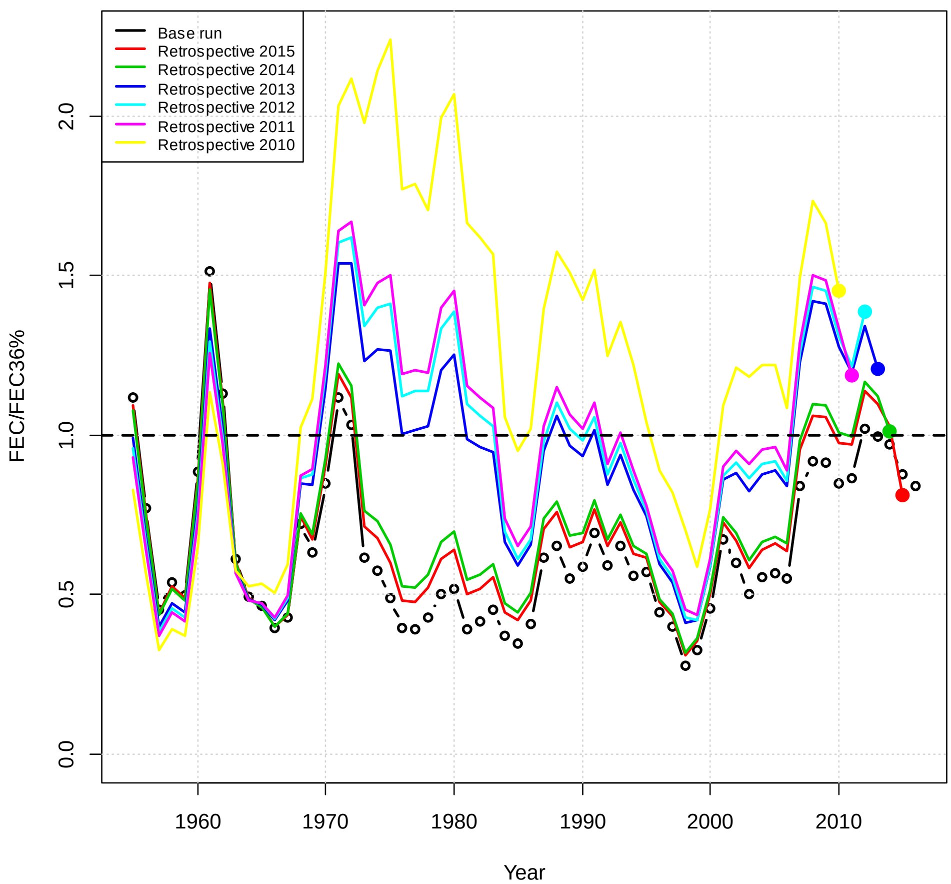


Figure 6.4.2.11 Fecundity over $FEC_{36\%}$ for the retrospective analysis of the assessment model.

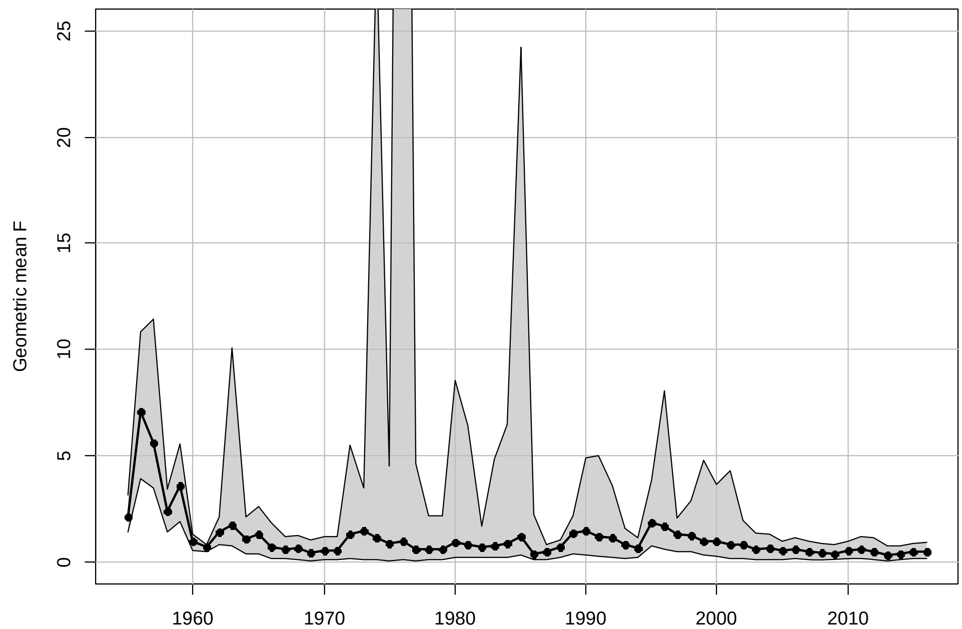


Figure 6.5.1. Geometric mean fishing mortality at ages-2 to -4 over time for the MCB runs. Gray area indicates 95% confidence interval; black line indicates base run.

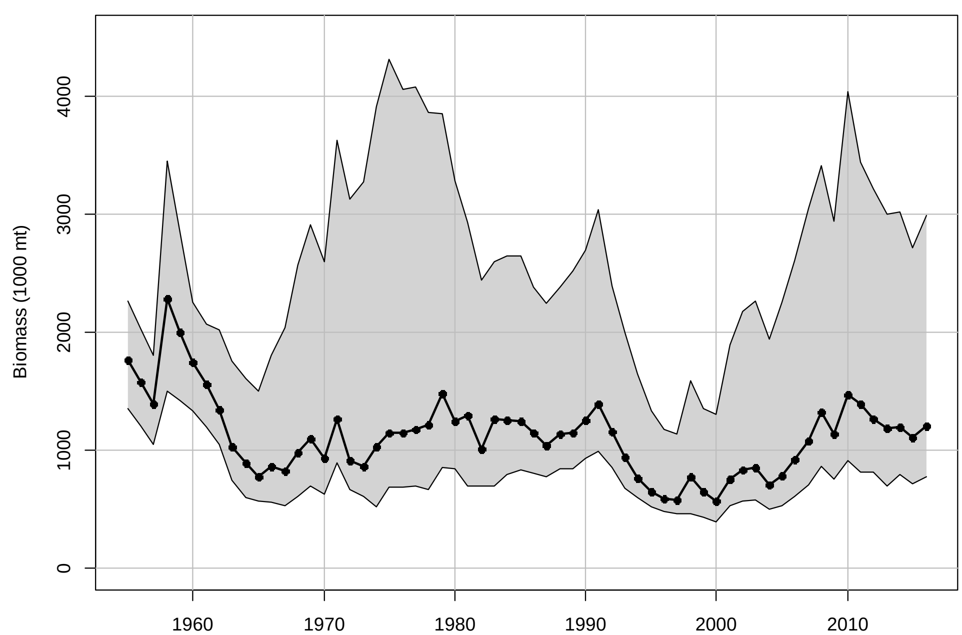


Figure 6.5.2. Age-1+ biomass in 1000s mt over time for the MCB runs. Gray area indicates 95% confidence interval; black line indicates base run.

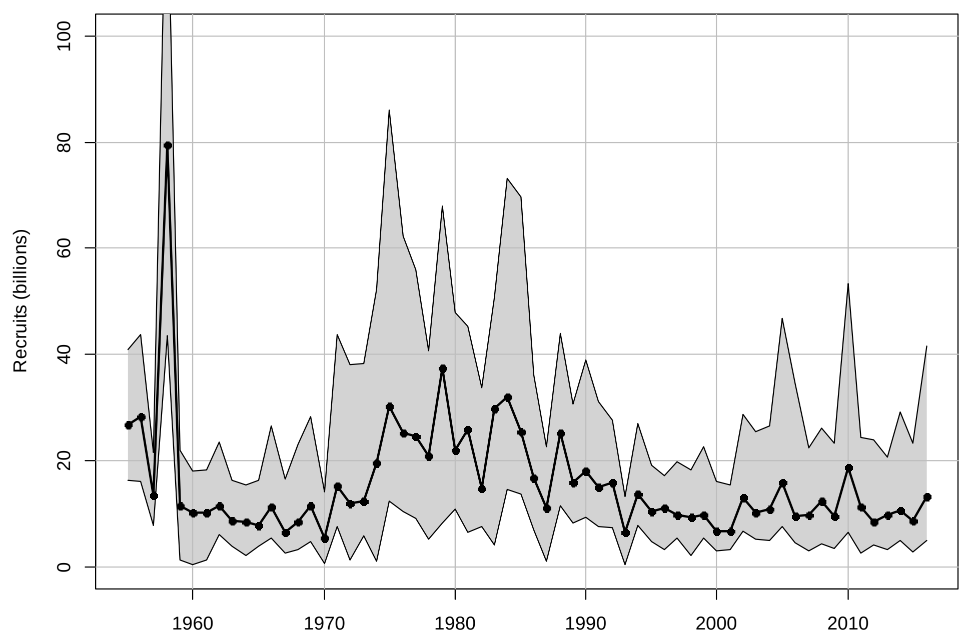


Figure 6.5.3. Recruitment over time for the MCB runs. Gray area indicates 95% confidence interval; black line indicates base run.

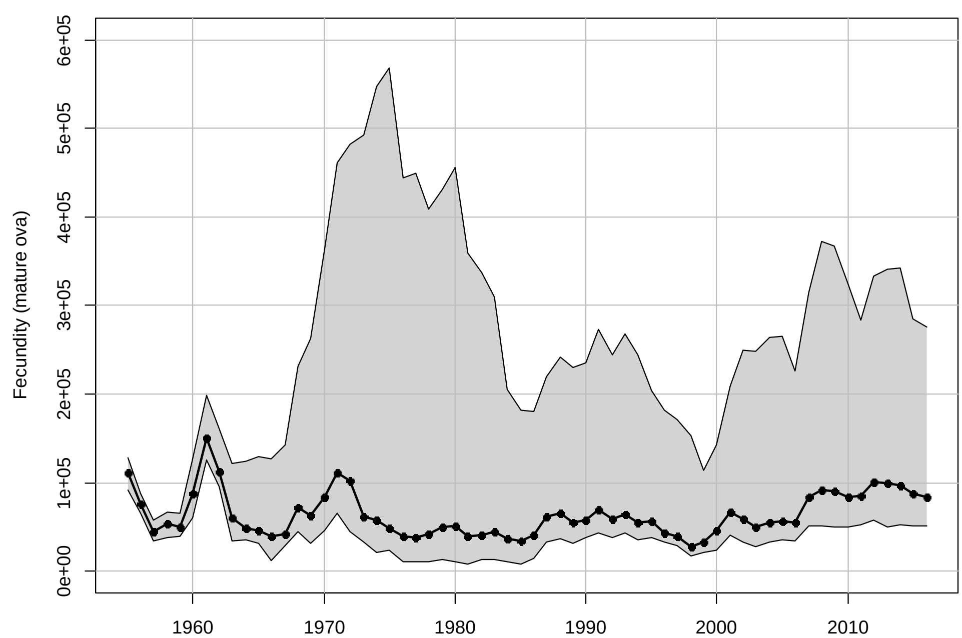


Figure 6.5.4. Fecundity over time for the MCB runs. Gray area indicates 95% confidence interval; black line indicates base run.

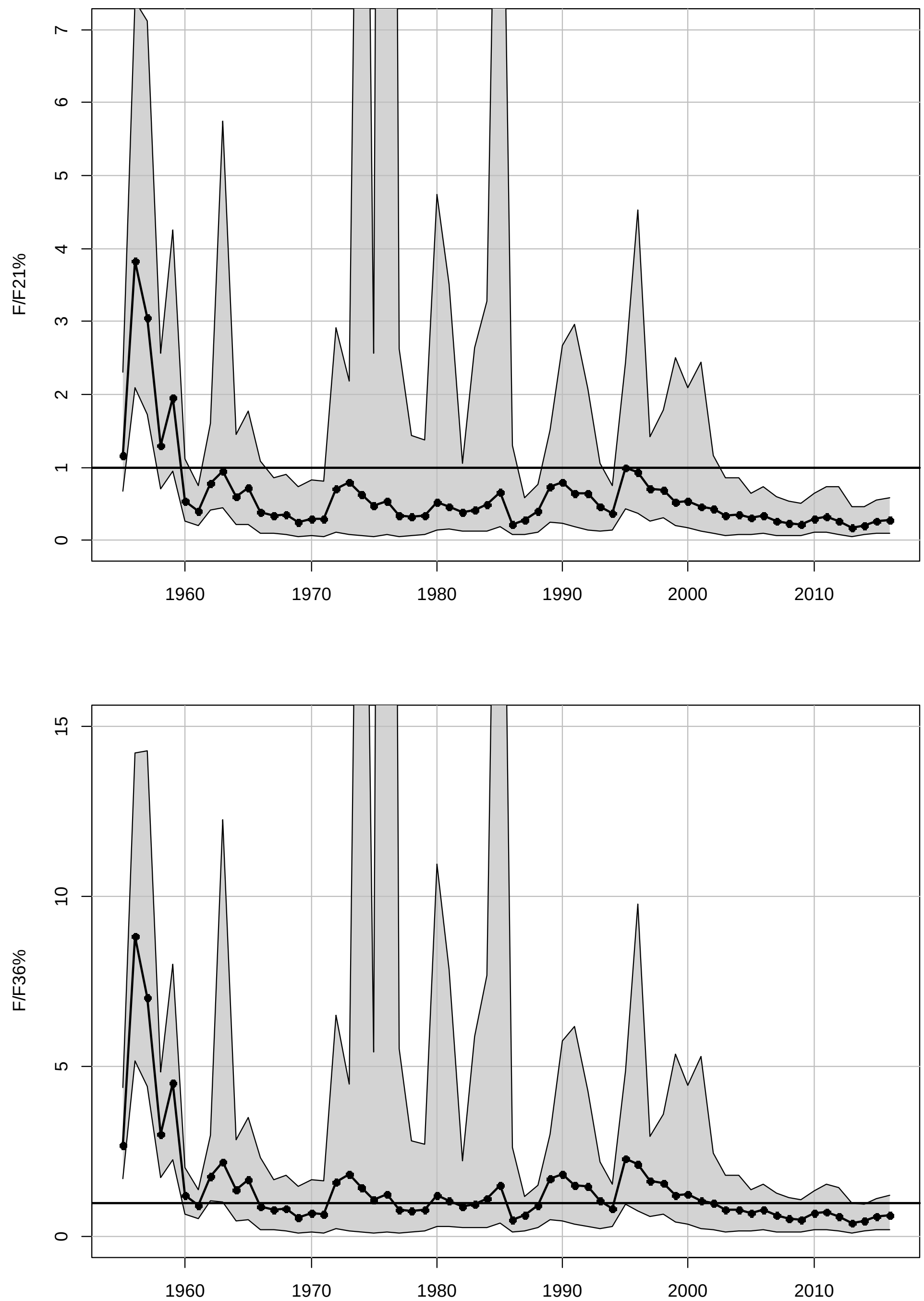


Figure 7.2.1.1 Geometric mean fishing mortality at ages-2 to -4 over time compared to the recommended SPR benchmarks based on the minimum and median $F_{X\%}$ during the time period 1960-2012.

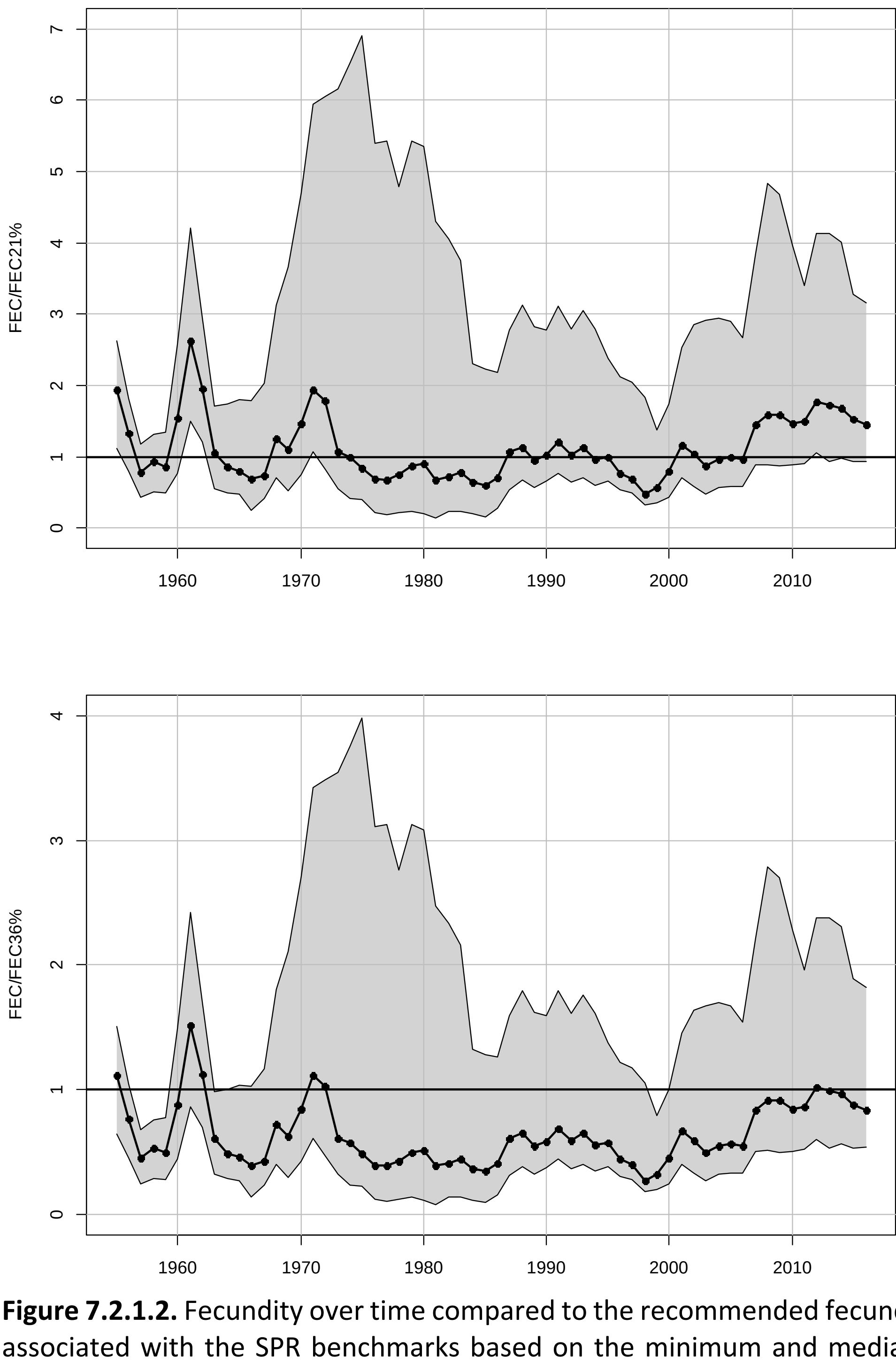
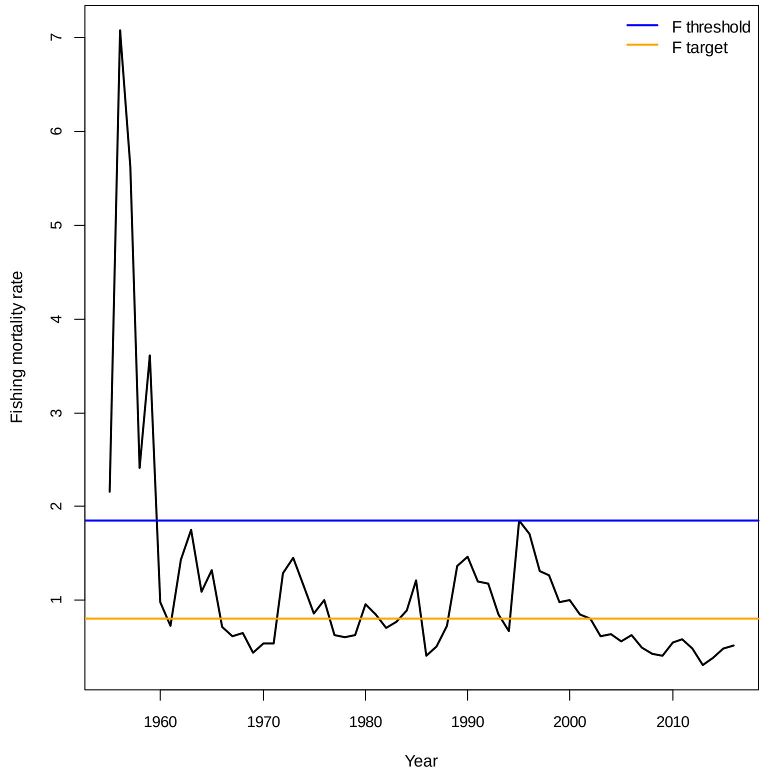


Figure 7.2.1.2. Fecundity over time compared to the recommended fecundity based benchmarks associated with the SPR benchmarks based on the minimum and median $F_{X\%}$ during the time period 1960-2012.



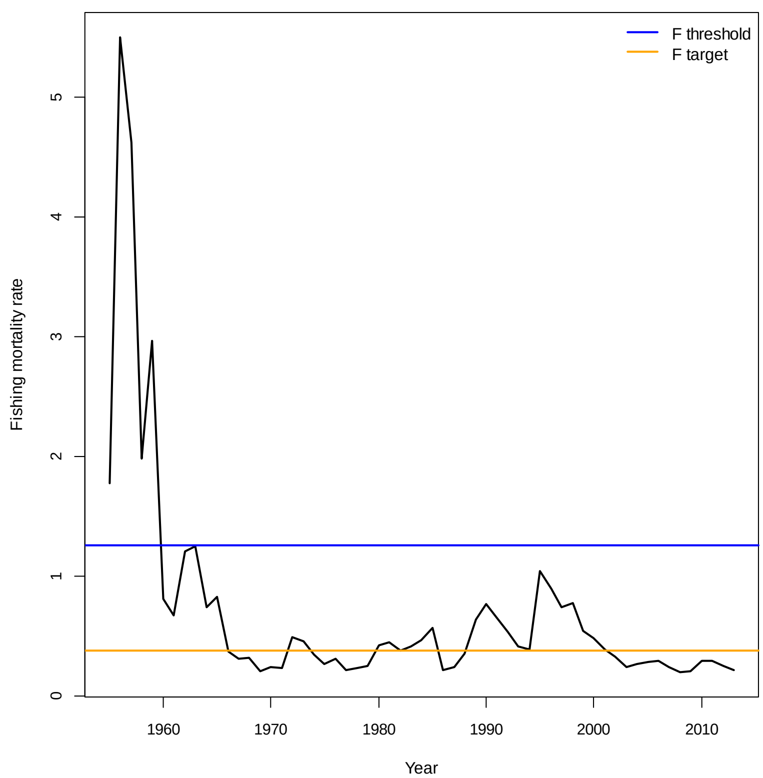


Figure 7.2.1.3 Update (above) and benchmark (below) geometric mean fishing mortality rate for ages-2 to 4 over time with the fishing mortality rate reference points indicated as horizontal lines.

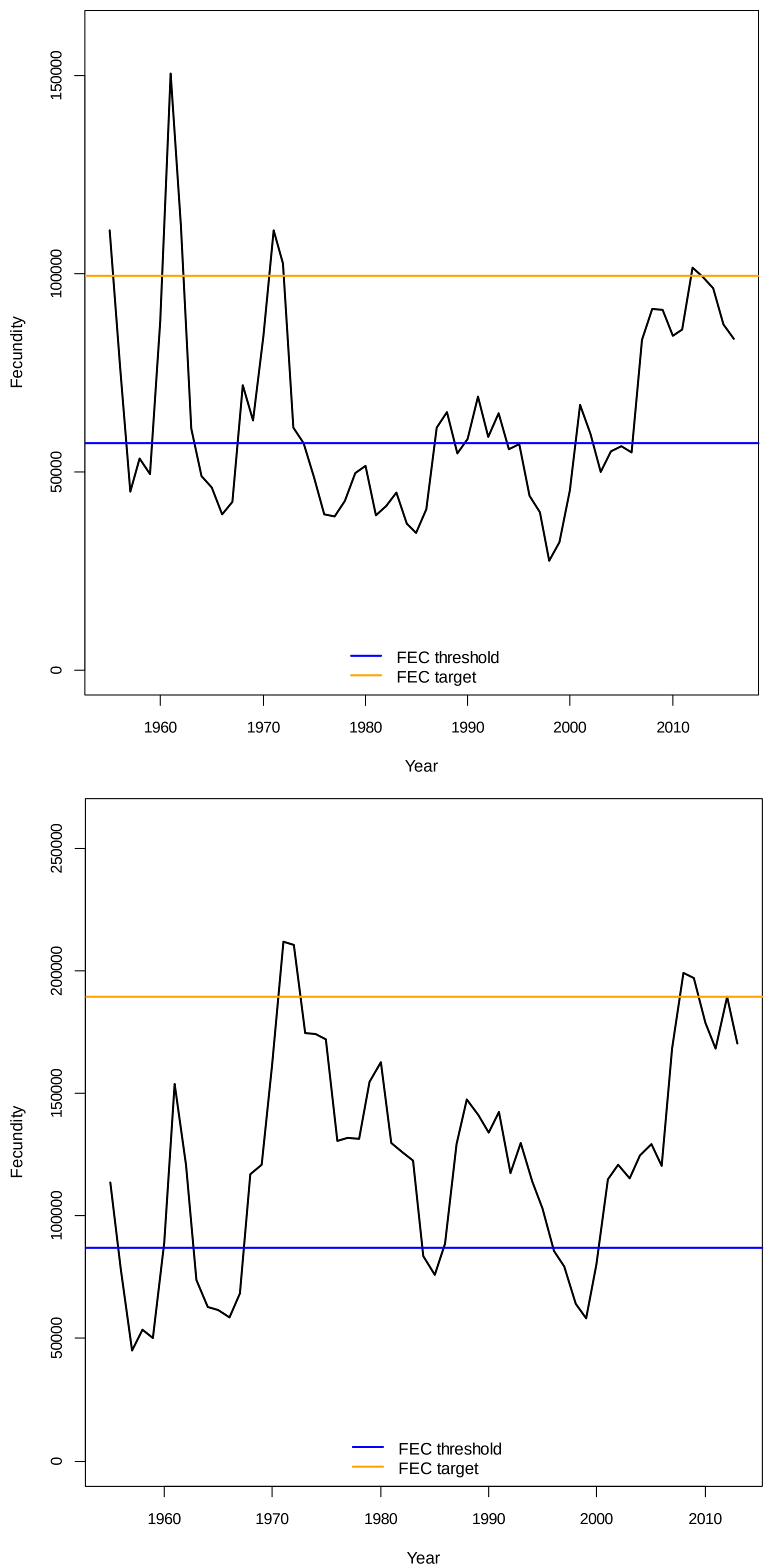


Figure 7.2.1.4 Update (above) and benchmark (below) fecundity over time with the fecundity reference points indicated as horizontal lines.

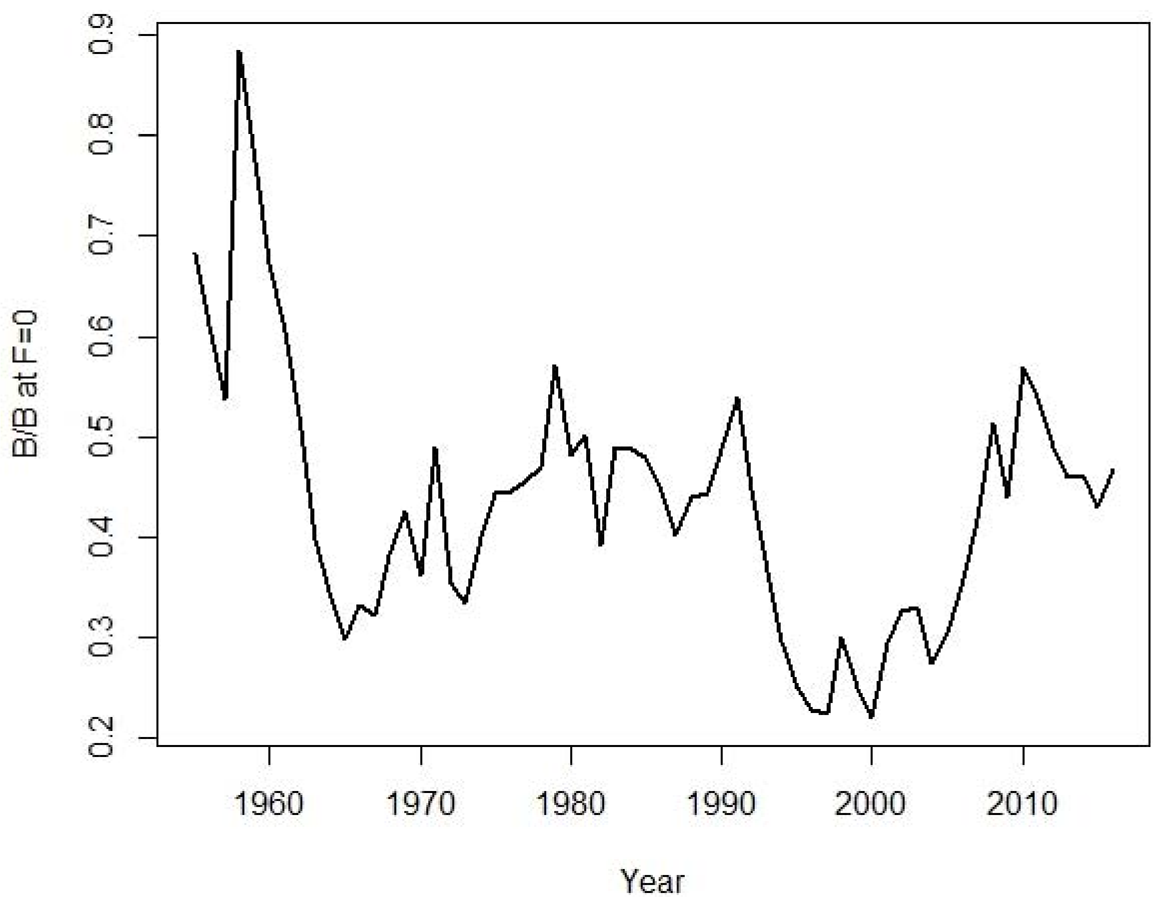


Figure 7.2.1.5. Biomass over time divided by the biomass at $F = 0$.

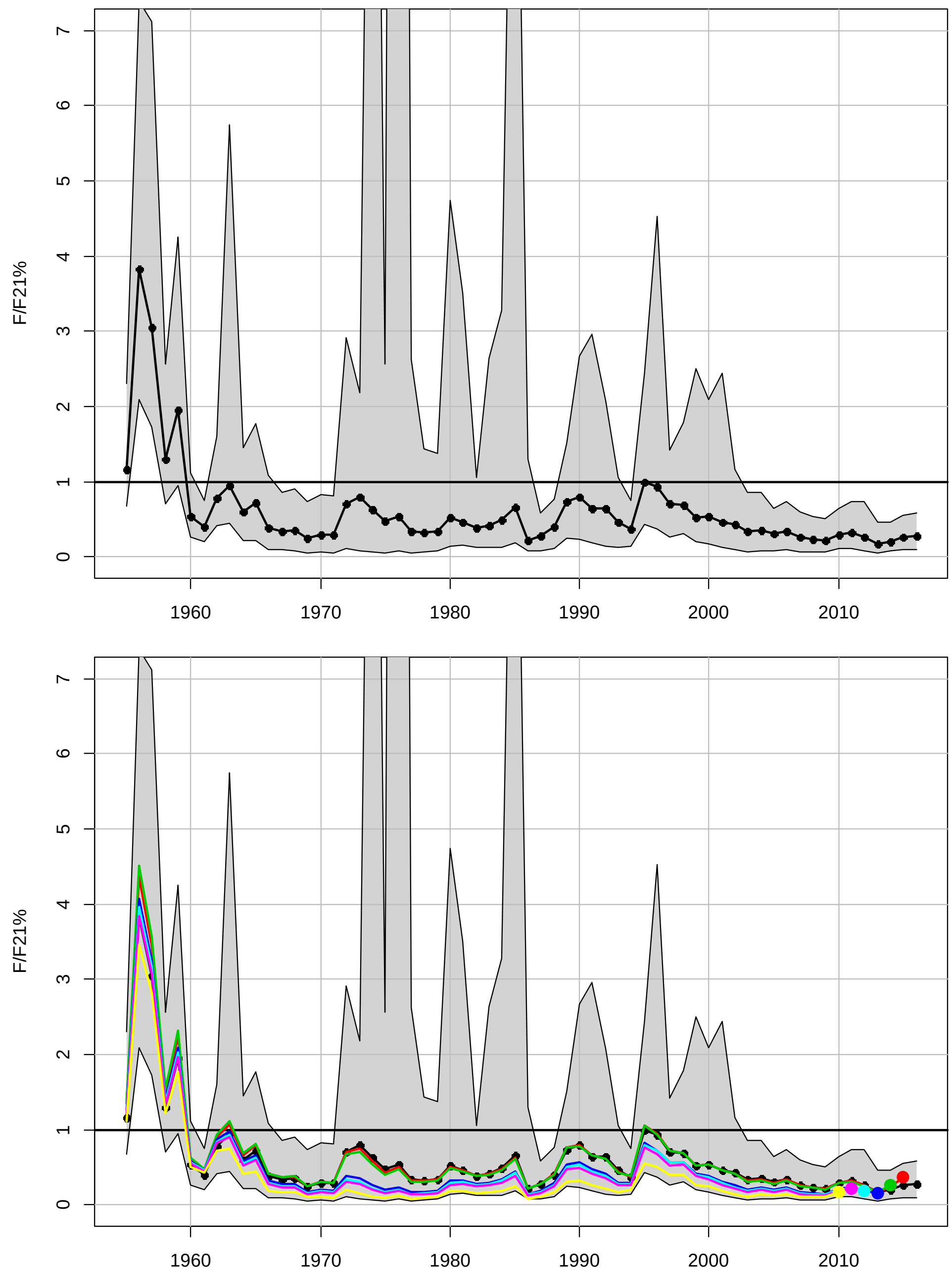


Figure 7.2.2.1. Geometric mean fishing mortality at ages-2 to 4 over $F_{21\%}$ over time for the MCB runs. Gray area indicates 95% confidence interval; black line indicates base run. In lower panel, the retrospective analysis is overlaid on the MCB analysis.

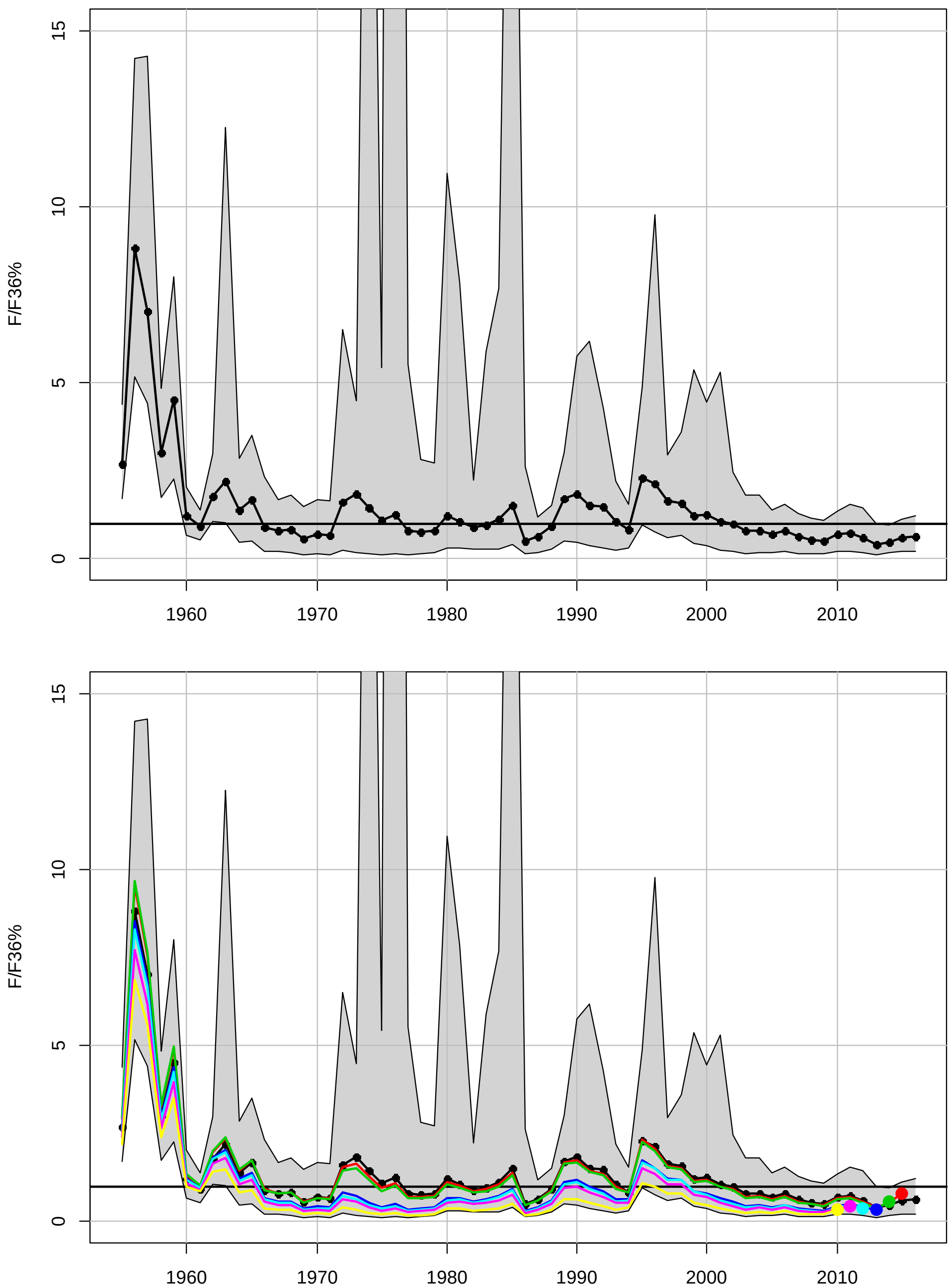


Figure 7.2.2.2. Geometric mean fishing mortality at ages-2 to 4 over $F_{36\%}$ over time for the MCB runs. Gray area indicates 95% confidence interval; black line indicates base run. In lower panel, the retrospective analysis is overlaid on the MCB analysis.

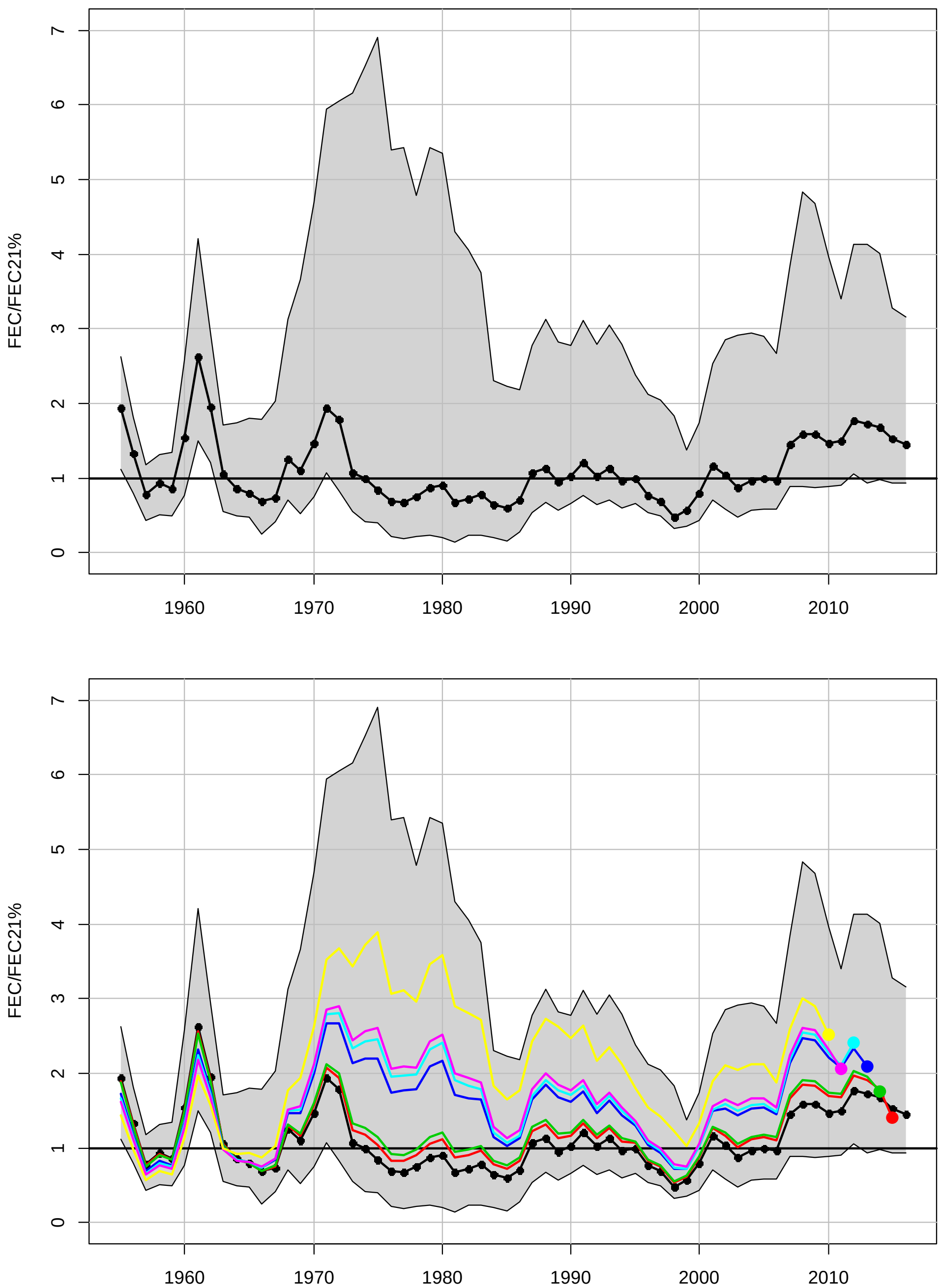


Figure 7.2.2.3. Fecundity over *$FEC_{21\%}$* over time for the MCB runs. Gray area indicates 95% confidence interval; black line indicates base run. In lower panel, the retrospective analysis is overlaid on the MCB analysis.

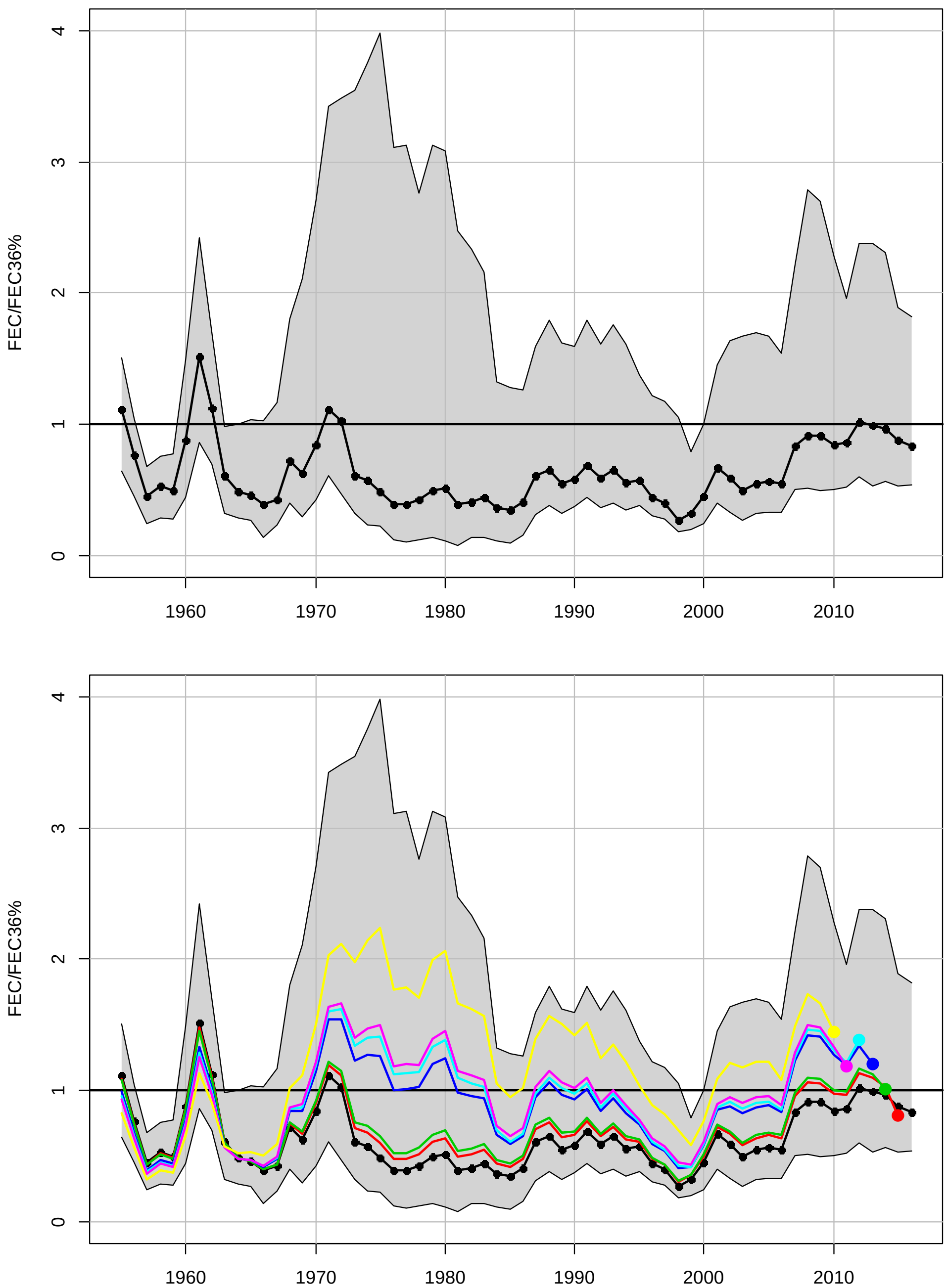


Figure 7.2.2.4. Fecundity over $FEC_{36\%}$ over time for the MCB runs. Gray area indicates 95% confidence interval; black lines indicates base run. In lower panel, the retrospective analysis is overlaid on the MCB analysis.

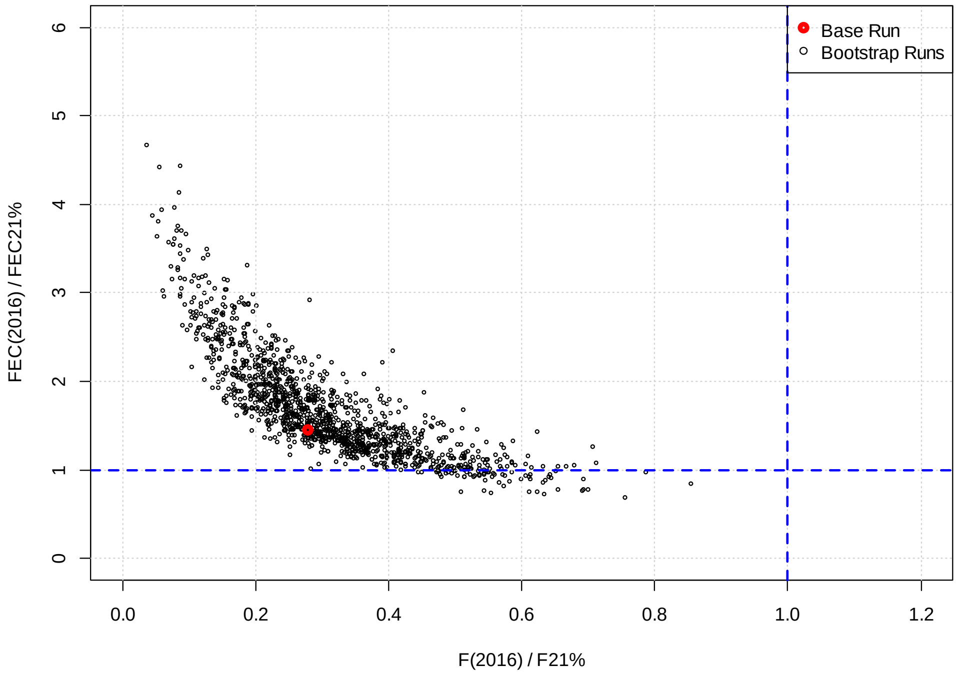


Figure 7.2.2.5. Plot of the terminal year geometric mean fishing mortality at ages-2 to 4 and the terminal year fecundity relative to their respective threshold benchmarks for the base run and each bootstrap run.

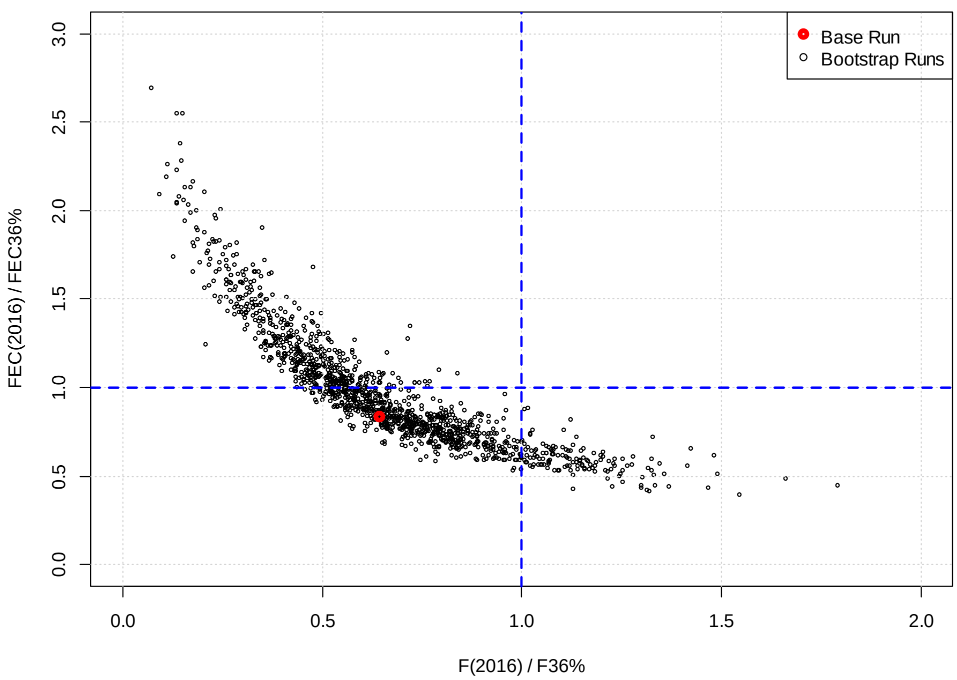


Figure 7.2.2.6. Plot of the terminal year geometric mean fishing mortality at ages-2 to 4 and the terminal year fecundity relative to their respective target benchmarks for the base run and each bootstrap run.

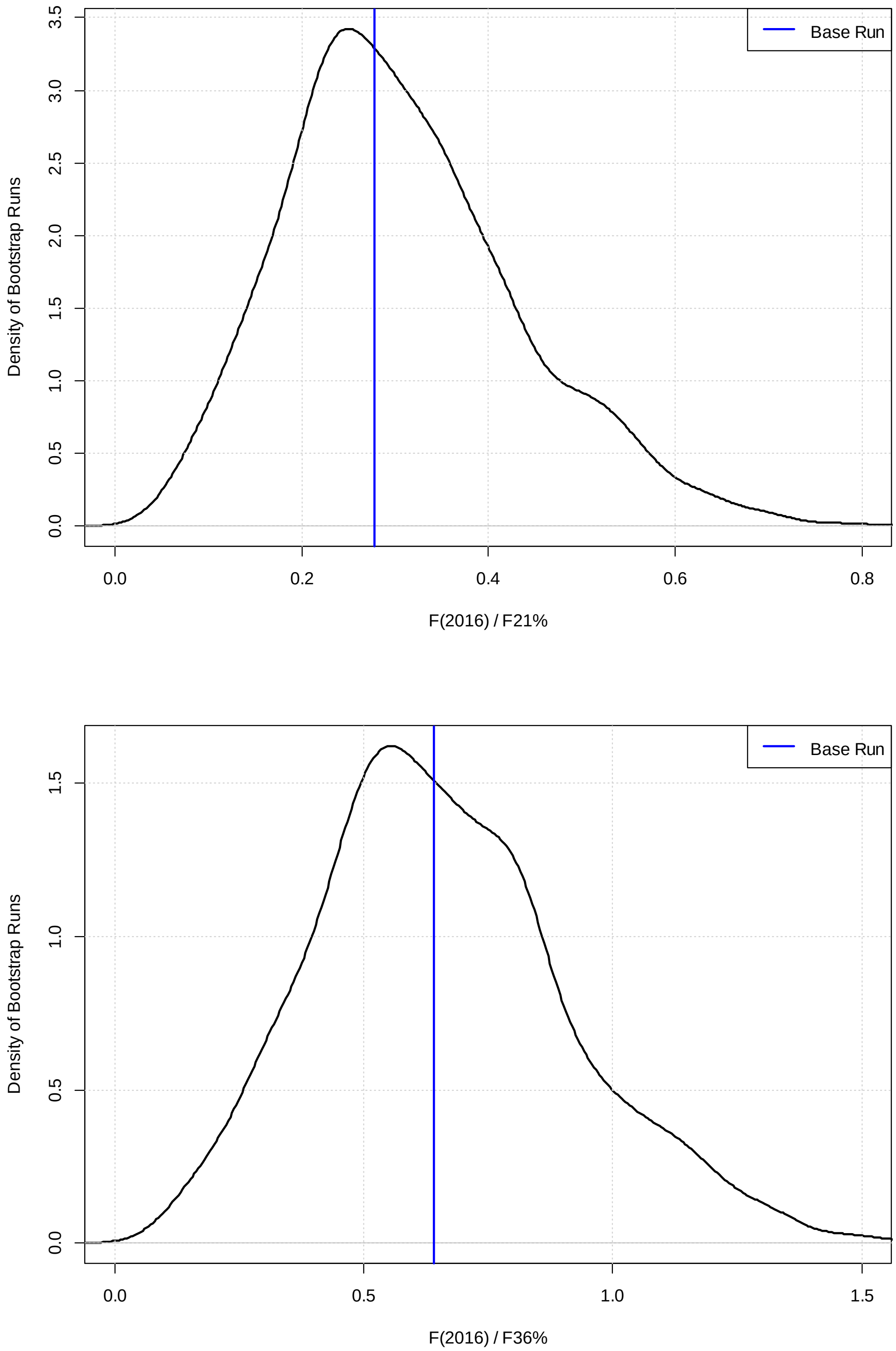


Figure 7.2.2.7. Density plots for terminal year geometric mean fishing mortality at ages-2 to 4 over the $F_{21\%}$ threshold (above) and $F_{36\%}$ target (below) benchmarks across the base run and MCB runs.

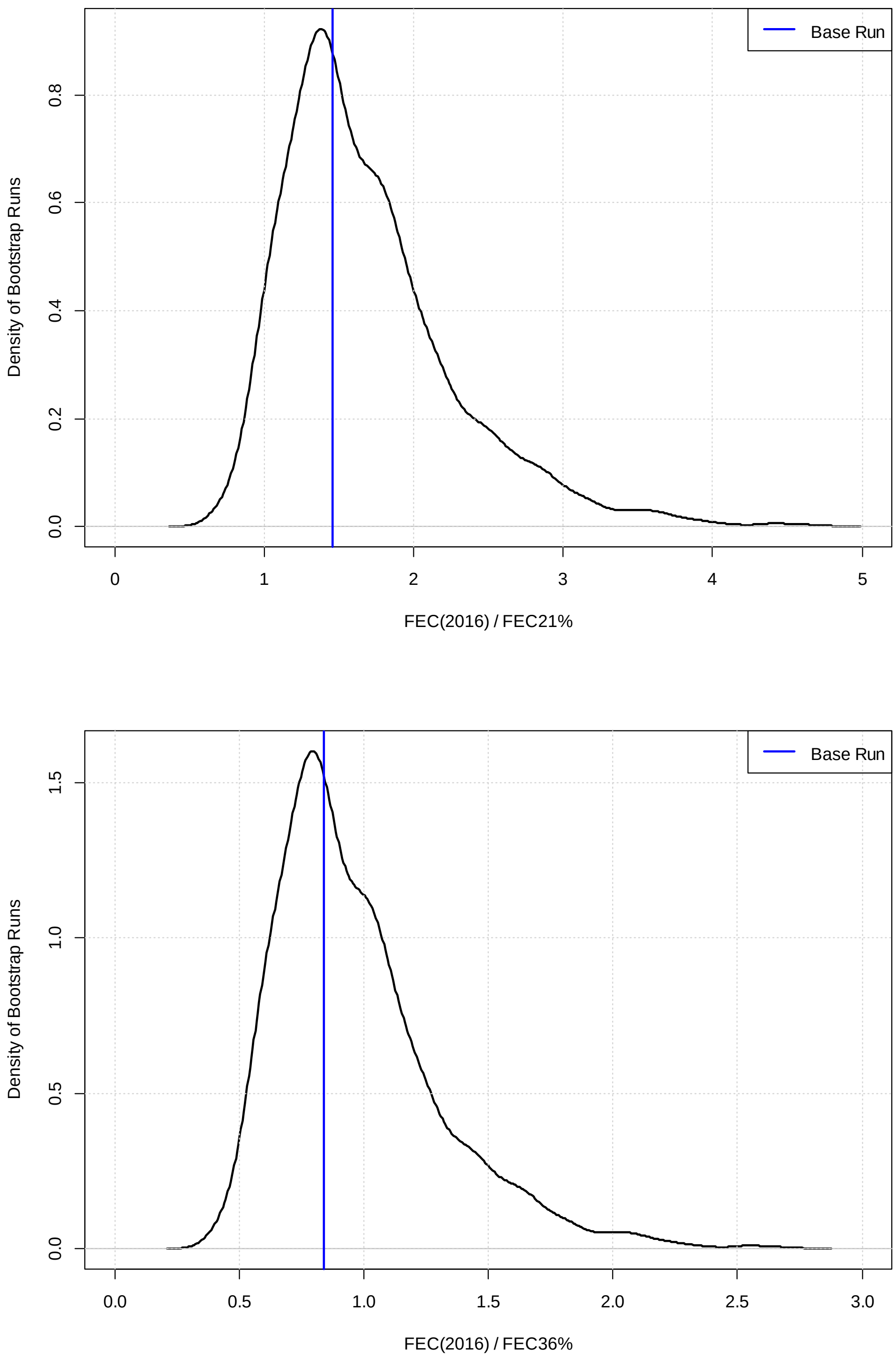


Figure 7.2.2.8. Density plots for terminal year fecundity over the $FEC_{21\%}$ threshold (above) and $FEC_{36\%}$ target (below) benchmarks across the base run and MCB runs.

13.0 Appendix A. Standardization of Abundance Indices for Atlantic Menhaden

Three indices of abundance for Atlantic menhaden were developed from several surveys and used in the most recent benchmark stock assessment (SEDAR 2015). Below is a description of the GLM standardization of each of the surveys and any changes or notes in the survey or model structure for this report.

Rhode Island Trawl Survey

Age0 Index: A full model that predicted catch as a linear function of year, bottom temperature, and depth as categorical factors was compared with nested submodels using AIC. The model that included year and bottom temperature was selected because it produced the lowest AIC (% deviance = 41). The model was unchanged from the previous benchmark assessment and updated through 2016.

Connecticut Long Island Sound Trawl Survey

Age0 Index: A full model that predicted catch as a linear function of year, stratum, month, starting depth of the tow, surface temperature, bottom temperature, surface salinity, bottom salinity, and season was compared with nested submodels using AIC. The model that included year, and depth was selected because it produced the lowest AIC and good model diagnostics. The model formula was unchanged from the previous benchmark assessment, but the use of the standard glm model was a departure from the previously selected model (zero inflated negative binomial model) from the benchmark assessment.

Adult Index: A full model that predicted catch as a linear function of year, stratum, month, starting depth of the tow, surface temperature, bottom temperature, surface salinity, bottom salinity, and season was compared with nested submodels using AIC. The model that included year and stratum was selected because it produced the lowest AIC and good model diagnostics. The model was changed from the previous benchmark assessment, which had year and season as effects.

Connecticut River Seine Survey

Age0 Index: A full model that predicted catch as a linear function of year, month, and site was compared with nested submodels using AIC. The same model parameterization as the previous assessment for binomial (year+month+site) and lognormal (year+month) components was used.

Connecticut Thames Seine Survey

Age0 Index: A full model that predicted catch as a linear function of year, month, and site was compared with nested submodels using AIC. The same model parameterization as the previous assessment (year+month+site) for both the binomial and lognormal components was used.

New York Peconic Bay Trawl Survey

Age0 Index: A full model that predicted catch as a linear function of year, depth, and bottom salinity was compared with nested submodels using AIC. The model including year, depth, and bottom salinity factors was selected because it produced the lowest AIC (% deviance = 32). While data was supplied for the update assessment, adding the 2014-2016 data resulted in an unstable model with convergence issues and unreasonable estimated values. This could not be resolved and therefore this index was not updated with the last 3 years of data (2014-2016), although values from the previous benchmark were included in the update.

New York Western Long Island Seine Survey

Age0 Index: A full model that predicted catch as a linear function of year, month, region, temperature, and salinity was compared with nested submodels using AIC. Relative to the previous assessment, the covariate dissolved oxygen was eliminated from consideration because of missing values, particularly early in the time series. This decision probably should have been made during the previous assessment because data filtering to complete dissolved oxygen led to the elimination of data for 1997. Slightly different parameterizations were therefore supported for the binomial (year+month+region+temp+salinity) and lognormal (year+month+region+temp) components. The estimated index and CV for 1988 differs considerably from that of the previous assessment. Since dissolved oxygen was no longer considered, more data records were retained for analysis, including a single catch of 30,000 fish which created a much higher index value. This haul also contributed to the extremely high bootstrapped CV value for that year.

New Jersey Ocean Trawl Survey

Age0 Index: A full model that predicted catch as a linear function of year, station, stratum, vessel, month, starting depth of the tow, bottom temperature, bottom salinity, and bottom dissolved oxygen was compared with nested submodels using AIC. Additionally, a zero inflated negative binomial model was also run for comparison. The zero inflated model that included year, bottom temperature, and bottom salinity was selected because it produced the lowest AIC and good model diagnostics. The choice of zero inflated over standard glm was made from the outcome of the vuongs non nested hypothesis test. The model formula was unchanged from the previous benchmark assessment, but the use of the zero inflated model was a departure from the previously selected model from the benchmark assessment.
Adult Index: A full model that predicted catch as a linear function of year, station, stratum, vessel, month, starting depth of the tow, bottom temperature, bottom salinity, and bottom dissolved oxygen was compared with nested submodels using AIC. The model that included year, bottom temperature, and bottom salinity was selected because it produced the lowest AIC and good model diagnostics. The model was unchanged from the previous benchmark assessment.

New Jersey Juvenile Striped Bass Seine Survey

Age0 Index: A full model that predicted catch as a linear function of year, month, river, salinity, and dissolved oxygen was compared with nested submodels using AIC. For the previous assessment both model components were parameterized the same (year+month+river+sal+DO), however, for the update assessment, the supported binomial model differed slightly (year+month+river+DO) while the lognormal model remained the same.

Delaware Inland Bays Trawl Survey

Age0 Index: A full model that predicted catch as a linear function of year, sea surface temperature, and surface salinity was compared with nested submodels using AIC. The full model was selected because it produced the lowest AIC (% deviance = 42). The model was unchanged from the previous benchmark assessment and updated through 2016.

Delaware 16 ft Trawl Survey

Age0 index: A full model that predicted catch as a linear function of year, station, month, starting depth of the tow, surface temperature, surface salinity, surface dissolved oxygen, and tide was compared with nested submodels using AIC. The model that included year, surface temperature, surface salinity, and tide was selected because it produced the lowest AIC and good model diagnostics. The model was changed from the previous benchmark assessment, which only had year and temperature as effects.

Adult index: A full model that predicted catch as a linear function of year, station, month, starting depth of the tow, surface temperature, surface salinity, surface dissolved oxygen, and tide was compared with nested submodels using AIC. The model that included year, surface temperature, surface salinity, and tide was selected because it produced the lowest AIC and good model diagnostics. The model was changed from the previous benchmark assessment, which only had year, surface temperature, and surface salinity as effects.

Delaware 30 ft Trawl Survey

Adult index: A full model that predicted catch as a linear function of year, month, and station as categorical factors was compared with nested submodels using AIC. The model that included year and month was selected because it produced the lowest AIC. The model was unchanged from the previous benchmark assessment and updated through 2016.

Maryland Coastal Bays Trawl Survey

Age0 Index: A full model that predicted catch as a linear function of year, surface salinity, and sea surface temperature was compared with nested submodels and the submodel that included year and salinity was selected because it produced the lowest AIC (% deviance = 32). The model was unchanged from the previous benchmark assessment and updated through 2016.

Maryland Juvenile Striped Bass Seine Survey

Age0 index: A full model that predicted catch as a linear function of year, month, and region was compared with nested submodels using AIC. The same model parameterization as previous assessment (year+month+region) for both the binomial and lognormal components was used.

ChesFIMS Trawl Survey

Adult index: A full ZINB that predicted catch as a function of the categorical variables year and season was compared with nested submodels using AIC. For the 2015 benchmark stock assessment, a reduced model that removed the covariate season from the count model of the ZINB was selected because it produced the lowest AIC. This index was not updated through 2016 and remained unchanged from the benchmark assessment.

ChesMMAP Trawl Survey

Adult index: A full ZINB model that predicted catch as a function of the categorical variables year, stratum and cruise, and the continuous variable area swept was compared with nested submodels using AIC. For the 2015 benchmark stock assessment and this update, a reduced model that removed the covariate year from the negative binomial count sub-model was selected because it produced the lowest AIC.

Virginia Striped Bass Seine Survey

Age0 index: A full model that predicted catch as a linear function of year, month, river, salinity, and temerpature was compared with nested submodels using AIC. Same model parameterization as previous assessment (year+month+river+sal+temp) for both the binomial and lognormal components. Models were fitted with and without 2016 data due to gear change and no calibration coefficients. Troy Tuckey (VIMS) discovered that a gear changed occurred in 1999 and indications thus far are that there is not catchability differences for YOY striped bass, but potential changes for menhaden have not been evaluated.

VIMS Juvenile Fish Trawl Survey

Age0 index: Models that predicted catch as a linear function of year, river system and either bottom salinity, bottom temperature, depth, or dissolved oxygen were compared using AIC. The model that included year and depth was selected because it produced the lowest AIC and no convergence problems (% deviance = 36). The model is unchanged from the most recent benchmark assessment and updated through 2016.

Adult index: A full model that predicted catch as a linear function of year, river system, bottom salinity, bottom temperature, depth, or dissolved oxygen was compared with nested submodels using AIC. The model with year, river system, bottom salinity, bottom temperature, and depth selected because it produced the lowest AIC (% deviance=18). The model is unchanged from the most recent benchmark assessment and updated through 2016.

South Carolina Electrofishing Survey

Age0 index: A full ZINB model that predicted catch as a function of the categorical variables year, month, tidal stage, and stratum, and the continuous variables depth, salinity duration, and water temperature was compared with nested submodels using AIC. In both the 2015 benchmark assessment and the 2017 update, a reduced model that removed the covariates month, tidal stage, depth, duration and water temperature from the negative binomial count sub-model and the covariates depth duration and water temperature from the binomial sub-model was selected because it produced the lowest AIC.

Georgia Ecological Monitoring Trawl Survey

Age0 index: A full model that predicted catch as a linear function of year, surface salinity, tow duration, depth, and sea surface temperature was compared with nested submodels. The submodel that included year, tow duration, temperature, and salinity was selected because it produced the lowest AIC. The model was unchanged from the latest benchmark assessment and updated through 2016.

Adult index: A full model that predicted catch as a linear function of year, surface salinity, tow duration, depth, and sea surface temperature was compared with nested submodels. The submodel that included year, temperature, salinity, tow duration, and depth was selected because it produced the lowest AIC. For the 2015 benchmark assessment, year, temperature, and salinity was selected so the model is slightly changed for the update.

SEAMAP-SA Coastal Trawl Survey

Adult index: A full ZINB that predicted catch as a function of the categorical variables year, season, and strata and continuous variables water temperature and salinity was compared with nested submodels using AIC. A reduced model that removed the covariate salinity from the count model of the ZINB was selected because it produced the lowest AIC. The model is unchanged from the most recent benchmark assessment and updated through 2016.

Atlantic States Marine Fisheries Commission

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MEMORANDUM

TO: Atlantic Menhaden Management Board

FROM: Biological Ecological Reference Points Workgroup

DATE: July 14, 2017

SUBJECT: Review of Hilborn et al. 2017

At its May meeting, the Atlantic Menhaden Management Board tasked the Biological Ecological Reference Points Workgroup (WG) to review Hilborn et al. (2017). The WG contacted Dr. Hilborn, who agreed to present the main conclusions of his research and examples from other research that supported those conclusions. The WG developed a list of questions that were distributed to Dr. Hilborn prior to the call to help guide the discussion. After the discussion the WG concluded:

1. The overarching conclusion of Hilborn et al. (2017) is that modeling of the impacts of fishing on forage fish needs to be approached on a case-by-case basis. Management must recognize the high natural variability of forage fish populations and the adaptation of predators to that variability. Predators that focus on young, immature fish may not be affected by fishing pressure on their forage species, since forage species production is heavily influenced by environmental conditions. However, predators with a different size preference may compete with the fishery for suitable size prey. Flexible prey preferences and size selectivity by the predators, fishery size selectivity, environmental effects on recruitment strength etc. are all factors that need to be considered when models are built for each specific system. Trophic models such as Ecopath-with-Ecosim (EwE) often do not incorporate these factors and can overestimate the effect of fishing on forage fish on predators. The general conclusions of this paper are consistent with the previous conclusions of the WG in that ecosystem models should be built specific to the system of interest (see Memo M15-30).
2. Models of Intermediate Complexity for Ecosystem assessments (MICE) were recommended by Dr. Hilborn for most systems. These models are built specifically to address the main management questions that are under consideration and are useful for addressing the impacts of fishing on predator-prey dynamics.
3. The 2015 Atlantic Menhaden Peer Review Workshop Report also recommends that ecosystem reference points be developed through the use of “minimum sufficient complexity” models (similar to MICE) that couple Atlantic menhaden dynamics with that of their main predators.
4. The WG is currently developing of a suite of intermediate complexity menhaden-specific models that align with the general recommendations from both Dr. Hilborn and the 2015 Stock Assessment Peer Review Panel. The WG anticipates that these models will be ready for peer review in 2019.
5. Both Hilborn et al. (2017) and Pikitch et al. (2012) agree that specific ecosystem models are preferred. However, the difference between the two lies in what reference points to use in the interim while ecosystem-specific models are in production. Pikitch et al. (2012) recommends the use of default generic reference points based on an expectation of a negative response in predator populations caused by forage fisheries. In contrast, Hilborn et al. (2017) finds very little evidence that fishing on forage fish affects the population growth rate of predators, even

predators for which a large fraction of their diet is comprised of the forage species in question (i.e., 'dependent' predators).

6. The WG notes that they have encountered problems in translating the EwE-derived generalizations into single-species equivalents that place emphasis on maintaining a portion of total biomass rather than spawning potential. See the conclusions section of Memo M17-74 for further details.
7. Overall, the selection of reference points is highly dependent on the management goals and objectives that are determined by the preferred tradeoffs of a specific ecosystem.

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Hilborn R., Amoroso, R.O., Bogazzi, E., Jensen, O.P., Parma, A.M., Szuwalski, C. and Walters C.J. 2017. When does fishing forage species affect their predators? Fisheries Research 191, 211-221.

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When does fishing forage species affect their predators?

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Ecopath

ABSTRACT

This paper explores the impact of fishing low trophic level "forage" species on higher trophic level marine predators including other fish, birds and marine mammals. We show that existing analyses using trophic models have generally ignored a number of important factors including (1) the high level of natural variability of forage fish, (2) the weak relationship between forage fish spawning stock size and recruitment and the role of environmental productivity regimes, (3) the size distribution of forage fish, their predators and subsequent size selective predation (4) the changes in spatial distribution of the forage fish as it influences the reproductive success of predators. We show that taking account of these factors generally tends to make the impact of fishing forage fish on their predators less than estimated from trophic models. We also explore the empirical relationship between forage fish abundance and predator abundance for a range of U.S. fisheries and show that there is little evidence for a strong connection between forage fish abundance and the rate of change in the abundance of their predators. We suggest that any evaluation of harvest policies for forage fish needs to include these issues, and that models tailored for individual species and ecosystems are needed to guide fisheries management policy.

1. Introduction

There has been considerable interest in recent years on the impact of fishing low trophic level fishes, commonly called "forage fish", on the higher trophic level fishes, marine birds and marine mammals (Cury et al., 2011; Pikitch et al., 2012; Smith et al., 2011). For our purposes we consider forage fish to be the major small pelagic fishes and squid, but the juveniles of many species are also an important part of the diet of many predators. There is good evidence and theory to suggest that (1) fishing reduces the abundance of targeted fish stocks, and (2) reproductive success of predators is affected by the local density of their prey. The logic seems clear, lower fishing pressure results in more forage fish in the ocean, and thus better reproductive success and higher abundance of the higher trophic level predators. Pikitch et al. and Smith et al. used ecosystem models to quantitatively evaluate the impact of fishing forage fish on their predators, and both papers suggested that forage fish should be harvested at rates lower than would provide long term maximum yield of the forage fish.

Although it would therefore seem obvious that fishing forage fish would have a negative effect on the abundance of their predators, the empirical relationships between forage fish abundance and predator abundance, or population rates of change, have not been examined in a systematic way. There is evidence in the literature (Cury et al., 2011) showing changes in reproductive success in relation to local food abundance, but the assumed link between the changes in total population size of predators and the total forage fish abundance has not been evaluated against historical trends in abundance. Another way to explore the impact of fishing forage fish is to examine the population trends in a dependent predator. Given that most forage fish in the U.S. have been harvested more heavily in the past than they are at present, if predator populations increased under past fishing pressure on forage species, then fishing at those levels did not preclude the ability of the predators to increase. For many reasons, the predators of most concern should be those others that have been decreasing in abundance over recent decades.

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Most forage fish are well documented to undergo substantial fluctuations in abundance unrelated to fishing (Schwartzlose et al., 1999), a feature that is ignored in the ecosystem models used to evaluate ecological impacts of fishing which were mentioned above. This was recognized as a deficiency by the authors of the Pikitch et al. paper. "Major fluctuations in forage fish abundance have been observed and recorded for centuries. Forage fish can respond dramatically to shifts in oceanic conditions and may exhibit strong decadal-scale variability. Forage fish may be capable of responding quickly to favorable environmental conditions, but their populations cannot be expected to maintain a steady state and can plummet when conditions become unfavorable" (Pikitch et al., 2012, page 84).

Such fluctuations can range over three orders of magnitude. Vert-pre et al. (2013) showed that for about 50% of fish stocks, there were major changes in the productivity of the stocks unrelated to fish stock size. Given great natural variability in abundance of forage fish, a key question is how much does fishing impact abundance relative to the natural fluctuations?

The commonly accepted assumption that higher spawning stock sizes lead (in expectation) to higher recruitment (Myers and Barrowman, 1996; Myers et al., 1994) is implicit in EwE models that do not break taxonomic groups into size or age groups, and explicit in ATLANTIS models and EwE models that do break a group into stages. The assumption that increasing spawning stock size will lead to higher recruitment has been challenged first by Gilbert (1997) then by Szuwalski et al. (2014) who showed that most stocks do not exhibit a stock recruit relationship and of those that do, a large fraction of them have shifts in average recruitment over time. Myers et al. (1999) estimated that forage fish show clear relationships between spawning stock abundance and recruitment, but low spawning stock and low recruitment can be explained equally well by low recruitment generating low spawning stock (Szuwalski et al., 2014). If abundance of forage fish and their recruitment are primarily environmentally driven, then the impact of fishing on the food supply of higher trophic level predators is mainly through depletion of prey cohorts by fishing, not by reduced recruitment.

In addition to the assumption of a direct link between spawning stock and recruitment, the EwE models used to evaluate the impacts of fishing forage fish have a direct link between forage fish abundance, predator consumption and predator abundance implicit in the dynamics. However, few of these models have considered the life histories of the forage fish and their predators in enough detail to capture several key issues in the interaction between fishing on forage fish and impacts on dependent predators. None of the 11 EwE models used by Pikitch et al. considered the size or age structure of the forage fish (Essington and Plaganyi, 2013) and in five cases the modeling was not conducted at the species level, but instead grouped up to eight forage species, amongst which many may exhibit negative covariation in abundance. Indeed, two of the authors of the Pikitch et al. study subsequently questioned the use of "recycled" ecosystem models (i.e., those developed for other purposes) to understand the impacts of forage fish abundance on their predators; "We find that the depth and breadth with which predator species are represented are commonly insufficient for evaluating sensitivities of predator populations to forage fish depletion" (Essington and Plaganyi, 2013). All of the models used by Pikitch et al. were such recycled models.

A key factor determining reproductive success of many birds and marine mammals is the local density of prey within their foraging range of the breeding sites (Thaxter et al., 2012). So in addition to the variability induced by natural fluctuations in total abundance of the forage fish, the spatial availability can also vary, and two breeding colonies feeding on the same stock may see strikingly different food availability. Local density can either amplify natural variability in food supply, or the predators may be able to concentrate on high density locations even at low prey abundance, thus buffering them from the fluctuations in total abundance. Despite the importance of local forage abundance for central place foragers, there is little evidence relating abundance of forage species to the abundance of mobile predators. Jensen et al. (2012) cited several of the studies showing the importance of local abundance to central place foragers but also reviewed the empirical literature relating marine predatory fish abundance to abundance of their prey and found few clear links apart from a decline in cod productivity following the collapse of both herring and capelin in the Barents Sea (Hamre, 1994; Hjermann et al., 2004).

This brings us to another important factor in the life history of forage fish and their predators that is neglected in almost all of the EwE models. Some marine predators consume forage fish at sizes and ages before the fishery harvests them. This is most true for predatory fish and marine birds, where mouth gape sizes limit the maximum size of prey that can be eaten, and probably least true for marine mammals. As an example, Nelson et al. (2006) showed that the mean size of Atlantic menhaden (*Brevoortia tyrannus*) eaten by striped bass (*Morone saxatilis*) in Massachusetts was 8.4 cm but the mean size taken by the fishery was 28 cm. In the extreme, if the recruitment of forage fish is not affected by fishing, and the predators consume sizes smaller than taken by the fishery, then the fishery would have no impact on the food available to the predator. In other words, the fishery harvests only those individuals that have survived and grown large enough to escape most of their predators.

To summarize, the impact of fishing forage fish on dependent predators will depend on (1) the alternative prey available to the predators, (2) the impact of fishing on the recruitment of the forage fish, (3) natural variability in recruitment, (4) the relationship between abundance of the forage fish and what is actually available to the predators, (5) the overlap between sizes/ages eaten by the predators and those taken by the fishery, and (6) other factors that may limit the predator population abundance.

In this paper we explore these issues for a range of U.S. forage fish and their predators. First, we examine the relationship between forage fish abundance and predator population growth rates, then we evaluate the recruitment pattern for each forage species and evaluate the evidence regarding the relative importance of fishing and environmental influences on the recruitment. Thirdly, we compare the size/ages taken by predators to those taken by the fishery. We then model the changes in forage fish abundance as a function of different assumptions regarding the dependence of recruitment on fish stock size and environmental variability to generate scenarios of forage fish abundance as a function of fishing pressure. Finally we examine how much the abundance of forage fish in the target size range is affected by fishing.

2. Materials and methods

Eleven species of forage fish in the U.S. were selected for analysis, and for each of these species we conducted a literature review to identify: (1) what predators eat those species, (2) the importance of the forage fish species in the diet of the predator, and (3) the size range of each forage species found in the diet of the predator. The selected forage species were the Pacific sardine (*Sardinops sagax)*, Northern anchovy (*Engraulis mordax*), Market squid (*Doryteuthis opalescens*), Pacific hake (*Merluccius productus*), Pacific chub mackerel (*Scomber japonicus*), Atlantic herring (*Clupea harengus*), Atlantic menhaden, Atlantic mackerel (*Scomber scombrus*), Shortfin squid (*Illex illecebrosus*), Longfin inshore squid (*Doryteuthis pealeii*) and Gulf menhaden (*Brevoortia patronus*).

2.1. Literature search

A systematic review of the literature was conducted by querying the Academic Search and Google's online search engine for articles on prey and predators occurring in the California Current, U.S. East Coast and the Gulf of Mexico. Queries included topical keywords for diet and abundance for identified predators in the geographic range.

2.1.1. Diet

We recorded data from 127 relevant citations in peer-reviewed journal publications, books, technical reports, theses and from online databases (e.g. www.fishecology.org in September and October 2015). Data included individual occurrences of a predator eating a prey. Each record includes information on the citation, study location, date (year and season of observations), sampling methods (e.g. stomach content, visual observation), predator (life-history stage, size/age/sex, sample size) and prey (amount consumed and size eaten, usually estimated through otoliths or beak measurements).

The importance of a prey species in the diet of a predator was defined as the mean proportion of a forage fish consumed by a specific predator reported in a specific unit for measuring consumption. When more than one unit of consumption was available, the following order of preference was set: prey proportions by mass were preferred, followed by numbers, energetic contribution and finally frequency of occurrence.

2.1.2. Abundance of predators

The predators for which the importance of a single prey species was equal to or greater than 0.2 were selected as "dependent predators". We identified 86 different populations of dependent predators of which 52 are commercially important fish species or stocks, 33 are top predators (seabirds and marine mammals) and one is an invertebrate.

Abundance data for the dependent predators were obtained from several sources. For marine mammals, data were obtained primarily from the NMFS Marine Mammal Stock Assessments (Caretta et al., 2006; Waring et al., 2015). For commercially important fish species, data were obtained primarily from the RAM Legacy Stock Assessment Database (Ricard et al., 2012). Other sources of abundance data for seabirds and other species include agencies and government websites, peer-reviewed journal publications, books, technical reports and theses. Information on abundance trends were found for 50 of the 86 dependent predators species identified in this study.

An index of abundance was calculated using available data such as total and spawning stock biomass, density, estimated number of individuals, counts, pup production, nesting pairs, standardized catch per unit effort, breeding pairs and number of nests. The sources for these data are shown in supplemental Table S1.

Graphical data were extracted with DataThief III (Tummers, 2006) when original data in tabular form could not be found.

We compared the population per capita rates of change of the predators to the abundance of forage fish. For exploited species, we used the surplus production, should be there instead of; defined as the change in abundance from one year to the next, plus the catch. The relationship between forage fish abundance and predator rate of change was assessed using a linear model and the significance of the slope was tested using an F test.

2.2. Recruitment analysis

We analyzed the estimated forage fish abundance and subsequent recruitment to assess if recruitment was better explained by environmental variability or fish abundance. The spawner-recruit data were obtained from the RAM Legacy Stock Assessment Database (www.ramlegacy.org) for the forage fish of concern. Four models were fit to the data and compared using AIC: a traditional Beverton-Holt stock-recruitment model, a hockey-stick model, a model that assumes that recruitment is random and independent of stock size and a regime-shift model. In the latter, the presence of regimes was identified by estimating breakpoints in the recruitment time series where the statistical properties (mean and/or variance) change. Different segmentation algorithms exist to search over the entire parameter space for the number and location of breakpoints that maximize the likelihood of the data subject to a penalty to prevent overfitting. We used the PELT algorithm (Pruned Exact Linear Time) proposed by Killick et al. (2012) implemented in the "change point" library (Killick and Eckley, 2014) for the statistical software R (R Core Team, 2014). Differences in both the mean and the variance among segments were allowed and model selection was based on AIC while constraining the minimum segment length to either 5 or 10 years. The PELT method was preferred over the simpler sequential t-test method of Rodionov and Overland (2005) used by Vert-pre et al. (2013) because the later does not search over all possible combinations of breakpoint locations.

Stock-recruitment models (other than regime shift) were fitted using the software AD Model Builder (Fournier et al., 2012). For each model we computed the likelihood and the AIC assuming lognormal errors. The number of parameters in the regime-shift model was computed as the number of breakpoints plus the number of means and variances estimated. We excluded from the analysis the squid as well as the Northern anchovy, because the time series of abundance data available for these stocks were discontinuous.

2.3. Impacts of fisheries on prey abundance

We gathered biological and fisheries information on six species of forage fish and implemented a simulation model to quantify the reduction in food availability to predators from fishing given the size selectivity of both the fishery and the predators. An age structured model was used to simulate the effects of different fishing mortalities on fish abundance. The numbers of individuals of age a at time t were modeled as:

$$N_{a+1,t+1} = N_{a,t}\exp^{(-M+Fv_a)} \quad (1)$$

where M is the natural mortality, F the fishing mortality and v_a is an age specific selectivity. Two different scenarios of recruitment were simulated:

$$\begin{cases} N_{1,t} = R_t & \textit{Scenario 1} \\ N_{1,t} = \dfrac{aSE_{t-1}}{1+bS} & \textit{Scenario 2} \end{cases} \quad (2)$$

In Scenario 1, we assumed that recruitment was independent of the spawning biomass, while in Scenario 2 we used the standard Beverton-Holt stock-recruitment equation. Spawning stock biomass was calculated as:

$$S_t = \sum_a w_a m_a N_a \quad (3)$$

where w_a is the average weight of an individual of age a and m_a is the proportion of sexually mature individuals of age a. Weight at age was calculated as a power function of the average length

$$w_a = \alpha L_a{}^{\beta} \quad (4)$$

Length at age was modeled using the standard Von Bertalanffy growth equation.

$$L_a = L_\infty(1 - e^{(-k(a-t_0))}) \quad (5)$$

Table 1
Stock specific parameters used in the simulations. L∞ is asymptotic length, K is the Von-Bertalanffy growth rate, t0 = scale parameter of growth curve, M = instantaneous natural mortality rate, α = length to weight scale parameter, β = length to weight power.

Stock Parameters	Atlantic Herring	Atlantic Menhaden	Gulf Menhaden	Pacific Chub Mackerel	Pacific Hake	Pacific Sardine
L∞ (cm)	32	36.5	26.25	39.2	52	23.7
K	0.36	0.363	0.39	0.39	0.32	0.318
t0 (years)	−1.17	−1.3	−0.99	−2	0	−2.01
M	0.52	0.45	1.1	0.5	0.213	0.4
α (×10^{-6})	8.21	4.07	7.41	2.7	5	7.52
B	3	3.2	3.19	3.4	3	3.2332
Maturity at age	1 = 0; 2 = 0.01; 3 = 0.21; 4 = 0.81; 5 = 0.98; 6+ = 1	<2 = 0; 2 = 0.12; 3 = 0.85; 4+ = 1	<2=0; 2 + = 1	0 = 0; 1 = 0.48; 2 = 0.63; 3 = 0.76; 4 = 0.85; 5–6 = 0.91; 7+ = 1	1 = 0; 2 = 0.01; 3 = 0.21; 4 = 0.82; 5 = 0.98; 6+ = 1	1 = 0; 2 = 0.99; 2+ = 1
Selectivity at age	1 = 0; 2 = 0.18; 3 = 0.54; 4 = 0.7; 5+ = 1	<2=0; 2 = 0.1; 3–4 = 1; 5 = 0.19; 6 + = 0	1 = 0.05; 2 = 1; 3–4 = 0.35; 5 + = 0	0 = 0.5; 1 + = 1	1 = 0.07; 2 = 0.18; 3 = 0.37; 4 = 0.62; 5 = 0.81; 6 = 0.92; 7 = 0.97; 8+ = 1	1 = 0.18; 2 = 0.37; 3 = 0.62; 4 = 0.81; 5 = 0.92; 6 + = 1

A global food depletion estimate can be calculated by comparing the equilibrium biomass for a given F with the equilibrium biomass in the unfished state. However, as predators may select prey by size, we are interested in assessing the food depletion for different prey's length intervals. We generated a length composition of the population by assuming that the size of individuals within an age class is normally distributed with mean L_a and standard deviation σ_a. For simulation purposes we assumed a constant coefficient of variation in size-at-age of 20%. We calculated the numbers of individuals (Eq. (6)) and the biomass (Eq. (7)) in the size interval $l_1 - l_2$ as:

$$N_{l_1-l_2} = \sum_a N_{a,l_1-l_2} \quad (6)$$

$$B_{l_1-l_2} = \sum_a w_a N_{a,l_1-l_2} \quad (7)$$

For each fish stock we ran the model for 5000 years under different fishing mortalities and randomly sampled 500 iterations to assess the reduction in the food available to predators. Under Scenario 1, the model was forced using the historical recruitment estimated in stock assessments in order to account for natural variability (we sequentially repeated the recruitment time series to achieve 5000 observations). To perform the simulation under the assumption of a stock recruitment relationship (Scenario 2) we used the spawner-recruit curve best fit to the stock assessment data. To account for natural variability, we calculated the log residuals and used them as multiplicative errors. Similar to Scenario 1, we sequentially repeated the observed errors to achieve 5000 observations.

Our simulations are a simplification of the stock dynamics, since key parameters such as selectivity, growth and natural mortality can be time, size or density dependent. For each fish stock we gathered mortality, growth, maturity, vulnerability to fishing and weight-at-length parameters from stock assessment documents. We ran the simulations for only one fishery for a given stock; when more than one fishery targeted that stock, we used the vulnerability to the fishery that accounted for the largest fraction of the catch.

We calculated the biomass depletion for four size ranges, (small, small-medium, medium-large and large fish) set at the quartiles of the length frequency distribution in the unfished state. We explored the impacts of fishing under $F = 0$, 0.5 F_{MSY}, and F_{MSY}. When possible, the value of F_{MSY} was calculated using the stock-recruitment, maturity and growth parameters used in the simulations. For stocks where the stock-recruitment relationship was a flat line, the calculation of F_{MSY} was unreliable, and instead we used the value estimated as part of the stock assessment which was often a proxy. For each F, we computed the median biomass compared to median biomass in the unfished state. Parameters used in the simulations are summarized in Table 1.

3. Results

3.1. Diet data compilation

The literature review yielded 1041 predator-prey pairs that contained information on predators' diet (size eaten and/or proportion of the prey in the diet). For a given predator and prey species, the database can contain several records, since we included an individual entry for the same pair of species if data were obtained in different locations and/or different years or when the data were recorded for different sexes or stages in the life cycle. These records corresponded to 119 species of predators and 11 species of prey, and included multiple years of data for the same species in one location as well as data for one species from different regions. The number of individual predator species identified for each forage fish ranged from five for the Gulf menhaden to 46 for the Northern anchovy.

We identified 203 prey-predator pairs where the mean proportion of a prey item in the diet in a given location was larger than 0.2 (Table S1).

3.2. Empirical relationships between predator and prey trends

Trends in abundance of both predator and prey covering overlapping periods were available for 50 predator-prey pairs out of the 203 pairs where the proportion of a specific forage fish in the diet was larger than 0.2. When multiple abundance time series were available we selected the longest one that did not present gaps in the data. Trends in abundance of most dependent predators were either growing, stable, or fluctuating between periods of high and low abundance (Figs. 1 and S1). Six cases showed a clear decreasing trend in the predator's abundance index over time: Atlantic cod (*Gadus morhua*) in Georges Bank, sablefish (*Anoplopoma fimbria*) on the Pacific coast, mako shark (*Isurus oxyrinchus*), silky shark (*Carcharhinus falciformis*) and spiny dogfish (*Squalus acanthias*) in the N.W. Atlantic, and yellowtail rockfish (*Sebastes flavidus*) on the Pacific coast. No obvious relationship between the prey and predator abundance was apparent in the majority of the cases (Fig. 1 insets).

Although a positive relationship between prey and predator abundance can be interpreted as evidence of trophic dependence, a better way to assess the role of prey abundance in the population dynamics of the predator is to analyze the predator population rate of change or surplus production against the abundance of the

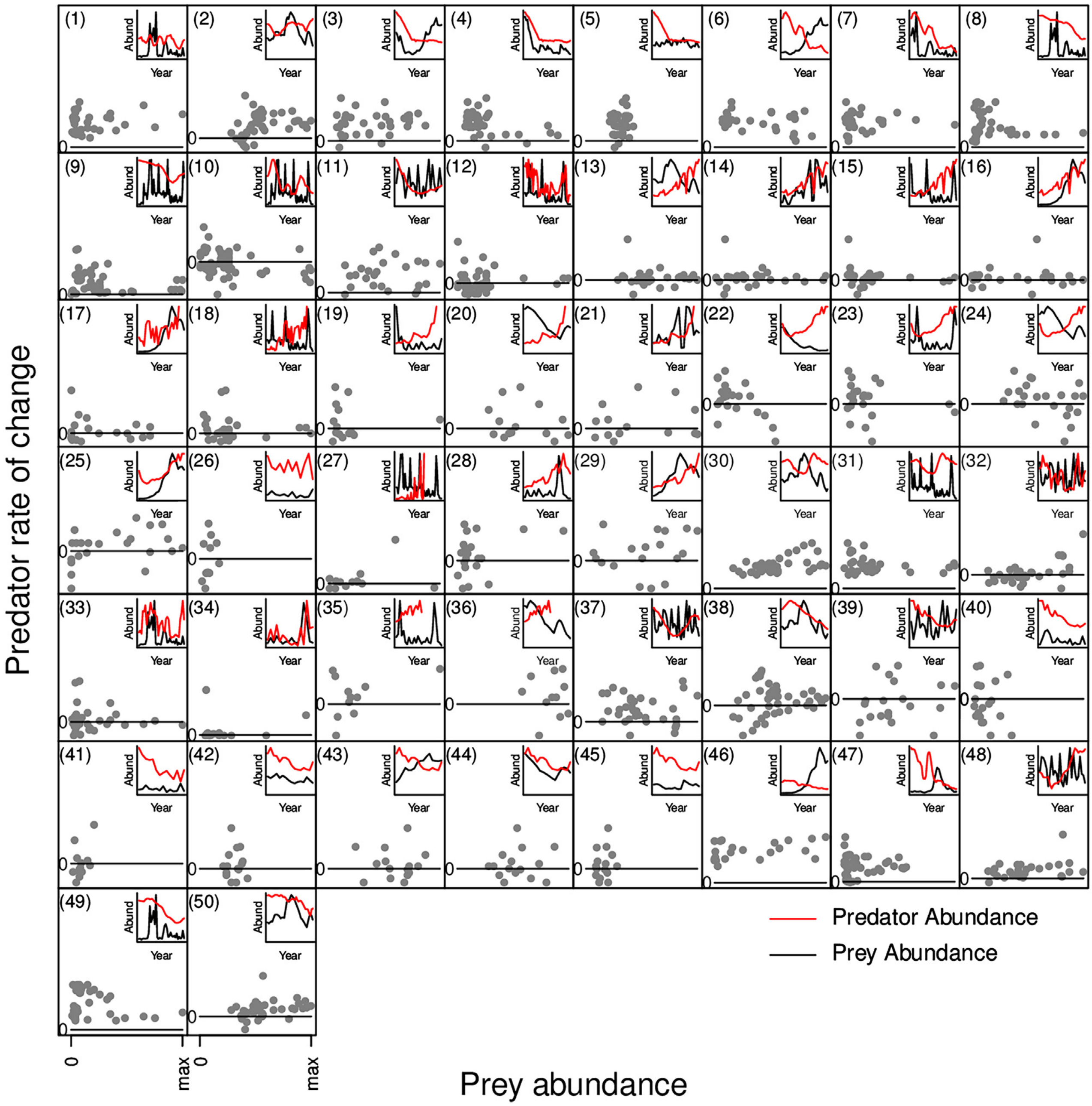

Fig. 1. Relationship between the annual surplus production of the predators and prey abundance. Each panel shows a pair of temporally overlapping predator rate of change and prey abundance data (grey dots). The subplot in each panel shows the relative trend in the abundance index for the prey (black line) and the predator (red line). (1) albacore tuna and shortfin squid; (2) arrowtooth flounder and Pacific hake; (3) Atlantic bluefin tuna and Atlantic herring; (4) Atlantic bluefin tuna and Atlantic mackerel; (5) Atlantic bluefin tuna and Atlantic menhaden; (6) Atlantic cod and Atlantic herring; (7) Atlantic cod and shortfin squid; (8) bigeye tuna and shortfin squid; (9) black rockfish and Northern anchovy; (10) bluefin tuna and Northern anchovy; (11) bluefish and longfin inshore squid; (12) Brandt's cormorant and Northern anchovy; (13) California sea lion and Pacific hake; (14) California sea lion and market squid; (15) California sea lion and Northern anchovy; (16) California sea lion and Pacific sardine; (17) California brown pelican and Pacific sardine (18) California brown pelican and Northern anchovy; (19) common murre and Northern anchovy; (20) common murre and Pacific hake; (21) common murre and market squid; (22) thresher shark and Pacific chub mackerel; (23) thresher shark and Northern anchovy; (24) thresher shark and Pacific hake; (25) thresher shark and Pacific sardine; (26) dolphinfish and shortfin squid; (27) elegant tern (chicks) and Northern anchovy; (28) humpback whale and Northern anchovy; (29) humpback whale and Pacific sardine; (30) North Pacific albacore and Pacific hake; (31) North Pacific albacore and Northern anchovy; (32) offshore hake (mid Atlantic bight) and longfin inshore squid; (33) offshore hake (mid Atlantic bight) and shortfin squid; (34) Pacific bonito and Northern anchovy; (35) Pacific harbor seal and Northern anchovy; (36) Pacific harbor seal and Pacific hake; (37) Gulf of Maine pollock and longfin inshore squid; (38) sablefish and Pacific hake; (39) shortfin mako shark and longfin inshore squid; (40) shortfin mako shark and shortfin squid; (41) silky shark and shortfin squid; (42) spiny dogfish and Atlantic menhaden; (43) spiny dogfish and Atlantic herring; (44) spiny dogfish and Pacific hake; (45) spiny dogfish and Atlantic mackerel; (46) striped marlin and Pacific sardine; (47) striped marlin and Pacific chub mackerel; (48) summer flounder and longfin inshore squid; (49) swordfish and shortfin squid; (50) yellowtail rockfish and Pacific hake.

prey. The data set showed almost no evidence of a strong positive relationship between the predator surplus production and the prey abundance (Fig. 1). While in half of the cases the slope estimates were positive, in only four cases did we find a statistically significant positive relationships between predator and prey abundance (Fig. S2) (with no correction for multiple comparisons): arrowtooth flounder (*Atheresthes stomias*) and Pacific hake (Figure 1.2), yellowtail rockfish and Pacific hake (Figure 1.50), North Pacific

Table 2
Summary table for the regime shift (shifts), random, Beverton-Holt and hockey-stick stock recruitment (SR) models. We recognize that this violates the independence assumption of the AIC, but believe it is indicative of relative strength of evidence for competing hypotheses. N is number of years in the time series and Corr is the coefficient of auto-correlation of the logarithm of recruitment. N shifts = number of estimated breakpoints.

Species	Area	N	Corr	N shifts	AIC Shifts	AIC BH	AIC Hockey	AIC Random	Winner
Pacific chub mackerel	California Current	79	0.66	6	166	201	206	239	Shift
Atlantic herring	US East Coast	37	0.34	2	76	81	81	85	Shift
Gulf menhaden	Gulf of Mexico	35	0.06	1	20	22	22	20	Random
Atlantic menhaden	US East Coast	51	0.50	3	63	83	91	89	Shift
Pacific hake	California Current	47	−0.29	1	166	168	168	166	Random
Pacific sardine	California Current	27	0.84	2	85	63	62	112	Hockey
Atlantic mackerel	US East Coast	47	0.52	2	143	129	129	155	BH/Hockey

albacore (*Thunnus alalunga*) and Pacific hake (Figure 1.30), and offshore hake (*Merluccius albidus*) (mid Atlantic bight) and longfin inshore squid (*Doryteuthis pealeii*) (Figure 1.32). The percent variance explained in these four cases ranged from 10% to 34%. The 95% confidence bounds on the estimated slope (y and x axes in units of standard deviation) were often wide, with upper bounds exceeding a value of 0.5 in close to half of the cases.

3.3. Recruitment analysis

For the seven species assessed, the stock-recruitment models outperformed the regime shift and the random models in two cases: Pacific sardine and Atlantic herring (Table 2). For the other five species the regime-shift or the random model had lower values of AIC. This result was independent of the minimum segment length specified for the changepoint analysis (shorter segment lengths yielded larger number of breakpoints, but the general result remained the same).

The hockey-stick and the Beverton-Holt models performed similarly when fit to the stock-recruitment data. Only in three cases – Pacific chub mackerel, Atlantic herring and Pacific sardine – was a breakpoint estimated by the hockey-stick model, indicating a decrease in recruitment below a given stock size. The breakpoint was estimated respectively at 17%, 19% and 13% of the maximum value of spawning biomass in the series. For Atlantic mackerel, a linear decrease in recruitment over the entire time series was favored with no identifiable breakpoint. The species for which evidence of decreased recruitment at lower spawning stock size was strongest also showed a highly auto-correlated recruitment (Table 2). By contrast, no evidence of a decrease in recruitment at low stock abundance was observed for the two menhaden stocks and for Pacific hake. Pacific hake and Gulf menhaden both had the lowest AIC for the random model while a regime-shift model was favored for Atlantic menhaden. Pacific chub mackerel and Atlantic herring also had the lowest AIC for the regime-shift model.

Pacific chub mackerel, Atlantic mackerel and Pacific sardine do show significantly lower recruitment at lower spawning stock size. However, each of those species shows highly auto-correlated recruitments that are consistent with environmentally driven regime changes and the apparent spawner recruit relationship may in fact simply be that periods of low recruitment lead to periods of low spawning stock size.

3.4. Simulated impacts of fisheries on prey abundance

For the six examples considered, the simulations conducted assuming recruitment is independent of spawning stock (Scenario 1) suggest that the abundance of small and small-medium size fish is unaffected by fishing (Fig. 2) and even in the absence of fishing the abundance of all sizes fluctuates greatly. Typically, the small sizes tend not to be caught in the corresponding fisheries (Fig. 3). In contrast, the abundance of large fish can be substantially reduced when F is set at F_{MSY}. When a stock-recruitment relationship is assumed (Scenario 2), in most cases a reduction in fish abundance was observed for all size ranges, the magnitude of which increased with fishing pressure.

Additionally, variability was reduced as fishing pressure increased. The two exceptions were Pacific hake and Gulf menhaden (Fig. 2). For these two species, the fit of the Beverton-Holt curve was flat in the range of observed abundances, which is similar to the assumption that recruitment is independent of stock size (Fig. 4). The fishery simulated for Gulf menhaden targeted almost exclusively individuals of age 2 (approximately 15 cm, Fig. 3), while the population was mainly composed of 0+ (small) and 1+ (small-medium) fish. This is most likely the main reason why abundance of fish does not respond to fishing pressure for this stock. In the case of Pacific hake, a substantial fishing impact was observed only for medium-large and large fish, which corresponds to the sizes selected by the fishery.

These results emphasize the relevance of the size composition of the diet when the fishing effects on predators are assessed. Unfortunately, data on the size compositions of diets are scarce. We could only find 74 records of size of forage fish prey (Fig. 3). While some predators selectively eat small fish (usually not selected by the fishery), others prey on a large range of forage fish sizes. The degree of overlap between fisheries and predators is highly variable. For example, most predators foraging on market squid and Pacific hake do not seem to be in direct competition with fisheries. On the other hand, Pacific chub mackerel, Pacific sardine and Atlantic herring fisheries seem to overlap with predator's preferred prey sizes.

4. Discussion

4.1. Trends in predator populations and growth rates of predators vs prey

For the populations studied, we found little evidence that the abundance of individual species of forage fish was positively related to the per capita rate of change in their predator populations. Of the 50 comparisons, we found five that had a significantly positive relationship between prey abundance and predator rate of change The fact that only four of the time series of predator abundance showed a downward trend also provides some evidence that historical fishing practices on forage prey species have not led to major predator decreases.

Given the very large range of abundance fluctuations seen in many of the forage fish populations, it is surprising that a relationship between forage fish abundance and predator rate of change does not emerge. The most obvious explanation would be diet flexibility. If the predators can switch between alternative prey, then the fluctuations in any individual forage species may be well buffered by the predator switching to other forage species. We also explored various time lags between prey abundance and predator rate of change, and did not find higher rates of correlation. We did not look at the abundance of forage species in aggregate in our one species at a time comparison.

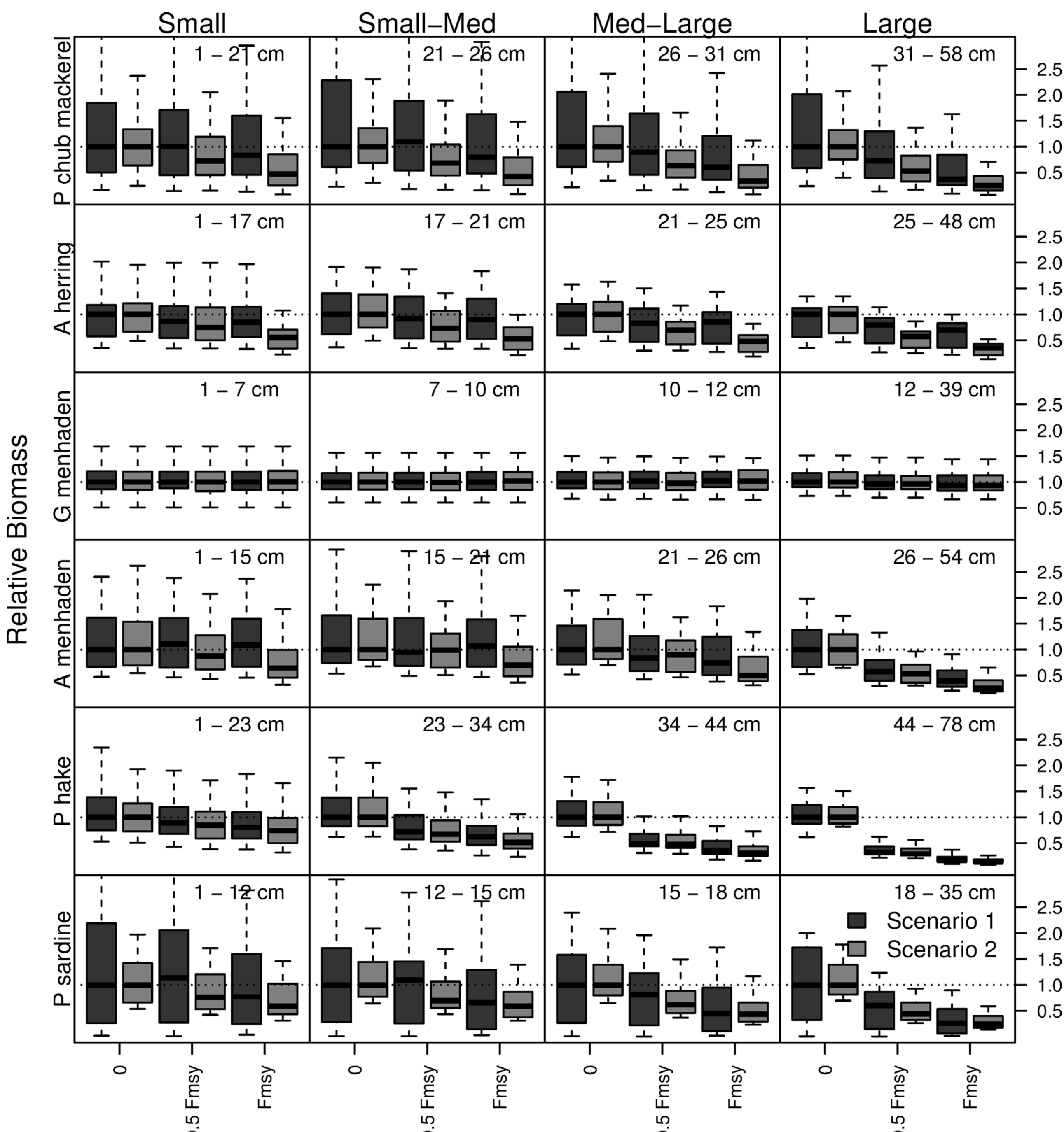

Fig. 2. Change in prey abundance predicted by the simulation model for six forage fish species in different size ranges. Scenario 1: recruitment independent of stock size; Scenario 2: Beverton-Holt stock recruitment relationship.

4.2. Recruitment analysis

If we simply look at the spawner-recruit data for the forage species examined we see little evidence that smaller spawning stocks produce smaller recruitments for both Atlantic and Gulf menhaden, and Pacific hake. Good year classes seem to come from both large and small spawning stock sizes. Pacific chub mackerel, Atlantic mackerel and Pacific sardine do show significantly lower recruitment at lower spawning stock size. However, each of those species shows highly auto-correlated recruitments that are consistent with environmentally driven regime changes and the apparent spawner recruit relationship may in fact simply be that periods of low environmental suitability result in long periods of low recruitment leading to low spawning stock. The relatively short life span of forage fish and several shifts from high to low productivity over the recruitment time series enhances this effect.

We have used statistical tests with changepoint analysis to try to quantify the support for regime changes vs stock-recruitment relationships and for each of these three species (Pacific chub mackerel, Atlantic herring and Atlantic Menhaden) the AIC analysis supports a regime change. This approach is only exploratory and does not provide a reliable basis for choosing a single operating model. Rather, the policy implications of alternative hypotheses should be evaluated within a management-strategy-evaluation framework and understanding the changes in recruitment is essential before evaluating alternative harvest strategies. However, we would argue

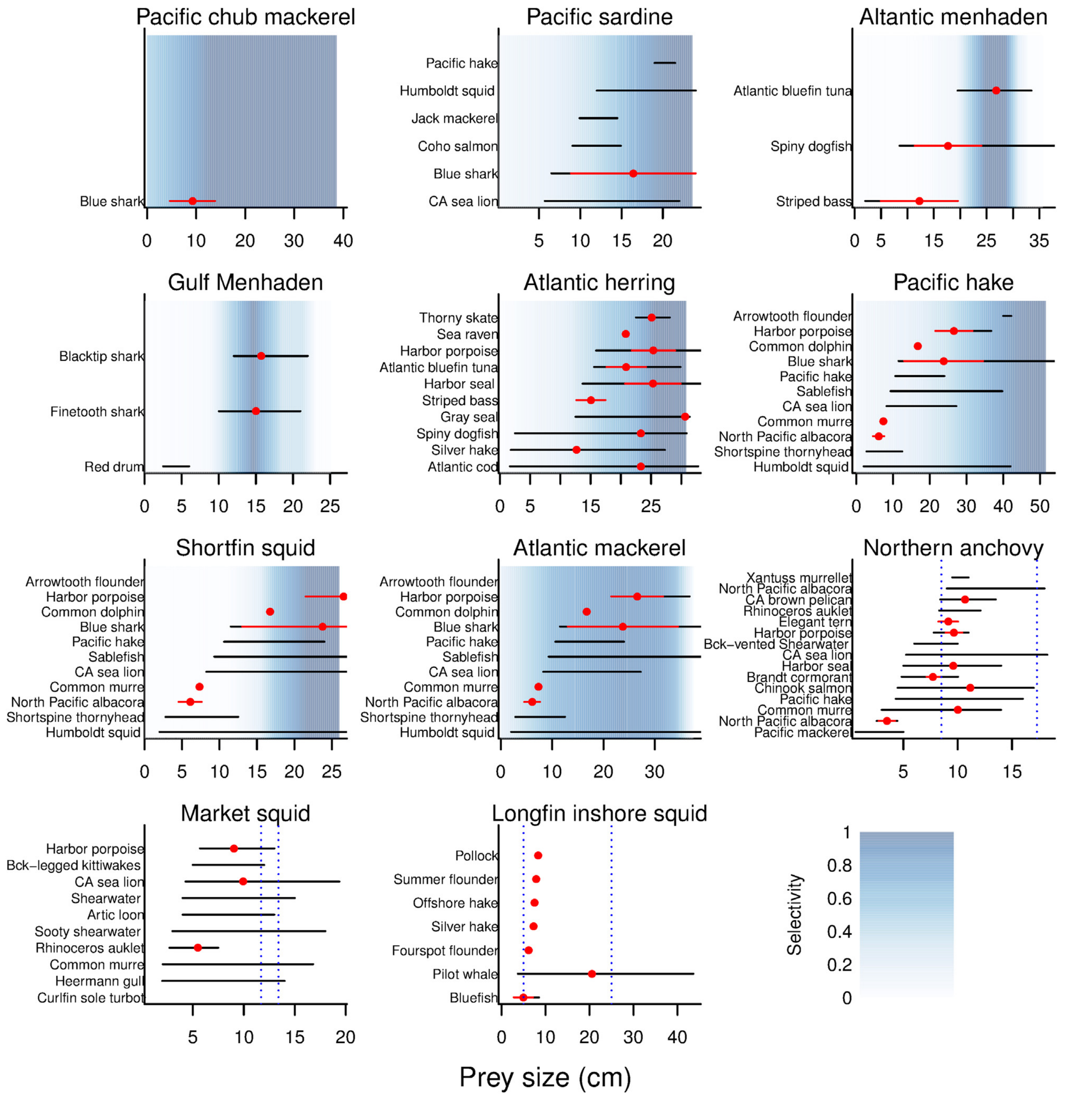

Fig. 3. Prey size consumed by different predators. Black lines indicate the range of sizes eaten. The red dots indicate the mean size of the prey, and the red line the standard deviation. The shading in the background indicates how fishery selectivity changes with fish length. When no estimates of fishery selectivity were found the dotted blue lines indicate the size range of the commercial catch.

that there is strong evidence that recruitments are largely independent of fishing pressure as has been widely accepted for Pacific sardine (Punt et al., 2016) and suggested for many other species globally (Szuwalski and Hilborn, 2015). It is of course not credible that recruitment is independent of stock size for all stock sizes (no eggs, no recruits). We assert only that the range of spawning stock sizes is often not wide enough within regimes to see any effect. It should be noted that within-regime stock-recruitment analysis is subject to strong time series bias, with over-representation of high recruitments at low stock size and low recruitments at high stock size (Walters, 1985) leading to overestimation of the initial stock-recruitment slope and reduced apparent dependence of recruitment on spawning stock size.

4.3. Impacts of fisheries on prey abundance

We found that small size classes are largely unaffected by fishing when the recruitments are simulated at historical levels assuming no impact of spawning stock, and that many, but not all of the predators rely on the smaller sized fish not targeted by fisheries. If we assume a spawner recruit model, then recruitment at F_{MSY} is reduced, so that the abundance of small size classes is also reduced. Given that for most stocks examined, a random recruitment or regime recruitment model was estimated to be best, the evidence for those stocks examined supports little impact of fishing on abundance of smaller size classes of fish. Thus one cannot generalize about the impacts of fishing on food availability to predators

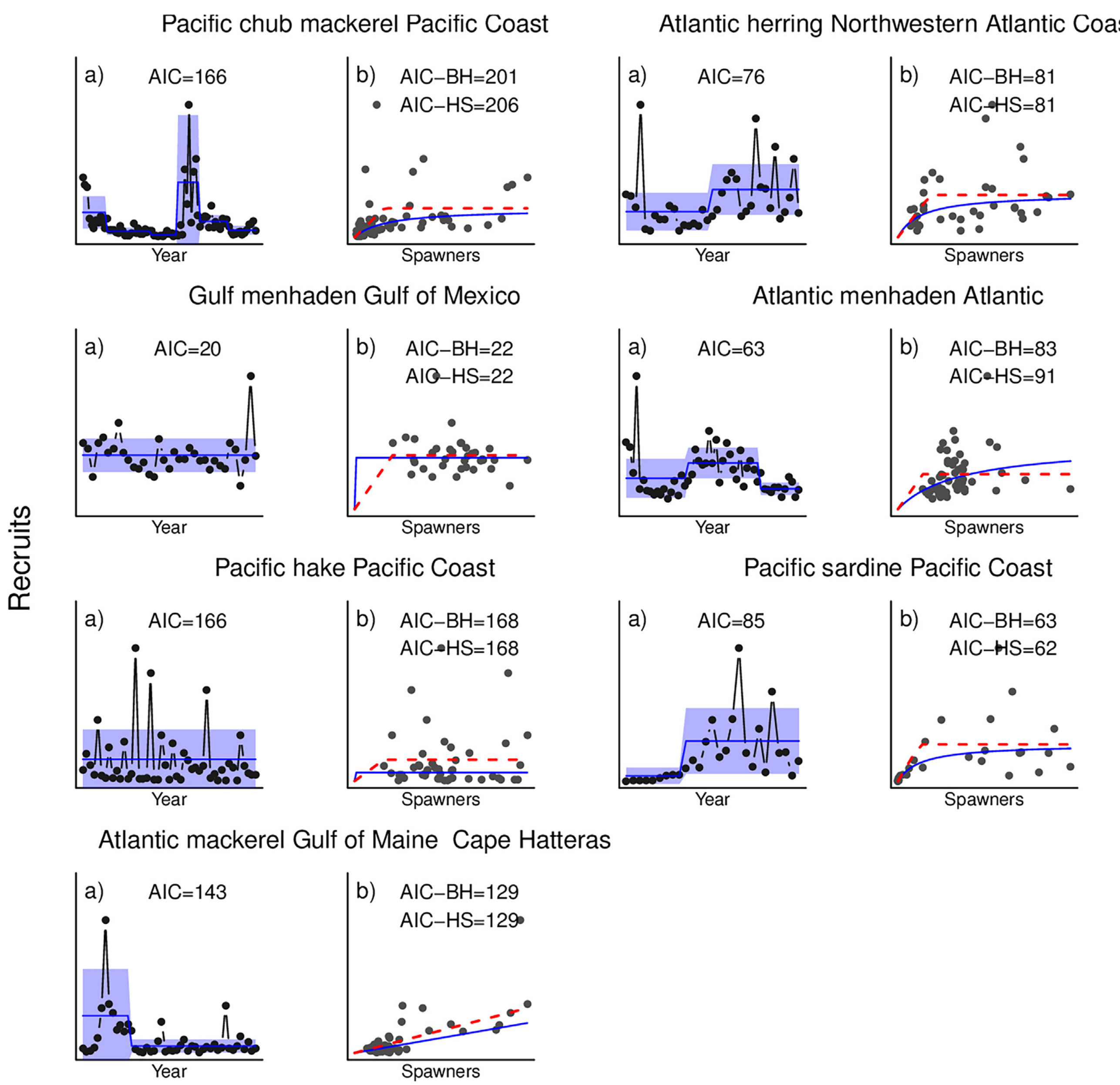

Fig. 4. Alternative models to explain recruitment variability: a regime-shift model, a Beverton-Holt stock-recruitment model and the hockey-stick model. The blue lines indicate the model maximum likelihood estimates. The purple polygons indicate the standard deviation in each regime identified by the changepoint analysis.

and each case must be examined on its own merits with respect to the impact of fishing on recruitment and the size preferences of the predators.

The diet of predators consists not only of the key species we examined here, but many other species, including juveniles of many larger species. Furthermore, the impact of fishing higher trophic level fishes has often caused forage species to be more abundant than they would be in the absence of fishing (Christensen et al., 2014; Kolding et al., 2016; Jennings and Collingridge, 2015).

4.4. Spatial distribution of forage fish

A major factor (though one which has been considered only qualitatively in this paper) is the relationship between the distribution of the forage fish, their abundance, and the location of breeding sites for dependent birds and mammals. Large fluctuations in abundance of the forage fish are accompanied by major changes in their distributional range – at high abundance the fish are found over a much larger area than at low abundance (MacCall, 1990). If there tend to be "core" areas where even at low overall abundance the forage fish can be found at high density, and these core areas are close to breeding sites of predators, predators would see far more stability in prey availability than indicated by total population size. On the other hand, if fisheries target prey hotspots or feeding areas close to breeding sites, then the impact of fishing may be larger than expected based on overall prey depletion.

This spatial dynamic is an important factor in modulating the response of pelican and sea lion abundance to fishing sardines and anchovy on the US West coast. Pelicans are more vulnerable to declines in sardine and anchovy because of a more restricted diet and more limited foraging area compared to sea lions (Punt et al., 2016). Spatial dynamics are especially important to consider when the distribution of forage fish shifts. Robinson et al. (2015) showed that decreases in the penguin population at Robben Island in South Africa were primarily due to changes in the distribution of sardines, not to the total sardine abundance.

Cury et al. (2011) showed a relationship between the abundance of key prey species and reproductive success of birds. However the index of forage fish abundance in half of the data sets they presented was not the total abundance of forage fish, but rather either local abundance measured around the nesting site, or amount of prey brought to the nest. Thus for those data sets, the relationship between total abundance of prey as influenced by fishing and reproductive success would be weaker than the relationship shown in the paper. Perhaps the best example of this is the data presented for three nesting sites for two bird species in Cook Inlet, Alaska (Piatt, 2002). Prey abundance around the nesting site was estimated by hydroacoustic surveys, and two of the sites generally showed good reproductive success associated with high prey abundance while one of the sites showed poor reproductive success and lower prey abundance. However, these results related to the same fish stock, subject to the same fishery, at all three sites.

The EwE models used in the Pikitch et al. and Smith et al. papers did not take the spatial structure of the forage fish populations into account, but instead assumed that total prey abundance, as influenced by fishing, was exactly what would determine the growth and survival of the predators. To evaluate the influence of fishing on the predators reliably, the changes in spatial distribution need to be considered. This is why both the Punt et al. (2016) and Robinson et al. (2015) papers estimate far less influence of fishing on predator populations than the simpler EwE models of Pikitch et al. and Smith et al. though some of the models used in the Smith et al. paper were ATLANTIS models that included some elements of spatial structure. Walters et al. (2016) also showed that the impact of fishing forage fish would depend greatly on how models were structured and that the conclusions of EwE models are very sensitive to model setup.

5. Conclusions

The purpose of this paper is to identify key factors that need to be included when analyzing the impacts of fishing on forage fish. We find several reasons to concur with the conclusion of Essington and Plaganyi (2013) that the models used in previous analysis were frequently inadequate for estimating impact of fishing forage species on their predators.

The most important feature that needs to be considered is the natural variability in forage fish population size. Their abundance is highly variable even in the absence of fishing, and a creditable analysis of the fishing impacts must consider how the extent of fishing-induced depletion compares with that of natural variability. As an example, Punt et al. (2016) estimated that the probability that brown pelicans would drop below 0.5 K with fishing was 5.3%, and without fishing was 4.5%. For marine fishes in general, "stochastic depletion" i.e. populations falling below 0.5 K, can be expected about 5% of the time even in the absence of fishing (Thorson et al., 2014). Models like EwE without stochasticity would suggest zero probability of such declines in the absence of fishing.

There is a need for a much more thorough analysis of the nature of recruitment trends in forage fish. That there are major environmentally-driven regime changes for many species is unarguable, but what exactly changes is unclear. It is unrealistic to assume that there is no relationship between spawning stock abundance and subsequent recruitment, so what is presumably changing with the environment is either the basic carrying capacity for forage fish, the basic productivity (recruits per spawner) or some combination of the two. The actual dynamics may not involve discrete regimes, but rather gradual changes in the spawner recruitment relationship. The harvest strategy that maximizes long-term fishery yield will depend greatly on exactly how the spawner recruit relationship is changing. If it is the carrying capacity that changes, then a constant fishing mortality rate will produce long-term yields that are very close to the theoretical optimum (Walters and Parma, 1996). If, however, it is the underlying productivity that changes, the fishing mortality rate may need to be respectively increased or decreased as productivity changes upwards or downwards.

The size distribution of both predator and prey and the size selectivity in diet need to be included in any analysis. In cases where recruitment is largely independent of spawning stock, and the predators take prey before they are fished, there is no influence of the fishery on availability of prey to predators. We identified numerous examples where this is the case (Fig. 3), but it is not universal. Some predators compete directly with the fishery for the same sizes of prey and such competition must be considered if we are to manage fisheries appropriately for both predators and prey.

We have found several examples of the importance of changes in spatial distribution of prey affecting the predators that suggest any analysis that does not consider such changes will not properly evaluate the impact of fishing forage fish on their predators. These include the South African penguin and sardine interaction and the Cook Inlet example (Piatt, 2002).

Our analysis of the relationship between predator rate of change and abundance of individual prey species suggests little evidence for strong connections. This is likely due to the many factors discussed above that mediate the link between fishing, prey abundance, spatial distribution and size, and predator population dynamics. The fact that few of the predator populations evaluated in this study have been decreasing under existing fishing policies suggests that current harvest strategies do not threaten the predators and there is no pressing need for more conservative management of forage fish. Hannesson (2013) showed that declines of Pacific sardine, Norwegian spring spawning herring, and Peruvian anchoveta had small impacts on their fish predators, although he relied on catches of the predators rather than direct measures of abundance. This is further evidence that general rules proposed by Pikitch et al. (2012) are not appropriate for all species and a case by case analysis is needed.

Pikitch et al. (2012) argued forcefully that their analysis provided general conclusions that should be broadly applied. However, relevant factors are missing from the analysis contained in their work, and this warrants re-examination of the validity and generality of their conclusions. We have illustrated how consideration of several factors which they did not consider would weaken the links between impacts of fishing forage fish on the predator populations.

Smith et al. (2011) were much more reserved in their conclusions, ending primarily with the estimate that fishing mortality rates on forage fish could be well below F_{MSY} with only a 20% decrease in catch of forage fish while having appreciable benefits to their predators. All single species population models show little decrease in yield with fishing mortality rates less than F_{MSY} and this would be true for forage fish as well. The very simple logistic growth model suggests that a fishing morality rate of 0.5 F_{MSY} would produce 75% of MSY. However, the evidence presented here suggest that reductions in fishing mortality rate would benefit predators less than argued by Pikitch et al. (2012). Most of the issues we raised in this paper apply to most of the models used by Smith et al. (2011).

It must be remembered that small pelagic fish stocks are a highly important part of the human food supply, providing not only calories and protein, but micronutrients, both through direct human consumption and the use of small pelagics as food in aquaculture. Some of the largest potential increases in capture fisheries production would be possible by fishing low trophic levels much harder than currently (Garcia et al., 2012; Kolding et al., 2016). While fishing low trophic levels harder may reduce the abundance of higher level predators, that cost should be weighed against the environmental cost of increasing food production in other ways. As Sharpless and Evans (2013) point out, fish provide food without

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substantial use of freshwater, fertilizer, antibiotics and soil erosion. Forage fish also have among the lowest carbon footprints of any form of protein production (Pelletier et al., 2011). Thus it is not clear that from a global environmental perspective that reductions in fishing mortality rates on forage fish would necessarily be precautionary.

We have used examples of predators and forage fish only from U.S. fisheries, which are widely recognized to be among the best managed in the world, and also have extensive legal protections for many higher trophic level birds and mammals. While the deficiencies we have identified in the existing models are general, the status and trends of predators and prey may be quite different in other parts of the world.

Acknowledgments

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.fishres.2017.01.008.

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Atlantic States Marine Fisheries Commission

Draft Amendment 3 to the Interstate Fishery Management Plan for Atlantic Menhaden

ASMFC Vision Statement:
Sustainably Managing Atlantic Coastal Fisheries

June 2017

Amendment 3 to the Interstate Fishery Management Plan for Atlantic Menhaden

Prepared by

Atlantic States Marine Fisheries Commission
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This is a report of the Atlantic States Marine Fisheries Commission pursuant to U.S. Department of Commerce, National Oceanic and Atmospheric Administration Award Nos. XXXXXXXXX.

The Atlantic States Marine Fisheries Commission seeks your input on Draft Amendment 3 to the Atlantic Menhaden Fishery Management Plan.

The public is encouraged to submit comments regarding this document during the public comment period. Comments must be received by **5:00 PM (EST) on XXXXX.** Regardless of when they were sent, comments received after that time will not be included in the official record. The Atlantic Menhaden Management Board will consider public comment on this document before finalizing Amendment 3.

You may submit public comment by attending a public hearing held in your state or jurisdiction or mailing, faxing, or emailing written comments to the address below. Comments can also be referred to your state's members on the Atlantic Menhaden Management Board or Atlantic Menhaden Advisory Panel; however, only comments received at a public hearing or written comments submitted to the Commission will become part of the public comment record.

Mail: Megan Ware
Atlantic States Marine Fisheries Commission
1050 N. Highland Street, Suite 200 A-N
Arlington VA. 22201

Email: comments@asmfc.org
(Subject: Amend 3)
Phone: (703) 842-0740
Fax: (703) 842-0741

If your organization is planning to release an action alert in response to Draft Amendment 3, or if you have questions, please contact Megan Ware at (703)-842-0740.

The timeline for completion of Amendment 3 is as follows:

	Oct 2016	Nov 2016 – Jan 2017	Feb 2017	Mar – July 2017	Aug 2017	Sept – Oct 2017	Nov 2017
Approval of Draft PID by Board	**X**						
Public review and comment on PID		**X**					
Board review of public comment; Board direction on what to include in Draft Amendment 3			**X**				
Preparation of Draft Amendment 3				**X**			
Review and approval of Draft Amendment 3 by Board for public comment ***Current Step***					**X**		
Public review and comment on Draft Amendment 3						**X**	
Board review of public comment on Draft Amendment 3							**X**
Review and approval of the final Amendment 3 by the Board, Policy Board and Commission							**X**

Table of Contents

1.0 INTRODUCTION

The Atlantic States Marine Fisheries Commission (ASMFC), under the authority of the Atlantic Coastal Fisheries Cooperative Management Act, is responsible for managing Atlantic menhaden (*Brevoortia tyrannus)* from Maine through Florida. ASMFC has coordinated the interstate management of Atlantic menhaden in state waters (0-3 miles) since 1981. Amendment 3 to the Interstate Fishery Management Plan for Atlantic menhaden replaces Amendment 2 (ASMFC, 2013). Management authority in the exclusive economic zone (3-200 miles from shore) lies with NOAA Fisheries.

1.1 BACKGROUND INFORMATION

At their May 2015 meeting, the Atlantic Menhaden Management Board (Board) initiated the development of Amendment 3 to the Atlantic Menhaden FMP to pursue the development of ecological reference points (ERPs) and revisit allocation methods. The Board approved the Amendment 3 Public Information Document for public comment in October 2016. Public comment was received and hearings were held between December 2016 and January 2017. At their February 2017 meeting, the Board tasked the Plan Development Team (PDT) with developing Draft Amendment 3.

1.1.1 Statement of Problem

1.1.1.1 Ecological Reference Points

Amendment 2 established single-species reference points to manage the menhaden stock. These reference points were based on maximum spawning potential (MSP) and included a measure of fishing mortality (F) and spawning stock biomass (SSB) to determine an overfishing and overfished status. Per Amendment 2, overfishing was defined by a target and threshold of $F_{30\%MSP}$ and $F_{15\%MSP}$, respectively, while an overfished stock was defined by a target and threshold of $SSB_{30\%MSP}$ and $SSB_{15\%MSP}$, respectively.

In 2015, the Board approved a new Atlantic Menhaden Benchmark Stock Assessment which updated the reference points for Atlantic menhaden in order to provide a better measure of sustainability (SEDAR, 2015). Specifically, the reference points were changed to be the maximum and median geometric mean fishing mortality rate for ages 2-4 during 1960-2012, a period deemed sustainable. Corresponding reference points based on fecundity (FEC) were also established to determine an overfished status. This method was applied to the 2017 Stock Assessment Update. Resulting reference points are an overfishing threshold and target of $F_{21\%}$ and $F_{36\%}$, respectively, and an overfished threshold and target of $FEC_{21\%}$ and $FEC_{36\%}$, respectively. As of 2016, the terminal year used in the 2017 Stock Assessment Update, the stock is not overfished and overfishing is not occurring.

An important outcome of the 2015 Stock Assessment and Peer Review Report was the high priority given to the development of ERPs for Atlantic menhaden management. Menhaden serve an important role in the marine ecosystem as they convert phytoplankton into protein and, in turn, provide a food source to a variety of species including larger fish (e.g., weakfish, striped bass, bluefish, cod), birds (e.g., bald eagles, osprey), and marine mammals (e.g., humpback whales, bottlenose dolphin). As a result, changes in the abundance of menhaden may have implications for the marine ecosystem. ERPs provide a method to assess the status of menhaden not only with regard to the sustainability of human harvest, but also with regard to their interactions with predators and the status of other prey species. This method accounts for several species' menhaden predation requirements when setting an overfished and overfishing threshold for menhaden. The benefit of this approach is that it allows fishery managers to consider the harvest of menhaden within a broad ecosystem context, which includes other fish, birds, mammals, and humans who utilize and depend on marine resources.

1.1.1.2 Allocation

Amendment 2 established a first-ever commercial total allowable catch (TAC) for Atlantic menhaden and divided this catch into commercial quotas for participating jurisdictions from Maine through Florida. The allocation formula assigns each state a percentage of the TAC based on each jurisdiction's average landings between 2009 and 2011. Since it was implemented in 2013, the quota system has maintained the annual directed harvest of menhaden below the annual coastwide TAC set by the Board.

Amendment 2 requires allocation to be revisited every three years. In reviewing menhaden allocations, the Board expressed interest in investigating different allocation methods and timeframes given concerns that the current approach may not strike a balance between gear types and regions. Specifically, some states have expressed concern that under the current allocation method, increases in the TAC result in limited benefits to small-scale fisheries. In addition, there is concern that the current allocation method does not provide a balance between the present needs of the fishery and future growth opportunities. Given the apparent geographic expansion of the stock, particularly in New England, the 2009-2011 time-period on which allocation is based may limit states who currently have minimal quota from participating in the growing fishery. Some states have also found evidence of un-reported landings during the reference period, meaning the quota system may have reduced their fisheries to a greater extent than originally intended.

1.1.2 Benefits of Implementation

Amendment 3 is designed to integrate the ecological role of menhaden into the management of the species and establish an allocation method which provides fair and equitable access to all participants in the fishery.

Amendment 3 contains a management program designed to account for the multiple roles that menhaden play, both in supporting fisheries for human use and the marine ecosystem. Issues addressed in Amendment 3 include:

1. Reference Points: How menhaden are allocated between the marine ecosystem and those that harvest menhaden for human use.

2. Allocation Method: How menhaden are allocated between those jurisdictions and fisheries which directly or indirectly harvest menhaden.
3. Allocation Timeframe: The timeframe upon which the allocation method is based.
4. Quota Transfers: How menhaden quota is moved between those stakeholders which receive an allocation.
5. Quota Rollovers: Whether unused quota can be rolled over into the subsequent fishing year.
6. Incidental Catch: How landings from non-directed and small scale fisheries are accounted for in the management of the species.
7. Episodic Events Program: Whether there is a program designed to minimize discards in the fishery when menhaden are in greater abundance than they normally occur.
8. Chesapeake Bay Reduction Fishery Cap: Whether there is a cap which limits harvest by the reduction fishery in the Chesapeake Bay, an important nursery ground for menhaden.

1.1.2.1 Ecological Benefits
Atlantic menhaden occupy an important link in the coastal marine food chain as they transfer planktonic material into animal biomass. Due to their interconnectivity with other species, menhaden help to provide top-down controls on phytoplankton and zooplankton populations while supporting a variety of predator species. These predators include important commercial and recreational species such as striped bass and weakfish, iconic birds such as osprey and bald eagles, and charismatic marine mammals such as the humpback whale. Reduced menhaden populations may impact the abundance and diversity of predator populations, particularly if other prey options are limited or not available. Given menhaden are found from Maine to Florida, the species serves an ecological role along much of the Atlantic coast. Thus, maintaining a healthy Atlantic menhaden population contributes to a balanced marine ecosystem (see *Section 1.2.1.5 Ecological Roles* for additional information).

1.1.2.2 Social/Economic Benefits
Menhaden play an important ecological role while supporting valuable and culturally significant commercial fisheries. Incorporating ecological reference points into menhaden management may provide ancillary benefits to a wide variety of coastal stakeholders who value species which depend on menhaden as a food source. Establishing quota allocation methods that provide fair and equitable access to all fishery participants may enhance social and economic benefits by increasing derived value and stabilizing economic returns. This in turn improves resilience in fishery-dependent communities along the Atlantic coast.

1.2 DESCRIPTION OF THE RESOURCE

1.2.1 Species Life History

1.2.1.1 Stock Structure and Migration
Atlantic menhaden is a euryhaline species that inhabits nearshore and inland tidal waters from Florida to Nova Scotia, Canada. Size-frequency information and tagging studies indicate that the

Atlantic menhaden resource is a single unit stock (Dryfoos et al., 1973; Nicholson, 1972; Nicholson, 1978). Recent genetic studies also support the designation of Atlantic menhaden as a single stock (Anderson, 2007; Lynch et al., 2010).

Spawning occurs principally at sea, with some activity in bays and sounds in the northern portion of its range (Judy and Lewis, 1983). Eggs hatch at sea and the larvae are transported by ocean currents (Checkley et al., 1988; Nelson et al., 1977; Quinlan et al., 1999) to estuaries where they metamorphose and grow rapidly as juveniles (Edwards, 2009). Adults stratify by size during the summer, with older and larger individuals migrating farthest, reaching Narragansett Bay by May and the Gulf of Maine by June. During November and December, most of the adult population moves south to the Virginia and North Carolina capes. Adults that remain in the south Atlantic region during spring and summer migrate further south later in the year, reaching northern Florida by fall. Schools of adult menhaden reassemble in late March or early April and migrate northward. By June the population is redistributed from Florida to Maine (Ahrenholz, 1991).

1.2.1.2 Age and Growth

During the 1950s and early 1960s, Atlantic menhaden older than age-6 were present in the spawning population; however, fish older than age-6 have been uncommon in recent years. Today, the majority of the landings are comprised of fish ages 1-4 (SEDAR, 2015).

The growth of Atlantic menhaden varies from year-to-year and occurs primarily during the warmer months (AMTC, 2006). Growth of juveniles is density-dependent (Ahrenholz et al., 1987) such that growth rates are accelerated during the first year when juvenile abundance is low and are reduced when juvenile abundance is high. Lengths of young-of-year menhaden range in size, and this variation is a function of density, timing of larval ingress, temperature, and food availability (Ahrenholz, 1991; Houde, 2011). Adult menhaden can reach a total length of up to 500 mm and a weigh over 1.5 kg (Cooper, 1965; SEDAR, 2015; Smith and O'Bier, 1996). Due to their extensive migratory range (see *Section 1.2.1.1*), larger fish of a given age are captured farther north than smaller fish of the same age (Nicholson, 1978; Reish et al., 1985). This fact complicates attempts to estimate overall growth for the entire stock from size-at-age data compiled from a single area along the coast.

1.2.1.3 Spawning and Reproduction

Some Atlantic menhaden become sexually mature during their first year, with more than 50% mature at age-2 (SEDAR, 2015). First-spawning age-3 fish have accounted for most of the stock's egg production since 1965 (Vaughan and Smith, 1988). Atlantic menhaden mature at smaller sizes at the southern end of their range (180 mm FL in the south Atlantic versus 210 mm FL in the Chesapeake Bay and 230 mm farther north) because of latitudinal differences in size-at-age and the fact that larger fish of a given age are distributed farther north than smaller fish of the same cohort (Lewis et al., 1987).

Spawning of Atlantic menhaden is thought to occur throughout the year (Higham and Nicholson, 1964); however, it varies by season and region based on migration patterns.

Spawning in the north occurs in the summer months (Judy and Lewis, 1983; Kendall and Reintjes, 1975; Lozano and Houde, 2012), spawning in the Mid-Atlantic occurs in early fall, and peak spawning in the South Atlantic Bight occurs in December (Higham and Nicholson, 1964; Judy and Lewis, 1983; Lozano and Houde, 2012). Spawning is followed by the coastward dispersion of eggs and larvae, and ingress into estuaries where juvenile development occurs (Houde et al., 2016; Lozano and Houde, 2013; Rice et al., 1999; SABRE, 1999; Warlen, 1994; Warlen et al., 2002).

Timing and location of spawning seem to be limited by temperature, usually occurring in waters warmer than 14-16°C (Stegmann et al. 1999, Light and Able, 2003), or within the 15-20°C isotherms (MDSG 2009). Hall et al. (1991) report that temperatures below 5°C or above 33°C are lethal to larvae. Based on a review of field and laboratory studies, Warlen et al. (2002) concluded that optimum temperature for hatching, larval survival, and growth is ≥16°C. Reported salinities range from ~25 to 33 (MDSG 2009), although salinity tolerances for eggs and larvae are wide ranging. Available literature has not been summarized to indicate typical or persistent locations of continental shelf spawning areas but egg concentrations have been observed near shorelines, bay mouths, inlets, and 70 to 140 km offshore (Judy and Lewis 1983; Kendall and Reintjes, 1975; Marak et al., 1962).

Recently, there has been progress in relating measures of primary productivity to recruitment and growth of young-of-year (YOY) menhaden. Research has shown there is a positive correlation between recruitment and euphotic-zone *chl-a* and integrated annual primary production in the Chesapeake Bay (Houde and Harding, 2009), suggesting that menhaden populations are controlled in part by bottom-up processes (i.e., quantity of food available). Despite these findings, additional work has found no significant correlation between YOY menhaden abundance and *chl-a* for the entire four-decade period that included times of both low and high menhaden recruitment events in Chesapeake Bay. The strong correlation between YOY menhaden abundance and *chl-a* in recent years (1989-2004) as noted above did not persist throughout the longer time series (1966-2006). On average, years with low freshwater flow and low turbidity supported higher abundances and recruitment of YOY menhaden (Houde et al., 2016; Love et al., 2006; Lynch et al., 2010). Other correlations between YOY menhaden abundance and environmental or hydrographic variables were not significant or were only marginally significant (e.g., negative correlations with total dissolved phosphorus and with abundances of zooplankton taxa favored by low salinities). These conflicting bodies of work further highlight the complexity that exists between nutrient cycling, climatic drivers, and understanding the life history traits of Atlantic menhaden.

1.2.1.4 Mortality

The Atlantic menhaden population is subject to a high natural mortality rate, particularly during the first two years of life. Estimates of natural mortality have ranged from M = 0.37 (Schaaf and Huntsman, 1972) to M= 0.52 (Dryfoos et al., 1985). Previous assessments, beginning with Ahrenholz et al. (1987), used M=0.45, whereas the 2015 Benchmark Stock Assessment used a time varying but age constant natural mortality to better account for known sources of natural mortality such as predation, pollution, habitat degradation, toxic algal blooms, and hypoxia (SEDAR, 2015).

Predation remains a large source of natural mortality for menhaden due to their high abundance in estuaries and coastal waters (Ahrenholz, 1991). Many large piscivorous sea mammals, birds, and fish are potential predators of Atlantic menhaden, including bluefish, striped bass, king mackerel, Spanish mackerel, pollock, cod, weakfish, silver hake, tunas, swordfish, bonito, tarpon, and a variety of sharks. See additional details in *Section 1.2.1.5: Ecological Roles*.

Coastal pollution, habitat degradation, and disease also threaten marine fish species such as Atlantic menhaden which spend their first year of life in estuarine waters and the rest of their life in both ocean and estuarine waters. Fish kills, due principally to low dissolved oxygen conditions, disease, and parasites are additional yet poorly understood sources of natural mortality (Burkholder et al., 1992; Blazer et al., 1999; Noga, 2000; Law, 2001; Glasgow et al., 2001; Vogelbein et al., 2001; Kiryu et al., 2002; Reimschussel et al., 2003; Burkholder et al., 2005). A variety of diseases are thought to affect menhaden survival (Stephens et al., 1980; Noga and Dykstra, 1986; Noga et al., 1988; Levine et al., 1990a; Levine et al., 1990b; Dykstra and Kane, 2000; Goshorn et al., 2004; Stine et al., 2005; Blazer et al., 2007). Menhaden are also known to induce fatal hypoxic events, where reports of such school-induced hypoxia and resulting fish kills going back to the 1800's (Oviatt et al., 1972; Smith, 1999).

1.2.1.5 Ecological Roles

Menhaden occupy an important link in the coastal marine food chain, transferring planktonic material into animal biomass. As a result, menhaden influence the conversion and exchange of energy and organic matter within the coastal ecosystem throughout their range (Lewis and Peters, 1984; Peters and Lewis, 1984; Peters and Schaaf, 1981). Studies have indicated that menhaden are a part of the diet of many species including striped bass, bluefish, weakfish, and piscivorous birds (Viverette et al. 2007). As a result, changes in the abundance and distribution of menhaden can have impacts on a variety of species given their role in the food web.

Atlantic menhaden occupy two distinct types of feeding niches during their lifetime. Phytoplankton is the major food of juvenile and young adult menhaden. The role of zooplankton in the diet becomes more important in older menhaden as gill-raker spacing on their filtering apparatus increases in size (Friedland et al., 1984; 2006). The relative importance of each food type varies with ontogeny, region, and local availability.

The role of Atlantic menhaden in systems function and community dynamics has received much attention in recent years. Spatially-explicit bioenergetics models have been used to estimate the carrying capacity of menhaden in the Chesapeake Bay as well as the reduction of habitat volume from eutrophication and hypoxia (Brandt and Mason, 2003; Luo et al., 2001). Additionally, simulation models of Narragansett Bay and the Chesapeake Bay indicate that Atlantic menhaden could have substantial effects on zooplankton and phytoplankton populations, and on nutrient dynamics (Durbin and Durbin 1975; 1998; Gottlieb 1998).

However, a study by Lynch et al. (2010) suggests that the menhaden population probably plays little role in removing nitrogen from Chesapeake Bay waters, and may actually provide additional nitrogen to Bay phytoplankton. Results suggest that YOY menhaden focus their grazing on patches of elevated phytoplankton abundance and/or supplement their diet with other sources (e.g. zooplankton and detritus) to maintain a positive nitrogen balance. As a result, the study suggests that menhaden may play a minimal role in net nitrogen removal from the Chesapeake Bay.

1.2.2 Stock Assessment Summary

Based on tagging (Dryfoos et al., 1973; Nicholson, 1978) and genetic studies (Anderson, 2007; Lynch, 2010), the Atlantic menhaden fishery is believed to be a single stock or population of fish, and is assessed as a single coastwide stock. Data used in the stock assessment includes commercial and recreational landings at-age from Maine to Florida, two fishery independent adult indices based on nine state surveys, one each for the northern and southern regions, and a juvenile abundance index (JAI) developed from state seine, trawl, and other gear surveys along the coast.

Growth is estimated using a time invariant weight-length relationship based on fishery-dependent data that is bias corrected using the methods in Schueller et al. (2014). Weight at age is estimated from overall weight-length parameters and annual lengths at age. Maturity at age is developed using maturity records from reduction fishery catches and NEAMAP survey data. A logistic regression is fit to length and maturity data in addition to using time-varying lengths at age to calculate time-varying maturity at age. Natural mortality is calculated by an age-varying, time invariant approach using the methods of Lorenzen (1996) that are scaled to tagging estimates of natural mortality. This estimate of natural mortality accounts for multiple sources of mortality including predation, pollution, habitat degradation, toxic algal blooms, and hypoxia. The assessment model is structured into “fleets-as-areas” in order to account for differences between bait and reduction fisheries in the north and south. In addition, dome shaped selectivity is used for all fishery fleets.

The Beaufort Assessment Model (BAM) is used to produce final assessment results. This is a statistical forward-projection model that has been used in previous Atlantic menhaden assessments (SEDAR, 2015).

1.2.2.1 Abundance and Structure

Annual Atlantic menhaden population size (age 0 and older at the start of the fishing season) has ranged from approximately 10 to 85 billion fish since 1955 (Figure 2). Population size averaged 45.0 billion menhaden during 1955-1959 when landings were high (averaging >600,000 mt). During the 1960’s, the menhaden stock contracted geographically, and the population averaged 14.9 billion fish. Total menhaden landings dropped to a low of 172,200 mt in 1969. In the 1970s and 1980s the menhaden population began to expand and the population size averaged 30.8 billion fish. During this time period, average landings rose to over 300,000 mt. During the 1990s, the Atlantic menhaden stock contracted again, and catches declined from

429,300 mt in 1990 to 206,000 mt in 1999. From 2000-2016, the population size averaged 16.4 billion fish and total catches have averaged about 200,000 mt per year.

The oldest menhaden age classes comprise the smallest proportion of the population (Figure 2), but this proportion has increased in recent years (SEDAR, 2015). For this reason, biomass is likely increasing at a faster rate than abundance because of the increased number of older fish at age and the associated increase in weight at age (SEDAR, 2015).

1.2.2.2 Fishing Mortality
Highly variable fishing mortalities are noted throughout the entire time series and are dependent upon fishing effort. The highest fishing mortalities for the commercial reduction fishery in the north are estimated to have occurred in the 1950s (Figure 3), whereas the highest fishing mortality rates for the commercial reduction fishery in the south are estimated to have occurred during the 1970s and 1990s (Figure 3). The highest fishing mortalities for the commercial bait fishery in the north are estimated to have occurred in the 1950s and 1990s (Figure 4), while the highest fishing mortality rates for the commercial bait fishery in the south are estimated to have occurred during the late 1990s and early 2000s (Figure 4).

In the 2015 Benchmark Stock Assessment, the Technical Committee (TC) initially recommended that the Board adopt a fishing mortality threshold based on the maximum F value at age-2 during the 1960-2012 time period and a target fishing mortality based on the median F value during this time period. However, in order to provide a more robust measure of fishing pressure under changing selectivity, it was recommended by the Peer Review panel that the geometric mean fishing mortality on ages-2 to -4 be used instead of the suggested age-2 reference points. This recommendation was accepted for use by the TC because these ages represent the fully selected fishing mortality rates depending upon the year and fishery (i.e., bait and reduction). As a result of the 2017 Stock Assessment Update, the fishing mortality reference points are F-target ($F_{36\% \, MSP}$) = 0.80 and F-threshold ($F_{21\% \, MSP}$) = 1.85.

Based on these reference points, fishing mortality has remained below the fishing mortality threshold (1.85) since the 1960s, hovered around the target (0.80) throughout most of the time-series, and was estimated to be 0.51 in 2016 (the terminal year of the assessment).

1.2.2.3 Recruitment
Age-0 recruits of Atlantic menhaden (Figure 5) were high during the late 1950s, especially the 1958 year-class. Recruitment was generally poor during the 1960s and high during the late 1970s and early 1980s. Since then, recruitment has been low with notable year classes in 2005 and 2010. The estimated number of age-0 fish in 2016 (the terminal year of the assessment) was 13.36 billion fish.

1.2.2.4 Spawning Stock Biomass (Fecundity)
Often reproductive capacity of a stock is modeled using female weight-at-age, primarily because of a lack of fecundity data. To the extent that egg production is not linearly related to female weight, indices of egg production (fecundity) are better measures of the reproductive

output of a stock at a given size and age structure. Additionally, fecundity better emphasizes the important contribution of older and larger individuals to egg production. Thus, in the most recent benchmark stock assessment (SEDAR, 2015), modeling increases in egg production with size was preferable to female biomass as a measure of the reproductive capability of the stock.

Population fecundity (*FEC*, number of maturing ova) was highest in the early 1960s, early 1970s, and the present decade, and has generally been higher with older age classes making up a larger proportion of the population (Figure 6). Large values of population fecundity were present in 2012 and 2013. Throughout the time series, age-2 and age-3 fish have produced most of the total estimated number of eggs spawned annually; however, in more recent years, ages-4+ have contributed a higher proportion to the overall number of eggs.

1.2.2.5 Maximum Spawning Potential

Amendment 2 (2013) implemented maximum spawning potential (MSP) based reference points that relate current stock conditions as a percent of unfished conditions. An unfished stock is equal to 100% MSP. Considering the modeling and data input changes that occurred in the 2015 Benchmark Stock Assessment, the TC and Peer Review Panel recommended new MSP based reference points that are applicable to the results of the assessment (ASMFC 2015).

The fecundity (FEC) reference points match the F reference points, meaning they are equal to the fecundity estimated when the population reaches equilibrium when fishing under the fishing mortality target and threshold MSP levels, respectively. The associated reference points for population fecundity are FEC-target ($FEC_{36\%MSP}$) = 99,467 (billions of eggs), and FEC-threshold ($FEC_{21\%MSP}$) = 57,295 (billions of eggs). In other words, the FEC target would maintain 36% of the spawning potential of an unfished stock, and the threshold would preserve 21% of the spawning potential of an unfished stock. In 2016, fecundity was estimated to be 83,486 billion eggs.

1.2.3 Current Stock Status

The current stock status determination is based on the 2017 Atlantic Menhaden Stock Assessment Update (ASMFC, 2017). The fishing mortality reference points are *F*-target ($F_{36\%}$) = 0.80 and *F*-threshold ($F_{21\%}$) = 1.85. The associated reference points for population fecundity are *FEC*-target ($FEC_{36\%}$) = 99,467 (billions of eggs), and *FEC*-threshold ($FEC_{21\%}$) = 57,295 (billions of eggs). As of 2016, overfishing is not occurring because fishing mortality for the terminal year is estimated to be $F =$ 0.51, below both the target and the threshold (Figure 7). Additionally, the stock is not overfished because fecundity for 2016 is estimated to be *FEC* = 83,486 billion eggs, above the threshold and just below the target (Figure 8).

1.3 DESCRIPTION OF THE FISHERY

1.3.1 Commercial Fishery

Atlantic menhaden have supported one of the United States' largest fisheries since colonial times. Menhaden have repeatedly been listed as one of the nation's most important commercial fisheries in terms of quantity. Preliminary Atlantic menhaden landings in 2016 totaled 181,344 mt (399.8 million lb) (Table 16). Landings records indicate that roughly 25 million mt (55.1 billion lb) of Atlantic menhaden have been caught by fishing fleets operating from Maine to Florida since 1940.

Native Americans were the first to use menhaden, primarily as fertilizer. Colonists soon recognized the value of menhaden as fertilizer and local seine fisheries gradually developed from Maine to New York. In 1811, the menhaden oil industry began in Rhode Island (Frye, 1999). Numerous small factories were located along the Northeast coasts; however, their supply was limited to fish that could be captured by the traditional shore-based seines. In 1845, the purse seine was introduced, enabling fishermen to harvest a larger quantity of menhaden further from shore. By 1870, the industry had expanded southward, with several plants in the Chesapeake Bay and North Carolina areas (Whitehurst, 1973). The industry gradually developed during the late 1800s and early 1900s and was described in considerable detail prior to World War I by Greer (1915). After World War I, the primary use of menhaden changed from fertilizer to animal feed due to the development of a process known as fish reduction. Menhaden meal began to be mixed into poultry, swine, and cattle feeds as the amount used for fertilizer decreased (Harrison, 1931). The current commercial fishery is divided into the reduction fishery, in which menhaden are produced into fish meal and fish oil, and the bait fishery, in which menhaden are harvested as a bait source for other commercial and recreational fisheries. A variety of gears are used to harvest menhaden commercially.

1.3.1.1 Reduction Fishery

<u>Vessels, Reduction Plants, and Harvest Capacity</u>

Several technological advances have helped the menhaden reduction fishery maintain its viability over the last century. The early menhaden purse seine reduction fishery utilized sailing vessels; however, the introduction of coal-fired steamers after the Civil War enabled the reduction fishery to fish further grounds. In the 1930s, vessels again improved through the use of diesel-power which replaced many of the coal-fired steamers. A critical development in the reduction fishery was the use of spotter aircraft in 1946. This practice is still used today to locate schools of menhaden. The refrigeration of vessel holds in the 1960s and 1970s was another crucial development for the reduction fishery. Despite restricted access to a number of traditional fishing grounds, a reduced fleet size, and fewer processing plants to land fish, refrigerated holds enabled the fleet to maximize the harvest during peak resource availability. Refrigeration also allowed the fleet to stay out longer and access a wider geographic area, greatly improving the ability to catch fish when and where they were available. All seven vessels in the menhaden fleet in 2013 utilized refrigerated fish holds, compared to only 60% of the fleet in 1980.

Currently, menhaden reduction operations use spotter aircraft to locate schools of menhaden and direct vessels to the fish. When a school is located, two purse boats, with a net stretched between them, are deployed. The purse boats encircle the school and close the net to form a purse, or bag. The net is then retrieved to concentrate the catch, and the mother ship comes along the side and pumps the catch into refrigerated holds. Individual sets can vary from 10 mt to more than 100 mt, and large vessels can carry 400-600 mt of refrigerated fish.

Overall, the total number of vessels participating in the menhaden reduction fishery has declined through time. Greer (1915) reported 147 vessels in 1912. During 1955-1959, about 115-130 vessels fished during the summer season, while 30-60 participated in the North Carolina fall fishery. As the resource declined during the 1960s, fleet size decreased by more than 50%. Through the 1970s, approximately 40 vessels fished during the summer season, while roughly 20 were active in the fall fishery. During 1980-1990, 16-33 vessels fished the summer season, and the level of effort in the fall fishery ranged from 3 to 25 vessels. In 2013, only seven vessels participated in the reduction fishery.

One of the major changes in the reduction fishery has been the decrease in the number of operating reduction plants. During peak landing years (1953-1962), there were anywhere from 19 to 25 reduction plants in operation located along the Atlantic coast from Maine to Florida. Many plants closed in the late 1960s as the resource began to decline and, in 1975, there were 12 reduction plants in operation. In 1985, this decreased to six plants and by 1994, there were only three plants located in Virginia and North Carolina. A major change in the reduction industry took place following the 1997 fishing season, when the two reduction plants operating in Reedville, VA, consolidated into a single company and a single factory; this significantly reduced effort and overall production capacity. Another major event within the industry occurred in the spring of 2005 when the fish factory in Beaufort, NC, closed and the owners sold the property to coastal developers. Today, there is a single reduction plant along the U.S. Atlantic coast located in Reedville, Virginia.

Reduction landings averaged 310,900 mt from 1940-2016, but only averaged 161,700 mt from 2000 – 2016 (Table 17, Figure 9). Reduction landings since 1940 peaked in 1956 at 712,100 mt, with the lowest value since 1940 occurring in 2013 (131,000 mt). It is important to note that 2013 was the first year a TAC was implemented in the menhaden fishery. This TAC represented a 20% reduction from average landings in 2009-2011. Other causes of declines in reduction harvest include lower menhaden abundance, reduced fleet size, and reduced reduction plant capacity.

The menhaden reduction fishery is seasonal as the presence of menhaden schools is dependent on the temperature of coastal waters. Two fairly distinct fishing seasons occur: the ‘summer fishery’ and the ‘fall fishery’. The summer fishery begins in April with the appearance of schools of menhaden off the North Carolina coast. The fish migrate northward, appearing off southern New England in May-June. The fall fishery begins when migratory fish appear off Virginia and North Carolina. In early fall, this southward migration is initiated by cooling ocean temperatures. By late November-early December, most of the fish are found between Cape Hatteras and Cape Fear, North Carolina.

Reduction Fishery Products

Menhaden reduction plants, through a process of heating, separating, and drying, produce fish meal, fish oil, and fish solubles from fresh menhaden. Meal is a valuable ingredient in poultry and livestock feeds because of its high protein content (at least 60%). Meal can also be found in pet foods for fish and dogs. Menhaden oil is (or has been) used in cooking oils, margarine, soap, linoleum, waterproof fabrics, and certain types of paint. Menhaden oil is often marketed as a source of omega-3 fatty acids and can be incorporated into food and beverage products as well as dietary supplements. Solubles are the aqueous liquid component remaining after oil removal. In general, most meal producers add the soluble component to the meal to create a product termed "full meal". Solubles can be used in the aquaculture industry as an attractant and as a fertilizer.

Internal Waters Processing

Section 306 of the Magnuson-Stevens Fishery Conservation and Management Act (PL 94-265) allows foreign fish processing vessels to operate within the internal waters of a state with the permission of the Governor of that state. Up to three internal waters processing (IWP) ventures operated within Maine's coastal waters during 1988-1993. Under state jurisdiction, a foreign vessel was permitted to process menhaden caught by US vessels into fish meal and oil during the 1988-1993 fishing seasons. In 1987, two New England-based menhaden vessels began to fish in the Gulf of Maine, landing the catch at a Canadian processing plant. Another Canadian factory in Nova Scotia processed menhaden in 1992 and 1993. No menhaden have been processed in the North Atlantic since the summer of 1993.

1.3.1.2 Bait Fishery

Menhaden from bait fisheries is primarily harvested with purse seines, pound nets, gill nets, and trawls, with a smaller amount of harvest coming from cast nets, fyke nets, and haul seines. Menhaden are taken for bait in almost all Atlantic coast states and are frequently used for bait in crab pots, lobster pots, and hook and line fisheries (both sport and commercial).

Since 1985, the proportion of menhaden landed as bait has generally increased (Table 17, Figure 9). Reported bait landings averaged 10% of the total Atlantic menhaden landings from 1985-2000 and 20% of total landings from 2001-2016. This increase in the percent of coastal bait landings can be attributed to better data collection in the fishery and a decline in coastal reduction landings. The closure of reduction plants in New England and the Mid-Atlantic may have influenced growth in the bait fishery, making more product available for the lobster and crab pot fisheries, as well as bait for sport fishermen. Additionally, the passage of a net ban in Florida in November 1994 reduced the availability of bait in that state, which may have opened up new markets for menhaden bait caught in Virginia and the Mid-Atlantic States. The appearance of growth in the Atlantic coast bait fishery must be tempered by the knowledge that reporting systems for bait landings, particularly for Atlantic menhaden, have historically been incomplete.

Menhaden bait landings have not always been well-documented leading to an under-estimate of historic harvest. Historically, there have been some well-documented, large-scale, directed bait fisheries for menhaden using gears such as purse seines, pound nets, and gill nets; however, there have also been many small-scale directed bait fisheries, such as those using cast nets and beach seines, which have supplied large quantities of bait and had few, if any, reporting requirements. Estimates of menhaden bait landings have improved over the years as most states implemented reporting requirements for the smaller scale fisheries by the late 2000s. States were required to implement timely reporting as a part of Amendment 2 (2012) in order to monitor quota allocations.

Given the geographic expanse of the menhaden bait fishery, there are regional differences in how and when menhaden are harvested. In the southeast, menhaden landings are dominated by Florida and North Carolina. In Florida, menhaden landings are primarily landed with cast nets since the state implemented a net ban in 1994. Prior to this time, Florida had significant bait landings from gill nets and purse seines. Fishermen in North Carolina use cast nets, gill nets, and pound nets to harvest menhaden. The principal use for menhaden as bait in North Carolina is in the blue crab fishery. In addition, some keep menhaden alive in holding tanks for “slow trolling” of species such as king mackerel. There are no directed menhaden fisheries in South Carolina and Georgia.

Menhaden bait landings in Virginia are dominated by purse seine vessels referred to as ‘snapper rigs’. These vessels range from about 80-135 ft long and primarily sell bait to the sport and crab fisheries. In contrast, the Maryland and Potomac River bait fisheries are primarily executed by pound nets, a large fixed gear. The pound net fishery in the Chesapeake Bay region is carried out by numerous small, non-refrigerated vessels. Maximum hold capacity of these pound net vessels is 9 mt or less, but daily catches are usually well below vessel capacity and are limited by the number of fish encountered in the fixed gear. The majority of these fish supply the local blue crab fishery.

In the Mid-Atlantic, there has been an expansion of the purse seine bait fishery, particularly in New Jersey. The New Jersey menhaden fishery utilizes about 20 carry vessels and about 15 catch vessels per year. Most operations have a catch vessel paired with a specific carry vessel, but some vessels are both catch and carry. Carry vessel length ranges from 59-90 ft and catch vessel length ranges from 40-88 ft. Net length is restricted to 150 fathoms (900 ft) by regulation. In New York and Delaware, menhaden bait landings are primarily caught in pound nets, gill nets, casts, and seines.

In the New England region, purse seine landings in Maine, Massachusetts and Rhode Island account for the majority of the recorded bait landings. The New England operators are fairly small, typically with one harvest vessel, ranging in size from the 30 to 90 feet in length. In Rhode Island, there is a historic floating fish trap fishery which harvests the majority of menhaden landed in the state. In Connecticut, smaller directed gill net fisheries also harvest menhaden. The bulk of menhaden landings for bait in New England are used in the lobster fishery.

1.3.2 Recreational Fishery

Menhaden are important bait in many recreational fisheries and, as a result, some recreational fishermen employ cast nets to capture menhaden or snag them with hook and line. Recreational harvest is not well captured by the Marine Recreational Information Program (MRIP) because there is not a known direct harvest for menhaden, other than for bait. MRIP intercepts typically capture the landed fish from recreational trips as fishermen come to the dock or on the beach. Since the menhaden caught by recreational fishermen are used as bait during their trip, they typically are not part of the catch that is seen by the surveyor completing the intercept.

From what is known, recreational catch has varied over time with a high of 672.3 mt in 1992 and a low of 12.2 metric tons in 2000. The average harvest between 1981 and 2015 was 206.8 mt. Landings have averaged 382.5 mt between 2011 and 2015. Preliminary recreational landings from 2016 are 845 mt, which would be a new high for the time series (Figure 10).

1.3.3 Subsistence Fishing

No subsistence fisheries for Atlantic menhaden have been identified at this time.

1.3.4 Non-Consumptive Factors

Menhaden provide an important forage base for many fish, bird, and marine mammal species. Please refer to *Section 1.1.2.1 Ecological Benefits*.

1.3.5 Interactions with Other Fisheries

Incidental bycatch of other finfish species in menhaden purse seines has been a topic of interest and concern for many years (Christmas et al., 1960; Oviatt, 1977; Smith, 1896). Past studies have indicated that there is little or no bycatch in the menhaden purse seine fishery; however, there is currently no requirement for at-sea observers.

The Virginia Institute of Marine Science studied bycatch levels of finfish, turtles, and marine mammals in the Atlantic menhaden fishery. Results from that study indicated that bycatch in the 1992 Atlantic menhaden reduction fishery was minimal, comprising about 0.04% by number (Austin et al., 1994). The maximum percentage of bycatch occurred in August (0.14%) while the lowest occurred in September (0.002%). Among important recreational species, bluefish accounted for the largest portion of bycatch (0.0075% of the total menhaden catch). No marine mammals, sea turtles, or other protected species were killed, captured, entangled, or observed during sampling.

Additional data are available from the Gulf of Maine IWP fishery in 1991. Every catch unloaded onto the processing vessel was inspected by a state observer. A total of 93 fish were taken as bycatch along with roughly 60,000,000 individual menhaden (D. Stevenson, Maine DMR, pers. comm.; as cited in ASMFC 1992).

1.4 HABITAT CONSIDERATIONS

1.4.1 Physical Description of Habitat

1.4.1.1 Gulf of Maine

The Gulf of Maine is a semi-enclosed sea of 36,300 mi^2 (90,700 km^2) bordered on the northeast, north and west by the coasts of Nova Scotia, New Brunswick, and the New England states. To the south and east, the Gulf is open to the North Atlantic Ocean; however, Georges Bank forms a partial southern boundary below about 165 ft (50 m). The interior of the Gulf of Maine is characterized by five major deep basins (>600 ft, 200 m) which are separated by irregular topography that includes shallow ridges, banks, and ledges. Basins make up about 30% of the floor area (Thompson, 2010). Retreating glaciers (18,000–14,000 years ago) left behind a variety of patchily distributed sediment types including silt, sand, clay, gravel, and boulders (NMFS, 2015). Major tributary rivers are the St. John in New Brunswick; St. Croix, Penobscot, Kennebec, Androscoggin, and Saco in Maine; and Merrimack in Massachusetts.

The predominantly rocky coast of Maine is characterized by steep terrain and bathymetry, with numerous islands, embayments, pocket beaches, and relatively small estuaries. Tidal marshes and mud flats occur along the margins of these estuaries. Farther south, the coastline is more uniform with few sizable bays, inlets, or islands, but with many small coves. Extensive tidal marshes, mud flats, and sandy beaches along this portion of the coast are gently sloped. Marshes exist along the open coast and within the coves and estuaries.

The surface circulation of the Gulf of Maine is generally counterclockwise, with an offshore flow at Cape Cod which joins the secondary, clockwise gyre on the northern edge of Georges Bank. The Northeast and Great South Channels, which bookend Georges Bank, serve as the primary inflow and outflow channels of marine waters, respectively. Some of the water entering the Northeast Channel flows into the Bay of Fundy; another portion turns west to feed the Maine Coastal Current, initiating the counterclockwise direction of flow. The counterclockwise gyre is more pronounced in the spring when river runoff adds to the southwesterly flowing coastal current. Surface currents reach velocities of 1.5 knots (80 cm/sec) in eastern Maine but gradually diminish to 0.2 knots (10-20 cm/sec) in Massachusetts Bay where tidal amplitude is about 10 ft (3 m) (Thompson, 2010).

There is great seasonal variation in sea surface temperature in the Gulf, ranging from 4°C in March throughout the Gulf to 18°C in the western Gulf and 14°C in the eastern Gulf in August. The Gulf of Maine sea surface temperature has been warming steadily over the last 35 years. In the most recent decade, the warming trend (0.23 °C /year) was faster than 99 percent of the global ocean (Pershing et al., 2015). The warming is related to a northward shift in the Gulf Stream and to changes in the Atlantic Multidecadal Oscillation and Pacific Decadal Oscillation (Pershing et al., 2015). The salinity of the surface layer also varies seasonally, with minimum values in the west occurring during summer, from the accumulated spring river runoff, and during winter in the east under the influence of runoff from the St. Lawrence River (from the previous spring). With the seasonal temperature and salinity changes, the density stratification in the upper water column also exhibits a seasonal cycle. From well mixed, vertically uniform conditions in winter, stratification develops through the spring and reaches a maximum in the summer. Stratification is more pronounced in the southwestern portion of the Gulf where tidal mixing is diminished.

1.4.1.2 Mid-Atlantic Region

The coastal zone of the Mid-Atlantic states varies from a glaciated coastline in southern New England, to the flat and swampy coastal plain of North Carolina. Along the coastal plain, the beaches of the barrier islands are wide, gently sloped, and sandy, with gradually deepening offshore waters. The area is characterized by a series of sounds, broad estuaries, large river basins (e.g., Connecticut, Hudson, Delaware, and Susquehanna), and barrier islands. Conspicuous estuarine features are Narragansett Bay (Rhode Island), Long Island Sound and Hudson River (New York), Delaware Bay (New Jersey and Delaware), Chesapeake Bay (Maryland and Virginia), and the nearly continuous band of estuaries behind barrier islands along southern Long Island, New Jersey, Delaware, Maryland, Virginia, and North Carolina. The complex estuary of Currituck, Albemarle, and Pamlico Sounds behind the Outer Banks of North Carolina (covering an area of 2,500 square miles) is an important feature of the region. Coastal marshes border those estuaries along much of the glaciated coast from Cape Cod to Long Island Sound. Nearly continuous marshes occur along the shores of the estuaries behind the barrier islands.

At Cape Hatteras, the Continental Shelf extends seaward approximately 20 mi (33 km), and gradually widens northward to about 68 mi (113 km) off New Jersey and Rhode Island where it is intersected by numerous underwater canyons. Surface circulation north of Cape Hatteras is generally southwesterly during all seasons, although this may be interrupted by coastal in-drafting and some reversal of flow at the northern and southern extremities of the area. Speeds of drift north of Cape Hatteras are on the order of six miles (9.7 km) per day. There may be a shoreward component to this drift during the warmer half of the year and an offshore component during the colder half. The western edge of the Gulf Stream meanders off Cape Hatteras, sometimes coming within 12 mi (20 km) of the shore; however, it becomes less discrete and veers to the northeast above Cape Cod. Surface currents as high as 4 knots (200 cm/sec) have been measured in the Gulf Stream off Cape Hatteras.

Hydrographic conditions in the Mid-Atlantic region vary seasonally due to river runoff and changing water temperatures. The water column becomes increasingly stratified in the summer and homogeneous in the winter due to fall-winter cooling of surface waters. In the winter, the mean range of sea surface temperatures is 0-7°C off Cape Cod and 1-14°C off Cape Charles (at the southern end of the Delmarva Peninsula). In the summer, the mean range is 15-21°C off Cape Cod and 20-27°C off Cape Charles. The tidal range averages slightly over 3 ft (1 m) on Cape

Cod, decreasing to the west. Within Long Island Sound and along the south shore of Long Island, tide ranges gradually increase, reaching 6 ft (2 m) at the head of the Sound and in the New York Bight. South of the Bight, tide ranges decrease gradually to slightly over 3 ft (1 m) at Cape Hatteras. Prevailing southwest winds during the summer along the Outer Banks often lead to nearshore upwelling of colder bottom water from offshore, so that surface water temperatures can vary widely during that period (15-27°C over a period of a few days).

The waters of the coastal Mid-Atlantic region have a complex and seasonally dependent circulation pattern. Seasonally varying winds and irregularities in the coastline result in the formation of a complex system of local eddies and gyres. Surface currents tend to be strongest in late spring, due to river runoff, and during periods of highest winds in the winter. In late summer, when winds are light and estuarine discharge is minimal, currents tend to be sluggish, and the water column is generally stratified.

1.4.1.3 South Atlantic Region

The south Atlantic coastal zone extends in a large oceanic bight from Cape Hatteras south to Biscayne Bay and the Florida Keys. North of Florida, the south Atlantic coastal zone is bordered by a coastal plain that stretches inland for a hundred miles and a broad continental shelf that reaches into the ocean for nearly an equal distance. This broad shelf tapers down to a very narrow and precipitous shelf off the southeastern coast of Florida. The irregular coastline of North Carolina, South Carolina, Georgia, and eastern Florida is generally endowed with extensive bays and estuarine waters, bordered by nutrient-rich marshlands. Barrier beaches and dunes protect much of the shoreline. Along much of the southern coast from central South Carolina to northern Florida, estuarine salt-marsh is prominent. Most of the east coast of Florida varies little in general form. Sand beaches with dunes are sporadically interrupted by mangrove swamps and low banks of earth and rock.

The movements of oceanic waters along the South Atlantic coast have not been well defined. The surface currents, countercurrents, and eddies are all affected by environmental factors, particularly winds. The Gulf Stream flows along the coast at 6-7 miles per hour (10-11 km/hr). It is nearest to the coast off southern Florida and gradually moves away from the coast as it flows northward. Inshore of the Gulf stream, there is a current that flows southward for most of the year in regions north of Cape Canaveral.

Sea surface temperatures during the winter increase southward from Cape Hatteras to Fort Lauderdale, Florida, with mean minimums ranging from 2-20°C and maximums ranging from 17-26°C. In the summer, the increases are more gradual, ranging north to south from minimums of 21-27°C to maximums of 28-30°C. Mean sea-surface salinity is generally in the range of 34 to 36 ppt year round. Mean tidal range is just over 3 ft (1 m) at Cape Hatteras and increases gradually to about 6-7 ft (2 m) along the Georgia coast. Tides decrease south of Cape Canaveral to 3 ft (1 m) at Fort Lauderdale.

1.4.2 Environmental Requirements of Atlantic Menhaden

1.4.2.1 Temperature, Salinity, and Dissolved Oxygen

While Atlantic menhaden occur throughout a wide range of physicochemical conditions, several studies have raised questions about the species' environmental limits and optimum conditions. In particular, studies have noted an affinity of young menhaden for low salinity waters. Wilkens and Lewis (1971) speculated that larval menhaden require low salinity water to metamorphose properly, and Lewis (1966) found that, although larvae metamorphosed in salinities of 15-40 ppt, one-third of the juveniles developed slightly crooked vertebral columns. Furthermore, larvae reared by Hettler (1976) at a lower salinity of 5-10 ppt exhibited significantly higher activity levels, metabolic rates, and growth rates than those reared at 28-34 ppt. Rogers et al. (1984) noted that pre-juveniles of many fishes, including those of *Brevoortia* species, enter estuarine habitats during seasonal peaks of freshwater influx when the area of low salinity and fresh tidal water is greatest.

Studies also suggest that temperature also has an important effect on larval development and dispersion. In the South Atlantic region, sea surface temperature readings during the months of highest egg capture were generally 12-20^{o}C (Walford and Wicklund, 1968). In the North Atlantic, the lowest temperature at which Atlantic menhaden eggs and larvae were collected was between 10 and 13^{o}C (Ferraro, 1980). The temperature range for the Mid-Atlantic region was 0-25^{o}C, but most eggs and larvae were collected at 16-19^{o}C (Kendall and Reintjes, 1975). Studies suggest that the limits of larval temperature tolerance are affected by acclimation time. Survival above 30^{o}C (Lewis and Hettler, 1968) and below 5^{o}C (Lewis, 1965) was progressively extended by acclimation temperatures closer to test values, suggesting that rapid changes to extreme temperatures are more likely to be lethal than prolonged exposure to slowly changing values. Mortality of juvenile Atlantic menhaden to a temperature decrease of 10^{o}C (from 15 to 5^{o}C) was less when temperature was decreased at a rate of 6.7^{o}C /h or lower.

A potential management consideration is that, historically, estuarine zones received freshwater from contiguous wetlands and riverine systems. However, channelization, diking of river courses, ditching and draining of marginal wetlands, and urbanization have reduced the freshwater retention capacities of coastal wetlands. Furthermore, extensive filling of estuarine marshlands has diminished the area receiving runoff in many locations. In combination, these changes cause the rapid discharge of freshwater during brief periods and reduced amounts of freshwater at other times. High inflows, particularly those that occur in early spring after the arrival of pre-juvenile menhaden, can expose fish to extreme fluctuations of temperature, turbidity, and other environmental conditions. Although the effects of altered freshwater flow regimes on Atlantic menhaden are not known, effects on other estuarine dependent, offshore spawned fishes range from disappearance (Rogers et al., 1984) to death (Nordlie et al., 1982).

Dissolved oxygen, particularly at low levels, can also impact the survival of menhaden. Lewis and Hettler (1968) observed increased survival of juveniles at 35.5^{o}C with increased dissolved oxygen (DO) saturation. Burton et al. (1980) reported a mean lethal DO concentration of 0.4

mg/l, but warned against interpretation of this value as “safe”, in view of the interactive nature of environmental factors.

1.4.2.2 Primary Production

Abundance of YOY juvenile menhaden is strongly and positively correlated with *chl-a* and primary production in the Chesapeake Bay (Houde and Harding, 2009). Although recent research indicates that age-1+ menhaden may derive most energy from zooplankton food (Lynch et al., 2010; Friedland et al., 2011), it is apparent that YOY menhaden can efficiently filter small phytoplankton (Friedland et al., 2006) and that it is their primary food. The timing, intensity, quality, and spatial variability of the spring phytoplankton bloom in the Chesapeake Bay show high inter-annual variability and are strongly affected by climate (Adolf et al., 2006; Miller and Harding, 2007). This variability in primary production is likely a key factor controlling production potential of young menhaden in estuarine habitats.

1.4.2.3 Sediments and Turbidity

Forest clearing, and the removal of the buffer provided by trees, shrubs, plants, and wetlands, has led to changes in sediment loading due to unrestricted stormwater flow (Brush, 1986). This results in erosion that brings increased sediment into estuaries, such as the Chesapeake Bay. In addition, the dramatic increase in impermeable surfaces has also increased runoff, as impervious surfaces amplify storm water discharges into streams (Goetz and Jantz, 2006). One consequence of these changes is that sediment grain size has changed over time so that very fine sediment now predominates, which reduces light penetration. Secchi disk readings from the Chesapeake Bay have steadily declined since 1985 from just over 2 meters to about 1 meter in 2008 (Greer, 2008). Because filter feeding juvenile menhaden can retain particles as small as 5-7 µm, and to a minor extent particles <5 µm, there is a possibility that menhaden feeding could be compromised (Friedland et al., 1984).

The resulting increased turbidity acts to shade submerged aquatic vegetation (SAV), thus decreasing the extent and composition of SAV beds. Loss of SAV may indirectly affect menhaden by increasing turbidity even further as a result of increased sediment resuspension (Orth et al., 2006), which in turn can lower phytoplankton productivity. SAV has also been shown to exercise control over ecosystem function through nutrient recycling and linkage to fish productivity (Orth et al., 2006; Hughes et al., 2009), which may impact menhaden abundance, although specific impacts are not known at present.

1.4.2.4 Water Movement

Currents and circulation features play an important role in cueing reproduction, and in controlling dispersal of larval stages, assuring that some larvae are transported to the coastal estuaries and embayments that serve as juvenile nurseries. Most larval menhaden are found shoreward of the Gulf Stream Front (GSF); those sampled in the GSF, or seaward of it, presumably are rapidly advected northeast and lost to the population although it is possible that warm-core rings and onshore streamers could return some larvae to the shelf (Hare and Govoni, 2005). There is ample evidence, based on observations and models, that coastward transport of larvae is supported by favorable winds and currents on the shelf (Checkley et al.

1988; Werner et al., 1999). Models and observations of advective mechanisms at estuary mouths present a less-clear picture of how menhaden larvae move into estuaries, although it is apparent that winds, tides, and larval behavior control the ingress.

Inter-annual variability in recruitment is believed to be, at least partly, controlled by variability in oceanographic conditions that affect hydrography, circulation, and possibly biological productivity. Weather and climate patterns are probable drivers of such variability. Wood et al. (2004) demonstrated that prevalence of a late-winter climate pattern that brings dry and warm weather to the Mid-Atlantic region is associated with high recruitment of Atlantic menhaden. This weather pattern may promote favorable shoreward transport or feeding conditions for early-stage menhaden larvae while on the continental shelf.

1.4.2.5 Substrate and System Features

The association of Atlantic menhaden with estuarine and nearshore systems during all phases of its life cycle is well documented. It is evident that young menhaden require these food rich waters to survive and grow, and the fishery is concentrated near major estuarine systems. Filling of estuarine wetlands, in addition to exacerbating extremes in environmental conditions, has physically limited the nursery habitat available to Atlantic menhaden and other estuarine-dependent species. The relative importance, however, of different habitat types (i.e. sounds, channels, marshes) and salinity regimes has received little detailed attention (Rogers and Van Den Avyle 1989).

1.4.3 Identification and Distribution of Essential Habitat

Estuarine and nearshore waters along the Atlantic coast from Florida to Nova Scotia serve as important habitat for juvenile and/or adult Atlantic menhaden. Within this wide geographic range, hydrographic and circulation features constrain population distribution (MDSG 2009). Adult menhaden distribution is bounded by the Gulf Stream Front on the seaward side and by water temperatures greater than 10°C (MDSG 2009).

Adult Atlantic menhaden spawn in oceanic waters along the continental shelf, as well as in sounds and bays in the northern extent of their range (Judy and Lewis, 1983). Winds and tides transport larvae shoreward from the shelf (Checkley et al., 1988; Werner et al., 1999) toward nursery grounds in the estuaries. Larvae are between one and three months old, usually closer to two months, at first ingress into estuaries (Warlen et al., 2002; MDSG, 2009). After entering the estuary, larvae congregate in large concentrations near the upstream limits of the tidal zone, where they metamorphose into juveniles (June and Chamberlin 1959, Houde 2011).

Historically, Chesapeake Bay was considered to be the most productive nursery area (contributing 69% of Atlantic menhaden recruits [age 1] to the coast wide population), followed by the south Atlantic (17%), and the Mid-Atlantic sections from Maryland to New York (12%) (Ahrenholz et al., 1989; ASMFC, 2004; Anstead et al., 2017). However new research credits the Chesapeake Bay with 30% of age 1 recruits and New England and the southeast estuaries contributing equal portions to the population (Anstead et al., 2016). Furthermore, recruits from all three areas, in the same proportions, have been shown to persist in the population beyond the first year to ages 2-4, therefore becoming part of the reproductive population (Anstead et al. 2017).

1.4.4 Anthropogenic Impacts on Atlantic Menhaden and Their Habitat

The human population along the coast is steadily increasing, and the average number of people per square mile in coastal counties has nearly doubled since 1960 (U.S Census Bureau 2010). Increasing human presence precipitates industrial and municipal expansion, thus intensifying anthropogenic pressure on resources and accelerating competition for use of land and water. Consequently, estuarine and coastal habitats have been significantly reduced and continue to be stressed by dredging, filling, coastal construction, energy plant development, pollution, waste disposal, nutrient loading, and other human-related activities.

Degraded water quality in estuaries threatens critical nursery habitat for young menhaden. Concern has been expressed (Ahrenholz et al., 1987) that the outbreaks of ulcerative mycosis in the 1980s may have been symptomatic of deteriorating water quality in estuarine waters along the east coast. Human population growth and increasing development in the coastal zone are expected to further reduce water quality unless steps are taken to ameliorate their effect on the environment (Cross et al., 1985). Altering habitats and water quality can affect menhaden habitat use and productivity - responses that are magnified in estuaries where human use and biological productivity heavily interact.

Perhaps the most significant physical alteration of the Chesapeake Bay watershed in recent decades has been the increase in impervious surfaces. More than 400,000 hectares are currently categorized as impervious surface and that value continues to climb (Brush 2009). These surfaces increase the nutrient, sediment, and contaminant flow rate to the Chesapeake Bay (Clagett 2007), and exacerbate eutrophication and expansion of hypoxic and anoxic zones. Although not well studied at present, reduced water quality associated with increases in impervious surfaces could diminish habitat quality for menhaden or their predators.

Menhaden fish kills, both human-caused and naturally occurring, are a persistent problem in bays and estuaries throughout the range. Most states keep records of fish kills, documenting water quality, number of fish killed, and likely causes. Localized die-offs often occur due to critically low dissolved oxygen (DO) levels, which may result from a variety of factors including high temperature, low flow, overcrowding, or algal blooms. Infectious diseases, parasites, toxicants, or miscellaneous human activity (e.g. thermal shock or fishing discards) may also cause localized mortality. In Maryland, nearly 50 years of records document annual menhaden kills ranging from tens to tens-of-millions of fish (max est. 47M fish in 1974), caused by a variety of factors from concussive explosions to disease and toxicants from spills or discharge (C. Poukish, MD DNR, pers. comm.). The most common factor was low DO in the presence of algal blooms, which causes an annual spring die-off. In the Neuse and Tar-Pamlico River estuaries in North Carolina, low oxygen events cause significant mortality of Atlantic menhaden and other fish species nearly every summer (R. Wilson Laney, USFWS, pers. Comm.). In Florida, nutrient inputs, exacerbated by low flushing in the Indian River Lagoon, result in Harmful Algal Blooms (HABs) and, ultimately, menhaden kills (K. Smith, FL FWC, pers. comm.).

In recent years the menhaden population appears to be rebounding and expanding to reoccupy its historic geographic range. With more fish returning to areas heavily used and impacted by humans, the potential for fish kills increases. For example, in 2016, tens of thousands of menhaden were killed when a lock closure trapped them in the Shinnecock Canal in New York.

At one time, fish kills may have solely been a natural occurrence, but anthropogenic impacts to water quality and flow have certainly exacerbated the frequency and intensity of these mortality events. State efforts to track fish kills can provide information on patterns and trends. North Carolina, for example, instituted a fish kill investigation procedure in 1996 to collect and track fish kill information. Data is maintained in a central database and is reviewed as part of an effort to monitor water quality trends.

A growing body of literature is beginning to describe shifts in species distributions and spawning locations and seasons, possibly due to a changing climate on the Atlantic coast (e.g. Walsh et al., 2015; Kleisner et al., 2016). Menhaden ingress to estuaries is sensitive to changes in wind patterns and temperatures, which are known to be variable and may be influenced by climate change (Quinlan et al,. 1999; Austin, 2002). Moreover, nursery habitats within bays and estuaries are likely to be altered by the effects of climate change, in some cases potentially enhancing menhaden productivity and other cases, resulting in lower production and recruitment. The effects of climate change are predicted to include: increased water temperatures, sea-level rise, and changes in precipitation patterns and climate variability (Sherman et al., 2009). These changes can influence salinity, temperature, and nutrients throughout nursery grounds.

In addition to long-term climate change, the Atlantic coast has also experienced shorter-term, decadal fluctuations in weather, shifting between cold-wet and warm-dry periods. Austin (2002) showed that the 1960s were warmer and wetter than the 1970s and 1990s in the Mid-Atlantic. Menhaden recruitment success tends to be relatively high in years when late winter-spring conditions are warm and dry (Wood, 2000). Although menhaden recruitment has been correlated with the Atlantic Multidecadal Oscillation (Buchheister et al., 2016), the correlation between Chesapeake Bay and southern New England is reversed and the mechanisms of influence are unknown. The generally low recruitment of YOY menhaden in recent years appear to be constrained by frequent cool and wet winter-spring conditions that favor recruitment of anadromous spawners, but not offshore-spawning fishes such as menhaden (Kimmel et al., 2009). It is not certain whether climate change will have positive or negative impacts on the long-term abundance and productivity of menhaden.

1.4.5 Description of Programs to Protect, Restore, & Preserve Atlantic Menhaden Habitat

The federal Coastal Zone Management Act provides a framework under which individual coastal states have developed their own coastal habitat protection programs. In general, wholesale dredging and filling are not allowed. Individual development projects are subject to state and federal review and permit limitations. Every Atlantic coast state has a coastal habitat protection program in place (Table 11.27 in ASMFC 1992). These protection programs have greatly reduced the loss of vital coastal habitat to dredging and filling since the mid-1970s. Virtually all proposals affecting coastal habitat are now reviewed by a variety of local, state, and federal agencies, and wholesale destruction of coastal wetlands is rare. Many important estuarine habitats are now protected as part of various wildlife refuges, national and state parks, and public and private nature preserves. In addition, a federal permit program is conducted by the U.S. Army Corps of Engineers, generally in cooperation with the state programs. Every state also conducts water quality protection programs under the federal Clean Water Act. National Pollution Discharge Elimination System permits are required for point-source discharges.

Unfortunately, these programs provide much less control over non-point pollution, especially from agricultural and silvicultural activities, and excess nutrient inputs from diverse sources continue to contribute to hypoxic and anoxic conditions in estuarine menhaden habitat. Additional work to more precisely define menhaden habitat parameters for all life stages and to develop accompanying map products is needed to inform diverse multi-agency and project applicant consultations and permitting processes so that further impacts to menhaden habitats are avoided or minimized.

1.5 IMPACTS OF THE FISHERY MANAGEMENT PROGRAM

1.5.1 Biological and Ecological Impacts

1.5.1.1 Reference Points

The adoption of ecosystem reference points (ERPs) will expand the focus of menhaden management by assessing the status of menhaden in relation to other prey and predator species. ERPs will seek to ensure maintenance of a forage base needed to support larger finfish (e.g. striped bass, bluefish, weakfish), coastal birds (e.g. osprey), and marine mammals (e.g. humpback whales). An ecosystem approach to setting reference points for menhaden may also increase the spawning biomass of the menhaden stock, promoting a higher stock abundance along the coast.

Sustained use of the existing single-species reference points using the method outlined in the 2015 Stock Assessment will continue to provide a greater measure of sustainability than the reference points established in Amendment 2; however, these reference points consider the status of menhaden independent of other species. As a result, it is unclear if they are protecting a large enough forage base to support predator populations. Under the current reference points, the menhaden stock is not overfished and overfishing is not occurring.

1.5.1.2 Total Allowable Catch

Limiting menhaden harvest through a Total Allowable Catch (TAC) provides a way to maintain the menhaden population above the overfished threshold and below the overfishing threshold.

After the TAC is harvested in a given year, the directed fishery closes. This allows for greater protection of the spawning biomass, as opposed to allowing fishing to continue above and beyond the TAC. If properly set and enforced, quotas will prevent overfishing and ensure a sustainable resource for the future. Maintenance of a sustainable resource will also increase the forage base for commercially and recreationally important predator species.

1.5.1.3 Quota Allocation

The purpose of quota allocation in this Amendment is to identify a fair and equitable method through which menhaden quota can be distributed to various fisheries, gear types and regions. An allocation method which addresses the needs of each user group and is flexible to respond to future changes in the fishery will provide stability for the fishery and resource. It may also reduce the need for other management tools, such as an incidental catch provision or small-scale fishery set aside (*Section 4.3.5: Incidental Catch and Small Scale Fisheries*).

1.5.1.4 Chesapeake Bay Reduction Fishery Cap

The intent of the Chesapeake Bay Reduction Fishery Cap is to ensure protection of an important nursery ground for menhaden. Currently, harvest of menhaden by the reduction fishery in the Chesapeake Bay is prohibited when 100% of the cap has been reached. This protection helps support menhaden recruitment in the Bay and protects a forage base for predators such as striped bass.

The Chesapeake Bay Reduction Fishery Cap was originally implemented in 2005 to prevent localized depletion of menhaden. Given the concentrated harvest of menhaden within the Chesapeake Bay, there was concern that localized depletion could be occurring in the Bay. In 2005, the Board established the Atlantic Menhaden Research Program (AMRP) to evaluate the possibility of localized depletion. Results from the peer review report in 2009 were unable to conclude localized depletion is occurring in the Chesapeake Bay and noted that, given the high mobility of menhaden, the potential for localized depletion could only occur on a “relatively small scale for a relatively short time”.

While the AMRP peer review report was not able to provide conclusive evidence that localized depletion is occurring, maintenance of the Chesapeake Bay reduction fishery cap does provide a greater level of protection in the region than the TAC alone.

1.5.1.5 Data Collection and Reporting Requirements

This Amendment requires states to implement timely quota monitoring programs so that the harvest of menhaden stays within the TAC and the potential for overages is limited. Furthermore, purse seine or bait seine vessels are required to submit Captain’s Daily Fishing Reports on a daily basis, and states must collect biological samples relative to their level of harvest. This level of reporting is necessary for the implementation of a quota management system, as lengthy delays could lead to quota overages or premature closures of the fishery. Furthermore, continued biological sampling will increase knowledge on the stock’s age structure, improving the precision of menhaden abundance estimates in future stock assessments.

1.5.2 Social and Economic Impacts

This Amendment includes several measures which could carry social and economic impacts, notably potential changes to the reference points and allocation method. The use of ERPs may affect those who derive value from finfish, coastal birds, or marine mammals which predate upon menhaden. Ensuring a stable forage base for these species could increase their abundances, leading to positive social and economic impacts for individuals, groups, or communities which rely on these resources for consumptive (e.g., commercial or recreational harvest) or non-consumptive (e.g., bird or whale watching) purposes. Individuals who hold non-use values (e.g., existence value from knowing a particular environmental resource exists or bequest value from preserving a natural or cultural heritage for future generations) associated with affected species may also benefit from increased abundances. Estimates of potential economic or social impacts to these stakeholders as a result of ERPs is challenging given complex and dynamic ecological relationships as well as the lack of socioeconomic data, especially for nonmarket goods and services.

For the commercial fisheries, ERPs may lead to changes in the TAC, which could negatively impact the bait and reduction fisheries. The extent and distribution of negative socioeconomic effects arising from changes to the TAC is dependent on price elasticities (responsiveness of demand to a change in price), substitute products, fishing costs, alternative employment opportunities, fishing community structure, and possibly other factors.

Identifying quota allocation methods which are fair and equitable among fishery sectors, gear types, and regions will enhance socioeconomic net benefits if changes in allocation result in higher value use of the menhaden resource. Shifts in allocation, while potentially beneficial overall, could disadvantage individual stakeholders through reductions in harvests, revenues, and profits. Implementation of data collection programs to ensure effective quota monitoring may add additional management costs.

A recently completed socioeconomic study of the commercial bait and reduction fisheries, funded by the ASMFC, contains several findings which elucidate possible social and economic impacts resulting from changes in menhaden management. In this study, researchers interviewed and surveyed industry members to uncover salient themes, analyzed historic landings data to resolve market relationships, performed economic impact analyses to consider the effects of various TAC changes, and conducted a public opinion survey to assess attitudes toward menhaden management (see Whitehead and Harrison, 2017 for the full report). Interviews and surveys of commercial fishers and other industry members found mixed opinions on several subjects; however, many agreed that the demand for menhaden bait, oil, and meal has increased in recent years. Exogenous demand increases, if leading to increases in ex-vessel prices, could benefit menhaden bait and reduction industry members; however, it is important to note that these benefits are unrelated to management actions discussed in this Amendment.

Analysis of historic landings data revealed that prices for menhaden were negatively related to landings levels, but that this relationship was small and insignificant in some instances. In particular, state-level analysis showed ex-vessel price is insensitive to landings. This finding suggests that reductions in the TAC might reduce commercial fishery revenues as decreases in landings are not fully compensated by higher prices. Ex-vessel prices of menhaden are not uniform along the coast, with some states having higher prices than others.

Economic impact analyses of changes to the TAC found income and employment decreases (increases) corresponding to TAC decreases (increases), with the largest impacts concentrated in New Jersey and Virginia. For example, the analysis suggests that when totaling direct, indirect, and induced economic changes in the bait fishery, a 5% increase in the TAC from the 2017 baseline would result in 18 more jobs, a $476,000 increase in total earnings, and a $1.7 million increase in total economic output. Looking at the reduction sector, a 5% increase in the TAC from the 2017 baseline is estimated to increase total economic output (includes direct, indirect, and induced economic effects) by $3.6 million in Northumberland county and add 77 full and part-time jobs. Interestingly, subsequent analysis of coastal county income and employment changes in response to changes in bait landings (not reduction landings) showed little effect, casting some doubt on the conclusion that adjustments in menhaden TAC consistently lead to changes in fishery income and employment in the bait fishery. It may also be that the magnitude of impact is dependent the size of the fishery in each state and the ability of fishermen to harvest other species.

A public opinion survey asked respondents to vote for or against hypothetical TAC changes which led to associated changes in fishery revenues, jobs, and ecosystem services. Results from this survey indicated that the public recognized management tradeoffs and were willing to trade some economic losses for improvements in ecosystem services. For example, survey respondents were willing to forgo $10.5-12 million in ex-vessel revenue in exchange for positive impacts on gamefish. On the other hand, survey respondents were willing to accept $4-7 million in additional ex-vessel revenue in exchange for negative impacts to gamefish. The range of results is due to the variety of model configurations used in the analysis. It is also important to note that respondent characteristics and attitudes (ie: knowledge of menhaden, perceived importance of fishery to state) significantly influenced voting patterns.

2.0 GOALS AND OBJECTIVES

2.1 HISTORY OF MANAGEMENT

The first coastwide fishery management plan (FMP) for Atlantic menhaden was approved in 1981 (ASMFC 1981). The 1981 FMP did not recommend or require specific management actions, but provided a suite of options should they be needed. After the FMP was approved, a combination of additional state restrictions, the establishment of local land use rules, and changing economic conditions resulted in the closure of most reduction plants north of Virginia (ASMFC 1992). In 1988, ASMFC concluded that the 1981 FMP had become obsolete and initiated a revision to the plan.

The 1992 Plan Revision included a suite of objectives to improve data collection and promote awareness of the fishery and its research needs (ASMFC 1992). Under this revision, the menhaden program was directed by the Board, which at the time was composed of up to five state directors, up to five industry representatives, one representative from the National Marine Fisheries Service, and one representative from the National Fish Meal and Oil Association.

Amendment 1, passed in 2001, provided specific biological, social/economic, ecological, and management objectives for Atlantic menhaden. No recreational or commercial management measures were implemented as a result of Amendment 1. Representation on the Board was also revised in 2001 to include three representatives from each state in the management unit, including the state fisheries director, a legislator, and a governor's appointee. This restructuring brought the Board's composition in line with others at the Commission. The reformatted Board has passed two amendments and six addenda to the 1992 FMP revision.

Addendum I (2004) addressed biological reference points for menhaden, specified the frequency of stock assessments to be every three years, and updated the habitat section of the FMP.

Addendum II (2005) instituted a harvest cap on the reduction fishery in the Chesapeake Bay. This cap, based on average landings from 2000-2004, was established for the 2006 through 2010 fishing seasons. Addendum II also outlined a series of research priorities to examine the possibility of localized depletion of Atlantic menhaden in the Chesapeake Bay. They included: determining menhaden abundance in Chesapeake Bay; determining estimates of removal of menhaden by predators; exchanging of menhaden between bay and coastal systems; and conducting larval studies.

Addendum III (2006) revised the Chesapeake Bay Reduction Fishery Cap to 109,020 metric tons, which is an average of landings from 2001-2005. Implementation of the cap remained for the 2006 through 2010 fishing seasons. Addendum III also allowed a harvest underage in one year to be added to the next year's quota. As a result, the maximum cap in a given year was extended to 122,740 metric tons.

Addendum IV (2009) extended the Chesapeake Bay harvest cap three additional years (2011-2013) at the same levels as established in Addendum III.

Addendum V (2011) established a new F threshold and target rate based on maximum spawning potential (MSP) with the goal of increasing abundance, spawning stock biomass, and menhaden availability as a forage species.

Amendment 2, approved in December 2012, established a 170,800 metric ton (mt) total allowable catch (TAC) for the commercial fishery beginning in 2013. This TAC represented a 20% reduction from average landings between 2009 and 2011. The 2009-2011 time period was also used to allocate the TAC among the jurisdictions. In addition, the Amendment established requirements for timely reporting and required states to be accountable for their respective quotas by paying back any overages the following year. The amendment included provisions that allowed for the transfer of quota between jurisdictions and a bycatch allowance of 6,000 pounds per trip for non-directed fisheries that operated after a jurisdiction's quota has been landed. Further, it reduced the Chesapeake Bay reduction fishery harvest cap by 20% to 87,216 metric tons.

At its May 2015 meeting, the Board established an 187,880 mt TAC for the 2015 and 2016 fishing years. This represents a 10% increase from the 2013 and 2014 TAC. In October 2016, the Board approved a TAC of 200,000 mt for the 2017 fishing year, representing a 6.45% increase from the 2015 and 2016 fishing years.

In August 2016, the Board approved Addendum I which added flexibility to the current bycatch provision by allowing two licensed individuals to harvest up to 12,000 pounds of menhaden bycatch when working together from the same vessel using stationary multi-species gear. The intent of this Addendum was to accommodate cooperative fishing practices which traditionally take place in the Chesapeake Bay.

In May 2013, the Board approved Technical Addendum I which established an episodic events set aside program. This program set aside 1% of the coastwide TAC for the New England States (Maine through Connecticut) to harvest Atlantic menhaden when they occur in higher abundance than normal. In order to participate in the program, a state must reach its individual quota prior to September 1, require daily harvester reporting, and implement a trip limit no greater than 120,000 pounds. At its October 2013 meeting, the Board extended the episodic event set aside program through 2015, adding a re-allocation provision that distributes unused set aside as of October 31 to all states based on the same allocation percentages included in Amendment 2. At its May 2016 meeting, the Board again extended the episodic events program until final action on Amendment 3 and added New York as an eligible state to harvest under the program.

At its February 2014 meeting, the Board passed a motion to manage the menhaden cast net fisheries under the bycatch allowance for 2014 and 2015, with the states bearing responsibility for reporting. At its November 2015 meeting, the Board approved a motion to continue the management of cast net fisheries under the bycatch allowance for 2016. In February 2017, the Board extended management of the cast net fishery under the bycatch provision until implementation of Amendment 3.

2.2 PURPOSE AND NEED FOR ACTION

The 2015 Atlantic Menhaden Benchmark Stock Assessment and Peer Review Report categorized the development of ERPs as a high priority for management of the species. Currently, the stock is assessed with single-species biological reference points, which are defined in the 2015 Stock Assessment. While the stock assessment accounts for natural mortality, this factor alone may not adequately account for the unique and significant ecological services that menhaden provide, or how changes in the population of predator species may impact the abundance of menhaden. ERPs are intended to consider the multiple roles that menhaden play, both in supporting fisheries for human use and their role in the marine ecosystem.

In addition, Amendment 2 requires quota allocations to be revisited every three years. The Atlantic menhaden quota is currently allocated to Atlantic coast jurisdictions based on average landings between 2009 and 2011. In revisiting the allocations, the Board decided to investigate different allocation methods and timeframes given concerns that the current allocation method does not strike a balance between gear types and regions, as well as current and future harvest opportunities. Some states have also expressed concerns about unreported landings during the baseline years and the administrative burden of managing small allocations, the cost of which may outweigh the value of the fishery they are allocated.

In order to consider the implementation of ERPs as well as changes to the allocation method and timeframe, the Board should consider changes in the management tools used to regulate the fishery.

2.3 GOAL

Amendment 3 to the Interstate Fishery Management Plan for Atlantic Menhaden replaces Amendment 2 to the 1981 FMP for Atlantic Menhaden.

The goal of Amendment 3 is to manage the Atlantic menhaden fishery in a manner which equitably allocates the resource's ecological and economic benefits between all user groups. The primary user groups include those who extract and utilize menhaden for human use, those who extract and utilize predators which rely on menhaden as a source of prey, and those whose livelihood depends on the health of the marine ecosystem. Pursuit of this goal will require a holistic management approach which allocates the resource in a method that is biologically, economically, and socially sound in order to protect the resource and those who benefit from it.

2.4 OBJECTIVES

The following objectives are intended to support the goal of Amendment 3.

- Maintain the Atlantic menhaden stock at levels which sustain viable fisheries and support predators which depend on the forage base.
- Ensure sufficient menhaden spawning stock biomass to prevent stock depletion and recruitment failure.
- Construct regulations based on the best available science and coordinate management efforts among the Atlantic coast jurisdictions.
- Develop a management program which ensures fair and equitable access to the fishery for all regions and gear types.

- Support a greater understanding of menhaden biology and multi-species interactions that may bear upon predator-prey dynamics.
- Maintain existing culture and social features of the fishery to the extent possible.

2.5 MANAGEMENT UNIT

The management unit for Amendment 3 is defined as the range of Atlantic menhaden within U.S. waters of the northwest Atlantic Ocean, from the estuaries eastward to the offshore boundary of the Exclusive Economic Zone (EEZ). This definition is consistent with recent stock assessments which treat the entire resource in U.S. waters of the northwest Atlantic as a single stock.

2.5.1 Management Area

The management area for Amendment 3 shall be the entire Atlantic coast distribution of the resource from Maine through Florida.

2.6 REFERENCE POINTS

2.6.1 History of Reference Points

2.6.1.1 Amendment 1 Reference Points

The reference points outlined in Amendment 1 (2001) were developed from the historic spawning stock per recruit (SSB/R) relationship. As such, F_{REP} was selected as the $F_{threshold}$, representing replacement level of stock, and F_{target} was based on F_{MAX}, representing the maximum fishing mortality before the process of recruitment overfishing begins. The Board also adopted a spawning stock biomass target, a proxy for B_{MSY} (the biomass that allows the fish stock to produce maximum sustainable yield), and a spawning stock biomass threshold.

2.6.1.2 Addendum 1 Reference Points

Based on the 2003 Benchmark Stock Assessment for Atlantic menhaden, the reference points were modified per the recommendation of the TC (ASMFC 2004). The TC recommended using population fecundity (number of maturing or ripe eggs) as a more direct measure of reproductive output of the population compared to spawning stock biomass (the weight of mature females). For Atlantic menhaden, older menhaden release more eggs than younger menhaden per unit of female biomass. By using the number of eggs released, more reproductive importance is given to older fish in the population. The TC also recommended modifications to the fishing mortality (F) target and threshold. Specifically, the TC recommended continued use of F_{REP} as the $F_{threshold}$, but estimated it using fecundity per recruit rather the SSB per recruit. They also recommended that the F_{target} be based on the 75th percentile. This approach was consistent with the approach used for the $F_{threshold}$. For biomass (or egg) benchmarks, the TC recommended maintaining the approach used in Amendment 1.

2.6.1.3 Addendum V Reference Points
In November 2011, Addendum V was approved, which established an interim fishing mortality threshold of $F_{15\%MSP}$ and target of $F_{30\%MSP}$, where MSP is the maximum spawning potential.

2.6.1.4 Amendment 2 Reference Points
The Board adopted an interim biomass threshold of $SSB_{15\%MSP}$ and target of $SSB_{30\%MSP}$ to match the interim fishing mortality reference points adopted through Addendum V.

2.6.1.5 2015 Benchmark Stock Assessment Reference Points
As a part of the 2015 Stock Assessment, the TC recommended that the Board adopt reference points based on the maximum and median geometric mean fishing mortality rate for ages 2-4 during 1960-2012. The 1960-2012 time period represents a time with little to no restrictions on total harvest in which the population appears to have been sustainable given that the population did not experience collapse. Because the fisheries have dome-shaped selectivity, which varies by fleet over time, the age at full fishing mortality changes over time. Ages 2-4 represent the ages of fully selected fishing mortality rates depending upon the year and fishery (i.e., bait and reduction). The Board accepted these updated reference points following approval of the 2015 Stock Assessment for management use.

2.6.1.6 2017 Stock Assessment Update
Using the method outlined in the 2015 Stock Assessment (*Section 2.6.1.5*), the 2017 Stock Assessment Update determined the overfishing threshold and target to be $F_{21\%MSP}$ and $F_{36\%MSP}$, respectively. The overfished threshold and target were calculated to be $FEC_{21\%MSP}$ and $FEC_{36\%MSP}$, respectively.

2.6.2 ASMFC Multi-Species Management Efforts

In May 2010, the Board tasked the Multi-Species Technical Committee (MSTC), along with the Atlantic Menhaden TC, with developing alternative reference points for menhaden that account for predation. These groups led to a reformation of the subcommittee that updated and refined the Multispecies Virtual Population Analysis (MSVPA). The MSVPA-X model generated a natural mortality matrix which could be input to the single-species menhaden assessment. While this approach was attempted for several Atlantic menhaden stock assessments, the Board tasked this group with developing ERPs for menhaden using multispecies models. This joint subcommittee was eventually renamed the Biological Ecological Reference Points Workgroup (BERP Workgroup) because model consideration for the Board task expanded beyond the MSVPA. The overarching goal of the BERP Workgroup is to develop menhaden-specific ERPs that account for the abundance of menhaden and the species role as a forage fish.

In the *Ecological Reference Points for Atlantic Menhaden* report, the BERP Workgroup presented a suite of preliminary ERP models and ecosystem monitoring approaches for feedback as part of the 2015 Benchmark Stock Assessment (Appendix E, SEDAR 40 Stock Assessment Report). In this report, the BERP Workgroup recommended the use of facilitated workshops to develop specific ecosystem and fisheries objectives to drive further development of ERPs for Atlantic menhaden. This Ecosystem Management Objectives Workshop (EMOW) contained a broad range of representation including Commissioners, stakeholders, and technical representatives to provide various perspectives on Atlantic menhaden management. The EMOW identified potential ecosystem goals and objectives that were reviewed and approved by the Board. The BERP Workgroup then assessed the ability of each preliminary ERP model to address the identified management objectives and performance measures, and selected models accordingly.

Currently, the BERP Workgroup is evaluating this suite of multispecies models to ensure they are able to generate ERPs which meet as many management objectives as possible. One of the models under consideration is a Bayesian surplus production model with a time-varying population growth rate. This model estimates the trend in total Atlantic menhaden stock biomass and fishery exploitation rate by allowing the population growth rate to fluctuate annually in response to changing environmental conditions. The approach produces dynamic, maximum sustainable yield-based ERPs that account for the forage services menhaden provide. Another production model being evaluated is a Steele-Henderson model, which permits non-fisheries effects (predation and environmental) to be quantified and incorporated into the single-species stock assessments. As a result, fixed and time-varying ecological thresholds can be estimated. This approach is not intended to replace more complex multispecies ecosystem assessment models, but rather to expand the scope of the single-species assessments to include the effects of fishing, predation, and environmental effects. Finally, a multispecies statistical catch-at-age model is being considered. In this approach, single-species models are linked using trophic calculations to provide a predator-prey feedback between the population models. The model is believed to be an improvement from the existing MSVPA because the use of statistical techniques may help to estimate many of the model parameters while incorporating the inherent uncertainty in the data. An external model being considered is an Ecopath with Ecosim model; however, the application of this model is to explore tradeoffs, not quota setting advice. For example, this model could be used to project fishery performance under the various reference points produced from the other multi-species models.

The development of menhaden-specific ERPs is expected to continue over the next couple of years. In 2017, the BERP Workgroup will finish their review of the merits of each modeling approach and decide which models are appropriate frameworks for menhaden ERPs. In 2018, the BERP Workgroup will hold data workshops to collect, select, and standardize the data that will be used as model inputs. This will include data that pertains not only to menhaden abundance but also the abundance of species such as bluefish, striped bass, and other prey species. In early 2019, assessment workshops will be held to review preliminary model results and in the fall of 2019, the multi-species models will be peer-reviewed, along with the current single-species model, which has traditionally been used for menhaden management. This will allow for direct comparison between the two modeling approaches. Table 18 outlines the current schedule for the BERP Workgroup.

2.6.3 External Guidelines for the Management of Forage Fish

In addition to the menhaden-specific ERPs, which are being developed by the BERP Workgroup, there are also precautionary guidelines for developing ERPs for forage fish in general. These guidelines are based on a series of models that look at a variety of forage fish species across diverse ecosystems. An advantage of these guidelines is that they are readily available for use and provide a precautionary approach to the management of forage fish. However, given they are based on a variety of species and regions, the guidelines are not specific to the Atlantic menhaden stock and, as a result, make generalizations regarding stock recruit relationships and the prevalence of menhaden in predator diets.

One guideline for the management of forage fish species is the 75% rule-of-thumb, which recommends that forage fish populations be maintained at three-fourths of their unfished biomass levels to lower impacts on marine ecosystems (Smith et al., 2011). The peer-reviewed analysis investigated five regions around the world to determine ecosystem impacts of fishing low trophic level species. While results varied among forage fish species, in general, the analysis found that the proportion of ecological groups impacted increased with the depletion of forage fish. Relative abundance of the forage fish species in comparison to other prey species and food web connectivity were found to be important factors in determining the level of impact on other ecological groups. The study concluded that a target of 75% unfished biomass for forage fish species would reduce impacts on other species while maintaining fisheries yields at roughly 80% of their current levels. Menhaden was not a species included in this study.

The Lenfest Ocean Program, a grant-making program managed by The Pew Charitable Trusts, has also developed guidelines for the development of forage fish ERPs. In their 2012 report by Pikitch et al., Lenfest describes how they used a suite of 10 previously published Ecopath with Ecosim models to assess the impacts of forage fish harvest on a variety of ecosystems. The Chesapeake Bay was a region modeled in this analysis. Various management strategies which specify fishing mortality were run in the Ecopath with Ecosim models to determine impacts on predator populations. From these results, a general equation was developed to predict predator responses to forage fish harvest. The analysis recommends a hockey stick control rule in which fishing mortality is dependent on stock size but would not exceed half of the forage species natural mortality rate. Maximum allowable fishing mortality would occur when the stock is at carrying capacity (unfished biomass) and F declines linearly to zero when biomass falls below 40% of unfished biomass. This report was reviewed by three external reviewers; however, the full report has not been reviewed by a scientific journal.

Although generalized forage fish models may provide interim guidance on how to manage menhaden while ERPs are developed, some contend that harvest policies for lower trophic level species should be based on models specific to the species of interest, even in the interim. Hilborn et al. (2017) investigated eleven species of U.S. forage fish, including Atlantic menhaden, to determine what factors should be analyzed when assessing the impacts of fishing lower trophic level species on predators. Given spawner-recruit data indicates good year classes can come from both small and large stock sizes, Hilborn et al. (2017) states that recruitment is likely dependent on environmental conditions and stock abundance may be variable even in the absence of fishing. Further, the paper states that precautionary guidelines may not consider the size of prey eaten by various predator species, versus those that are harvested by the fishery. Hilborn et al. (2017) also notes that the spatial distribution of forage fish in relation to the location of predators may be a critical factor, particularly if there are 'core' areas of forage fish abundance on which predators are dependent. As a result, Hilborn et al. (2017) contends that harvest control strategies should include these factors (i.e. natural variability of forage fish abundance, size selectivity of predators, spatial distribution of forage fish) when assessing the impact of forage fish harvest on predator species.

In summary, there is varied advice on how to manage forage fish species. While some support the use of precautionary guidelines to manage forage fish until ERPs can be developed, others contend that species-specific models are needed to account for natural population variability and changes in spatial distribution.

2.6.4 Definition of Overfishing and Overfished/Depleted

The Board will evaluate the current status of the Atlantic menhaden stock with respect to its reference points. Changes to the reference points can be made through Board action following a peer-reviewed stock assessment or through Adaptive Management (*Section 4.6*). The Board can adopt any advice of the stock assessment report or peer review report. Reference points can be recalculated during an update or benchmark stock assessment.

Threshold reference points are the basis for determining stock status (i.e., whether overfishing is occurring or if a stock is overfished). When the fishing mortality rate (F) exceeds the $F_{threshold}$, then overfishing is occurring. This means that the rate of removal of fish by the fishery exceeds the ability of the stock to replenish itself. When the biomass or reproductive output (measured as population fecundity) falls below the threshold, then the stock is overfished, meaning there is insufficient mature female biomass or egg production to replenish the stock.

Reference points will direct the Board on when additional management measures are needed in the menhaden fishery. If the current F exceeds the threshold level, the Board will take steps to reduce F to the target level. If current F exceeds the target, but is below the threshold, the Board may consider steps to reduce F to the target level. If current F is below the target F, then no action is necessary to reduce F. Similarly, if the current biomass/fecundity is below the threshold level, the Board will take steps to increase biomass/fecundity to the target level; if current biomass/fecundity is below the target, but above the threshold, the Board may consider steps to increase biomass/fecundity to the target level. If current biomass/fecundity is above the target biomass/fecundity, then no action is necessary to increase biomass/fecundity.

<u>Option A: Single-Species Reference Points</u>
Single-species reference points are used to manage the Atlantic menhaden fishery. Single-species reference points for the Atlantic menhaden population are based on the maximum and median geometric mean fishing mortality rate for ages 2-4 during 1960-2012. Using this

method, the 2017 Stock Assessment Update found the fishing mortality target and threshold for Atlantic menhaden to be $F_{36\%MSP}$ and $F_{21\%MSP}$ and the corresponding fecundity target and threshold for Atlantic menhaden to be $FEC_{36\%MSP}$ and $FEC_{21\%MSP.}$ As of 2016, the terminal year of the 2017 Stock Assessment Update, the stock is not overfished and overfishing is not occurring (Table 1). Under this option, the development of ERPs would not be pursued.

Option B: BERP Workgroup Continues to Develop Menhaden-Specific ERPs with Interim Use of Single-Species Reference Points

Under this option, single-species reference points are used to manage the Atlantic menhaden fishery while the BERP Workgroup continues to develop menhaden-specific ERPs. The single-species reference points used in the interim match those described above in Option A. As of 2016, the terminal year of the 2017 Stock Assessment Update, the stock is not overfished and overfishing is not occurring (Table 1). The expected timeline for completion of ERPs is late 2019, as outlined in *Section 2.6.2*.

Option C: BERP Workgroup Continues to Develop Menhaden-Specific ERPs with Interim Use of Pikitch et al. Reference Points

Under this option, a hockey stick harvest control rule is used to manage the Atlantic menhaden fishery while the BERP Workgroup continues to develop menhaden-specific ERPs. Under the hockey stick control rule, fishing mortality does not exceed one half of the natural mortality rate when stock size is equal to unfished biomass. As the biomass decreases from B_0 (unexploited biomass), the fishing rate linearly decreases along the control rule. If biomass falls below 40% unfished biomass ($B/B_0<0.4$), fishing is prohibited. Figure 1 shows the hockey stick control rule applied to Atlantic menhaden. Current biomass from the 2017 Stock Assessment Update is $B/B_0=0.467$, which is above the biomass threshold of $B/B_0=0.4$. As a result, the stock is not overfished. Should biomass fall below $B/B_0=0.4$, fishing would stop and a moratorium would be put in place. The target fishing mortality rate corresponding to current biomass ($B/B_0=0.467$) is 0.041. As of the terminal year of the 2017 Stock Assessment Update, the current fishing mortality rate is $F_{2016}=0.204$. This is above the fishing mortality rate recommended by the hockey-stick control rule but below the threshold of F=1/2M=0.367. This would indicate that fishing is higher than it should be at current biomass levels and a TAC should be set with the goal of achieving F=0.041.

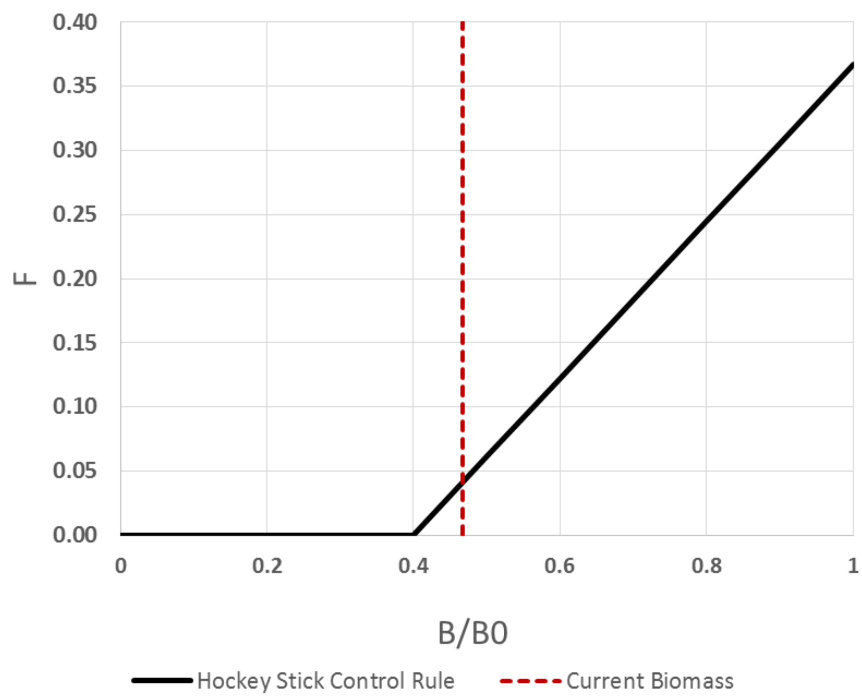

Figure 1: The Pikitch et al. (2012) hockey stick harvest control rule applied to Atlantic Menhaden. The black line represents the control rule and is defined by the points ($B=B_0$, $F=0.5M$) and ($B=0.4*B_0$, $F=0$), where B_0 is the unexploited biomass. When biomass falls below 40% unfished biomass, fishing is prohibited and the black line is horizontal. The red dotted line represents the current biomass as of the 2017 Stock Assessment Update. The red dotted line intersects the black line at ($B/B_0=0.467$, $F=0.041$).

<u>Option D: BERP Workgroup Continues to Develop Menhaden-Specific ERPs with Interim Use of 75% Rule of Thumb</u>

Under this option, the 75% rule of thumb is used to manage the Atlantic menhaden fishery while the BERP Workgroup continues to develop menhaden-specific ERPs. Under the 75% rule of thumb, a fishing mortality rate is established to achieve 75% unfished biomass per recruit. Based on results of the 2017 Stock Assessment Update, the fishing mortality rate that achieves the 75% unfished biomass is F=0.160. As of 2016, the terminal year of the 2017 Stock Assessment Update, $F_{2016}=0.204$ which is above this reference point (Table 1), indicating a reduction in fishing mortality would be needed.

<u>Option E: BERP Workgroup Continues to Develop Menhaden-Specific ERPs with Interim Use of 75% Target, 40% Threshold</u>

Under this option, a F_{target} that achieves 75% unfished biomass and a $F_{threshold}$ which achieves 40% unfished biomass are used to manage the Atlantic menhaden fishery while the BERP Workgroup continues to develop menhaden-specific ERPs. Based on results of the 2017 Stock Assessment Update, the F_{target} that achieves 75% unfished biomass is 0.160, and the $F_{threshold}$ that achieves 40% unfished biomass is 1.493. As of the terminal year of the 2017 Stock

Assessment Update, F_{2016}=0.204, which is above the target but below the threshold (Table 1), indicating overfishing is not occurring.

Table 1: Reference point alternatives presented in Options A through E and the current F-based reference points for the terminal year of the 2017 Stock Assessment Update. The single-species reference point values shown in this table are reported in a different currency then those reported in the Assessment Update report so that the various reference point options can be compared on a common scale. More specifically, all fishing mortality rates in the table are averaged over total biomass (includes ages 0 through 6) and weighted by age. In contrast, the single-species reference point values shown in *Section 1.2.3: Current Stock Status* are based on the geometric mean fishing mortality rates for ages 2-4.

Reference Point	Fishing Mortality Rule	Resulting Biomass-Weighted F
Single-species reference points (Options A and B)	$F=F_{21\%MSP}$	1.164 (threshold)
	$F=F_{36\%MSP}$	0.408 (target)
Pikitch et al. reference points (Option C)	F=0.5M	0.367 (threshold)
	F at current B/B_0	0.041 (target)
75% rule of thumb (Option D)	$F=F75\%B_0$	0.160
75% target with 40% threshold (Option E)	$F=F40\%B_0$	1.493 (threshold)
	$F=F75\%B_0$	0.160 (target)
Current status	F_{2016}	0.204

2.6.4 Stock Rebuilding Program

If it is determined that the Atlantic menhaden resource is experiencing overfishing or has become overfished, the Board will initiate and develop a rebuilding schedule.

3.0 MONITORING PROGRAM SPECIFICATION

In order to achieve the goals and objectives of Amendment 3, the collection and maintenance of quality data is necessary.

3.1 COMMERCIAL CATCH AND LANDINGS PROGRAM

The reporting requirements for the Atlantic menhaden fishery are based on Captains Daily Fishing Reports (CDFRs) and a Board approved method for timely quota monitoring (*Section 3.1.2*). ASMFC, National Marine Fisheries Service (NMFS), US Fish & Wildlife Service (USFWS), the New England, Mid-Atlantic, and South Atlantic Fishery Management Councils, and all the Atlantic coastal states have developed a coastwide fisheries statistics program called the Atlantic Coastal Cooperative Statistics Program (ACCSP). A minimum set of reporting requirements for fishermen and dealers has been developed as the standard for data collection on the Atlantic coast.

3.1.1 Reduction Fishery Catch Reporting Process

Daily vessel unloads (in thousands of standard fish) are emailed to NMFS each day. Harvest by the Reedville menhaden fleet is reported through Captains Daily Fishing Reports (CDFRs), which are deck logbooks that are maintained by the Virginia reduction purse-seine vessels. CDFRs are an important tool to monitor reduction harvest in the Chesapeake Bay so that harvest does not exceed the Chesapeake Bay Reduction Fishery Cap (*Section 4.3.7*).

Total removals by area are calculated at the end of the fishing season. At-sea catches from the CDFRs are summed by vessel, and compared to total vessel unloads from company catch records. Individual at-sea sets are then multiplied by an adjustment factor (company records/ at-sea estimates). Adjusted catches by set are converted to metric tons, and summed by fishing area. Catch totals are reported by ocean fishing areas and the Chesapeake Bay Bridge Tunnel delineates catches inside and outside of the Chesapeake Bay.

A NMFS port agent samples purse-seine catches dockside in Reedville, VA throughout the fishing season (May through December), providing data for age composition determination.

3.1.2 Bait Fishery Catch Reporting Process

Quota monitoring, whether for a state, region, coast, fleet, or sector is dependent upon the strength of state specific monitoring programs. As a part of Amendment 2, each state was required to implement a timely quota monitoring system in order to maintain menhaden harvest within the TAC and minimize the potential for overages. Table 19 outlines the reporting requirements of each jurisdiction under Amendment 2.

In order to monitor the menhaden quota allocations prescribed in Amendment 3, states must, at a minimum, maintain the current quota monitoring system in place. States must require menhaden purse seine and bait seine vessels (or snapper rigs) to submit CDFR's or similar daily trip level reports. Mandatory reporting requirements will be reviewed as a part of the annual fishery review (*Section 5.3 Compliance Reports*). States which habitually exceed their quota should assess the effectiveness of their current reporting program and make changes as necessary (e.g. increase the frequency of reporting). It is recommended that states collect the following ACCSP data elements: (1) trip start date; (2) vessel identifier; (3) individual fisherman identifier; (4) dealer identification; (5) trip number; (6) species; (7) quantity; (8) units of measurement; (9) disposition; (10) county or port landed; (11) gear; (12) quantity of gear; (13) number of sets; (14) fishing time; (15) days/hours at sea; (16) number of crew; and (17) area fished. See Tables 20 and 21 for details on these data elements.

If an allocation method is implemented which does not have a jurisdictional component, states must work to report landings via the Standard Atlantic Fisheries Information System (SAFIS). Specifically, menhaden landings must be reported through SAFIS so that regional, fleet, disposition, or coastwide quotas may be monitored in near real-time. SAFIS is an electronic platform which allows fishermen and dealers to submit commercial landings reports into a single database. This system, which meets ACCSP data standards, allows managers to monitor landings and appropriately respond when a quota is met. It also fulfils state and federal reporting requirements, and allows fishermen and dealers to access previous data submissions. States may choose to implement either a one ticket or two ticket system; however, the system must be comprehensive to all fishermen who are required to report through SAFIS. Reports should include: date, species landed, quantity landed, units of measure, disposition (bait or reduction), state landed, and gear type. Gear type will be critical if a fleet-capacity option is chosen. It is recommended that trip-level reports be submitted to SAFIS, at a minimum, on a weekly basis. Fleets which are managed under a soft cap do not have to report landings to SAFIS; however, states must monitor these landings and report them as part of the Annual Compliance Report.

For jurisdictions which have a statutory requirement that landings be submitted to the state, landings reports may be subsequently uploaded to SAFIS following reporting to the state. If a state is unable to implement SAFIS reporting by the start of the 2018 fishing year, that state must submit landings reports to ASMFC so that a regional, fleet, sector, or coastwide quota may be monitored in 2018. All states must implement SAFIS reporting by 2019. Per *Section 4.5.3.1*, New Hampshire, Pennsylvania, South Carolina, and Georgia are exempt from timely quota monitoring and are not required to report through SAFIS.

Any changes to a state's current quota monitoring program must be reviewed by the PDT and approved by the Board.

3.1.2.1 Incidental Catch Reporting

Landings of menhaden under *Section 4.3.5: Incidental Catch and Small Scale Fisheries* must be reported as a part of the Annual Compliance Report. Landings of menhaden after the directed fishery has closed are required to be reported through the timely reporting system outlined in *Section 3.1.2*. The exception to this rule is if Option E: Small-Scale Fishery Set Aside is implemented; under this option, landings by small-scale gears are not required to be reported to SAFIS, but states must monitor landings and report them as a part of the Annual Compliance Report.

3.1.2.2 Episodic Events Reporting

States participating in the Episodic Events Program (*Section 4.3.6*) must implement daily trip level harvester reporting. Each state must track landings, either through state landings reports or SAFIS, and submit weekly reports to ASMFC staff. As the set aside is used, staff may request states submit reports on a more frequent basis, in order to avoid overages.

3.2 RECREATIONAL FISHERY CATCH REPORTING PROCESS

The Marine Recreational Information Program (MRIP) contains estimated Atlantic menhaden catches from 1981-2016. Recreational harvest of menhaden was previously collected through the Marine Recreational Fisheries Statistics Survey (MRFSS), which was a recreational data collection program used from 1981-2003. The MRFSS program was replaced by MRIP in 2004 and was designed to provide more accurate and timely reporting as well as greater spatial coverage. The MRFSS and MRIP programs were simultaneously conducted in 2004-2006 and this information was used to calibrate past MRFSS recreational harvest estimates against MRIP recreational harvest estimates. Recreational catches of menhaden were downloaded from http://www.st.nmfs.noaa.gov/st1/recreational/queries/index.html using the query option.

An online description of MRIP survey methods can be found here: http://www.st.nmfs.noaa.gov/recreational-fisheries/index#meth

3.3 FOR-HIRE FISHERY CATCH REPORTING PROCESS

ACCSP standards allow for the use of MRIP for-hire sampling or a census system such as ACCSP's eTrips. For-hire sampling provides bimonthly data but eTrips can provide data within a 24-hour period.

3.4 SOCIAL AND ECONOMIC COLLECTION PROGRAMS

Data on a number of variables relevant to social and economic dimensions of menhaden fisheries are collected through existing ACCSP data collection programs and MRIP; however, no explicit mandates to collect socioeconomic data for menhaden currently exist. In addition to landed quantities, commercial menhaden harvesters and dealers may report ex-vessel prices or value, fishing and landing locations, landing disposition, and a variety of measures capturing fishing effort. MRIP regularly collects information on recreational fishing effort and landings, and occasionally gathers socioeconomic data on angler motivations and expenditures; however, menhaden which are caught and then subsequently used as recreational bait are not always effectively captured in the survey.

A recent socioeconomic study of commercial menhaden fishery was conducted to collect information on the bait and reduction sectors and help inform management decisions (Whitehead and Harrison 2017). As a part of the study, researchers interviewed 43 industry members from both the bait and reduction fisheries to better understand gear usage, substitute products, market changes, and fishing community characteristics. Those interviewed include commercial fishermen, bait dealers, bait shop owners, and reduction facility managers. The study also performed county level, state-level, and coastwide analysis on menhaden landings and ex-vessel value to determine socioeconomic trends in the fishery. In addition, an economic impact analysis was conducted to determine effects (including direct, indirect, and induced impacts) from changes to the TAC. Finally, a public opinion survey was conducted in eight states to determine the public's tradeoff between economic increases and ecosystem services. Over 2,000 members of the public participated in the survey.

While this socio-economic study helped provided a more complete picture of the menhaden commercial fishery, information on factors such as fishing costs, employment levels, processing and distribution are not collected regularly for commercial menhaden fisheries. This information would be useful for future socioeconomic analyses.

3.5 BIOLOGICAL DATA COLLECTION PROGRAMS

3.5.1 Fishery-Dependent Data Collection

3.5.1.1 Reduction Fishery
The Beaufort Laboratory of the Southeast Fisheries Science Center conducts biological sampling of the Atlantic menhaden reduction fishery (Smith 1991). The program began sampling in the Mid-Atlantic and Chesapeake Bay areas during 1952-1954 and has continued uninterrupted since 1955, sampling the entire range of the Atlantic menhaden purse-seine reduction fishery. Detailed descriptions of the sampling procedures and estimates gathered through the program are cited in Smith (1991).

The biological data, or port samples, for length- and weight-at-age are available from 1955 through 2016, and represents one of the longest and most complete time series of fishery data in the nation. The NMFS employs a full-time port agent at Reedville, VA to sample catches throughout the fishing season for age and size composition of the reduction catch (Table 22).

3.5.1.2 Bait Fishery
10 Fish Sampling
Each state in the New England (ME, NH, MA, RI, CT) and Mid-Atlantic (NY, NJ, DE) regions are required to collect one 10-fish sample (age and length) per 300 metric tons landed for bait purposes. The TC recommends collecting the samples by gear type. One 10-fish sample consists of 10 fish collected from a distinct landing event (e.g., purse seine trip, pound net set). Each collection of 10 fish is from an independent sampling event; multiple 10-fish samples should not be collected from the same landing event.

Each state in the Chesapeake Bay (MD, PRFC, VA) and South Atlantic (NC, SC, GA, FL) regions are required to collect one 10-fish sample (age and length) per 200 metric tons landed for bait purposes. The TC recommends collecting the samples by gear type. One 10-fish sample consists of 10 fish collected from a distinct landing event (e.g., purse seine trip, pound net set). Each collection of 10 fish is an independent sampling event; multiple 10-fish samples should not be collected from the same landing event.

De minimis states are not required to conduct fishery-dependent biological sampling in the menhaden fishery (*Section 4.5.3: De Minimis Fishery Guidelines*).

Table 23 shows the number of 10-fish samples collected by the jurisdictions in 2016 as well as the number of age and length samples collected.

Pound Net Monitoring
Catch information from pound net fisheries is critical to determine changes in the relative abundance of adult menhaden along the east coast. At a minimum, each state with a pound net fishery must collect catch and effort data elements for Atlantic menhaden including total pounds (lbs) landed per day and number of pound nets fished per day. A pound net fishery includes floating fish traps and fishing weirs. These are harvester trip level ACCSP data

requirements. In order to characterize selectivity of this gear in each state, a goal of collecting five 10-fish samples annually is recommended. One 10-fish sample consists of 10 fish collected from a distinct landing event (e.g., pound net set). Each collection of 10 fish is an independent sampling event; multiple 10-fish samples should not be collected from the same landing event.

3.5.2 Fishery-Independent Data Collection

Assessment of the Atlantic menhaden stock requires information from a variety of fishery-independent surveys along the coast. As a part of the 2015 Benchmark Stock Assessment and the 2017 Stock Assessment Update, sixteen fishery-independent surveys were used to create a Juvenile Abundance Index, seven surveys were used to create a Northern Adult Index, and two surveys were used to create a Southern Adult Index. For many of the surveys used, the primary objective is to measure the abundance of species other than menhaden; however the bycatch of menhaden in these surveys can provide important information regarding stock conditions. Table 24 shows the surveys used to assess the status of Atlantic menhaden in the 2015 and 2017 stock assessments. State and federal agencies and academic institutions conducting these surveys are encouraged to continue them into the future to allow for the best possible assessment of Atlantic menhaden recruitment.

3.5.3 Observer Programs

As a condition of state and/or federal permitting, many vessels are required to carry at-sea observers when requested. A minimum set of standard data elements are to be collected through the ACCSP at-sea observer program (refer to the ACCSP Program Design document for details). Specific fisheries priorities will be determined by the Discard/Release Prioritization Committee of ACCSP.

3.6 ASSESSMENT OF STOCK CONDITION

An Atlantic menhaden stock assessment will be performed every three years by the Stock Assessment Subcommittee (SASC). The TC and Advisory Panel (AP) will meet to review the stock assessment and all other relevant data sources. The stock assessment report shall follow the general outline as approved by the Interstate Fisheries Management Program Policy Board (ISFMP Policy Board) for all Commission-managed species. In addition to the general content of the report as specified in the outline, the stock assessment report may also address the specific topics detailed in the following sections. Specific topics in the stock assessment may change as the SASC continues to provide the best model and metrics possible to assess the Atlantic menhaden stock.

3.6.1 Assessment of Population Age/Size Structure

Estimates of Atlantic menhaden age and size structure are monitored based on results of the stock assessment. Improvements to data sources and modeling assumptions during the 2015 Benchmark Stock Assessment, such as increased sampling of the bait fishery, addition of several surveys, and incorporation of dome shaped selectivity, greatly improved the understanding of size and age distribution of the menhaden stock.

3.6.2 Assessment of Annual Recruitment

Recruitment of Atlantic menhaden is currently estimated through two primary methods. The first is the estimate of recruitment to age-1 from the stock assessment model. The second is the examination of various fishery-independent data sources, including the juvenile abundance indices that are integrated in to the statistical modeling process.

3.6.3 Assessment of Fecundity

Population fecundity, a measure of total egg production by the population, is estimated from the stock assessment model every three years. Given egg production is not linearly related to female weight, indices of egg production may provide a better measures of reproductive output of a stock.

3.6.4 Assessment of Fishing Mortality

Fishing mortality (F) rates are estimated by the stock assessment model. Currently, fishing mortality rates are estimated for the reduction fishery, the bait fishery, and the recreational fishery.

3.7 STOCKING PROGRAM

There is currently no stocking program in place for Atlantic menhaden.

4.0 MANAGEMENT PROGRAM

4.1 RECREATIONAL FISHERY MANAGEMENT MEASURES

No recreational fishery management measures are proposed in this amendment. Recreational landings of Atlantic menhaden are currently believed to be insignificant in terms of total harvest. Therefore, regulation of the recreational fishery is unnecessary at this time. The Board has the option of considering management changes to the recreational fishery through a future addendum, as detailed in Adaptive Management (*Section 4.6*).

4.2 FOR-HIRE FISHERIES MANAGEMENT MEASURES

No management measures for the for-hire fisheries are proposed in this amendment. The Board has the option of considering management changes to the recreational fishery through a future addendum, as detailed in Adaptive Management (*Section 4.6*).

4.3 COMMERCIAL FISHERY MANAGEMENT MEASURES

4.3.1 Total Allowable Catch

The Board will set an annual or multi-year TAC based on the following procedure.

The Atlantic Menhaden TC will annually review the best available data including, but not limited to, commercial and recreational catch/landing statistics, current estimates of fishing mortality, stock status, survey indices, assessment modeling results, and target mortality levels. The TC will calculate TAC options based on the Board selected method of setting a TAC (see *Section 4.3.1.1*). The Board will set an annual TAC through Board action, with the option of setting a multi-year TAC.

4.3.1.1 TAC Setting Method

The Board will set the TAC based on the best available science (e.g., projection analysis); however, if the projections are not recommended for use by the TC, the Board will set a quota based on an ad-hoc approach. This could include the ad-hoc approach used by the Regional Fishery Management Councils (Berkson et al., 2011) (see description below) or an ad-hoc approach that is informed by the Commission’s ongoing development of a Risk and Uncertainty Policy.

Projection Analysis Used to Set a TAC (Preferred Method)

Projection analysis is conducted to explore a range of TAC alternatives and determine the percent risk of exceeding the F_{target} or the $F_{threshold}$. Monte Carlo Bootstrap runs of the base model run are used as the basis for the projection analysis. The Board can request specific TAC levels to be explored through the projection analysis or specify the probability level of the fishing mortality rate being between the F_{target} and $F_{threshold}$. Important assumptions of the projection analysis are that it does not include structural (model) uncertainty, fisheries are assumed to continue fishing at their estimated current proportions of total effort, and mortality is assumed to occur throughout the year.

Ad-hoc Approach to Setting a TAC

Should the TC not recommend the use of projection analysis to inform the specification process, an ad hoc approach used by several regional Fishery Management Councils can be adopted. This ad-hoc method is typically used for species with poor assessment data or uncertain stock assessment results. In these situations, most Councils use their landings/catch data as the only reliable means of setting harvest limits. A document entitled “Calculating Acceptable Biological Catch for Stocks that Have Reliable Catch Data Only (Only Reliable Catch Stocks – ORCS)” was recently published, and serves as guidance to set interim removal levels under these conditions (Berkson et al., 2011).

To summarize the ORCS report; generally, an average of the last 3-5 years of landings are used to reflect recent history. A precautionary multiplier is then applied to decrement the average landings and set a harvest limit. The appropriate multiplier is cautiously decided based on factors such as life history, ecological function, stock status, and an understanding of exploitation. Typically, this multiplier can range from 0.85 to 0.25 (Table 25).

In the New England approach for Atlantic herring and red crab, the multiplier was chosen at 1.0 suggesting catch be maintained at current levels. The rationale was that the stock was not overfished and overfishing was likely not occurring. Other evidence, such as size at age, also indicated that the overall stock status was good. Further, landings were well monitored and discards of the target stock were low.

In the case of the Pacific Fishery Management Council the multiplier for coastal pelagics was set at 0.25. This number reflected the importance of herring as forage for Stellar Sea Lions and other endangered mammals, the high level of exploitation, and the fact that Pacific Herring spawn in discreet aggregations that are vulnerable to fishing.

It should be noted that the multiplier is never set at a value greater than 1.0; indicating that catch should not be allowed to increase in these uncertain situations. Table 26 provides some additional decision making framework information that goes into the choice of a multiplier.

It is also important to note that in the Council process, the Science and Statistical Committee (SSC) sets an Overfishing Limit (OFL). The Council is then charged with setting an Allowable Biological Catch (ABC) which is below the OFL. Should this process be adopted in the Atlantic menhaden fishery, the TC will recommend a multiplier to be used in the ad-hoc method. The Board can then set a TAC that is at or below the catch level.

4.3.1.2 Indecision Clause

If the Board is unable to approve a TAC for the subsequent fishing year, a TAC needs to be specified. The following putlines options should the Board not set a TAC for the subsequent fishing year by December 31st of the current year:

Option A: The TAC for the subsequent fishing year will be set at three-fourths of the TAC for the current year. For example, if the current TAC is 200,000 mt, the subsequent year's TAC would be set at 150,000 mt.

Option B: The TAC for the subsequent fishing year will be the same as the TAC for the current fishing year; however, unused quota from the current fishing year cannot be rolled over into the subsequent year and quota overages which occur in the subsequent year cannot be ameliorated through quota transfers or quota reconciliation, depending on what is chosen in *Section 4.3.3: Quota Transfers*.

Option C: The TAC for the subsequent fishing year will be the same as the TAC for the current fishing year; however, in the subsequent fishing year there will be no episodic events set aside program and no incidental catch provision (this does not include Option E: Small Scale Fishery Set Aside in *Section 4.3.5*). Should a percentage of TAC be reserved for the episodic events set aside and/or the incidental catch provision, this amount of TAC will not be redistributed to the commercial fishery based on the allocation method chosen in *Section 4.3.2*.

Option D: The TAC for the subsequent fishing year will be the same as the TAC for the current fishing year. In addition, all provisions of the current management plan (including quota transfers, quota rollovers, episodic events set aside, and incidental catch provision) will be maintained.

4.3.2 Quota Allocation

The Board must determine how to allocate the TAC among the different participants in the menhaden fishery. Once an allocation has been harvested, the directed fishery for that state, coast, region, disposition, or fleet closes. Menhaden harvest for specific gear types or states may be permitted after an allocation has been reached, depending on the management options selected in *Section 4.3.3: Quota Transfers*, *Section 4.3.5: Incidental Catch* and *Section 4.3.6: Episodic Events Set Aside Program*. Should quota not be allocated by jurisdiction, states will be required to submit trip-level reports to SAFIS for near real-time monitoring of the quota. See *Section 3.1.2 Bait Fishery Catch Reporting Process* for additional information. The Board has the authority to adjust the closure of a fishery relative to the percent of quota harvested through Board action.

To account for the various combinations of allocation methods and timeframes, the management alternatives have been divided into four tiers. A management alternative must be selected in each tier to compile a single allocation method. To achieve the current allocation method specified in Amendment 2 (status quo), the Board would select: Tier 1, Option C: None of the Above; Tier 2, Option C: None of the Above; Tier 3, Option B: Jurisdictional; and Tier 4, Option A: 2009-2011.

The first tier presents three allocation options:
- Dispositional – subdivision of the TAC between the bait and reduction fisheries
- Allocation Based on TAC level – the allocation method switches to one which is more favorable to the bait fishery when the TAC is above 212,500 mt
- None of the above – none of the options in this tier are chosen

The second tier presents three allocation options:
- Fleet Capacity – subdivision of the TAC by gear type
- Fixed Minimum – subdivision of TAC by jurisdiction but each jurisdiction gets a baseline percentage
- None of the above – none of the options in this tier are chosen

The third tier presents three allocation options:
- Coastwide – no subdivision of TAC
- Jurisdictional – subdivision of TAC by state
- Regional – subdivision of TAC by region

The fourth tier presents five timeframe options that are presented for calculating allocation percentages:

- 2009-2011 (status quo)
- 2012-2016
- 1985-2016
- 1985-1995
- Weighted (50% each to 1985-1995 and 2012-2016)

Allocation percentages for the various options can be found in Tables 2-12.

Tier 1: Disposition, Allocation Based on TAC Level, or None of the Above

Option A: Disposition Quota

Menhaden commercial TAC is divided between the bait and reduction fishery. Should the bait quota not be further divided into jurisdictional quotas, SAFIS will be used to monitor landings in season. Once 80% of the bait allocation is reached (as indicated through SAFIS), a trip limit of 25,000 pounds will be implemented in the bait sector. The respective fisheries will close when 95% of the allocation has been reached (as indicated through SAFIS or CDFRs) in order to minimize overages. A fisherman cannot land menhaden more than once in a single calendar day. If the bait quota is further allocated by jurisdiction, the following do not apply: trip limits, a required fishery closure when 95% of the allocation has been reached, and reporting through SAFIS.

Sub-option 1: Seventy percent of the overall menhaden commercial TAC is allocated to the reduction fishery, and 30% of the overall TAC is allocated to the bait fishery. For reference, 30% of 200,000 metric tons (the 2017 TAC) is 60,000 mt or roughly 132 million pounds.

Sub-option 2: The percentage of menhaden commercial TAC allocated to the reduction fishery and the bait fishery is dependent on historical landings from one of the timeframes selected in Tier 4 (Table 2).

Option B: Allocation Based on TAC Level

The coastwide menhaden commercial TAC will be allocated using two different methods depending on the level at which the annual TAC is set. At or below the baseline annual TAC level of 212,500 mt, quotas will be allocated to jurisdictions based on average landings from 2009-2011 (i.e: the current allocation method, Table 10). If the annual TAC is set above the base level TAC, the difference between the annual TAC and 212,500 mt will be allocated using a strategy that is more favorable to the bait fishery. A sub-option below must be selected to determine the allocation method used when the TAC is greater than 212,500 mt.

**This allocation method cannot be combined with any of the other allocation methods presented in Tier 2 or Tier 3. If this method is chosen, the Board can skip to Tier 4.*

Sub-option 1: If the annual TAC is greater than 212,500 mt, the difference between the annual TAC and 212,500 mt will be distributed such that the reduction fishery gets 50% of the allocation (included in Virginia's quota) and the other 50% is distributed to jurisdictions based on bait landings during a timeframe chosen in Tier 4 (Table 3).

Sub-option 2: If the annual TAC is greater than 212,500 mt, the difference between the annual TAC and 212,500 mt will be distributed such that the reduction fishery gets 30% of the allocation (included in Virginia's quota) and the other 70% is distributed to jurisdictions based on bait landings during a timeframe chosen in Tier 4 (Table 4).

Option C: None of the Above
None of the allocation methods in Tier 1 are chosen and the Board can proceed to Tier 2.

Tier 2: Fleet Capacity, Fixed Minimum, or None of the Above
Option A: Fleet-Capacity Quota
Menhaden commercial TAC is divided based on the capacity of various gear types to harvest menhaden. Each fleet's fishery will be closed when 90% of the quota is reported to be caught (as indicated through SAFIS), including an allocation scenario in which a bait quota is further divided by fleet. This fishery closure does not apply to a fleet operating under a soft cap. If a fleet-capacity allocation method is chosen, a small-scale fishery set aside (Option E) in *Section 4.3.6 Incidental Catch and Small Scale Fisheries* does not apply.

Included in this allocation method is the option for a soft cap, which sets a target quota for a fleet but does not subject that fleet to a fishery closure. A rationale for the use of a soft cap is that it can relieve the administrative burden on states to implement timely quota reporting for small-scale gears which represent less than 6% of landings in the fishery. If a soft cap is chosen, states will continue to monitor landings by gear types in the small-capacity fleet; however, landings by the small capacity fleet do not need to be reported to SAFIS. Landings by gears subject to a soft cap will be reported to the Board as a part of the annual FMP Review (*Section 5.3: Compliance Report*). Should a gear type subject to a soft cap show a continued and significant increase in its proportion of landings relative to total landings in the fishery, the Board has the authority, through Adaptive Management (*Section 4.6*), to reduce an existing trip limit or re-assign that gear type to another fleet.

**Fleet allocation by jurisdiction cannot be shown due to issues with data confidentiality; however, it is possible for the Board to choose jurisdictional allocations (Option A in Tier 3) and then each state can further divide their quota by gear type. In addition, fleet landings by four regions cannot be shown due to confidentiality.*

Sub-option 1: Two Fleets Based on Gear Type
Quota is divided between two fleets (Table 5) which are defined as:

- Small-Capacity Fleet: cast nets, traps, pots, haul seines, fyke nets, hook and line, trawls (excluding pair trawls), bag nets, hoop nets, hand lines, trammel nets, bait nets, pound nets, anchored/staked gill nets, drift gill nets, fishing weirs, and floating fish traps.
- Large-Capacity Fleet: purse seines and pair-trawls.

Sub-option A: All fleet quotas are hard caps, in which all fisheries within a fleet are closed when the quota is met.

Sub-option B: The small-capacity fleet operates on a soft cap, in which the fisheries within the small-capacity-fleet do not close if the quota is met. All gears in the small-capacity fleet operate under a 25,000 pound trip limit per day throughout the fishing year. The purpose of this trip limit is to provide an input control on the small-scale fleet given the fishery does not close if the quota is met. The large-capacity fleet operates under a hard cap, in which all fisheries within the large-capacity fleet are closed when 90% of the quota is reported to be caught. There is no trip limit for the large-capacity fleet. If this option is chosen, the management alternatives in *Section 4.3.6 Incidental Catch and Small Scale Fisheries* do not apply.

Sub-option 2: Three Fleets Based on Gear Type
The commercial TAC is divided between three fleets (Table 6) which are defined as:

- Small-Capacity Fleet: cast net, traps (excluding floating fish traps), pots, haul seines, fyke nets, hook and line, bag nets, hoop nets, hand lines, trammel nets, and bait nets.
- Medium-Capacity Fleet: pound nets, anchored/staked gill nets, drift gill nets, fishing weirs, floating fish traps, and trawls (excluding pair trawls).
- Large-Capacity Fleet: pair trawls and purse seines.

Sub-option A: All fleet quotas are hard caps, in which all fisheries within a fleet are closed when the quota is met.

Sub-option B: The small-capacity fleet operates on a soft cap, in which the fisheries within the small-capacity fleet do not close if the quota is met. Gears in the small-capacity fleet operate under a 10,000 pound trip limit per day throughout the fishing year. The purpose of this trip limit is to provide an input control on the small-scale fleet given the fishery does not close if the quota is met. The large-capacity and medium capacity fleet quotas are hard caps, in which all fisheries within each fleet are closed when 90% of the quota is reported to be caught. There is no trip limit for the medium or large capacity fleets.

Option B: Jurisdiction Allocation with Minimum Base Allocation.
Under this option, all jurisdictions are allocated a fixed minimum amount of quota, including jurisdictions which have not previously been allocated quota. Should a jurisdiction desire to forgo the fixed minimum quota it has been allocated, it may, on an annual basis, choose to decline its quota completely or maintain 10,000 pounds for bycatch purposes and decline the remainder of the quota. Quota which is relinquished by the states will be redistributed to the other jurisdictions based on historic landings during an allocation timeframe chosen in Tier 4. Should a state choose to relinquish its annual quota, the Commission must be notified through the annual compliance report process.

**Given this allocation option implements a jurisdictional approach, the Board can proceed to Tier 4.*

Sub-option 1: Each jurisdiction receives 0.5% of the coastwide TAC prior to the allocation being divided (Table 7). For reference 0.5% of 200,000 mt equals 2.2 million pounds and 8% of 200,000 mt (the sum of each jurisdictions 0.5%) equals 35.3 million pounds.

Sub-option 2: Each jurisdiction receives 1% of the coastwide TAC prior to the allocation being divided (Table 8). For reference 1% of 200,000 mt equals 4.4 million pounds and 16% of 200,000 mt (the sum of each jurisdictions 1%) equals 70.5 million pounds.

Sub-option 3: Each jurisdiction receives 2% of the coastwide TAC prior to the allocation being divided (Table 9). For reference 2% of a 200,000 mt TAC equals 8.8 million pounds and 32% of a 200,000 mt TAC (the sum of each jurisdictions 2%) equals 141.1 million pounds.

Option C: None of the Above
None of the allocation methods in Tier 2 are chosen and the Board can proceed to Tier 3.

Tier 3: Coastwide, Jurisdictional, or Regional Approach
Option A: Coastwide Allocation. Under this option the TAC is not subdivided by jurisdiction or region. All fisheries will operate within the allocation structure selected in Tiers 1 and 2. If Option C was selected in both Tiers 1 and 2, there will be one coastwide TAC for the entire commercial fishery and a timeframe does not need to be chosen in Tier 4.

Option B: Jurisdictional Allocation. The coastwide commercial Atlantic menhaden TAC will be divided among the Atlantic coast jurisdictions based on the allocation timeframe chosen in Tier 4 (Table 10).

Option C: Regional Allocation.
The coastwide commercial Atlantic menhaden TAC will be divided by region. The fishery in each region will be monitored through SAFIS and will be closed when 90% of the allocation is reached.

Sub-option 1: A three-region split will be used to divide the coastwide commercial TAC. The regions are defined as (1) New England, Maine through Connecticut, (2) Mid-Atlantic, New York through Delaware, and (3) South Atlantic, Maryland through Florida. Menhaden landed in a state are attributed to its respective region (Table 11).

Sub-option 2: A four-region split will be used to divide the coastwide commercial TAC. The regions are defined as (1) New England, Maine through Connecticut, (2) Mid-Atlantic, New York through Delaware, (3) Chesapeake Bay, Maryland through Virginia and (4) South Atlantic, North Carolina through Florida. Menhaden landed in a state are attributed to its respective region (Table 12).

Tier 4: Allocation Timeframe
Option A: 2009-2011 (status quo)
The quota allocation is based on the three-year average landings from 2009 to 2011.

Option B: 2012-2016 (5 years)

The quota allocation time frame is based on the five-year average landings from 2012 to 2016. This time frame includes the five most recent years of data and encompasses years prior to and after the implementation of a quota system. Total landings include transfers, bycatch, and landings under the episodic events program.

Option C: 1985-2016 (31 years)

The quota allocation time frame is based on average landings from 1985 to 2016. This time frame includes the longest range of years available with adequate landings data, and as such should capture more variability in landings. Bait landings going back to 1985 include more uncertainty, primarily due to voluntary reporting of bait landings in some states. Reduction fisheries in North Carolina, Florida, and Maine also existed during this time period, but have not been in operation since 2005, 1987, and 1993, respectively. Total landings include transfers, bycatch, and landings under the episodic events program.

Sub-Option A: Reduction landings from states which no longer have a reduction fishery do not count towards the state's average landings.

Sub-Option B: Reduction landings from states which no longer have a reduction fishery do count towards the state's average landings.

Option D: 1985-1995 (11 years)

The quota allocation time frame is based on the eleven-year average landings from 1985 to 1995. Bait landings from 1985 to 1995 include more uncertainty, primarily due to voluntary reporting of bait landings in some states. Reduction fisheries in North Carolina, Florida, and Maine also existed during this time period, but have not been in operation since 2005, 1987, and 1993, respectively.

Sub-Option A: Reduction landings from states which no longer have a reduction fishery do not count towards the state's average landings.

Sub-Option B: Reduction landings from states which no longer have a reduction fishery do count towards the state's average landings.

Option E: Weighted Allocation

The quota allocation time frame is based on a weighted average of total landings, using the 1985-1995 and 2012-2016 time frames. Each time frame is given a 50% weighting. This option takes into account a more historical time period and the most recent time period. All potential data concerns for the 1985 -1995 time period mentioned in Option D would still apply.

Sub-Option A: Reduction landings from states which no longer have a reduction fishery do not count towards the state's average landings.

Sub-Option B: Reduction landings from states which no longer have a reduction fishery do count towards the state's average landings.

Table 2: Disposition Allocation

Percent of menhaden commercial TAC allocated to the reduction and bait fisheries based on historic landings (Tier 1, Option A). Table (a) is based on total reduction landings from all states which had, or have, a reduction fishery. Table (b) only includes reduction landings from Virginia, the sole Atlantic coast state which still has an active reduction plant.

(a) Allocations between the bait and reduction sector; includes all reduction landings

	Bait Quota	Reduction Quota
2009-2011	21.2%	78.8%
2012-2016	24.8%	75.2%
1985-2016	13.5%	86.5%
1985-1995	8.3%	91.7%
Weighted	14.1%	85.9%

(b) Allocations between the bait and reduction sector; only includes VA reduction landings. Three time periods are not shown due to confidentiality rules.

	Bait Quota	Reduction Quota
2009-2011	21.2%	78.8%
2012-2016	24.8%	75.2%
1985-2016	[redacted]	[redacted]
1985-1995	[redacted]	[redacted]
Weighted	[redacted]	[redacted]

Table 3: Allocation Based on TAC Level (Sub-Option 1)
Percent of menhaden commercial TAC greater than 212,500 mt that is allocated to each jurisdiction based on historic bait landings (Tier 1, Option B, Sub-Option 1). Under this scenario, the Virginia reduction fishery gets 50% of the difference between the annual TAC and 212,500 mt (included in Virginia's percentage below) and the states bait fisheries are allocated the other 50%. These allocation percentages only apply if the annual TAC is greater than 212,500 mt. If the TAC is less than or equal to 212,500 mt, allocations are based on jurisdictional landings from 2009-2011 (Table 10).

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted TAC %
ME	0.04%	0.45%	0.22%	0.11%	0.32%
NH	0.00%	0.00%	0.01%	0.04%	0.01%
MA	1.99%	1.19%	1.99%	3.54%	2.09%
RI	0.05%	0.30%	2.16%	7.39%	3.02%
CT	0.04%	0.02%	0.10%	0.12%	0.06%
NY	0.17%	0.51%	0.41%	0.57%	0.53%
NJ	26.66%	25.42%	19.17%	12.04%	20.29%
PA	0.00%	0.00%	0.00%	0.00%	0.00%
DE	0.03%	0.06%	0.06%	0.10%	0.08%
MD	3.57%	4.00%	3.60%	3.22%	3.70%
PRFC	1.47%	1.72%	3.66%	7.06%	3.77%
VA	64.76%	65.90%	66.65%	61.53%	64.22%
NC	1.17%	0.31%	1.55%	3.04%	1.36%
SC	0.00%	0.00%	0.00%	0.00%	0.00%
GA	0.00%	0.00%	0.00%	0.00%	0.00%
FL	0.05%	0.12%	0.42%	1.24%	0.55%

Table 4: Allocation Based on TAC Level (Sub-Option 2) Percent of menhaden commercial TAC greater than 212,500 mt that is allocated to each jurisdiction based on historic bait landings (Tier 1, Option B, Sub-Option 2). Under this scenario, the Virginia reduction fishery gets 30% of the difference between the annual TAC and 212,500 mt (included in Virginia's percentage below) and the state's bait fisheries are allocated the other 70%. These allocation percentages only apply if the annual TAC is greater than 212,500 mt. If the TAC is less than or equal to 212,500 mt, allocations are based on jurisdictional landings from 2009-2011 (Table 10).

	2009-2011 % TAC	2012-2016 % TAC	1985-2016 % TAC	1985-1995 % TAC	Weighted % TAC
ME	0.06%	0.62%	0.30%	0.16%	0.45%
NH	0.00%	0.00%	0.01%	0.05%	0.02%
MA	2.79%	1.67%	2.79%	4.96%	2.93%
RI	0.06%	0.42%	3.02%	10.34%	4.23%
CT	0.06%	0.03%	0.14%	0.17%	0.09%
NY	0.24%	0.71%	0.58%	0.80%	0.74%
NJ	37.32%	35.58%	26.84%	16.86%	28.40%
PA	0.00%	0.00%	0.00%	0.00%	0.00%
DE	0.05%	0.09%	0.09%	0.14%	0.11%
MD	5.00%	5.61%	5.03%	4.51%	5.18%
PRFC	2.06%	2.41%	5.12%	9.88%	5.27%
VA	50.66%	52.26%	53.30%	46.14%	49.91%
NC	1.64%	0.44%	2.17%	4.25%	1.90%
SC	0.00%	0.00%	0.00%	0.00%	0.00%
GA	0.00%	0.00%	0.00%	0.00%	0.00%
FL	0.07%	0.17%	0.59%	1.74%	0.77%

Table 5: Fleet Capacity Quota – Two Fleet

Percent of menhaden commercial TAC allocated to the small and large capacity fleets based on historic landings (Tier 2, Option A, Sub-Option 1). Given Florida did not code landings by gear type prior to 1993, percent landings by gear type in 1993 and 1994 were used to estimate gear landings from 1988-1992. Florida reduction landings were available for 1985-1987. Table (a) is based on total reduction landings from all states which had, or have, a reduction fishery. Table (b) only includes reduction landings from Virginia, the sole Atlantic coast state which still has an active reduction plant. Table (c) shows bait landings by fleet and is to be used if a disposition quota (Tier 1, Option A) is further allocated by fleet.

(a) Allocations by two fleets; includes all historic reduction landings

	2009-2011	2012-2016	1985-2016	1985-1995	Weighted
Large Capacity Quota	96.22%	94.18%	96.17%	96.04%	95.37%
Small Capacity Quota	3.78%	5.82%	3.83%	3.96%	4.63%

(b) Allocations by two fleets; only includes VA reduction landings

	2009-2011	2012-2016	1985-2016	1985-1995	Weighted
Large Capacity Quota	96.22%	94.18%	95.83%	95.53%	95.00%
Small Capacity Quota	3.78%	5.82%	4.17%	4.47%	5.00%

(c) Bait allocations by two fleets. These percentages are to be used if a disposition quota is further allocated by fleet. It is important to note that these percentages further divide the bait allocation presented in Tables 2a and 2b.

	2009-2011	2012-2016	1985-2016	1985-1995	Weighted
Large Capacity Quota	82.1%	76.6%	72.2%	54.2%	68.1%
Small Capacity Quota	17.9%	23.4%	27.8%	45.8%	31.9%

Table 6: Fleet Capacity Quota – Three Fleet
Percent of menhaden commercial TAC allocated to the small, medium, and large capacity fleets based on historic landings (Tier 2, Option A, Sub-Option 2). Given Florida did not code landings by gear type prior to 1993, percent landings by gear type in 1993 and 1994 were used to estimate gear landings from 1988-1992. Florida reduction landings were available for 1985-1987. Table (a) is based on total reduction landings from all states which had, or have, a reduction fishery. Table (b) only includes reduction landings from Virginia, the sole Atlantic coast state which still has an active reduction plant. Table (c) shows bait landings by fleet and is to be used if a disposition quota (Tier 1, Option A) is further allocated by fleet.

(a) Allocations by three fleets; includes all historic reduction landings

	2009-2011	2012-2016	1985-2016	1985-1995	Weighted
Large Capacity Quota	96.22%	94.18%	96.17%	96.04%	95.37%
Medium Capacity Quota	3.69%	5.56%	3.70%	3.86%	4.48%
Small Capacity Quota	0.09%	0.26%	0.13%	0.09%	0.15%

(b) Allocations by three fleets; only includes VA reduction landings

	2009-2011	2012-2016	1985-2016	1985-1995	Weighted
Large Capacity Quota	96.22%	94.18%	95.83%	95.53%	95.00%
Medium Capacity Quota	3.69%	5.56%	4.03%	4.37%	4.83%
Small Capacity Quota	0.09%	0.26%	0.14%	0.10%	0.16%

(c) Bait allocations by three fleets. These percentages are to be used if a disposition quota is further allocated by fleet. It is important to note that these percentages further divide the bait allocation presented in Tables 2a and 2b.

	2009-2011	2012-2016	1985-2016	1985-1995	Weighted
Large Capacity Quota	82.1%	76.6%	72.2%	54.2%	68.1%
Medium Capacity Quota	17.4%	22.4%	26.8%	44.7%	30.9%
Small Capacity Quota	0.4%	1.0%	0.9%	1.1%	1.1%

Table 7: Fixed Minimum Allocation – 0.5%
Percent of menhaden commercial TAC allocated to each jurisdiction based on historic landings, with each jurisdiction receiving, at a minimum, a 0.5% quota allocation (Tier 2, Option B, Sub-Option 1). Table (a) is based on total reduction landings from all states which had, or have, a reduction fishery. Table (b) only includes reduction landings from Virginia, the sole Atlantic coast state which still has an active reduction plant. Table (c) only includes bait landings and is to be used if the disposition allocation method (Tier 1, Option A) is combined with a fixed minimum approach.

(a) Allocations with a 0.5% fixed minimum quota; includes all historic reduction landings

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME	0.52%	0.70%	1.32%	2.23%	1.68%
NH	0.50%	0.50%	0.50%	0.51%	0.50%
MA	1.28%	1.04%	1.01%	1.07%	1.06%
RI	0.52%	0.64%	1.05%	1.69%	1.31%
CT	0.52%	0.51%	0.53%	0.52%	0.52%
NY	0.57%	0.73%	0.60%	0.59%	0.64%
NJ	10.89%	12.11%	5.38%	2.44%	5.93%
PA	0.50%	0.50%	0.50%	0.50%	0.50%
DE	0.51%	0.53%	0.52%	0.52%	0.52%
MD	1.89%	2.33%	1.42%	1.02%	1.49%
PRFC	1.07%	1.29%	1.43%	1.63%	1.51%
VA	78.77%	76.92%	76.63%	75.77%	76.19%
NC	0.96%	0.64%	7.43%	9.64%	6.39%
SC	0.50%	0.50%	0.50%	0.50%	0.50%
GA	0.50%	0.50%	0.50%	0.50%	0.50%
FL	0.52%	0.55%	0.69%	0.88%	0.76%

(b) Allocations with a 0.5% fixed minimum quota; includes only VA reduction landings

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME	0.52%	0.70%	0.56%	0.52%	0.59%
NH	0.50%	0.50%	0.50%	0.51%	0.50%
MA	1.28%	1.04%	1.05%	1.14%	1.10%
RI	0.52%	0.64%	1.10%	1.84%	1.37%
CT	0.52%	0.51%	0.53%	0.52%	0.52%
NY	0.57%	0.73%	0.61%	0.60%	0.65%
NJ	10.89%	12.11%	5.81%	2.69%	6.36%
PA	0.50%	0.50%	0.50%	0.50%	0.50%
DE	0.51%	0.53%	0.52%	0.52%	0.52%
MD	1.89%	2.33%	1.50%	1.08%	1.57%
PRFC	1.07%	1.29%	1.51%	1.78%	1.59%
VA	78.77%	76.92%	83.26%	85.51%	82.16%
NC	0.96%	0.64%	0.93%	1.05%	0.89%
SC	0.50%	0.50%	0.50%	0.50%	0.50%
GA	0.50%	0.50%	0.50%	0.50%	0.50%
FL	0.52%	0.55%	0.62%	0.73%	0.66%

(c) Bait allocations with a 0.5% fixed minimum quota; to be used if the bait sector is further allocated using the fixed minimum approach. It is important to note that these percentages further divide the TAC already allocated to the bait sector in Tables 2a and 2b.

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME	0.58%	1.32%	0.90%	0.71%	1.09%
NH	0.50%	0.50%	0.52%	0.57%	0.53%
MA	4.16%	2.69%	4.17%	7.02%	4.35%
RI	0.58%	1.05%	4.47%	14.09%	6.06%
CT	0.57%	0.55%	0.69%	0.72%	0.61%
NY	0.81%	1.43%	1.26%	1.55%	1.48%
NJ	49.56%	47.27%	35.78%	22.66%	37.83%
PA	0.50%	0.50%	0.50%	0.50%	0.50%
DE	0.56%	0.62%	0.62%	0.68%	0.64%
MD	7.07%	7.87%	7.12%	6.42%	7.31%
PRFC	3.21%	3.66%	7.23%	13.49%	7.43%
VA	27.65%	29.75%	31.13%	21.71%	26.67%
NC	2.66%	1.08%	3.35%	6.09%	3.00%
SC	0.50%	0.50%	0.50%	0.50%	0.50%
GA	0.50%	0.50%	0.50%	0.50%	0.50%
FL	0.59%	0.72%	1.28%	2.79%	1.51%

Table 8: Fixed Minimum Allocation – 1%

Percent of menhaden commercial TAC allocated to each jurisdiction based on historic landings, with each jurisdiction receiving, at a minimum, a 1% quota allocation (Tier 2, Option B, Sub-Option 2). Table (a) is based on total reduction landings from all states which had, or have, a reduction fishery. Table (b) only includes reduction landings from Virginia, the sole Atlantic coast state which still has an active reduction plant. Table (c) only includes bait landings and is to be used if the disposition allocation method (Tier 1, Option A) is combined with a fixed minimum approach.

(a) Allocations with a 1% fixed minimum quota; includes all historic reduction landings

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME	1.02%	1.19%	1.75%	2.58%	2.08%
NH	1.00%	1.00%	1.00%	1.01%	1.00%
MA	1.71%	1.50%	1.46%	1.52%	1.51%
RI	1.02%	1.13%	1.50%	2.08%	1.74%
CT	1.01%	1.01%	1.02%	1.02%	1.02%
NY	1.06%	1.21%	1.10%	1.08%	1.13%
NJ	10.48%	11.60%	5.46%	2.77%	5.96%
PA	1.00%	1.00%	1.00%	1.00%	1.00%
DE	1.01%	1.03%	1.01%	1.01%	1.02%
MD	2.27%	2.67%	1.84%	1.47%	1.91%
PRFC	1.52%	1.72%	1.85%	2.04%	1.92%
VA	72.46%	70.78%	70.51%	69.73%	70.11%
NC	1.42%	1.13%	7.33%	9.35%	6.38%
SC	1.00%	1.00%	1.00%	1.00%	1.00%
GA	1.00%	1.00%	1.00%	1.00%	1.00%
FL	1.02%	1.05%	1.17%	1.34%	1.24%

(b) Allocations with a 1% fixed minimum quota; includes only VA reduction landings

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME	1.02%	1.19%	1.05%	1.02%	1.08%
NH	1.00%	1.00%	1.00%	1.01%	1.00%
MA	1.71%	1.50%	1.50%	1.59%	1.55%
RI	1.02%	1.13%	1.55%	2.22%	1.80%
CT	1.01%	1.01%	1.03%	1.02%	1.02%
NY	1.06%	1.21%	1.10%	1.09%	1.14%
NJ	10.48%	11.60%	5.85%	3.00%	6.35%
PA	1.00%	1.00%	1.00%	1.00%	1.00%
DE	1.01%	1.03%	1.02%	1.02%	1.02%
MD	2.27%	2.67%	1.91%	1.53%	1.98%
PRFC	1.52%	1.72%	1.92%	2.17%	1.99%
VA	72.46%	70.78%	76.57%	78.62%	75.56%
NC	1.42%	1.13%	1.39%	1.50%	1.36%
SC	1.00%	1.00%	1.00%	1.00%	1.00%
GA	1.00%	1.00%	1.00%	1.00%	1.00%
FL	1.02%	1.05%	1.11%	1.21%	1.15%

(c) Bait allocations with a 1% fixed minimum quota; to be used if the bait sector is further allocated using the fixed minimum approach. It is important to note that these percentages further divide the TAC already allocated to the bait sector in Tables 2a and 2b.

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME	1.07%	1.75%	1.36%	1.19%	1.54%
NH	1.00%	1.00%	1.02%	1.06%	1.02%
MA	4.34%	3.00%	4.35%	6.95%	4.51%
RI	1.08%	1.51%	4.63%	13.41%	6.07%
CT	1.07%	1.04%	1.17%	1.20%	1.10%
NY	1.28%	1.85%	1.69%	1.96%	1.89%
NJ	45.79%	43.70%	33.21%	21.23%	35.08%
PA	1.00%	1.00%	1.00%	1.00%	1.00%
DE	1.05%	1.11%	1.11%	1.16%	1.13%
MD	6.99%	7.73%	7.04%	6.41%	7.22%
PRFC	3.48%	3.89%	7.14%	12.86%	7.33%
VA	25.79%	27.71%	28.96%	20.36%	24.89%
NC	2.97%	1.53%	3.60%	6.10%	3.28%
SC	1.00%	1.00%	1.00%	1.00%	1.00%
GA	1.00%	1.00%	1.00%	1.00%	1.00%
FL	1.08%	1.20%	1.71%	3.09%	1.93%

Table 9: Fixed Minimum Allocation – 2%
Percent of menhaden commercial TAC allocated to each jurisdiction based on historic landings, with each jurisdiction receiving, at a minimum, a 2% quota allocation (Tier 2, Option B, Sub-Option 3). Table (a) is based on total reduction landings from all states which had, or have, a reduction fishery. Table (b) only includes reduction landings from Virginia, the sole Atlantic coast state which still has an active reduction plant. Table (c) only includes bait landings and is to be used if the disposition allocation method (Tier 1, Option A) is combined with a fixed minimum approach.

(a) Allocations with a 2% fixed minimum quota; includes all historic reduction landings

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME	2.01%	2.15%	2.60%	3.28%	2.87%
NH	2.00%	2.00%	2.00%	2.00%	2.00%
MA	2.57%	2.40%	2.38%	2.42%	2.41%
RI	2.01%	2.10%	2.41%	2.88%	2.60%
CT	2.01%	2.01%	2.02%	2.01%	2.01%
NY	2.05%	2.17%	2.08%	2.07%	2.10%
NJ	9.68%	10.58%	5.61%	3.43%	6.01%
PA	2.00%	2.00%	2.00%	2.00%	2.00%
DE	2.01%	2.02%	2.01%	2.01%	2.02%
MD	3.03%	3.35%	2.68%	2.38%	2.73%
PRFC	2.42%	2.58%	2.69%	2.84%	2.75%
VA	59.85%	58.49%	58.27%	57.64%	57.94%
NC	2.34%	2.11%	7.12%	8.76%	6.35%
SC	2.00%	2.00%	2.00%	2.00%	2.00%
GA	2.00%	2.00%	2.00%	2.00%	2.00%
FL	2.01%	2.04%	2.14%	2.28%	2.19%

(b) Allocations with a 2% fixed minimum quota; includes only VA reduction landings

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME	2.01%	2.15%	2.04%	2.02%	2.07%
NH	2.00%	2.00%	2.00%	2.00%	2.00%
MA	2.57%	2.40%	2.41%	2.48%	2.45%
RI	2.01%	2.10%	2.44%	2.99%	2.64%
CT	2.01%	2.01%	2.02%	2.02%	2.01%
NY	2.05%	2.17%	2.08%	2.08%	2.11%
NJ	9.68%	10.58%	5.93%	3.62%	6.33%
PA	2.00%	2.00%	2.00%	2.00%	2.00%
DE	2.01%	2.02%	2.01%	2.01%	2.02%
MD	3.03%	3.35%	2.74%	2.43%	2.79%
PRFC	2.42%	2.58%	2.75%	2.95%	2.80%
VA	59.85%	58.49%	63.17%	64.84%	62.36%
NC	2.34%	2.11%	2.32%	2.41%	2.29%
SC	2.00%	2.00%	2.00%	2.00%	2.00%
GA	2.00%	2.00%	2.00%	2.00%	2.00%
FL	2.01%	2.04%	2.09%	2.17%	2.12%

(c) Bait allocations with a 2% fixed minimum quota; to be used if the bait sector is further allocated using the fixed minimum approach. It is important to note that these percentages further divide the TAC already allocated to the bait sector in Tables 2a and 2b.

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME	2.06%	2.61%	2.29%	2.16%	2.43%
NH	2.00%	2.00%	2.01%	2.05%	2.02%
MA	4.71%	3.62%	4.71%	6.82%	4.84%
RI	2.06%	2.41%	4.93%	12.05%	6.11%
CT	2.06%	2.03%	2.14%	2.17%	2.08%
NY	2.23%	2.69%	2.56%	2.78%	2.72%
NJ	38.26%	36.57%	28.08%	18.38%	29.59%
PA	2.00%	2.00%	2.00%	2.00%	2.00%
DE	2.04%	2.09%	2.09%	2.13%	2.10%
MD	6.85%	7.45%	6.89%	6.38%	7.04%
PRFC	4.00%	4.34%	6.97%	11.60%	7.12%
VA	22.07%	23.62%	24.64%	17.68%	21.34%
NC	3.59%	2.43%	4.11%	6.13%	3.85%
SC	2.00%	2.00%	2.00%	2.00%	2.00%
GA	2.00%	2.00%	2.00%	2.00%	2.00%
FL	2.06%	2.16%	2.58%	3.69%	2.75%

Table 10: Jurisdictional Allocation

Percent of menhaden commercial TAC allocated to each jurisdiction based on historic landings, including bycatch and episodic event landings (Tier 3, Option B). Table (a) is based on total reduction landings from all states which had, or have, a reduction fishery. Table (b) only includes reduction landings from Virginia, the sole Atlantic coast state which still has an active reduction plant. Table (c) shows the distribution of bait landings by state and should be used if a disposition quota (Tier 1, Option A) is being further allocated by jurisdiction.

(a) Jurisdictional allocations, including all reduction landings

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME	0.02%	0.22%	0.89%	1.88%	1.28%
NH	0.00%	0.00%	0.00%	0.01%	0.00%
MA	0.84%	0.59%	0.55%	0.62%	0.61%
RI	0.02%	0.15%	0.60%	1.29%	0.88%
CT	0.02%	0.01%	0.03%	0.02%	0.02%
NY	0.07%	0.25%	0.11%	0.10%	0.15%
NJ	11.29%	12.62%	5.31%	2.10%	5.90%
PA	0.00%	0.00%	0.00%	0.00%	0.00%
DE	0.01%	0.03%	0.02%	0.02%	0.02%
MD	1.51%	1.99%	1.00%	0.56%	1.08%
PRFC	0.62%	0.85%	1.01%	1.23%	1.10%
VA	85.08%	83.07%	82.75%	81.82%	82.27%
NC	0.50%	0.16%	7.53%	9.94%	6.40%
SC	0.00%	0.00%	0.00%	0.00%	0.00%
GA	0.00%	0.00%	0.00%	0.00%	0.00%
FL	0.02%	0.06%	0.20%	0.41%	0.28%

(b) Jurisdictional allocations, including just Virginia reduction landings

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME	0.02%	0.22%	0.06%	0.02%	0.10%
NH	0.00%	0.00%	0.00%	0.01%	0.00%
MA	0.84%	0.59%	0.60%	0.70%	0.66%
RI	0.02%	0.15%	0.65%	1.46%	0.95%
CT	0.02%	0.01%	0.03%	0.02%	0.02%
NY	0.07%	0.25%	0.12%	0.11%	0.17%
NJ	11.29%	12.62%	5.77%	2.38%	6.37%
PA	0.00%	0.00%	0.00%	0.00%	0.00%
DE	0.01%	0.03%	0.02%	0.02%	0.02%
MD	1.51%	1.99%	1.08%	0.64%	1.16%
PRFC	0.62%	0.85%	1.10%	1.39%	1.18%
VA	85.08%	83.07%	89.96%	92.41%	88.77%
NC	0.50%	0.16%	0.47%	0.60%	0.43%
SC	0.00%	0.00%	0.00%	0.00%	0.00%
GA	0.00%	0.00%	0.00%	0.00%	0.00%
FL	0.02%	0.06%	0.13%	0.25%	0.17%

(c) Bait landings by state. These percentages should be used if disposition bait quota is further allocated by state. It is important to note that these percentages further divide the TAC already allocated to the bait sector in Tables 2a and 2b.

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME	0.09%	0.89%	0.43%	0.23%	0.64%
NH	0.00%	0.00%	0.02%	0.07%	0.03%
MA	3.98%	2.38%	3.99%	7.08%	4.18%
RI	0.09%	0.60%	4.32%	14.78%	6.04%
CT	0.08%	0.05%	0.20%	0.24%	0.12%
NY	0.34%	1.01%	0.82%	1.14%	1.06%
NJ	53.32%	50.83%	38.35%	24.09%	40.58%
PA	0.00%	0.00%	0.00%	0.00%	0.00%
DE	0.06%	0.13%	0.13%	0.20%	0.15%
MD	7.14%	8.01%	7.19%	6.44%	7.41%
PRFC	2.95%	3.44%	7.31%	14.11%	7.53%
VA	29.51%	31.80%	33.29%	23.05%	28.44%
NC	2.34%	0.63%	3.10%	6.07%	2.72%
SC	0.00%	0.00%	0.00%	0.00%	0.00%
GA	0.00%	0.00%	0.00%	0.00%	0.00%
FL	0.09%	0.24%	0.85%	2.49%	1.10%

Table 11: Regional Allocation – Three Regions

Percent of menhaden commercial TAC allocated to three regions based on historic landings, including bycatch and episodic event landings (Tier 3, Option C, Sub-Option 1). Table (a) is based on total reduction landings from all states which had, or have, a reduction fishery. Table (b) only includes reduction landings from Virginia, the sole Atlantic coast state which still has an active reduction plant. Table (c) shows the distribution of bait landings by region and should be used if a dispositional bait quota (Tier 1, Option A) is being further allocated by jurisdiction. Table (d) shows the distribution of fleet landings by region and should be used if a fleet-capacity quota (Tier 2, Option A) is being further allocated by region. Table (e) shows the distribution of bait landings by fleet and region and should be used if a disposition quota (Tier 1, Option A) and a fleet allocation (Tier 2, Option A) have already been chosen.

(a) Three region allocations, including all historical reduction landings

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME, NH, MA, RI, CT	0.90%	0.97%	2.07%	3.82%	2.79%
NY, NJ, PA, DE	11.38%	12.90%	5.44%	2.22%	6.08%
MD, PRFC, VA, NC, SC, GA, FL	87.73%	86.12%	92.49%	93.96%	91.13%

(b) Three region allocations, only include VA reduction landings

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME, NH, MA, RI, CT	0.90%	0.97%	1.35%	2.21%	1.73%
NY, NJ, PA, DE	11.38%	12.90%	5.92%	2.51%	6.56%
MD, PRFC, VA, NC, SC, GA, FL	87.73%	86.12%	92.74%	95.28%	91.71%

(c) Bait landings by region. These percentages are to be used if a disposition quota is further allocated by region. It is important to note that these percentages further divide the TAC already allocated to the bait sector in Tables 2a and 2b.

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME, NH, MA, RI, CT	4.24%	3.92%	8.96%	22.40%	11.01%
NY, NJ, PA, DE	53.72%	51.97%	39.30%	25.42%	41.79%
MD, PRFC, VA, NC, SC, GA, FL	42.03%	44.10%	51.74%	52.17%	47.20%

(d) Fleet landings by three regions. These percentages are to be used if fleet capacity quotas are further allocated by region. Some timeframes cannot be shown due to confidentiality rules. It is important to note that these percentages further divide the TAC already allocated to fleets in Tables 5 and 6.

Large Fleet - All Historic Reduction Landings (2 or 3 Fleet Options)					
	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME, NH, MA, RI, CT	[redacted]	[redacted]	2.08%	[redacted]	[redacted]
NY, NJ, PA, DE	[redacted]	[redacted]	5.25%	[redacted]	[redacted]
MD, PRFC, VA, NC, SC, GA, FL	[redacted]	[redacted]	92.67%	[redacted]	[redacted]
Large Fleet - VA Only Reduction Landings (2 or 3 Fleet Options)					
	2009-2011	2012-2016	1985-2016	1985-1995	Weighted
ME, NH, MA, RI, CT	[redacted]	[redacted]	1.28%	[redacted]	[redacted]
NY, NJ, PA, DE	[redacted]	[redacted]	5.73%	[redacted]	[redacted]
MD, PRFC, VA, NC, SC, GA, FL	[redacted]	[redacted]	92.99%	[redacted]	[redacted]
Small Fleet (2 Fleet Option)					
	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME, NH, MA, RI, CT	1.36%	1.42%	1.85%	2.13%	1.81%
NY, NJ, PA, DE	5.38%	19.66%	10.27%	8.23%	13.42%
MD, PRFC, VA, NC, SC, GA, FL	93.26%	78.92%	87.88%	89.64%	84.77%
Medium Fleet (3 Fleet Option)					
	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME, NH, MA, RI, CT	0.86%	1.31%	1.32%	1.72%	1.54%
NY, NJ, PA, DE	5.07%	17.75%	9.53%	7.90%	12.32%
MD, PRFC, VA, NC, SC, GA, FL	94.07%	80.93%	89.15%	90.39%	86.15%
Small Fleet (3 Fleet Option)					
	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME, NH, MA, RI, CT	21.33%	3.76%	17.26%	19.61%	9.85%
NY, NJ, PA, DE	18.10%	60.32%	31.48%	22.21%	45.68%
MD, PRFC, VA, NC, SC, GA, FL	60.57%	35.91%	51.26%	58.18%	44.47%

(e) Bait landings by fleet and three regions. These percentages are to be used if a disposition quota is further allocated by fleet and region. Some timeframes cannot be shown due to confidentiality rules. It is important to note that these percentages further divide the TAC already allocated to the bait sector in Tables 2a and 2b and the fleets in Tables 5 and 6.

Large Fleet Bait (2 or 3 Fleet Options)					
	2009-2011	2012-2016	1985-2016	1985-1995	Weighted
ME, NH, MA, RI, CT	[redacted]	[redacted]	11.30%	[redacted]	[redacted]
NY, NJ, PA, DE	[redacted]	[redacted]	50.62%	[redacted]	[redacted]
MD, PRFC, VA, NC, SC, GA, FL	[redacted]	[redacted]	38.08%	[redacted]	[redacted]
Small Fleet Bait (2 Fleet Option)					
	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME, NH, MA, RI, CT	1.36%	1.42%	1.85%	2.13%	1.81%
NY, NJ, PA, DE	5.38%	19.66%	10.27%	8.23%	13.42%
MD, PRFC, VA, NC, SC, GA, FL	93.26%	78.92%	87.88%	89.64%	84.77%
Medium Fleet Bait (3 Fleet Option)					
	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME, NH, MA, RI, CT	0.86%	1.31%	1.32%	1.72%	1.54%
NY, NJ, PA, DE	5.07%	17.75%	9.53%	7.90%	12.32%
MD, PRFC, VA, NC, SC, GA, FL	94.07%	80.93%	89.15%	90.39%	86.15%
Small Fleet Bait (3 Fleet Option)					
	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME, NH, MA, RI, CT	21.33%	3.76%	17.26%	19.61%	9.85%
NY, NJ, PA, DE	18.10%	60.32%	31.48%	22.21%	45.68%
MD, PRFC, VA, NC, SC, GA, FL	60.57%	35.91%	51.26%	58.18%	44.47%

Table 12: Regional Allocation – Four Regions
Percent of menhaden commercial TAC allocated to four regions based on historic landings, including bycatch and episodic event landings (Tier 3, Option C, Sub-Option 2). Table (a) is based on total reduction landings from all states which had, or have, a reduction fishery. Table (b) only includes reduction landings from Virginia, the sole Atlantic coast state which still has an active reduction plant. Table (c) shows the distribution of bait landings by region and should be used if a disposition quota (Tier 1, Option A) is being further allocated by jurisdiction.

(a) Four region allocations, including all historical reduction landings

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME, NH, MA, RI, CT	0.90%	0.97%	2.07%	3.82%	2.79%
NY, NJ, PA, DE	11.38%	12.90%	5.44%	2.22%	6.08%
MD, PRFC, VA	87.21%	85.91%	84.76%	83.61%	84.44%
NC, SC, GA, FL	0.52%	0.21%	7.74%	10.35%	6.69%

(b) Four region allocations, only including VA reduction landings

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME, NH, MA, RI, CT	0.90%	0.97%	1.35%	2.21%	1.73%
NY, NJ, PA, DE	11.38%	12.90%	5.92%	2.51%	6.56%
MD, PRFC, VA	87.21%	85.91%	92.14%	94.43%	91.11%
NC, SC, GA, FL	0.52%	0.21%	0.59%	0.85%	0.60%

(c) Bait landings by region. These percentages are to be used if bait quota is further allocated by region. It is important to note that these percentages further divide the TAC already allocated to the bait sector in Tables 2a and 2b.

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME, NH, MA, RI, CT	4.24%	3.92%	8.96%	22.40%	11.01%
NY, NJ, PA, DE	53.72%	51.97%	39.30%	25.42%	41.79%
MD, PRFC, VA	39.60%	43.24%	47.80%	43.61%	43.38%
NC, SC, GA, FL	2.44%	0.86%	3.95%	8.57%	3.82%

4.3.2.1 Overage Payback
Any overage of a quota allocation is subtracted for that specific quota allocation in the subsequent year on a pound for pound basis. The exception to this rule is if a soft cap is implemented for a small-capacity fleet or if overage reconciliation (Options C) is adopted under *Section 4.3.3: Quota Transfers*. Overage determination is based on final allocations, including transfers if applicable. Overages will be subtracted from the subsequent year's quota following submission of state compliance reports. Should overages change as preliminary data is finalized, quotas will be re-adjusted accordingly.

4.3.2.2 Allocation Revisit Provision
Quota allocations will be revisited every three years following implementation of Amendment 3, or can be revisited at any time through the adaptive management process (*Section 4.6*).

4.3.3 Quota Transfers

The option to transfer quota only applies if the Board selects regional or state-based quotas, including state-specific quotas with a fixed minimum and an allocation strategy based on the TAC level. If a regional or state-based allocation option is not selected, no quota transfers are permitted.

All transfers require a donor region or state (giving the quota) and a receiving region or state (receiving the quota). Transfers cannot be greater than the amount of quota allocated to the donor region or state for that fishing year. In order to initiate a transfer, a member of each state agency involved must submit a signed letter to the Commission identifying the involved parties, the pounds of quota to be transferred, and justification for the transfer (i.e.: an expected quota overage, safe harbor landings, etc). Letters regarding regional quotas must indicate that all states in the region agree to the transfer and may be signed by multiple state agencies. The Executive Director, the ISFMP Director, and/or the FMP Coordinator will review all transfer requests. The transfer becomes final upon receipt of signed letters from the Commission to the donor and receiving parties. In the event that the donor or receiving member of a transaction subsequently wishes to change the amount of the transfer, both parties have to agree to the change and submit letters to the Commission which are signed by a member of the state agency. Parties participating in a quota transfer may add a provision which states that if the donor state or region incurs an overage in the current fishing year due to the transfer, the overage will be accommodated and paid back by the receiving state in the subsequent year.

If a region or state receives multiple requests to transfer quota at the same time, it is recommended that the state or region considers the requests in the order in which they were received. Transfer requests intended to resolve issues other than quota overages (i.e. safe harbor) may need to be addressed ahead of the order in which they were received.

Transfers do not permanently affect the region or state-specific shares of the coastwide quota, i.e., the region or state-specific shares remain fixed. Regions or states have the responsibility to close the Atlantic menhaden commercial fishery in their jurisdiction once the quota (or a percentage thereof) is reached. Once quota has been transferred, the region or state receiving quota becomes responsible for any overages of their new quota (the receiving region or state's original quota plus any quota transferred). Overages will be deducted from the corresponding region or state's quota the following fishing season.

Option A: Quota Transfers Permitted
Two or more regions or states, under mutual agreement, may transfer or combine their Atlantic menhaden quota.

Option B: Quota Transfers Permitted with Accountability Measures for Overages
Two or more regions or states, under mutual agreement, may transfer or combine their Atlantic menhaden quota. If a state or region exceeds its quota allocation (comprised of the allocation distributed at the beginning of year plus the distribution of unused episodic set aside, if applicable) by more than 5% each year for two years in a row, it may not receive a quota transfer in the third year.

Option C: Quota Reconciliation
In a year where coastwide landings do not exceed the TAC but some states or regions exceed their allocation, state or region quota overages are automatically forgiven in their entirety. As a result, overages are not deducted from subsequent year's quota. The intent of this option is to streamline the quota transfer process as quota transfers are not needed to address quota overages. Quota transfers can still be made between two or more regions or states, under mutual agreement, to address concerns unrelated to quota overages.

If coastwide landings do exceed the TAC and state(s) or region(s) have a quota overage, regions or states which do not have a quota overage automatically have their unused quota transferred to a "common pool". This "common pool" quota is then equally re-distributed to states or regions with overages based on the number of parties with an overage (Table 13). If a state or region still has a quota overage remaining after the redistribution of the "common pool" quota, this remaining overage is deducted from a region or state's quota the subsequent year. Quota transfers cannot be made to address remaining quota overages after quota reconciliation.

Quota reconciliation will occur following the submission of state compliance reports. Quota rollovers are not permitted under quota reconciliation (*Section 4.3.4*).

Table 13: Process for re-distribution of "common pool" quota when the coastwide TAC is exceeded (Option C). The redistribution process can be repeated until all of the unused quota is distributed. For this example, the amount of available common pool quota is 100,000 lbs. Two rounds of common pool allocation are needed to distribute the full 100,000 lbs.

	Available Common Pool Quota Round 1: 100,000		
	Overage (lbs)	**Quota Allocated from Common Pool (lbs)**	**Remaining Overage**
Region/State 1	100,000	33,333	66,667
Region/State2	50,000	33,333	16,667
Region/State 3	10,000	33,333 (accept 10,000)	0

	Available Common Pool Quota Round 2: 23,333		
	Overage (lbs)	**Quota Allocated from Common Pool (lbs)**	**Remaining Overage**
Region/State 1	66,667	11,667	55,000
Region/State 2	16,667	11,667	5,000

<u>Option D: Quota Reconciliation with Accountability Measures for Overages</u>

In a year where coastwide landings do not exceed the TAC but some states or regions exceed their allocation, a portion of the state or region's quota overage is forgiven. The portion of the overage forgiven is dependent on the state or region's history of overages (Table 14). For example, if a state or region had an overage in the two previous years and has an overage in the third year, only 50% of a state or region's quota overage is forgiven in the third year. In contrast, if the state or region did not have an overage in the previous year but has an overage in the current year, 100% of the overage is forgiven. States or regions must pay back any remaining portion of the overage in the subsequent year. The intent of this option is to dissuade states or regions from habitually exceeding their quota. Quota transfers can still be made between two or more regions or states, under mutual agreement, to address concerns unrelated to quota overages; quota transfers cannot be made to address remaining quota overages after quota reconciliation.

Table 14: The percentage of overage forgiven based on the number of consecutive years a state or region has had an overage. For example, a state or region which had an overage in the previous year gets 75% of its quota overage in the current year forgiven. If a state or region exceeded its quota in the three previous consecutive years or more, it must pay back in full its overage.

Number of Previous Consecutive Years of Overage	**% of Overage Forgiven**
0	100%
1	75%
2	50%
3 or more	0%

If coastwide landings do exceed the TAC and state(s) or region(s) have a quota overage, regions or states which do not have a quota overage automatically have their unused quota transferred to a “common pool”. This “common pool” quota is then equally re-distributed to states or regions with overages based on the number of parties with an overage (Table 15). The amount of redistributed common pool quota a state or region can receive is dependent on a state or region’s history of overages and cannot exceed the percentages outlined in Table 14. For example, a state or region which had overages in the two previous years and has an overage in the third year cannot receive an amount of redistributed common pool quota greater than the 50% of their overage. This process can be repeated until all common pool quota is distributed. Any overage that remains after the redistribution of the common pool quota is deducted from a region or state’s quota the subsequent year.

Quota reconciliation will occur following the submission of state compliance reports. Quota rollovers are not permitted under quota reconciliation (*Section 4.3.4*).

Table 15: Process for re-distribution of “common pool” quota when the coastwide TAC is exceeded and there are accountability measures for overages (Option D). The redistribution process can be repeated until either all 100,000 lbs of unused quota are distributed or each state reaches the maximum amount of quota it can accept due to a history of overages. In this example, there is 100,000 lbs of unused quota available for redistribution and it takes two rounds for each state to accept the maximum amount of quota it can receive.

	Available Common Pool Quota Round 1: 100,000					
	Overage (lbs)	**# of Previous Years With an Overage**	**Max Quota that Can Be Accepted (lbs)**	**Quota Allocated from Common Pool (lbs)**	**Quota Accepted from Common Pool (lbs)**	**Remaining Overage**
Region/ State 1	100,000	2	50,000	33,333	33,333	66,667
Region/ State2	50,000	0	50,000	33,333	33,333	16,667
Region/ State 3	10,000	1	7,500	33,333	7,500	2,500*

*The remaining overage is the amount that must be paid back based on the accountability measures outlined in Table 14.

	Available Common Pool Quota Round 2: 25,834					
	Overage (lbs)	**# of Previous Years With an Overage**	**Max Quota that Can Be Accepted (lbs)**	**Quota Allocated from Common Pool (lbs)**	**Quota Accepted from Common Pool (lbs)**	**Remaining Overage**
Region/ State 1	66,667	2	16,667	12,917	12,917	53,750
Region/ State2	16,667	0	16,667	12,917	12,917	3,750

4.3.4 Quota Rollovers

The option for quota rollovers only applies if the stock is not overfished and overfishing is not occurring. Should the stock be overfished but overfishing is not occurring, or vice versa, quota rollovers are not permitted.

Any quota that is rolled over must be used in the subsequent fishing year. If the rolled over quota is not used, it cannot be carried into a second fishing year. Quota rollovers are applicable to all allocation methods described in *Section 4.3.2*. If a state or region based allocation is adopted, unused quota from a specific state or region is rolled over to that state or region. If a coastwide allocation is adopted, unused quota is rolled over into the subsequent year's TAC. If a fleet-capacity allocation is adopted and there is no further allocation by state or region, unused quota from a specific fleet is rolled over to that fleet. If a disposition allocation is adopted and there is no further allocation by state or region, unused quota from a specific sector (bait vs. reduction) is rolled over to that sector. Quota rollovers are not permitted if quota reconciliation is implemented (*Section 4.3.3 Options C and D).* Therefore, if a reconciliation option is selected, Option A in this section is selected by default. Unused quota allocated to set aside programs, such as the small-scale fishery set aside, the incidental catch fishery set aside, or the episodic events set aside, cannot be rolled over into the subsequent year.

As part of the Annual Compliance Report, jurisdictions must submit annual landings no later than April 1st of each year. Importantly, landings reported on April 1st are often preliminary and subject to change as data becomes finalized. As a result, landings from the previous year will be considered final on July 1st of the subsequent year and unused quota from the previous year will be rolled over on July 1st. This will minimize changes to the amount of quota rolled over and reduce the administrative burden of this program. ASMFC staff will alert jurisdictions each year on July 1st as to the amount of quota rolled over. Should a change to a state's landings be made after July 1st, it will be addressed in the subsequent fishing year.

<u>Option A: Unused Quota May Not Be Rolled Over</u>
Unused quota may not be rolled over from one fishing year to the next.

<u>Option B: 100% Quota Rollover</u>
Any unused portion of a quota allocation may be rolled over into the subsequent fishing year only. Unused quota received as part of a transfer may not be rolled over.

<u>Option C: 10% Total Quota Rollover</u>
Up to 10% of a quota allocation may be carried over into the subsequent fishing year only. For example, if a quota allocation is 1 million pounds, up to 100,000 pounds of unused quota may be rolled over into the subsequent fishing year. Unused quota received as part of a transfer may not be rolled over.

<u>Option D: 5% Total Quota Rollover</u>
Up to 5% of a quota allocation may be carried over into the subsequent fishing year only. For example, if a quota allocation is 1 million pounds, up to 50,000 pounds of unused quota may be rolled over into the subsequent fishing year. Unused quota received as part of a transfer may not be rolled over.

Option E: 50% Unused Quota Rollover

Up to 50% of the unused portion of a quota allocation may be rolled over into the subsequent fishing year only. For example, if a quota allocation is 1 million pounds and 600,000 pounds were harvested, up to 200,000 pounds of unused quota could be rolled over into the subsequent year. Unused quota received as part of a transfer may not be rolled over.

4.3.5 Incidental Catch and Small Scale Fisheries

The Board may establish provisions for small-scale gears and non-directed gears to allow for moderate harvest following the closure of the directed fishery, or may set aside a portion of the TAC for harvest throughout the fishing year. Tables 27 and 28 show landings under the current bycatch provision from 2013-2016. For the purposes of this Amendment, **small-scale gears** include cast nets, traps (excluding floating fish traps), pots, haul seines, fyke nets, hook and line, bag nets, hoop nets, hand lines, trammel nets, and bait nets. **Non-directed gears** include pound nets, anchored/stake gillnets, drift gill net, trawls, fishing weirs, fyke nets, and floating fish traps. **Stationary multi-species gears** are defined as pound nets, anchored/stake gill nets, fishing weirs, floating fish traps, and fyke nets.

Landings under the incidental catch provision will be reported to the Board as a part of the annual FMP Review (*Section 5.3: Compliance Report*). Should a specific gear type show a continued and significant increase in landings under the incidental catch provision, or it becomes clear that a non-directed gear type is directing on menhaden under the incidental catch provision, the Board has the authority, through Adaptive Management (*Section 4.6*), to alter the trip limit or remove that gear from the incidental catch provision.

Please note: if a fleet-based allocation method is chosen in *Section 4.3.2 Quota Allocation*, Option E: Small-Scale Fishery Set Aside does not apply. If a two-fleet allocation method with a soft cap for the small-capacity fleet is chosen in *Section 4.3.2 Quota Allocation*, the management alternatives in this section do not apply. If a three-fleet allocation method with a soft cap for the small-capacity fleet is chosen in *Section 4.3.2 Quota Allocation*, the management alternatives in this section would only apply to non-directed gear types.

Option A: Catch Limit for Non-Directed Gear Types

After a quota allocation is met for a given jurisdiction, region, disposition, or fleet, the fishery moves to an incidental catch fishery in which **non-directed gear types** may land up to 6,000 pounds of menhaden per trip per day. Two permitted individuals, working from the same vessel fishing stationary multi-species gear, are authorized to work together and land up to 12,000 pounds from a single vessel – limited to one vessel trip per day. A trip is based on a calendar day such that no vessel may land menhaden more than once in a single calendar day. The use of multiple carrier vessels per trip to offload any bycatch exceeding 6,000 pounds of Atlantic menhaden is prohibited. Incidental catch landings are reported by states to the Commission as a part of Annual Compliance Reports. Under this option, landings in the incidental catch fishery do not count towards the TAC.

Option B: Catch Limit for Small Scale Fisheries and Non-Directed Gear Types
After a quota allocation is met for a given jurisdiction, region, disposition, or fleet, the fishery moves to an incidental catch fishery in which **small-scale gears** and **non-directed gear types** may land up to 6,000 pounds of menhaden per trip per day. Two authorized individuals, working from the same vessel fishing stationary multi-species gear, are permitted to work together and land up to 12,000 pounds from a single vessel – limited to one vessel trip per day. A trip is based on a calendar day such that no vessel may land menhaden more than once in a single calendar day. The use of multiple carrier vessels per trip to offload any bycatch exceeding 6,000 pounds of Atlantic menhaden is prohibited. Incidental catch landings are reported by states to the Commission as a part of Annual Compliance Reports. Under this option, landings in the incidental catch fishery do not count towards the TAC.

Option C: Catch Cap and Trigger
After a quota allocation is met for a given jurisdiction, region, disposition, or fleet, the fishery moves to an incidental catch fishery in which **small-scale gears** and **non-directed gear types** may land up to 6,000 pounds of menhaden per trip per day. Two authorized individuals, working from the same vessel fishing stationary multi-species gear, are permitted to work together and land up to 12,000 pounds from a single vessel – limited to one vessel trip per day. A trip is based on a calendar day such that no vessel may land menhaden more than once in a single calendar day. The use of multiple carrier vessels per trip to offload any bycatch exceeding 6,000 pounds of Atlantic menhaden is prohibited.

A catch cap for the incidental catch fishery is set at 2% of the TAC. For 2017, this represents approximately 8.8 million pounds, which is 2.2 million pounds higher than the maximum bycatch landing of 6.6 million pounds in a single year between 2013 and 2016. Incidental catch landings are reported by states to the Commission as a part of Annual Compliance Reports. If reported incidental catch exceeds the Cap by more than 10% in a single year or exceeds the Cap two years in a row, regardless of the percent overage, management action is triggered by the Board to reduce incidental landings in the fishery. Under this option, landings in the incidental catch fishery do not count towards the TAC as the Cap is a threshold against which incidental catch landings are measured; the Cap is not a set aside.

Option D: Incidental Catch Fishery Set Aside
2% of the overall TAC is set aside for an incidental catch fishery, which occurs after a quota allocation is met for a given jurisdiction, region, disposition, or fleet. Under an incidental catch fishery, there is a 6,000 pound per trip per day menhaden allowance for **small-scale gears and non-directed gear types.** All landings by these gear types which occur after a quota allocation has been met are counted towards the set aside. Two authorized individuals, working from the same vessel fishing stationary multi-species gear, are permitted to work together and land up to 12,000 pounds from a single vessel – limited to one vessel trip per day. A trip is based on a calendar day such that no vessel may land menhaden more than once in a single calendar day. The use of multiple carrier vessels per trip to offload any bycatch exceeding 6,000 pounds of Atlantic menhaden is prohibited.

Landings made by small-scale fisheries and non-directed fisheries following the closure of the directed fishery are reported by states to the Commission as a part of Annual Compliance Reports. If the set aside is exceeded in a given year, the overage is deducted from the subsequent year's set aside. Should quota reconciliation be chosen in *Section 4.3.3*, overages of the incidental catch fishery set aside will be forgiven if the coastwide TAC is not exceeded; however, if the coastwide TAC is exceeded, "common pool" quota will not be distributed to the incidental catch fishery set aside and the overage will be paid back in full the following year. Unused quota from a region or state can be transferred to the set aside to reduce an overage. The percentage of TAC set aside for the incidental catch fishery can be altered under Adaptive Management (*Section 4.6*). Under this option, landings in the incidental catch fishery do count towards the TAC.

<u>Option E: Small-Scale Fishery Set Aside</u>
1% of the overall TAC is set aside for **small-scale gears**. Landings by small-scale fisheries are reported by states to the Commission as a part of annual Compliance Reports; landings do not need to be reported to SAFIS, should this reporting method be implemented. If the coastwide set aside is exceeded in a given year, the overage is deducted from the subsequent year's set aside. Should quota reconciliation be chosen in *Section 4.3.3*, overages of the small-scale fishery set aside will be forgiven if the coastwide TAC is not exceeded; however, if the coastwide TAC is exceeded, "common pool" quota will not be distributed to the small-scale fishery set aside and the overage will be paid back in full the following year. Unused quota from a region or state can be transferred to the set aside to reduce an overage.

There is no trip limit for small scale gears under this set aside; however, should a gear type show a significant and persistent increase in landings, the Board may implement a trip limit through Adaptive Management (*Section 4.6*). In addition, the percentage of TAC set aside for small-scale fisheries can by altered under Adaptive Management.

If a jurisdictional allocation method is chosen in *Section 4.3.2* and a state which only has landings by small-scale gears is allocated quota, that state may choose to add its jurisdictional quota to the small-scale fishery set aside. For example, if Florida, a state which exclusively has a cast net fishery, is allocated 0.5% of quota, the state may aggregate its state quota with the small-scale fishery set aside, making the set aside allocation 1.5%.

Landings by all other gear types' count towards the quota allocated to either states, regions, dispositions, or fleets. Once the respective quota allocation is met, the menhaden fishery is closed and no landings of menhaden are permitted by those gear types. Under this option, landings in the small scale fishery do count towards the TAC.

<u>Option F: All Catch Included in TAC</u>
All catch of menhaden, including incidental catch, counts towards the directed fishery TAC. Once the quota allocation for a specific state, region, disposition, or fleet is reached, the menhaden fishery is closed and no landings of menhaden are permitted by that state, region, disposition or fleet.

4.3.6 Episodic Events Set Aside Program

The Board may set aside a portion of the TAC for episodic events. Episodic events are defined by any instance in which a qualified state has reached its annual quota allocation available to them prior to September 1 and the state can prove the presence of unusually large amounts of menhaden in its state waters. The goal of the set aside is to add flexibility to the management of the species so that states can harvest menhaden during episodic events, reduce discards, and prevent fish kills. Eligibility to participate in the episodic events set aside program is reserved for the states of Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, and New York. Landings per year under the set aside can be found in Table 29.

4.3.6.1 TAC Set Aside

A percentage of the TAC is set aside for use in the episodic events program.

<u>Option A: 1% of TAC is Set Aside (Status quo)</u>
1% of the overall TAC is set aside for episodic events.

<u>Option B: 3% of TAC is Set Aside</u>
3% of the overall TAC is set aside for episodic events.

<u>Option C: 0% of TAC is Set Aside</u>
No portion of the overall TAC is set aside for episodic events. Under this option, there is no episodic events program.

4.3.6.2 Mandatory Provisions

In order for an eligible state to participate in the episodic events set aside program, states must implement the following provisions.

1. Participating states must implement daily trip level harvester reporting. Each state must track landings and submit weekly reports to ASMFC staff. Should several states be approved to participate in the episodic event set aside program, ASMFC staff may require more frequent reporting to ensure the set aside is not exceeded.
2. Episodic events harvest and landings must be restricted to state waters of the jurisdiction approved to participate in the set aside.
3. Participating states must implement a maximum daily trip limit no greater than 120,000 pounds/vessel. A daily trip is defined by a calendar day such that no vessel harvesting under the episodic events program may land menhaden twice in a single calendar day.

4.3.6.3 Declaring Participation

A state must apply to participate in the episodic events program prior to September 1st. In order to apply, a state must send a letter to the ASMFC Executive Director, ISFMP Director, and FMP Coordinator declaring interest in harvesting under the set aside. The letter must demonstrate the following:

1. The state has implemented the mandatory provisions stated in Section 4.3.6.2.
2. The applying state has fully harvested its annual quota allocation prior to September 1.
   - If a jurisdictional quota is implemented, a state must reach its quota prior to September 1.
   - If a coastwide quota is implemented, the coastwide quota must be reached prior to September 1.
   - If a regional quota is implemented, the regional quota in which the state participates must be reached prior to September 1. A state within a region may apply to participate without the other states/jurisdictions within its region applying.
   - If disposition quotas are implemented, the quota allocated to the bait sector must be reached prior to September 1.
   - If fleet capacity quotas are implemented, only gear types which have reached their quota prior to September 1 are eligible to harvest under the set aside program. A state must declare in their letter to ASMFC, prior to approval to participate, which gear types will be allowed to harvest under the set aside program. Gears under a soft cap are allowed to participate in the episodic event set aside so that they can fish under a higher trip limit; these landings will count towards the episodic set aside quota.
3. The state has unusually large amounts of menhaden in its state waters. This can be demonstrated through:
   - Surveys (aerial, seine) which indicate high biomass;
   - Landings reports which indicate an unusually high rate of menhaden harvest at the time of declaration into the set aside;
   - Or information highlighting the potential for fish kills, associated human health concerns, and the ability of harvest under the set aside to reduce or eliminate the fish kill.
4. The state has not declared *de minimis* status. If a qualifying state was previously granted *de minimis* status, it will lose that status and will need to collect biological data and catch and effort data for an adult index as required *by Section 3.5: Biological Data Collection Programs*.

Once the application letter is received by ASMFC staff, the PRT will review the state's compliance with the requirements of the episodic events set aside program. Once verified, ASMFC will send a letter notifying the state that it can harvest menhaden under the set aside. Only harvest that occurs on or after the date of the aforementioned notification letter, and prior to the states eligibility ending, will be considered episodic event set aside harvest. ASMFC staff will also notify the Board when any state is approved to harvest under the set aside.

4.3.6.4 Procedure for Unused Set Aside
If an episodic event is not triggered by September 1 in any state, the unused set aside quota will be rolled into the overall TAC on September 1 and redistributed based on the allocation method and timeframe selected in *Section 4.3.2*. If an episodic event is triggered, any unused

set aside as of October 31st of each year will be redistributed based on the allocation method and timeframe selected in *Section 4.3.2*.

4.3.6.5 Procedure for Set Aside Overages

If the episodic event set aside is exceeded, any overages will be deducted from the next year's episodic event set aside amount. Should quota reconciliation be chosen in *Section 4.3.3*, overages of the episodic events set aside program will be forgiven if the coastwide TAC is not exceeded; however, if the coastwide TAC is exceeded, "common pool" quota will not be distributed to the episodic events set aside and the overage will be paid back in full the following year. Unused quota from a region or state can be transferred to the set aside to reduce an overage.

4.3.7 Chesapeake Bay Reduction Fishery Cap

The Chesapeake Bay Reduction Fishery Cap limits allowable harvest from the Chesapeake Bay by the reduction fishery. The intent of the Cap is to prevent all of the reduction fishery harvest from occurring in the Chesapeake Bay, a critical nursery area for Atlantic menhaden. Harvest for reduction purposes shall be prohibited within the Chesapeake Bay when 100% of the cap is harvested from Chesapeake Bay, which is defined as areas shoreward of the Chesapeake Bay Bridge Tunnel. Harvest above the Cap in any given year will be deducted from the next year's allowable harvest. Should quota reconciliation be chosen in *Section 4.3.3*, it does not apply to the Chesapeake Bay Reduction Fishery Cap meaning overages are not forgiven if the coastwide TAC is not exceeded. Furthermore, unused quota from a region or state cannot be transferred to the Cap to reduce an overage. In recent years, reduction harvest in the Chesapeake Bay has consistently underperformed the 87,216 mt cap, with less than 45,000 mt harvest in 2014 and 2016 and less than 50,000 mt harvested in 2015.

<u>Option A: Cap Set At 87,216 mt</u>
The Chesapeake Bay Reduction Fishery Cap is maintained as 87,216 metric tons.

> <u>Sub-Option A: Limited Rollover of Unused Cap Permitted</u>
> A maximum of 10,976 metric tons of un-landed fish under the Cap can be rolled over into the subsequent year. Unused landings under the Cap cannot be rolled over for multiple years and, as a result, the Cap in a given year cannot exceed 98,192 metric tons.
>
> <u>Sub-Option B: No Rollover of Unused Cap Permitted</u>
> Any amount of un-landed fished under the Cap cannot be rolled over into the subsequent year. As a result, the Cap is a given year cannot exceed 87,216 metric tons.

<u>Option B: Cap Set At 51,000 mt</u>
The Chesapeake Bay Reduction Fishery Cap is reduced to 51,000 metric tons. This value represents an approximation of the five-year average of reduction harvest from the Chesapeake Bay between 2012 and 2016. An approximate value is used because reduction landings in the Chesapeake Bay are confidential.

Sub-Option A: Limited Rollover of Unused Cap Permitted
A maximum of 6,418 metric tons of un-landed fish under the Cap can be rolled over into the subsequent year. Unused landings under the Cap cannot be rolled over for multiple years and, as a result, the Cap is a given year cannot exceed 57,418 metric tons.
Sub-Option B: No Rollover of Unused Cap Permitted
Any amount of un-landed fish under the Cap cannot be rolled over into the subsequent year. As a result, the Cap in a given year cannot exceed 51,000 metric tons.

Option C: Remove the Cap
Under this option, there is no limit on harvest by the reduction fishery in the Chesapeake Bay.

4.4 HABITAT CONSERVATION AND RESTORATION RECOMMENDATIONS

In order to ensure the productivity of populations, each state should identify and protect critical nursery areas for Atlantic menhaden within its boundaries. Such efforts should inventory historical habitats, identify habitats presently used by menhaden, and impose or encourage measures to retain or increase the quantity and quality of Atlantic menhaden habitat.

4.4.1 Preservation of Existing Habitat

States should provide inventories and locations of critical Atlantic menhaden habitat to other state and federal regulatory agencies. Regulatory agencies should be advised on the types of threats to Atlantic menhaden populations and recommended measures that should be employed to avoid, minimize or eliminate any threat to current habitat extent or quality.

4.4.2 Habitat Restoration and Improvement

While Atlantic menhaden appear to be utilizing the bulk of their historic nursery areas, water quality in these areas should be maintained or improved, if impaired, to prevent hypoxic fish kills and minimize the threat of increased mortality due to disease and parasitism. Protection of wetlands will protect and improve menhaden habitat.

4.4.3 Avoidance of Incompatible Activities

Federal and state fishery management agencies should take steps to limit the introduction of compounds which are known, or suspected, to accumulate in any animal species' tissue and which pose a threat to human health or any animals' health.

Each state should establish windows of compatibility for activities known or suspected to adversely affect Atlantic menhaden life stages and their habitats, such as navigational dredging, inlet modifications, and dredged material disposal, and notify the appropriate construction or regulatory agencies in writing.

Projects involving water withdrawal from nursery habitats (e.g. power plants, irrigation, water supply projects) should be scrutinized to ensure that adverse impacts resulting from larval/juvenile impingement, entrainment, and/or modification of flow, temperature and salinity regimes due to water removal, will not adversely impact estuarine dependent species, including Atlantic menhaden, especially early life stages.

Each state which contains Atlantic menhaden nursery areas within its jurisdiction should develop water use and flow regime guidelines which are protective of these nursery areas and which will ensure to the extent possible, the long-term health and sustainability of the stock.

4.4.4 Fishery Practices

The use of any fishing gear or practice which is documented by management agencies to have an unacceptable impact on Atlantic menhaden (e.g. habitat damage, bycatch mortality) should be prohibited within the effected essential habitats.

4.5 ALTERNATIVE STATE MANAGEMENT REGIMES

States are required to obtain prior approval from the Board of any changes to their management program for which a compliance requirement is in effect. Changes to non-compliance measures must be reported to the Board but may be implemented without prior Board approval. A state can request permission to implement an alternative management measure to any mandatory compliance measure only if that state can show, to the Board's satisfaction, that its alternative proposal will have the same conservation value as the measure contained in this amendment or any addenda prepared under Adaptive Management (*Section 4.6*). States submitting alternative proposals must demonstrate that the proposed action will not contribute to overfishing of the resource. All changes to a state's plan must be submitted in writing to the Board and to the Commission as part of the Annual Compliance Reports.

4.5.1 General Procedures

A state may submit a proposal for a change to its regulatory program or any mandatory compliance measure under this amendment to the Commission. Such changes shall be submitted to the Chair of the Plan Review Team (PRT), who shall distribute the proposal to appropriate groups, including the Board, the PRT, the TC, and the AP.

The PRT is responsible for gathering the comments of the TC and the AP. The PRT is also responsible for presenting these comments to the Board for decision.

The Board will decide whether to approve the state proposal for an alternative management program if it determines that it is consistent with the target fishing mortality rate applicable as well as the goals and objectives of this amendment.

In order to maintain consistency within a fishing season, new rules should be implemented prior to the start of the fishing season. Given the time needed for the TC, AP, and Board to review the proposed regulations, as well as the time required by an individual state to promulgate new regulations, it may not be possible to implement new regulations for the on-going fishing season. In this case, new regulations should be effective at the start of the following season after a determination to do so has been made.

4.5.2 Management Program Equivalency

The TC, under the direction of the PRT, will review any alternative state proposals under this section and provide its evaluation of the adequacy of such proposals to the Board. The PRT can also ask for reviews by the Law Enforcement Committee (LEC) or the AP.

4.5.3 De Minimis Fishery Guidelines

The ASMFC Interstate Fisheries Management Program Charter defines *de minimis* as "a situation in which, under the existing condition of the stock and scope of the fishery, the conservation and enforcement actions taken by an individual state would be expected to contribute insignificantly to a coastwide conservation program required by a Fishery Management Plan or amendment," (ASMFC 2016).

A state can apply annually for *de minimis* status if a state does not have a reduction fishery, following the procedure in *Section 4.5.3.2.* To be eligible for *de minimis* consideration in the bait fishery, a state must prove that its commercial bait landings in the most recent two years for which data are available did not exceed 1% of the coastwide bait landings.

4.5.3.1 Plan Requirements if De Minimis Status is Granted

If *de minimis* status is granted, the *de minimis* state is required to implement, at a minimum, the coastwide management requirements contained in *Section 4.0*. Additionally, all *de minimis* states except New Hampshire, Pennsylvania, South Carolina, and Georgia must adhere to timely quota monitoring as approved by the Board (*Section 3.1.2*).

States granted *de minimis* status are exempt from collecting biological data and the adult CPUE index data (*Section 3.5.1.2*).

If the coastwide fishery is closed for any reason through Emergency Procedures (*Section 4.7*), *de minimis* states must close their fisheries as well.

Any additional components of the FMP, which the Board determines necessary for a *de minimis* state to implement, can be defined at the time *de minimis* status is granted.

4.5.3.2 Procedure to Apply for De Minimis Status

States must specifically request *de minimis* status each year. Requests for *de minimis* status will be reviewed by the PRT as part of the annual FMP review process (*Section 5.3: Compliance Report*). Requests for *de minimis* must be submitted to the ASMFC Atlantic Menhaden FMP Coordinator as a part of the state's yearly compliance report. The request must contain the following information: all available commercial landings data for the current and 2 previous full years of data, commercial regulations for the current year, and the proposed management measures the state plans to implement for the year *de minimis* status is requested. The FMP Coordinator will then forward the information to the PRT.

In determining whether or not a state meets the *de minimis* criteria, the PRT will consider the information provided with the request, the most recent available coastwide landings data, any information provided by the TC and SASC, and projections of future landings. The PRT will make a recommendation to the Board to either accept or deny the *de minimis* request. The Board will then review the PRT recommendation and either grant or deny the *de minimis* classification.

The Board must make a specific motion to grant a state *de minimis* status. By deeming a given state *de minimis*, the Board is recognizing that: the state has a minimal Atlantic menhaden fishery; there is little risk to the health of the menhaden stock if the state does not implement the full suite of management measures; and the overall burden of implementing the complete management and monitoring requirements of the FMP outweigh the conservation benefits of implementing those measures in that particular state.

If commercial landings in a *de minimis* state exceed the *de minimis* threshold, the state will lose its *de minimis* classification, will be ineligible for *de minimis* in the following year, and will be required to implement all provisions of the FMP. If the Board denies a state's *de minimis* request, the state will be required to implement all the provisions of the FMP. When a state rescinds or loses its *de minimis* status, the Board will set a compliance date by which the state must implement the required regulations.

4.6 ADAPTIVE MANAGEMENT

The Board may vary the requirements specified in this Amendment as a part of adaptive management in order to conserve the Atlantic menhaden resource. The elements that can be modified by adaptive management are listed in *Section 4.6.2*. The process under which adaptive management can occur is provided below.

4.6.1 General Procedures

The PRT will monitor the status of the fishery and the resource and report on that status to the Board annually or when directed to do so by the Board. The PRT will consult with TC, the SASC, and the AP in making such review and report.

The Board will review the report of the PRT, and may consult further with the TC, SASC, or AP. The Board may, based on the PRT report or on its own discretion, direct the PDT to prepare an addendum to make any changes it deems necessary. The addendum shall contain a schedule for the states to implement the new provisions.

The PDT will prepare a draft addendum as directed by the Board, and shall distribute it to all states for review and comment. A public hearing will be held in any state that requests one. The PDT will also request comment from federal agencies and the public at large. After a 30-day review period, staff, in consultation with the PDT, will summarize the comments received and prepare a final version of the addendum for the Board.

The Board shall review the final version of the addendum prepared by the PDT, and shall also consider the public comments received and the recommendations of the TC, LEC, and AP. The Board shall then decide whether to adopt, or revise and then adopt, the addendum.

Upon adoption of an addendum by the Board, states shall prepare plans to carry out the addendum, and submit them to the Board for approval according to the schedule contained in the addendum.

4.6.2 Measures Subject to Change

The following measures are subject to change under adaptive management upon approval by the Board:

(1) Management areas and unit
(2) Reference points, including an overfishing and overfished definition
(3) Rebuilding targets and schedules
(4) TAC specification
(5) Quota allocation
(6) Quota transfers
(7) Quota rollovers
(8) Episodic events set aside program
(9) Small scale fishery set aside
(10) Incidental catch fishery set aside
(11) Incidental catch provision
(12) *De minimis* specifications
(13) Chesapeake Bay reduction fishery cap
(14) Effort controls
(15) Fishing year and/or seasons
(16) Trip limits
(17) Limited entry
(18) Area closures
(19) Fishery closures
(20) Gears assigned to fleets
(21) Gear restrictions including mesh sizes
(22) Recreational fishery management measures
(23) For-hire fishery management measures
(24) Research set aside programs
(25) Research or monitoring requirements

(26) Frequency of stock assessments
(27) Reporting requirements
(28) Measures to reduce or monitor bycatch
(29) Observer requirements
(30) Recommendations to the Secretaries for complementary actions in federal jurisdictions
(31) Any other management measures currently included in Amendment 3

4.7 EMERGENCY PROCEDURES

Emergency procedures may be used by the Board to require any emergency action that is not covered by, is an exception to, or a change to any provision in Amendment 3. Procedures for implementation are addressed in the ASMFC Interstate Fisheries Management Program Charter, Section Six (c)(10) (ASMFC 2016).

4.8 MANAGEMENT INSTITUTIONS

The management institutions for Atlantic menhaden shall be subject to the provisions of the ISFMP Charter (ASMFC 2016). The following is not intended to replace any or all of the provisions of the ISFMP Charter. All committee roles and responsibilities are included in detail in the ISFMP Charter and are only summarized here.

4.8.1 Atlantic States Marine Fisheries Commission and ISFMP Policy Board

The ASMFC (Commission) and the ISFMP Policy Board are generally responsible for the oversight and management of the Commission's fisheries management activities. The Commission must approve all fishery management plans and amendments, including Amendment 3. The ISFMP Policy Board reviews any non-compliance recommendations of the various Boards and, if it concurs, forwards them to the Commission for action.

4.8.2 Atlantic Menhaden Management Board

The Board was established under the provisions of the Commission's ISFMP Charter (Section Four; ASMFC 2016) and is generally responsible for carrying out all activities under this Amendment.

The Board establishes and oversees the activities of the PDT, PRT, TC, SASC, BERP Workgroup, and the AP. In addition, the Board makes changes to the management program under adaptive management, reviews state programs implementing the amendment, and approves alternative state programs through conservation equivalency. The Board reviews the status of state compliance with the management program annually, and if it determines that a state is out of compliance, reports that determination to the ISFMP Policy Board under the terms of the ISFMP Charter.

4.8.3. Atlantic Menhaden Plan Development Team

The Plan Development Team (PDT) is composed of personnel from state and federal agencies who have scientific knowledge of Atlantic menhaden and management abilities. The PDT is responsible for preparing and developing management documents, including addenda and amendments, using the best scientific information available and the most current stock assessment information. The ASMFC FMP Coordinator chairs the PDT. The PDT will either disband or assume inactive status upon completion of Amendment 3.

4.8.4 Atlantic Menhaden Plan Review Team

The Plan Review Team (PRT) is composed of personnel from state and federal agencies who have scientific and management ability and knowledge of Atlantic menhaden. The PRT is responsible for providing annual advice concerning the implementation, review, monitoring, and enforcement of Amendment 3 once it has been adopted by the Commission. After final action on Amendment 3, the Board may elect to retain members of the PDT as members of the PRT, or appoint new members.

4.8.5 Atlantic Menhaden Technical Committee

The Atlantic Menhaden Technical Committee (TC) consists of representatives from state or federal agencies, Regional Fishery Management Councils, the Commission, a university, or other specialized personnel with scientific and technical expertise, and knowledge of the Atlantic menhaden fishery. The Board appoints the members of the TC and may authorize additional seats as it sees fit. The role of the TC is to assess the species' population, provide scientific advice concerning the implications of proposed or potential management alternatives, and respond to other scientific questions from the Board, PDT, or PRT. The SASC reports to the TC.

4.8.6 Atlantic Menhaden Stock Assessment Subcommittee

The Atlantic Menhaden Stock Assessment Subcommittee (SASC) is appointed and approved by the Board, with consultation from the Atlantic Menhaden TC, and consists of scientists with expertise in the assessment of the Atlantic menhaden population. Its role is to assess the Atlantic menhaden population and provide scientific advice concerning the implications of proposed or potential management alternatives, and to respond to other scientific questions from the Board, TC, PDT or PRT. The SASC reports to the TC.

4.8.7 Biological Ecological Reference Point Workgroup

The Biological Ecological Reference Point Workgroup (BERP Workgroup) is comprised of representatives from each technical committee for weakfish, striped bass, bluefish, and menhaden, in addition to state and federal biologists with expertise on multispecies modeling approaches. The intent of the BERP Workgroup is to assist the Commission with its multispecies modeling efforts and facilitate the use of multispecies model results in management decisions. More specifically, the BERP Workgroup is tasked with identifying potential ecological reference points that account for Atlantic menhaden's role as a forage fish.

4.8.8 Atlantic Menhaden Advisory Panel

The Atlantic Menhaden Advisory Panel (AP) is established according to the Commission's Advisory Committee Charter. Members of the AP are citizens who represent a cross-section of commercial and recreational fishing interests and others who are concerned about Atlantic menhaden conservation and management. The AP provides the Board with advice directly concerning the Commission's Atlantic menhaden management program.

4.8.9 Federal Agencies

4.8.9.1 Management in the Exclusive Economic Zone

Management of Atlantic menhaden in the EEZ is within the jurisdiction of the three Regional Fishery Management Councils under the Magnuson-Stevens Act (16 U.S.C. 1801 et seq.). In the absence of a Council Fishery Management Plan, management is the responsibility of the National Marine Fisheries Service as mandated by the Atlantic Coastal Fishery Cooperative Management Act.

4.8.9.2 Federal Agency Participation in the Management Process

The Commission has accorded USFWS and NMFS voting status on the ISFMP Policy Board and the Atlantic Menhaden Management Board in accordance with the Commission's ISFMP Charter. The NMFS can also participate on the Atlantic Menhaden PDT, PRT, TC and SASC.

4.8.9.3 Consultation with Fishery Management Councils

At the time of adoption of Amendment 3, none of the Regional Fishery Management Councils had implemented a management plan for Atlantic menhaden, nor had they indicated an intent to develop a plan.

4.9 RECOMMENDATION TO THE SECRETARY OF COMMERCE FOR COMPLEMENTARY MEASURES IN FEDERAL WATERS

The quota management approach adopted can be implemented and monitored within the jurisdictions of the Atlantic states. Therefore, a specific recommendation to the Secretary for complimentary action in federal jurisdictions is unnecessary at this time. The Board may consider further recommendations to the Secretary if changes to Amendment 3 occur through the adaptive management process (*Section 4.6*).

4.10 COOPERATION WITH OTHER MANAGEMENT INSTITUTIONS

The Board will cooperate, when necessary, with other management institutions during the implementation of this amendment, including NMFS and the New England, Mid-Atlantic, and South Atlantic Fishery Management Council.

5.0 COMPLIANCE

The full implementation of the provisions included in this amendment is necessary for the management program to be equitable, efficient, and effective. States are expected to implement these measures faithfully under state laws. ASMFC will continually monitor the effectiveness of state implementation and determine whether states are in compliance with the provisions of this fishery management plan.

The Board sets forth specific elements that the Commission will consider in determining state compliance with this fishery management plan, and the procedures that will govern the evaluation of compliance. Additional details of the procedures are found in the ASMFC Interstate Fishery Management Program Charter (ASMFC 2016).

5.1 MANDATORY COMPLIANCE ELEMENTS FOR STATES

A state will be determined to be out of compliance with the provision of this fishery management plan according to the terms of Section Seven of the ISFMP Charter if:

- Its regulatory and management programs to implement Amendment 3 have not been approved by the Board; or
- It fails to meet any schedule required by Section 5.2, or any addendum prepared under adaptive management (*Section 4.6*); or
- It has failed to implement a change to its program when determined necessary by the Board; or
- It makes a change to its regulations required under *Section 4* or any addendum prepared under adaptive management (*Section 4.6*), without prior approval of the Board.

5.1.1 Regulatory Requirements

To be considered in compliance with this fishery management plan, all state programs must include a regime of restrictions on Atlantic menhaden fisheries consistent with the requirements of *Section 3.1: Commercial Catch and Landings Programs; Section 3.5: Biological Data Collection Programs;* and *Section 4.3: Commercial Fishery Management Measures*. A state may propose an alternative management program under *Section 4.5: Alternative State Management Regimes*, which, if approved by the Board, may be implemented as an alternative regulatory requirement for compliance.

States may begin to implement Amendment 3 after final approval by the Commission. Each state must submit its required Atlantic menhaden regulatory program to the Commission through ASMFC staff for approval by the Board. During the period between submission and Board approval of the state's program, a state may not adopt a less protective management program than contained in this Amendment or contained in current state law. The following lists the specific compliance criteria that a state/jurisdiction must implement in order to be in compliance with Amendment 3:

- Commercial fishery management measures as specified in *Section 4.3* including the Total Allowable Catch (*Section 4.3.1*), Overage Payback (*Section 4.3.2.1*), Quota Allocation (*Section 4.3.2*), Quota Transfers (*Section 4.3.3*), Quota Rollovers (*Section 4.3.4*), Incidental Catch and Small-Scale Fishery Provision (*Section 4.3.5*), Episodic Events Set Aside (*Section 4.3.6*), and the Chesapeake Bay Reduction Fishery Harvest Cap (*Section 4.3.7*).
- Monitoring requirements as specified in *Section 3.1*
- Fishery dependent data collection programs as specified in *Section 3.5.1*
- All state programs must include law enforcement capabilities adequate for successful implementation of the compliance measures contained in this Amendment.
- There are no mandatory research requirements at this time; however, research requirements may be added in the future under Adaptive Management, *Section 4.6*.
- There are no mandatory habitat requirements in Amendment 3. See *Section 4.4* for habitat recommendations.

5.2 COMPLIANCE SCHEDULE

States must implement this Amendment according to the following schedule:

Month Day, 201X:	Submission of state programs to implement Amendment 3 for approval by the Board. Programs must be implemented upon approval by the Board.
Month Day, 201X:	States with approved management programs must implement Amendment 3. States may begin implementing management programs prior to this deadline if approved by the Board.

5.3 COMPLIANCE REPORTS

Each state must submit to the Commission an annual report concerning its Atlantic menhaden fisheries and management program for the previous year, no later than April 1st. A standard compliance report format has been prepared and adopted by the ISFMP Policy Board. States should follow this format in completing the annual compliance report.

The report shall cover:

- The previous calendar year's fishery and management program including mandatory reporting programs (including frequency of reporting and data elements collected), fishery dependent data collection, fishery independent data collection, regulations in

effect, total harvest (including directed landings, incidental and small-scale fishery landings, landings under the episodic events program, and landings by gear type), *de minimis* requests, and future regulatory changes.
- The planned management program for the current calendar year summarizing regulations that will be in effect and monitoring programs that will be performed, highlighting any changes from the previous year.

5.4 PROCEDURES FOR DETERMINING COMPLIANCE

Detailed procedures regarding compliance determinations are contained in the ISFMP Charter, Section Seven (ASMFC 2016). In brief, all states are responsible for the full and effective implementation and enforcement of fishery management plans in areas subject to their jurisdiction. Written compliance reports as specified in the Amendment must be submitted annually by each state with a declared interest. Compliance with Amendment 3 will be reviewed at least annually; however, the Board, ISFMP Policy Board, or the Commission may request the PRT to conduct a review of state's implementation and compliance with Amendment 3 at any time.

The Board will review the written findings of the PRT within 60 days of receipt of a State's compliance report. Should the Board recommend to the Policy Board that a state be determined out of compliance, a rationale for the recommended noncompliance finding will be addressed in a report. The report will include the required measures of Amendment 3 that the state has not implemented or enforced, a statement of how failure to implement or enforce required measures jeopardizes Atlantic menhaden conservation, and the actions a state must take in order to comply with Amendment 3 requirements.

The ISFMP Policy Board will review any recommendation of noncompliance from the Board within 30 days. If it concurs with the recommendation, it shall recommend to the Commission that a state be found out of compliance.

The Commission shall consider any noncompliance recommendation from the ISFMP Policy Board within 30 days. Any state that is the subject of a recommendation for a noncompliance finding is given an opportunity to present written and/or oral testimony concerning whether it should be found out of compliance. If the Commission agrees with the recommendation of the ISFMP Policy Board, it may determine that a state is not in compliance with Amendment 3, and specify the actions the state must take to come into compliance.

Any state that has been determined to be out of compliance may request that the Commission rescind its noncompliance findings, provided the state has revised its Atlantic menhaden conservation measures.

5.5. ANALYSIS OF THE ENFORCEABILITY OF PROPOSED MEASURES

All state programs must include law enforcement capabilities adequate for successfully implementing that state's Atlantic menhaden regulations. The LEC will monitor the adequacy of a state's enforcement activity.

6.0 RESEARCH NEEDS

The following list of research needs have been identified in order to enhance the state of knowledge of the Atlantic menhaden resource. Research recommendations are broken down into several categories: data; assessment methodology, habitat, and socio-economic. Each category is further broken down into recommendations that can be completed in the short term (within 5 years) and recommendations that will require a long term commitment (6+ years).

6.1 STOCK ASSESSMENT AND POPULATION DYNAMICS RESEARCH NEEDS

6.1.1 Annual Data Collection

Short Term:

1. Continue current level of sampling from bait fisheries, particularly in the mid-Atlantic and New England. Analyze sampling adequacy of the reduction fishery and work with industry and states to effectively sample areas outside of that fishery.
2. Conduct ageing validation study to confirm scale to otolith comparisons. Use archived scales to do radio isotope analysis.
3. Conduct a comprehensive fecundity study.
4. Place observers on boats to collect at-sea samples from purse-seine sets.
5. Investigate relationship between fish size and school size in order to address selectivity.
6. Investigate relationship between fish size and distance from shore.
7. Evaluate alternative fleet configurations for removal and catch-at-age data.
8. Investigate inter-annual variability in the maturity of menhaden via collection of annual samples along the Atlantic coast.

Long Term:

1. Develop a menhaden specific coastwide fishery independent index of adult abundance at age.
2. Conduct studies on spatial and temporal dynamics of spawning.
3. Conduct studies on the productivity of estuarine environments related to recruitment.
4. Investigate environmental covariates related to recruitment.
5. Validate multispecies/ecosystem model parameters through the development and implementation of stomach sampling program that will cover major menhaden predators along the Atlantic coast. Validation of prey preferences, size selectivity and spatial overlap is critically important to the appropriate use of such model results.

6.1.2 Assessment Methodology

Short Term:

1. Conduct Management Strategy Evaluation (MSE) on the various reference point options (single-species, multi-species) for menhaden.
2. Continue to develop an integrated length and age based model.
3. Continue to improve methods for incorporation of natural mortality.
4. Consider estimating (time-varying) growth within the assessment model.
5. Account for co-variation among parameters and inputs in future uncertainty analyses of the assessment model.
6. Examine the variance assumption and weighting factors of all the likelihood components in the model.

Long Term:

1. Develop a seasonal spatially-explicit model, once sufficient age-specific data on movement rates of menhaden are available.
2. Continue exploring the development of multispecies models that can take predator-prey interactions into account. This should inform and be linked to the development of assessment models that allow natural mortality to vary over time.
3. Evaluate the sensitivity of reference points to recent productivity trends.
4. Reconsider models that allow natural mortality to vary over time.
5. Collect age-specific data on movement rates of menhaden to develop regional abundance trends.
6. Investigate the effects of global climate change on distribution, movement, and behavior of menhaden.

6.2 HABITAT RESEARCH NEEDS

1. Study specific habitat requirements for all life history stages.
2. Develop habitat maps for all life history stages.
3. Identify migration routes of adults.
4. Study the effects of large-scale climatic events and the impacts on Atlantic menhaden.
5. Evaluate effects of habitat loss/degradation on Atlantic menhaden.

6.3 SOCIO-ECONOMIC RESEARCH NEEDS

1. Develop a mechanism for estimating or obtaining data for economic analysis on the reduction fishery, due to the confidential nature of the data.
2. Conduct studies to fully recognize the linkages between the menhaden fishery and the numerous other fisheries which it supports and sustains.
3. Conduct studies on the recreational component of the menhaden fishery to better understand what gear is being used, where it is being prosecuted, disposition of the catch, and who the users may be in terms of socioeconomic issues and other factors.

4. Analyze the social aspects of the non-consumptive sector, including components of the bird watching and whale watching industries, including where they live and what their particular interests are in menhaden.

7.0 PROTECTED SPECIES

In the fall of 1995, Commission member states, NMFS, and USFWS began discussing ways to improve implementation of the Marine Mammal Protection Act (MMPA) and the Endangered Species Act (ESA) in state waters. Historically, these policies had been only minimally implemented and enforced in state waters (0-3 miles). In November 1995, the Commission, through its ISFMP Policy Board, approved an amendment to its ISFMP Charter (Section Six (b)(2)) requiring protected species/fishery interactions to be discussed in the Commission's fisheries management planning process. As a result, the Commission's fishery management plans describe impacts of state fisheries on certain marine mammals and endangered species, collectively termed "protected species". The following section outlines: (1) the federal legislation which guides protection of marine mammals and sea turtles, (2) the protected species with potential fishery interactions; (3) the specific types of fishery interaction; (4) population status of the affected protected species; and (5) potential impacts to Atlantic coast state and interstate fisheries.

7.1 MARINE MAMMAL PROTECTION ACT REQUIREMENTS

Since its passage in 1972, one of the underlying goals of the MMPA has been to reduce the incidental serious injury and mortality of marine mammals in the course of commercial fishing operations to insignificant levels approaching a zero mortality and zero serious injury rate. Under the 1994 Amendments, the Act requires NMFS to develop and implement a take reduction plan to assist in the recovery of, or prevent the depletion of, each strategic stock that interacts with a Category I or II fishery. A strategic stock is defined as a stock: (1) for which the level of direct human-caused mortality exceeds the potential biological removal (PBR)[1] level; (2) which is declining and is likely to be listed under the Endangered Species Act (ESA) in the foreseeable future; or (3) which is listed as a threatened or endangered species under the ESA or as a depleted species under the MMPA. Category I and II fisheries are those that have frequent or occasional incidental mortality and serious injury of marine mammals, whereas Category III fisheries are those which have a remote likelihood of incidental mortality and serious injury to marine mammals. Each year NMFS publishes a List of Fisheries (LOF), which classifies commercial fisheries into one of these three categories.

Under 1994 mandates, the MMPA also requires fishermen in Category I and II fisheries to

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[1] PBR is the number of human-caused deaths per year each stock can withstand and still reach an optimum population level. This is calculated by multiplying the minimum population estimate by the stock's net productivity rate and a recovery factor ranging from 0.1 for endangered species to 1.0 for healthy stocks.

register under the Marine Mammal Authorization Program (MMAP). The purpose of this is to provide an exception for commercial fishermen from the general taking prohibitions of the MMPA. All fishermen, regardless of the category of fishery in which they participate, must report all incidental injuries and mortalities caused by commercial fishing operations within 48 hours.

Section 101(a)(5)(E) of the MMPA allows for authorization of the incidental take of ESA-listed marine mammals in the course of commercial fishing operations if it is determined that: (1) incidental mortality and serious injury will have a negligible impact on the affected species or stock; (2) a recovery plan has been developed or is being developed for such species or stock under the ESA; and (3) where required under MMPA Section 118, a monitoring program has been established, vessels engaged in such fisheries are registered, and a take reduction plan has been developed or is being developed for such species or stock. MMPA Section 101(a)(5)(E) permits are not required for Category III fisheries, but any serious injury or mortality of a marine mammal must be reported.

7.2 ENDANGERED SPECIES ACT REQUIREMENTS

The taking of endangered sea turtles and marine mammals is prohibited and considered unlawful under Section 9(a)(1) of the ESA. In addition, NMFS or the USFWS may determine Section 4(d) protective regulations to be necessary and advisable to provide for the conservation of threatened species. There are several mechanisms established in the ESA which allow for exceptions to the prohibited take of protected species listed under the ESA. Section 10(a)(1)(A) of the ESA authorizes NMFS to allow the taking of listed species through the issuance of research permits, which allow ESA species to be taken for scientific purposes or to enhance the propagation and survival of the species. Section 10(a)(1)(B) authorizes NMFS to permit, under prescribed terms and conditions, any taking otherwise prohibited by Section 9(a)(1)(B) of the ESA if the taking is incidental to, and not the purpose of, carrying out an otherwise lawful activity. In recent years, some Atlantic state fisheries have obtained section 10(a)(1)(B) permits for state fisheries. Recent examples are at http://www.nmfs.noaa.gov/pr/permits/esa_review.htm#esa10a1b.

Section 7(a)(2) requires federal agencies to consult with NMFS to ensure that any action that is authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat of such species. If, following completion of the consultation, an action is found to jeopardize the continued existence of any listed species or cause adverse modification to critical habitat of such species, reasonable and prudent alternatives need to be identified so that jeopardy or adverse modification to the species does not occur. Section (7)(o) provides the actual exemption from the take prohibitions established in Section 9(a)(1), which includes Incidental Take Statements that are provided at the end of consultation via the ESA Section 7 Biological Opinions.

7.3 PROTECTED SPECIES WITH POTENTIAL FISHERY INTERACTIONS

A number of protected species inhabit the management unit, which includes inshore and nearshore waters, for Atlantic Menhaden. Ten are classified as endangered or threatened under the ESA; the remainder are protected under provisions of the MMPA. The species found in coastal Northwest Atlantic waters are listed below.

<u>Endangered</u>	
Right whale	(*Eubalaena glacialis*)
Blue Whale	*(Balaenoptera musculus)*
Fin whale	(*Balaenoptera physalus*)
Leatherback turtle	(*Dermochelys coriacea*)
Kemp's ridley	(*Lepidochelys kempii*)
Hawksbill turtle	*(Eretmochelys imbricata)*
Shortnose sturgeon	(*Acipenser brevirostrum*)
Atlantic sturgeon	*(Acipenser oxyrinchus oxyrinchus)*
<u>Threatened</u>	
Loggerhead turtle	(*Caretta caretta*)
North Atlantic Green turtle dps	*(Chelonia mydas)*
<u>MMPA</u>	
Includes all marine mammals above in addition to:	
Minke whale	(*Balaenoptera acutorostrata*)
Humpback whale	*(Megaptera novaeangliae)*
Bottlenose dolphin	(*Tursiops truncatus*)
Atlantic-white sided dolphin	*(Lagenorhynchus acutus)*
Harbor seal	(*Phoca vitulina*)
Grey seal	(*Halichoerus grypus*)
Harp seal	(*Phoca groenlandica*)
Harbor porpoise	*(Phocoena phocoena)*

In the Northwest Atlantic waters, protected species utilize marine habitats for feeding, reproduction, nursery areas, and migratory corridors. For several stocks of marine mammals, including humpback whales, menhaden are an important prey species. Some species occupy the area year round while others use the region only seasonally or move intermittently nearshore, inshore, and offshore. Interactions may occur whenever fishing gear and marine mammals overlap spatially and temporally.

For sea turtles, the Atlantic seaboard provides important developmental habitat for post-pelagic juveniles, as well as foraging and nesting habitat for adults. The distribution and abundance of sea turtles along the Atlantic coast is related to geographic location and seasonal variations in water temperatures. Water temperatures dictate how early northward migrations begin each year and is a useful factor for assessing when turtles will be found in certain areas.

Interactions may occur whenever fishing gear and sea turtles overlap spatially and temporally.

7.3.1 Marine Mammals

Five marine mammal species are primarily known to co-occur with or become entangled in gear used by the Atlantic menhaden fishery. They include the Atlantic right whale, humpback whale, fin whale, coastal bottlenose dolphin, and harbor porpoise.

North Atlantic Right Whale
The North Atlantic right whale (*Eubalaena glacialis*) is among the most endangered large whale species in the world. Despite decades of conservation measures, the population remains at low numbers. In 2012, 440 individually recognized whales were known to be alive (Corkeron et al., 2016). Models using data collected through the mid-1990s indicated that if the conditions present at that time were to continue, western North Atlantic right whales would be extinct within 200 years (Caswell et al., 1999).

North Atlantic right whales have a wide distribution throughout the Atlantic Ocean but are generally found west of the Gulf Stream, from the southeast U.S. to Canada (Kenney, 2002; Waring et al., 2009). North Atlantic right whales frequent Stellwagen Bank, Jeffreys Ledge, the Bay of Fundy, and Browns Banks in the warmer months. The distribution of right whales in the summer and fall is linked to the distribution of zooplankton (Winn et al., 1986). Right whales feed by swimming continuously with their mouths open, filtering large amounts of water through their baleen and capturing zooplankton on the baleen's inner surface. Calving occurs in the winter months in coastal waters off of Georgia and Florida (Kraus et al., 1988). Mid-Atlantic waters are used as a migratory pathway from the spring and summer feeding/nursery areas to the winter calving grounds off the coast of Georgia and Florida.

The North Atlantic Right Whale is listed as endangered throughout its range. Ship strikes and fishing gear entanglements are the principal factors believed to be hindering recovery of western North Atlantic right whales population (NMFS, 2012). Data collected from 1970 through 1999 indicate that anthropogenic interactions in the form of ship strikes and gear entanglements were responsible 19 out of 45 reported right whale deaths (Knowlton and Kraus, 2001).

Humpback Whale
Humpback whales, known for their displays of breeching and bubble net feeding, can be found in all major oceans. In the western North Atlantic, humpback whales calve and mate in the West Indies and then migrate to northern feeding areas during the summer months. In the Gulf of Maine, sightings are most frequent from mid-March through November (CETAP, 1982). There they feed on a number of species of small schooling fish, particularly sand lance, mackerel, and Atlantic herring. Humpback whales have also been observed feeding on krill (Wynne and Schwartz, 1999).

In the western Atlantic Ocean, humpback whales have become increasingly more abundant.

The overall North Atlantic population, estimated from genetic tagging data collected by the Years of the North Atlantic Humpback (YONAH) project, was estimated to be 4,894 males and 2,804 females in the 1990's. As a result, the West Indies population of humpback whales, which migrates up to New England, was not considered at risk of extinction or likely to become threatened within the foreseeable future (81 FR 62259, September 8, 2016). While not listed as endangered or threatened, the major known sources of anthropogenic mortality and injury of humpback whales are commercial fishing gear entanglements and ship strikes.

Fin Whale

Fin whales inhabit a wide range of latitudes between 20 to 75 degrees north and 20 to 75 degrees south (Perry et al., 1999). Like right and humpback whales, fin whales are believed to use high latitude waters primarily for feeding, and low latitude waters for calving. However, evidence regarding the location of where fin whales primarily winter, calve, and mate is still scarce. Clark (1995) reported a general pattern of fin whale movements in the fall from the Labrador/Newfoundland region, south past Bermuda and into the West Indies, but also noted strandings along the U.S. Mid-Atlantic coast from October through January. This could suggest the possibility of an offshore calving area (Clark 1995; Hain et al. 1992). The predominant prey of fin whales varies greatly in different areas depending on what is locally available (IWC, 1992). In the western North Atlantic, fin whales feed on a variety of small schooling fish (e.g., herring, capelin, and sand lance) as well as squid and planktonic crustaceans (Wynne and Schwartz, 1999).

The fin whale is listed as endangered throughout its range. Like right whales and humpback whales, anthropogenic mortality of fin whales includes entanglement in commercial fishing gear and ship strikes (NMFS, 2011). Of 12 fin whale mortalities recorded between 2009 and 2013, nine were associated with vessel interactions (Waring et al., 2016). Experts believe that fin whales are struck by large vessels more frequently than any other cetacean (Laist et al., 2001).

Bottlenose Dolphin

Common bottlenose dolphins are found throughout the western Atlantic coast, with primary habitat along the U.S. ranging from New York through Florida. The distribution of the species changes seasonally, with a greater abundance of bottlenose dolphins found in the Mid-Atlantic waters in the summer (NMFS, 2008). In the winter, most bottlenose dolphins are found south of the Virginia-North Carolina border (NMFS, 2008). The species is often aggregated in groups, ranging up to 15 individuals inshore and even larger herds offshore. Bottlenose dolphins eat a variety of prey including invertebrates and fish.

On the Atlantic coast, five stocks of common bottlenose dolphins are considered depleted under the MMPA, meaning that the population stock is below its optimum sustainable level (Waring et al., 2016). The primary source of human-induced mortality is interactions with fishing gear, particularly coastal gillnets. Between 1995 and 2000, 12 bottlenose dolphin mortalities were reported in gillnets targeting dogfish, striped bass, Spanish mackerel, kingfish, and weakfish (NMFS, 2008). Four more mortalities were observed in 2003-2006 (NMFS, 2008).

In response, a Bottlenose Dolphin Take Reduction Plan was implemented in May 2006 to reduce the incidental mortality and serious injury of bottlenose dolphins in commercial fishing gear (71 FR 24776, April 26, 2006).

Harbor Porpoise

The harbor porpoise ranges from West Greenland to North Carolina. The southern-most stock of harbor porpoise is referred to as the Gulf of Maine/Bay of Fundy stock and spends its winters in the Mid-Atlantic region. Harbor porpoises are generally found in coastal and inshore waters, but will also travel to deeper, offshore waters. There are insufficient data to determine population trends for this species because harbor porpoises are widely dispersed in small groups, they spend little time at the surface, and their distribution varies from year to year depending on environmental conditions (NMFS, 2002). Shipboard line transect sighting surveys have been conducted to estimate population size of the harbor porpoise stock. The best estimate of abundance for the Gulf of Maine/Bay of Fundy harbor porpoise stock is 79,883 individuals from a 2011 survey (NMFS, 2016).

The Gulf of Maine harbor porpoise was proposed to be listed as threatened under the ESA on January 7, 1993, but NMFS determined this listing was not warranted (NMFS, 1999). NMFS removed this stock from the ESA candidate species list in 2001. The primary threat to the harbor porpoise is incidental catch in fishing gear, such as gillnets and trawls. The Harbor Porpoise Take Reduction Plan was implemented to reduce incidental mortality and serious injury in gillnet fisheries in the Gulf of Maine and mid-Atlantic.

7.3.1.1 Gear Interactions with Marine Mammals

Marine mammal interactions have been documented in the primary fisheries that target menhaden, including the purse seine, pound net, and gillnet fisheries, and in those fisheries for which menhaden is bycatch, including trawl, haul seine, pound net and gillnet fisheries. The bycatch reports included below do not represent a complete list but rather available records. It should be noted that without an observer program for many of these fisheries, actual numbers of interactions are difficult to obtain.

Purse Seine

The U.S. mid-Atlantic menhaden purse seine fishery is currently listed as a Category II fishery while the Gulf of Maine menhaden purse seine fishery is listed as a Category III fishery (82 FR 3655, January 12, 2017).

Historically, Atlantic menhaden purse seine fishermen reported an annual incidental take of one to five coastal bottlenose dolphins (NMFS, 1991). This information comes from reports required under a small take exemption issued under the then Section 101(a)(4) of the MMPA. The Atlantic purse seine fishery reported the lethal incidental take of one minke whale in 1990 (NMFS, 1993); however, the target species of the purse seine (i.e. tuna or menhaden) is unknown. In addition, an incidental take of a humpback whale in the mid-Atlantic menhaden purse seine fishery was reported in 2001 (66 FR 6545, January 22. 2001); however, in 2005 humpback whales were removed from the list species killed or injured in the fishery because an interaction had not been reported in subsequent years. In 2006, the mid-Atlantic menhaden purse seine fishery was elevated from a Category III fishery to a Category II fishery (71 FR 48802, August 22, 2006). This change was made after interactions with bottlenose dolphins in other purse seine fisheries, such as those in the Gulf of Mexico. This required the fishery to comply with registration requirements, applicable take reduction plan requirements, and observer coverage. Limited observer coverage has occurred in the fishery since 2008.

Pound Nets

The Virginia pound net fishery is listed as a Category II fishery in the 2017 LOF due to documented interactions with bottlenose dolphins (82 FR 3655, January 12, 2017). Between 2004 and 2008, there were 17 bottlenose dolphins killed in pound net gear and 3 bottlenose dolphins were released alive (76 FR 37716, June 28, 2011). There is no formal observer coverage for the Virginia pound net fishery but there has been sporadic monitoring by the Northeast Fishery Observer Program. All other Atlantic coast pound net fisheries are listed as a Category III fishery.

Gillnets

The mid-Atlantic gillnet fishery is listed as a Category I fishery in the 2017 LOF (82 FR 3655, January 12, 2017). The fishery was originally listed as a Category II fishery but in 2003, it was elevated to a Category I fishery after stranding and observer data documented the incidental mortality and serious injury of bottlenose dolphins (68 FR 41725, July 15, 2003). Other species with documented interactions include the harbor porpoise, common dolphin, harbor seal, harp seal, long-finned pilot whale, short-finned pilot whale, and white-sided dolphin; however, since gillnet fisheries target many species, not all incidents may have occurred while harvesting menhaden. Between 1995 and 2013, observer coverage has ranged from 1% to 5%.

The Chesapeake Bay inshore gillnet, the North Carolina inshore gillnet, the northeast anchored float gillnet, the northeast drift gillnet, and the southeast Atlantic gillnet fisheries are all listed as Category II fisheries in the 2017 LOF (82 FR 3655, January 12, 2017). The primary species reported interacting with these gears is the bottlenose dolphin; however, the harbor seal, humpback whale, and white-sided dolphin have been documented in the northeast anchored float gillnet. Both the Chesapeake Bay inshore gillnet and the North Carolina inshore gillnet fisheries were elevated from a Category III fishery to a Category II fishery in the 2006 and 2001 LOFs, respectively (66 FR 42780, August 15, 2001; 71 FR 48802, August 22, 2006).

The Delaware River inshore gillnet, the Long Island Sound inshore gillnet, the southeast Atlantic inshore gillnet, and the Rhode Island/Southern Massachusetts/New York Bight inshore gillnet fisheries are listed as Category III fisheries in the 2017 LOF (82 FR 3655, January 12, 2017). There have been no documented interactions with marine mammals in the past five years with the exception of the southeast Atlantic inshore gillnet fishery which has documented an interaction with a bottlenose dolphin.

Haul/Beach Seine

The Mid-Atlantic haul/beach seine fishery is listed as a Category II fishery in the 2017 LOF due to interactions with coastal bottlenose dolphin (82 FR 3655, January 12, 2017). NMFS has recorded one observed take of a bottlenose dolphin in this fishery in 1998 (Waring and Quintal 2000). Harbor porpoise was removed from the list of species killed or injured in the Mid-Atlantic haul/beach seine fishery due to no other interactions between 1999 and 2003. The fishery was observed from 1998-2001 but there has been limited observer coverage since 2001.

Fyke Net, Floating Fish Trap, Fish Weir
Floating fish traps, northeast and Mid-Atlantic fyke nets, and fish weirs are listed as a Category III fishery in the 2017 LOF (82 FR 3655, January 12, 2017). There are no documented interactions between marine mammals in the northeast/mid-Atlantic fyke net fishery nor the floating fish trap fisheries. In the Mid-Atlantic mixed species weir fishery there have been documented interactions with bottlenose dolphins.

Trawls
The mid-Atlantic mid-water trawl fishery is listed as a Category II fishery in the 2017 LOF (82 FR 3655, January 12, 2017). In 2001, the mid-Atlantic mid-water trawl fishery was elevated to Category I based on mortality and injury of common dolphins and pilot whales. In 2007, the fishery was down-graded to a Category II fishery due to reductions in the interactions with common dolphins and pilot whales (72 FR 14466, March 28, 2007). The mid-Atlantic mid-water trawl fishery continues to be listed as a Category II fishery due to interactions with white-sided dolphins. Interactions with other species include the gray seal and the harbor seal. Observer coverage in the fishery has ranged from 0% to 13.33% between 1997 and 2008.

The northeast mid-water trawl fishery is also listed as a Category II fishery in the 2017 LOF (82 FR 3655, January 12, 2017). The fishery has had documented interactions with the common dolphin, gray seal, harbor seal, long-finned pilot whale, short-finned pilot whales, and minke whale. Importantly, not all mid-water trawls target menhaden as this is the primary gear used in the northeast groundfish fisheries. Observer coverage in the fishery has ranged from 0% to 19.9% between 1997 and 2008.

Cast Net
Currently, cast net is listed as a Category III fishery in the 2017 LOF (82 FR 3655, January 12, 2017). There are no documented marine mammal species incidentally injured or killed in the cast net fishery.

Traps/Pots
The Atlantic mixed species trap/pot fishery is listed as a Category II fishery in the 2017 LOF (82 FR 3655, January 12, 2017). The gear is primarily involved in entanglement events with species such as the fin whale and the humpback whale. Historically, the minke whale and the harbor porpoise were also listed as species injured or killed by the Atlantic mixed species trap/pot fishery but these species were removed in 2005 because interactions had not been documented in recent years. There is no observer program for this fishery.

7.3.2 Sea Turtles

All sea turtles that occur in U.S. waters are listed as either endangered or threatened under the ESA. Five sea turtle species occur along the U.S. Atlantic coast, namely the loggerhead (*Caretta caretta*), Kemp's Ridley (*Lepidochelys kempi*), green (*Chelonia mydas*), leatherback (*Dermochelys coriacea*), and hawksbill (*Eretmochelys imbricata*).

Loggerhead Turtle
The loggerhead turtle is the most abundant species of sea turtle in U.S. waters, commonly occurring throughout the inner continental shelf from Florida through Cape Cod, Massachusetts. This species is found in a wide range of habitats throughout the temperate and tropical regions of the globe, including the open ocean, continental shelves, bays, lagoons, and estuaries (NMFS, 2013). NMFS and USFWS have identified five nesting sub-populations along the northwest Atlantic Ocean. They include 1) southern Florida through Georgia; 2) Florida through Key West; 3) the Dry Tortugas; 4) the northern Gulf of Mexico; 5) and the greater Caribbean (76 FR 58867, September 22, 2011). Nesting sites along the coast of the U.S. primarily occur from Virginia through Alabama (76 FR 58867, September 22, 2011). The activity of the loggerhead is limited by temperature, with loggerhead turtles not appearing in the Gulf of Maine before June and generally leaving by mid-September. Loggerhead sea turtles are primarily benthic feeders, opportunistically foraging on crustaceans and mollusks. Under certain conditions they also feed on finfish, particularly if they are easy to catch (*e.g.,* caught in gillnets or inside pound nets where the fish are accessible to turtles).

The northwest Atlantic population of loggerhead turtles is listed as threatened under ESA. Threats to the population include destruction of nesting habitat as the result of development and erosion, sand dredging, fishing practices, and marine pollution (76 FR 58867, September 22, 2011).

Kemp's Ridley
Kemp's ridley sea turtles are found throughout the Gulf of Mexico and North Atlantic coast; however their only major nesting site is in Rancho Nuevo, Tamaulipas, Mexico (Carr 1963). Juvenile Kemp's ridleys use northeastern and mid-Atlantic waters of the U.S. Atlantic coastline as primary developmental habitat, with shallow coastal embayments serving as important foraging grounds during the summer months. Juvenile ridleys migrate south as water temperatures cool, and are predominantly found in shallow coastal embayments along the Gulf Coast during the fall and winter months. Kemp's ridleys can be found from New England to Florida, and are the second most abundant sea turtle in Virginia and Maryland waters (Keinath *et al.* 1987; Musick and Limpus, 1997). In the Chesapeake Bay, ridleys frequently forage in shallow embayments, particularly in areas supporting submerged aquatic vegetation (Lutcavage and Musick, 1985; Bellmund *et al.,* 1987; Keinath *et al,.* 1987; Musick and Limpus, 1997). These turtles primarily feed on crabs, but also consume mollusks, shrimp, and fish (Bjorndal, 1997).

Kemp's ridley are listed as endangered primarily as the result of the destruction of habitat, particularly nesting habitat in Mexico, bycatch in fisheries, the harvesting of eggs and nesting turtles, and vessel collisions.

Green Turtle

Green turtles are distributed throughout the world's oceans, primarily between the northern and southern 20^o isotherms (Hirth, 1971). Most green turtle nesting in the continental United States occurs on the Atlantic Coast of Florida, with documented nests also along the Gulf coast of Florida and the Florida Panhandle. While nesting activity is important in determining population distributions, the availability and location of foraging grounds also plays an important role in their spatial distribution. Juvenile green sea turtles occupy pelagic habitats after leaving the nesting beach and are primarily omnivorous (Bjorndal, 1985). At approximately 20 to 25 cm carapace length, juveniles leave pelagic habitats and enter benthic foraging areas, shifting to an herbivorous diet (Bjorndal, 1997). Post-pelagic green turtles feed primarily on sea grasses and benthic algae (Bjorndal ,1985). Known feeding habitats along U.S. coasts of the western Atlantic include shallow lagoons and embayments in Florida, such as the Indian River Lagoon (Ehrhart et al., 1986). Along the Atlantic coast, green turtles can be found from Florida up to Massachusetts.

Green turtles are listed as threatened along the North Atlantic. Threats to the North Atlantic population of green turtles includes the degradation of nesting beaches due to coastal development, the degradation of forage habitat due to pollution, the illegal harvest of green turtles and their eggs, entanglement in fishing gear such as gillnets, trawls, longlines, and traps, vessel strikes, and the persistence of an often lethal disease known as fibropapillomatosis (81 FR 20057, May 6, 2016).

Leatherback Turtle

The leatherback is the largest living turtle and its range is farther than any other sea turtle species (NMFS, 2013). Leatherback turtles are often found in association with jellyfish, with the species primarily feeding on Cnidarians (medusae, siphonophores) and tunicates (salps, pyrosomas). While these turtles are predominantly found in the open ocean, they do occur in coastal water bodies such as Cape Cod Bay and Narragansett Bay, particularly the fall. The most significant nesting in the U.S. occurs in southeast Florida (NMFS, 2013).

The leatherback turtle is listed as endangered throughout its range. Primary causes of this population decline include the degradation of nesting beaches as the result of coastal development and beach sand mining, the poaching of eggs on nesting beaches, increased human pollution in pelagic waters, the presence of disease and parasites, and the entanglement of leatherbacks in active and abandoned fishing gear (NMFS, 2013).

Hawksbill Turtle

The hawksbill turtle is found throughout the world's oceans, primarily between 30^{o}N and 30^{o}S latitude. In the continental U.S., hawksbill turtles commonly occur in southern Florida and the Gulf of Mexico, with a preferred habitat being coral reefs and other hard bottom habitats (NMFS, 2007). Nesting sites in the Atlantic are typically found in Mexico, Puerto Rico, and the U.S. Virgin Islands (NMFS, 2007). During their juvenile life stage, hawksbill turtles occupy the pelagic environment, floating with algal mats in the Atlantic (NMFS 2007). The diet of hawksbill turtles primarily consists of sponges, invertebrates, and algae (NMFS 2007).

The hawksbill turtle is listed as endangered throughout its range. Primary threats to the population include loss of coral reef habitat, the illegal harvest of eggs and nesting females, increased recreational and commercial use of beaches, and the incidental capture of hawksbill turtles in fishing gear (NMFS 2007).

7.3.2.1 Potential Impacts of Menhaden Fishery on Sea Turtles

The Atlantic seaboard provides important developmental habitat for post-pelagic juveniles, as well as foraging and nesting habitat for adult sea turtles. The distribution and abundance of sea turtles along the Atlantic coast is related to geographic location and seasonal variations in water temperatures. Water temperatures dictate how early northward migration begins each year and is a useful factor for assessing when turtles will be found in certain areas. Moderate to high abundances of sea turtles have been observed both offshore and nearshore when water temperatures are greater than or equal to 21° C. As a result, sea turtles do not usually appear on the summer foraging grounds in the Gulf of Maine until June, but are found in Virginia as early as April. As water temperatures decline below 11° C, abundance declines and turtles typically move from cold inshore waters in the late fall to warmer waters in the Gulf Stream, generally south of Cape Hatteras, North Carolina.

The effect of water temperature on the distribution of sea turtles is important in assessing possible interactions with the menhaden fishery. Menhaden are also affected by water temperatures and similarly migrate north in the spring and south in the fall. Thus, the menhaden purse seine fishery exhibits seasonal changes, with the fishery ramping up off North Carolina in April and extending into New England in June. Observer data indicates minimal interaction between these purse seines and sea turtles. From September 1978 through early 1980, approximately 40 sea days were observed for fish sampling aboard menhaden purse seiners fishing from Maine south to North Carolina. No sea turtles were recorded as bycatch (S. Epperly, NMFS SEFSC, pers. comm.). Other gears used to catch menhaden include trawls, fixed nets, gillnets, haul/beach seines, pound nets, and cast nets. Several states have indicated that sea turtles have been incidentally captured in menhaden fixed nets and trawls, but not seine nets (ASMFC, Atlantic Coastal Fisheries Characterization Database, unpubl. data). An observer program for protected species has not been established for the menhaden fishery. However, under the ESA Annual Determination to Implement Sea Turtle Observer Requirement (80 FR 14319, April 18, 2015), two fisheries that target menhaden are included. These include the Chesapeake Bay Inshore Gillnet Fishery and Mid-Atlantic menhaden purse seine fishery,

7.3.3 Atlantic Sturgeon

The Atlantic sturgeon is an ancient anadromous fish that can live up to 60 years. Historically, sturgeon were found from Canada through Florida; however, the species currently extends through Georgia (ASMFC 1998). As adults, Atlantic sturgeon live in the ocean and migrate from the south Atlantic in the winter to New England waters in the summer (ASMFC 1998). Precise spawning locations of sturgeon are not known but it is thought that they prefer hard substrates such as rock or clay (Gilbert, 1989). As juveniles, sturgeon reside in brackish water near river mouths before moving into the coastal ocean waters. The diet of this species is primarily composed of mussels, shrimp, and small fish (ASMFC 1998).

Since 1998, there has been a moratorium on the harvest of Atlantic Sturgeon in both state and federal waters; however, the population has continued to decline and, in 2012, Atlantic sturgeon became listed under the ESA. The listing identifies five distinct population segments, which include the Gulf of Maine, the New York Bight, the Chesapeake Bay, Carolina, and the South Atlantic (77 FR 5914 and 77 FR 5880, February 6, 2012). All population segments are listed as endangered except for the Gulf of Maine population, which is listed as threatened. Primary threats to the species include historic overfishing, the bycatch of sturgeon in other fisheries, habitat destruction from dredging, dams, and development, and vessel strikes (77 FR 5914; 77 FR 5880).

Impacts on the Atlantic sturgeon population as a result of the menhaden fishery would likely occur through bycatch in gear types such as gillnets, pound nets, and purse seines. There has been no reported or observed bycatch of Atlantic sturgeon in the menhaden gillnet fisheries (77 FR 5880). Furthermore, some states have implemented measures to reduce the bycatch of sturgeon by restricting the use of gillnet gear in coastal waters and instituting seasonal closures for anchored or staked gillnets when sturgeon may be present (77 FR 5880). As a result, impacts to the sturgeon population from the menhaden fishery are thought to be limited.

7.3.4 Seabirds

Like marine mammals, seabirds are vulnerable to entanglement in commercial fishing gear. Under the Migratory Bird Treaty Act, it is unlawful "by any means or in any manner, to pursue, hunt, take, capture, [or] kill" any migratory birds except as permitted by regulation (16 U.S.C. 703). Given that an interaction has not been quantified in the Atlantic menhaden fishery, impacts to seabirds are not considered to be significant. Endangered and threatened bird species, such as the piping plover, are unlikely to be impacted by the gear types employed in the menhaden fishery. Other human activities such as coastal development, habitat degradation and destruction, and the presence of organochlorine contaminants are considered to be the major threats to some seabird populations.

7.4 PROPOSED FEDERAL REGULATIONS/ACTIONS PERTAINING TO THE RELEVANT PROTECTED SPECIES

In May 2016, NMFS proposed areas of Atlantic Sturgeon critical habitat along the Atlantic coast. The proposed critical habitat primarily consisted of rivers including the Penobscot River in Maine, the Hudson River in New York, the Potomac River in Maryland, and the Neuse River in North Carolina (81 FR 36077; 81 FR 35701). Comments on the proposal were accepted through the fall of 2016; however, a final rule has not yet been released.

7.5 POTENTIAL IMPACTS TO ATLANTIC COASTAL STATE AND INTERSTATE FISHERIES

There are several take reduction teams, whose management actions have potential impacts to coastal menhaden fisheries. The Northeast sink and Mid-Atlantic coastal gillnet fisheries are the two fisheries regulated by the Harbor Porpoise Take Reduction Plan (50 CFR 229.33 and 229.34). Amongst other measures, the plan uses time area closures in combination with pingers in Northeast waters, and time area closures along with gear modifications for both small and large mesh gillnets in mid-Atlantic waters. Although the plan predominately impacts the dogfish and monkfish fisheries due to higher porpoise bycatch rates, other gillnet fisheries are also affected.

The Atlantic Large Whale Take Reduction Plan (50 CFR 229.32) addresses the incidental bycatch of large baleen whales, primarily the northern right whale and the humpback whale, in several fisheries including the Northeast sink gillnet and Mid-Atlantic coastal gillnet. Amongst other measures, the plan closes right whale critical habitat areas to specific types of fishing gear during specific seasons, and modifies fishing gear and practices. The Atlantic Large Whale Take Reduction Team continues to identify ways to reduce possible interactions between large whales and commercial gear. In 2014 and 2015, the Atlantic Large Whale Take Reduction Plan was modified to reduce the number of vertical lines associated with trap/pot fisheries and required expanded gear markings for gillnets and traps in Jeffrey's Ledge and Jordan Basin (79 FR 35686, June 27, 2014; 80 FR 30367, May 28, 2015).

The Bottlenose Dolphin Take Reduction Team first convened in 2001 to discuss incidental catch of coastal bottlenose dolphins in Category I and II fisheries. In 2006, a Bottlenose Dolphin Take Reduction Plan was established, which created gear regulations for the mid-Atlantic coastal gillnet fishery, the Virginia pound net fishery, the mid-Atlantic beach seine fishery, and the North Carolina inshore gillnet fishery, among others. Specifically, the plan established mesh sizes for the gill net fisheries and prohibited night fishing for some regions and gear types (71 FR 24776, April 26, 2006).

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9.0 TABLES

Table 16: Atlantic menhaden total commercial landings by jurisdiction (in pounds). This includes directed landings, landings under the bycatch allowance, and episodic events landings.

	ME	NH	MA	RI	CT	NY	NJ	DE	MD	PFRC	VA	NC	SC	GA	FL
1985	C	C	3,039,625	8,388,046	234,800	901,800	2,879,766	176,135	5,372,193	16,768,889	620,119,243	97,738,403	C	-	7,579,674
1986	C	C	3,411,000	10,389,187	254,400	399,650	2,453,593	C	5,449,350	10,971,973	445,664,204	66,377,931	9,952	-	7,997,973
1987	C	C	1,215,175	13,609,224	94,900	206,795	2,563,163	22,034	5,793,683	13,120,698	622,989,111	55,498,571	C	-	2,776,777
1988	C	C	8,047,320	15,583,437	175,200	504,100	1,984,045	127,713	6,430,164	13,231,368	565,962,962	73,715,713	C	-	1,026,228
1989	C	C	1,459,402	19,033,173	148,500	449,100	2,854,361	104,382	6,166,236	8,334,174	590,581,595	66,756,288	C	-	1,372,959
1990	5,744,597	264,500	1,709,605	17,102,650	96,706	649,710	9,041,459	167,116	1,662,275	4,523,776	699,320,699	72,231,989	-	-	2,636,497
1991	C	C	12,798,310	5,090,375	96,300	650,150	16,597,402	278,774	3,540,179	5,376,264	638,130,543	110,528,754	C	-	2,062,983
1992	C	C	13,499,450	2,849,359	91,200	1,131,701	27,470,906	131,033	1,777,088	5,061,565	566,222,504	57,515,712	C	-	2,788,592
1993	C	C	1,211,569	5,146,280	195,827	1,048,993	28,296,741	164,406	2,326,613	7,884,001	622,024,284	64,711,384	C	-	2,584,766
1994	-		351,251	533,800	60,128	961,474	38,176,201	78,672	2,369,071	6,680,937	502,576,593	73,853,901	-	-	1,387,012
1995	-		2,910,613	5,873,315	255,264	1,087,978	36,572,507	101,388	4,264,754	7,002,818	691,212,717	58,374,046	-	-	687,944
1996	-		8,500	802	82,851	11,135	35,516,726	100,063	3,906,808	5,111,423	579,027,717	56,583,873	-	-	294,936
1997	C	C	238,500	5,750	72,329	553,953	38,118,579	55,733	3,457,237	5,757,370	494,098,429	56,295,597	C	-	408,492
1998	C	C	121,200	400	338,817	430,084	33,287,641	58,048	2,933,818	3,980,738	513,869,130	97,473,775	C	-	301,566
1999	-		292,800	2,330	30,298	242,886	27,753,567	78,551	4,460,534	4,860,883	374,934,651	57,434,540	-	-	288,144
2000	-		72,600	320,000	14,423	565,800	31,266,780	47,995	3,935,307	5,023,374	358,228,939	42,034,812	-	-	260,710
2001	-		144,600	-	38,865	576,426	26,375,573	53,257	3,970,243	3,329,035	484,517,820	57,261,488	-	-	179,951
2002	-		301,500	5,750	1,138,788	444,739	24,716,412	80,261	4,023,389	3,122,050	362,633,153	55,600,503	-	-	55,304
2003	-		218,255	62	46,515	384,875	17,080,463	43,193	3,163,252	2,438,790	372,479,419	68,444,122	-	-	35,810
2004	C	C	-	39,232	33,210	543,481	20,678,813	75,635	5,369,952	5,411,043	394,093,117	48,318,743	C	-	21,220
2005	-		2,177,724	14,453	30,636	871,081	17,574,826	120,658	10,635,776	4,759,905	370,689,041	50,987,985	-	-	39,404
2006	-		2,524,255	15,524	866,235	811,934	21,290,309	111,405	6,841,296	3,413,517	369,912,280	12,846,438	-	-	157,117
2007	C	C	5,543,805	8,948	90,254	483,557	37,202,485	81,850	11,210,764	5,036,906	416,447,111	1,134,167	C	-	71,373
2008	C	C	14,131,256	269,288	104,881	410,121	38,210,688	72,970	8,153,008	4,820,645	344,813,285	645,231	C	-	60,098
2009	166,942	33	6,719,048	107,548	170,907	330,496	33,329,177	69,476	7,756,192	3,191,905	349,413,370	2,124,733	-	-	52,800
2010	C	C	4,973,857	78,149	42,489	394,556	50,497,253	51,933	6,903,300	2,790,728	430,527,995	1,299,130	C	-	76,593
2011	56,000		116,151	83,899	26,929	279,117	74,324,485	70,326	6,505,890	2,759,597	411,802,254	3,529,967	-	-	146,534
2012	C	C	1,648,395	106,606	37,454	258,271	85,457,890	140,375	13,746,098	5,892,228	386,545,236	538,783	C	-	126,141
2013	-		2,314,888	99,821	26,463	1,187,525	39,819,342	125,909	7,074,727	3,295,295	315,724,384	454,172	-	-	224,872
2014	-		2,226,294	500,903	36,552	825,549	41,449,670	161,524	7,005,271	3,175,893	324,209,381	917,375	-	-	220,587
2015	C	C	2,932,828	2,060,381	87,472	1,468,165	47,810,037	150,542	7,551,430	2,739,035	351,281,666	896,919	C	-	377,729
2016	4,548,566	-	3,069,433	317,328	66,957	1,439,173	45,826,473	75,238	5,635,694	2,504,823	335,641,958	397,725	-	-	272,425

Table 17: Bait and reduction landings from 1985-2016 in thousands of metric tons.

	Reduction Landings (1000 mt)	Bait Landings (1000 mt)
1985	306.7	26.6
1986	238.0	21.6
1987	327.0	25.5
1988	309.3	43.8
1989	322.0	31.5
1990	401.2	28.1
1991	381.4	29.7
1992	297.6	33.8
1993	320.6	23.4
1994	260.0	25.6
1995	339.9	28.4
1996	292.9	21.7
1997	259.1	24.2
1998	245.9	38.4
1999	171.2	34.8
2000	167.2	33.5
2001	233.7	35.3
2002	174.0	36.2
2003	166.1	33.2
2004	183.4	34.0
2005	146.9	38.4
2006	157.4	27.2
2007	174.5	42.1
2008	141.1	47.6
2009	143.8	39.2
2010	183.1	42.7
2011	174.0	52.6
2012	160.6	63.7
2013	131.0	37.0
2014	131.1	41.8
2015	143.5	45.9
2016	137.4	44.4

Table 18: Timeline for BERP Workgroup development of menhaden-specific ecosystem reference points.

2016	Summer	Review steele-henderson multi-species model
		Evaluate data needs of model
		Review preliminary methodology of statistical catch-at-age and production models
	Fall	Review results of Ecopath with Ecosim model
2017	Winter	Review multi-species statistical catch at age model
		Evaluate data needs of model
	Summer	Review multi-species production model
		Evaluate data needs of model
	Fall	Review finalized modeling plan and candidate models
		Decide which candidate models will be included for ERP development and peer review
		Discuss data requirements of the models and data sources
2018	Winter	**Data Workshop #1**
		Review data sources for the multi-species models
		Develop criteria for inclusion of data in models
	Summer	**Data Workshop #2**
		Approve data sources of multi-species models
		Discuss standardization of data across sources
2019	Winter	**Assessment Workshop #1**
		Review base run results from multi-species models
		Discuss sensitivity runs for models
	Spring	**Assessment Workshop #2**
		Review final model results of multi-species models
		Summarize findings and recommendations
	Summer	Write stock assessment report
	Fall	**Peer Review Workshop**
		Independent review of multi-species models and single-species BAM model

Table 19: Current reporting requirements in the menhaden commercial fishery per state.

State	Dealer Reporting	Harvester Reporting	Notes
ME	monthly	**monthly/daily**	Harvesters landing greater than 6,000 lbs must report daily during episodic event
NH	**weekly**	monthly	Exempt from timely reporting. Implemented weekly, trip level reporting for state dealers.
MA	**weekly**	monthly/daily	Harvesters landing greater than 6,000 lbs must report daily
RI	**twice weekly**	quarterly/daily	Harvesters using purse seines must report daily
CT	**weekly/monthly**	monthly	No directed fisheries for Atlantic menhaden
NY	**Weekly**	monthly	Capability to require weekly harvester reporting if needed
NJ	**weekly**	monthly	All menhaden sold or bartered must be done through a licensed dealer
DE	—	**monthly/daily**	Harvesters landing menhaden report daily using IVR
MD	monthly	**monthly/daily**	PN harvest is reported daily, while other harvest is reported monthly.
PRFC	—	**weekly**	Trip level harvester reports submitted weekly. When 70% of quota is estimated to be reached, then pound netters must call in weekly report of daily catch.
VA	—	**monthly/weekly/daily**	Purse seines submit weekly reports until 97% of quota, then daily reports. Monthly for all other gears until 90% of quota, then reporting every 10 days.
NC	**monthly (combined reports)**		Single trip ticket with dealer and harvester information submitted monthly. Larger dealers (>50,000 lbs of landings annually) can report electronically, updated daily.
SC	**monthly (combined reports)**		Exempt from timely reporting. Single trip ticket with dealer and harvester information.
GA	**monthly (combined reports)**		Exempt from timely reporting. Single trip ticket with dealer and harvester information.
FL	**monthly/weekly (combined reports)**		Monthly until 50% fill of quota triggers implementation of weekly.

Table 20: ACCSP data elements, and descriptions, for commercial harvester reporting.

DATA ELEMENT	DESCRIPTION
Form Type/Version Number	Version identification number for the ACCSP reporting form
Reporting Form Series Number	Individual number for each reporting form (ie: trip ticket number)
Trip Start Date	Date trip started
Vessel Identifier	Unique vessel ID such as US Coast Guard documentation or state registration number
Individual Fisherman Identifier	Identified unique to a fisherman
Dealer Identification	Identifier for the dealer at point of transaction
Unloading Date	Date of the landing at dealer
Trip Number	Sequential number representing the number of a trip taken in a single day by either a vessel or individual
Species	Genus and species for each species landed, sold, released, or discarded
Quantity	Amount that is landed, sold, released, or discarded
Units of Measure	Landed units
Disposition	Fate of catch
Ex-vessel Value or Price	Dollar value or price for each species that is landed or sold
County or Port Landed	Location within a state where the product was landed
State Landed	State where the product was landed or unloaded
Gear	Types(s) of gear used to catch the landed species
Quantity of Gear	Amound of gear employed
Number of Sets	Total number of sets or tows of gear during a trip
Fishing Time	Total amount of time that the gear is in the water
Days/Hours at Sea	Time from the start of the trip to the return to the dock
Number of Crew	Number of crew, including the Captain
Area Fished	NOAA Fisheries statistical area where fishing occurred
Distance From Shore	Determination of catch distance from shore
Sale Disposition	To whom catch was sold

Table 21: ACCSP standard measurements of gear quantity, fishing time, and sets for commercial harvester reporting.

TYPE OF GEAR	QUANTITY	FISHING TIME	# SETS
Pound nets, traps and pots	# of traps, pots, or pound nets fished	Total soak time for each pot, trap, or pound net	# of strings hauled or # of pound nets fished
Trawls	# of trawls towed	Total tow time of each trawl	# of tows
Gill Nets	Float line length for string	Total soak time	# of strings/hauls
Nests/cast nets	# of pieces of apparatus	Search time	# of hauls/throws
Hook and line	# of lines	Total soak time	n/a
Purse seines	Length of floatline	Total search time	# of sets
Hand gear	# of lines	Total soak time	n/a

Table 22: Number of ten fish samples from the reduction fishery landings at Reedville, VA from 2007-2016.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
# 10 fish samples	379	277	283	327	323	263	213	208	256	251

Table 23: Number of ten fish samples required and collected by each jurisdiction in the bait fishery in 2016. Number of samples required is based on total bait landings in that jurisdiction.

State	#10-fish samples required	#10-fish samples collected	Gear/Comments
ME	7	9	purse seine
MA	5	7	purse seine (2), cast net (5)
RI	0	5	floating fish trap
CT	0	1	gill nets
NY	2	9	seines
NJ	69	113	purse seine (100), and other gears (13)
DE	0	5	drift gill net
MD	13	19	pound net
PRFC	6	9	pound net
VA	74	82	pound net (16), gill net (64), haul seine (2)
NC	1	6	gillnet, seine
Total	**177**	**265**	

Table 24: Fishery independent surveys used in the juvenile abundance index, the northern adult index, and the southern adult index as a part of the 2015 Stock Assessment.

Index	Survey
Juvenile Abundance Index	Rhode Island Trawl Survey
	Connecticut Seine Survey
	Connecticut Thames River Survey
	Connecticut Long Island Sound Trawl Survey
	New York Peconic Bay Trawl Survey
	New York Western Long Island Sound Seine Survey
	New Jersey Ocean Trawl Survey
	New Jersey Juvenile Striped Bass Seine Survey
	Delaware Bay Juvenile 16ft Trawl Survey
	Delaware Inland Bay Juvenile Trawl Survey
	Maryland Juvenile Striped Bass Seine Survey
	Maryland Coastal Trawl Survey
	Virginia Striped Bass Seine Survey
	VIMS Juvenile Trawl Survey
	South Carolina Electrofishing Survey
	Georgia Trawl Survey
Northern Adult Index	Connecticut Long Island Sound Trawl Survey
	New Jersey Ocean Trawl Survey
	Delaware Bay Juvenile 16ft Trawl Survey
	Delaware Bay Juvenile 30ft Trawl Survey
	Chesapeake Bay Fishery-Independent Multispecies Survey
	ChesMMAP
	VIMS Juvenile Trawl Survey
Southern Adult Index	Georgia Trawl Survey
	SEAMAP Trawl Survey

Table 25. Summary of ad-hoc approaches used by Fishery Management Councils to set harvest limits in data poor situations.

Council	Species group	Multiplier	Comments
New England	Atlantic herring	1	Not OF, OF not occurring
New England	Red crab	1	Based on stock status
Caribbean		0.85	Used to set ABC and ACL
New England	Groundfish	0.75	
Pacific		0.75	Used to set ABC
Pacific	Groundfish	0.5	Used to set OY
Pacific	Coastal pelagics	0.25	Used to set ABC

Table 26. The method table showing possible actions for determining ABC based on different fishery impact categories and expert opinion. Taken from the workshop report of the 2nd National SSC meeting (from ORCS, 2011).

Historical Catch	Expert Judgment	Possible Action
Nil, not targeted	Inconceivable that catch could be affecting stock	Not in fishery; Ecosystem Component; SDC not required
Small	Catch is enough to warrant including stock in the fishery and tracking, but not enough to be of concern	Set ABC and ACL above historical catch; Set ACT at historical catch level. Allow increase in ACT if accompanied by cooperative research and close monitoring.
Moderate	Possible that any increase in catch could be overfishing	ABC/ACL = f(catch, vulnerability) So caps current fishery
Moderately high	Overfishing or overfished may already be occurring, but no assessment to quantify	Set provisional OFL = f(catch, vulnerability); Set ABC/ACL below OFL to begin stock rebuilding

ABC = Acceptable Biological Catch ACL = Annual Catch Limit
ACT = Annual Catch Target OFL = Overfishing Level

Table 27: Total number of bycatch trips by year from 2013-2016 separated into 1,000 pound landings bins

Bins (LBS)	2013 Trips	2014 Trips	2015 Trips	2016 Trips	Total Trips	% of Total Trips 2013-2016
1-1000	1,875	3,673	3,163	1,450	10,161	69%
1001-2000	252	517	582	148	1,499	10%
2001-3000	148	318	316	73	855	6%
3001-4000	110	190	139	48	487	3%
4001-5000	131	206	132	48	517	4%
5001-6000	158	265	196	108	727	5%
6000+	130	109	140	33	412	3%
Total	**2,804**	**5,278**	**4,668**	**1,908**	**14,658**	

Table 28: Average landings under the bycatch allowance from 2013–2016 by gear type (stationary and mobile) and jurisdiction. Highlighted cells represent the gear type with the highest landings within a jurisdiction. (C) = confidential landings, and (-) = no landings. Total confidential landings are 183,747 pounds (i.e., the sum of all C's in the table below). Note that sum of pounds and percent of total columns do not include confidential data.

State/Jurisdiction	ME	RI	CT	NY	NJ	DE	MD	PRFC	VA	FL	Sum lbs (NonConf)	% of Total
Stationary Gears While Fishing												
Pound net	-	47,907	-	96,176	C	-	1,974,979	688,428	112,609	-	2,920,097	61.62%
Anchored/stake gill net	-	C	913	0	79,850	23,227	19,722	1,704	966,832	C	1,092,248	23.05%
Pots	-	-	-	C	-	C	C	-	-	C	-	0.00%
Fyke nets	-	-	-	-	C	-	C	26	77	-	103	0.00%
Mobile Gears While Fishing											-	
Cast Net	-	C	-	152,669	C	-	C	-	-	150,585	303,253	6.40%
Drift Gill net	-	-	-	24,443	83,697	53,381	12,061	-	62,189	-	235,771	4.98%
Purse Seine	C	-	-	-	-	-	-	-	-	-	-	0.00%
Seines Haul/Beach	-	-	-	177,173	-	-	C	35	3,840	-	181,048	3.82%
Trawl	-	C	C	6,565	C	-	-	-	-	-	6,565	0.14%
Hook & Line	-	C	C	-	-	-	C	-	-	C	-	0.00%
Sum lbs (NonConf)	-	47,907	913	457,025	163,547	76,608	2,006,762	690,193	1,145,547	150,585	4,739,085	
% of Total	0.00%	1.01%		9.64%	3.45%	1.62%	42.34%	14.56%	24.17%	3.18%		

Table 29: Episodic event set aside for 2013-2016 and the percent used by participating states.

Year	Set Aside (lbs)	Landed (lbs)	% Used	Participating State	Unused Set Aside Reallocated (lbs)
2013	3,765,491				
2014	3,765,491	295,000	8%	RI	3,470,491
2015	4,142,040	1,883,292	45%	RI	2,258,748
2016	4,142,040	3,810,145	92%	ME, RI, NY	331,895

10.0 FIGURES

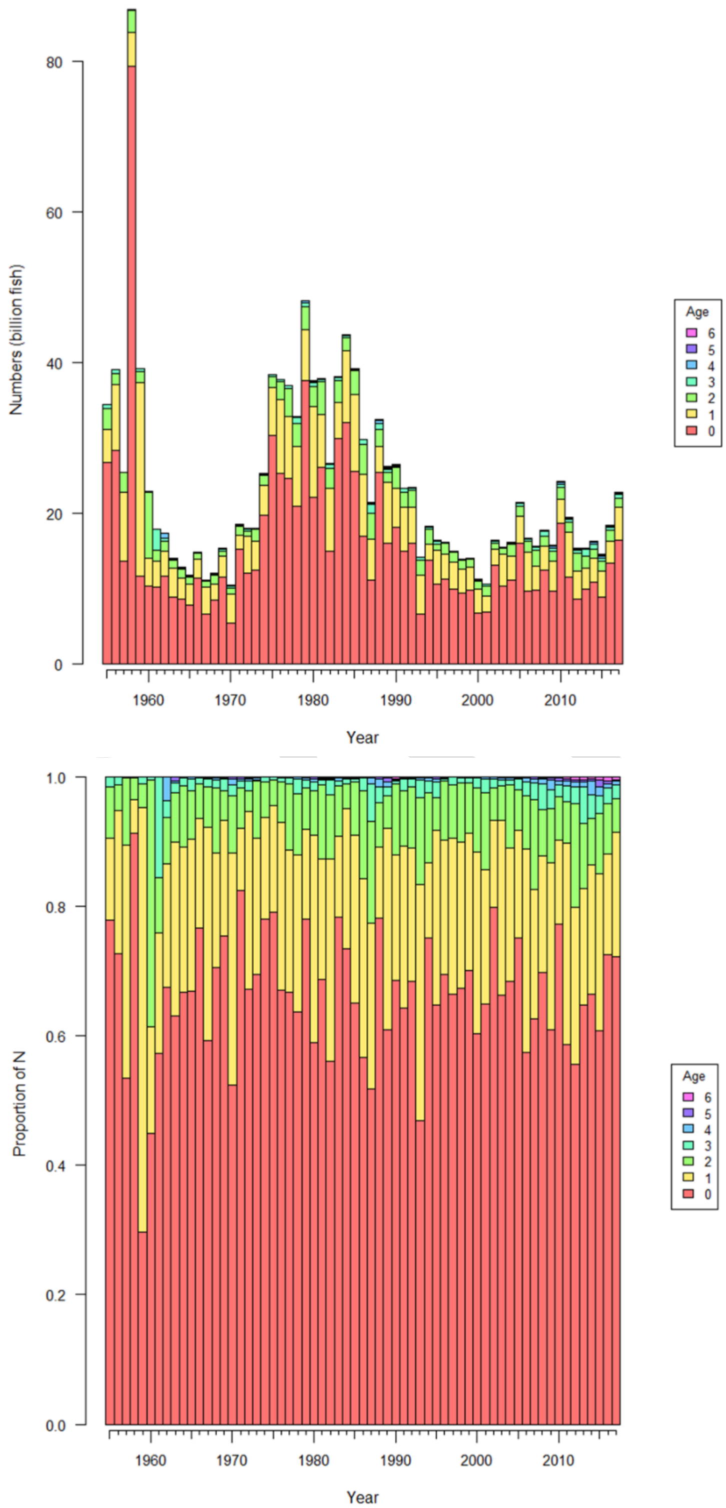

Figure 2. Numbers at age (upper panel) and proportion of numbers at age (lower panel) estimated from the base run of the BAM for ages 0-6+ during the time period 1955-2016. (Source: 2017 Stock Assessment)

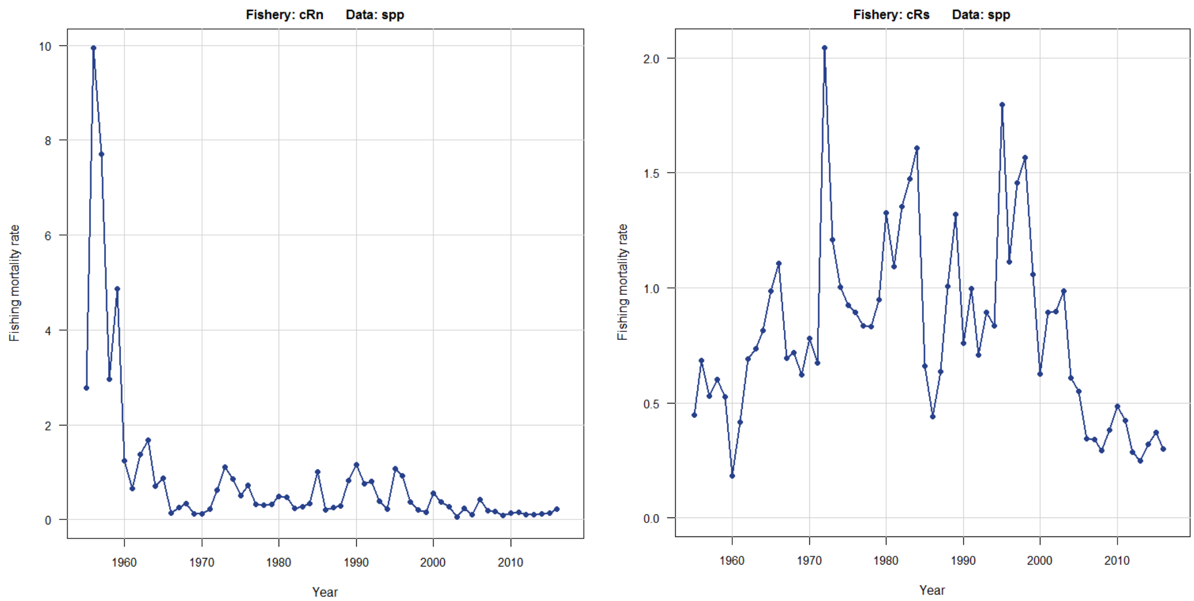

Figure 3. Fishing mortality rate for the northern commercial reduction fishery (left) and southern commercial reduction fishery (right) from 1955- 2016. The northern region is defined as waters north of Machipongo Inlet, VA and the southern region is comprised of waters south of Machipongo Inlet, VA. (Source: 2017 Stock Assessment)

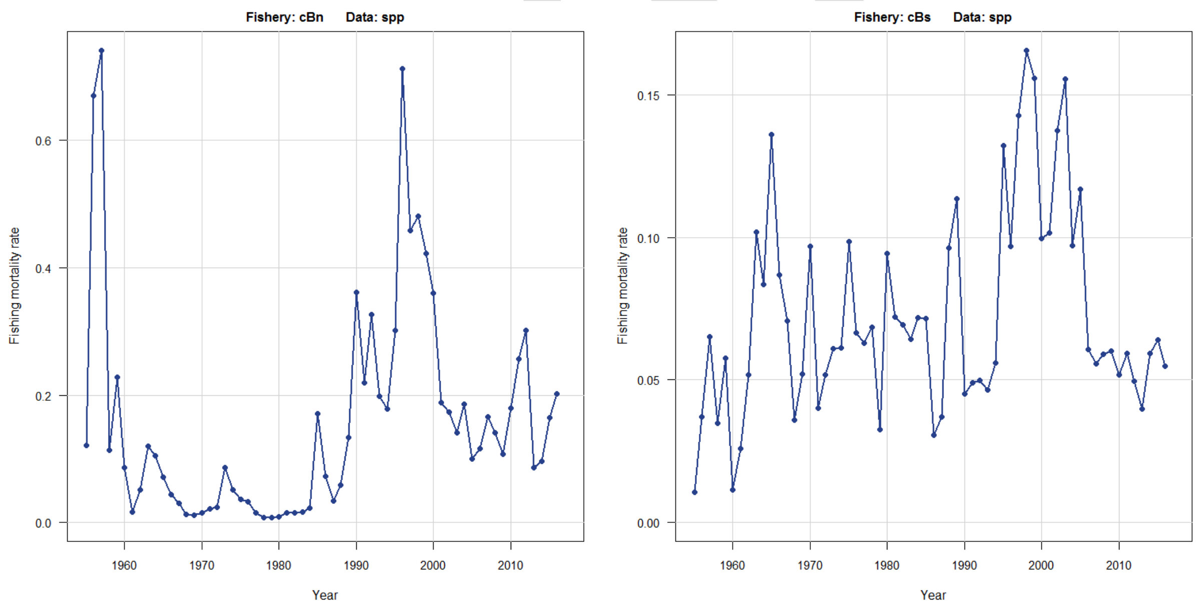

Figure 4. Fishing mortality rate for the northern commercial bait fishery (left) and the southern commercial bait fishery (right) from 1955-2016. The northern region is defined as waters north of Machipongo Inlet, VA and the southern region is comprised of waters south of Machipongo Inlet, VA. (Source: 2017 Stock Assessment)

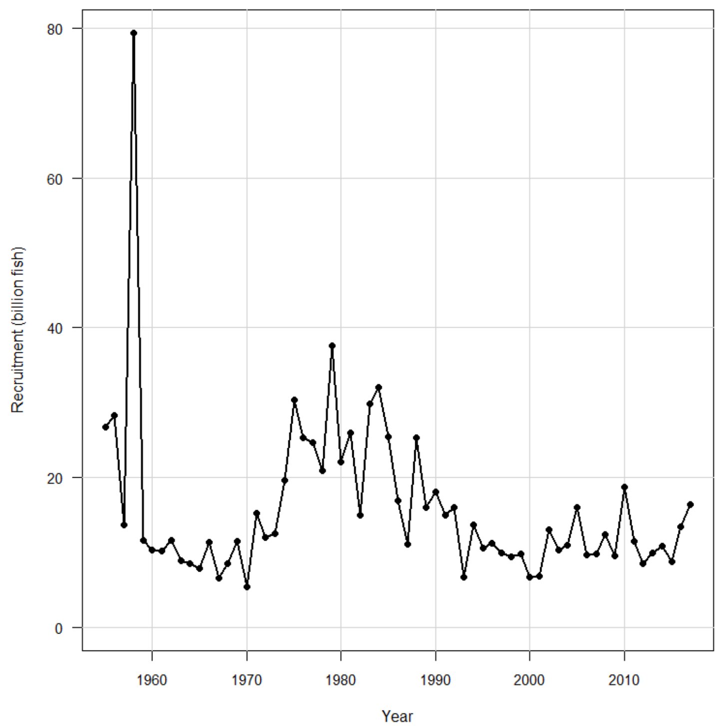

Figure 5. Number of recruits in billions of fish predicted from the base run of BAM for 1955-2016. (Source: 2017 Stock Assessment)

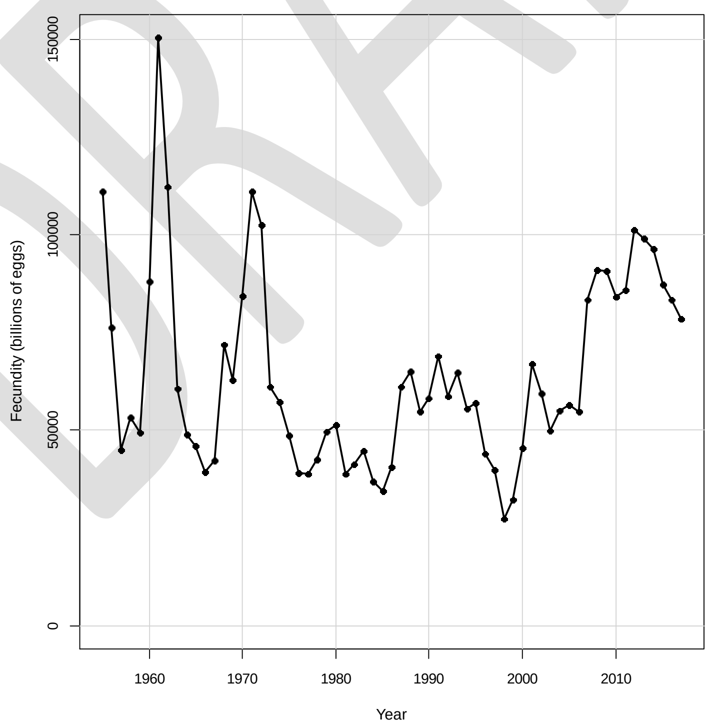

Figure 6. Fecundity in billions of eggs over time, 1955-2017, with the last year being a projection based on 2016 mortality. (Source: 2017 Stock Assessment)

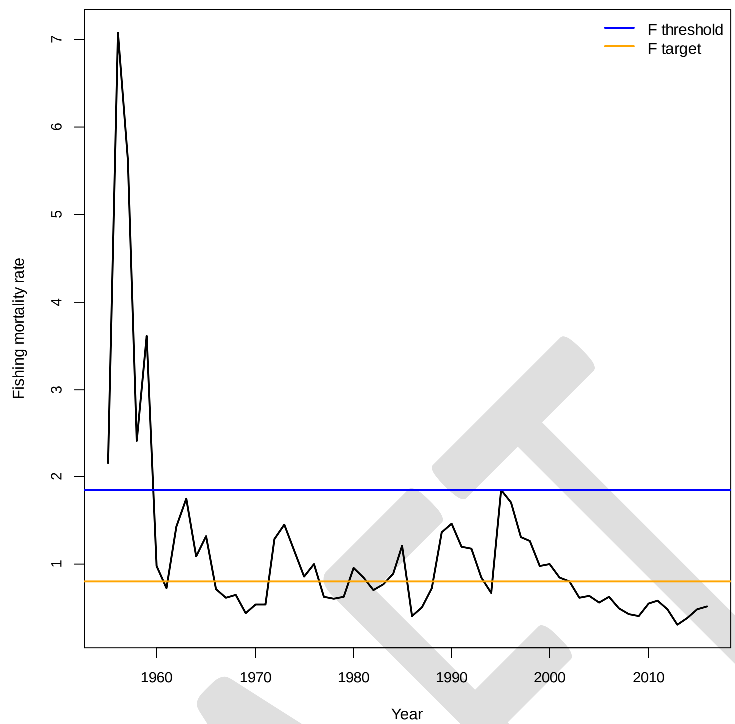

Figure 7: Atlantic menhaden fishing mortality (ages 2-4) from 1955-2016. The yellow line is the target ($F_{36\%}$) and the blue line is the threshold ($F_{21\%}$). Results of this figure show that overfishing is not occurring as fishing mortality is below the target. (Source: 2017 Stock Assessment)

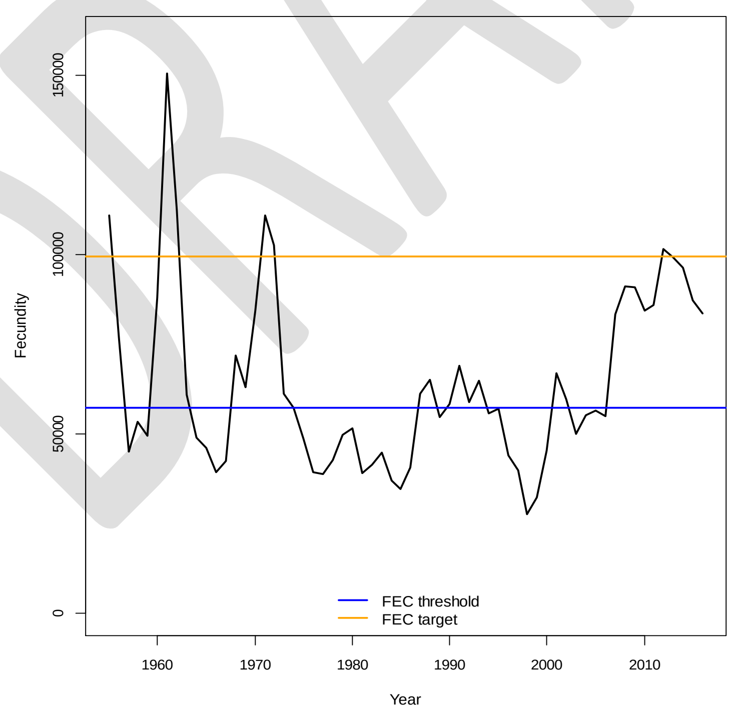

Figure 8: Atlantic menhaden fecundity (in billions of eggs) from 1955 -2016. The yellow line is the target ($FEC_{36\%}$) and the blue line is the threshold ($FEC_{21\%}$). Results of this figure show the stock is not overfished as the fecundity is well above the threshold. (Source: 2017 Stock Assessment)

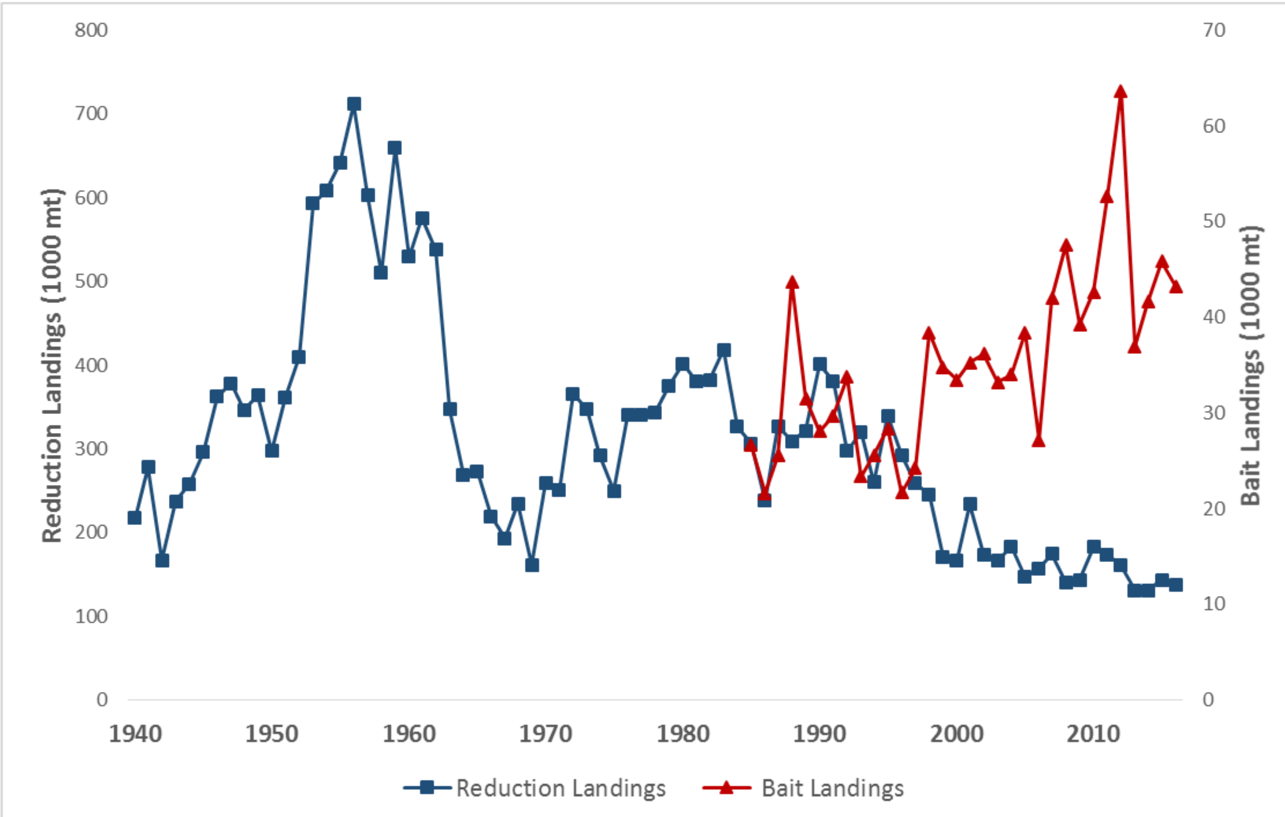

Figure 9: Landings from the reduction purse seine fishery (1940–2016) and bait fishery (1985–2016) for Atlantic menhaden. Note there are two different scales on the y-axes.

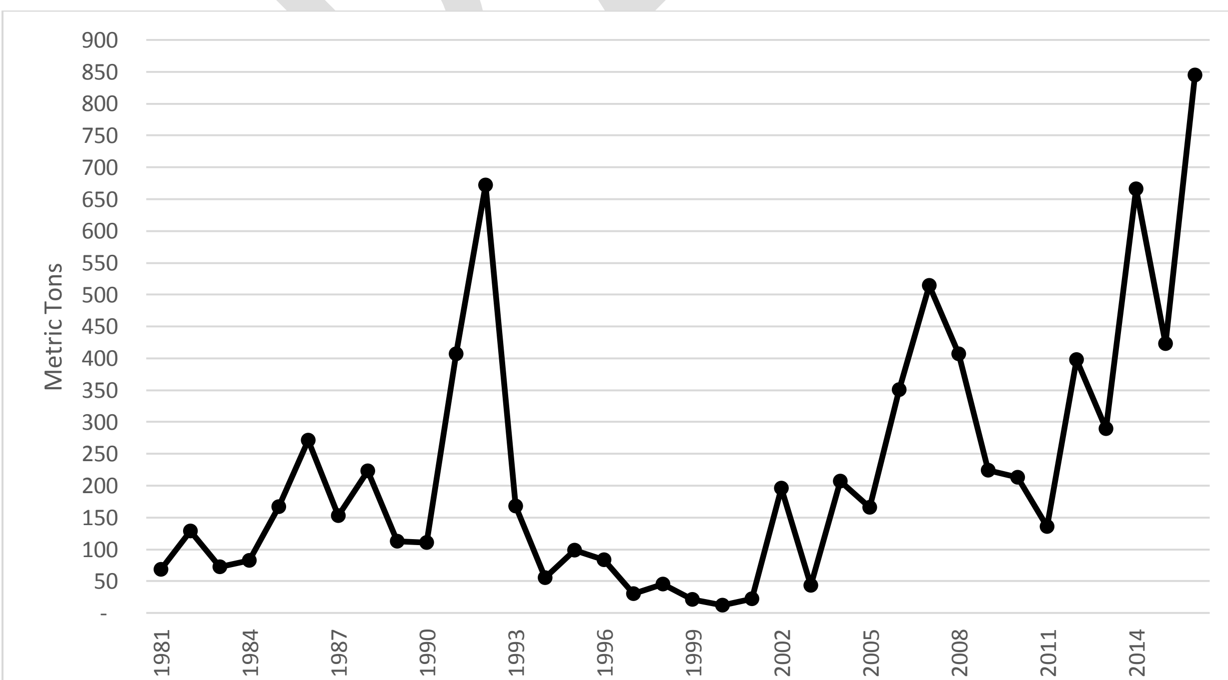

Figure 10: Recreational harvest of Atlantic menhaden from 1981-2016. Note: 2016 recreational landings are preliminary. (Source: MRIP).

Atlantic States Marine Fisheries Commission

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MEMORANDUM

TO: Atlantic Menhaden Management Board

FROM: Biological Ecological Reference Points Workgroup

DATE: July 14, 2017

SUBJECT: Interim Reference Points Calculations

The Biological Ecological Reference Points Workgroup (WG) was tasked by the Atlantic Menhaden Management Board (Board) to calculate the interim reference points. The Board is considering these reference points through Amendment 3, while the models for ecological reference points are in development. The WG met with members of the Lenfest Forage Fish Task Force to make sure that these interim reference points are properly calculated and congruent with the intention of Pikitch et al. (2012). The WG developed a list of questions that were distributed to the Task Force prior to the call. The WG discussed the recommendations generated from these questions during two subsequent calls to come to consensus on how to calculate these reference points. All calculations were done using the latest results from the 2017 Stock Assessment Update. To make all reference points comparable, F values will be reported below as biomass-weighted averages over the entire population. So for instance, the reference points from the 2017 stock assessment update presented below represent the same level of fishing pressure, but the values differ from the mean F values over ages 2-4 you may be accustomed to seeing. Options below are labeled identically to draft Amendment 3 for consistency and for comparison current F and B levels from the 2017 stock assessment are provided. The WG has a number of comments and caveats regarding the calculation of these reference points which are found at the conclusion of this document.

Description	Reference Point	B-weighted F
Single species target and threshold from 2017 assessment update (Options A/B)	F=$F_{FEC21\%}$	1.164
	F=$F_{FEC36\%}$	0.408
Hockey-stick harvest control rule Pikitch et al. 2012 (Option C)	$F_{threshold}$ (F=0.5M)	0.367
	F_{target}	0.041
B75% rule of thumb/$F_{B75\%}$ & $F_{B40\%}$ target and threshold (Options D/E)	F=F75%B_0	0.160
	F=F40%B_0	1.493

Current levels from 2017 stock assessment	
F_{2016}	0.204
B_{2016}	46.7% B_0

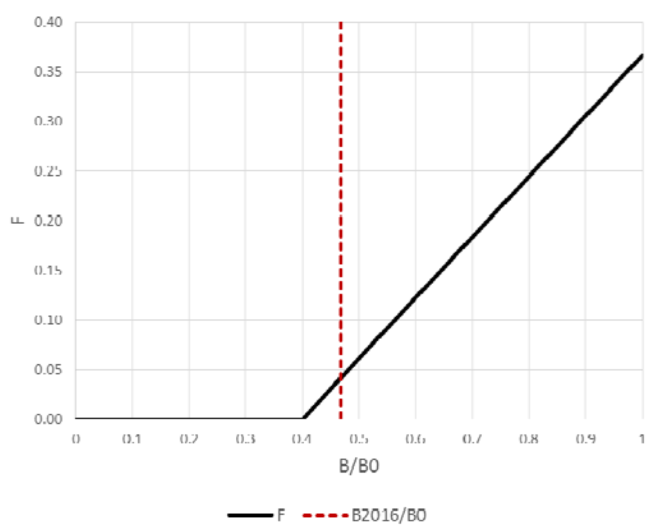
Option A/B: Single species reference points from 2017 Stock Assessment Update ($F=F_{FEC36\%}$, $F=F_{FEC21\%}$)

These reference points were calculated as per the 2017 stock assessment update, but in order to be comparable to the biomass-weighted interim reference points, the biomass-weighted average F have been provided instead of the geometric mean over ages 2-4.

Option	B-weighted F
$F=F_{FEC21\%}$ (Threshold)	1.164
$F=F_{FEC36\%}$ (Target)	0.408

Option C: Pikitch et al (2012) A hockey-stick control rule where F does not exceed half of M and fishing is prohibited if biomass falls below 40% unfished biomass

To calculate a target F for the next fishing season, Pikitch et al. (2012) recommends management actions for species in the "intermediate information tier" (previously determined for Atlantic menhaden by the WG, 2015) in the form of applying a hockey stick harvest control rule with $B_{LIM} \geq 0.4B_0$ (B_0= unfished biomass) and $F \leq 0.5 * M$. In this scenario, fishing would be prohibited when biomass levels fall below 40 percent of unfished biomass. When biomass is greater than 40 percent of unfished biomass, the fishing mortality would not exceed half the natural mortality rate and would depend on how large the population is relative to B_0. To calculate F target rates at $40\%B_0 < B < B_0$, a straight line was fitted between F=0 at $40\%B_0$ and F=0.5M at $100\%B_0$, shown in black in the figure below. The red-hashed line represents the ratio of current biomass to B_0 from the 2017 Stock Assessment Update (B_{2016} = 46.7% B_0, above B_{LIM}) and intersects the black line at F=0.041. This makes the F target in this scenario equal to 0.041. As of 2016, the terminal year of the 2017 Stock Assessment Update, F(2016)=0.204 which is above this target, but less than the threshold of 0.5M (0.367).



Option	B-weighted $F_{threshold}$	2016 F_{target}
F=0.5M	0.367	0.041

Option D: The 75% rule of thumb which specifies that a species be managed to 75% unfished biomass
Option E: An F target of 75% unfished biomass and threshold of 40% unfished biomass

For Options D and E, the F reference points that achieve specific percentages of unfished biomass, we use biomass per-recruit calculations from the assessment model to estimate biomass-weighted F rates that achieve 40% and 75% unfished biomass per recruit. This produces a full F that can be translated to a biomass-weighted average F for comparison with the F=0.5 M reference points. For comparison of reference points, the equilibrium biomass-at-age under that level of F is used to weight the full F.

Option	B-weighted F
F=F75%B_0	0.160
F=F40%B_0	1.493

For Option D, the fishing mortality rate which achieves the 75% unfished biomass is F=0.160. As of 2016, the terminal year of the 2017 Stock Assessment Update, F(2016)=0.204 which is above this reference point. In addition, B_{2016} = 46.7%B_0, below 75%B_0.

For Option E, the F-target which achieves 75% unfished biomass is 0.160 and the F-threshold which achieves 40% unfished biomass is 1.493. As noted above, F(2016)=0.204, which is above the target but below the threshold.

<u>Workgroup Conclusions on Interim Reference Points</u>

- Even after consultation of the WG with the author and coauthors of Pikitch et al (2012), it was not readily apparent to either group how best to translate reference points derived from an Ecopath-with-Ecosim meta-analysis to an age-structured single species framework. This is a novel application rather than standard practice.
- The WG has concerns about the use of reference points that preserve a certain proportion of total biomass instead of spawning stock biomass or fecundity, because they may result in a level of spawning potential well below the FEC limit. For menhaden, age 0 and 1 represent a significant proportion of the total biomass, but do not contribute to the spawning population, and are not targeted by the fishery. Therefore, the level of fishing pressure that reduces total biomass to 40%B_0 is higher than almost anything seen in the history of the fishery and results in almost total loss of spawning adults.
- Although biomass-weighted Fs allow comparison across different types of reference points, they are averaged across the entire population, including the unexploited biomass of ages 0 and 1. This means that the population average F is lower than the F experienced by the most heavily exploited age groups, even for values of fully recruited F which would be considered unachievable or unrealistically high in an age-structured framework.
- The ecosystem models used in Pikitch et al. (2012) to develop biomass and fishing mortality reference points assumed constant selectivity over the entire population or over all adult size classes for the forage groups. The Atlantic Menhaden BAM model uses a dome-shaped selectivity where the oldest age classes are less vulnerable to the fishery than the middle age classes. Thus, the ecosystem models used in Pikitch et al. (2012) make fundamentally different assumptions about the behavior of the fisheries and the effects of fishing on forage fish populations than the BAM assessment.

Atlantic States Marine Fisheries Commission

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MEMORANDUM

TO: Atlantic Menhaden Management Board

FROM: Atlantic Menhaden Plan Development Team

DATE: July 12, 2017

SUBJECT: New York's Proposal to Recalibrate Menhaden Landings

On April 11th, ASMFC staff received a proposal from New York to re-calibrate the state's menhaden landings. The intent of this proposal is to address either non-existent or inconsistent reporting of menhaden landings in New York prior to 2013. The proposal compares landings from 2013-2016 (when reporting was mandatory and enforced) to 2009-2012 (when reporting was not enforced) and then scales historic landings by the difference.

The Plan Development Team (PDT) met via conference call on April 26th and May 22nd to review this proposal. On the April 26th call, the PDT developed several questions for New York to better understand the methods used in the proposal and investigate other changes which may over occurred in the fishery between 2009-2012 and 2013-2016. On the May 22nd call, the PDT reviewed the response from New York to these questions and crafted the following evaluation of the proposal.

Overall, the PDT feels the methods used by New York to recalibrate their menhaden landings are appropriate. The response letter from New York includes recalibrated landings which do not include purse seine landings. Given purse seiners were required to report landings to the state prior to 2009, the PDT feels this second recalibration is more appropriate. In addition, the PDT has a higher level of comfort with the calibration based on the comparison of landings between the two time periods (the lower multiplier of 2.9) as opposed to the calibration based on the comparison of the number of trips (the higher multiplier of 4.62). Members of the PDT noted that the number of trips per year can be more variable, thus lending landings to be a better comparison of the 2009-2012 and the 2013-2016 New York menhaden fishery.

Importantly, the PDT does note some concerns for the Board to consider. The first is that there does appear to be an increase in the abundance of menhaden in the mid-Atlantic and New England states in the past couple of years. This higher abundance could contribute to the higher landings reported by New York in 2013-2016. Moreover, the increase in abundance of menhaden in New York waters, as opposed to the increase in reporting, may explain the higher landings in New York. Secondly, the PDT notes that there may be some challenges applying the recalibrated New York landings to the fleet-capacity allocation method given the recalibrated landings are not broken down by gear type. Should the Board use these recalibrated landings, assumptions will have to be made on how this higher estimate of landings is divided among the various gear types. Finally, the PDT notes that approving this proposal does set a precedent and may invite other states with inconsistent reporting to recalibrate their own landings; however, the time to react to other proposals is quite limited. Other proposals to recalibrate state landings cannot be considered after the August Board meeting given allocation percentages in Draft Amendment 3 cannot change during the public comment process.

For reference, a series of allocation tables which include New York's recalibrated landings are included below. The table numbers correspond to the table numbers in Draft Amendment 3. Given New York's recalibrated landings were not divided by gear type, landings by gear type as reported in the state's compliance report were used to divide the recalibrated landings by gear type.

Table 2: Disposition Allocation

Percent of menhaden commercial TAC allocated to the reduction and bait fisheries based on historic landings (Tier 1, Option A). Table (a) is based on total reduction landings from all states which had, or have, a reduction fishery. Table (b) only includes reduction landings from Virginia, the sole Atlantic coast state which still has an active reduction plant.

(a) Allocations between the bait and reduction sector; includes all reduction landings

	Bait Quota	Reduction Quota
2009-2011	21.3%	78.7%
2012-2016	24.8%	75.2%
1985-2016	13.7%	86.3%
1985-1995	8.5%	91.5%
Weighted	14.2%	85.8%

(b) Allocations between the bait and reduction sector; only includes VA reduction landings. Three timeframes are not shown due to confidentiality.

	Bait Quota	Reduction Quota
2009-2011	21.3%	78.7%
2012-2016	24.8%	75.2%
1985-2016	[redacted]	
1985-1995		
Weighted		

Table 3: Allocation Based on TAC Level (Sub-Option 1)

Percent of menhaden commercial TAC greater than 212,500 mt that is allocated to each jurisdiction based on historic bait landings (Tier 1, Option B, Sub-Option 1). Under this scenario, the Virginia reduction fishery gets 50% of the difference between the annual TAC and 212,500 mt (included in Virginia's percentage below) and the states bait fisheries are allocated the other 50%. These allocation percentages only apply if the annual TAC is greater than 212,500 mt. If the TAC is less than or equal to 212,500 mt, allocations are based on jurisdictional landings from 2009-2011 (Table 10).

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted TAC %
ME	0.04%	0.45%	0.21%	0.11%	0.32%
NH	0.00%	0.00%	0.01%	0.04%	0.01%
MA	1.98%	1.19%	1.97%	3.47%	2.07%
RI	0.05%	0.30%	2.13%	7.23%	2.99%
CT	0.04%	0.02%	0.10%	0.12%	0.06%
NY	0.49%	0.55%	0.99%	1.62%	0.97%
NJ	26.49%	25.39%	18.95%	11.79%	20.11%
PA	0.00%	0.00%	0.00%	0.00%	0.00%
DE	0.03%	0.06%	0.06%	0.10%	0.08%
MD	3.55%	4.00%	3.55%	3.15%	3.67%
PRFC	1.46%	1.72%	3.61%	6.91%	3.73%
VA	64.66%	65.88%	66.45%	61.28%	64.10%
NC	1.16%	0.31%	1.53%	2.97%	1.35%
SC	0.00%	0.00%	0.00%	0.00%	0.00%
GA	0.00%	0.00%	0.00%	0.00%	0.00%
FL	0.05%	0.12%	0.42%	1.22%	0.55%

Table 4: Allocation Based on TAC Level (Sub-Option 2) Percent of menhaden commercial TAC greater than 212,500 mt that is allocated to each jurisdiction based on historic bait landings (Tier 1, Option B, Sub-Option 2). Under this scenario, the Virginia reduction fishery gets 30% of the difference between the annual TAC and 212,500 mt (included in Virginia's percentage below) and the state's bait fisheries are allocated the other 70%. These allocation percentages only apply if the annual TAC is greater than 212,500 mt. If the TAC is less than or equal to 212,500 mt, allocations are based on jurisdictional landings from 2009-2011 (Table 10).

	2009-2011 % TAC	2012-2016 % TAC	1985-2016 % TAC	1985-1995 % TAC	Weighted % TAC
ME	0.06%	0.62%	0.30%	0.16%	0.44%
NH	0.00%	0.00%	0.01%	0.05%	0.02%
MA	2.77%	1.66%	2.76%	4.85%	2.90%
RI	0.06%	0.42%	2.99%	10.12%	4.19%
CT	0.06%	0.03%	0.14%	0.17%	0.09%
NY	0.68%	0.77%	1.38%	2.26%	1.35%
NJ	37.09%	35.55%	26.53%	16.51%	28.15%
PA	0.00%	0.00%	0.00%	0.00%	0.00%
DE	0.04%	0.09%	0.09%	0.13%	0.11%
MD	4.96%	5.60%	4.98%	4.41%	5.14%
PRFC	2.05%	2.40%	5.06%	9.67%	5.23%
VA	50.53%	52.24%	53.03%	45.79%	49.73%
NC	1.63%	0.44%	2.14%	4.16%	1.88%
SC	0.00%	0.00%	0.00%	0.00%	0.00%
GA	0.00%	0.00%	0.00%	0.00%	0.00%
FL	0.06%	0.17%	0.59%	1.70%	0.76%

Table 5: Fleet Capacity Quota – Two Fleet

Percent of menhaden commercial TAC allocated to the small and large capacity fleets based on historic landings (Tier 2, Option A, Sub-Option 1). Given Florida did not code landings by gear type prior to 1993, percent landings by gear type in 1993 and 1994 were used to estimate gear landings from 1988-1992. Florida reduction landings were available for 1985-1987. Table (a) is based on total reduction landings from all states which had, or have, a reduction fishery. Table (b) only includes reduction landings from Virginia, the sole Atlantic coast state which still has an active reduction plant. Table (c) shows bait landings by fleet and is to be used if a disposition quota (Tier 1, Option A) is further allocated by fleet.

(a) Allocations by two fleets; includes all historic reduction landings

	2009-2011	2012-2016	1985-2016	1985-1995	Weighted
Large Capacity Quota	96.08%	94.16%	96.01%	95.86%	95.25%
Small Capacity Quota	3.92%	5.84%	3.99%	4.14%	4.75%

(b) Allocations by two fleets; only includes VA reduction landings

	2009-2011	2012-2016	1985-2016	1985-1995	Weighted
Large Capacity Quota	96.08%	94.16%	95.66%	95.32%	94.87%
Small Capacity Quota	3.92%	5.84%	4.34%	4.68%	5.13%

(c) Bait allocations by two fleets. These percentages are to be used if a disposition quota is further allocated by fleet. It is important to note that these percentages further divide the bait allocation presented in Tables 2a and 2b.

	2009-2011	2012-2016	1985-2016	1985-1995	Weighted
Large Capacity Quota	81.6%	76.5%	71.4%	53.1%	67.5%
Small Capacity Quota	18.4%	23.5%	28.6%	46.9%	32.5%

Table 6: Fleet Capacity Quota – Three Fleet

Percent of menhaden commercial TAC allocated to the small, medium, and large capacity fleets based on historic landings (Tier 2, Option A, Sub-Option 2). Given Florida did not code landings by gear type prior to 1993, percent landings by gear type in 1993 and 1994 were used to estimate gear landings from 1988-1992. Florida reduction landings were available for 1985-1987. Table (a) is based on total reduction landings from all states which had, or have, a reduction fishery. Table (b) only includes reduction landings from Virginia, the sole Atlantic coast state which still has an active reduction plant. Table (c) shows bait landings by fleet and is to be used if a disposition quota (Tier 1, Option A) is further allocated by fleet.

(a) Allocations by three fleets; includes all historic reduction landings

	2009-2011	2012-2016	1985-2016	1985-1995	Weighted
Large Capacity Quota	96.08%	94.16%	96.01%	95.86%	95.25%
Medium Capacity Quota	3.79%	5.57%	3.82%	4.01%	4.57%
Small Capacity Quota	0.12%	0.27%	0.17%	0.13%	0.18%

(b) Allocations by three fleets; only includes VA reduction landings

	2009-2011	2012-2016	1985-2016	1985-1995	Weighted
Large Capacity Quota	96.08%	94.16%	95.66%	95.32%	94.87%
Medium Capacity Quota	3.79%	5.57%	4.15%	4.53%	4.94%
Small Capacity Quota	0.12%	0.27%	0.19%	0.15%	0.19%

(c) Bait allocations by three fleets. These percentages are to be used if a disposition quota is further allocated by fleet. It is important to note that these percentages further divide the bait allocation presented in Tables 2a and 2b.

	2009-2011	2012-2016	1985-2016	1985-1995	Weighted
Large Capacity Quota	81.6%	76.5%	71.4%	53.1%	67.5%
Medium Capacity Quota	17.8%	22.4%	27.4%	45.5%	31.3%
Small Capacity Quota	0.6%	1.1%	1.2%	1.5%	1.2%

Table 7: Fixed Minimum Allocation

Percent of menhaden commercial TAC allocated to each jurisdiction based on historic landings, with each jurisdiction receiving, at a minimum, a 0.5% quota allocation (Tier 2, Option B, Sub-Option 1). Table (a) is based on total reduction landings from all states which had, or have, a reduction fishery. Table (b) only includes reduction landings from Virginia, the sole Atlantic coast state which still has an active reduction plant. Table (c) only includes bait landings and is to be used if the disposition allocation method (Tier 1, Option A) is combined with a fixed minimum approach.

(a) Allocations with a 0.5% fixed minimum quota; includes all historic reduction landings

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME	0.52%	0.70%	1.32%	2.23%	1.68%
NH	0.50%	0.50%	0.50%	0.51%	0.50%
MA	1.27%	1.04%	1.01%	1.07%	1.06%
RI	0.52%	0.64%	1.05%	1.69%	1.31%
CT	0.52%	0.51%	0.53%	0.52%	0.52%
NY	0.69%	0.75%	0.75%	0.76%	0.76%
NJ	10.87%	12.11%	5.38%	2.43%	5.92%
PA	0.50%	0.50%	0.50%	0.50%	0.50%
DE	0.51%	0.53%	0.52%	0.52%	0.52%
MD	1.89%	2.33%	1.41%	1.02%	1.49%
PRFC	1.07%	1.28%	1.43%	1.63%	1.51%
VA	78.66%	76.91%	76.50%	75.63%	76.09%
NC	0.96%	0.64%	7.42%	9.62%	6.38%
SC	0.50%	0.50%	0.50%	0.50%	0.50%
GA	0.50%	0.50%	0.50%	0.50%	0.50%
FL	0.52%	0.55%	0.69%	0.88%	0.76%

(b) Allocations with a 0.5% fixed minimum quota; includes only VA reduction landings

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME	0.52%	0.70%	0.56%	0.52%	0.59%
NH	0.50%	0.50%	0.50%	0.51%	0.50%
MA	1.27%	1.04%	1.05%	1.14%	1.10%
RI	0.52%	0.64%	1.10%	1.84%	1.37%
CT	0.52%	0.51%	0.53%	0.52%	0.52%
NY	0.69%	0.75%	0.78%	0.80%	0.78%
NJ	10.87%	12.11%	5.80%	2.68%	6.35%
PA	0.50%	0.50%	0.50%	0.50%	0.50%
DE	0.51%	0.53%	0.52%	0.52%	0.52%
MD	1.89%	2.33%	1.49%	1.08%	1.57%
PRFC	1.07%	1.28%	1.51%	1.78%	1.59%
VA	78.66%	76.91%	83.12%	85.33%	82.05%
NC	0.96%	0.64%	0.93%	1.05%	0.89%
SC	0.50%	0.50%	0.50%	0.50%	0.50%
GA	0.50%	0.50%	0.50%	0.50%	0.50%
FL	0.52%	0.55%	0.62%	0.73%	0.66%

(c) Bait allocations with a 0.5% fixed minimum quota; to be used if the bait sector is further allocated using the fixed minimum approach. It is important to note that these percentages further divide the TAC already allocated to the bait sector in Tables 2a and 2b.

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME	0.58%	1.32%	0.89%	0.71%	1.08%
NH	0.50%	0.50%	0.52%	0.57%	0.53%
MA	4.14%	2.69%	4.12%	6.88%	4.32%
RI	0.58%	1.05%	4.42%	13.81%	6.01%
CT	0.57%	0.55%	0.69%	0.72%	0.61%
NY	1.40%	1.52%	2.32%	3.47%	2.28%
NJ	49.24%	47.22%	35.37%	22.19%	37.50%
PA	0.50%	0.50%	0.50%	0.50%	0.50%
DE	0.56%	0.62%	0.62%	0.68%	0.64%
MD	7.02%	7.86%	7.04%	6.30%	7.25%
PRFC	3.19%	3.66%	7.15%	13.21%	7.37%
VA	27.48%	29.72%	30.77%	21.26%	26.44%
NC	2.64%	1.08%	3.32%	5.97%	2.98%
SC	0.50%	0.50%	0.50%	0.50%	0.50%
GA	0.50%	0.50%	0.50%	0.50%	0.50%
FL	0.59%	0.72%	1.27%	2.74%	1.50%

Table 8: Fixed Minimum Allocation -1%

Percent of menhaden commercial TAC allocated to each jurisdiction based on historic landings, with each jurisdiction receiving, at a minimum, a 1% quota allocation (Tier 2, Option B, Sub-Option 2). Table (a) is based on total reduction landings from all states which had, or have, a reduction fishery. Table (b) only includes reduction landings from Virginia, the sole Atlantic coast state which still has an active reduction plant. Table (c) only includes bait landings and is to be used if the disposition allocation method (Tier 1, Option A) is combined with a fixed minimum approach.

(a) Allocations with a 1% fixed minimum quota; includes all historic reduction landings

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME	1.02%	1.19%	1.74%	2.58%	2.07%
NH	1.00%	1.00%	1.00%	1.01%	1.00%
MA	1.71%	1.50%	1.46%	1.52%	1.51%
RI	1.02%	1.13%	1.50%	2.08%	1.74%
CT	1.01%	1.01%	1.02%	1.02%	1.02%
NY	1.17%	1.23%	1.23%	1.24%	1.24%
NJ	10.47%	11.60%	5.45%	2.76%	5.95%
PA	1.00%	1.00%	1.00%	1.00%	1.00%
DE	1.01%	1.03%	1.01%	1.01%	1.02%
MD	2.27%	2.67%	1.84%	1.47%	1.90%
PRFC	1.52%	1.72%	1.85%	2.03%	1.92%
VA	72.37%	70.76%	70.39%	69.60%	70.02%
NC	1.42%	1.13%	7.32%	9.33%	6.37%
SC	1.00%	1.00%	1.00%	1.00%	1.00%
GA	1.00%	1.00%	1.00%	1.00%	1.00%
FL	1.02%	1.05%	1.17%	1.34%	1.24%

(b) Allocations with a 1% fixed minimum quota; includes only VA reduction landings

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME	1.02%	1.19%	1.05%	1.02%	1.08%
NH	1.00%	1.00%	1.00%	1.01%	1.00%
MA	1.71%	1.50%	1.50%	1.59%	1.55%
RI	1.02%	1.13%	1.54%	2.22%	1.80%
CT	1.01%	1.01%	1.03%	1.02%	1.02%
NY	1.17%	1.23%	1.25%	1.27%	1.26%
NJ	10.47%	11.60%	5.84%	2.99%	6.34%
PA	1.00%	1.00%	1.00%	1.00%	1.00%
DE	1.01%	1.03%	1.02%	1.02%	1.02%
MD	2.27%	2.67%	1.91%	1.53%	1.98%
PRFC	1.52%	1.72%	1.92%	2.17%	1.99%
VA	72.37%	70.76%	76.43%	78.46%	75.46%
NC	1.42%	1.13%	1.39%	1.50%	1.36%
SC	1.00%	1.00%	1.00%	1.00%	1.00%
GA	1.00%	1.00%	1.00%	1.00%	1.00%
FL	1.02%	1.05%	1.11%	1.21%	1.15%

(c) Bait allocations with a 1% fixed minimum quota; to be used if the bait sector is further allocated using the fixed minimum approach. It is important to note that these percentages further divide the TAC already allocated to the bait sector in Tables 2a and 2b.

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME	1.07%	1.75%	1.36%	1.19%	1.53%
NH	1.00%	1.00%	1.02%	1.06%	1.02%
MA	4.32%	3.00%	4.31%	6.82%	4.48%
RI	1.08%	1.51%	4.58%	13.15%	6.03%
CT	1.07%	1.04%	1.17%	1.20%	1.10%
NY	1.82%	1.93%	2.66%	3.72%	2.62%
NJ	45.50%	43.66%	32.84%	20.81%	34.78%
PA	1.00%	1.00%	1.00%	1.00%	1.00%
DE	1.05%	1.11%	1.11%	1.16%	1.13%
MD	6.96%	7.72%	6.97%	6.30%	7.17%
PRFC	3.46%	3.88%	7.07%	12.61%	7.27%
VA	25.63%	27.68%	28.64%	19.95%	24.68%
NC	2.96%	1.53%	3.57%	5.99%	3.26%
SC	1.00%	1.00%	1.00%	1.00%	1.00%
GA	1.00%	1.00%	1.00%	1.00%	1.00%
FL	1.08%	1.20%	1.70%	3.05%	1.92%

Table 9: Fixed Minimum Allocation – 2%

Percent of menhaden commercial TAC allocated to each jurisdiction based on historic landings, with each jurisdiction receiving, at a minimum, a 2% quota allocation (Tier 2, Option B, Sub-Option 3). Table (a) is based on total reduction landings from all states which had, or have, a reduction fishery. Table (b) only includes reduction landings from Virginia, the sole Atlantic coast state which still has an active reduction plant. Table (c) only includes bait landings and is to be used if the disposition allocation method (Tier 1, Option A) is combined with a fixed minimum approach.

(a) Allocations with a 2% fixed minimum quota; includes all historic reduction landings

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME	2.01%	2.15%	2.60%	3.28%	2.87%
NH	2.00%	2.00%	2.00%	2.00%	2.00%
MA	2.57%	2.40%	2.37%	2.42%	2.41%
RI	2.01%	2.10%	2.41%	2.88%	2.60%
CT	2.01%	2.01%	2.02%	2.01%	2.01%
NY	2.14%	2.19%	2.19%	2.20%	2.19%
NJ	9.67%	10.58%	5.60%	3.43%	6.01%
PA	2.00%	2.00%	2.00%	2.00%	2.00%
DE	2.01%	2.02%	2.01%	2.01%	2.02%
MD	3.03%	3.35%	2.68%	2.38%	2.73%
PRFC	2.42%	2.58%	2.69%	2.84%	2.74%
VA	59.77%	58.47%	58.18%	57.53%	57.87%
NC	2.34%	2.11%	7.11%	8.74%	6.35%
SC	2.00%	2.00%	2.00%	2.00%	2.00%
GA	2.00%	2.00%	2.00%	2.00%	2.00%
FL	2.01%	2.04%	2.14%	2.28%	2.19%

(b) Allocations with a 2% fixed minimum quota; includes only VA reduction landings

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME	2.01%	2.15%	2.04%	2.02%	2.07%
NH	2.00%	2.00%	2.00%	2.00%	2.00%
MA	2.57%	2.40%	2.41%	2.47%	2.45%
RI	2.01%	2.10%	2.44%	2.99%	2.64%
CT	2.01%	2.01%	2.02%	2.02%	2.01%
NY	2.14%	2.19%	2.20%	2.22%	2.21%
NJ	9.67%	10.58%	5.92%	3.61%	6.33%
PA	2.00%	2.00%	2.00%	2.00%	2.00%
DE	2.01%	2.02%	2.01%	2.01%	2.02%
MD	3.03%	3.35%	2.73%	2.43%	2.79%
PRFC	2.42%	2.58%	2.75%	2.95%	2.80%
VA	59.77%	58.47%	63.06%	64.70%	62.28%
NC	2.34%	2.11%	2.32%	2.41%	2.29%
SC	2.00%	2.00%	2.00%	2.00%	2.00%
GA	2.00%	2.00%	2.00%	2.00%	2.00%
FL	2.01%	2.04%	2.09%	2.17%	2.12%

(c) Bait allocations with a 2% fixed minimum quota; to be used if the bait sector is further allocated using the fixed minimum approach. It is important to note that these percentages further divide the TAC already allocated to the bait sector in Tables 2a and 2b.

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME	2.06%	2.61%	2.29%	2.15%	2.43%
NH	2.00%	2.00%	2.01%	2.05%	2.02%
MA	4.69%	3.62%	4.68%	6.71%	4.82%
RI	2.06%	2.41%	4.90%	11.84%	6.07%
CT	2.05%	2.03%	2.14%	2.16%	2.08%
NY	2.66%	2.75%	3.34%	4.20%	3.31%
NJ	38.03%	36.53%	27.77%	18.03%	29.35%
PA	2.00%	2.00%	2.00%	2.00%	2.00%
DE	2.04%	2.09%	2.09%	2.13%	2.10%
MD	6.82%	7.44%	6.83%	6.29%	6.99%
PRFC	3.99%	4.34%	6.91%	11.39%	7.08%
VA	21.94%	23.60%	24.37%	17.34%	21.17%
NC	3.58%	2.43%	4.08%	6.04%	3.83%
SC	2.00%	2.00%	2.00%	2.00%	2.00%
GA	2.00%	2.00%	2.00%	2.00%	2.00%
FL	2.06%	2.16%	2.57%	3.66%	2.74%

Table 10: Jurisdictional Allocation

Percent of menhaden commercial TAC allocated to each jurisdiction based on historic landings, including bycatch and episodic event landings (Tier 3, Option B). Table (a) is based on total reduction landings from all states which had, or have, a reduction fishery. Table (b) only includes reduction landings from Virginia, the sole Atlantic coast state which still has an active reduction plant. Table (c) shows the distribution of bait landings by state and should be used if a disposition quota (Tier 1, Option A) is being further allocated by jurisdiction.

(a) Jurisdictional allocations, including all reduction landings

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME	0.02%	0.22%	0.89%	1.88%	1.28%
NH	0.00%	0.00%	0.00%	0.01%	0.00%
MA	0.84%	0.59%	0.55%	0.62%	0.61%
RI	0.02%	0.15%	0.60%	1.29%	0.88%
CT	0.02%	0.01%	0.03%	0.02%	0.02%
NY	0.21%	0.27%	0.28%	0.29%	0.28%
NJ	11.27%	12.62%	5.30%	2.10%	5.90%
PA	0.00%	0.00%	0.00%	0.00%	0.00%
DE	0.01%	0.03%	0.02%	0.02%	0.02%
MD	1.51%	1.99%	0.99%	0.56%	1.08%
PRFC	0.62%	0.85%	1.01%	1.23%	1.09%
VA	84.96%	83.05%	82.61%	81.66%	82.16%
NC	0.50%	0.16%	7.52%	9.92%	6.39%
SC	0.00%	0.00%	0.00%	0.00%	0.00%
GA	0.00%	0.00%	0.00%	0.00%	0.00%
FL	0.02%	0.06%	0.20%	0.41%	0.28%

(b) Jurisdictional allocations, including just Virginia reduction landings

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME	0.02%	0.22%	0.06%	0.02%	0.10%
NH	0.00%	0.00%	0.00%	0.01%	0.00%
MA	0.84%	0.59%	0.60%	0.70%	0.66%
RI	0.02%	0.15%	0.65%	1.46%	0.95%
CT	0.02%	0.01%	0.03%	0.02%	0.02%
NY	0.21%	0.27%	0.30%	0.33%	0.31%
NJ	11.27%	12.62%	5.76%	2.37%	6.36%
PA	0.00%	0.00%	0.00%	0.00%	0.00%
DE	0.01%	0.03%	0.02%	0.02%	0.02%
MD	1.51%	1.99%	1.08%	0.63%	1.16%
PRFC	0.62%	0.85%	1.10%	1.39%	1.18%
VA	84.96%	83.05%	89.80%	92.21%	88.64%
NC	0.50%	0.16%	0.47%	0.60%	0.43%
SC	0.00%	0.00%	0.00%	0.00%	0.00%
GA	0.00%	0.00%	0.00%	0.00%	0.00%
FL	0.02%	0.06%	0.13%	0.25%	0.17%

(c) Bait landings by state. These percentages should be used if disposition bait quota is further allocated by state. It is important to note that these percentages further divide the TAC already allocated to the bait sector in Tables 2a and 2b.

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME	0.09%	0.89%	0.43%	0.22%	0.63%
NH	0.00%	0.00%	0.02%	0.07%	0.03%
MA	3.96%	2.38%	3.94%	6.93%	4.15%
RI	0.09%	0.60%	4.27%	14.46%	5.99%
CT	0.08%	0.05%	0.20%	0.24%	0.12%
NY	0.97%	1.11%	1.98%	3.23%	1.93%
NJ	52.98%	50.78%	37.90%	23.58%	40.22%
PA	0.00%	0.00%	0.00%	0.00%	0.00%
DE	0.06%	0.13%	0.13%	0.19%	0.15%
MD	7.09%	8.00%	7.11%	6.30%	7.34%
PRFC	2.93%	3.43%	7.23%	13.82%	7.47%
VA	29.33%	31.76%	32.90%	22.56%	28.19%
NC	2.33%	0.63%	3.06%	5.94%	2.69%
SC	0.00%	0.00%	0.00%	0.00%	0.00%
GA	0.00%	0.00%	0.00%	0.00%	0.00%
FL	0.09%	0.24%	0.84%	2.44%	1.09%

Table 11: Regional Allocation – Three Regions

Percent of menhaden commercial TAC allocated to three regions based on historic landings, including bycatch and episodic event landings (Tier 3, Option C, Sub-Option 1). Table (a) is based on total reduction landings from all states which had, or have, a reduction fishery. Table (b) only includes reduction landings from Virginia, the sole Atlantic coast state which still has an active reduction plant. Table (c) shows the distribution of bait landings by region and should be used if a dispositional bait quota (Tier 1, Option A) is being further allocated by jurisdiction. Table (d) shows the distribution of fleet landings by region and should be used if a fleet-capacity quota (Tier 2, Option A) is being further allocated by region. Table (e) shows the distribution of bait landings by fleet and region and should be used if a disposition quota (Tier 1, Option A) and a fleet allocation (Tier 2, Option A) have already been chosen.

(a) Three region allocations, including all historical reduction landings

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME, NH, MA, RI, CT	0.90%	0.97%	2.06%	3.81%	2.79%
NY, NJ, PA, DE	11.50%	12.92%	5.60%	2.41%	6.20%
MD, PRFC, VA, NC, SC, GA, FL	87.61%	86.10%	92.34%	93.78%	91.01%

(b) Three region allocations, only include VA reduction landings

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME, NH, MA, RI, CT	0.90%	0.97%	1.35%	2.21%	1.73%
NY, NJ, PA, DE	11.50%	12.92%	6.08%	2.72%	6.69%
MD, PRFC, VA, NC, SC, GA, FL	87.61%	86.10%	92.57%	95.08%	91.58%

(c) Bait landings by region. These percentages are to be used if a disposition quota is further allocated by region. It is important to note that these percentages further divide the TAC already allocated to the bait sector in Tables 2a and 2b.

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME, NH, MA, RI, CT	4.21%	3.92%	8.85%	21.93%	10.91%
NY, NJ, PA, DE	54.02%	52.02%	40.01%	27.00%	42.30%
MD, PRFC, VA, NC, SC, GA, FL	41.77%	44.06%	51.14%	51.07%	46.78%

(d) Fleet landings by three regions. These percentages are to be used if fleet capacity quotas are further allocated by region. It is important to note that these percentages further divide the TAC already allocated to fleets in Tables 5 and 6.

Large Fleet - All Historic Reduction Landings (2 or 3 Fleet Options)					
	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME, NH, MA, RI, CT			2.08%		
NY, NJ, PA, DE			5.25%		
MD, PRFC, VA, NC, SC, GA, FL			92.67%		
Large Fleet - VA Only Reduction Landings (2 or 3 Fleet Options)					
	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME, NH, MA, RI, CT			1.28%		
NY, NJ, PA, DE			5.73%		
MD, PRFC, VA, NC, SC, GA, FL			92.99%		
Small Fleet (2 Fleet Option)					
	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME, NH, MA, RI, CT	1.31%	1.42%	1.78%	2.03%	1.76%
NY, NJ, PA, DE	8.67%	19.98%	13.93%	12.41%	15.77%
MD, PRFC, VA, NC, SC, GA, FL	90.02%	78.60%	84.29%	85.55%	82.47%
Medium Fleet (3 Fleet Option)					
	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME, NH, MA, RI, CT	0.84%	1.31%	1.28%	1.65%	1.50%
NY, NJ, PA, DE	7.68%	17.96%	12.39%	11.36%	14.26%
MD, PRFC, VA, NC, SC, GA, FL	91.48%	80.73%	86.33%	86.99%	84.24%
Small Fleet (3 Fleet Option)					
	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME, NH, MA, RI, CT	15.88%	3.63%	12.99%	13.87%	8.33%
NY, NJ, PA, DE	39.04%	61.78%	48.42%	44.97%	54.05%
MD, PRFC, VA, NC, SC, GA, FL	45.09%	34.60%	38.59%	41.16%	37.61%

(e) Bait landings by fleet and three regions. These percentages are to be used if a disposition quota is further allocated by fleet and region. It is important to note that these percentages further divide the TAC already allocated to the bait sector in Tables 2a and 2b and the fleets in Tables 5 and 6.

Large Fleet Bait (2 or 3 Fleet Options)					
	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME, NH, MA, RI, CT			11.30%		
NY, NJ, PA, DE			50.62%		
MD, PRFC, VA, NC, SC, GA, FL			38.08%		
Small Fleet (2 Fleet Option)					
	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME, NH, MA, RI, CT	1.31%	1.42%	1.78%	2.03%	1.76%
NY, NJ, PA, DE	8.67%	19.98%	13.93%	12.41%	15.77%
MD, PRFC, VA, NC, SC, GA, FL	90.02%	78.60%	84.29%	85.55%	82.47%
Medium Fleet (3 Fleet Option)					
	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME, NH, MA, RI, CT	0.84%	1.31%	1.28%	1.65%	1.50%
NY, NJ, PA, DE	7.68%	17.96%	12.39%	11.36%	14.26%
MD, PRFC, VA, NC, SC, GA, FL	91.48%	80.73%	86.33%	86.99%	84.24%
Small Fleet (3 Fleet Option)					
	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME, NH, MA, RI, CT	15.88%	3.63%	12.99%	13.87%	8.33%
NY, NJ, PA, DE	39.04%	61.78%	48.42%	44.97%	54.05%
MD, PRFC, VA, NC, SC, GA, FL	45.09%	34.60%	38.59%	41.16%	37.61%

Table 12: Regional Allocation – Four Regions

Percent of menhaden commercial TAC allocated to four regions based on historic landings, including bycatch and episodic event landings (Tier 3, Option C, Sub-Option 2). Table (a) is based on total reduction landings from all states which had, or have, a reduction fishery. Table (b) only includes reduction landings from Virginia, the sole Atlantic coast state which still has an active reduction plant. Table (c) shows the distribution of bait landings by region and should be used if a disposition quota (Tier 1, Option A) is being further allocated by jurisdiction. Table (d) shows the distribution of fleet landings by region and should be used if a fleet-capacity quota (Tier 2, Option A) is being further allocated by region. Table (e) shows the distribution of bait landings by fleet and region and should be used if a disposition quota (Tier 1, Option A) and a fleet allocation (Tier 2, Option A) have already been chosen.

(a) Four region allocations, including all historical reduction landings

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME, NH, MA, RI, CT	0.90%	0.97%	2.06%	3.81%	2.79%
NY, NJ, PA, DE	11.50%	12.92%	5.60%	2.41%	6.20%
MD, PRFC, VA	87.09%	85.89%	84.62%	83.46%	84.34%
NC, SC, GA, FL	0.52%	0.21%	7.72%	10.33%	6.68%

(b) Four region allocations, only including VA reduction landings

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME, NH, MA, RI, CT	0.90%	0.97%	1.35%	2.21%	1.73%
NY, NJ, PA, DE	11.50%	12.92%	6.08%	2.72%	6.69%
MD, PRFC, VA	87.09%	85.89%	91.98%	94.23%	90.98%
NC, SC, GA, FL	0.52%	0.21%	0.59%	0.84%	0.60%

(c) Bait landings by region. These percentages are to be used if bait quota is further allocated by region. It is important to note that these percentages further divide the TAC already allocated to the bait sector in Tables 2a and 2b.

	2009-2011 TAC %	2012-2016 TAC %	1985-2016 TAC %	1985-1995 TAC %	Weighted
ME, NH, MA, RI, CT	4.21%	3.92%	8.85%	21.93%	10.91%
NY, NJ, PA, DE	53.72%	52.02%	40.01%	27.00%	42.30%
MD, PRFC, VA	39.60%	43.20%	47.24%	42.68%	43.00%
NC, SC, GA, FL	2.44%	0.86%	3.90%	8.38%	3.78%

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New York Menhaden Landings Recalibration

Historically, New York supported a large and active Atlantic menhaden processing fishery. The importance of this fishery diminished during the early to mid-1900s and the last processing plant ceased operations in 1969. From 1950-1969, menhaden harvest in New York averaged over 70 million pounds a year. From 1970 to present the menhaden fishery in New York has primarily been for local bait.

Many permit types in New York allow for the harvest of menhaden, although the only permit type requiring mandatory reporting of menhaden landings prior to 2009 was the menhaden purse seine license. New York implemented mandatory reporting on state trip reports for all permit holders between 2009 and 2011. However, compliance monitoring was not performed until 2013 due to staffing and funding constraints. In addition, discussions with permit holders post compliance monitoring indicated that many were unaware menhaden bait harvest needed to be reported. Thus, the validity of New York's menhaden landings history is of concern due to the significant under reporting of landings prior to 2013.

A previous effort to establish a more accurate landings history in New York occurred in 2013. Letters were sent to permit holders eligible to harvest menhaden between 2009 and 2012 requesting verifiable proof of landings during that time. Acceptable proof of landings included dated receipts, log book records, or trip reports that were not submitted to the state. Only five people were able to provide verifiable landings. While this process helped collect some of the missing information in our landings history, it still left New York with historical harvest data that does not represent the totality of our menhaden fishery during that time.

The current allocation system employed in Amendment 2 divides the TAC to each state/jurisdiction based on average landings between 2009 and 2011. This provides New York 0.055% of the TAC. The current allocation options proposed in the Public Information Document for Amendment 3 cover the time period during which New York's menhaden landings history is incomplete (1985-2012) and when our landings have been constrained by quotas and harvest limits (2013-2016) implemented in Amendment 2. The use of this information to set future quotas will continue to negatively impact New York menhaden fishers by setting quota limits well below true historical harvest levels in New York.

In order to provide a better estimate of our landings history, we compared landings and effort in the years prior to our compliance program (2009-2012) to post initiation of the program (2013-2016) (Table 1). The average annual menhaden reported landings were 315,610 lbs in 2009 - 2012, while average annual reported landings were 1,230,027 lbs in 2013 - 2016. The average yearly number of reported trips taken to harvest menhaden was 162 in 2009-2012, and 912 in 2013-2016. These values were used to determine the amount that reported landings and effort increased after compliance measures were in place.

Average Annual Landings			Average Annual Number of Trips	
2009-2012	315,610		2009-2012	162
2013-2016	1,230,027		2013-2016	912
Increase	2.90		Increase	4.62

Table 1. Average annual landings and effort pre (2009-2012) and post (2013-2016) initiation of New York's compliance program.

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It was then assumed that during the years in which reporting was poor, prior to the beginning of our compliance program, landings were severely underreported. The landings multiplier (2.9) is assumed to be a low estimate of how much higher New York's landings were in the past, given that our landings in 2013-2016 occurred under Amendment 2 quotas/trip limits. In the same way, during 1985-2012 when there were no restrictions on menhaden harvest, it is probable that effort was at least 462% higher than reported based upon reporting levels from 2013-2016. For this reason, the effort multiplier (4.62) serves as a higher estimate of where New York's landings may have been during this time period. We present three time series of recalibrated landings in New York from 1985-2012; a low adjusted estimate (2.9 times our current landings), a higher adjusted estimate (4.62 times our current landings), and an average of the two (3.76 times our current landings), in order to account for the unreported landings during this time period (Table 2). In all three cases, these multipliers are still confounded by the limitations imposed by Amendment 2 and may represent underestimates.

	NY Landings		Adjusted Landings (Low-2.9)	Adjusted Landings (Higher-4.62)	Adjusted Landings (Average-3.76)
1985	901,800		2,612,786	4,167,178	3,389,982
1986	399,650		1,157,906	1,846,765	1,502,335
1987	206,795		599,147	955,590	777,369
1988	504,100		1,460,529	2,329,424	1,894,976
1989	449,100		1,301,178	2,075,271	1,688,224
1990	649,710		1,882,405	3,002,281	2,442,343
1991	650,150		1,883,680	3,004,314	2,443,997
1992	1,131,701		3,278,878	5,229,540	4,254,209
1993	1,048,993		3,039,248	4,847,350	3,943,299
1994	961,474		2,785,679	4,442,928	3,614,304
1995	1,087,978		3,152,199	5,027,498	4,089,848
1996	11,135		32,261	51,454	41,858
1997	553,953		1,604,968	2,559,792	2,082,380
1998	430,084		1,246,083	1,987,399	1,616,741
1999	242,886		703,714	1,122,365	913,040
2000	565,800		1,639,293	2,614,537	2,126,915
2001	576,426		1,670,079	2,663,639	2,166,859
2002	444,739		1,288,543	2,055,119	1,671,831
2003	384,875		1,115,099	1,778,490	1,446,794
2004	543,481		1,574,628	2,511,401	2,043,015
2005	871,081		2,523,783	4,025,226	3,274,505
2006	811,934		2,352,417	3,751,911	3,052,164
2007	483,557		1,401,010	2,234,495	1,817,753
2008	410,121		1,188,244	1,895,151	1,541,697
2009	330,496		957,546	1,527,207	1,242,377
2010	394,556		1,143,147	1,823,226	1,483,186
2011	279,117		808,686	1,289,787	1,049,236
2012	258,271		748,289	1,193,459	970,874
2013	1,187,525		1,187,525	1,187,525	1,187,525
2014	825,549		825,549	825,549	825,549
2015	1,467,861		1,467,861	1,467,861	1,467,861
2016	1,439,173		1,439,173	1,439,173	1,439,173
Average	640,752		1,564,735	2,404,153	1,984,444

Table 2. Current landings in New York and the values adjusted by the low, higher, and average multipliers.

In table 3, we show what our initial Amendment 2 quota would have been under each of the adjusted landings scenarios. In all cases, the quota New York would have received is more in line with our average total harvest of 1,230,027 pounds between 2013 and 2016. This is especially true for the higher and average scenarios, where our quota would have been 1,237,392 pounds, and 1,006,613 pounds respectively.

	Low Adjusted Landings	Higher Adjusted Landings	Average Adjusted Landings
2009-2011 Average Landings	969,793	1,546,740	1,258,267
20% Reduction (Amendment 2)	193,959	309,348	251,653
Quota	775,834	1,237,392	1,006,613

Table 3. New York's Initial Amendment 2 quota based on the low, higher, and average adjusted landings.

We believe that these scenarios provide a more realistic representation of the historical menhaden landings in New York, given the limitations of historical reporting.

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Answers to PDT Questions- NY Menhaden Landings Recalibration

1. The analysis notes that prior to 2009, purse seine landings were reported to the state. Were purse seine landings included in the re-calibration of NY's menhaden landings? If they were, the PDT recommends that the re-calibration only be done on non-purse seine landings.

Although there was a law in place requiring purse seine vessels to report menhaden catches to the state, there was no enforcement of this requirement prior to 2013 as was the case for all other licenses eligible to harvest menhaden. There was a single record of a purse seine catch that was reported to NOAA fisheries in 2003. This was included in the original analysis but has been removed prior to running the analysis a second time.

	Adjusted Landings (Low-2.9)	Adjusted Landings (Higher-4.62)	Adjusted Landings (Average-3.76)
1985	2,612,786	4,167,178	3,389,982
1986	1,157,906	1,846,765	1,502,335
1987	599,147	955,590	777,369
1988	1,460,529	2,329,424	1,894,976
1989	1,301,178	2,075,271	1,688,224
1990	1,882,405	3,002,281	2,442,343
1991	1,883,680	3,004,314	2,443,997
1992	3,278,878	5,229,540	4,254,209
1993	3,039,248	4,847,350	3,943,299
1994	2,785,679	4,442,928	3,614,304
1995	3,152,199	5,027,498	4,089,848
1996	32,261	51,454	41,858
1997	1,604,968	2,559,792	2,082,380
1998	1,246,083	1,987,399	1,616,741
1999	703,714	1,122,365	913,040
2000	1,639,293	2,614,537	2,126,915
2001	1,670,079	2,663,639	2,166,859
2002	1,288,543	2,055,119	1,671,831
2003	939,018	1,442,444	1,190,731
2004	1,574,628	2,511,401	2,043,015
2005	2,523,783	4,025,226	3,274,505

2006	2,352,417	3,751,911	3,052,164
2007	1,401,010	2,234,495	1,817,753
2008	1,188,244	1,895,151	1,541,697
2009	957,546	1,527,207	1,242,377
2010	1,143,147	1,823,226	1,483,186
2011	808,686	1,289,787	1,049,236
2012	748,289	1,193,459	970,874
2013	1,187,525	1,187,525	1,187,525
2014	825,549	825,549	825,549
2015	1,467,861	1,467,861	1,467,861
2016	1,439,173	1,439,173	1,439,173
Average	1,559,233	2,393,652	1,976,442

2. What percentage of NY's landings are by purse seines?

In all years from 1985-2016, except for 2003, purse seine landings account for 0% of the menhaden landings in New York. In 2003, they accounted for 24% of the total landings.

3. For the 2009-2012 and the 2013-2016 timeframes, can you provide a breakdown of average landings by gear type and average number of participants in the fishery. The PDT is interested in seeing what other changes might of occurred in the NY menhaden fishery between the two timeframes.

The table below includes average landings by gear type in the two timeframes. Confidential landings are displayed with a "C". The total value of all confidential landings is 14,380 lbs.

Year	Cast Nets	Fixed Nets	Gill Nets	Hook and Line	Pots and Traps	Seines	Trawls	Not Coded
2009-2012	84,302	C	220,136	C		C	1,293	900
2013-2016	348,155	272,073	196,286	C	C	405,049	5,230	3

New York has a number of different permits that allow a fisher to harvest menhaden. This makes it difficult to determine the exact number of participants in the fishery over the years. It is further complicated by the fact that reporting was poor prior to 2013. In the table below we display the average number of permit holders that could have harvested menhaden and the average number in reporting compliance during the two timeframes.

Year	Average # of Permit Holders	Average % in Compliance
2009-2012	1144	39.4
2013-2016	1130	85.2

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MEMORANDUM

TO: Atlantic Menhaden Management Board

FROM: Atlantic Menhaden Advisory Panel

DATE: June 27, 2017

SUBJECT: AP Recommendations on Draft Amendment 3 and 2018 Fishery Specifications

The Advisory Panel (AP) met via conference call on June 26, 2017 to formulate comments on Draft Amendment 3 and provide recommendations on 2018 fishery specifications. Panel members in attendance represented commercial harvesters, recreational anglers, and conservation coalition members. The following is a summary of the conference call.

AP Attendance

Donald Swanson (NH)
Patrick Paquette (MA)
Dave Monti (RI)
Meghan Lapp (RI)
Melissa Dearborn (NY)
Jeff Kaelin (NJ, Chair)
Leonard Voss (DE)
David Sikorski (MD)
Jeff Deem (VA)
James Kellum (VA)
Peter Himchak (VA)
Ken Hinman (Non-trad)

Draft Amendment 3

AP members were asked to provide feedback on the content of Draft Amendment 3, including the variety of options presented and clarity of the document. Preferred management alternatives were not discussed as there will be a separate meeting for this during the Draft Amendment 3 public comment period.

Reference Points

- The AP recommended that stock projections be developed for the interim reference point options presented in Draft Amendment 3. They noted that it is difficult to translate the various reference point options into a TAC.
- The AP also recommended that the methods used by the BERP Workgroup to develop the interim reference point values be provided to the public. ASMFC staff noted that a memo outlining methods used by the BERP Workgroup is being developed and will be included in meeting materials.

TAC and Allocation Methods

- Overall, the AP supported the wider range of options developed for the indecision clause (*Section 4.3.1.2*) but recommended that a fourth option be developed (Option D) which specifies that the same management plan used in the previous year (including the TAC) be carried over into the subsequent year. Those who recommended this option commented that under the current options (Options A through C), the industry is punished for the Board's inability to set a TAC.

- One AP member asked if, under Option C in *Section 4.3.1.2: Indecision Clause* (this option specifies that the current TAC is carried over to the subsequent year but there is no episodic events program or incidental catch provision), the 1% typically set aside for the episodic events program would be re-distributed or if current allocations would remain the same, meaning only 99% of the TAC would be allocated. Staff indicated the PDT would work to address this question ahead of the August Board meeting.
- One AP member commented that several of the allocation methods in Draft Amendment 3, such as the fleet capacity option, may promote a race to fish. The AP member recommended the Board consider this effect when reviewing the allocation methods.

<u>Other Commercial Management Measures</u>

- One AP member asked that the language describing the quota reconciliation options in *Section 4.3.3: Quota Transfers* be clarified, particularly in terms of what happens when coastwide landings are above or below the TAC. Staff indicated the PDT will work to clarify this language ahead of the August Board meeting.
- One AP member asked that a greater variety of options be developed for the various set aside programs, including the episodic event set aside (*Section 4.3.6*), the small-scale fishery set aside (*Section 4.3.5*), and the incidental catch set aside (*Section 4.3.5*). Specifically, the AP member asked that a range of options be developed to explore what percentage of the TAC should be set aside in each program. Currently, only the episodic events program includes a range of options on the percentage of TAC set aside. This AP member recommended that options for the episodic set aside be expanded to include 1%, 1.5%, 2%, 2.5%, and 3% and options for the small-scale set aside include 1%, 1.5%, and 2%.
- One AP member recommended that the redistribution of quota from various programs be done on the same date. Currently, unused episodic events quota is redistributed on November 1st and unused quota rollovers occur on July 1st.
- Two AP members asked that a research set aside program be established through Draft Amendment 3, with options that allow for up to 3% of the TAC to be used for scientific purposes. One AP member noted that, while Draft Amendment 3 allows the Board to establish a research set aside in the future, there are on-going projects which could benefit from a set aside today.
- One AP member recommended that the start of the fishing year be changed from January 1st to May 1st. The AP member noted that rolling over unused quota on July 1st and redistributing unused episodic event set aside quota on November 1st is too late as his state's fishery has already ended for the year. If the fishery started on May 1st, this redistributed quota could be used to harvest menhaden in the early spring.

2018 Fishery Specifications

The AP reviewed the TC memo on stock projections and was asked to provide recommendations to the Board on 2018 fishery specifications. The AP was split in its recommendation to the Board and, as a result, the range of AP recommendations is provided below.

- Six AP members did not support any increase in the TAC. Two AP members noted that menhaden are still expanding to their former geographic range and the Board should not increase the TAC until menhaden fully return to the Gulf of Maine. Four others noted that the Board is close to completing Amendment 3, which has the potential to change the reference points and allocation methods used to manage the stock. Given this imminent action, the Board should maintain status quo. These AP members also noted the importance of considering ecosystem reference points given menhaden's important role as forage fish.
- Four AP members recommended an increase in the TAC for 2018. One AP member recommended that the TAC be increased to 240,000 mt, but noted that at 314,500 mt there is only a 50% risk of exceeding the fishing mortality target. He commented that, from a federal Council perspective, the 314,500 mt TAC is still conservative given the regional Councils have a policy under Magnuson Stevens Act that allows for a 50% risk of exceeding the overfishing limit (OFL) when setting quotas. Another AP member recommended the TAC be increased to 288,500 mt as the projections indicate there is minimal risk of exceeding the fishing mortality threshold. Another AP member commented that the TAC should be, at a minimum, increased to 212,500 mt which represents status quo landings between 2009 and 2011. Finally, one AP member noted that the Board has taken a very precautionary approach to the management of menhaden and the projections, which are based on robust estimates of natural mortality, indicate minimal risk of exceeding the current reference points.

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MEMORANDUM

TO: Atlantic Menhaden Management Board

FROM: Atlantic Menhaden Technical Committee

DATE: June 30, 2017

SUBJECT: Projection Runs for 2018 Fishery Specifications

Projections

Monte Carlo Bootstrap (MCB) runs of the base run of the Beaufort Assessment Model (BAM) were used as the basis for the projections (see Appendix D of 2015 assessment for projection methodology). Projections were run for four years (2017-2020).

Actual landings for the four fleets, north and south as well as reduction and bait, for 2017 were the same in all runs and were 200,000 mt. Constant landings from 2018 to 2020 were allocated to the bait and reduction fishery in the northern and southern regions using the proportions established in Amendment 2 and used by the state of Virginia.

The TC explored nine separate projection runs as requested by the Board. The projections explored a range of TAC levels from status quo to catch levels up to 40% higher than the current TAC. In addition, there were several runs looking at the probability of the fishing mortality rate being below the F target, as specified in the 2017 Stock Assessment Update. Specifically, projections were run using the following TAC scenarios:

1) 200,000 mt = current TAC (status quo)
2) 210,000 mt = if Board implemented a 5% increase to the current TAC
3) 220,000 mt = if Board implemented a 10% increase to the current TAC
4) 240,000 mt = if Board implemented a 20% increase to the current TAC
5) 260,000 mt = if Board implemented a 30% increase to the current TAC
6) 280,000 mt = if Board implemented a 40% increase to the current TAC
7) TAC that has a 50% probability of being below F target in 2018
8) TAC that has a 55% probability of being below F target in 2018
9) TAC that has a 60% probability of being below F target in 2018

Projections 1-6

Results in the table below indicate a percent risk of exceeding the F_{target} (Table 1) or the $F_{threshold}$ (Table 2) under the various projected TAC levels for 2018-2020.

Table 1. Percent risk of exceeding the F_{target} for a given TAC scenario.

	TAC (mt)	**2018**	**2019**	**2020**
Percent Risk of exceeding F_{target}	200,000	9.5%	0.5%	0%
	210,000	12%	1.5%	0%
	220,000	15.5%	3.5%	0%
	240,000	22.5%	9.5%	2.5%
	260,000	29.5%	20.5%	10.5%
	280,000	37.5%	33%	29%

Table 2. Percent risk of exceeding the $F_{threshold}$ for a given TAC scenario.

	TAC (mt)	**2018**	**2019**	**2020**
Percent Risk of exceeding $F_{threshold}$ (Overfishing)	200,000	0%	0%	0%
	210,000	0%	0%	0%
	220,000	0%	0%	0%
	240,000	0.5%	0%	0%
	260,000	1.5%	0%	0%
	280,000	2.5%	0%	0%

Projection 7

The TAC that resulted in a 50% probability of being below the F target in 2018 was 314,500 mt (Table 3).

Table 3. Percent risk of a 314,500 mt TAC exceeding F_{target} or $F_{threshold}$ in 2018.

	2018
Percent risk of exceeding F_{target}	50%
Percent Risk of exceeding $F_{threshold}$	5%

Projection 8

The TAC that resulted in a 55% probability of being below the F target in 2018 was 288,500 mt (Table 4).

Table 4. Percent risk of a 288,500 mt TAC exceeding F_{target} or $F_{threshold}$ in 2018.

	2018
Percent risk of exceeding F_{target}	45%
Percent Risk of exceeding $F_{threshold}$	3%

Projection 9

The TAC that resulted in a 60% probability of being below the F target in 2018 was 286,000 mt (Table 5).

Table 5. Percent risk of a 286,000 mt TAC exceeding F_{target} or $F_{threshold}$ in 2018.

	2018
Percent risk of exceeding F_{target}	40%
Percent Risk of exceeding $F_{threshold}$	3%

Uncertainty in Projections

Projections should be interpreted in light of the model assumptions and key aspects of the data. Some major considerations are the following:

- In general, projections of fish stocks are highly uncertain, particularly over the long-term (e.g., beyond three years). The projection for any year should be considered a range of values rather than a single point.
- Although the projections include many major sources of uncertainty, they do not include structural (model) uncertainty. That is, projection results are conditional on one set of functional forms used to describe population dynamics, selectivity, recruitment, etc.
- Fisheries were assumed to continue fishing at their estimated current proportions of total effort (for bait and reduction fisheries), using the estimated current selectivity patterns. New management regulations that alter those proportions or selectivities would likely affect projection results.
- All of the projections assume that the probability of the size of a recruitment event in any projection year is equivalent to the probability of such recruitment being observed during the years modeled in the stock assessment. If future recruitment is characterized by runs of large or small year classes, possibly due to environmental or ecological conditions, stock trajectories may be affected.
- Projections apply the Baranov catch equation to relate F and landings using a one-year time step, as in the assessment. The catch equation implicitly assumes that mortality occurs throughout the year. This assumption is violated when seasonal closures are in effect, introducing additional and unquantified uncertainty into the projection results.

Table 6. Allocation (in pounds) to states/jurisdiction under the different potential TAC scenarios using Amendment 2 allocation percentages after 1% of the TAC has been set aside for Episodic Events. This table contains potential TACs associated with the constant harvest projection runs 1 through 6.

Metric Tons	200,000	210,000	220,000	240,000	260,000	280,000
Pounds	440,924,524	462,970,750	485,016,976	529,109,429	573,201,881	617,294,334
After Set Aside	436,515,279	458,341,043	480,166,807	523,818,335	567,469,862	611,121,390
ME	171,882	180,477	189,071	206,259	223,447	240,635
NH	131	138	144	157	170	184
MA	3,660,454	3,843,476	4,026,499	4,392,544	4,758,590	5,124,635
RI	78,195	82,105	86,015	93,834	101,654	109,473
CT	76,152	79,960	83,767	91,383	98,998	106,613
NY	242,032	254,134	266,235	290,439	314,642	338,845
NJ	48,853,880	51,296,574	53,739,268	58,624,656	63,510,044	68,395,432
DE	57,646	60,529	63,411	69,176	74,940	80,705
MD	5,991,662	6,291,246	6,590,829	7,189,995	7,789,161	8,388,327
PRFC	2,709,809	2,845,300	2,980,790	3,251,771	3,522,752	3,793,733
VA	372,443,990	391,066,190	409,688,389	446,932,788	484,177,187	521,421,586
NC	2,150,995	2,258,545	2,366,095	2,581,194	2,796,294	3,011,393
SC	-	-	-	-	-	-
GA	-	-	-	-	-	-
FL	78,449	82,371	86,294	94,139	101,983	109,828

Table 7. Allocation (in pounds) to states/jurisdiction using Amendment 2 allocation percentages after 1% of the TAC has been set aside for Episodic Events for the scenarios with 50%, 55%, and 60% probabilities of being below F target in 2017.

Percentage	50%	55%	60%
Metric Tons	314,500	288,500	286,000
Pounds	693,353,814	636,033,626	630,522,069
After Set Aside	686,420,276	629,673,290	624,216,849
ME	270,285	247,940	245,792
NH	206	189	187
MA	5,756,063	5,280,204	5,234,449
RI	122,962	112,797	111,819
CT	119,749	109,850	108,898
NY	380,596	349,131	346,106
NJ	76,822,726	70,471,722	69,861,048
DE	90,649	83,155	82,434
MD	9,421,889	8,642,973	8,568,077
PRFC	4,261,175	3,908,900	3,875,027
VA	585,668,174	537,250,456	532,594,906
NC	3,382,440	3,102,811	3,075,923
SC	-	-	-
GA	-	-	-
FL	123,361	113,162	112,182

Figures

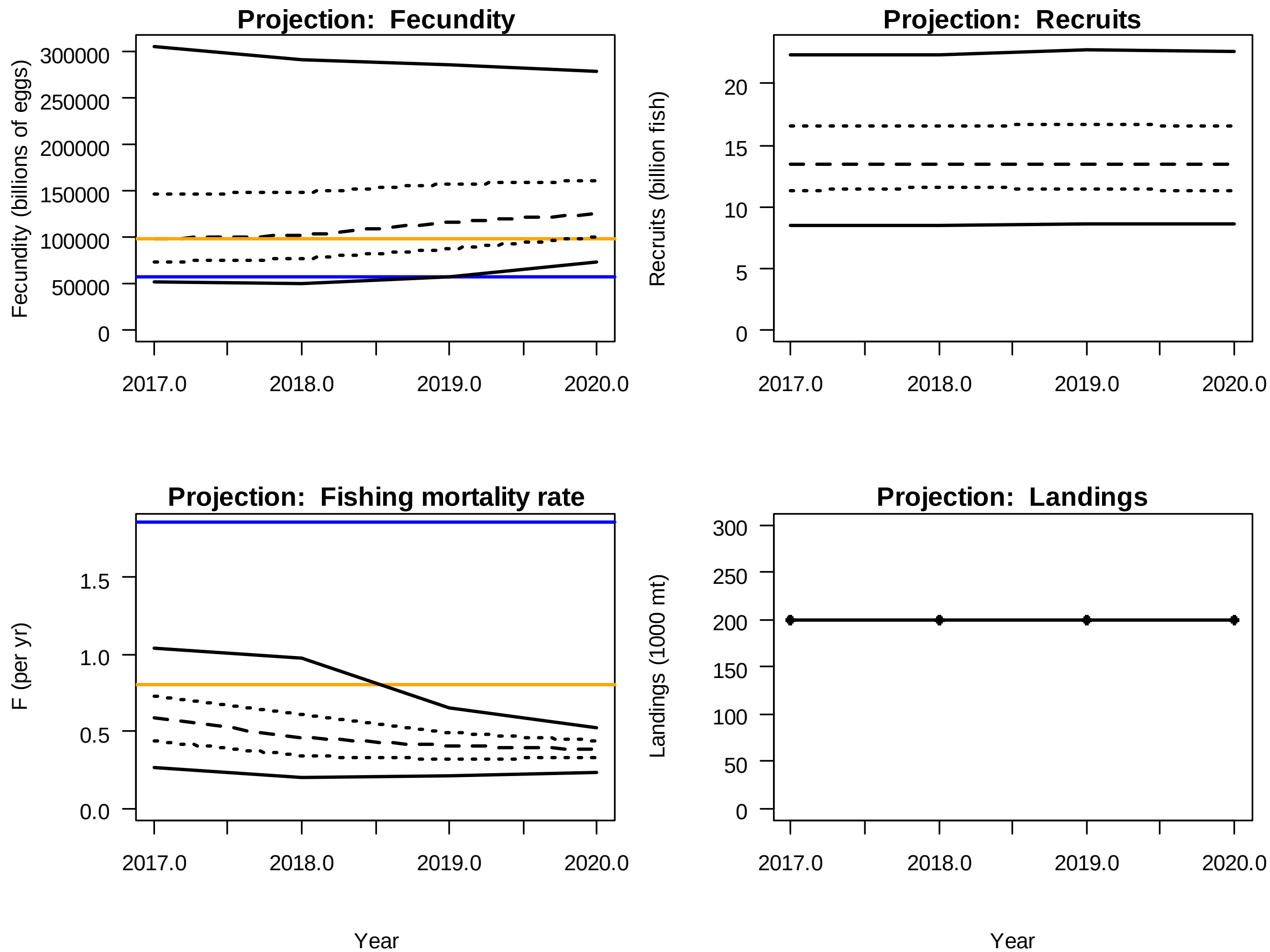

Figure 1. Projection panels for a 200,000 mt TAC during 2017-2020. Fecundity, recruits, geometric mean fishing mortality (*F*) over ages-2 to -4, and landings over time based on constant landings for 2018 to 2020 and median recruitment with variability based on estimated deviations for each MCB run. The solid flat lines in the fishing mortality rate and fecundity panels are the threshold (blue) and target (orange) benchmark values recommended by the TC from the base run. The solid black lines are the 5 and 95% quantiles, the dotted lines are the 25 and 75% quantiles, and the dashed line is the median.

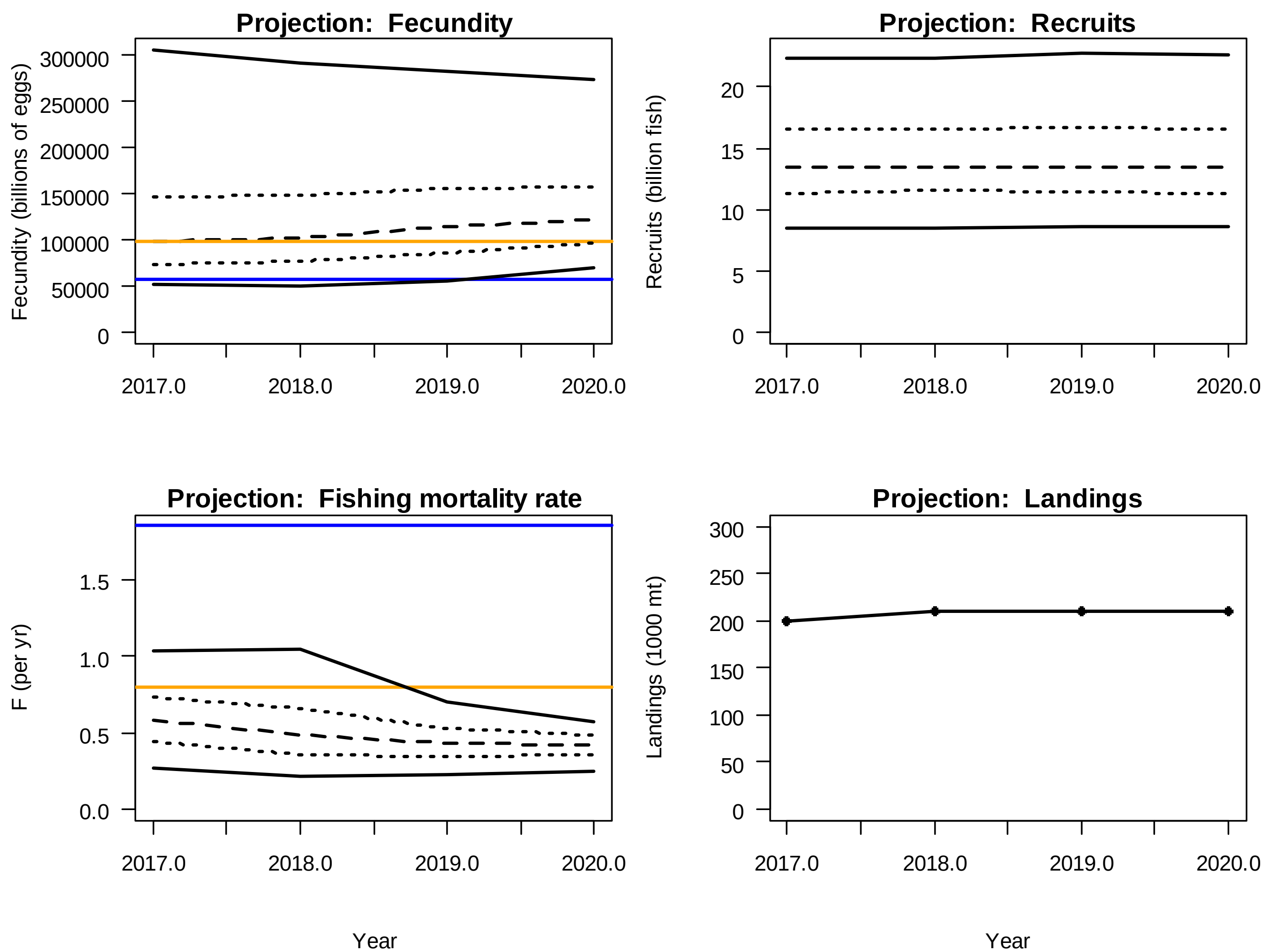

Figure 2. Projection panels for a 210,000 mt TAC during 2017-2020. Fecundity, recruits, geometric mean fishing mortality (*F*) over ages-2 to -4, and landings over time based on constant landings for 2018 to 2020 and median recruitment with variability based on estimated deviations for each MCB run. The solid flat lines in the fishing mortality rate and fecundity panels are the threshold (blue) and target (orange) benchmark values recommended by the TC from the base run. The solid black lines are the 5 and 95% quantiles, the dotted lines are the 25 and 75% quantiles, and the dashed line is the median.

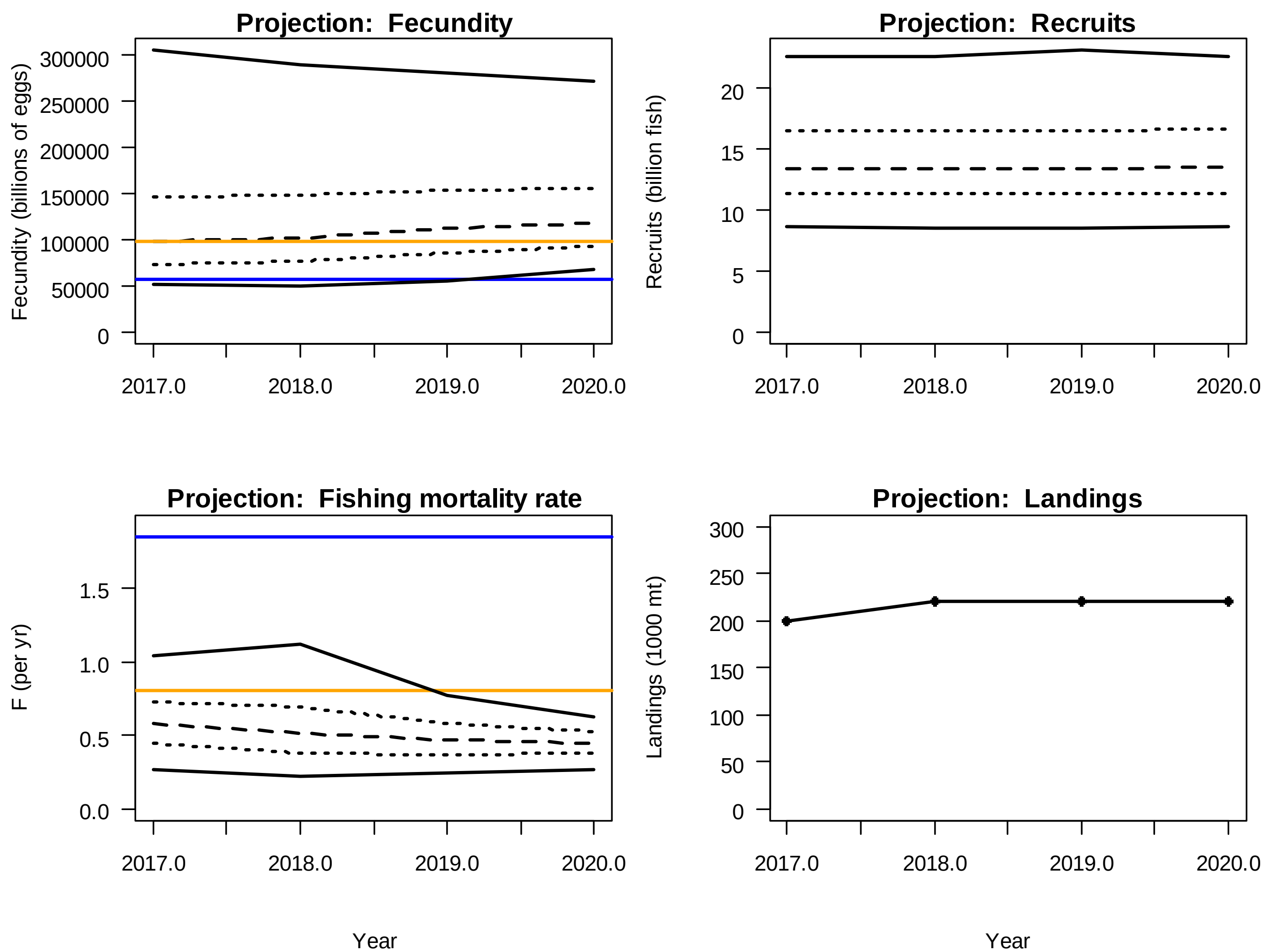

Figure 3. Projection panels for a 220,000 mt TAC during 2017-2020. Fecundity, recruits, geometric mean fishing mortality (*F*) over ages-2 to -4, and landings over time based on constant landings for 2018 to 2020 and median recruitment with variability based on estimated deviations for each MCB run. The solid flat lines in the fishing mortality rate and fecundity panels are the threshold (blue) and target (orange) benchmark values recommended by the TC from the base run. The solid black lines are the 5 and 95% quantiles, the dotted lines are the 25 and 75% quantiles, and the dashed line is the median.

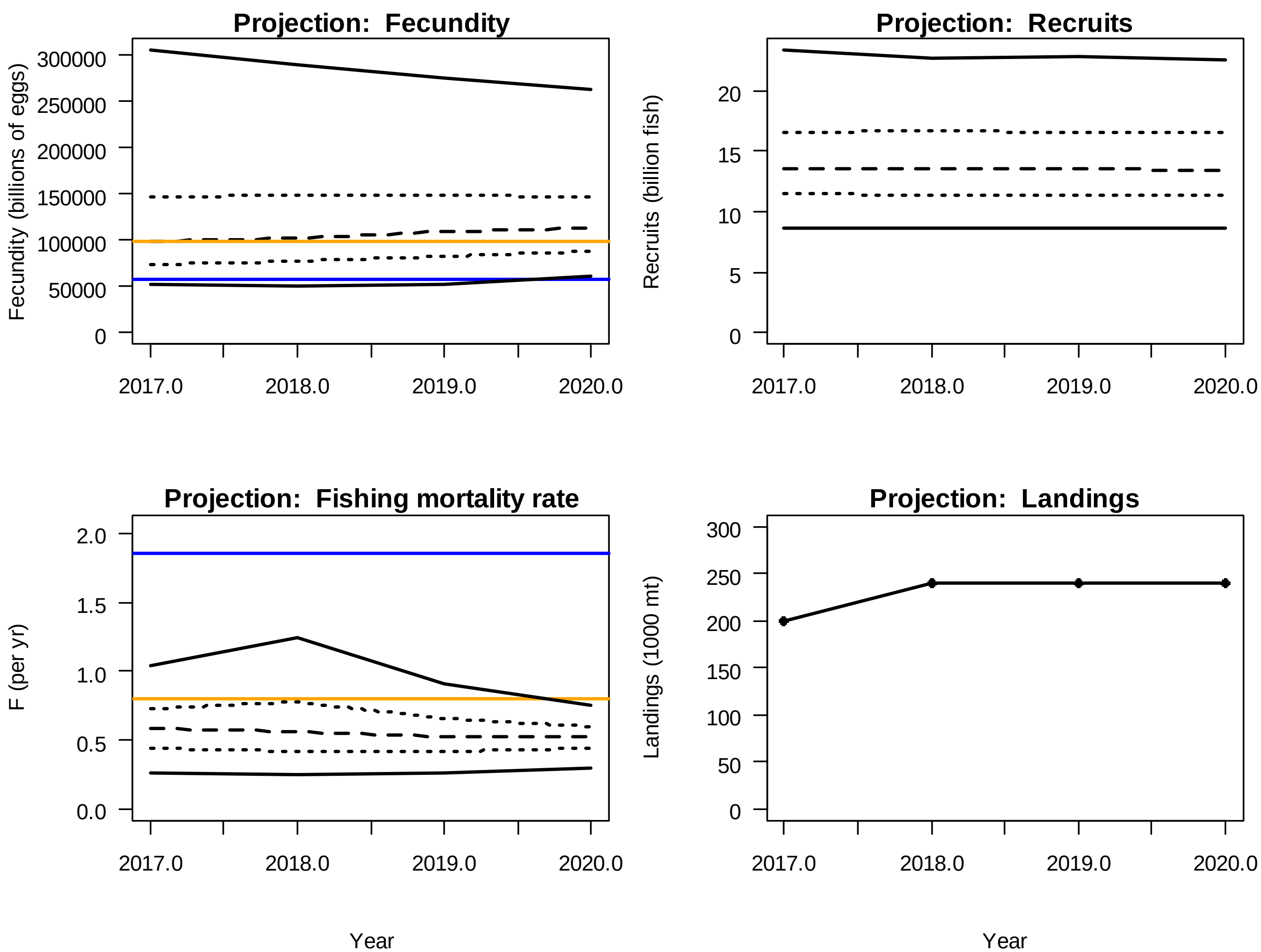

Figure 4. Projection panels for a 240,000 mt TAC during 2017-2020. Fecundity, recruits, geometric mean fishing mortality (*F*) over ages-2 to -4, and landings over time based on constant landings for 2018 to 2020 and median recruitment with variability based on estimated deviations for each MCB run. The solid flat lines in the fishing mortality rate and fecundity panels are the threshold (blue) and target (orange) benchmark values recommended by the TC from the base run. The solid black lines are the 5 and 95% quantiles, the dotted lines are the 25 and 75% quantiles, and the dashed line is the median.

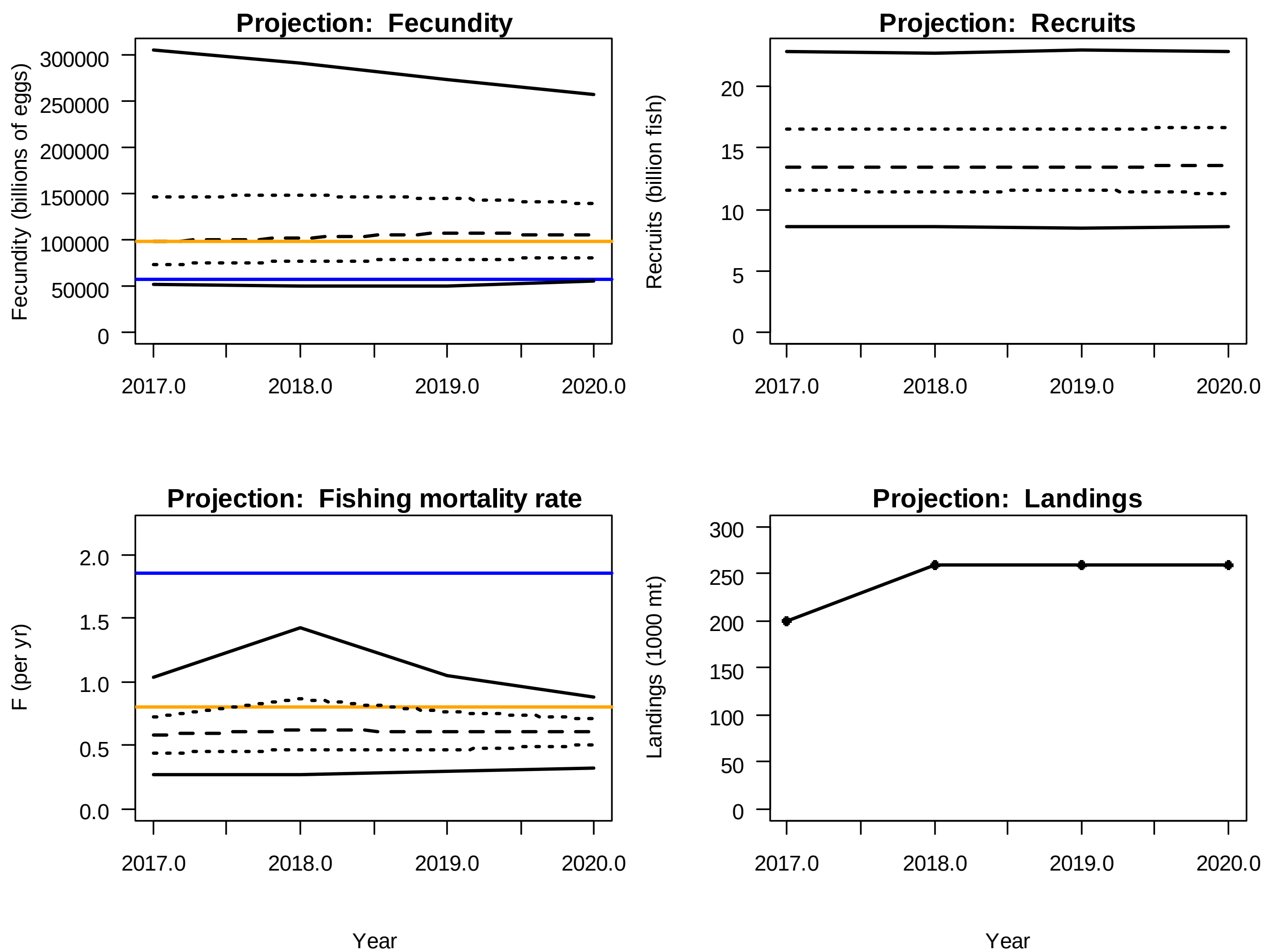

Figure 5. Projection panels for a 260,000 mt TAC during 2017-2020. Fecundity, recruits, geometric mean fishing mortality (*F*) over ages-2 to -4, and landings over time based on constant landings for 2018 to 2020 and median recruitment with variability based on estimated deviations for each MCB run. The solid flat lines in the fishing mortality rate and fecundity panels are the threshold (blue) and target (orange) benchmark values recommended by the TC from the base run. The solid black lines are the 5 and 95% quantiles, the dotted lines are the 25 and 75% quantiles, and the dashed line is the median.

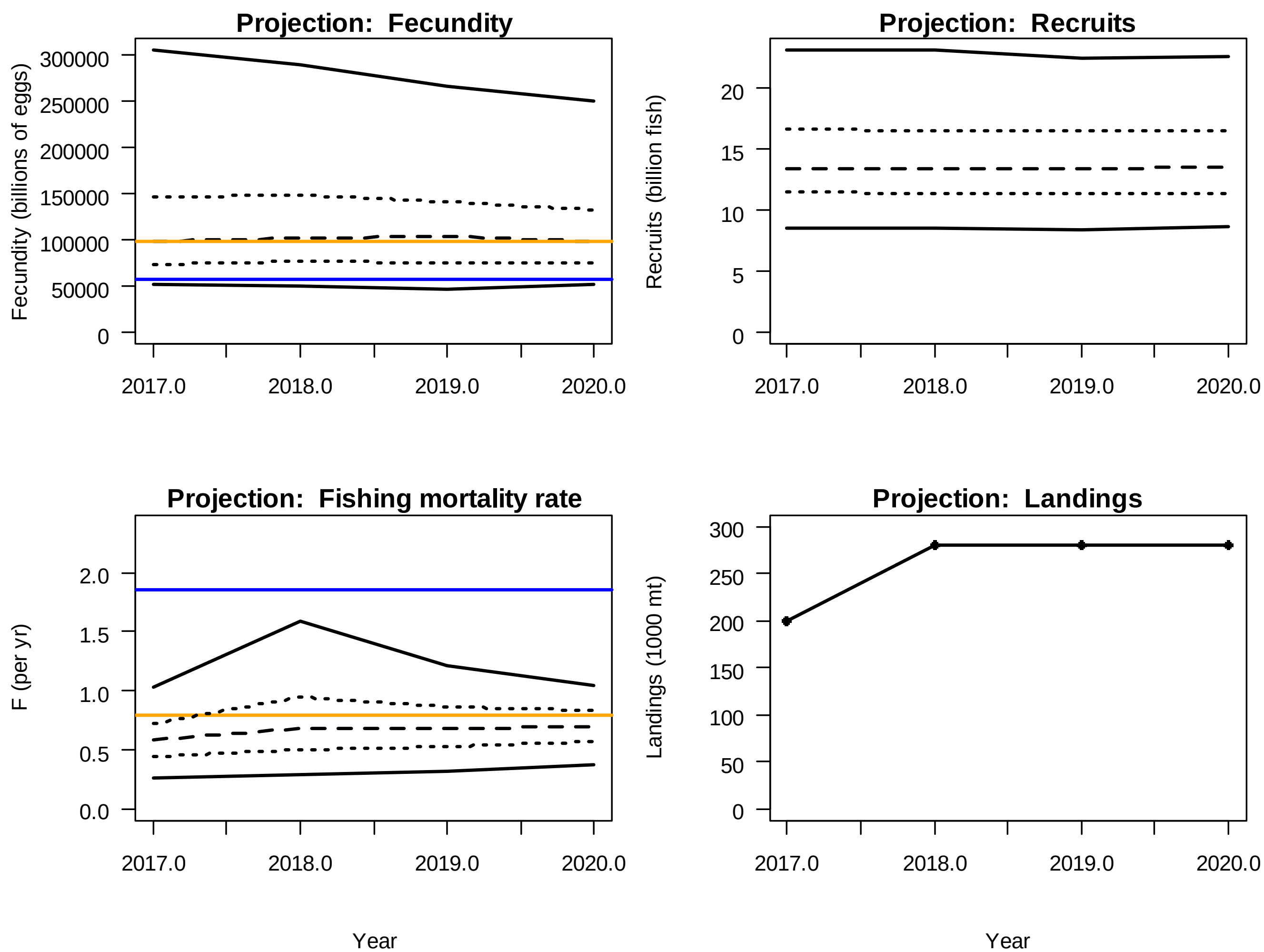

Figure 6. Projection panels for a 280,000 mt TAC during 2017-2020. Fecundity, recruits, geometric mean fishing mortality (*F*) over ages-2 to -4, and landings over time based on constant landings for 2018 to 2020 and median recruitment with variability based on estimated deviations for each MCB run. The solid flat lines in the fishing mortality rate and fecundity panels are the threshold (blue) and target (orange) benchmark values recommended by the TC from the base run. The solid black lines are the 5 and 95% quantiles, the dotted lines are the 25 and 75% quantiles, and the dashed line is the median.

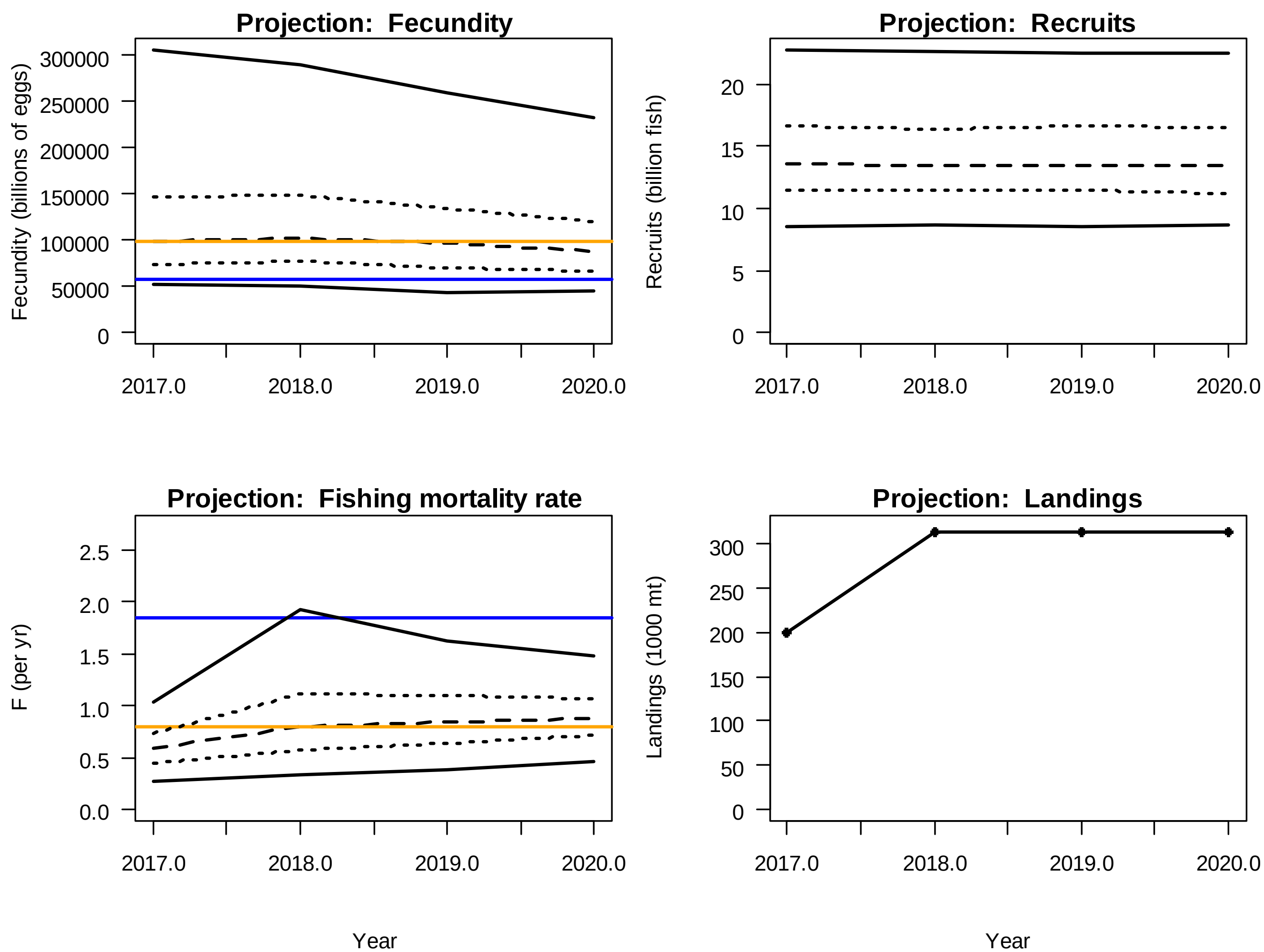

Figure 7. Projection panels for a 314,500 mt TAC in 2018 which results in a 50% probability of being below the F target in 2018. Fecundity, recruits, geometric mean fishing mortality (*F*) over ages-2 to -4, and landings over time based on constant landings for 2018 to 2020 and median recruitment with variability based on estimated deviations for each MCB run. The solid flat lines in the fishing mortality rate and fecundity panels are the threshold (blue) and target (orange) benchmark values recommended by the TC from the base run. The solid black lines are the 5 and 95% quantiles, the dotted lines are the 25 and 75% quantiles, and the dashed line is the median.

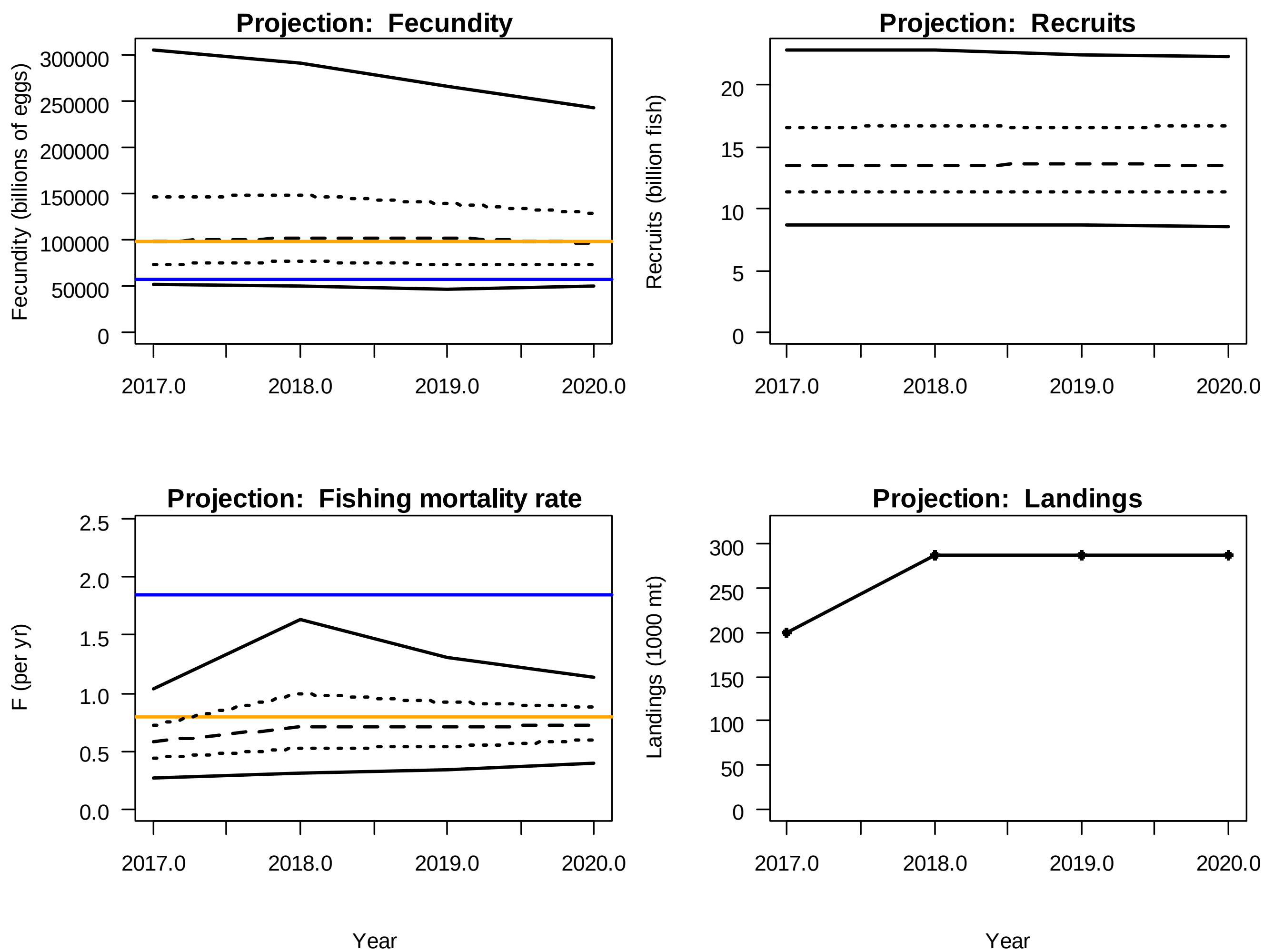

Figure 8. Projection panels for a 288,500 mt TAC in 2018, which results in a 55% probability of being below the F target in 2018. Fecundity, recruits, geometric mean fishing mortality (*F*) over ages-2 to -4, and landings over time based on constant landings for 2018 to 2020 and median recruitment with variability based on estimated deviations for each MCB run. The solid flat lines in the fishing mortality rate and fecundity panels are the threshold (blue) and target (orange) benchmark values recommended by the TC from the base run. The solid black lines are the 5 and 95% quantiles, the dotted lines are the 25 and 75% quantiles, and the dashed line is the median.

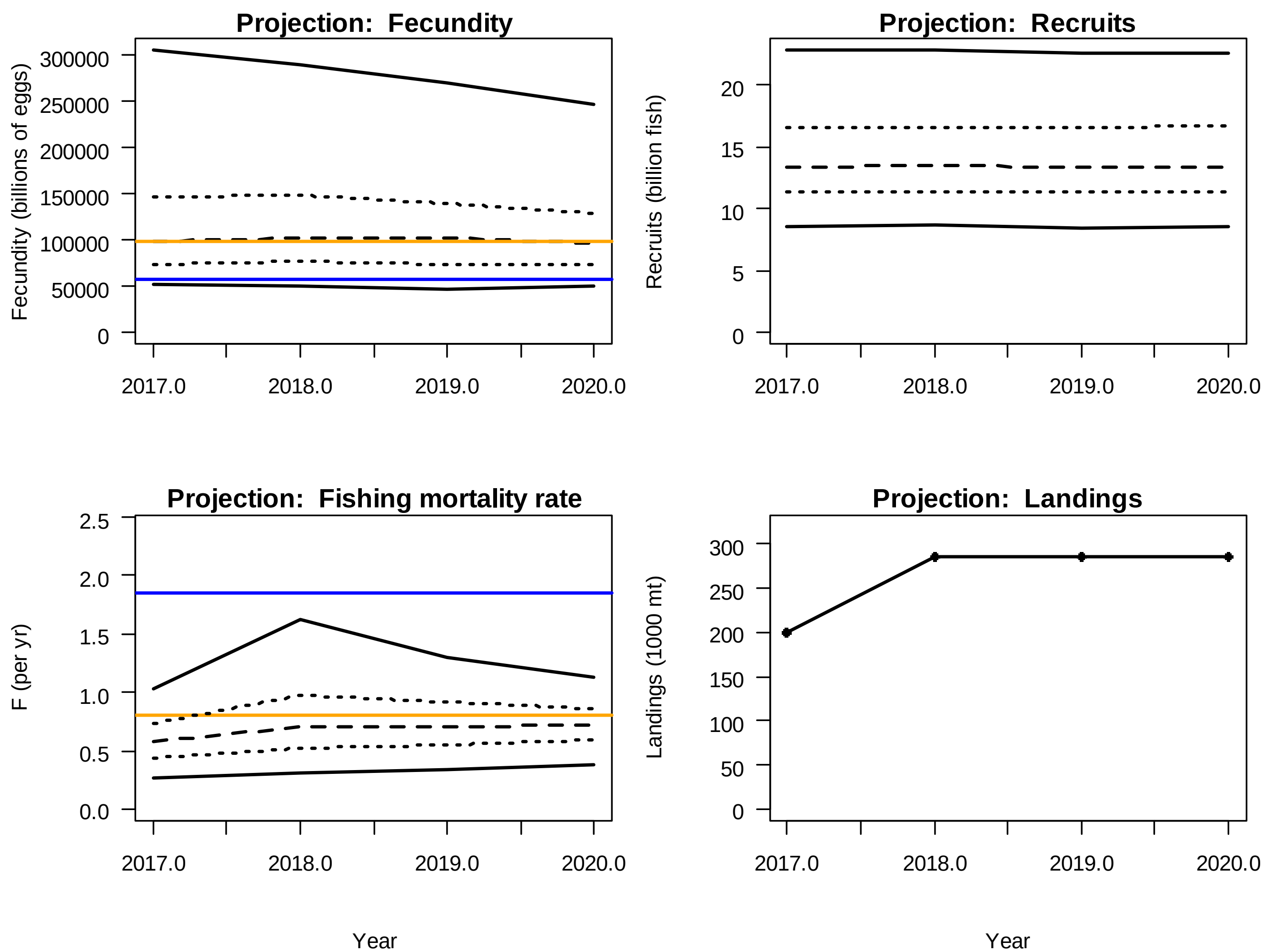

Figure 9. Projection panels for a 286,000 mt TAC in 2018, which results in a 60% probability of being below the F target in 2018. Fecundity, recruits, geometric mean fishing mortality (*F*) over ages-2 to -4, and landings over time based on constant landings for 2018 to 2020 and median recruitment with variability based on estimated deviations for each MCB run. The solid flat lines in the fishing mortality rate and fecundity panels are the threshold (blue) and target (orange) benchmark values recommended by the TC from the base run. The solid black lines are the 5 and 95% quantiles, the dotted lines are the 25 and 75% quantiles, and the dashed line is the median.

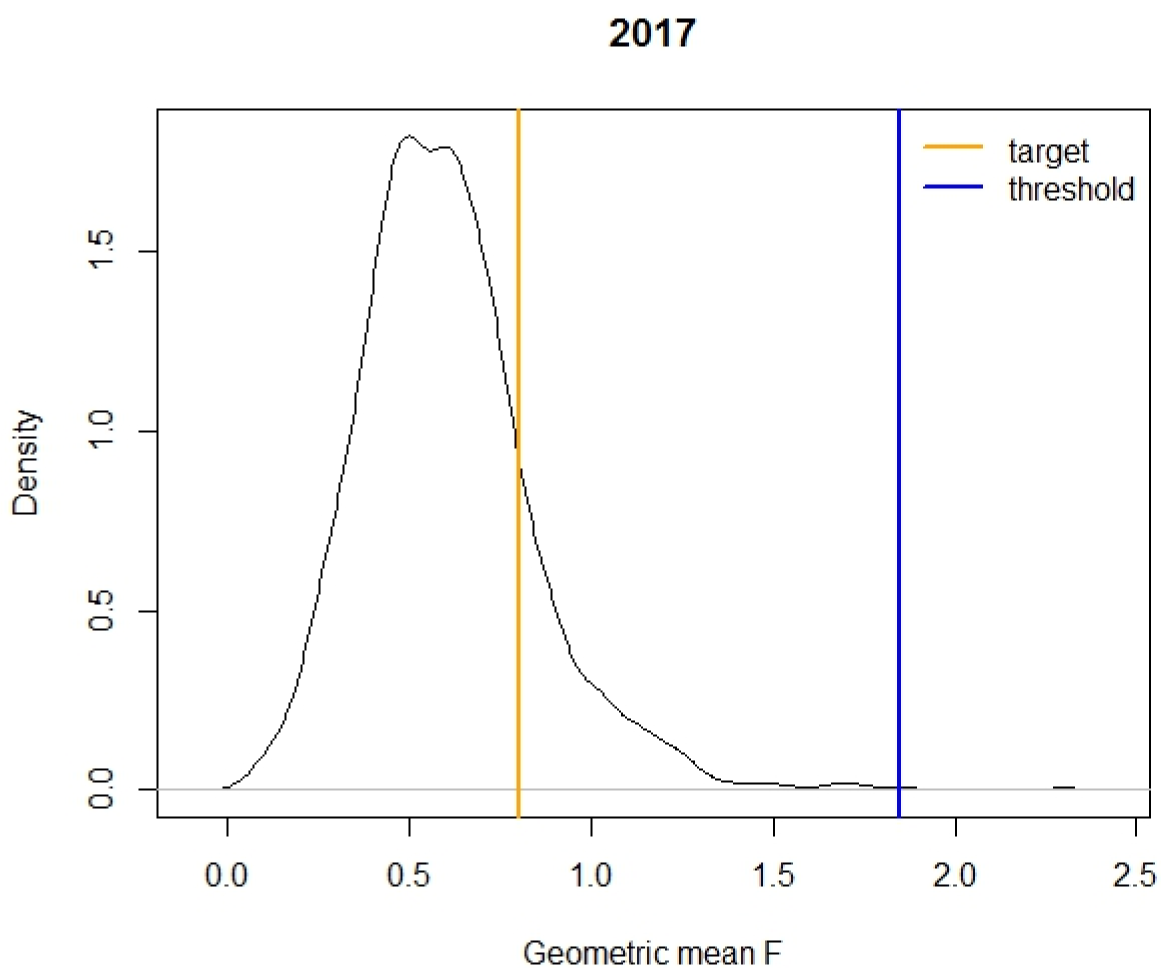

Figure 10: Density distribution of the geometric mean fishing mortality rate for ages 2-4 under the 2017 200,000 mt TAC. The vertical lines are the threshold (blue) and target (orange) benchmark values recommended by the TC from the base run.

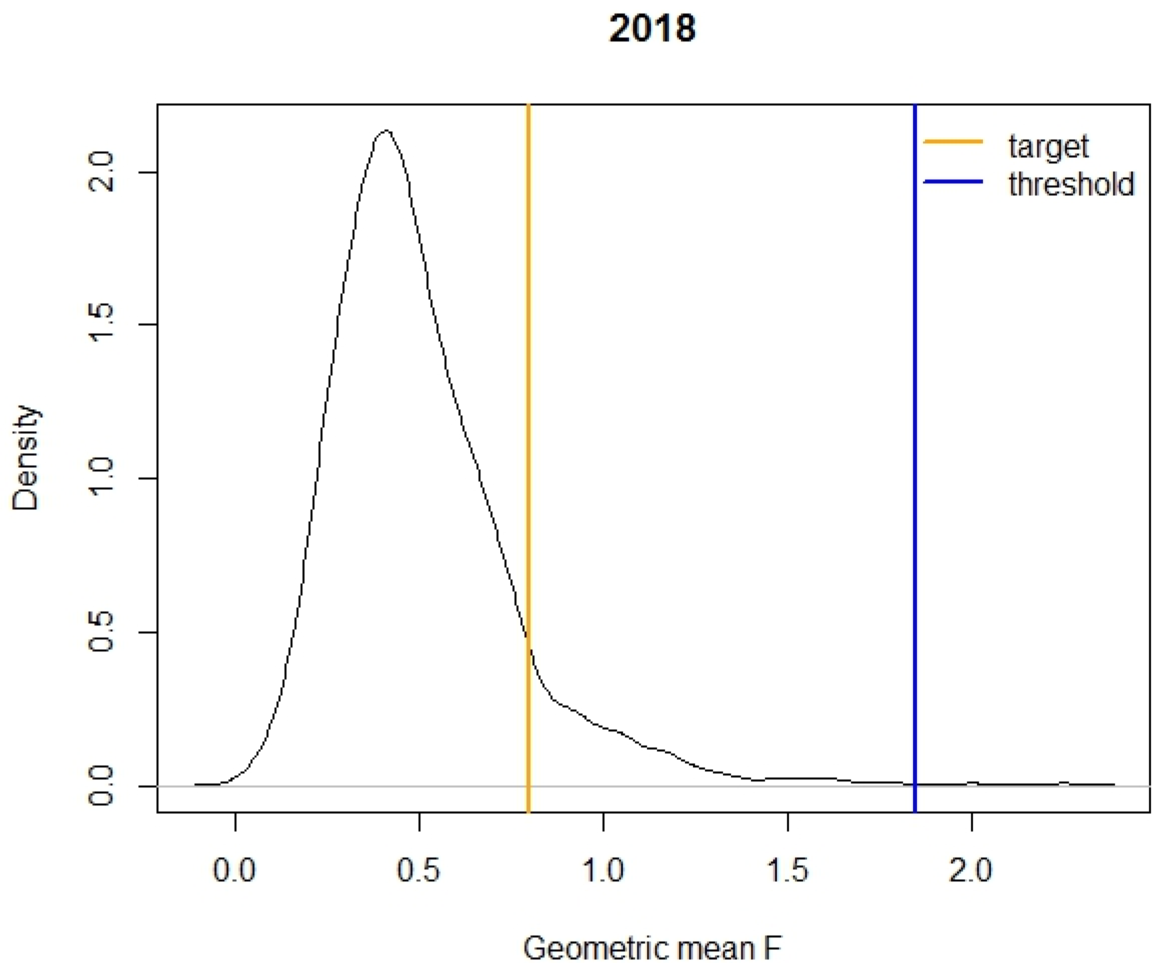

Figure 11: Density distribution of the geometric mean fishing mortality rate for ages 2-4 under a 200,000 mt TAC in 2018. The vertical lines are the threshold (blue) and target (orange) benchmark values recommended by the TC from the base run.

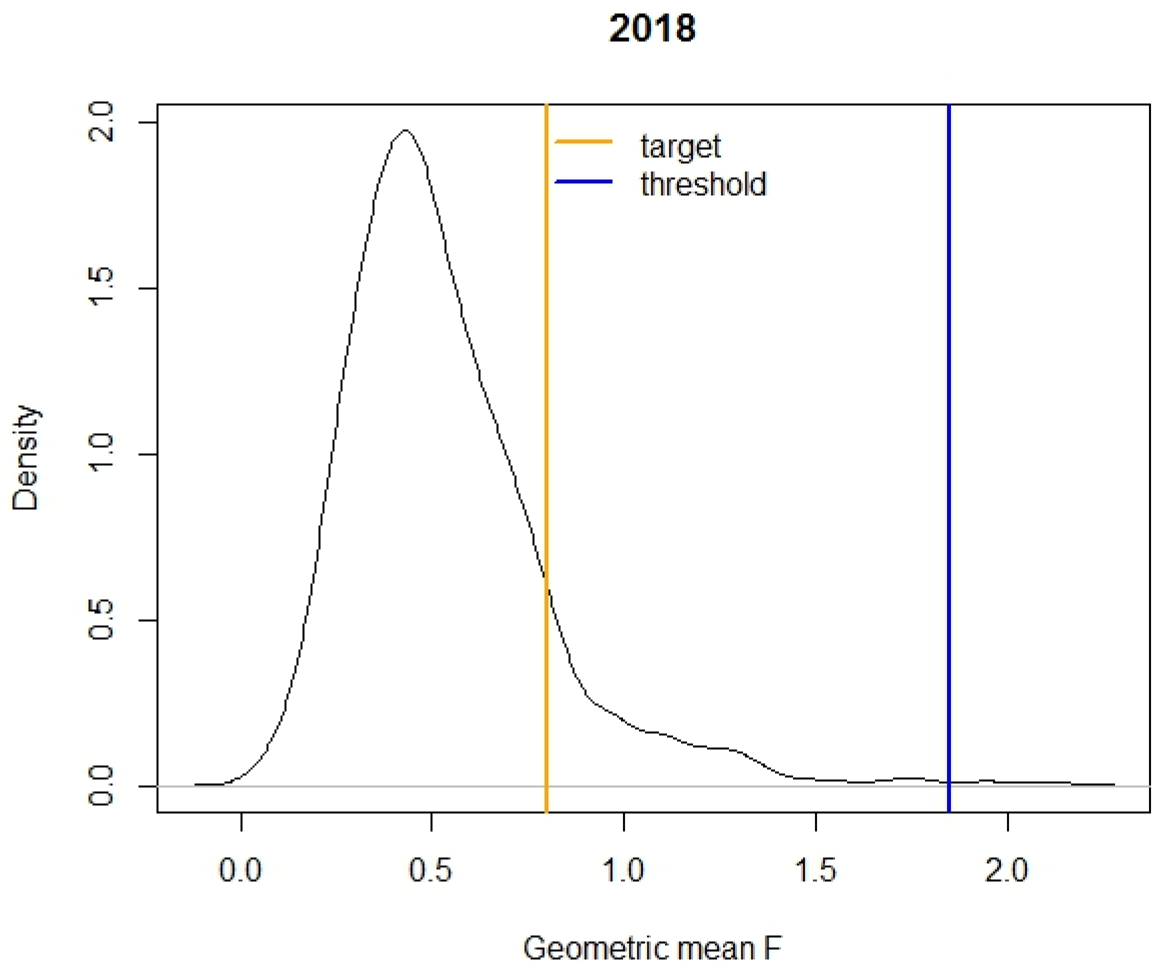

Figure 12: Density distribution of the geometric mean fishing mortality rate for ages 2-4 under a 210,000 mt TAC in 2018. The vertical lines are the threshold (blue) and target (orange) benchmark values recommended by the TC from the base run.

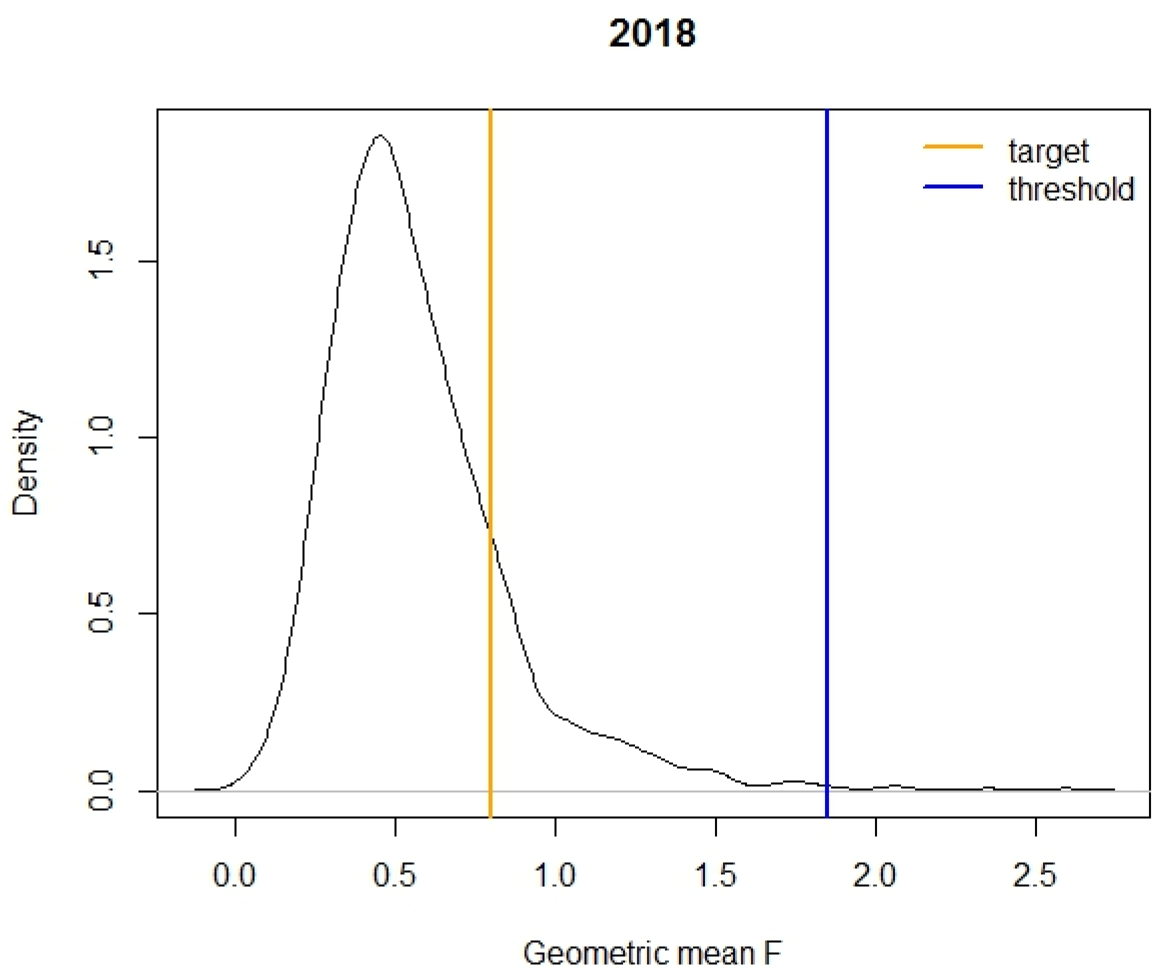

Figure 13: Density distribution of the geometric mean fishing mortality rate for ages 2-4 under a 220,000 mt TAC in 2018. The vertical lines are the threshold (blue) and target (orange) benchmark values recommended by the TC from the base run.

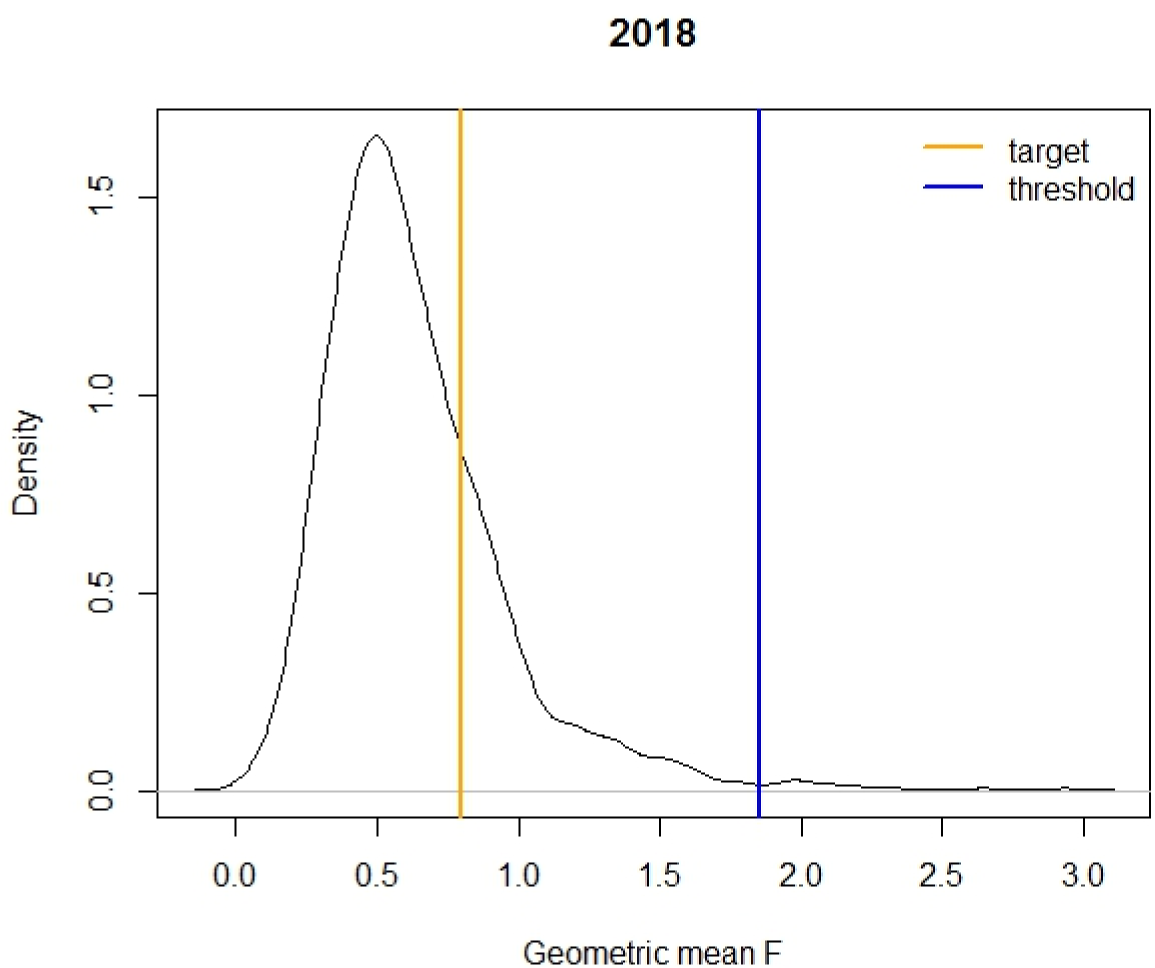

Figure 14: Density distribution of the geometric mean fishing mortality rate for ages 2-4 under a 240,000 mt TAC in 2018. The vertical lines are the threshold (blue) and target (orange) benchmark values recommended by the TC from the base run.

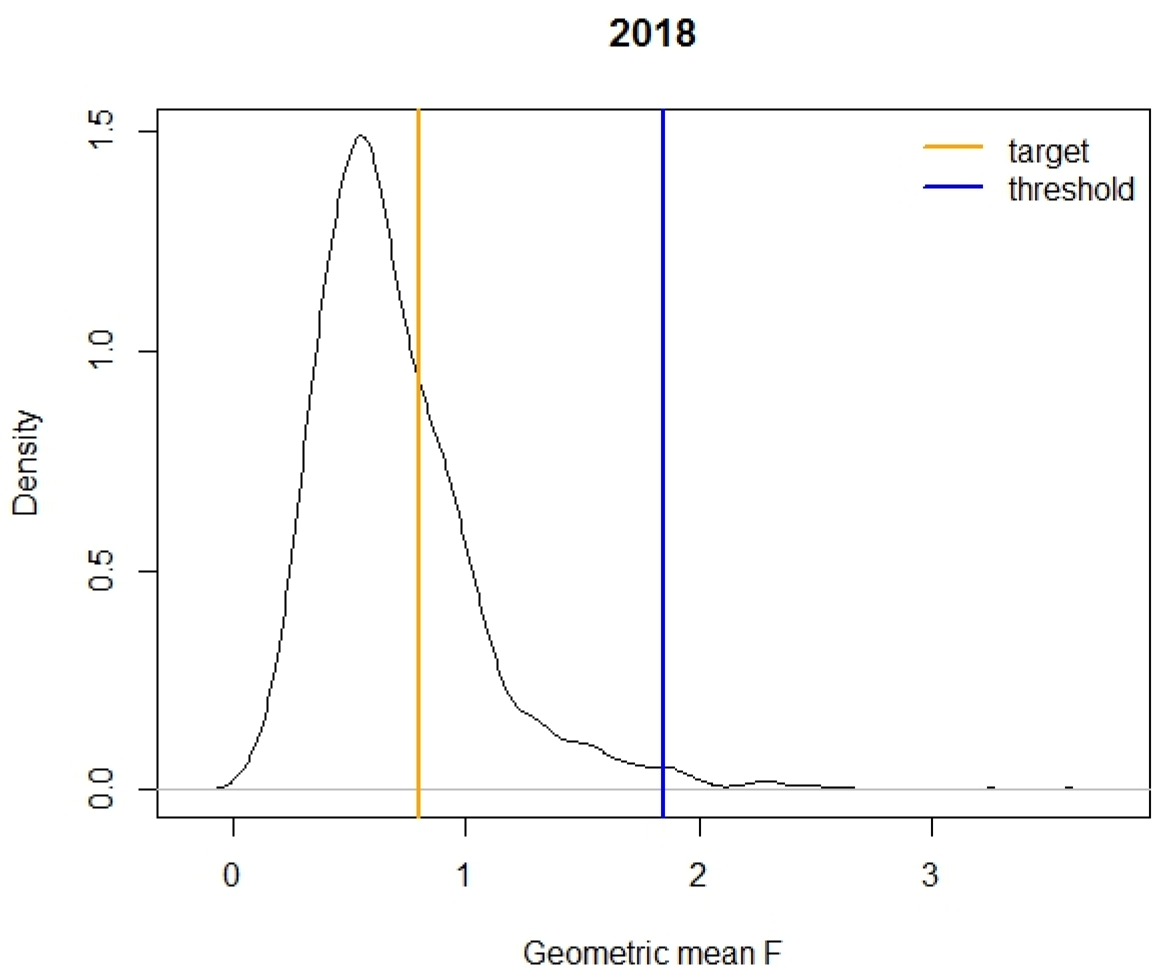

Figure 15: Density distribution of the geometric mean fishing mortality rate for ages 2-4 under a 260,000 mt TAC in 2018. The vertical lines are the threshold (blue) and target (orange) benchmark values recommended by the TC from the base run.

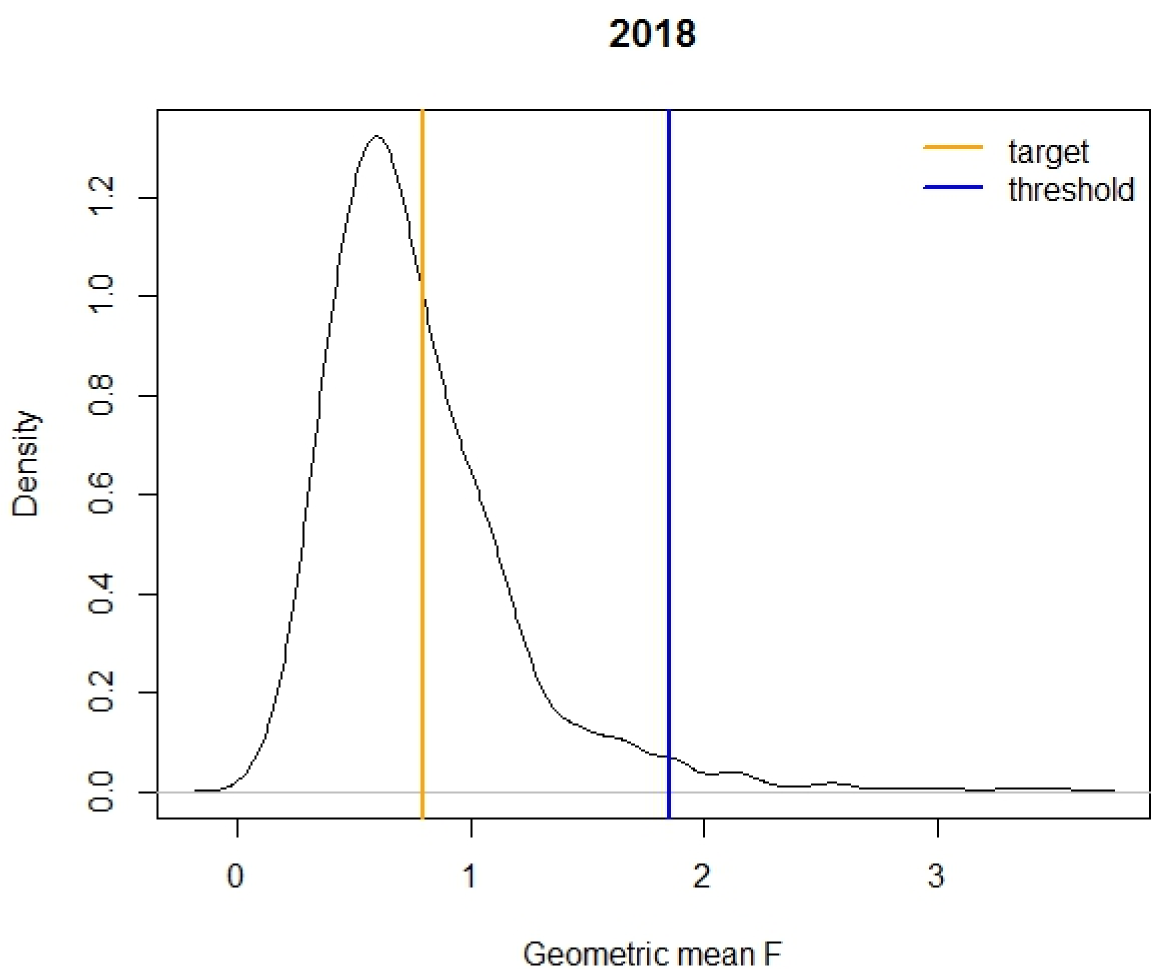

Figure 16: Density distribution of the geometric mean fishing mortality rate for ages 2-4 under a 280,000 mt TAC in 2018. The vertical lines are the threshold (blue) and target (orange) benchmark values recommended by the TC from the base run.

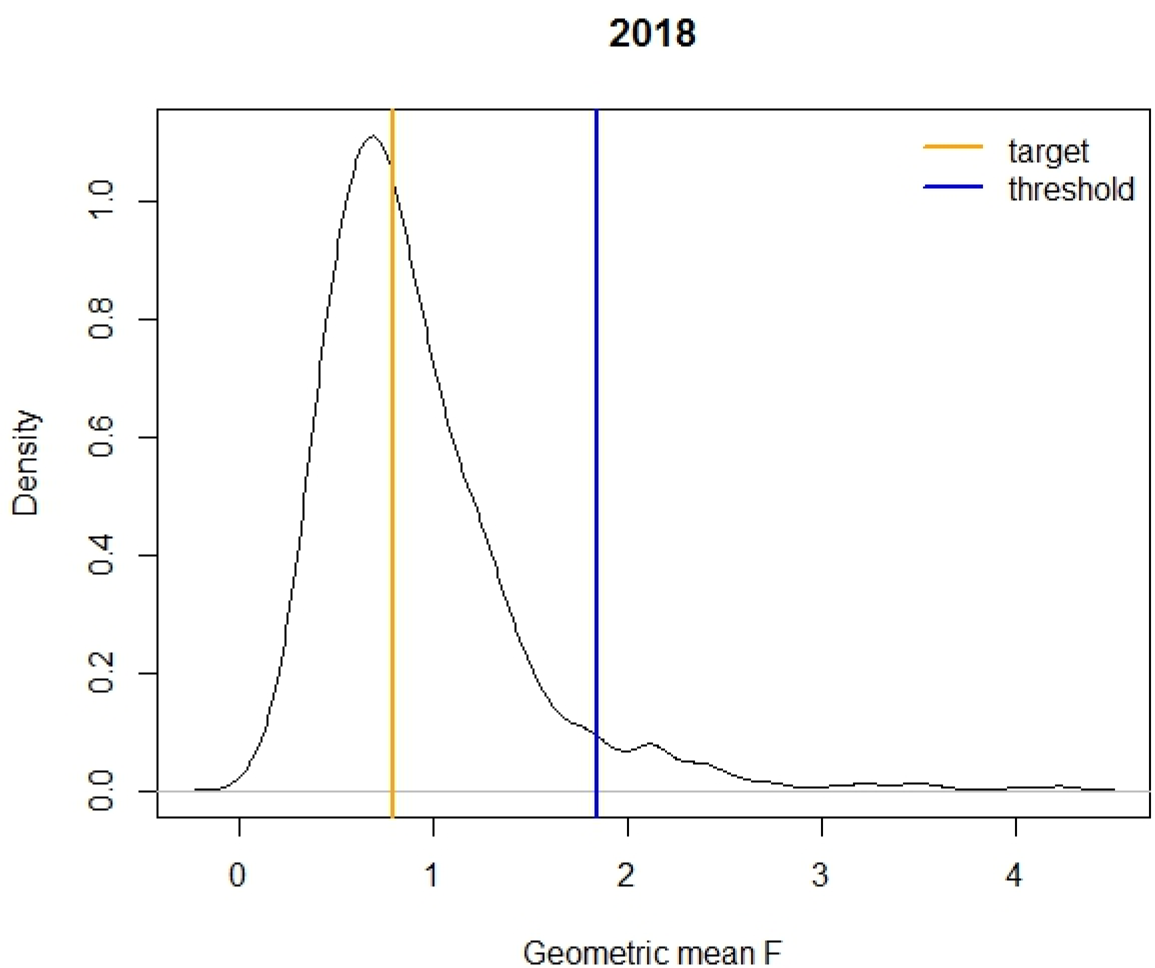

Figure 17: Density distribution of the geometric mean fishing mortality rate for ages 2-4 under a 314,500 mt TAC, which is equivalent to a TAC which has a 50% probability of being below the F target in 2018. The vertical lines are the threshold (blue) and target (orange) benchmark values recommended by the TC from the base run.

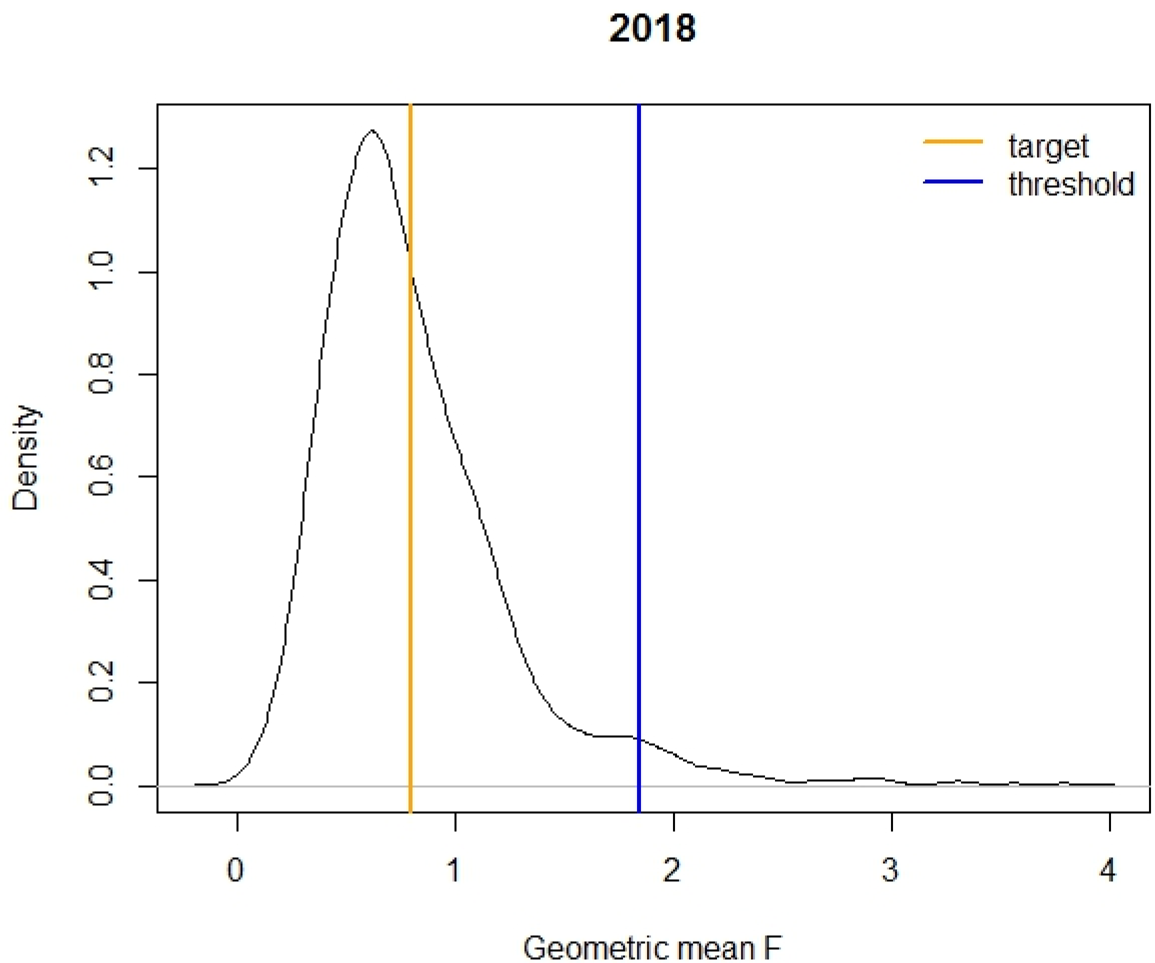

Figure 18: Density distribution of the geometric mean fishing mortality rate for ages 2-4 under a 288,500 mt TAC, which is equivalent to a TAC which has a 55% probability of being below the F target in 2018. The vertical lines are the threshold (blue) and target (orange) benchmark values recommended by the TC from the base run.

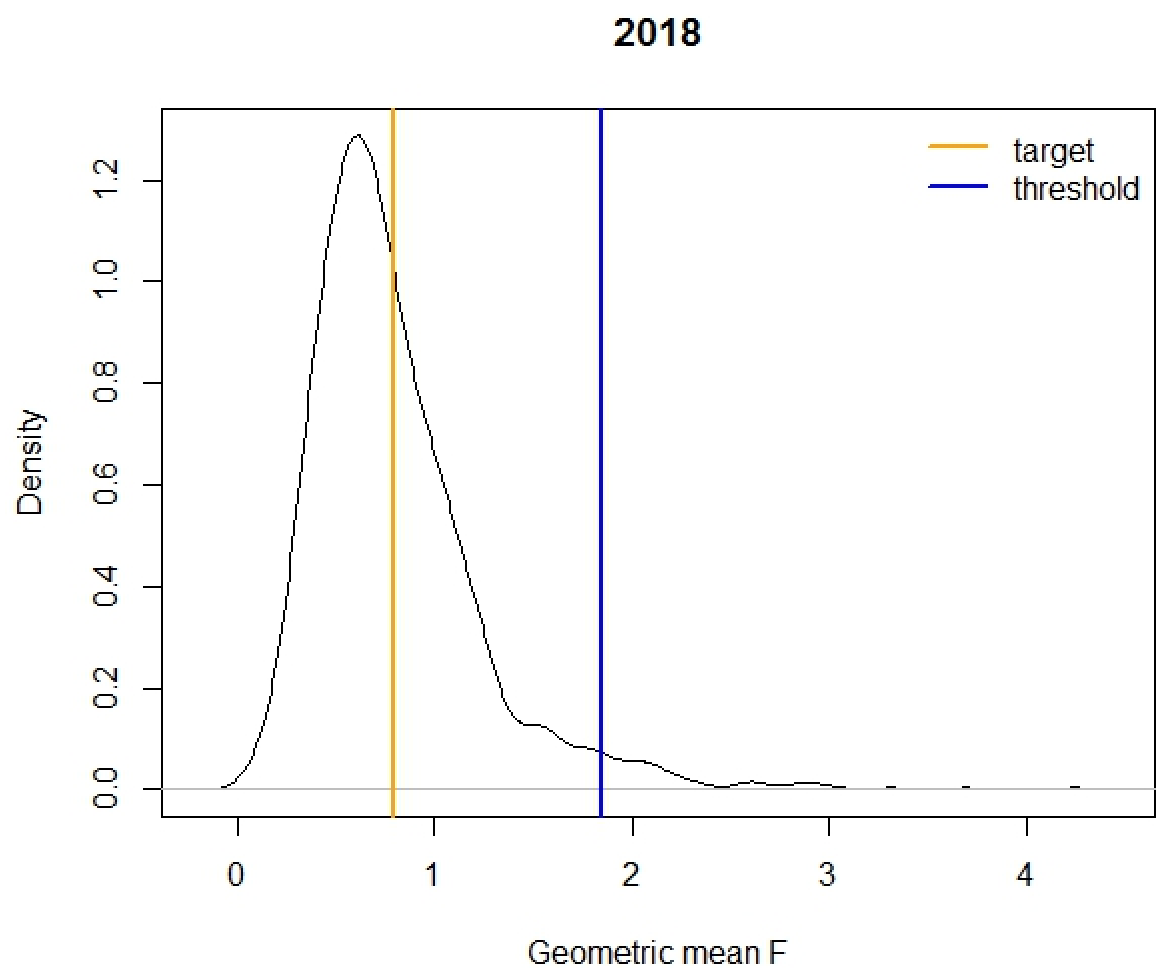

Figure 19: Density distribution of the geometric mean fishing mortality rate for ages 2-4 under a 286,000 mt TAC, which is equivalent to a TAC which has a 60% probability of being below the F target in 2018. The vertical lines are the threshold (blue) and target (orange) benchmark values recommended by the TC from the base run.

Atlantic States Marine Fisheries Commission

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MEMORANDUM

TO: Atlantic Menhaden Management Board

FROM: Megan Ware, FMP Coordinator

DATE: July 10, 2017

SUBJECT: 2017 Closure of Episodic Events Set Aside Program

The intent of this memo is to notify the Atlantic Menhaden Management Board (Board) that the 2017 episodic events fishery has closed and that the set aside was exceeded by 283,889 pounds.

The episodic events set aside quota for the 2017 fishing year was 4,409,245 pounds with the states of Maine, Rhode Island, and New York actively participating in the program. On Friday, June 30th, ASMFC staff notified the Board that roughly 80% of the episodic events set aside had been used. As a result, participating states were asked to close their episodic events fishery by 11:59pm on Wednesday, July 5th. Following final reporting of episodic events landings to ASMFC staff, a total of 4,693,134 pounds were landed under the set aside (Table 1). This represents 106% of the set aside, and an overage of 283,889 pounds. Per Technical Addendum I, overages in the episodic events set aside program are deducted from next year's set aside amount. Given all of the episodic events quota was harvested, there will be no distribution of unused set aside on November 1st.

Table 1: 2017 harvest under the episodic events program.

2017 Episodic Set Aside Quota	4,409,245 lbs
Harvest by ME, RI, and NY	4,693,134 lbs
Percent of Quota Harvested	106.4%
Set Aside Overage	283,889 lbs

Note: Due to confidentiality rules, harvest by the three participating states has been combined.