Atlantic States Marine Fisheries Commission

South Atlantic State/Federal Fisheries Management Board

February 2, 2017
12:15 – 2:45 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 *(J. Estes)* — 12:15 p.m.

2. Board Consent — 12:15 p.m.
   - Approval of Agenda
   - Approval of Proceedings from October 2016

3. Public Comment — 12:20 p.m.

4. Public Comment Summary of the Draft Cobia Public Information Document (*L. Daniel*) — 12:30 p.m.
   - Review Public Comment
   - Review Advisory Panel Report

5. Provide Guidance to the Plan Development Team for the Draft Cobia FMP (*J. Estes*) — 12:55 p.m.

6. 2016 Red Drum Stock Assessment **Final Action** — 1:25 p.m.
   - Presentation of Stock Assessment Report (*A. Giuliano*)
   - Presentation of Peer Review Panel Report (*P. Campfield*)
   - Consider Acceptance of Benchmark Stock Assessment and Peer Review Report for Management Use
   - Consider Management Response to 2016 Red Drum Stock Assessment (*J. Estes*)

7. Progress Report on the Spot and Atlantic Croaker Benchmark Stock Assessments (*J. Kipp*) — 2:25 p.m.

8. Consider 2016 Fishery Management Plan Review and State Compliance for Spot (*M. Schmidtke*) **Action** — 2:35 p.m.

9. Other Business/Adjourn — 2:45 p.m.

The meeting will be held at the Westin Alexandria, 400 Courthouse Square, Alexandria, Virginia 22314; 703.253.8600

MEETING OVERVIEW

South Atlantic State/Federal Fisheries Management Board Meeting
Thursday, February 2, 2017
12:15 p.m. – 2:45 p.m.
Alexandria, Virginia

Chair: Jim Estes (FL) Assumed Chairmanship: 02/16	Technical Committee Chair: Red Drum: Ryan Jiorle (VA) Atlantic Croaker: Chris McDonough (SC)	Law Enforcement Committee Representative: Capt. Bob Lynn (NC)
Vice Chair: Pat Geer	Advisory Panel Chair: Tom Powers (VA)	Previous Board Meeting: October 25, 2016
Voting Members: NJ, DE, MD, PRFC, VA, NC, SC, GA, FL, NMFS, USFWS, SAFMC (12 votes)		

2. Board Consent

- Approval of Agenda
- Approval of Proceedings from October 25, 2016

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.

4-5. Consider Draft Cobia FMP Public Information Document (PID) for Public Comment (12:30 – 1:25 p.m.) Action
Background • The South Atlantic Council Fishery Management Council (Council) requested the Commission consider joint or complementary management of cobia with the Council. • In 2105, 82% of the cobia harvest occurred in state waters. The ACL was exceeded by approximately 91,000 pounds. • The Council is looking for a more flexible management approach to allow for timely adjustments of measures but still provide equitable access across multiple jurisdictions while meeting conservation goals. • Staff to draft a white paper to outline how Cobia management would work under a joint, complementary, ASMFC only or Council only plan and the Board initiated a complementary FMP for Cobia. • A Draft FMP PID was approved by the Board for Public Comment. Public hearings were held in December, 2016.
Presentations • L. Daniel will present the Public Comment Summary of the Draft Cobia FMP PID (**Meeting Materials**)

- L. Daniel will present Advisory Panel recommendations on the PID (**Supplemental Materials**)

Board actions for consideration at this meeting

- Provide guidance to the Plan Development Team for the Draft Cobia FMP

6. Red Drum Stock Assessment (1:25 – 2:25 p.m.) Final Action

Background

- The 2016 update stock assessment and peer review was presented to the Board in May of 2016.
- The Board had questions/concerns regarding the assessment inputs, reference points, and model types and tasked the TC/SAS to investigate several questions.
- Following the responses and recommendations of the TC/SAS, the Board directed the SAS to complete the update stock assessment using a statistical catch-at-age (SCAA) model rather than Stock Synthesis III.
- The SAS has completed the stock assessment, and the stock assessment has undergone a desk review.

Presentations

- A. Giuliano will present the Stock Assessment Report (**Meeting Materials**)
- P. Campfield will present the Peer Review Panel Report (**Supplemental Materials**)

Board actions for consideration at this meeting

- Consider acceptance of the Stock Assessment and Peer Review Report for management use.

7. Progress Update on Spot and Atlantic Croaker Stock Assessments (2:25 – 2:35 p.m.)

Background

- A data workshop for both species was held in September 2015.
- The first of two assessment workshops we held one in February and one in September 2016.
- It is expected that both assessments will be completed in early 2017.

Presentations

- J. Kipp will present an update on these stock assessments.

8. 2016 Fishery Management Plan Review (2:35 -2:45 a.m.) Action

Background

- Spot State Compliance Reports are due on October 1. The Plan Review Team reviewed each state report and compiled the annual FMP Review. Georgia has applied for *de minimis.*

Presentations

- M. Schmidtke will present an overview of the Spot FMP Review Report. **(Meeting Materials)**

Board actions for consideration at this meeting

- Accept 2016 Spot FMP Review and State Compliance Reports.
- Approve GA *de minimis* request.

9. Other Business/Adjourn

DRAFT PROCEEDINGS OF THE

ATLANTIC STATES MARINE FISHERIES COMMISSION

SOUTH ATLANTIC STATE/FEDERAL FISHERIES MANAGEMENT BOARD

The Harborside Hotel
Bar Harbor, Maine
October 25, 2016

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

2. **Approval of Proceedings of August 2016** by consent (Page 1).

3. **Move to accept the Draft Cobia FMP Public Information Document for public comment as amended** (Page 17). Motion by Robert Boyles; second by Lynn Fegley . Motion passes unanimously (Page 17).

4. **Move to accept the FMP review and compliance reports for the black drum 2014/2015 fishing years** (Page 26). Motion by Malcolm Rhodes; second by Wilson Laney. Motion passes unanimously (Page 26).

5. **Move to approve the FMP review and compliance reports for Spanish mackerel 2015 fishing year, and approve the *de minimis* status for Georgia, New Jersey and Delaware** (Page 27). Motion by Malcolm Rhodes; second by John Clark. Motion passes unanimously (Page 27).

6. **Move to accept the FMP review and compliance report for spotted sea trout for the 2015 fishing year and approve *de minimis* status for New Jersey and Delaware** (Page 29). Motion by Robert Boyles; second by Pat Geer. Motion passes unanimously (Page 29).

7. **Move to accept Bill Parker, Glenn Ulrich, Lee Southward, and Aaron Kelly to the South Atlantic Advisory Panel** (Page 31). Motion by Malcolm Rhodes; second by Chris Batsavage. Motion passes unanimously (Page 31).

8. **Motion to adjourn** by Consent (Page 31).

ATTENDANCE

Board Members

John Clark, DE, proxy for D. Saveikis (AA)
Roy Miller, DE (GA)
Rachel Dean, MD (GA)
David Blazer, MD (AA)
Ed O'Brien, MD, proxy for Del. Stein (LA)
Cathy Davenport, VA (GA)
Joe Cimino, VA, proxy for J. Bull (AA)
Kyle Schick, VA, proxy for Sen. Stuart (LA)
Doug Brady, NC (GA)
Chris Batsavage, NC, proxy for B. Davis (AA)
Robert Boyles, SC (AA)
Malcolm Rhodes, SC (GA)
Sen. Ronnie Cromer, SC (LA)
Patrick Geer, GA, proxy for Rep. Nimmer (LA)
Nancy Addison, GA (GA)
Spud Woodward, GA (AA)
Jim Estes, FL, proxy for J. McCawley (AA)
Martin Gary, PRFC
Wilson Laney, USFWS
John Carmichael, SAFMC

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

Ex-Officio Members

Staff

Toni Kerns
Robert Beal
Mike Schmidtke

Guests

Lynn Fegley, MD DNR
Ross Self, SC DNR
Phil Moran, SC DNR
Trisha Cheney, ME DNR
Matthew Gates, CT DEEP
Tim Sartwell, NOAA
Kathy Knowlton, GA DNR
Kevin Sullivan, NH F&G
Diedre Boelke, NEFMC
Arnold Leo, E. Hampton, NY
Susan Shipman
John Carmichael

The South Atlantic State/Federal Fisheries Management Board of the Atlantic States Marine Fisheries Commission convened in the Stotesbury Grand Ballroom of the Bar Harbor Club, Harborside Hotel, Bar Harbor, Maine, October 25, 2016, and was called to order at 10:15 o'clock a.m. by Chairman Jim Estes.

CALL TO ORDER

CHAIRMAN JIM ESTES: I would like to call the South Atlantic State and Federal Fisheries Management Board to order, please. My name is Jim Estes; I am the Administrative proxy from Florida, and I am going to try to facilitate the meeting today. We have a new staff member that Toni is going to introduce.

MS. TONI KERNS: To my right here is Mike Schmidtke. He is coming to us from Old Dominion University, where he is just finishing up his PHD on blueline tilefish. He is going to continue to work on some of that with the South Atlantic and the Mid-Atlantic Council; so you may see him doing some blueline tilefish work in the future. A little fun fact about Mike is that he played football at NC State for the North Carolina's commissioners. You can talk to him about that. His son was recently born a couple months ago. He moved to D.C., and we're excited to have him.

CHAIRMAN ESTES: Nothing like a couple hours spent with friends, and that's what we hope to do for the next couple hours.

APPROVAL OF AGENDA

You all have an agenda. Are there any changes suggested to the agenda? Are there any objections to approving the agenda, as is? Seeing none; the agenda is approved.

APPROVAL OF PROCEEDINGS

You all should also have proceedings from our August meeting. Are there any changes suggested for those proceedings? Are there any objections to approval of those proceedings? Seeing none; the proceedings are approved.

I don't think that we have anyone signed up from the public to speak, but is there anyone from the public that would speak on items not on the agenda? Not seeing a big line of people rushing up to the microphone; we'll go on to Item Number 4, and that is Consider Draft Cobia FMP Information Document for public comment. I think Dr. Daniel is going to present that.

CONSIDER DRAFT COBIA FMP PID FOR PUBLIC COMMENT

DR. LOUIS B. DANIEL: Good morning, everybody. It is good to be with you all again. What I would like to do real quickly is go through -- you should all have a copy of the Public Information Document in your briefing materials. That was an excellent work completed by your Plan Development Team; that was developed between the last meeting and now.

I can't say enough about the help that those folks did, and everyone on the Plan Development Team was very involved and active in the development of this Public Information Document. I just would like to say that at the very end of the presentation I do have a couple of questions that were raised by the Plan Development Team members that I would like to go through real quick, to perhaps begin your discussion. Just to go over real quickly what I would like to go through today. Review the current issues, where we stand. Have a brief discussion on the 2016 South Atlantic Council meeting down in Myrtle Beach that Executive Director Beal and I attended, and review the South Atlantic's Framework 4 to the Coastal Migratory Pelagics FMP to implement accountability measures to slow harvest in 2017. That was their primary objective in that discussion.

Then review the PID and the proposed management issues for your consideration, for going out to public meetings between now and the February meeting. Somewhat of a review from the last meeting with the white paper. As most of you know, the National Marine Fisheries Service announced a closure to the Atlantic migratory group cobia; effective June 20th of '016 for exceeding the ACL.

It was around 630,000 pounds and landings were about 1.5 million pounds. We'll have some discussion over the methodology with which the landings data were accounted. The closure impacted the fishery throughout the range of the cobia, but impacts were greatest for the outer banks of North Carolina and the states from Virginia to the northern extent of the range.

The quota ran out and it seemed to be right during peak season, particularly for Virginia that the closure occurred. North Carolina and Virginia reacted to those closures by implementing some state-specific regulations to lessen the impact of that closure in 2016. Briefly, the 2013 cobia benchmark stock assessment through the SEDAR process looked at data through 2011.

That's the most current information that we have, in terms of a peer-reviewed stock assessment. While it indicates that the stock is not overfished and overfishing is not occurring; we are seeing a fairly consistent trend in declining biomass. That was a concern raised by the Plan Development Team, and the time between the past benchmark assessment in 2011 and the possibly proposed stock assessment that will be available for management purposes probably in '18, '19, maybe even 2020.

The council has sort of modified a little bit their methodology for developing stock assessments, and it makes a lot of sense; if you think about it in terms of a research. They're looking at a research tracked stock assessment that is scheduled for 2018/2019. What they are trying to do there is to try to keep all the information together and to continue to look at these stocks, but not have those stock assessments result in any management action or management recommendations from the panel.

But then what they would do is over time they would maintain these research stock assessments for all the stocks, and then on occasion, and in this case in 2019/2020 do what they call an operational stock assessment; which would actually result in management advice coming out of the SEDAR process and out of the South Atlantic Council.

That is generally the timeline that we have for stock status and for the stock assessments coming up. There will be some questions and concerns raised by the PDT at the end of this presentation. One of the big issues that continue to -- in fact, I got two e-mails this morning from the public regarding the stock boundary. Those boundaries were established through the South Atlantic Council's Amendment 20B in March of 2015. Atlantic migratory group cobia annual catch limits apply from the Georgia/Florida line through New York. Cobia caught off the east coast of Florida are counted against the Florida east coast allocation of the Gulf of Mexico cobia annual catch limit. There is a proposal to include cobia in the Stock ID Workshop in 2017. That was done during a SEDAR discussion at the South Atlantic, where they were looking at stock ID workshops and with the interest of cobia; it was kind of thrown into the mix.

It was thrown in with multiple other species for stock ID work. There is some concern raised by some of the principal stock ID folks, primarily in South Carolina, that it is possible that a lot of the data that they're working on right now, along with the collaborative and cooperative work being done with other states, may not actually be ready in 2017.

There is some discussion there from the PDT that I'll review later. Going back to the stock boundaries section real quickly. I will say, that from talking with Dr. Denson, who is on the Plan Development Team, he had a large hand in developing the genetic information in your public information document.

There is some really good data there, and a lot of collaborative cooperative work done with some of the other states. But they're still trying to process additional samples around that mixing zone, which tends to be that border between Florida and Georgia. It is not a knife-edge distinction, north of which is all Atlantic migratory group, south of which is Gulf.

There is some fuzz there that you have to keep in mind. The work being done, by South Carolina in collaboration with other states, will hopefully narrow the information on exactly where that line needs to be. But it may behoove the commission at some point in time to actually ask Dr. Denson to come and give the presentation that he gave to the South Atlantic Council in Myrtle Beach. It was an outstanding presentation on the analysis that he and others have done on the cobia genetic boundary.

It answers a lot of questions. The next slide with Framework Action 4, Proposed Measures, these were developed at the Myrtle Beach meeting in South Carolina. There was a lot of discussion over various options and issues, and what were submitted to the Secretary through the Council were the following measures:

To reduce the recreational bag limit from two fish down to one fish; to increase the minimum size limit from 33 inches to 36 inches fork length and to limit commercial harvest to two fish per person or six per vessel; whichever is more restrictive. As far as I know, that is now either out of the Regional Office to the Secretary or in the Regional Office still being reviewed.

The expectation, the hope was that those measures would be in place to curb harvest in 2017, recognizing that the commission would be unlikely to implement anything to curb harvest for this upcoming spring season, which primarily operates from May through July/August. Just to give you a quick, short term timeline on where we are, today we're discussing the PID for your review, approval and any edits or comments that you would like to include.

Between now and January, it would be my hope to conduct public meetings for those states that request those meetings and accept public comment. Then have those public comment summaries and the comment available for board review; and direction for FMP development at the February, 2017 meeting in the DC area.

With that, moving into the management issues for the Public Information Document, we discussed with the Plan Development Team the following management issues and questions for your consideration. I'll go through those one at a time.

Management Issue 1, one of the overarching questions relates to complementary management with the council. Complementary management of cobia is intended to increase our flexibility and management reaction time at the state level, while providing us the ability to more actively and adequately manage the fishery in your respective states.

Some of the questions that we propose putting out for public comment and review are, should the commission develop a complementary cobia FMP: a plan complementary to the South Atlantic Council's Coastal Migratory Pelagics Fishery Management Plan? What federal measures that are in place or currently proposed should be required, if any, in the commission plan?

What states should be included in the management unit? Again, the genetic analysis that has been done at least to this point, suggests, and the council has concurred that the most appropriate boundary for cobia in our region is the Atlantic migratory group from the Georgia/Florida line through New York.

I will make one note here that in the documents, you will see Rhode Island included in some of the landings information. I didn't exactly know how to handle that. It was 2 or 300 pounds every couple of years. Instead of involving the New England Council and complicating that too much, I simply note – I realize they're not in the Mid-Atlantic Council, but there are a few landings that occur in Rhode Island.

Given the upcoming genetic workshop that is proposed for 2017 at this time, should the commission plan provide the flexibility to make changes to management and stock units to reflect changes in the science? What I mean by that is if the information that is coming out of the genetics labs and the work that is being done suggests that perhaps there is a better line that may be down into the state of Florida, like some of the mackerel boundaries that occur off of Florida, would we want to be able to have the flexibility to modify our plan to coordinate and complement that new work?

The second intent and purpose is to provide a management plan that achieves the long term sustainability of the resource, and tries to implement and maintain consistent coastwide measures, while allowing our states the flexibility to implement the alternate strategies to accomplish the objectives of the plan.

Clearly, we want to provide for sustainable recreational and commercial fisheries, maximum cost effectiveness of current information gathering and prioritize state obligations to minimize costs of monitoring and management. This was an issue that was raised by the Plan Development Team, and some concerns over the cost and expense of collecting data on a fish that moves so much.

It may be that current data collection programs are about as good as we'll have at the present time; unless money is afforded to collect more data. Adopt a long term management regime, which minimizes or eliminates the need to make annual changes or modifications to management measures.

This is a very important for-hire fishery, and folks are setting up trips and the like for the following year in many cases. Changes in the quotas and changes in the potential seasonality can have significant trickle-down impacts to the fishery. The question for the public is what should be the objectives in managing the cobia fisheries through the commission? There may be others that the public would like to weigh in on.

Management Issue 3, Coastwide, Regional or State-by-State management issues. Many of the states currently manage their cobia fisheries independently. We're considering coordinating that management, in order to avoid states being disadvantaged, based on where they occur along the migratory route; while maintaining harvest at the council's ACL level.

Just using one example with spiny dogfish, when the fishery would start up in the northeast and move south, oftentimes, there weren't a lot of fish left over by the time the seasons got to Virginia and North Carolina. The commission decided to move forward with a plan that would try to mitigate some of those disadvantages by geography of losing out on those fish towards the tail end of the season.

This is sort of a reverse of that where the fishery generally starts to our south, and ends up in the northern extreme. Without some controls early in the season it is probable that some of these quotas may be taken prior to peak fisheries or primary fishing opportunities in the more northern extreme.

Questions that the PDT worked on and developed for this section would be that are consistent state-specific management measures coordinated by the commission needed for cobia? Are there regional differences in the fishery and/or resource that need to be considered when implementing management measures? Should the plan require a coastwide closure if the council quota or ACL is met? Should the FMP require coastwide measures, for example, size and bag limits being consistent throughout the region?

Should the FMP require regional measures? Should the plan develop a suite of options for the allocation of state-specific quotas and allow states to adopt unique size, bag and season measures? One example of a point that I would bring up that is in your Public Information Document, is the work that was analyzed and put together for us by Ryan Jiorle from Virginia on the Plan Development Team that showed there is a lot of variability in the stock fishery occurring in federal and state waters.

It varies from almost no fish taken in state waters to 100 percent as you move north, because there is a lot of variability in the fishery and how it operates from Florida to the states north of Virginia. Those may need to be taken into account as we move forward with the plan.

The Management Issue 4, Commercial and Recreational Management Tools. This is where we hope to get some information on the potential tools that could be used to manage cobia. What are the appropriate commercial and recreational measures for cobia is one question we would ask. Should the plan consider gear restrictions? For example, circle hooks with live and dead bait fisheries for cobia or the prohibition on gaffing cobia. Those are being used in certain regions and locations, the effectiveness we're not totally certain of at this particular point.

But with an increase in size limit from 33 to 36 inches, that is likely going to be a more difficult fish to handle. Unless you net those fish, one of the only ways to get them in the boat to measure them would be to gaff them.

Consideration of some of the measures that have been considered in other states to require netting of those fish as opposed to gaffing is something we would like to receive some public information on. Are there other management options that should be considered, for example, slot limits, spawning season closures, et cetera? Should the plan consider some level of de minimis or threshold landings where cobia harvest is minimal or episodic; which tends to be in those states north of Virginia.

Finally, we would ask the public to comment on any other issues for consideration in the development of the commission's draft FMP for cobia. Those are the general management issues and strategies and questions that we wanted to put out to the public between now and the February meeting.

Real quickly, and there may be the expertise around the table, and certainly up at the head of the table, to discuss a couple of the issues that were raised by the PDT that I think are germane and important for your discussion here today. First, there was concern raised by the Plan Development Team membership on delay in the stock assessment.

There is a lot of concern, recognizing that the SEDAR process is lengthy and has got a lot of irons in the fire from many species that a lot of people deem very important. There was concern raised over the fact that we are dealing with a terminal year in the assessment of 2011. We're looking at a stock at this present time where there seems to be a decline in absolute biomass spawning stock; concerns being raised about the harvest.

We're looking at probably about a ten-year period, and at least another several years before we have the semblance of a new peer-reviewed stock assessment. That was one concern raised by the Plan Development Team that I'm really not sure how we address. The second issue that I wanted to bring up, and this was a discussion that was also had by the Plan Development Team, is the Stock ID Workshop timing.

I believe I completely and fully understand the reason why cobia were included in the Stock ID workshop, and I think that was a good move.

The question is, will the information from the primary data collector, which is Dr. Denson in South Carolina, will that be available either early or late in 2017? It does not appear that that may be the case.

What type of information may be gleaned from an upcoming stock ID workshop in 2017 is for the most part unknown at this particular time. Those were the two primary issues brought up by the Plan Development Team as we moved forward. Those are not issues that have to be resolved, I don't believe, here today.

The main question is, do we have the management issues accounted for in the document, and are you comfortable moving this forward for public comment? With that, I will stop and try to address any questions that the board may have related to the PID or cobia in general.

CHAIRMAN ESTES: Maybe to be efficient, let's do these questions first, and then I would like to hear a short discussion about the questions that Louis brought up. Then we can talk about what we want to do with the PID. First off are our questions.

DR. WILSON LANEY: Well not a question, Mr. Chairman. Are you looking for editorial suggestions now as well?

CHAIRMAN ESTES: Yes, I would like to hold that off. Let's exhaust the questions first and then we can do that if it's okay.

MR. JOE CIMINO: Thank you, Louis; I appreciate all the work done. You guys had a great team with the PDT, and it was good work and really also, a lot of good questions I think that came out of what we have here. As far as the questions, I am curious if the Science Center feels that a slight delay is possible in the workshop; question Number 1.

Question 2 would be, and forgive me because I am not that familiar with the new terms. It wouldn't be an update it would be a research assessment, is that right? Is that the new term? We said, it wouldn't be used for management, but if it was done and it showed overfishing, would there be a need to take some action or do we still wait for – I'm going to use the other term – benchmark, which is no longer a benchmark. Those are two questions I have.

DR. DANIEL: I'm going to ask John Carmichael to address the majority of those comments. I did fail to mention one thing that I would like to go ahead and get on the record. Dr. Michelle Duval is oftentimes a member of this board, and is the Chairman of the South Atlantic Council. I did want to bring up three points that she made, since she wasn't going to be able to be here, for your consideration. This may address some of the questions.

First off, the allocations of the commercial and recreational fishery of 92 percent recreational and 8 percent commercial, actually began and started in January of 2012, not 2016 as is reported in the PID. Then she also brought up the similar issues about the stock ID workshop being actually late 2017 as opposed to early. I'm not sure that matters for Dr. Denson's concerns.

Then the other point she made was the issue on the research versus the operational track assessments. That is certainly something that I think is new lexicon for this board; and so hopefully that will be something that John can also review and have some discussion on in his comments.

MS. KERNS: I have an additional question for the assessment timing. Can you also explain in your answer how the South Atlantic Council or SEDAR or the Southeast Regional Office has been talking about how the new MRIP information would be incorporated into the assessment timing? Currently, as it stands the MRIP information should be out in 2018. Since this is a species that is quota managed, how that new data coming out would impact the ACL or how we manage against the ACL.

MR. JOHN CARMICHAEL: I guess I'll start with the easy one first, which is probably the MRIP question. With the timing of this assessment, the recalibrated MRIP information for the new survey should be available. The intent in the assessment is to use that information directly, and not have to do anything more after that. That is the plan, certainly, and whatever that does to the estimates is what impact it will have on ACLs and allocations and everything else that comes with it.

The other issue is the Stock ID Workshop. This is somewhat new territory for us within SEDAR. The attention the stock ID is getting is somewhat driven by the issues we've dealt with lately on blueline tilefish, and also by the realization from cobia, from hogfish, from a number of recent assessments looking at the stock ID information, and realizing that these stocks can be more complicated than perhaps was assumed in the past. Also realizing that one of the important things when you're dealing with that is to make sure that everybody who is going to have a management role within that stock has an opportunity to be at the table when the assessment is done.

This is one of the issues with the previous assessment of blueline, where it was done; the stock was extended up into the area of the Mid-Atlantic jurisdiction; and folks from the Mid-Atlantic weren't really involved in that assessment along the way and that created some issues. What we're trying to do is make sure we find out where these mismatches occur between management jurisdictions and stock biological definitions early enough in the process; that everyone who needs a seat at the table during the assessment, is given a seat at the table.

Everyone who needs to make sure that their management needs are going to be met by the products from the assessment, have an opportunity to comment on things like the terms of reference or that assessment. We're working on that now with blueline, and that led us to have this realization that we needed to have this Stock ID Workshop, and then that has grown as we've seen how important it is to have that and get all these various people at the table.

This workshop was planned to do a number of species. One of the keys for doing not single species approaches but several species approaches, is it lets you get more bang for your buck, in terms of bringing people who are experts in the various pieces of data that contribute to your understanding of stock ID.

I think all of you guys probably realize that genetics data can be quite controversial, and genetics experts can vary widely in their interpretation of that data. We've certainly seen that with cobia and with pretty much every stock we've looked at. One of the keys to that seems to be to bring in as many genetics experts as you can.

To get that critical mass, it can help to have multiple species that you're working with and doing that. Blueline, again, was an example. We had a dedicated stock workshop, and it was very hard to get the competing genetics experts in that place at that time and be devoted to that topic. One of the really 'bang for the buck' we were hoping for in the multiple species is to try and overcome that problem.

That put us into having this multiple species approach, and that somewhat drives the timing of the workshop. Another thing that has affected the timing of the workshop is of course the many other things that are going on with SEDAR; and balancing the data deliverables and other things between this workshop and other assessments that we have going on.

That left us really two windows to do this, which was going to be sometime in fall, 2017, sometime in July, 2017. When we discussed this at the Steering Committee, because of a lot of the concerns with what we've experienced so far in stock ID, the recommendation was that whatever comes out of this workshop should go through some type of peer review.

We're looking forward to convening something with our SSC representatives, and CIE representatives, Center for Independent Experts, that would review that information. Because we're finding that if a council is brought into an assessment and their technical folks, their SSC or in your case your Technical Committee folks, weren't involved in that. Well, then that doesn't really build support.

That causes a lot of doubt, and when you get in situations where they say well, we're not sure we're going to go along with the recommendation of that group of experts; because none of our experts were part of that group. That led the Steering Committee to say, what we really need to have then is this peer review, so that when we go into this assessment we know what the stock boundaries are, and we have pretty good confidence in the overlap in those.

Because, if not, what happens is we get in situations like we did with blueline and others, or even cobia, where you make that recommendation early in the data workshop process. It goes through the peer review in the very end, and even if they accept it, people suddenly start having issues with it and questioning things that were done.

We've decided that it's really critical to have that decision made up front. Have it go through an independent peer review, so that you can then go into the assessment with confidence. It seems like a lot to do, something that 20 years ago in assessments we didn't hardly give a second thought to. But the reality is the stock ID is absolutely critical to everything that comes afterward in the assessment.

Models today are complicated catches modeled, indices are modeled, selectivity is modeled, catchability is modeled, and all of that is modeled on a stock-by-stock basis. All the data needs to be parsed out according to the stocks. We experienced with the first cobia assessment, delays because the stock ID changed along the way.

All the data that were put together in one set of bins had to be put together in another set of bins, and in fact they wanted to explore a couple set of bins; which was a huge demand on our data people. Because of all that, the data people are the ones who've kind of demanded, you've got to settle stock ID up front.

Something that has been relatively simple in the past is now incredibly complicated. That has affected the timing, so we're trying to get this early so we can have this peer review. Now that brings me to cobia. It has just come to my attention, certainly here, that there may be some concerns with data being collected in South Carolina that aren't going to be ready for a workshop that looks like now is going to be held in July.

Just by way of timing, the weeks were only picked about 12 days ago. There was a meeting of the folks organizing this workshop that happened after the Steering Committee approved it happening. We're early in the planning stages for this, and not everyone who is going to be participating has been reached out to. They're just working on the list of key folks now, based on the stocks.

Later this week and next week, Julia Byrd, who is the plan coordinator for all of this and making all this happen, is going to be reaching out to key people and try to find out which dates work, and certainly at that time try to find out where things stand on data. If we get in a situation where the cobia information is not going to be ready for the timing of this workshop, then I think we have to consider, perhaps doing cobia on a stand-alone or through some other way that we can make sure that information is available.

Because we certainly don't want to do this and know that there is going to be new information available six months or a year down the road. Now that could affect the overall timing of the cobia assessment, I don't know. That would really come down to when it's going to be done and when the data is available. I guess I'll pause here, because I feel like I've been talking a long time, to see if there are any other questions about the stock ID. If we get through that, then I will talk about the research track and the timing of the cobia assessment.

MS. KERNS: Following up on the timing for the MRIP data, just to confirm. Will the Southeast Regional Science Center then develop a method to back calculate the MRIP data so that what we judge the recreational fishery on, in terms of if they achieved or did not achieve the RHL?

Because if the new estimates have the potential to be six fold higher than what we set the ACL based on, because we used the old method data, to set what it's based on. Then using the new information every year to judge until 2020 or when the new assessment comes out; so somebody would back track it?

MR. CARMICHAEL: Certainly, all my participation with the various transition teams and calibration teams is that the intent is, we would have to adjust management parameters to match the new data, or we would have to calibrate the new process to the old data; which developed the management parameters.

But everyone involved recognizes that you can't change the survey, thus change your yardstick without changing what you're trying to measure. Which way it goes, I don't think we know at this point. Whether we adjust the entire landing streams, and then managers make the change to change their ACLs, or we have a calibration of the new MRIP survey that is consistent with the way MRIP is done up to this point.

The latter is probably a little bit cleaner for management purposes, because they're not taking framework actions or what have you to change all of their ACLs. But certainly, that has to be done. Everyone knows that you can't evaluate and apply an ACL measurement on a new way of measuring your fishery without updating what it is you're trying to achieve.

CHAIRMAN ESTES: Mr. Bush, did you have a question?

MR. DAVID BUSH: Dr. Daniel, thank you for the presentation. Maybe two questions after a brief statement. I'm sure you've probably been beat up with a few e-mails asking questions about certain aspects of this, one of them being the tagging study from the Chesapeake Bay showing about 80 percent of the fish supposedly stayed there. When you were looking at biomass, did you include this biomass in that overall reduction, or reduction of biomass that you mentioned?

DR. DANIEL: You'll have to repeat the question, David; because I'm having a hard time hearing you back there.

MR. BUSH: Sorry, I'll move up here a little closer. Again, thank you for your presentation. The question I had was, the VIM study that was done out in the Chesapeake Bay showing approximately 80 percent of the tagged fish stayed there. Now that particular biomass, since you don't really have the stock IDs pinned down at this point, I know it is sort of a crystal ball-ish kind of question, but was that biomass taken into consideration when you were looking at an overall decrease in the biomass?

DR. DANIEL: I'm not exactly certain if that information specifically was used in the biomass calculations. I would tend to doubt that it was. But the issue really, if you see the presentation that was done by Dr. Denson, he does bring up these specific distinct population segments of which Chesapeake Bay actually, he believes, is a distinct population segment; along with a distinct population segment in the southern part of South Carolina.

South Carolina actually has moved forward with some management measures to protect those fish in the southern portion of South Carolina DPS. I don't know that anything yet has been done with the Virginia portion. I think, again, that any of the information related to the tagging data, the length of time that the tags were at large, you know, certainly, those fish are moving inshore and offshore, north and south.

It would be very difficult, I think, with the information that's available to date, to be able to make any specific recommendations in terms of biomass trends based on those movements; that really are rudimentary at this point, I think. But as Dr. Denson begins to collect more samples and collects more information, which I know he's working with Virginia specifically, North Carolina and other states to collect that data.

Hopefully, a pattern there will arise. But at the present time, as John indicated, the complexity of the genetic IDs and trying to parse out the various genetic components of these stocks is extraordinarily difficult and complicated. Until that information is lock solid, I don't believe it would be use to manipulate or modify the way that the general stock assessment has been completed to this time.

MR. BUSH: My second question is sort of more for my own edification. When the ACLs were set and then the couple of northern states that were added to that list, the allocation was set kind of without those states being involved; if I understand correctly. Do we anticipate that possibly being readjusted at some point?

DR. DANIEL: Well, I think the ACL is based on the stock assessment and what number comes out. For cobias position, we're not overfished and overfishing is not occurring. The current ACL has been set as a precautionary measure to avoid overfished and overfishing occurring; which kicks in a whole new set of council and National Marine Fisheries Service protocol and requirements for the plan.

At the present time the ACL is set at a level that's precautionary to avoid those problems from occurring. I don't believe that the distribution of the catches really have played a role in the ACL at all, it is a specific number. Where you run into an issue there, potentially, is with the allocation and the current 92-8, whether or not that takes into account any of the issues that are going on say, north of Virginia.

I would be doubtful that it would have much of an effect, because of the extraordinarily low landings that are measured north of Virginia. I think once you get up there, I would be speculating at the percentage, but it is an extraordinarily low percentage that I doubt would have much of an impact on either the ACL or the allocation distribution.

But certainly, I believe -- I assume that it would be the intent of the commission if they move forward with this plan, to provide the opportunity for any state that has an interest in cobia, to make sure that their state's interests are reflected in anything that occurs at the commission level.

MR. CIMINO: I would like to follow up on Mr. Bush's question. Perhaps I didn't fully understand it. I would like John to correct me if I'm wrong. Virginia participated in the last SEDAR. We contributed quite a bit of data. We had some of the best age data on the coast, and in fact, we were responsible for increasing that maximum age. This was a statistical catch-at-age model, and I think we well represented the catch-at-age for the Chesapeake Bay harvest. As far as the last assessment, that biomass and that catch is certainly a part of that model. I just wanted to point that out.

MR. ADAM NOWALSKY: One item that I don't see in the document right now, and I'm curious if there was discussion at the PDT level. The reason we're really here is a function of what the recreational catch estimates have been in recent years. What we've learned, despite the many improvements with the MRIP program, is that individual intercepts can drive these numbers by a factor of literally hundreds of thousands individual intercepts.

When you're talking about the very low rate of intercept, that has huge implications, now I'm not familiar with how the South Atlantic has dealt with these recreational issues in the past. I know at the Mid-Atlantic two of the FMPs we deal with, one for summer flounder, black sea bass, scup looks at a catch on an annual basis, compares it to the last year and then changes the regulations accordingly.

The bluefish plan, however, does it differently, allowing for an averaging of recent years harvest. My question right now is, did the PDT have discussion about these different methods for using the recreational catch data, and what options, if they did have that discussion, did they consider putting in the document for comment on the public on how best to try to mitigate these impacts that the MRIP data is having.

DR. DANIEL: Very good question, and then I'll make an effort and then if others want to step in, I guess, Mr. Chairman that would be okay. There was discussion at the PDT level on the landings, primarily because I messed them up in the document when I was initially putting them together. I was comparing apples and oranges using some of the MRIP data and some of the Southeast Fishery Science Service data.

We decided to go with the Southeast Fishery Science Service data, because that was what was being used to manage the quota. That information had remained relatively stable over time. The PDT is not making a determination as to which one is better or not. It is just simply that that was the number that was consistent, it was the number that was used to close the fishery in '016, and so that was the number that we were consistent with.

I think that is the key is being consistent in the methodology that you use. My understanding, and there are folks in this room that know a lot more about the MRIP specifics than I do. But one of the things that occur is that there are adjustments made to MRIP over time, and that those numbers can fluctuate.

When you go to look at the landings data, they may be 1.5 million one day and 1.7 million after some time. It does make it a little more difficult. I think, as John indicated, the intent and purpose is to try to get the MRIP data, which we've all bought into and agreed to, as the primary methodology that's used for managing and for accounting for the harvest of recreationally caught cobia. I think our concern at the present time, concentrating on cobia and not delving into the specifics of the Southeast Center's data collection programs and the MRIP collection programs, was to be consistent at least in what we presented to the board.

In terms of any kind of proposal of any kind of increases, there have been efforts and attempts to incorporate for-hire logbooks and trying to collect information on the for-hire sector that has not gone well, dealing with the for-hire folks, at least in certain regions. How to improve that data collection program on what tends to be a fairly rare species, there is information coming out right now about some of the PSEs, at least in the Virginia and the North Carolina estimates for this year that has raised some concerns.

I'm not sure that anyone and I certainly don't have the answer to those questions at this specific moment. But they are definitely issues that I'm certain will be raised throughout the public comment period and into the next several iterations of the FMP, if we move forward with one. Not a whole lot, but it just explained that there are a lot of issues and I concur with your concern.

MS. KERNS: Adam, I think what you're asking in addition is, can we add a question or two in the PID document about how we address harvest for recreational landings, and can we do averaging, can we not do averaging of that landings information; and how do we use those data, whether it be to determine whether or not we've hit the RHL or not with averaging data, or do we only use averaging data or some other format of the information to help set the measures?

We can add that question to Issue 4. What Louis did just bring up, though, is a question for this management board. Typically, when the commission pulls data for the recreational fishery, we use MRIP data from the document, or for documents that we manage. The South Atlantic Council does not use MRIP data; they use the information that comes out of the Southeast Fisheries Science Center.

I don't know, and this is a question to John, does the Southeast Fisheries Science Center go outside of the southern states for the landings? For example, as Louis said, Rhode Island has landings of cobia. They are very small, but it is still something that we should be including in our management document. It is not there right now.

If it is not done by the Southeast Fisheries Science Center, then the board needs to decide how we want to move forward. Because we will have to consider what data we use, say, you decide you want to do allocations. We have to know what set of data to use to do those allocations.

MR. CARMICHAEL: The South Atlantic is a lot like the Mid-Atlantic it sounds, we have some that use averages and some that use annual years for your first question. Cobia is one that was set up with averages, the three-year-moving average, but the clock restarts when there is a change in the ACL, so that is the situation we were in. The ACL had changed and that's why the moving average couldn't be used.

But it is certainly something that can be considered. As far as the MRIP, it is correct. The Southeast Center does some additional post processing of the MRIP data, and they use the core estimates that are available from MRIP; and their processing addresses the weight estimates from MRIP. I think if any of you have looked at an MRIP query, you know it warns you, weight data is measured with great uncertainty and is not as reliable as the estimates of the numbers of fish caught, because that is what they ask people about numbers. They measure fewer fish than what they actually see.

There is always great uncertainty in the poundage that is associated with any of those MRIP estimates. That is really a problem for many of the South Atlantic species. We manage many species; some of them are very rare in their recreational database. What the Center has done, is come up with a way to do a different sampling approach to try to fill in missing values or when there maybe is only one fish measured for a wave mode, what have you combination, perhaps within a year.

They borrow from adjacent cells, essentially, and they try to come up with a better estimate of what the actual average weight is for a given fish within a given component of MRIP. How much of that borrowing they do, obviously depends on how good the sampling is. For some species it's very little and their estimates will pretty well match, most of the time exactly what you see if you take an MRIP query and then you look at something put out by the Southeast Center for the actual poundage that is landed.

That is assuming, of course. you're only looking at the private and charterboats, because you can't forget also, within the southeast we have a separate survey that does the headboat. If you were to do an MRIP query and look at landings of recreational in the southeast, and compare it to something from the Center that included the estimates from the Southeast Headboat Survey; the two are not going to match and are never going to match, because that component is not in the MRIP query database.

We have two things that are at work here within the southeast. One is the headboat survey that has to be accounted for, so you're not going to get the MRIP exact, and the other is the alternative approach for dealing with the weights. Then the southeast also includes the Gulf, so if we have species that, depending on how they wrap around the South Atlantic and Gulf jurisdictions, and what you're doing with Monroe County down in the Florida Keys, that could lead to other post processing things that are done to get the data to match the actual stock or the management unit, which may not make them match within the overall MRIP queries that you do.

MRIP, within the southeast, is a much more complicated beast than it is with the guy say, in the Mid-Atlantic and New England; and we're kind of jealous of that at times. Because we have so many other things that are in play, it makes it very hard to just do a simple query and get the information. But, in general, they rely on the estimates, but there are things that have to be done afterwards to make sure that they are complete and accurate.

MS. LYNN FEGLEY: Switching topics slightly. I think, under Issue 3, I just wanted to confirm that there is some room for conversation for the public for issues like the Chesapeake Bay, where we may have access to a smaller fish. I'm wondering about conservation equivalency; if the flexibilities that are mentioned under Issue 3 cover that, or if we need to have more specific language for the public to comment on something of that nature.

DR. DANIEL: That was not specifically discussed by the PDT. In the development of this, I don't recall that being brought up. Certainly, if it's something that the board wanted to consider, we could try to -- I think that the regional differences bullet, the second bullet, probably addresses that; if the board agrees that it addresses that. If not, we could make some slight modifications to the language to make sure that it addressed that if it was the desire of the board. That was not discussed or considered, but it could be.

CHAIRMAN ESTES: I think, if there is not any objection, we'll ask that that be clarified in the document.

DR. DANIEL: That's not a problem.

CHAIRMAN ESTES: Other questions. Robert. Comment?

MR. ROBERT H. BOYLES, JR. I was wondering, Mr. Chairman, if you were ready for a motion.

CHAIRMAN ESTES: Yes, but do we want to first discuss the type of data that we want to use to estimate harvest? Do we want to do that here?

MR. NOWALSKY: I appreciate the responses I received to my question, and while Toni might have most directly answered it, the information from Louis and John were extremely helpful in building on that. Based on those complexities, it gives me pause and to think that those issues should actually be described for the public; and that should be an issue that we go out to the public and get some more information on.

I would recommend -- I appreciate the suggestion of adding one bullet point under recreational management tools. But from what I've heard, I think the whole issue of recreational deserves its own issue, quite frankly. There are just so many questions about the data; how it's used. What should be used, what to use to calculate the RHL for a comparison basis, whether to trigger ACLs.

I think I've just touched the tip of the iceberg, not to take away from Dr. Steneck's presentation yesterday. I think it's an entire issue unto itself, and I would encourage consideration by this board of requesting that recreational be broken out as a separate issue, and a number of these topics that have been discussed recently be described to the public, and asked for comment on.

MS. KERNS: Adam, we can definitely separate the two issues. I just am curious, what kind of feedback will you be looking for, in terms of asking the public whether or not we should use the Southeast Regional Data versus the MRIP data? Do you think that the complexity of the issue is a decision that you all should decide. What would you be seeking us to find from the public on them; or is that something that the board can answer for us today?

MR. NOWALSKY: Well, I would like to believe that the fishermen would have some input, as far as collaborative basis, with regard to their thoughts about what the pros and cons, the strengths and weaknesses of each of those datasets are.

Getting that feedback could potentially help inform us with the decision. Moreover, I would like to hear the thoughts about ways to help mitigate those impacts. These impacts, and we're talking directly about cobia, but the impacts of that harvest data go way beyond cobia. Any and all opportunities that we have to get some more information about how to mitigate the extreme impacts of the limitations of the data, I think we would be remiss if we didn't take advantage of that opportunity.

MR. BOYLES: Along those lines, and to keep the conversation moving along, it strikes me that if the commission customarily addresses these questions by using the MRIP data, then I, for one, would be in favor of being consistent and using the MRIP data in compiling the information for the PID.

DR. DANIEL: Obviously, we'll do whatever the board recommends. Is cobia the place to have this huge debate and deliberation? I am asking the question. This is a major issue for the commission, if we're going to move into this discussion as to what's better; Southeast data or MRIP data. Again, I will restate that the PDT, as long as we were consistent in using the various technologies and methods that we have available, was that appropriate.

What the impacts are to an individual state or an individual fisherman. I don't think we know the answer to that question at this time. In a fishery where there tends to be less interest north of Virginia, I don't want to say any more than that about it. This is a coastwide issue that we're delving into here with cobia that may not be the most appropriate place to address this question; just a comment.

CHAIRMAN ESTES: Robert, follow up?

MR. BOYLES: I want to follow Dr. Daniel's comments with something he said earlier. For the board, I think it is helpful for us to take a deep breath and remember why we're here. The latest stock assessment under which we're operating for cobia suggests we're not overfishing and the stock is not overfished.

In 2015, we blew the ACL by 2.5 times. I believe, one of the purposes here, is to get us all on the same page to help us manage and sustain and conserve this fishery; so that the next stock assessment will also reveal that we're not overfishing, and the stock is not overfished. Dr. Daniel, I appreciate your comments.

The point about the data and the veracity of the data, the representativeness of the data is in my estimation, in my opinion, is a discussion for a much broader audience. The cobia anglers that I know, not only in my state, but elsewhere, I don't think are going to be well served by that conversation. I struggle with understanding sometimes the distinction between Southeast Fisheries Science Center produced data, catch estimates and MRIP.

It is a difficult concept for me to grasp. I'm not sure that it's really necessary to go to the public with an inside baseball question. I just would, again, encourage the board to remember the purpose here. I believe, when the policy board said yes, let's develop an interstate fishery management plan, is to let's see if we can develop a framework under which and by which we may work together to sustain this resource in conjunction with the council, in a complementary fashion, so that we do not end up with this fishery overfished and overfishing.

DR. ROY CRABTREE: I agree with some of the comments Robert made. The way that the Southeast Fisheries Science Center, I think, re-stratifies and reweights some of the weights and things, is done across all of the species that we're tracking now in the southeast. If we were going to make a change in how we do that, I think we would have to apply it across all of these species to be consistent. But at this point, I mean the Science Center is advising us that the re-stratification the way they're doing it, produces the most reliable and the best estimates. That's what we're going to have to use to track ACLs at the federal level at least; until something changes with that.

I'm not sure that going out to the public on a question like that is really going to be productive, because I think it largely gets into a highly technical statistical discussion about how to deal with, what I think, as John said, is principally the weights that are used. I don't even understand exactly how they do that myself.

I'm not sure we're going to get a lot of good input from the public on that. I think that is a larger question. As Robert pointed out, we did have a substantial ACL overrun in 2015. We have the preliminary catch estimates for 2016 through Wave 4, and it appears to me that the catches in '16 may be as high ultimately at the end of the year as they were in '15; because I'm seeing that the preliminary estimate is something on the order of 1.2 million pounds being caught at the end of August.

Again, that is off the MRIP site. There will be changes to that. As John pointed out, that doesn't include the headboat survey, so there are more catches that will be added into that. But it does, based on everything we know, look like that we're fishing this stock at a level that is not sustainable. Even with all of the uncertainties about the catches, the differences are so great that it's hard to ignore it.

I think we do have a real problem here. I think federal management alone cannot solve this problem. I think even if the EEZ was completely closed year round, I don't think it would make a great difference in the magnitude of these catches, because most of them seem to be coming out of state waters.

I think that the only way we're going to get these catches to a sustainable level is through a commission management plan. I think there is a lot of room for discussion between the commission and the council, as to what, if any, role federal management needs to play in this. But it's clear to me that successful management is going to require an ASMFC plan.

MR. CARMICHAEL: I think it will be helpful in the document to clarify the different data sources. To be clear that it's not an issue of MRIP versus Southeast Center data, they are all MRIP data. The Center just has a separate processing step applied to the MRIP data. It would certainly be helpful to clarify that to explain why an MRIP query that people can readily access may not be the same as the document.

Also, because this is probably new to many of the affected fishermen, this idea that there is this separate monitoring of the headboats of the Southeast Regions Headboat Survey; folks are accustomed to being able to go to MRIP and see the entire recreational landings in one-stop-shopping. They are not going to get that in this.

I think it would be very important for the document to at least acknowledge that; that there are separate estimates brought in from the headboat survey, and they are not available over the MRIP system. I think we would all love one day if you could get all of that information in one place consistently. But until that time, it would help to clarify what the different sources are, so that people that aren't accustomed to this aren't then coming back to you and saying, look, you don't even have the landings right. We do this a lot, just because we do face that quite often when people go to the readily accessible sites and get information and it doesn't match what's in assessments or management plans or what have you. It is important to explain it to them.

DR. LANEY: It seems like we have gotten into comments a little bit, and I did have one editorial concern, I think. If you look at Page 2 of the document, it states that there was a closure during 2016, and it did have an economic impact et cetera, et cetera. Then if you go to Page 3, it clearly states that North Carolina and Virginia came up with alternative measures so they didn't have to close.

I just think there needs to be some clarity in the document that states up front somewhere that there was a closure in federal waters, but that there wasn't a closure in state waters. We just heard Dr. Crabtree share the preliminary results for 2016. My concern is over how we say or what adjectives we use, I guess, relative to economic impact.

Clearly, if a closure is put in place in federal waters, then that has some level of impact. But if you continue fishing in state waters in North Carolina and Virginia, what's the real magnitude of the economic impact? If we have data that we could cite about numbers of trips declining or numbers of clients who canceled trips or things like that.

It would be good if we could share that information. But I do think we need to state up front, as opposed to reading something on Page 1 that implies there was a closure and then Page 2 says well, yes, but it didn't apply in North Carolina and Virginia state waters. I think we just need to fix that. It's just an editorial thing.

Oh and then, I did want to complement the PDT and Louis, I think they did a great job putting the PID together. I'm especially attuned to the genetic information that's in there. Again, I think I said it at our last meeting and I'll say it at this one. I think we, as a commission, have a responsibility, not only to look at things like age structure and SSB and distribution of fishes; but also the genetic health of the stock.

In those cases where you have stocks that are homing, and that was clearly pointed out in the PID. There are aggregations of fish that are spawning in different geographic areas that we need to be concerned about. I'm really waiting to see the outcome of the genetic work that helps us to further differentiate where there are actually different spawning stocks.

I have this fear of, well not a fear, but a desire to avoid ending up where things wound up in some parts of the northeast, where you had a whole lot of local cod stocks that were spawning locally that didn't get recognized until after they had already been fished out. Hopefully, we can avoid any sort of scenario like that.

CHAIRMAN ESTES: I think we will clarify that issue. Are there any objections to, in the document, regarding the sources of data, identifying the sources of data to be consistent use the data that we get from the Southeast Science Center? Are there any objections to doing that? Seeing none; that's what we'll do. Do we have more questions?

DR. DANIEL: Just a comment. That's what I have on my list at this particular point in time, just so everybody is clear; a distinction using the southeast data but also distinguishing between the Southeast Science Center information and the MRIP data so that that is clear, particularly bringing up the point that John raised about the headboat survey information, and addressing Wilson's point on the implication that it was closed when it really maintained openness in Virginia and North Carolina after the closure. Those are the corrections that I have for the public draft at this time.

CHAIRMAN ESTES: We've got Lynn and then Joe.

MS. FEGLEY: I think this goes into the editorial category, but it links with what Wilson was saying. It might be helpful for the public under Issue 1 to be a bit more descriptive about what exactly a complementary management plan means. In the white paper that we went through in August, there is a really nice description of the different ways you can manage, whether it is joint or complementary or ASMFC specific.

I feel like it is not particularly clear what we're buying when we do a complementary plan. I think some clarification there, and I think it speaks to what Wilson was saying, as well. When the states are open but the feds are closed, what exactly are we doing here?

CHAIRMAN ESTES: Good point; we'll add that in there.

MR. CIMINO: I appreciate the order you chose, because this will be a follow up to Lynn's question then. When this board voted on implementing this public information document to go down this road, if I'm not mistaken Dr. Duval's motion specifically stated that this would be complementary management.

I believe the Policy Board also voted on going towards complementary management. I'm curious, since that's the first question is should this be complementary management. Is this being revisited and would the board be re-voting on whether or not that is the path we're taking?

DR. DANIEL: I'll be honest, I wasn't altogether clear on what action the board was specifically taking there; and felt that because of some of the comments that we had received that that may be something that you would want to have some public comment on. Certainly, if the board has decided that it will be complementary management with the South Atlantic, we can make some modifications to the document to reflect that.

I appreciate those comments. It is a similar issue with the management unit. The council has made the decision and the genetics data seem to confirm that that Georgia/Florida line to New York is Atlantic migratory group cobia. But we are going to provide the opportunity to the public to make some comments on that; whether it's contrary or consistent with the data or not is a tough one. I would be standing by for any suggestions on how to address that contrary to the way the document lays it out at this time.

MS. KERNS: Joe, the only other thing that I would add is we could make it clear in the document that it is the intention of the South Atlantic Board to do complementary management; does the public have a differing opinion. Because you do have the ability, since it is not a final decision until you approve the FMP, you can alter from your initial initiation of the plan.

MR. CIMINO: That works for me, thank you.

CHAIRMAN ESTES: Are there any more comments before I go to Robert, because I think he had a motion.

MR. BOYLES: Again, a nice shout-out to the Plan Development Team; with that and with the discussion around here at the board, as amended, **I would make a motion that we approve the Draft PID for public comment.**

CHAIRMAN ESTES: **As amended, did I hear you say that?**

MR. BOYLES: **Yes**.

CHAIRMAN ESTES: I thought so, thank you. Do I have a second? Lynn. Okay, I will read the motion; apparently not yet. Okay, move to accept the Draft Cobia FMP Public Information Document for public comment as amended; motion by Dr. Boyles, seconded by Ms. Fegley. **Are there any objections to the motion? Seeing none; the motion passes unanimously.** The next item is the Red Drum Working Group Report. I think that is going to be given by Jeff.

RED DRUM WORKING GROUP REPORT

MR. JEFF KIPP: Good morning, everyone. I'll be reporting on the work and recommendations for the tasks from this board to the Red Drum Technical Committee and Stock Assessment

Subcommittee following the presentation of the stock synthesis model estimates. Just a summary of those tasks, looking at the appropriateness of the current biological reference points, looking at F based reference points for juveniles only.

The validity of age-based models for red drum given some data limitations in their life history, also looking at the tag return rates from the stock synthesis models and determining how to treat the tag recapture data within those models. The final is doing continuity runs of the statistical catch-at-age models using SEDAR 18.

This is just a summary of the meetings that we've had for addressing these tasks with those highlighted in red occurring since the August meeting, when we last updated the board on the progress for these tasks. I'll just go ahead and read the tasks as they were given into the record.

The first was biological reference points; investigate whether the current biological reference point for overfishing 40 percent SPR target and 30 percent SPR threshold, is appropriate, given the species long life history.

This task is twofold in that the board is interested in whether spawning stock biomass is an appropriate metric, and whether the 30 percent threshold and 40 percent target are suitable goals. The board also requests the development for an overfished reference point recommendation.

Two of the major items that the group looked at to address this task were first, a literature review and discussion amongst the group of the theory and use of these percent SPR reference points relative to red drum life history.

In the document that was provided for meeting materials, there is kind of annotated bibliography of a lot of the reference that was reviewed by the Technical Committee relating to SPR reference points; and also some projections under various stock recruit relationships and a different percent SPR or escapement trajectories. This is just an example of what we looked at for the projections, and this actually comes from analysis Mike Murphy did for Gulf of Mexico red drum in Florida. But these figures show two equally or close to equally plausible stock recruit relationships for red drum within the purple lines.

Those stock recruit relationships are fit to biomass and recruit estimates out of models. Then also, different expected recruitment and spawning stock biomass values from a population, given that stock recruit relationship and various fishing levels at different SPR percentages, which are the different dashed line trajectories. You can see under these two equally plausible stock recruit relationships you have very different effects on the expected recruitment under those different fishing mortality regimes.

This is some of the uncertainty that the group looked at, when trying to determine if the current target and threshold are appropriate for red drum. The recommendation from the Technical Committee for this task is to maintain a 30 percent SPR threshold and 40 percent SPR target for both red drum stocks.

They did note that improved information on the stock recruit relationship is necessary before alternative percent SPR levels can be reliably evaluated for management of red drum. An overfished reference point is not recommended without reliable spawning stock biomass estimates.

But they did note since SPR is a recruit-based reference point, it is important to qualitatively consider the recruitment trend from the model estimates with SPR estimates in the absence of these biomass estimates in an overfished status. The SPR doesn't necessarily reflect any potential declines in recruitments, so it is necessary to consider this information with no biomass estimates from the models.

The F based reference point, given concerns regarding the appropriateness of the current reference point and the lack of data on adult red drum, the board would like to see an investigation of the feasibility of an F based reference point that looks strictly at the harvest of juvenile red drum.

The board looks for guidance on whether this type of reference point would provide an appropriate level of information for management. The group started with discussion around advantages and disadvantages of a potential juvenile F-based reference point. Here the advantages are listed.

We did note a strong relationship between juvenile fishing mortality estimates and SPR estimates out of the modeling approaches, which hence that you could potentially use a juvenile fishing mortality reference point or juvenile fishing mortality estimates almost as sort of a proxy for SPRs across the entire age structure.

There is the potential for improved precision for these estimates, since most of the data does come from juvenile fish. There is also potential for reliable estimates from several different approaches, which could be used to validate these alternative approaches. These figures show the relationship between the SPR estimates on the Y axis and the F estimates on the X axis from the stock synthesis models for the southern stock on the left and the northern stock on the right.

These are some of the disadvantages the group considered when looking at this task. One that's a reoccurring issue that has been discussed in past assessments for red drum, mainly around a potential use of escapement as a reference point, is the difficulty identifying the appropriate reference point; particularly without information on the stock recruit relationship, and how these different fishing mortality levels on the juvenile stock affect spawning stock biomass and subsequently future recruitment.

Another major disadvantage is that this type of a reference point would ignore fishing mortality on mature fish. The current data does support increasing fishing mortality on mature fish, mostly due to increasing catch and release across the different stocks. Also another disadvantage is the juvenile-based fishing mortality reference point would be independent of recruitment, similar to as I mentioned for the SPR reference points.

There is the potential if spawning stock biomass declines, there could be a decline in recruitment, and even though you are fishing that declined recruitment levels above the threshold or target that doesn't provide information on that declining recruitment. That wouldn't necessarily trigger management action by just using that reference point.

This just shows that increasing trend of the fishing mortality on the mature fish from the estimates from the stock synthesis models with the northern stock in the upper left hand panel and the estimates for the southern stock in the lower right hand corner. The recommendation for this reference point, the Technical Committee concluded that management with juvenile F-based reference point could lead to stock depletion.

This could occur as a result of declines in recruitment due to declines in spawning stock biomass and/or poor recruitment due to the high variability in recruitment that has been observed in red drum. The Technical Committee recommends against using a juvenile F-based reference point solely to manage the red drum stocks.

The validity of age-based models task. The board is concerned that the lack of information on adult red drum, especially in the northern stock, may impact the ability of the stock synthesis model to accurately measure stock abundance. As a result, the board asks for an evaluation of how red drum life history and current regulations, namely the moratorium on fishing in federal waters, may limit the validity of an age-based model such as SS3.

I'll just highlight here a couple of the main points that the group discussed when discussing this task. The first is a lack of contrast in the data used to inform potential stock productivity in the models. The model time series is short relative to red drum longevity, and also the history of the fisheries. The model time series starts in 1989; due to lack of different data types prior to that year.

Also the longline indices, which provides information on the adult portion of the stock, showed little contrast and again, provides little information on the potential productivity of the stocks. All fishery selectivities are dome shaped, due to the regulations and also the life history of red drum as they move offshore and become less vulnerable to fisheries.

This can confound the estimate of selectivity where you have a descending slope of selectivity for older fish. The model can struggle to estimate what that descent is due to a decline in mortality, and what portion of that descent is due to a decline in reduced availability as those fish move offshore.

These two points here are of concern. These get more to potential data bias in the data than were used in the models. It was noted that estimated harvest of the adult fish from MRFSS back in the late eighties and early nineties is very low, in a period when harvest of these adult fish was legal. The information from tag recapture data conflicts with these estimates, suggesting that a high proportion of adult fish were actually harvested during this same time period.

Also, we used volunteer tag recapture length data as a proxy for the size structure of the dead recreational discards and the recreational CPUE. There are some limitations of using these data based on instructions that were given to recreational anglers on certain sizes that were supposed to be tagged and things like that.

The recommendation for this task is to continue using age-structured models for red drum. The Technical Committee believes that the differences in red drum life history characteristics and vulnerability to fisheries across ages, is best modeled with an age-structured model that tracks cohorts through time.

However, they do recommend addressing some of the effects that I just went over of data limitations through additional assumptions and reduced model complexity. The next task was to look at the tag return rates. Given the sensitivity of the SS3 models to the tag return reporting rate, the board asks for an evaluation of potential tag return rates for each region and to determine if the tag return data should be incorporated in new model runs.

The board is specifically interested in a run which uses an 18 percent tag return rate, per the suggestion of the desk review report. I'll note here that most of this work focused on the northern model, due to the inconsistencies between the reporting rates out of that model, and the reporting rates in previous literature looking at the tag recovery data.

Some of the things that were done to look into this task were a likelihood profile, data weighting sensitivity runs, comparison of external tag recovery model estimates to the estimates from the stock synthesis model, and model runs with simulated recapture data. For the southern stock model there were sensitivity runs that we completed looking at some of the fixed reporting rates, specifically that 18 percent that was requested. This is a likelihood profile for the northern stock, and the Y axis has the change in the negative log likelihood relative to the minimum negative log likelihood.

What this shows is for these lines here, particularly this black line, which is the total negative log likelihood. As that line increases and gets the higher values, it suggests that the parameter values on the X axis, which are the reporting rate estimates for reporting of tagged red drum, become less likely given the data that are used in the model. As you increase the reporting rate from 10 percent, which is at the very far left of the X axis up to 95 percent. The model suggests that those estimates are less likely as you increase, given the data that you're using in the model.

However, I will note that there does appear to be some conflicts amongst the different data components that make up the total negative log likelihood; and these are the other colored lines here on this figure. If you look at the blue line, that is the length composition data, and that mostly agrees with this increase in the total negative log likelihood. But certain data components like the conditional age-at-length data, which is the green line, have a different trend and seem to conflict with some of these other data components. These are some of the estimates from the different runs in the likelihood profiling. On the left are the annual spawning potential ratios, and on the right are the Age 0 recruitment estimates, and you don't need to see the specific lines here and what they are.

But I will just note that for the lower SPR estimates all bundled up, those are from model runs where the tag reporting rate is fixed at 45 percent and lower. The one gray line in the middle are the SEDAR 18 SPR estimates, with the target SPR the dash black line. Then the other sort of group of high SPR estimates are from model runs with the reporting rate fixed at 50 percent and greater.

Similar to that for the Age 0 recruitment, you can't really see but there is a line that is much lower and there are several overlapping lines. Again, those are the estimates from the models with the reporting rate fixed at 45 percent and lower. The black dash line are the recruitment estimates from SEDAR 18, and then the other group of recruitment estimates bundled together are the recruitment estimates from the models with reporting rate fixed at 50 percent and higher.

What this shows is that the model is kind of flip flopping between two drastically different solutions here, which suggests some instability in the model when the tag recapture data are included and the reporting rates are fixed. This further shows that instability I just mentioned. On the left, again, are likelihood profile plots.

These are for the unfished recruitment estimate out of the model, and for the left figure, that is the likelihood profiling with the tag recapture data and the reporting rate fixed at different values. What this shows is that the value from the base model, which is 5.5 on the lower left hand end of the X axis on that first panel, are the most likely estimates of that parameter, given your data used in the model.

As you fix that reporting rate at higher and higher values, the data support those parameter estimates less and less. On the right side is a likelihood profile over the unfished recruitment, from the stock synthesis model without the tag recapture data. This shows a much more expected pattern in those estimates across the different values for that parameter, with a very defined lowest likelihood in the very bottom of that convex shape.

Then as you get further and further away from that most likely parameter estimate, the likelihood increases, suggesting a less likely parameter value. Given these data conflicts that were observed when we included a tag recapture data; there is the potential for different weightings of the different data components in your model to have significant impacts on your model estimates.

What we tried to do here is to adjust the weighting of the different data components, specifically the tag recapture data, to see what kind of influence that had on the model. Just a quick note here on that, the model was generally insensitive to these alternative weighting scenarios. One tendency was to estimate a more depleted stock than the base model which we reviewed a couple meetings ago.

As the weighting of the length composition data is decreased and/or the weighting of the conditional age-at-length data is increased. Another analysis we did here was to look at external tag recapture model estimates, so we used the program MARK, which is tag recapture modeling software, and looked at what the estimates from those models were. However, this was very limited in what we could do because of how the data had to be treated, and how that was different, and how they are treated in stock synthesis. This didn't provide a lot of information on the differences in the estimates out of this type of a modeling approach and not a stock synthesis.

But it did highlight this pattern that we see here. These are the tag recapture data matrices for Age 1 fish in the top matrix, and Age 0 fish in the bottom matrix. This is a ratio of recapture rates in the tagging data that was used in Batchelor et al, 2008, which is a paper that we've referenced often with the 18 percent reporting rate estimates out of that paper; and then also the tag recapture data as it was used in stock synthesis.

This shows that the data used in that Batchelor et al paper consistently had a higher proportion of recaptures than in the stock synthesis data. This kind of suggested that possibly to explain the discrepancy in the reporting rate estimates is this data. They were using the two different analyses. What we did is we went back and we tried to manually adjust the recapture data to match the recapture rates in the Batchelor et al paper.

But that did not have much effect on the model estimates, and actually those recapture rates had to be increased significantly before this tag recapture data agreed with the other data components and stock synthesis, while returning a reporting rate that was much more expected, given the published literature studies. These other runs for the southern stock, the sensitivity runs, these are the annual SPR estimates, with the black lines showing the SPR estimates from the base model that was presented to the board. The dotted black line is the SPR estimates from the model with no tag recapture data. You can see again there is little influence of taking that tag recapture data out.

The blue line is the model run with reporting rate fixed at 18 percent. The red line is the model run with the reporting rate fixed at 60 percent, and then the dotted blue line are the SPR estimates from SEDAR 18. This model had a little bit more of the expected response to fixing that reporting rate, where it generally scaled the estimates up and down and more of a gradient as opposed to two very drastically different solutions that the model was kind of going back and forth to.

The conclusions after looking at these different analyses. The tag recapture data currently have little influence in the SS3 models, unless reporting rate parameters are fixed. Specifically for the northern model, fixing reporting rate parameters indicated model instability; when looking at the likelihood profiles.

Some conflicts in other data components are likely contributing to this model instability. The recommendation, moving forward, is to not to include tag recapture data in the current SS3 models, with fixed reporting rates. It is noted that the data conflicts that were observed need to be addressed before including the tag recapture data with fixed reporting rates.

The last task. The statistical catch-at-age continuity runs, the board asks for an investigation of whether the previous statistical catch-at-age model would be useful for management, and if so, to conduct a continuity run for both regions. The board does not specify if the continuity run should only contain data sources using SEDAR 18, and leaves it to the discretion of the investigators to incorporate new data sources as they see fit. If it is believed additional data sources will significantly improve the performance of the statistical catch-at-age model, the board encourages these additions. We did review the statistical catch-at-age model runs with data through 2013, which was our terminal year used in the stock synthesis modeling and carried forward for this analysis.

The data changes were minimal, but they do include the addition of longline surveys now within the model, which index the adult relative abundance and also some changes to the juvenile index choices in the southern stock. The recommendation from reviewing the model estimates from this modeling framework is to use the updated statistical catch-at-age model, not as a continuity analysis, but rather as a preferred model for management advice.

This is based on some of the things that we've gone over reviewing these tasks. The data conflicts we've seen within the different data components of the stock synthesis model, and the need to determine the appropriate treatment of these data conflicts. Then also the departure of the SS3 model estimates from literature estimates, the SEDAR 18 estimates, and now the updated statistical catch-at-age model estimates.

I did note some data changes to the model relative to how it was configured for SEDAR 18, and so that will require a peer review. We'll be providing the results from these model runs to peer review for their determination on whether this is useful for management advice. We hope to provide the results of the models and the review to the 2017 ASMFC Winter Meeting. Just to bring it back and provide a summary of the recommendations. The Technical Committee recommends maintaining the SPR reference points.

They recommend against managing red drum solely using juvenile F based reference points. They do endorse the continuation of using age-structure models, and they suggest reviewing the updated statistical catch-at-age models for management advice; and recommend to not use the SS3 model estimates until data conflicts and parameter discrepancies are resolved. That concludes my presentations and I'll take any questions.

CHAIRMAN ESTES: Jeff, thank you very much for a lot of work. Are there questions? I would like to pose maybe a question to the board. Roy.

DR. CRABTREE: If we follow all of that advice and we use the statistical catch-at-age model for management advice, where does that leave us in terms of the status of the northern and southern stock; relative to overfishing?

MR. KIPP: I did not include results of the model runs in the presentation here today, just because I think the group feels that it is appropriate for the results to go to a peer review first, to get their recommendation on whether those would be useful for management or not; before providing those results.

CHAIRMAN ESTES: Other questions? You note that the data that were used here go through 2013. I think there's a question about whether we would like to have that updated through 2015 if possible, and then maybe if that is important, discuss the timing and about how we would do that. Robert.

MR. BOYLES: I was just going to go ask that question of Jeff or Toni. Can you give us a sense of timing on if we were to update the statistical catch-at-age model with data through 2015, what kind of timing we would be able to get to Dr. Crabtree's $64,000.00 question?

MS. KERNS: If we do not update the data and we just use data through 2013, we can get you the results of this peer review assessment in February; but it would only be through 2013. If we wanted to update the data and then give you the results, it depends on how much time it will take the states to pull that information together; what type of priority you give your staff to work on that whether or not we could get that completed by the May meeting or the August meeting.

I think we can definitely do it by the August meeting, potentially by May. I think you have two avenues that you could move forward, and both avenues I think by updating the data it would either be May or August. You could follow sort of what we did with Tautog, where we had an assessment.

It was through an earlier time set, so go ahead and do it, the review; get the results with the 2013 data in February, and then immediately do an assessment update with the most recent data; which wouldn't need to be peer reviewed later. The flip side is you could task the group to get the new years of data, include it and then do your peer review. That peer review would come either May or August. In either case the most recent data would be May or August, depending on your staff's time.

MR. BOYLES: Speaking very parochially, this is a very important fishery for us in South Carolina. I think everybody recognizes that. Either of those timeframes, as you all know; you have heard me pontificate before about our legislative process. Our legislature goes home in May this year.

All else equal, given the fact that we won't have anything for us necessarily to have in our pocket as we go talk to our general assembly, I think I would just as soon update it through 2015. That would be my sense, and have the most up-to-date information that we have, so that should we need to make additional management changes we've got the benefit of the most recent data.

CHAIRMAN ESTES: Other comments about that issue? Are there any objections to updating it through 2015?

MR. CHRIS BATSAVAGE: I'm still kind of mulling through the options, the one given that was similar to what was done with tautog seems intriguing, since this has been a pretty long process to get where we are today. You have a peer review assessment in place, and then we can start soon after that on a data update.

Possibly one advantage of that is if we're into 2017, it could include 2016 information, as well. The other side of it is although data through 2013 is a little old; this is a long-lived fish. It probably lends itself better to red drum as opposed to say spot, where it would be a couple of generations past. I guess the question for whichever scenario is, how will that impact other stock assessments that are currently being done by the commission?

MS. KERNS: Most of this work has been done by Angela out of Maryland, and so that would be a question to Lynn of what her workload is. Jeff has been helping her with a couple of parts of this, and Jeff is essential in a couple other assessments that we're moving down the line. If Angela takes the brunt of that work to update, I can't answer that question. But you all have staff members that would need to be updating their datasets, and you all know how long that can or cannot take. As I said before, it would be how much of a priority you would give your staff members to work on those.

MS. FEGLEY: Really, Angela and the team as a whole, they're our heroes. They have been working very hard on this. I can't answer right now what Angela's ability would be. I would need to go back and circle back with her. I might need to medicate her. We can certainly follow up, however you want us to follow up, by e-mail or however to see what we can do.

MR. CIMINO: I would be remiss if I didn't just say thank you to everybody. There was an incredible amount of work put into this, and we would certainly do whatever needs to be done to help Angela with the update of the northern model. I just wanted to make one plug, I think, and I wouldn't stand against a motion from Robert in the opposite direction.

But for a path forward like tog, because I think it would give staff a chance to know whether or not we have any major errors and what we're dealing with before we put more work into this. There has been an incredible amount of work. If the peer review says what was done is solid, and now going forward, all we have to do is that update. I think I am pretty comfortable with that procedure.

DR. CRABTREE: This is certainly an important assessment. There is not getting around it, 2013 is getting to be a concern. But I do think this is something that we're going to need to begin to deal with the management implications sooner rather than later. I hope that we can find a path forward that allows us to begin talking about what actions need to be taken to deal with some of these issues as quickly as we can.

CHAIRMAN ESTES: Any other questions or comments before I try to summarize things? It sounded like what I heard was some interest in getting a review of the data through 2013, then immediately following up and update that through 2015 or 2016. Does that satisfy everyone? If not, let's discuss it some more. Any objections to that plan? Jeff, does that give clear direction?

MR. KIPP: Yes that's clear, thank you.

CHAIRMAN ESTES: Thank you very much for your work. Next agenda item is Jeff again; he's going to give a progress update on Spot and Croaker Stock Assessments.

PROGRESS REPORT ON SPOT AND ATLANTIC CROAKER BENCHMARK STOCK ASSESSMENTS

MR. KIPP: Since I last gave an update at the August meeting, we had, right after that, a second assessment workshop in August at our office in Arlington, and we also have had several progress calls since that assessment workshop. Right now, we're putting the final touches on a two-stage catch-survey analysis type model for spot and a stock synthesis model for croaker.

We'll be having a few more calls to review that work and the additional work that needs to be done for those modeling approaches, and then putting that information into the final report; which will go to the Technical Committee, and then subsequently to peer review and then we'll be scheduling the peer review. If there are any questions on those assessments, I can take those now.

CHAIRMAN ESTES: Any questions on that? Seeing none; we'll roll right along. I think the next agenda item is Plan Review, and Amy is going to give plan reviews for Spanish mackerel, black drum and spotted sea trout.

CONSIDER FMP REVIEWS AND STATE COMPLIANCE FOR SPANISH MACKEREL, BLACK BRUM AND SPOTTED SEA TROUT

MS. AMY HIRRLINGER: We're going to go over the Black Drum 2016 FMP Review. This covers both the 2014 and 2015 fishing years. The following graphs represent black drum harvest within the management unit from New Jersey to Florida. Looking at total harvest, I wanted to point out a recent 2012 low point of less than one million pounds.

After a spike in 2013, landings again dropped 21 percent to 1.42 million pounds in 2014, which is under review, and then remained relatively constant in 2015 at 1.48 million pounds. These past two years have been about 30 percent below the previous ten-year average, which was inflated by the 2008/2009 recreational harvest spike.

Commercial harvest is relatively stable, accounting for 19 percent and 16 percent of the total in 2014 and 2015; 2014 landings decreased 8 percent from the previous year and then dropped again by 9 percent to 238,000 pounds in 2015. Florida and Virginia led the 2014 commercial harvest and Virginia led the 2015 harvest with 39 percent.

Recreational landings indicate that fewer but larger fish are being caught in recent years. The number of fish harvested continues to drop at 166,000 fish in 2015. The catch in pounds actually rose last year to 1.25 million pounds, so this decrease in numbers can be attributed to the establishment of minimum sizes by the 2013 FMP, but the increased poundage is likely due to increased monitoring in the Mid-Atlantic region.

The 2015 harvest represents a 62 percent decrease in numbers bringing a 35 percent decrease in pounds from the previous 10-year average. Florida anglers landed 60 percent in 2015 recreational harvest. That is the longest slide we have out of all of these. Hopefully, we can get through the rest of this pretty quick.

The yellow portion of the bar shows the proportion of recreational harvest that was released. Percentage of releases has increased drastically over the last few years. From 47 percent released in 2013, releases increased to 71 percent in 2014, and again to 90 percent in 2015. Actual releases totaled 720,000 in 2014 and 1.5 million in 2015.

The recreational discard mortality is estimated at 8 percent. We can also attribute the steep increase in releases to the minimum size established by the 2013 FMP. The yellow portion of the bar shows the proportion of recreational harvest that is released. In the interest of time we can just say the FMP requires states with a declared interest to implement a maximum possession limit by 2014, and a minimum size limit of 14 inches or more by 2016. Sorry about the technical difficulties.

The PRT pulled the state specific requirements; also, it is not the possession and size limits stated by the FMP. Is that going to go now? As seen in the previous slide, the PRT finds that all states have implemented the FMP requirements and also no state requested de minimis in either 2014 or 2015. After that, hopefully, it's not too confusing review. Are there any comments or questions?

CHAIRMAN ESTES: Questions? Any actions anybody would like to take? Would you like to accept the FMP review and grant de minimis to the states that she pointed out?

DR. MALCOLM RHODES: I move that the board accept the Spanish mackerel compliance report as presented or the FMP and compliance report for black drum, I'm sorry.

CHAIRMAN ESTES: Do I have a second, Wilson. **Okay, so the motion is to move to accept the FMP review and compliance reports for the black drum 2014/2015 fishing years;** motion by Dr. Rhodes and seconded by Dr. Laney**. Are there any objections to the motion? Seeing none; the motion passes unanimously.** Okay, Amy, next.

MS. HIRRLINGER: Now we're going to go over the Spanish mackerel FMP review, which covers the 2015 fishing year. Total Spanish mackerel landings in 2015 are estimated at 3 million pounds, which is a 1.4 million pound decrease from last year, and both commercial and recreational landings have been in general decline for the past few years, aside from a few upticks.

The commercial fishery harvested approximately 7 percent of the total, and the recreational fishery about 30 percent. Coastwide commercial landings have generally been below 4 million pounds since 1995, which was when Florida banned entanglement nets, since they are historically the largest harvester.

Coastwide commercial harvest in 2015 totaled 2.3 million pounds, a 1 million pound decrease from the previous year, and Florida is responsible for 75 percent of the harvest. Now check out the trending recreational landings, because we're about to break that down. Recreational anglers harvested about 628,000 Spanish mackerel or 695,000 pounds in 2015.

This is a 29 percent decrease from last year and a 44 percent decrease from the local 2013 peak of 1.1 million pounds. North Carolina recently passed Florida to lead recreational landings with 61 percent in number of fish in 2015, and South Carolina also passes here at 21 percent, leaving Florida in third with 13 percent.

This is the first year that South Carolina is responsible for a larger portion of the recreational landings. The percentage of recreational releases has generally increased over time, and was higher than ever before in 2015 with 65 percent of the fish released. A stock assessment was completed through SEDAR in 2012, which incorporated data through 2011.

It determined that the stock is not overfished or experiencing overfishing. To save time, here are the commission's regulations for Spanish mackerel; it includes the minimum length, bag limit and commercial trip limit. But the one important thing to note is that Addendum I introduced a pilot program which allows states to reduce the minimum size of their commercial pound net fishery from July to September.

They can lower the minimum size to 11.5 inches to reduce discards of slightly undersized fish. The reason why I brought that up was because North Carolina implemented this pilot program, and they did so from July 4th to September 30th. The state regulations table behind me is meant to illustrate that all the states are complying with the minimum size recreational creel limit and commercial trip limit. The PRT finds that all states have implemented the requirements of the FMP. Also in New Jersey, Delaware and Georgia request de minimis status, and the PRT notes that these states meet the requirements; and that's it.

CHAIRMAN ESTES: Questions, comments, actions? Malcolm.

DR. RHODES: I'll try not to have a technical glitch. **I move that the board accept the Spanish mackerel compliance reports and FMP, noting that Georgia, New Jersey and Delaware be granted de minimis status.**

CHAIRMAN ESTES: Second. John Clark. Malcolm, are you okay with saying approve de minimis?

DR. RHODES: Yes.

CHAIRMAN ESTES: The motion is move to approve the FMP review and compliance reports for Spanish mackerel 2015 fishing year, and approve the de minimis status for Georgia, New Jersey and Delaware. **Motion by Dr. Rhodes, seconded by Mr. Clark. Are there any objections to the motion? Seeing none; the motion passes unanimously.** One more time, Amy.

MS. CIMINO: Mr. Chair, before we move off Spanish mackerel, it was on the same timeline, well, the last SEDAR assessment timeline was the same as cobia; so I was just wondering if we could get an update on when Spanish mackerel may be coming back around.

MR. CARMICHEAL: We were looking into probably trying to do a standard assessment, so an update of Spanish in a couple years. I think it was fitting in either 2018 or 2019.

MS. HIRRLINGER: Okay, last one; Spotted Sea Trout 2016 FMP Review covering the 2015 fishing year. The following graphs represent sea trout harvest within the management unit from Maryland to Florida; 2015 saw one million pounds landed in total, which is 0.8 million decrease from 2014.

Commercial landings seen in blue here were 175,000 pounds, roughly half of last year's commercial total. All states saw a decrease in commercial landings except for South Carolina, which increased their commercial landings. Florida accounted for about a third of the total coastwide catch last year, and North Carolina came in second with 27 percent.

Leaders in commercial landings were North Carolina with 73 percent followed by Florida with 22. Check out the trend in growing recreational landings and the low point you see in 2015, because the next slide will break that down. The following graphs represent sea trout harvest. Here are the recreational landings broken down by harvest and release.

Looking at catch in black, you can see a general upward trend 20.8 million fish peak in 2012. This is followed by a declining recreational catch over the past few years, so right now we're at a local low point of 5.7 million fish in 2015. Recreational harvest, which you can see in red, has remained relatively stable throughout the time series with a 1.3 million fish average, but over the past few years, we have seen a decline with a record low in 2015 at 534,000 fish.

This is 52 percent lower than last year, 71 percent lower than the 2012 peak; and Florida and Georgia both led this harvest with about 30 percent each. The low harvest in the past few years could be attributed to a recent increase in releases, which you can see in green; and these are on the rise, partly due to increasing catch-and-release trends as well as season closures and size and bag limits in place. The highest release percentage ever seen was in 2015 at 90.6 percent, and the previous 10 year average has been about 80.

The 12 inch minimum total length required by the 2011 amendments shows that all states have complied. The PRT finds that all states have implemented requirements of the FMP. Also, New Jersey and Delaware request continuation of de minimis status, and the PRT notes that these states meet the requirements of de minimis; and that is the end of the presentation.

MR. BOYLES: Amy, did you suggest spotted sea trout commercial landings are up in 2015 in South Carolina?

MS. HIRRLINGER: Let's take a look, let me see. In South Carolina commercial landings, according to the data that was submitted with the compliance reports did increase in 2015. Do you think something different? Because I can check that.

MR. BOYLES: We've not changed spotted sea trout regulations in a number of years, and it's a game fish. Hmmm. We'll have to look into that.

MS. HIRRLINGER: I can look at that and get back to you, yes I'll check that out.

MR. ROY MILLER: Amy may not be able to answer this, but I'm just curious if we know why there is an increasing trend in releases of spotted sea trout, when my recollection is that management has been fairly constant over the years for that particular fishery, or at least since early 2000s, anyway.

CHAIRMAN ESTES: Does anybody want to try that?

MS. KERNS: Roy, we can bring it back to the PRT and ask them if they have any information on why they think we're seeing these shifts and come back to the board at the next meeting and follow up.

MR. MILLER: Yes, it just kind of out of curiosity, I'm wondering if it's a paradigm shift in the way people fish or whether it's something else going on here with the increased number of releases.

MR. BATSAVAGE: I'll try to answer, at least from the fishery in North Carolina; 2015 we had another cold stun event that had an impact on the legal size fish, and actually had a cold stun in 2014 as well. The landings in North Carolina went down as a result of that. There was a pretty decent recruitment following up, which most of those fish were below the minimum size limit, and the releases were high.

In 2016, I think we'll see that those fish have moved into the minimum size limit and our harvest will be higher this year than it was last year, and probably 2014, as well. The other point, too, is although there really haven't been very many changes at the ASMFC level, as far as regulations go, the states have made changes, and North Carolina increased their minimum size limit from 12 inches to 14 inches around

2009 plus or minus a year. That certainly had an impact on the harvest in our state.

MR. CIMINO: Just a follow up. Virginia did decrease the bag limit, but I also think that there has been an increasing trend in the fishery for catch and release, as well.

CHAIRMAN ESTES: Any other questions, Dr. Rhodes, did you have something? In fact, I think we already have maybe typed up what you were thinking, if you'll just wait for a second.

MR. BOYLES: **Mr. Chairman, I would move to accept the FMP review and compliance report for spotted sea trout for the 2015 fishing year and approve de minimis status for New Jersey and Delaware.**

CHAIRMAN ESTES: Do I have a second? Pat Geer. Okay, so the motion is to move to accept the FMP review and compliance reports for the spotted sea trout 2015 fishing year and approve de minimis status for New Jersey and Delaware; motion by Mr. Boyles and seconded by Mr. Geer. **Are there any objections to approval of the motion? Seeing none; it passes unanimously**. The last item on our agenda. Shanna is going to give us an update about SEAMAP funding.

SEAMAP FUNDING UPDATE

MS. SHANNA MADSEN: I'm going to make this brief and depressing. Funding updates are not usually good. SEAMAP decided that we wanted to give a quick date to the South Atlantic Board regarding our funding. Just as a reminder, ASMFC actually coordinates the portion of the program in the South Atlantic, but SEAMAP also includes stretches through the Gulf and Caribbean, as well.

The graph that you're looking on at the screen is our overall funding for all three of those components. Obviously, since SEAMAP South Atlantic Data supports a lot of the management species in the South Atlantic Board, we thought that it was important to kind of bring some of our funding issues to your attention.

If you'll look at the graph on the screen, it represents our funding over the past few years. Our congressional appropriation to the overall program is the one that is represented in blue, while the actual funds that our program receives are in red. As you'll see, although our congressional appropriation has increased since 2013, the amount available to our surveys to actually collect the data is decreasing.

One of these reasons is because the taxes and assessments that are being levied on the program now constitute about 16 percent of our budget, when back in 2014 they were only about 5 percent. SEAMAP is also recently struggling with the impacts of just level funding. Obviously, as survey costs increase, personnel costs increase, and being consistently on level funding obviously causes a lot of funding gaps that we're trying to address.

Throughout the years, SEAMAP has historically depended on a lot of historical funding sources from either states or other granting agencies to maintain their current capacity; but obviously those funding sources are seeing a lot of the same cuts and starting to dwindle, as well. The reductions in our funding have definitely impacted our surveys greatly.

You know, that can come out as reductions in sea days, reductions in the number of stations sampled, and sometimes we're getting rid of entire programs. Essentially, the slides that I have following are going to kind of briefly outline some of the reductions that we're seeing in our SEAMAP programs since 2011.

The first. The coastal trawl survey has been in effect since 1986. It's providing long term fishery independent data, seasonal abundance, biomass; and the survey overall has provided data to Spanish mackerel, menhaden, spot, croaker; just to name a few of the species. With the reductions that we've seen in funding there, we've actually cut our sampled stations from

201 to 112. We also saw a large reduction in the collection and processing of important life history information, including the elimination of all of our diet studies for that survey.

Essentially, should SEAMAP funding remain level or continue to decrease, we're starting to think about losing one of our entire sampling seasons. We usually hit spring, summer, fall; we would get rid of one of those. Next, focusing in our reef fish survey, reef fish survey data has been included in stock assessments for black sea bass, blueline tilefish and a lot of various species in the snapper grouper complex.

Unfortunately, with the reductions in funding available to this survey, we've completely eliminated our gag ingress sampling component and reduced our sea days down from 35 to 19. We expect that should our funding remain level, this survey should see a further reduction in sea days or the loss of their entire longline sampling component.

They are also considering decreasing a lot of their life history processing. Overall, the impact on our coastal longline surveys, which are the ones that are collecting all that useful data for red drum and coastal sharks. We've seen in South Carolina, we've already reduced our sea days from 15 to 10.

Should SEAMAP remain at a level or decreased funding, we've discussed making a lot of changes to the Georgia Longline Survey, either reducing our sea days by half, modifying how we sample, or getting rid of entire sampling season or area. In North Carolina they're discussing reducing their sea days by about a week.

Some of our plans that we're going to do to try to tackle some of these issues is we are going to meet with the SEAMAP South Atlantic Committee, this is our Oversight Committee, and we'll meet in conjunction with some of the survey leads from our coastal surveys, and from our longline surveys; to discuss how we want to modify these surveys based on our budget constraints.

These aren't good modifications. It is important to note that we really don't know what's going to happen if we continue to reduce sea days and reduce stations sampled, because obviously we're losing all of that data; and that might have some unintended consequences on a lot of the stock assessments that this board is going to see in the future.

It is also worth noting that many of our surveys do anticipate an increase in their personnel cost, due to the fair labor standards act. I know a bunch of the states are facing the same issue. We might face further sampling reductions in the future, should our funding remain level or decreasing.

Essentially, since you all know where our data is coming from and it's supporting the management of the species on this board, we just wanted to bring these funding issues up front and center, to let you all know what the situation is. We are definitely, as you see in the spring, and we're going to start to discuss how to put together maybe a few letters to potentially reduce some of the taxes that are being levied on the SEAMAP program. But it's not going to cover a lot of the gaps and a lot of the struggles that we're already facing. With that, I am going to let you all be sad for a little while.

MR. CLARK: I was just curious. Where is that 16 percent in taxes going?

MS. MADSEN: Essentially, what happened was, before when we were about at the 5 percent we were only being taxed through headquarters. We were lucky enough that the Southeast Fisheries Science Center was not imposing any overhead on us, which they technically can. But just recently, they were told that they had to, and that's where the large increase in taxes is coming from.

MR. BOYLES: Shanna, thank you for the excellent presentation and representation of what's going on with SEAMAP. A question for Bob, perhaps; Bob, we learned a lot, I think, meeting with NMFSS leadership back in August, and even at the state directors meeting that perhaps one way to address this is to get programs like these added to the ATBs, the adjustments to base, it's part of the NOAA budget. Is that a realistic avenue for us to perhaps begin chipping away at this erosion of buying power?

EXECUTIVE DIRECTOR ROBERT E. BEAL: I guess the answer is hopefully. We've been focusing on Atlantic Coastal Act for the most part recently, to try to get that adjusted and more consistent with the increase that that line item has seen in the budget. We have not focused a lot on SEAMAP yet; however, Dave Donaldson from the Gulf States Commission and Randy Fisher from the Pacific States Commission and I will be meeting with the appropriations staff next Thursday, I believe it is, Deke.

One of the common areas that Dave Donaldson from the Gulf and I always bring up is SEAMAP. One of the priority areas, it affects the Gulf obviously and the Caribbean and us, and it is one of the priority areas that we try to convey the importance to the appropriations folks on the Hill.

We'll do that. I think I'll pull some of the pieces out of Shanna's presentation and let them know that where we are right now, there are real world cuts, things are disappearing pretty quickly. Stock assessments will be impacted and the ability to manage these fish will be impacted. We'll keep working on it. It's a pretty tight time to get money out of the Hill right now, but we'll just keep trying.

CHAIRMAN ESTES: Any other questions? Shanna.

MS. MADSEN: I just wanted to mention that in your meeting materials, there is actually a letter that outlines in further detail the cuts to both the South Atlantic and the Gulf programs, if anybody is interested in seeing those in more depth.

CHAIRMAN ESTES: There will be more discussion about this issue, I expect, in February when we meet. Is there any more business to come before the board? Oh, Tina, I am sorry; I forgot.

REVIEW AND POPULATE ADVISORY PANEL MEMBERSHIP

MS. TINA BERGER: I just want to quickly go over -- you have four new nominations to the South Atlantic Species Advisory Panel, they are Aaron Kelly from North Carolina, Bill Parker from South Carolina, Glen Ulrich from South Carolina and Lee Southward from Georgia; and I present them for the board's approval today.

CHAIRMAN ESTES: Okay, do we have a motion? Malcolm.

DR. RHODES**: I move the board accept Captain Bill Parker, Glenn Ulrich, Lee Southard and Aaron Kelly to the South Atlantic Advisory Panel.**

CHAIRMAN ESTES**: Second, Chris. Is there any objection to the motion? Seeing none; it passes unanimously.**

ADJOURNMENT

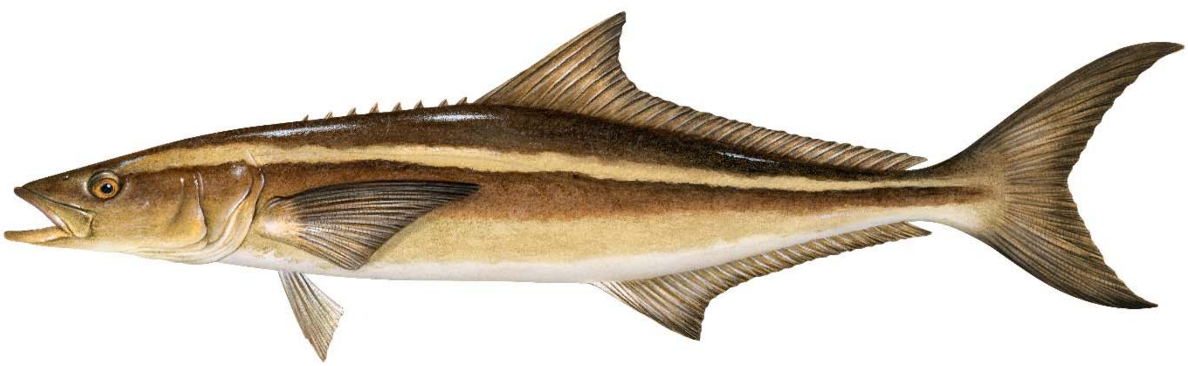
CHAIRMAN ESTES**:** Now let me try again, is there any more business before the board? Seeing none; do I have a motion to adjourn? I see Pat; we're adjourned, thank you.

(Whereupon the meeting adjourned at 12:36 p.m. on October 25, 2016.)

Atlantic States Marine Fisheries Commission

PUBLIC INFORMATION DOCUMENT

For the Interstate Fishery Management Plan For Cobia



November 2016

Vision: Sustainably Managing Atlantic Coastal Fisheries

The Atlantic States Marine Fisheries Commission seeks your input on the initiation of an Interstate Cobia 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 January 6, 2017.** Regardless of when they were sent, comments received after that time will not be included in the official record. The South Atlantic State/Federal Fishery Management Board will consider public comment on this document when developing the first draft of the Fishery Management Plan.

You may submit public comment in one or more of the following ways:

1. Attend public hearings held in your state or jurisdiction, if applicable.
2. Refer comments to your state's members on the South Atlantic State/Federal Fishery Management Board or South Atlantic Advisory Panel, if applicable.
3. Mail, fax, or email written comments to the following address:

Louis Daniel
Fishery Management Plan Coordinator
Atlantic States Marine Fisheries Commission
1050 North Highland Street, Suite 200A-N
Arlington, Virginia 22201
Fax: (703) 842-0741
ldaniel@asmfc.org (subject line: Cobia PID)

If you have any questions please call Louis Daniel at (252) 342-1478.

YOUR COMMENTS ARE INVITED

The Atlantic States Marine Fisheries Commission (Commission) is developing an Interstate Fishery Management Plan (FMP) for Cobia. The Commission, under the Atlantic Coastal Fisheries Cooperative Management Act, is charged with developing FMPs which are based on the best available science and promote the conservation of the stock throughout its range.

This is the public's first opportunity to inform the Commission about changes observed in the fishery, management measures the public feels should not be included in the FMP, regulation, enforcement, research, development, enhancement and any other concerns the public has about the resource or the fishery. In addition, this is the public's chance to present possible reasons for the changes and concerns for the fishery.

WHY IS THE ASMFC PROPOSING THIS ACTION?

At its August 2016 meeting, the Commission's South Atlantic State/Federal Management Board initiated the development of the first interstate Cobia FMP to be complementary with the South Atlantic Fishery Management Council's (SAFMC) Coastal Migratory Pelagic Fishery Management Plan.

Currently, the SAFMC and NOAA Fisheries manage cobia under the Coastal Migratory Pelagic (CMP) FMP through an allowable catch limit (ACL), combined with possession and minimum size limits. An overage of the recreational ACL occurred in 2015 and resulted in a shortened recreational season in 2016 for federal waters, consistent with the accountability measures (AMs) implemented by the SAFMC. The closure had measureable impacts to member states when their recreational fisheries were shut down at the peak of their season (Outer Banks of North Carolina and all of Virginia). The closures occurred at the peak of the Outer Banks fishery and the Virginia recreational fishery causing an economic loss. Concerned by these impacts and recognizing that a significant but variable proportion of reported recreational landings are harvested in state waters, the SAFMC requested the Commission consider complementary or joint management of the cobia resource.

The Commission's Interstate Fisheries Management Program Policy Board reviewed a white paper at its August 2016 Meeting and agreed Commission management of cobia was prudent. . The Commission tasked the development of an FMP to the South Atlantic State/Federal Fisheries Management Board, complementary with the SAFMC plan for cobia (*Rachycentron canadum*).

SAFMC management, based on current genetic information, addresses the management of Atlantic Migratory Group (AMG) of cobia that occur from Georgia through New York (Figure 1). Cobia that occur off the east coast of Florida are part of the Gulf stock, but the SAFMC manages the portion of that stock on the Florida east coast that occurs within its jurisdiction (Florida/Georgia (FL/GA) border to the Monroe County line). Tag recapture data suggested two main stocks overlap at Brevard County Florida and corroborated the genetic findings. The genetic findings also determined there were two distinct population segments (DPS) in Port Royal Sound, South Carolina and Chesapeake Bay, Virginia. The main South Atlantic and Gulf stocks were separated for management purposes at the FL/GA border because genetic data suggested the split is north of the Brevard/Indian River County line and there was no tagging data to dispute this split. The FL/GA border was selected as the stock boundary based on recommendations from the commercial and recreational work groups of the Southeast Data Assessment and Review (SEDAR) 28 stock assessment (2013) as well as enforcement and administrative concerns.

Cobia occurring off the east coast of Florida are part of the Gulf Migratory Group (GMG) of cobia, but the Gulf of Mexico Fishery Management Council (GMFMC) allocated a portion of the GMG cobia ACL for the SAFMC to manage. SAFMC sets measures for the Florida east coast to achieve the sub-ACL set by the GMFMC. The Florida east coast boundary and the revised ACLs based on the stock boundary changes were implemented through Amendment 20B to the CMP FMP (GMFMC/SAFMC014). Collection of genetic samples from northern Florida (east coast) and Georgia continues and analysis will be used in a stock identification workshop planned for 2017 that will review the stock boundary between the south Atlantic and Gulf stocks.

Recreational cobia landings in 2015 were 1,565,186 pounds, well above the 2015 ACL of 630,000 pounds. This overage resulted in a June 20, 2016 closure of the fishery by NOAA Fisheries. Concern was expressed by individual states whose recreational seasons were reduced by the 2016 closure. North Carolina and Virginia developed alternate management strategies for harvest in state waters to avoid the June 20, 2016 closure enacted by NOAA Fisheries. Measures enacted by North Carolina and Virginia in 2016 resulted in a delay of state waters closures until September 30 in North Carolina and August 30 in Virginia. South Carolina recently implemented more restrictive measures to protect an inshore spawning population in southern South Carolina that was independent of the actions taken by NOAA fisheries.

Commercial cobia landings in 2015 were 71,790 pounds (landed weight) that exceeded the commercial ACL of 60,000 pounds (landed weight). Unusual fall landings occurred in 2015 that prevented a timely closure. Landings can be reported as both gutted or whole weight. Management uses “landed” weight to determine if the ACL has been met. Since landed weight includes both gutted and whole fish total weight harvested is likely underestimated.

STATEMENT OF THE PROBLEM

Historically, cobia has been managed through the federal Gulf of Mexico and Atlantic CMP FMP; the plan's measures had been considered precautionary due to the low bag limits. Both sectors of the fishery have been managed with a two fish possession limit and 33" fork length (FL) minimum size since formal management began in 1990 (under Amendment 6). The ACLs and AMs were established through Amendment 18 and then updated in Amendment 20B (GMFMC/SAFMC 2012 and 2014). The 2013 stock assessment conducted through the SEDAR process indicated overfishing was not occurring and the stock was not overfished. However, biomass/abundance had been as trending steadily downward over the previous two decades. Additionally, the stock assessment used a different stock boundary than that in the FMP. The current ACL is a conservative approach to prevent the stock from reaching an overfished status. The recent overage in 2015 exceeded the SAFMC's defined overfishing limit, meaning the stock is undergoing overfishing. Further, quota overages would continue to contribute to overfishing and could lead to the stock becoming overfished.

Efforts to more closely monitor state-specific harvest to ensure that quotas are not exceeded and that overfishing is averted is the Commission's primary focus. Further, by developing a Commission plan, the impacts of a single, federal closure may be mitigated through state-specific measures designed to maintain traditional seasons at reduced harvest rates. The proposed interstate FMP considers potential management approaches to maintain a healthy resource while minimizing the socioeconomic impacts of seasonal closures.

DESCRIPTION OF CURRENT MANAGEMENT

SAFMC management of cobia is consistent for the AMG in federal waters with a two fish possession limit and 33" FL minimum size limit for commercial and recreational harvest. To reduce recreational harvest and attempt to extend seasons, some states have recently modified their state water measures (Table 1). Because cobia found in Florida waters are not a part of the AMG, they have a different set of management measures designed to achieve the sub-ACL.

Table 1. Recreational measures in 2016 for Cobia in Virginia, North Carolina, South Carolina, Georgia**,** and Florida.

State	**Bag limit (Fish per person/ day)**	**Vessel limit (Fish per vessel per day)**	**Size Limit (inches)**	**Legal Gear**
Virginia	1 *	2	40" TL, only 1 > 50" TL	No gaffing permitted
North Carolina	1 **	For-hire: 4/vessel or 1 person when less than 4 people on board Private: 2 fish on vessels with more than 1 person on board	37" FL	
South Carolina – north of Jeremy Inlet, Edisto Island	2	None	33" FL	
South Carolina-south of Jeremy Inlet, Edisto Island	1 (June 1-Apr 30) Catch and release only May 1-May 31	3, or 1 per person, whichever is lower	33" FL	
Georgia	2	None	33" FL	
Florida	1	1 per person or 6 per vessel, whichever is less	33" FL	spears, gigs, hook and line, seine, cast net

*VA State waters close 8/30/16.

**NC State waters close 9/30/16; private recreational can only retain cobia on Mondays, Wednesdays, and Saturdays. Shore based anglers may retain 1 fish per day, 7 days per week.

In September 2016, the SAFMC recommended NOAA Fisheries approve the following measures contained in Framework 4: recreational harvest limits of one fish per person per day or six per vessel per day, and a minimum size limit of 36" fork length (FL) for recreational harvest; a commercial harvest limit of two fish per person per day or six per vessel, whichever is more restrictive, but no change to the commercial minimum size limit of 33" FL.

The SAFMC is also proposing modifications to the recreational AMs for AMG cobia. These changes are expected to be implemented in spring 2017. In December 2016, the Council will review and recommend to NOAA Fisheries approval of an amendment to change the recreational fishing year for AMG cobia, the current fishing year is January 1 – December 31. The amendment's preferred alternative would change the fishing year to May 1 – April 30.

The allocation of the SAFMC's ACL between commercial and recreational sectors is based on historical landings (50% is based on the average 2000-2008 landings and 50% is based on the average 2006-2008 landings). Beginning in 2016, the ACL is split 92% recreational and 8% commercial. The 2016 ACL for cobia is 670,000 pounds, with 620,000 comprising the recreational ACL and 50,000 comprising the commercial ACL. The ACL for 2015 was slightly higher at 690,000 pounds.

LIFE HISTORY AND STATUS OF THE STOCK

Cobia is a fast growing, moderately lived (14 years old) species, with most fish maturing by age two. Females grow faster and attain larger sizes than males, but become sexually mature later. Cobia migrate south to north as well as east to west. Spawning occurs when water temperatures reach 20-21° C from April through September with spawning occurring earlier in Florida and later in Virginia. Cobia form aggregations and spawn multiple batches of eggs throughout a relatively short season. Year class strength can be highly variable but trends in the data show a very strong year class occurs once in a decade. Both tag recapture and genetic data show cobia exhibit natal homing and are often recaptured on the same structure or in locations where they were caught years before. This natal homing and spawning aggregation behavior make them very predictable and easily located by fishermen.

The results of the SEDAR 28 stock assessment determined the FL/GA border as the demarcation between the Atlantic and Gulf of Mexico stocks. As previously mentioned, a workshop in early 2017 will evaluate all the current cobia genetic information. While cobia do frequent areas north of Virginia, the harvest is uncommon and sporadic. Landings have been episodically reported from Maryland, New York, New Jersey and Rhode Island and make up from 3-15% of the total Mid-Atlantic landings.

The SEDAR 28 stock assessment indicated overfishing was not occurring and the stock is not overfished. The current ACL is a precautionary approach to prevent the stock reaching an overfished status. The recent overage in 2015, exceeded the Council defined overfishing limit, meaning overfishing is occurring. The stock assessment does indicate concerns. While the terminal year of the assessment was 2011, spawning stock biomass (SSB) experienced a general decline from 2002 forward (Figure 2). Further, recreational landings have increased over the latter portion of the time series that may increase potential overfishing issues in the next assessment. The Council proposed cobia be included in the 2019 SEDAR schedule for a research track assessment which will give guidance on the appropriate data and models to be used in the 2020 stock assessment.

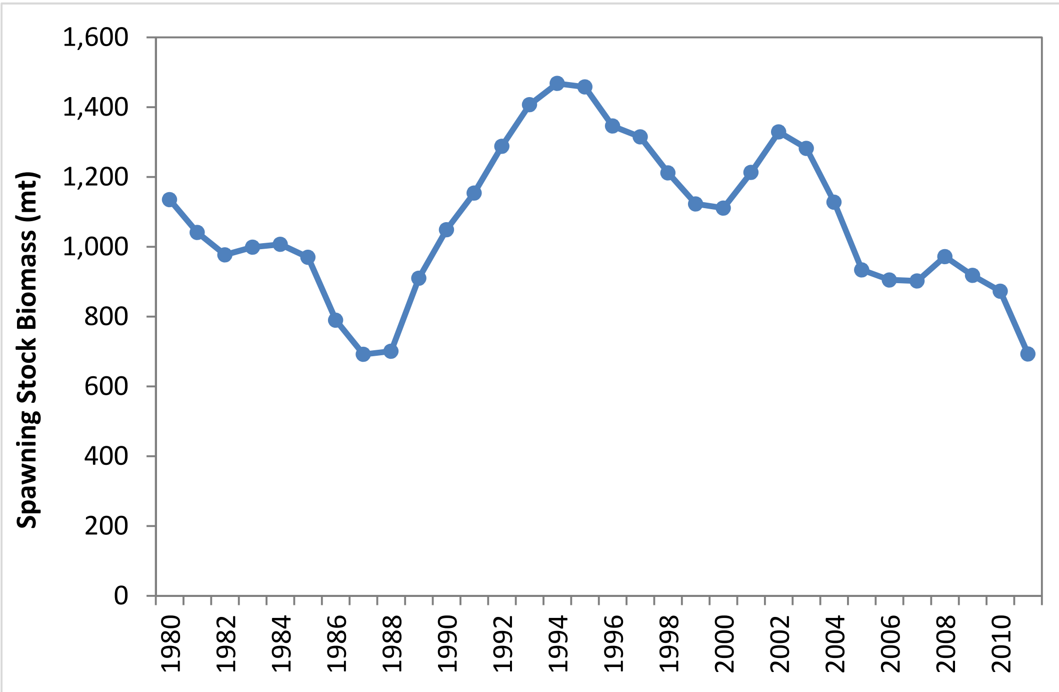


Figure 2. Cobia spawning stock biomass, 1980-2011.

DESCRIPITON OF THE FISHERY

Data collection programs vary by state and will be further described in the upcoming draft FMP. However, research efforts at the state level are confounded by the observation that cobia only occur in specific state jurisdictions in aggregations for a brief period each year and often in locations conflicting with the peak of recreational fishing. Directed sampling efforts are difficult outside of the primary recreational season that extends from April through August, because fish are migrating from spawning locations and not found in large concentrations.

Recreational Fishery

Cobia supports a valuable recreational fishery throughout the South Atlantic and into the Mid-Atlantic region. Known for their readiness to take a bait, tough fighting abilities and excellent table fare, the fishery is popular in the recreational sector. Current information indicates a variable proportion of landings come from state waters and can range from 0 to 100% (Table 2). The 10 year average, annual percentage of cobia taken in state waters with and without east coast Florida included are 66% and 51% respectively (Tables 3 and 4).

Recreational fisheries are prosecuted similarly along the coast. The directed cobia fishery is prosecuted in two distinct ways. Bottom fishing with live or dead baits, often while chumming, in estuarine waters or around inlets or offshore around structure, buoys, markers, natural and artificial reefs. More recently, an active method of searching for fish traveling alone or in small groups on the surface or associated with schools of Atlantic menhaden or other bait fishes has grown in popularity. This newer method has resulted in the further development of the for-hire sector for cobia, as well as the development of specific artificial baits and boat modifications (e.g., towers) to facilitate spotting and catching the fish. A third method primarily prosecuted in offshore waters is to target large rays, large sharks, sea turtles or floating debris around which cobia congregate. This more active method likely confounds reported landings being in state or nearshore federal waters as vessels tend to move in and out of state and federal waters following the bait or the fish. Additionally, the Atlantic coast of Florida is starting to see more directed spearfishing pressure on cobia. Specifically, spearfishers are chumming for bull shark and then diving/free-diving to spear cobia that associate with them. Spearfishing also occurs off North Carolina, along with a popular pier fishery.

The recreational fishery also takes cobia as bycatch in offshore bottom fisheries such as snapper/grouper, nearshore trolling for king mackerel, bluefish, and dolphin and any other fishery that employs live or dead bait fished on or near the bottom. While the directed fishery appears to focus more on the spring-summer spawning migration, bycatch, especially offshore, can yield cobia virtually year-round.

Recreational landings for cobia have varied with little trend since 2005; landings did hit a time series high in 2015 resulting in a significant overage of the federal ACL (Figure 3). Since 2005, the highest landings have occurred in the east coast of Florida, North Carolina and Virginia. The three year average landings (2103-2015) in the east coast of Florida, North Carolina and Virginia were approximately 446,218, 466,944 and 429,179 pounds, respectively. In 2015, the three states with the highest recreational landings were Virginia (718,647 pounds), North Carolina (630,373 pounds) and Florida (east coast) (481,956 pounds) (Table 4).

Table 2. Percentage of cobia in the recreational fishery harvested in state waters (zero implies all were harvested from federal waters). All data are final MRIP estimates, which may differ from SEFSC estimates.

	Florida	Georgia	South Carolina	North Carolina	Virginia
2006	22	0	98	30	100
2007	9	0	0	47	100
2008	14	0	0	50	100
2009	53	0	0	58	100
2010	59	39	41	75	94
2011	33	0	0	90	50
2012	21	80	0	49	42
2013	9	0	61	79	83
2014	17	0	52	82	100
2015	13	0	6	92	97

Table 3. 10-year average percentage of cobia harvested in state waters with and without east coast Florida. All data are final MRIP estimates, which may differ from SEFSC estimates.

	Percent of Cobia Harvested in State Waters GA-NY	Percent of Cobia Harvested in State Waters FL-NY
2006	87	68
2007	52	34
2008	29	22
2009	80	71
2010	75	68
2011	56	40
2012	34	28
2013	77	59
2014	83	47
2015	85	71

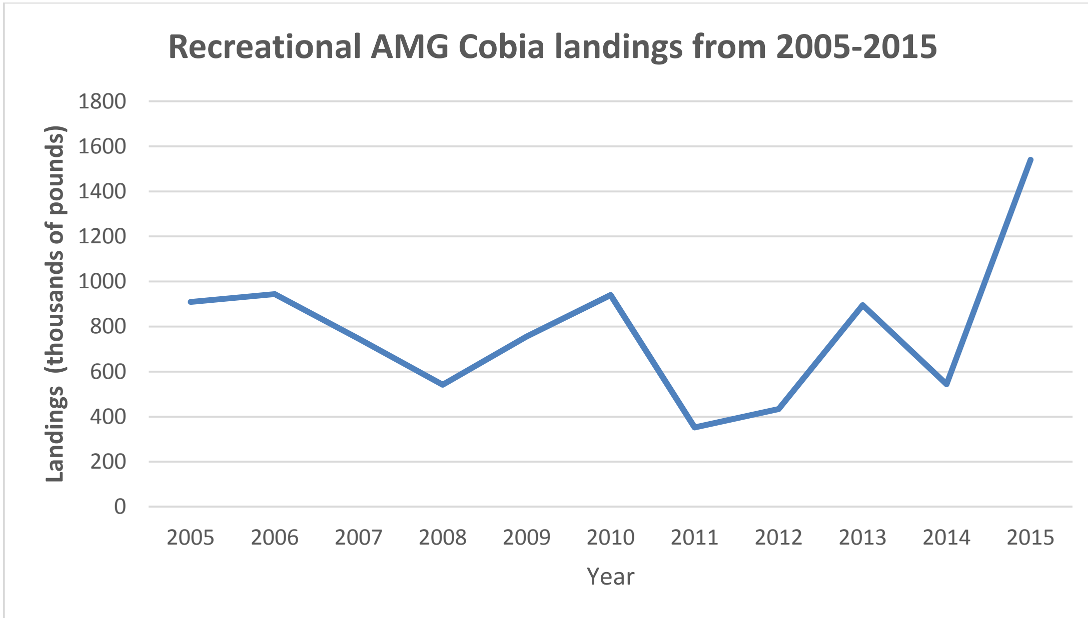


Figure 3. Recreational landings of AMG cobia (2005-2015)

Commercial Fishery

The commercial fishery has traditionally been a bycatch in other directed fisheries such as the snapper/grouper hook and line fishery and troll fisheries for various species (e.g., king mackerel, dolphin, wahoo, amberjack). Directed fisheries are generally precluded as a result of the low possession limits, but do occur, specifically Virginia's commercial hook and line fishery. Cobia from for-hire trips may also be sold commercially, depending on the state's permit requirements for selling fish.

Commercial harvest has been increasing in North Carolina since 2011 and in the Mid-Atlantic since 2012 (Figure 4). Commercial harvest has remained stable in Georgia and South Carolina since 2010. Commercial cobia landings on the east coast of Florida ranged from 57,003 to 156,069 pounds (avg. = 88,278 pounds) during the 2007-2011 time series. Commercial landings in Georgia and South Carolina were low and values for the two states were combined from 2010-2015 to avoid confidentiality issues and averaged 3,867 pounds per year (Table 5).

The commercial cobia fishery closed December 11, 2014. The 2015 overages would have been deducted if the stock were overfished; however, given they are not overfished, the commercial quota for 2016 remains 50,000 pounds (Figure 4). In 2015, North Carolina landings (52,684 pounds) accounted for nearly the entire commercial quota and would have exceeded the 2016 quota (Table 5).

Commercial landings for the Mid-Atlantic region (Virginia, Maryland, New Jersey, New York,) and Rhode Island are combined in Table 6 to avoid confidentiality issues in several Mid-Atlantic states. The majority of the Mid-Atlantic landings come for Virginia. The average landings from 2010-2015 were 14,732 pounds per year.

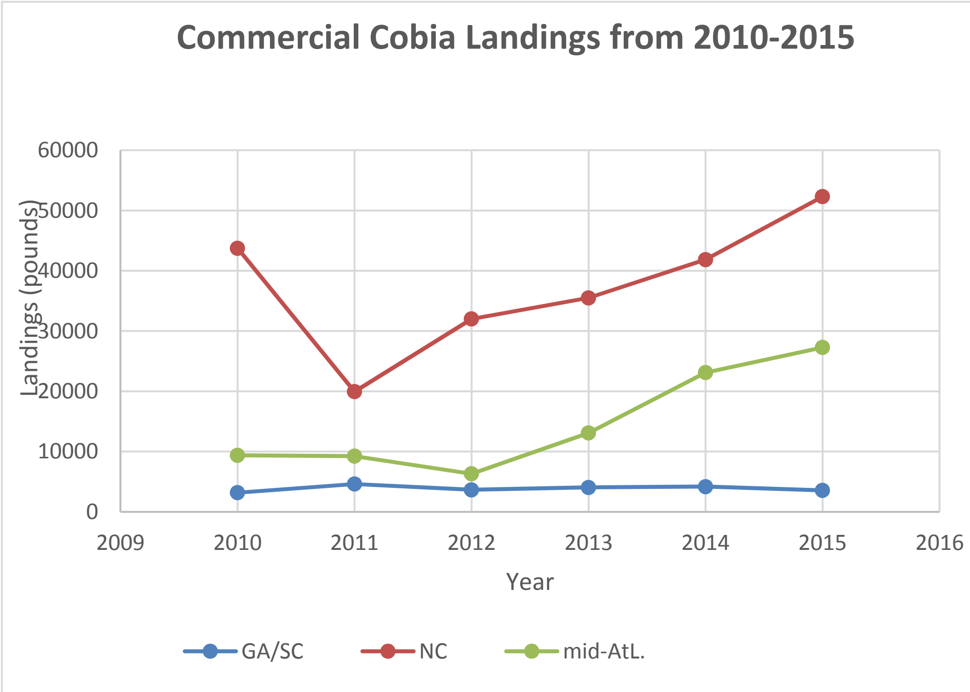


Figure 4. Commercial landings of cobia (2010-2015)

Table 4. Recreational landings of AMG cobia from 2005-2015 in pounds. Data sources: SEFSC

Year	Virginia	North Carolina	South Carolina	Georgia	Total AMG (VA-GA)	East Coast of Florida
2005	577,284	322,272	5,793	3,358	908,707	287,267
2006	733,740	104,259	101,018	4,824	943,841	493,334
2007	322,887	90,197	268,677	64,708	746,469	580,632
2008	167,949	66,258	50,108	257,690	542,006	438,621
2009	552,995	123,061	76,229	3,997	756,282	361,120
2010	232,987	561,486	65,688	79,855	940,015	745,228
2011	136,85u9	121,689	3,565	90,375	352,488	761,440
2012	36,409	68,657	224,365	105,193	434,623	370,373
2013	354,463	492,969	19,130	29,224	895,786	274,276
2014	214,427	277,489	31,927	20,642	544,485	582,423
2015	718,647	630,373	123,952	67,804	1,565,186	481,956

* There are no MRIP-estimated recreational landings of AMG cobia in states north of Virginia.

Table 5. Commercial cobia landings (pounds) and revenues (2014 dollars) by state/area, 2010-2015.

Year	GA/SC	NC	Mid-Atlantic*	Total
		Commercial Landing in Pounds		
2010	3,174	43,737	9,364	56,275
2011	4,610	19,950	9,233	33,793
2012	3,642	32,008	6,309	41,959
2013	4,041	35,496	13,095	52,632
2014	4,180	41,848	23,111	69,139
2015	3,555	52,315	27,277	71,790
Average	3,867	37,559	14,732	56,158
		Dockside Revenues (2014 dollars)		
2010	$11,377	$70,377	$19,976	$101,730
2011	$19,666	$37,893	$21,666	$79,224
2012	$15,554	$66,887	$14,597	$97,038
2013	$15,639	$79,397	$35,792	$130,828
2014	$13,320	$95,462	$67,972	$176,754
2015	$11,151	$147,160	$75,360	$233,672
Average	$14,451	$82,863	$39,227	$136,541

Georgia and South Carolina landings are combined to avoid confidentiality issues.
Source: SEFSC Commercial ACL Dataset (December 2015) for 2010-2014 data; D. Gloeckner (pers. comm., 2016) for 2015 data.
*Mid-Atlantic States include Virginia, Maryland, New York, New Jersey.

WHAT IS THE PROCESS FOR DEVELOPING A FMP?

The publication of this document and announcement of the Commission's intent to develop a Cobia FMP is the formal, first step of the FMP development process. Following the initial phase of information gathering and public comment, the Commission will evaluate potential management alternatives and the impacts of those alternatives. The Commission will then develop a draft FMP, incorporating the identified management alternatives, for public review. Following the review and public comment, the Commission will specify the management measures to be included in the FMP, as well as a timeline for implementation.

The timeline for completion of the FMP is as follows:

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

WHAT IS THE PURPOSE OF THIS DOCUMENT?

The purpose of this document is to inform the public of the Commission's intent to gather information concerning the cobia fisheries, develop management measures to assist the SAFMC in maintaining harvest levels within the prescribed ACL, and provide management flexibility to the states to minimize the impact of potential closures. The PID provides an opportunity for the public to identify and/or comment on issues and alternatives relative to the management of cobia. Input received at the start of the FMP development process can have a major influence on the final outcome of the FMP. This document is intended to draw out observations and suggestions from fishermen, the public, and other interested parties, as well as any supporting documentation and additional data sources.

To facilitate public input, this document provides an overview of issues identified for consideration in the FMP, as well as background information on the cobia stock, fisheries and management. The underlying question for public comment is: **"How would you like the cobia fishery and population to look in the future?"** The Commission is looking for both general comments on cobia management in state waters and any comments specific to the issues listed in this document.

WHAT ISSUES WILL BE ADDRESSED?

The primary issues considered in the PID are:

- Complementary Management with the SAFMC
- Management Objectives
- Coastwide, Regional or State-by-State Approach to Management
- Commercial and Recreational Management Tools

ISSUE 1: COMPLEMENTARY MANAGEMENT WITH THE COUNICL

Background: The SAFMC manages cobia through the CMP FMP with consistent bag, trip and size limits in federal waters. A recent ACL has been employed to protect the resource and minimize the possibility of cobia being subjected to overfishing or becoming overfished. Complementary management of cobia is intended to increase flexibility and management reaction time, while providing states the ability to more actively and adequately manage the fishery in their respective states. It is anticipated Commission would adopt the ACLs and biological reference points established by the benchmark cobia stock assessment developed by the SAFMC.

States have historically mirrored the SAFMC's size and bag limit regulations in state waters. The recreational closure in 2015 resulted in Virginia and North Carolina modifying their regulations in order to reduce the impacts of the June 20, 2016 federal closure. South Carolina has developed various, additional regulations based on area-specific genetic work and concern over the condition of a DPS that occurs in its southern waters.

A complementary management plan separates the management processes between the two bodies (Federal/Council and ASMFC Board) and attempts to have measures that are consistent and not in direct conflict. Specifically, the Commission develops its own management documents that may contain aspects of the plan that are consistent with the Council but it is not required. Under a complementary plan, States are the responsible party for monitoring quotas and closing state waters once quota is reached. Stock assessments are conducted with the SEFSC/Council/Commission. Typically, the SEFSC is the lead for the stock assessment.

Management Questions:

- It is the intention of the Commission develop a complementary Cobia FMP to the SAFMC's CMP FMP. Do you think the Commission should have a different approach?
- What federal management measures should be required in the Commission plan?
- What states should be included in the management unit?

- Given the upcoming genetic workshop in 2017, should the FMP provide the flexibility to make changes to management and stock units to reflect changes in the science?

ISSUE 2: MANAGEMENT OBJECTIVES AND GOALS

- **Background:** The first step in proactive fisheries management is to decide what is meant by optimizing the benefits for a fishery. Goals and objectives can be divided into four subsets: biological, ecological, economic, and social, where social includes political and cultural goals. The biological and ecological goals can be thought of as constraints in achieving desired economic and social benefits. Examples of goals under each of these categories include:
- Maintain the target species at or above the levels necessary to ensure their continued productivity (biological);
- Minimize the impacts of fishing on the physical environment and on non-target (bycatch), associated and dependent species (ecological);
- Maximize the net incomes of the participating fishers (economic); and
- Maximize employment opportunities for those dependent on the fishery for their livelihoods (social).

Identifying such goals is important in clarifying how the fish resources are to be used. Without such goals, there is no guidance on how the fishery should operate, which results in a high probability of ad hoc decisions and poor use of the resources (resulting in lost benefits), and increases the probability of conflicts among user groups.

The Commission could consider the following management objectives for the Cobia FMP and is soliciting other ideas or options that could be raised.

A. Provide a management plan that achieves the long-term sustainability of the resource and strives, to the extent practicable, to implement and maintain consistent coastwide measures, while allowing the states the flexibility to implement alternative strategies to accomplish the objectives of the FMP
B. Provide for sustainable recreational and commercial fisheries.
C. Maximize cost effectiveness of current information gathering and prioritize state obligations in order to minimize costs of monitoring and management.
D. Adopt a long-term management regime which minimizes or eliminates the need to make annual changes or modifications to management measures.

Management Questions
What should be the objectives in managing the cobia fisheries through the Commission?

ISSUE 3:

Background: States currently manage their cobia fisheries independently. The Commission is considering coordinating the management of cobia in order to

COASTWIDE, REGIONAL OR STATE-BY-STATE MANAGEMENT

avoid states being disadvantaged based on where they occur along the migratory route, while maintaining harvest at the SAFMC's ACL level.

States have been disadvantaged by geography in the past when they occur on the northern or southern end of a migratory range, often resulting in early closures or no fishery at all. While consistent, coastwide measures may be desirable, they may result in disproportionate impacts to certain states.

More flexibility to individual states may be available through state-by-state allocations of the cobia ACLs. Allocations can allow limits and seasons to be imposed that maximize the individual state fishery needs, and reduce the impact of other state overages.

Management Questions:

- ➢ Are consistent, state-specific management measures, coordinated by the Commission, needed for cobia?
- ➢ Are there regional differences in the fishery and/or resource that need to be considered when implementing management measures?
- ➢ Should the FMP require a coastwide closure if the SAFMC ACL is met?
- ➢ Should the FMP require a coastwide measures (e.g., size and bag limit)?
- ➢ Should the FMP require regional measures?
- ➢ Should the FMP develop a suite of options for the allocation of state-specific quotas, and allow states to adopt unique size, bag, and season measures?
- ➢ Should states be permitted to submit proposals for alternative management that is conservationally equivalent to the required management program (e.g., a less restrictive bag limit given a more restrictive minimum size limit)?

ISSUE 4: RECRATIONAL MANAGEMENT TOOLS

Background: Cobia supports a valuable recreational fishery throughout the South Atlantic and into the Mid-Atlantic region. Current information indicates a variable proportion of landings come from state waters and can range from 0 to 100% (Table 2). The 10 year average, annual percentage of cobia taken in state waters with and without east coast Florida included are 66% and 51% respectively (Tables 3 and 4).

In federal waters there is a two fish possession limit and 33" fork length (FL) minimum size, but the states have differing measures (Table 1). A complementary recreational measures for cobia could provide the states the flexibility to respond to changes in the fishery and stock that meet their state fisheries needs without impacting federal fisherman while meeting the goals and objectives of the FMP.

Recreational cobia landings collected through the Marine Recreational Information Program, but landings estimates for this document are generated from the Southeast Fisheries Science Center (SEFSC). The SEFSC data are used for the following two reasons. The SEFSC data includes landings from the Southeast Headboat Survey that are not included in the MRIP data. In addition, MRIP data use two different methodologies to estimate landings in weight over the time series. To apply a consistent methodology over the entire recreational time series, the SEFSC implemented a method for calculating average weights for the MRIP landings, which they believe is a better representation of the weight of the cobia catch.

Management Options:

- What are the appropriate recreational measures for cobia? Potential management tools include: minimum size restrictions, maximum size restrictions, bag/trip/boat limits, seasons or gear restrictions.
- Should the FMP consider gear restrictions, e.g. circle hooks for all live and dead bait fisheries for cobia or prohibition on gaffing cobia?
- Are there other management options that should be considered (e.g., slot limits, spawning season closures, etc.)?
- When using recreational data should averaging of the data be permitted to set measures or determine if the RHL has been met? (e.g average the total harvest over 3-5 year to compare to the RHL in a given year, in some cases this could help to minimize impacts caused by overages. In other cases, years with very high overages, impacts would continue to be carried forward for several years
- Should the FMP consider some level of *de Minimis* or threshold landings where cobia harvest is minimal?

ISSUE 5: COMMERCIAL MANAGEMENT TOOLS

Background: The commercial fishery is managed consistently throughout state and federal jurisdictions with a two fish possession limit and 33" FL minimum size limit. Through the FMP process, the Commission could consider changes to the commercial fishery measures.

Management Options:

- What issues face the commercial fishery now and what potential issues could arise in the fishery?
- What tools should be included in the FMP for managers to address these issues?
- What are the appropriate commercial measures for cobia? Potential management tools include: minimum size restrictions, maximum size restrictions, bag/trip/boat limits, seasons or gear restrictions.
- Should the FMP consider some level of de Minimis or threshold landings where cobia harvest is minimal or episodic?

ISSUE 6:
OTHER ISSUES The public is asked to comment on any other issues for consideration in the development of the Commission's Draft Fishery Management Plan for Cobia.

Atlantic States Marine Fisheries Commission

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MEMORANDUM

To: South Atlantic State/Federal Fishery Management Board
From: Louis Daniel, Cobia FMP Coordinator
RE: Public Comment on the Public Information Document for Cobia

The following pages represent a summary of all public comment received by ASMFC by January 6, 2017 at 5:00 p.m. (closing deadline) on the Public Information Document for the Cobia Fishery Management Plan.

A total of 16 written comments were received during the public comment period. Four of those comments were from the following groups and organizations: Peninsula Saltwater Fishing Club, Coastal Conservation Association-Virginia, Virginia Saltwater Sportfishing Association, Coastal Conservation Association-North Carolina. Individual written comments were primarily submitted by recreational and for hire fishermen and their locations ranged from Virginia to Florida. A summary of the written comment is provided below and individual comment letters follow this memo.

Four states within the management unit held a public hearing: Virginia, North Carolina (2), South Carolina, and Florida. In total, approximately 60 individuals attended the public hearings. A summary of the comments received at the public hearings is provided, followed by summaries of the written comments and the specific written comments as submitted.

Review of ASMFC Public Hearings on Cobia Public Information Document

The ASMFC conducted five public meetings to gather public comments on the Public Information document for cobia. Meetings were held in Virginia, North Carolina South Carolina, and Florida. Attendees were compiled from sign in sheets and may contain misspellings.

<u>Virginia Marine Resources Commission</u>
December 6, 2016; 6 PM
2600 Washington Ave, 4th Floor
Newport News, Virginia 23607

<u>ASMFC Staff</u>: Louis Daniel
<u>Attendees</u>: Jonathan French, Pat Link, Wes Blow, Alex Field, Chris Obrien, Joe Cimino (VMRC), Ryan Jiorle (VMRC), Alex Aspinwall (VMRC)

Jonathan French provided a general presentation on issues and concerns consistent with his previously provided, written comments contained in briefing materials. An overall concern, shared by those in attendance, centers around the use of the best science, particularly the genetics data used to split the Atlantic Migratory Group cobia from the Gulf group cobia. Mr. French also provided detailed written comments that are included in the written comments as well.
Pat Link provided a copy of recent MRIP data, expressing concerns over the few samples observed to generate harvest estimates.
Wes Blow provided a handout on Virginia citation data and felt the number of larger fish were declining and needed to be protected. He expressed the need for ASMFC management and was concerned with Virginia's lack of representation on the SAFMC. He proposed a 2 fish boat limit but had concerns over a circle hook requirement.
Alex Field raised concerns over reporting and the need to have better catch estimates.
Chris O'Brien indicated that commercial limits from last year were fine.
A good, general discussion with the audience focused on concerns with the genetics data and catch statistics. A common issue was the need to provide a gaff exemption for piers and to take care when developing regulations not to disadvantage the unique pier fishery.

<u>North Carolina Division of Marine Fisheries</u>
December 8, 2016
Atlantic Beach, North Carolina

Meeting held in conjunction with the South Atlantic Fishery Management Council

<u>ASMFC Staff</u>: Louis Daniel (staff), Bob Beal (staff)
Michelle Duval (Commissioner)
<u>Attendees</u>: Bill Gorham, Mark Brown, Chris Elkins, Tom Roller, Joel Fodrie, Mel Bell (SCWMRD), Randy Gregory (NCDMF), Lara Clarke, Wilson Laney (USFWS), John Carmichael (SAFMC), Amber

Von Harten (SAFMC), Kari MacLauchlin (SAFMC), John Hadley (SAFMC), Gregg Waugh (SAFMC), Doug Haymans (GADNR).

Chris Elkins, North Carolina CCA president, read a statement from his organization that is included in written materials.
Bill Gorham introduced himself as a tackle manufacturer from Southern Shores, NC who is dependent on the cobia fishery. He expressed concerns over the current ACL and does not feel any allocation is fair.
Art Brown commented that cobia are fast growing and should be able to recover quickly.

December 15, 2016;
Manteo, North Carolina

Michelle Duval (Commissioner) conducted the meeting
Attendees: Bill Gorham, Joey VanDyke, Travis Kemp, Ann H?, Jon Worthington, Glenn Collins, John Welch, Bob Feldmans, Aaron Kelly, Louis Argiro, Steve Hussey, Tom Boyd, Reese Stecher, Casey Russell, Gerrad Otto, Joe Smith Bobby Smith, Rick Caton, Karl Helmkamp, Seth Levine, Browny Douglas, Abigail Haber, Douglas Haber, Jeff Reibel, Will Smith, Unknown Hatteras captain, Willie Etheridge, Steven Poland (NCDMF)

Bill Gorham commented to oppose ASMFC involvement. Believes the ASMFC is unable to change ACL or stock boundary that is the number one problem he has and feels those need to be changed. If ASMFC continues with management, Florida should be included. Oppose Louis Daniel being a liaison involved in the Cobia FMP.

Crowd was asked if they agreed with Mr. Gorham and they indicated by voice that they did.

Bobby Smith, charter boat captain. Prefers 2 fish at 33 inches, year round. Request that NMFS, SAFMC, and ASMFC representatives be at any future meetings on this issue.
Abigail Haber agrees with original laws and limits. Document not compatible with facts. Questioned landing whole versus gutted weight. Referenced different landings estimates from MRIP and SEFSC. Numbers don't look right in Virginia. 10 years old and wants to study these things but so far none of this seems right. If a 10 year old can see this is wrong, why cant the Board?
Reese Stecher—Charter boat captain. Supported Bill Gorham comments. Felt NMFS, SAFMC, and ASMFC representatives should be at meeting. Raised concern over data collection when waters are closed outside of miles. Why taking action when stock is not overfished. Support 2 fish per day, 33 inches. Should not be a different season for recreational fishermen (reference to NC rule).

Will Etheridge—Wanchese—supports Bill Gorham comments. Numbers from Virginia this year cannot be right.
Doug Haber agrees with Bill Gorham. Useful to have all parties attend meetings. Hold meetings on-line to ensure participation.

Will Etheridge asked for a show of hands (n = 27) who supported comments from Bill Gorham.

South Carolina Department of Natural Resources
December 12, 2016
Okatie, South Carolina

ASMFC staff: Louis Daniel
Attendees: Tony Royal, David Cargile, Captain Bill Parker, Emily Becker, Bill Hennigh, Charles Bridgham, Cole Mickey, Matt Perkinson, Sharon Stewart, Doug McGowan, Jim Dufresne, Chris Kehner, David Hartse, Dick Stewart, Captain Tim Deehard, Tony Constant, Captain Joseph Marshall, Jerry Nerad, Pat Geer (GADNR), Chris Kalinowski (GADNR), Karl Breckert, Captain Waldo A. Phinney, Jr., Michael Denson (SCWMRD), Al Stokes, Kari MacLauchlin (SAFMC), Amber Von Harten (SAFMC).

Questions about recreational landings data came up. Where do they come from? How does MRIP actually work?

Is stocking cobia an option for helping the stock to rebuild quicker and to be able to maintain a fishery? "Might be a good investment". Discussion of SCDNR past and recent stocking work in Port Royal Sound (PRS).

Discussion of SCDNR acoustic tagging work with cobia done in SC and GA with cooperating anglers (charterboat captains). Fish tagged in Port Royal Sound have been detected on acoustic receivers primarily in the vicinity of PRS. No acoustically tagged fish were detected north of Murrells Inlet as of OCT. Also discussion of SCDNR recreational tagging efforts (voluntary anglers) now and back into the early 1980's. Broad level of interest in and support for these type efforts from the fishing public. Public view such efforts as ways in which they can assist in collecting useful data related to cobia movement and defining proper stock boundaries. Voluntary tagging of cobia very desirable.

Dave Harter (Hilton Head Sport fishing Club and Port Royal Sound Foundation). "I am convinced that the states need to be regulating the cobia fishery".
Wally Phiney (charterboat captain > 33 years). "Fishing has gone to hell". Cobia should be managed in a similar fashion to Spanish and king mackerel. Interstate management is needed. Spanish and king fisheries are also not what they used to be. "We have to be able to manage across state boundaries". Offshore fishing for cobia occurs on artificial reefs like the Betsy Ross Reef. Heavy fishing pressure occurs particularly on Saturdays and Sundays and there is an assumption that people are keeping over the limit. There appears to be no Law Enforcement presence on the reefs when this is going on. More enforcement is needed.
Concerned was expressed that heavy fishing, particularly in VA could jeopardize SC local cobia fishing in the future. However, if VA is fishing too heavily on their own fish (DPS) within their own waters they may only be hurting themselves.

The methods by which charterboat data are collected was discussed. The need for reliable and improved recreational landings data was discussed. Fear was expressed that many people are using private docks to land cobia and these fish are never captured in any type of creel survey work. Sale of recreationally landed fish (directly to restaurants) is still a problem in Beaufort County.

“State by state management in the recreational cobia fishery is needed” (multiple people). Discussion about cobia movement patterns (inshore-offshore; north-south) took place. A better understanding of that could be achieved through more tagging and genetics work. Mention was made of SCDNR genetics work and ongoing efforts to get fin clips from cooperating anglers for analysis. Questions were asked about the current stock boundaries used by the SAFMC (how were they determined?).

Changes in the start date for the cobia fishery were discussed. Concern was expressed that SC not be left out (disadvantaged) in the establishment of any new fishery start date. Per new state law (May 2016) SC key state waters (Southern Cobia Management Zone) are “take and release only” for cobia during the month of May already. This is to take fishing pressure off the SC DPS of cobia that spawn in the high salinity southern sounds and rivers.
“We need to be proactive in managing this fishery”. “More tagging work needs to be done”. We must better understand the impacts of environmental changes, including water quality, on the health our cobia stock. “Studies on environmental impacts on habitats, food chains and cobia need to be conducted – but money is limited”.

Bill Parker (charterboat captain > 31 years; South Atlantic Species AP member). Concerned that VA’s heavy inshore fishing efforts on fish spawning inside the Chesapeake Bay could be an example of “the illusion of plenty” (hyperstability) in the fishery there and could have serious consequences for the overall cobia fishery in the future. Possibly similar to what may have occurred in the inshore waters of SC in recent years. Expressed concerns about increased fishing pressure and targeting of cobia in federal waters off SC, especially on well-known and very popular artificial reefs. Concerned that these fish (part of the offshore population) are also spawning when off SC. South Carolina’s cobia landings have shifted from heavily inshore to heavily offshore in recent years. The boat limit in federal waters needs to be reduced to 3 fish. Concerned that raising the legal retention length to 36 inches places more pressure on females – this could prove to be an issue. Expressed real concerns about large swings in MRIP landings. Has a lack of confidence in MRIP data. Expressed concerns about Florida’s lack of reporting in the charterboat fishery in state waters. SC has been reporting charterboat landings since 1993. “Reporting landings is for our own good”.
Chris (Port Royal Maritime Center). “Self-reporting for all private boat anglers is needed”. A system to accomplish that should be developed.
Discussion of the concept of self-reporting from the private boat sector took place. A recommendation was made to adopt something similar to what is used in the federal duck stamp program (HIP) where reporting is mandatory. Many thought it might be a good idea, but understood the challenges of getting such data from all recreational anglers that could be useful and scientifically valid.

Someone suggested that implementing lower bag limits was a reasonable solution and that a boat limit of three cobia was needed. Someone else pointed out that charterboats might need more fish to satisfy clients. Mention was also made that on artificial reefs off Port Royal Sound when the fish were aggregating, charterboats were making multiple trips per day and limiting out.

If cobia are managed through the ASMFC and some sort of formula is worked out to allocate quotas for each state concern was expressed that SC and GA could be severely disadvantaged by high landings in NC and particularly VA over the past two years where very high landings have been reported. Concern over fair allocations and the process used to determine them was expressed. "In determining allocations for VA cobia quotas should be calculated starting with a zero-based budgeting concept".

Florida Fish and Wildlife Conservation Commission
December 14, 2016
New Smyrna Beach, Florida

ASMFC staff: Louis Daniel
Attendees: Jim Estes (FFWCC), Chris Kalinowski (GADNR), Krista Shipley (FFWC), Jim Whittington (FFWC), Erica Robbins (FFWC)

No public attended the New Smyrna Beach meeting.

Cobia PID Written Comment Summary

Issue 1: Complementary Management with the Council.
Written comments were split, with 7 commenters supporting ASMFC management and 9 commenters opposed. Those opposed to ASMFC management raised concerns over the lack of confidence in the management unit split between Florida and Georgia. Several opposed commenters raised concerns that the current management unit disadvantages the states from Georgia north by reducing the available quota and that ASMFC has no ability to remedy this problem. Data was provided by one commenter (French) to support comments that the stocks of cobia along the east coast were homogeneous, suggesting they do not contain any distinct populations or are separate stocks north and south of the Florida/Georgia line.

Commenters in support of complementary management (n = 7) also supported state by state allocations (n = 5) and the flexibility of states to manage their specific quotas (n = 4).

Issue 2: Management Objectives and Goals.
Two written comments specifically expressed the need to manage cobia primarily for recreational interests and several (n=5) supported maintaining the commercial fishery as a bycatch fishery. Three commenters specifically opposed a directed commercial fishery. One commenter supported efforts to ensure predictable seasons and limits for the fishery moving forward.

Issue 3: Coast wide, regional, or state-by-state management.
Few comments directly addressed this issue. There were suggestions for various recreational and commercial management strategies but none were specifically mentioned as coast wide. As stated above, commenters that supported ASMFC involvement referenced the flexibility it provides.

Issue 4: Recreational management tools.
There were only a few specific recommendations for recreational management measures. Several supported measures to protect the larger fish (50 inches+) with slot limits. Per person limits were suggested at 1 or 2 with boat limits from 2 to 4. Individual comments included mandatory catch reporting, no circle hooks, no spearfishing or bang sticks, and prohibit gaffing.

Issue 5: Commercial Management Issues.
There were few comments specifically related to the commercial fishery**.** Specific comments (n=5) supported maintaining cobia as a bycatch fishery with a 2 fish per person limit. One commenter suggested all landings be reported in whole weight.

Cobia PID Written Comments Received

I am a charter captain in Virginia and specialize in cobia fishing. I have been fishing for cobia in Virginia for the past 25 years. Virginia's cobia fishery seems as healthy now as it has been over the last 25 years. The pressure on this fishery has increased with the advent of sight fishing in Virginia. I am pro conservation and management based on good science and data, and I truly want this fishery managed correctly. I was very involved in the federal request to close the fishery last year, and was appalled at the lack of good science and data they were using to try to close a multi-million dollar recreational fishery in our state.

I am requesting that ASMFC get on board with the management of Virginia's cobia fishery. The SAMFC does not have Virginia's interest at stake when making management decisions. Feel free to contact me if you have any questions. Thank you for your consideration in this matter.

Jorj Head
400 Claxton Creek Rd.
Seaford, VA 23696
757-262-9004

January 3, 2017

Dear Dr. Daniel

My name is Wes Blow I am a recreational fisherman in VA. I have been catching cobia in the lower Chesapeake Bay for the last 11 seasons averaging about 21 trips a year. I have caught from a few in a season my first years to about 90 a season. I have caught cobia up to 105 pounds.

Issue 1
If you use Table 4 on page 11 of the PID and add in the 2016 landings you will see that for the past 12 years VA has landed 50% of the total recreational landings north of the FL/GA line. (NC 31.7%, 10.6% and GA 7.3%) According to a MRIP catch time series query for the last 12 years 97% of the landings in VA have come from state waters and 71.8% of the landings for NC have come from state waters. So that is 89.5% of the total landings for cobia from GA north to NY for the last 12 years have come from state waters of two states. This is why I believe ASMFC should be involved in managing cobia.

I think there should be a state by state allocation system established with the individual states being able to set their own regulations and season to not exceed their allocation. I do believe a boat limit of 2 to 3 fish per day should be established. A two fish boat limit worked in VA in 2016 and I have been told by several charter captains this was not a problem.

One item that I feel is imperative to maintain a quality fishery is a coast wide rule for only one fish of a boat limit allowed to be over 50 in TL or 46 in FL. This would be to protect the larger breeding fish. Although there are far more cobia available now in the smaller sizes I have seen a decline in the larger fish in recent years.

All east coast states to NY should be included in the management plan. MRIP is not currently reporting landings north of VA but I have heard of more and more cobia caught north of VA.

Issue 2 & 3

I believe the objective for ASMFC to manage cobia should be to develop a state by state allocation system based on historical catches that allows the individual states to set regulations not to exceed the allocations. With cobia being a pulse fishery I see no other way than a state by state allocation to effectively and fairly manage cobia.

I would like to see the FMP set a coast wide boat limit of 2 or 3 fish per day with only one allowed over 50 in TL or 46 in FL. The FMP should allow the individual states to set their own seasons and size limits other than the one large fish per boat limit previously mentioned.

Issue 4

First I question the stated numbers in the background information. When I looked at NOAA Office of Science and Technology and " Run a Data Query" I get much higher percentages of fish caught in state waters.

I believe the FMP should consider some gear restrictions. I have recently heard of multiple treble hook rigs used for cobia fishing and this type of rigs should be restricted. I adamantly would oppose being required to only use circle hooks and not allowed to use single J hooks. Hook up ratios can be poor on cobia with circle hooks and of the hundreds of cobia I have caught far less than 1% are hooked with a J hook that I could not remove.

I would support prohibiting gaffing but I feel there should be an exception for pier fisherman.

Primary spawning season closures and slot limits should be considered but by individual states. What and when something is right for VA it would not be the same for GA or other areas.

Issue 5

I believe the current federal 2 fish per person for commercial fishing should be enforced in all states. Also an across the board reporting of whole weight not gutted. Commercials should be restricted from being allowed to harvest over a certain size. We need the bigger fish breeding. Primary spawning season closures are needed.

Issues 6

Protecting the larger fish is a very important issue. This can be done with only one fish of a boat limit allowed over 50 in TL or 46 in FL. Here in VA we are seeing a steady decline in large citation fish registered the last few years. No fish over 100 pounds in the last 5 years and 2016 we did not have any in the 90 pound range.

Thanks

Wes Blow

VMRC may be facing an unanticipated war with recreationals

I am in favor of more militant actions than most will support

When the humble citizen asks the government----

That is---asks the government bureaucracy for solutions, the drequessting pulbic should expect nothing more than a bumblign bureaucratic solution;

This exactly what recreationals got from the General Assembly several years when we asked for a recreational salt water fishing license---when is was finally signed by the governor, it was nothing like what we asked for nor what we expected

When the Finfish Committee asked VMRC staff to solve the Tilefish-Cobia- Amberjack problem....\ VMRC staff came up with a bureaucratic and paralyzing set of rules and regs which recreationals should never accept

Recreational salt water fishing in VA has collapsed and is a disaster for Tourism and the Tidewas\ter fishing community

JOhn Bull, Rob O reilly and VMRC staff have known a rebellion was brewing for two months....I sent an e mail . What have they done to ease the tensions of recreational salt water anglers? NOTHING !!

TIME TO ACT.

Bob Allen

Louis Daniel 2 January
2017
Fishery Management Plan Coordinator
Atlantic States Marine Fisheries Commission
1050 North Highland Street, Suite 200A-N
Arlington, Virginia 22201
Fax: (703) 842-0741
ldaniel@asmfc.org
Subject line: Cobia PID

I would like to thank you for the opportunity to comment on the Atlantic States Marine Fisheries Commission's Public Information Document for Cobia. Cobia are an important species for recreational fishers along the SE Atlantic coast, providing great sport close to shore in state waters for a few months each year. I believe they should be managed as a primarily recreational species, with an emphasis on access and abundance. Management should strive to manage the cobia resource for maximum practicable abundance

Complementary Management: it can be problematic when there is a sizeable portion of the catch in state waters, as the fishery rarely, if ever, occurs at the same time in each state, and a one-size-fits-all approach inevitably disadvantages some states. I believe a system where the SAFMC sets the overall allowable harvest level and then allows the states to tailor their harvest measures within that framework to be the best system for cobia.

Management objective: Allowing states the opportunity to set their own season and bag limits within an overall framework makes sense, as the fisheries occur at different times of the year within each state.

Coast wide, Regional or state by state approach to management: allowing the states to set their own season and bag limits within an overall framework would be preferable.

Commercial and Recreational Management Tools: The standard size limit, bag limit and season approach to managing recreational fisheries should be the proper way to manage the Atlantic cobia recreational fishery. I strongly encourage maintaining the historic bycatch management for the commercial fishery, with a 2 fish/person/day bag limit. I believe allowing a directed commercial fishery to develop would only add to problems with management, this has been seen in the State of Virginia, when the commercial regulations were liberated and the catch increased dramatically.

Thank you for the opportunity to express my comments

James D. Agee
702 Lake Dale Way

Yorktown, VA
.23693

2 January 2017
Louis Daniel
Fishery Management Plan Coordinator
Atlantic States Marine Fisheries Commission
1050 North Highland Street, Suite 200A-N
Arlington, Virginia 22201
Fax: (703) 842-0741
ldaniel@asmfc.org
Subject line: Cobia PID

The Peninsula Saltwater Sport Fisherman's Association 300 members would like to thank you for the opportunity to comment on the Atlantic States Marine Fisheries Commission's Public Information Document for Cobia. Cobia are an important species for recreational fishers along the SE Atlantic coast, providing great sport close to shore in state waters for a few months each year. I believe they should be managed as a primarily recreational species, with an emphasis on access and abundance. Management should strive to manage the cobia resource for maximum practicable abundance

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Thank you for the opportunity to express our fishing club felling about this document

David Agee

Dear sir,

Writing to express my opinion as a charter boat captain who cobia fishes on the chesapeake bay. I would like to see the ASMFC be involved n the management of cobia. I would also be in favor of a state by state allocation system based on historical catches. I would also be in favor of a coast wide boat limit with a one big fish rule such as we had here in virginia this year.

I am a virginia angler and business owner with a large investment in catching just these fish. Please consider the points i've outlined in the previous paragraph.

Thank you,
Donald Bowers
Bonita Chaser Charters

Louis Daniel
Fishery Management Plan Coordinator
Atlantic States Marine Fisheries Commission
1050 North Highland Street, Suite 200A-N
Arlington, Virginia 22201
Fax: (703) 842-0741
ldaniel@asmfc.org

subject line: Cobia PID

CCA VA would like to thank you for the opportunity to comment on the Atlantic States Marine Fisheries Commission's Public Information Document for Cobia. Cobia are an important species for recreational fishers along the SE Atlantic coast, providing great sport close to shore in state waters for a few months each year.
With regard to the question posed in the Public Information Document: "How would you like the cobia fishery and population to look in the future?" we believe they should be managed as a primarily recreational species, with an emphasis on access and abundance.
Recreational fisheries respond to increased abundance with increased trips and catch, and do the opposite with decreased abundance. Increased abundance and the resultant increase in trips maximize the economic value of the fishery to local communities. In recent years, the abundance of most recreational species in Virginia have been in a sharp decline with the exception of Cobia.

Management should strive to manage the cobia resource for maximum practicable abundance. This would necessarily mean defining a catch level at an optimum yield that is less than maximum sustainable yield in order to increase abundance.
The Atlantic States Marine Fisheries Commission (ASMFC) would like comment on four areas:
1. Complementary Management with the South Atlantic Fishery Management Council (SAFMC)
2. Management Objectives
3. Coast-wide, Regional or State-by-State Approach to Management
4. Commercial and Recreational Management Tools

1. Complementary Management with the SAFMC Currently management of cobia is entirely through the South Atlantic Fishery Management Council via their Coastal Migratory Pelagics Fishery Management Plan (FMP), with states adopting the Council's regulations. With species that are entirely or mostly caught in the Exclusive Economic Zone, this style of management can work. However, it can be problematic when there is a sizeable portion of the catch in state waters, as the fishery rarely, if ever, occurs at the same time in each state, and a one-size-fits-all approach inevitably disadvantages some states.
In this instance, with harvest in both state and Federal waters, **complementary management would seem to make the most sense**. This is very similar to the federal waterfowl framework, where the Federal government sets the general season length and bag limits and allows the states to pick the actual days they allow hunting and bag limits within that framework. CCA VA believes a system where the SAFMC allows the states to tailor their harvest measures within that framework to be the best system for cobia

2. Management Objectives The Atlantic cobia fishery has been primarily a recreational fishery and should be continued with that tenet in mind, first and foremost. As stated previously, that means managing for access and abundance. Allowing states the opportunity to set their own season and bag limits within an overall framework makes sense, as the fisheries occur at different times of the year within each state.

A secondary management objective might be to get to a point where the season and bag limit are predictable from year to year.

3. Coastwide, Regional or State-by-State Approach to Management If possible, allowing the states to set their own season and bag limits within an overall framework would be preferable.

4. Commercial and Recreational Management Tools The standard size limit, bag limit and season approach to managing recreational fisheries should be the proper way to manage the Atlantic cobia recreational fishery.

We strongly encourage maintaining the historic bycatch management for the commercial fishery, with a 2 fish/person/day bag limit. We believe allowing a directed commercial fishery to develop would only add to problems with management. We also believe that allowing a directed commercial fishery would reduce the significant value this fishery generates through recreational fishing.

Thanks again for the opportunity to comment on the Cobia PID

Frank A. Kearney III
CCA VA Government Affairs Committee
Hampton, VA 23669

Phone 757-723-7652

To whom it may concern:

ASMFC should be the agency setting allocations for recreationally caught Cobia. Virginia has no representation on South Atlantic Couincil and Va accounts for largest part of recreational Cobia catch along Atlantic seaboard.
Current regulations set by S A Council are an unbalanced hardship on recreational fishing industry here in VA

Respectfully,
Dr. Robert Allen
50+ years a recreatioonal angler in VA
1038 Port Harbour Arch
Hampton VA 23664
757 869 0157

In regards to the cobia PID document and questions, all answers are NO.

The overwhelming peer reviewed science and SEDAR 28 (last cobia stock assesment) proving the zone split of the ATLANTIC Cobia, and resulting low ACL are unfounded.

The ASMFC has no power or authority to change the zone boundary or ACL. Any involvement of the ASMFC is against the will of the majority of stakeholders in NC.
--
Jon Worthington
405 Japonica Drive
Camden NC 27921
252-562-2914

228th Session Graduate

I have noticed a decrease in the March, April cobia migration in the waters offshore Cape Canaveral. We have cobia more year round but overall it does seem to be on the decline. I think the stock is still healthy but I feel recreational fisherman need to realize less is more. I propose a 1 per person or 2 per boat whatever is less bag limit in State & Federal waters 25 inch minimum. No spear fishing or power head fishing. Here is the problem with spearing. These fish are on manta rays, mud rays and sharks. The big heavy fish are full of eggs and will not eat. The spear fishing pulls the trigger on these larger more important fish and several fish pull from the spear with not much chance of survival. However the 1 per person 2 per boat may solve all the problem. Same should apply for commercial harvest. These are bonus fish for commercial mackerel fishing and the bonus gets abused by loading several friends on a commercial boat and keeping per person when the fish concentrate due to thermo cline conditions and other factors up and down the East Coast. The commercial guys that keep their 1 or 2 as a bonus should be allowed to harvest them in that manner.

Captain Greg Rapp
321-794-3474
www.sealeveler.com
www.facebook.com/SeaLeveler
www.twitter.com/SeaLeveler2

Mr. French's email clearly outlined several points that we discovered during our continued research and I would like to reinforce our concern that the Atlantic States is repeating known misleading statements in their PID.

The entire issue with the managment of the "Atlantic Migratory Group" of cobia is the zone split and resulting ACL. This zone split and reduction in harvest was conceived first as a "want" within the SAFMC council. We have provided documents that clearly show the timelines and methods in which this zone split and reduction was achieved.

The Atlantic States has no authority or ability to fix, correct, or alter the zone split or ACL for cobia. Given the extremely low ACL, there is nothing the Atlantic States can do that would result in fair and equable access as compared to the East Coast of Florida. Tagging results from VA, NC, SC, and Gulf are clear in that certain portions of the cobia biomass migrate between the "Atlantic Group" and "Gulf Group" managment areas. To attempt to try joint managment at this point would be a pure waste of tax payer monies.

We ask that the Atlantic States hold off on any joint managment until a proper stock assessment, one that truly includes the most up to date Best Available Science is completed.

I have requested a detailed explanation as to the benefits of what joint managment could bring and have yet to receive any.

Until such time an explanation can be given, any involvement or actions by the Atlantic States, as it relates to the managment of cobia, is totally against the will of the majority of stakeholders.

Thank you
Daniel Burrus

Mr. French's email clearly outlined several points that we discovered during our continued research and I would like to reinforce our concern that the Atlantic States is repeating known misleading statements in their PID.

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Until such time an explanation can be given, any involvement or actions by the Atlantic States, as it relates to the managment of cobia, is totally against the will of the majority of stakeholders.

Thank you
Patrick Link

Dr. Daniels,

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Thank You

Cameron Whitaker

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Until such time an explanation can be given, any involvement or actions by the Atlantic States, as it relates to the managment of cobia, is totally against the will of the majority of stakeholders.

Thank you
Travis Kemp

Subject: Cobia PID

Mr. French's email clearly outlined several points that we discovered during our continued research and I would like to reinforce our concern that the Atlantic States is repeating known misleading statements in their PID.

The entire issue with the managment of the "Atlantic Migratory Group" of cobia is the zone split and resulting ACL. This zone split and reduction in harvest was conceived first as a "want" within the SAFMC council. We have provided documents that clearly show the timelines and methods in which this zone split and reduction was achieved.

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I have requested a detailed explanation as to the benefits of what joint managment could bring and have yet to receive any.

Until such time an explanation can be given, any involvement or actions by the Atlantic States, as it relates to the managment of cobia, is totally against the will of the majority of stakeholders.

Thank you,

Vandexter Williams

If you have any questions or concerns, please feel free to ask Billy Gorham or Jonathan French as they have been the forefront leaders spearheading this critical engagement in the wrong doing of our public trust.

Mr. Daniel

I am Bill Gorham owner of Bowed Up Lures and a recreational fisherman living in the Outer Banks. We have spoken via phone and met at the SAFMC meeting in South Carolina. As you know many stakeholders of who include, For Hire Captains, tackle shop owners, pier owners, rob builders, commercial watermen, and dozens of recreational anglers in NENC have entrusted Mr. French and I to speak on their behalf on matters that relate to cobia management.

Mr. French's email clearly outlined several points that we discovered during our continued research and I would like to reinforce our concern that the Atlantic States is repeating known misleading statements in their PID.

The entire issue with the managment of the "Atlantic Migratory Group" of cobia is the zone split and resulting ACL. This zone split and reduction in harvest was conceived first as a "want" within the SAFMC council. We have provided documents that clearly show the timelines and methods in which this zone split and reduction was achieved.

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I have requested a detailed explanation as to the benefits of what joint managment could bring and have yet to receive any.

Until such time an explanation can be given, any involvement or actions by the Atlantic States, as it relates to the managment of cobia, is totally against the will of the majority of stakeholders.

Thank you
Bill Gorham

I did not catch any nor did many friends that fish the early migration up the coast of NC. I guess you must have observers in another state? Where did they find 1.5 million ? I would like to try that fishery.

James Canady
Building Codes Administrator
Town of North Topsail Beach
2008 Loggerhead Court
Town of North Topsail Beach, NC 28460
910-328-1349

I think the key to better management of the recreational cobia fishery is to push for (demand) that the states provide a mandatory catch reporting system to get timely and accurate data on the catch. If recreational anglers were required to report or lose their opportunity to cobia fish the following year the regulators would have reliable data to base their fish management plans on.
bobalong1939@yahoo.com

Dear Dr. Daniels and ASMFC Commissioners,

I have had an opportunity to review the ASMFC Cobia PID http://www.asmfc.org/files/PublicInput/CobiaPID_PublicComment.pdf and would like to offer public comment.

First, there are several fundamental false assertions in the PID that fundamentally alter the management principles that should be applied. First, the PID makes the following assertion.

"SAFMC management, based on current genetic information, addresses the management of Atlantic Migratory Group (AMG) of cobia that occur from Georgia through New York (Figure 1). Cobia that occur off the east coast of Florida are part of the Gulf stock, but the SAFMC manages the portion of that stock on the Florida east coast that occurs within its jurisdiction (Florida/Georgia (FL/GA) border to the Monroe County line). Tag recapture data suggested two main 3 stocks overlap at Brevard County Florida and corroborated the genetic findings."

Unfortunately, the genetics research cited in the SAFMC rulemaking and the ASMFC advisory material is the South Carolina Department of Natural Resources Marine Resources Research Institute study titled "Population genetics of Cobia (Rachycentron canadum): implications for fi shery management along the coast of the southeastern United States" by Tanya L. Darden. The study does not conclude that there are two genetically unique populations of fish. Instead, the study determined "On the basis of a robust microsatellite data set from collections along the U.S. Atlantic coast (2008–09), offshore groups were **genetically homogenous**."

Dr. John Gold at Texas A&M (publicly available peer reviewed academically accepted research) also refuted the idea of the Gulf fish being genetically different from Atlantic cobia. Instead, he indicated that, "Cobias that were sampled from the coastal waters of Virginia, Mississippi, and Louisiana were genetically homogeneous based on assays of microsatellite genotypes and mtDNA haplotypes. This finding is consistent with observed migration patterns and tag-and-release studies of Cobias."http://agrilifecdn.tamu.edu/gold/files/2012/05/Gold-et-al.-2013.pdf

The basic fundamental issue that that the decision to split zones is based on something that is not true based on the best science available. The "genetics" argument was used to justify a split of management zones with E. Florida broken out of the Atlantic management zone. It was used to allocate 66% of the old quota to E. Florida and the Gulf. And the remaining quota was not consistent with the historic catch data, especially in the last five years where a much larger percentage of cobia are caught in Virginia waters than south of Cape Hatteras. We have had an opportunity to present this to SAFMC, however outside of a brief public comment window that I was provided (inappropriately, as the public comment was offered AFTER a motion was made) at the May ASMFC meeting, the ASMFC membership has not been provided with these details. This information was absent from all the meeting briefing materials and was not mentioned in the PID. It calls into credibility Dr. Daniels objective leadership on the issue, and given his past actions associated with violating open meeting laws in North Carolina, we ask for him to be recused.

The cited genetics research also speculates about the presence of a genetically unique species of cobia in Virginia waters. Since this study was conducted exclusively in South Carolina and no actual intercepts were cited, we don't regard this assertion as scientifically credible. We do, however, assert that SAFMC and SEDAR (which does not survey stock in Virginia waters) has GROSSLY underestimated the size of the cobia population that spends the entire summer in the Chesapeake Bay. The corresponding ACL does not come anywhere close to representing maximum sustainable yield for that population.

For the following questions:
Are consistent, state-specific management measures, coordinated by the Commission, needed for cobia? ¬ Are there regional differences in the fishery and/or resource that need to be considered when implementing management measures? ¬ Should the FMP require a coast-wide closure if the SAFMC ACL is met? ¬ Should the FMP require a coastwide measures (e.g., size and bag limit)? ¬ Should the FMP require regional measures? ¬ Should the FMP develop a suite of options for the allocation of state- specific quotas, and allow states to adopt unique size, bag, and season measures? ¬ Should states be permitted to submit proposals for alternative management that is conservationally equivalent to the required management program (e.g., a less restrictive bag limit given a more restrictive minimum size limit)?

The answer for all these questions is simply no. ASMFC should call on SAFMC to correct the errors within Amendment 28 of the federal FMP. SAFMC is making what I hope is a good faith effort to correct these issues. SAFMC has called for a new cobia management amendment, and a new stock assessment has been scheduled for the near future. Regulating based on a fundamental falsehood is not best science available, does not achieve a maximum sustainable yield, and therefore is a prime violation of National Standard 1 and 2 of the Magnuson Stevens Act.

We ask ASMFC to act accordingly. Please review and do not take action until SAFMC addresses these issues.

Thank You,
Jonathan E. French
Falls Church, VA

Note: Mr. French submitted several emails to Commissioners during the comment period.

Virginia Saltwater Sportfishing Association, Inc (VSSA)

PO Box 28898
Henrico, VA 23228
www.ifishva.org

Mike Avery
President

Curtis Tomlin
Vice President

Kevin Smith
Treasurer

Brent Bosher
Secretary

Board of Directors

John Bello,
Chairman

Dr. Robert Allen

Mike Avery

Jerry Aycock

Brent Bosher

Jerry Hughes

Doug Ochsenknecht

Bob Reed

Mike Ruggles

Kevin Smith

Murphy Sprinkle

Curtis Tomlin

Atlantic State Marine Fishery Commission
1050 N. Highland Street, Suite 200 A-N,
Arlington, VA 22201

Dear Mr. Daniels, December 22, 2016

The Virginia Saltwater Sportfishing Association (VSSA) is a growing organization of recreational fisherman in the Commonwealth of Virginia. Our mission includes representing the interests of Virginia's recreational saltwater anglers, ensuring the long-term sustainability of Virginia's fisheries, while protecting Virginia's marine, boat, and tackle industry jobs.

VSSA, along with hundreds of cobia anglers in NC and VA, **strongly oppose ASMFC joint or complimentary management of cobia** for the following reasons:

- The notion of overfishing or exceeding the Annual Catch Limit (ACL) is artificially driven by the unfair, poorly executed zone split by SAFMC granting east Florida more than their fair share of the ACL leaving GA-NY with a small fraction of what should have been allocated. The numbers clearly reflect the true Atlantic coast is not being overfished by any significant amount. There is nothing the ASMFC can do to change this situation by getting involved.
- There are only 4 states that have a vested interested, GA, SC, NC, and VA. The other voting states in ASMFC have no interest in this matter so there is no reason to force all the other states along the Atlatic coast to vote. If anything, some of the other states will want their fair share of the unfairly allocated ACL exaberating the problem even farther by ASMFC allocating an ever shrinking ACL to individual states.
- With ASMFC's authority to regulate catches in state waters, the angling public will no longer be able to influence our individual state commissioners to influence limits and seasons when the SAFMC clearly is not doing their due dilligence in managing cobia.

We respectfully request ASMFC hault any plans to jointly manage cobia with SAFMC. Once a new, fair, stock assessement is complete, then ASMFC should consider this action but not before. Additional information is enclosed.

If you have any questions, please contact me phone or e-mail, ifishva@gmail.com, or my phone: 757-329-5137.

Sincerely,

Mike Avery

Mike Avery, President

The PID makes a fundamental false assertion. The Denson/Darden South Carolina Department of Natural Resources study of cobia genetics cited by SAFMC, the PID, and the SEDAR 28 CLEARLY states "On the basis of a robust microsatellite data set from collections along the U.S. Atlantic coast (2008–09), offshore groups were genetically homogenous. However, the 2 sampled inshore aggregations (South Carolina and Virginia) were genetically distinct from each other, as well as from the offshore group." http://fishbull.noaa.gov/1121/darden.pdf

Note, SEROs own genetics science in NO WAY substantiates the justification given for the management zone split given by SEDAR28 and SAFMC. It directly refutes the claim.

Migratory cobia being genetically homogeneous is supported by Dr. John Gold at Texas A&M (publicly available peer reviewed academically accepted research.) Instead of saying that there are two genetic groups of cobia in the Gulf and Atlantic, he indicated that, "Cobias that were sampled from the coastal waters of Virginia, Mississippi, and Louisiana were genetically homogeneous based on assays of microsatellite genotypes and mtDNA haplotypes. This finding is consistent with observed migration patterns and tag-and-release studies of Cobias."http://agrilifecdn.tamu.edu/.../2012/05/Gold-et-al.-2013.pdf

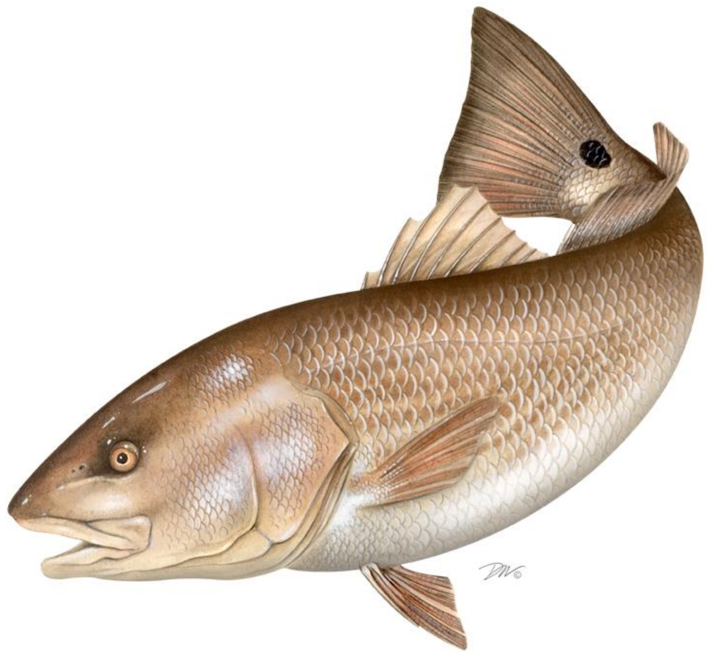
The basic fundamental issue that that the decision to split zones is based on something that is not true based on the best science available. Yet, here is the justification in the PID: "SAFMC management, based on current genetic information, addresses the management of Atlantic Migratory Group (AMG) of cobia that occur from Georgia through New York (Figure 1). Cobia that occur off the east coast of Florida are part of the Gulf stock, but the SAFMC manages the portion of that stock on the Florida east coast that occurs within its jurisdiction (Florida/Georgia (FL/GA) border to the Monroe County line). Tag recapture data suggested two main 3 stocks overlap at Brevard County Florida and corroborated the genetic findings."

The Magnuson Stevens Act MANDATES that the regional commissions use the best science available. Clearly SAFMC and SERO have not. Before ASMFC completes a complimentary fisheries management plan, SAFMC must complete the stock ID workshop and stock assessment (currently scheduled for 2017 and 2018 respectively) to correct this issue. Only then would it be appropriate for complimentary management. Our recommendation is that ASMFC immediately stop any development of a fisheries management plan until SAFMC has completed the new stock ID workshop and stock assessment so the resulting ACL and allocation appropriately reflects the best science available.

Virginia Saltwater Sportfishing Association
PO Box 28898, Henrico, VA 23228
www.ifishva.org

Atlantic States Marine Fisheries Commission

Red Drum Assessment for Peer Review



November 2016

Vision: Sustainably Managing Atlantic Coastal Fisheries

Atlantic States Marine Fisheries Commission

Red Drum Stock Assessment

November 2016

Prepared by the
ASMFC Red Drum Stock Assessment Subcommittee:

Ms. Angela Giuliano, Maryland Department of Natural Resources
Ms. Carolyn Belcher, Georgia Department of Natural Resources
Dr. Steve Arnott (Chair), South Carolina Department of Natural Resources
Mr. Jeff Kipp, Atlantic States Marine Fisheries Commission
Mr. Lee Paramore, North Carolina Division of Marine Fisheries
Mr. Mike Murphy, Florida Fish and Wildlife Research Institute (Retired)
Mr. Mike Schmidtke, Atlantic States Marine Fisheries Commission
Mr. Ryan Jiorle, Virginia Marine Resources Commission

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Acknowledgments

The Atlantic States Marine Fisheries Commission (ASMFC or Commission) thanks all of the individuals who contributed to the development of the red drum stock assessment. The Commission specifically thanks the ASMFC Red Drum Technical Committee (TC) and Stock Assessment Subcommittee (SAS) members who developed the consensus stock assessment report.

Executive Summary

During the SouthEast Data, Assessment, and Review (SEDAR) 44 Benchmark Stock Assessment for red drum (SEDAR 2015b), assessment models were developed with the Stock Synthesis 3 (SS3) integrated analysis framework (SS3, Methot 2013). Models using this framework were not accepted by the South Atlantic State/Federal Fisheries Management Board (Board) due to concerns with the reliability of population parameter estimates. Instead, the Board tasked the TC and SAS to evaluate the utility of the statistical catch-at-age (SCA) models used in the previous benchmark assessment (SEDAR18; SEDAR 2009) for management advice. The SAS explored several potential changes to these models, including data changes, but ultimately recommended models with minimal structural changes for management advice. This report includes results of the SCA models for both the northern and southern red drum stocks. For assessment terms of reference (TORs) and information on red drum life history, management, and data, including model data inputs, see the SEDAR 44 Data Workshop Report (SEDAR 2015b).

The northern and southern red drum stocks were assessed relative to static spawning potential ratio (sSPR) reference points defined in Amendment 2 to the Red Drum Interstate Fisheries Management Plan (ASMFC 2002). The 2011-2013 three year average sSPR was estimated to be 43.8% in the northern stock and 53.5% in the southern stock, both above the sSPR30% threshold and sSPR40% target, indicating that overfishing is not occurring. However, most of the issues that arose with the models during SEDAR18 remained. Abundance estimates of older fish continued to be more uncertain and, particularly in the southern stock, had large standard errors. Similar to SEDAR18, initial abundance estimates of older fish (ages 7^{+}) were unrealistically large for the northern stock. Abundance estimates in the south were so uncertain that they are likely indicative only of relative trends. Therefore, an abundance or biomass status (overfished/not overfished) could not be determined for either stock. In addition, the estimation of sSPR was much more uncertain in the south. Most of the sensitivity runs that were conducted for the southern model, however, suggested that the sSPR likely is above the threshold.

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1. Methods

A standard statistical catch-at-age (SCA) model was used for red drum, which included special features for capturing some information from tagging programs and restricting the selectivity estimated for older fish. These analyses were defined for the period 1989-2013 and included age-specific data for red drum ages 1 through 7^+.

1.1. Data Sources

The observed data used in the analyses for the southern and northern stock of red drum included the total annual harvest (landings plus release mortalities) attributed to each fishery, the estimated age-proportions in these annual harvests, indices of abundance, and for the northern model, tagging derived instantaneous fishing mortality-at-age (F-at-age) for harvested fish and full instantaneous fishing mortality (F) for released fish. For all observed data, measures of precision were available for use in the models. Data input files are in appendices A and B for the northern and southern stocks, respectively.

In the SCA framework all input data can be considered as “tuning” indices. The inputs included the 1989-2013 total annual kill of red drum by the northern fisheries: commercial gillnet and beach seine, other commercial gears (mostly pound nets and seines), recreational landings, and recreational live release mortalities. Recreational catch estimates were calibrated following methods in working paper SEDAR44-DW04. Since the commercial fishery statistics are considered a complete census of the landings, the coefficients of variation (CV = standard error / mean) for each year’s landings was assumed low, at 0.01. The CVs for the annual recreational harvest and the annual live release mortalities were taken as the proportional standard errors (PSEs) estimated for the Marine Recreational Fisheries Statistics Survey’s (MRFSS) and Marine Recreational Information Program’s (MRIP) Type A+B1 catch (landings) and Type B2 catch (live releases), respectively. The 1989-2013 southern stock’s total annual landings of red drum were grouped as: Florida recreational landings, Georgia recreational landings, South Carolina recreational landings, Florida live release mortalities, and Georgia/South Carolina live release mortalities. The CVs associated with these estimates were derived as explained above for the northern stock recreational catches.

The input data for the age compositions (SEDAR44-DW06) of the catch from the fisheries listed above were generally derived from random fish length samples taken from the catch that were then converted to ages using various age-length keys. The age data were rarely available directly for the recreational live release fisheries, but some information was available from angler-taken measurements of released fish. These data sources included the volunteer logbook program from Florida and reported recaptures of tagged fish which were released alive in North Carolina and South Carolina. These data were deemed sufficient for the South Carolina and Georgia live release fisheries but not for the northern stock or for the Florida live release fishery where North Carolina tagging study results (Bacheler et al. 2008) were used to infer the catch age-structure. The use of South Carolina tag recapture data, rather than data from a two year log book study conducted by South Carolina, for estimating the age composition of the live release fishery is a data change since SEDAR18 (SEDAR 2009).

The age composition proportions were represented as a multinomial distribution so the number of aged fish in the annual samples indicated the precision of the observed proportions. Because these ages weren't direct random samples from the catch, the SAS used what were assumed to be independent sampling events as sample sizes (e.g., longline set, tow, etc.) with a minimum level of two used for the years when no age-length data were available. This minimum sample size of two was also used for the age composition data estimated for the Georgia/South Carolina live release fishery. These sample sizes were then scaled to a maximum of 50 to avoid assigning too much precision to the composition data relative to other data components.

Indices of abundance are used in the assessment model to "tune" agreement between the model- predicted and observed trends in abundance. For the northern stock, five indices were used to model trends in abundance (Table 1). Two indices measured young-of-the-year (age 1) abundance: the North Carolina Independent Gillnet Survey (IGNS) and the North Carolina bag seine survey, though the former was for late year age-1 red drum and the latter was for the beginning-of-the-year age-1 fish. The other juvenile indices of abundance used in the northern stock were the IGNS catch rates for age-2 red drum (mid-year) and the MRIP total catch rate (assumed to apply to the aggregate late year abundance of ages 1-3). The final index of abundance for the northern stock, which was used for the first time with this benchmark assessment, was the North Carolina longline survey which is assumed to track aggregated relative abundance of age 7^+ fish later in the year.

For the southern stock, there were eleven indices of abundance (Table 2). Four indices measured young-of-the-year trends: the Florida small seine survey, the Georgia monofilament gill net survey, the South Carolina stop net survey, and the South Carolina trammel net survey. The Florida survey was compared to beginning-of-year abundance, the Georgia survey was compared to mid-year abundance, and the last two surveys were compared to late year abundance estimates. Other age-specific surveys included: the Florida haul seine survey used separately for age-2 and age-3 and the South Carolina trammel net survey for age-2, all compared to mid-year abundance. Finally, four pooled-age indices were used: MRIP for ages 1-3, the Georgia longline survey (ages 7^+), the South Carolina 1 mile longline survey (7^+), and the South Carolina 1/3 mile longline survey (ages 7^+). The MRIP survey was used to indicate mid-year abundance; the longline surveys for abundance had survey mid-points 11 months into the calendar year. Estimated annual arithmetic means or standardized year effects and their CVs were used for all indices. Index values were all scaled to means for use in the model. Index choices represent the major data changes since the last benchmark assessment (SEDAR 2009). The South Carolina electrofishing survey was used in SEDAR18 but removed in this assessment. The new indices used included the South Carolina stop net survey, the South Carolina age-1 trammel net survey, the South Carolina 1/3 mile longline survey, and the Georgia longline survey.

Less conventional "tuning" was provided by estimates of age-specific instantaneous F available from a long-term tag-recapture program conducted in North Carolina (Bacheler et al. 2008). In the northern stock, estimates for F-at-age were available for the combined harvest fisheries (commercial and recreational A+B1). These estimates and associated CVs were used to "tune" the model-estimated F-at-age for ages 1-4^{+} during 1989-2004. The 1989-2004, annual fully recruited Fs estimated for the live releases were also used to compare against that fishery's fully recruited Fs estimated within the model. Only the fully recruited Fs were fit, as the selectivity-at-age information was also used to estimate the age composition of the live release fishery mortality in the northern model.

The temporal and age framework for these analyses for both the northern and southern stock models was 1989-2013 and ages 1-7^{+}. The assessment model was configured under the separability assumption that there was a year-specific apical F for each fishery and age-specific selectivities as portions of this fully recruited F. Selectivities were estimated for ages 1-5^{+}, with selectivity for age 4 and 5^{+} fish estimated as proportions of age-3 selectivity (constrained to the bounds of 0 and 1). These estimated proportions of age-3 selectivity, or selectivity constraints, were assumed to be the same for all fleets and were time invariant. The selectivity blocks used for the northern stock were 1989-1991, 1992-1998, and 1999-2013 for all fisheries, chosen mostly to reflect changes in size limits in North Carolina where the vast majority of landings, on average, occur (Table 3). In the southern stock, where regulatory actions were not as coincidental among the states, constant selectivity within each fishery was assumed to occur during: 1989-2013 for the Florida recreational fisheries (both harvest and live release); 1989-1991, 1992-2001, and 2002-2013 for the Georgia recreational harvest fishery; 1989-1993, 1994-2000, 2001-2013 for the South Carolina recreational harvest fishery; and 1989-1991, 1992-2013 for the Georgia/South Carolina pooled recreational live release fishery (Table 4). Selectivity was not estimated for the Florida recreational live release fishery. The selectivity for this fishery was assumed equal to the North Carolina tagging study findings for the period 1999-2004. During this period there were generally similar size limit regulations in place in North Carolina that corresponded to the Florida selectivity period (1989-2013).

Natural mortality (M) was assumed constant over time, though varying with age, for each stock (Lorenzen 1996). M for the northern stock was the same as estimated in SEDAR18 (SEDAR 2009). For the southern stock, M was updated to match the M estimated in SEDAR44 (SEDAR 2016). In SEDAR18, one maturity schedule was used for both the northern and southern stocks (SEDAR 2009). For this assessment, maturity-at-age was determined separately for the northern and southern stocks using North Carolina and South Carolina data (SEDAR44-DW02). Weights-at-age were estimated in SS3 for each stock (SEDAR44; SEDAR 2016).

1.2. Model Configuration and Equations

The population dynamics models were based on annual fleet- and age-specific separable F :

$$F_{f,y,a} = F^{*}_{f,y} s_{f,y,a},$$

where $F_{f,y,a}$ is the instantaneous F caused by fleet f in year y on age a fish, F* is the apical F for fleet *f* in year *y*, and *s* is the selectivity, a bounded number ranging from zero to one. Given red drum's inherent reduced vulnerability after age-3 due to their movement from estuarine waters to nearshore waters and more recently to enacted maximum size limits, the selectivity for ages-4 and 5^+ fish were restricted to be between 0-100% of the selectivity at age-3. Selectivity was therefore estimated for ages 1-3 in each of the time periods for which the selectivity was assumed not to have changed for each fishery. Selectivity for ages 4 and 5^+ was derived from the estimated age 3 selectivity for a given time period and the proportional selectivity parameters for ages 4 and 5^+. These proportional selectivity parameters were assumed to be constant across selectivity blocks and fleets.

The abundances of the different age groups in the population are modeled forward in time beginning with estimates for a series of recruits ($N_{y,1}$ in 1989 through 2013) and an initial year's abundance-at-age ($N_{1989,a}$ for ages 2-7^+). These initial conditions were both modeled as lognormally distributed variables. From these starting abundances, older ages are sequentially modeled as:

$$N_{y+1,a+1} = N_{y,a} e^{-\sum_f F_{f,y,a} - M_a},$$

where M_a is the age-specific instantaneous M rate. A "plus" group abundance included survivors from both the previous year's plus group and that year's next-to-oldest age group

$$N_{y+1,A} = N_{y,A-1} e^{-\sum_f F_{f,y,A-1} - M_{A-1}} + N_{y,A} e^{-\sum_f F_{f,y,A} - M_A},$$

where *A* is age 7^+.

The observation model for these analyses involves total catch, the proportion of the fleet- and year-specific catch in each age group, and indices of abundance. The fleet- and year-specific predicted catch-at-age, $C_{f,y,a}$, was calculated using the Baranov catch equation:

$$\hat{C}_{f,y,a} = N_{y,a} \frac{F_{f,y,a}}{\sum_f F_{f,y,a} + M_a} \left(1 - e^{-\sum_f F_{f,y,a} - M_a}\right),$$

with the annual total catch for each fleet determined by summing across ages and the proportion-at-age in the catch determined from the age-specific catch relative to this annual total. The observed catch has an assumed lognormal error, ε_{fya}, from the true catch and the model estimates the true catch.

Indices of abundance were assumed linearly related to the stock abundance of chosen age group(s):

$$\hat{I}_{s,y} = q_s N_y,$$

where $I_{s,y}$ is the predicted index of relative abundance for the age(s) caught by survey *s* in year *y*, q_s is the proportionality constant for survey *s*, and N_y is the abundance for the age(s) included in the index.

The objective function used to confront the observation model predictions with the observed data contained abbreviated lognormal negative log likelihoods for fleet- and year-specific total catch and annual indices of abundance where:

$$negLL\left(\mathrm{T}_{f}\right)=\sum_{y}\left(0.5\frac{\left(\ln\left(\overset{o}{T}_{f,y}+1.e^{-6}\right)-\ln\left(\sum_{a}\hat{C}_{f,y,a}+1.e^{-6}\right)\right)^{2}}{\sigma_{f,y}^{2}}+\ln\left(\sigma_{f,y}\right)\right)$$

where $T_{f,y}$ is the observed total number killed each year y by fleet f and $\sigma_{f,y}$ is the standard error of the total catch within each fleet each year. The variance was estimated from the reported CVs using $\sigma^2=\ln(CV^2+1)$. The CVs were available for the recreational fisheries as the proportional standard error (PSE) and were assumed low (0.01) for the commercial fisheries. Likewise, the negative log likelihoods for the indices of abundance were:

$$negLL\left(\mathrm{I}_{s}\right)=\sum_{y}\left(0.5\frac{\left(\ln\left(\overset{o}{I}_{s,y}+1.e^{-6}\right)-\ln\left(q_{s}\sum_{a}\hat{N}_{y,a}+1.e^{-6}\right)\right)^{2}}{\sigma_{s,y}^{2}}+\ln\left(\sigma_{s,y}\right)\right)$$

where $I_{s,y}$ is the observed index for the age(s) in the survey in year y, and $\sigma_{s,y}$ is the standard error of the survey index in year y, estimated from the original data or from a standardization procedure, e.g. delta lognormal method (Lo *et al*. 1992). Of course, in the case of multi-age indices, estimated abundances across these ages would be compared to the index value.

For the catch proportion-at-age, a multinomial negative log likelihood was used:

$$negLL\left(P_{f,y}\right)=-\sum_{a}\left(n_{f,y}\left(\overset{o}{P}_{f,y,a}+1.e^{-6}\right)\ln\left(\frac{\hat{C}_{f,y,a}}{\sum_{a}\hat{C}_{f,y,a}}+1.e^{-6}\right)\right)$$

where $P_{f,y,a}$ is the observed proportion-at-age a in the total catch for fleet f in year y and $n_{f,y}$ is the sample size for aged fish. These components were not included for the fleets where the selectivity estimates based on tagging were used (northern live release recreational fishery and the southern stock's Florida recreational live release fishery).

There were additional observed data derived from a long-term tag-recapture study conducted in North Carolina that was utilized in the northern stock analyses. The estimated F-at-age and their standard errors for the pooled harvest (kept) fisheries in the north during 1989-2004 were included in the northern stock's objective function as:

$$negLL\left(F_{tag(y)}\right)=\sum_{y}\left(0.5\frac{\left(\ln\left(F_{tag(y,a)}\right)-\ln\left(\sum_{f}\hat{F}_{f,y,a}\right)\right)^{2}}{\sigma_{tag(y,a)}^{2}}+\ln\left(\sigma_{tag(y,a)}\right)\right)$$

where $F_{tag(y,a)}$ and $\sigma_{tag(y,a)}$ are the observed F and its estimated standard deviation for year *y* and age *a*. The estimated *F*-at-age were only tallied for the recreational kept and commercial fisheries. Likewise, F-at-age estimates for the recreational live release fishery were available for the period 1989-2004 from the tagging program. However, since the selectivity vectors from this program were used as input parameters because of the lack of observations for the catch-at-age for this fishery, only the information from its fully-recruited *F*s were used in the northern stock's analysis:

$$negLL\left(F_{full(y)}\right)=\sum_{y}\left(0.5\frac{\left(\ln\left(F_{full(y)}\right)-\ln\left(\hat{F}_{full(y)}\right)\right)^{2}}{\sigma_{full(y)}^{2}}+\ln\left(\sigma_{full(y)}\right)\right)$$

where $F_{full(y)}$ and $\sigma_{full(y)}$ represent the fully recruited *F*s for the recreational live release fishery and its standard deviation.

The final component of the objective function included the sum of squares for the log of the unstandardized (to unity) selectivitities for each fleet-specific selectivity period for ages 1 through 3. These values were configured as a deviation vector whose sum equaled zero. This added stability to the solution search routine.

The resulting objective function included input weights (*λ*s) for the different likelihoods that reflected the relative perceived levels of accuracy associated with the estimation equations for the predicted values. The final objective function was:

$$ObjFunction=\sum_{f}\left(\lambda_{TC(f)}negLL\left(T_{f}\right)\right)+\sum_{f,y}\left(\lambda_{P(f,y)}negLL\left(P_{f,y}\right)\right)+\sum_{s}\left(\lambda_{s}negLL\left(I_{s}\right)\right)+\sum_{1989}^{2004}\left(\lambda_{Ftag}negLL\left(F_{tag(y)}\right)\right)+\sum_{1989}^{2004}\left(\lambda_{Ffull}negLL\left(F_{full(y)}\right)\right).$$

Note that the F_{tag} and F_{full} negative log-likelihoods were not part of the southern stock analyses.

1.3. Parameters Estimated

Parameters were estimated for: age 1-3 selectivity during each block of years within a fishery where selectivity was assumed constant, age 4 and age 5^{+} selectivity as a proportion of age-3 selectivity, the fully recruited instantaneous F (also referred to as apical F) for each fishery each year, the initial abundance for ages $2\text{-}7^{+}$, annual recruitment (1989-2013), and catchability coefficients for each survey. All parameters were estimated in log space. For the northern stock, 165 parameters were estimated (Table 5) and for the southern stock, 196 parameters were estimated (Table 6).

The observed data for these analyses included: total annual kill by fleet, CVs for total annual kill by fleet, proportion-at-age each year, effective number of ages sampled each year for each fleet, F-at-age for the combined “harvest” fleets during 1989-2004 (northern stock only), CVs for F-at-age for the combined “harvest” fleets during 1989-2004, fully-recruited F for recreational live release fishery during 1989-2004 (northern stock only), CVs for fully-recruited F for the recreational live release fishery during 1989-2004, annual survey catch per unit effort, and CVs for annual survey catch per unit effort. There were 783 observations (data points), not including CVs for many of the data points or aged sample-size observations, in the northern stock (Table 7) and 976 in the southern stock (Table 8).

There were a number of input parameters (part of model structure) that were assumed to be known and without error. These input parameters included: M-at-age, defined periods of constant selectivity, selectivity for all ages for Florida and northern recreational live release fisheries, release mortality, ages selected for each survey, survey time of year, and external weights for likelihoods from fleet-specific total catch.

1.4. Evaluation of Model Fits

The SAS carried over a number of hypotheses in relation to the data sets developed in the previous benchmark assessment (Tables 9 and 10) and used the total standardized residual sum of squares (RSS), visual inspection of data fits, index standardized residual sum of squares, and qualitative evaluation of age 4 and 5^+ proportional selectivity parameter estimates (i.e., estimates away from the upper bound of 1) as criteria for choosing the most appropriate formulation.

1.5. Uncertainty and Measures of Precision

Estimated CVs (or PSEs) were used as measures of the precision for observed kill, index, and tagging F data. For the proportion-at-age data, the sample sizes and proportion indicated the precision of the observed data. For the model-estimated parameters, asymptotic standard errors were estimated during the model fitting process. The precision of important derived values, e.g., terminal three year average sSPR, was explored by describing their likelihood profiles. The implied precision from likelihood profiles is probably too great (i.e., narrow) given that there were no errors associated with input parameters, e.g., M-at-age, and the standard deviations of the standardized residuals (SDSR) often departed significantly from 1.0. This would suggest that there was additional “process error” that was not included in the model. For these reasons, the precision of the estimated parameters and derived values is almost certainly too great, i.e., confidence bands are too narrow. Iterative reweighting was done in sensitivity runs to acknowledge the additional “process error” not included in the base model and achieve “expected” fits to data (Francis 2011; SEDAR 2015a). SDSRs were calculated for each data component with input precision. Input precision was iteratively adjusted in subsequent model runs for each index and, in the north, tag data component, for those indices that had SDSRs that exceeded the upper bound suggested by Francis (2011) for a given number of observations. This process was repeated until all SDSRs fell below their upper bounds. Additional sensitivity runs were conducted to evaluate the effects model and data assumptions had on model fits and estimates. Additionally, a five year retrospective analysis was completed to determine whether there was any directional bias in the estimates as years were removed from the model.

1.6. Benchmark and Reference Points

The ASMFC (2002) defines the overfishing threshold for red drum to be 30% static spawning potential ratio (sSPR) and a management goal (fishing target) of 40% sSPR. Due to the noisiness of the data and the general imprecision of terminal year F estimates, the reviewers in SEDAR18 recommended using a three year average for management of red drum. The benchmarks estimated for this assessment include the sSPR, three year average sSPR, and escapement rate through age-5.

The sSPR is calculated as the spawning stock biomass per recruit expected under the current year's fishing regime divided by the theoretical spawning stock biomass under no fishing. This was calculated as:

$$sSPR_y = \frac{\sum_a Mat_a B_a \prod_1^a e^{-M_a - F_{y,a}}}{\sum_a Mat_a B_a \prod_1^a e^{-M_a}}$$

where Mat_a and B_a are the maturity- and weight-at-age vectors through the maximum ages (62 years in north and 41 years in south), respectively.

A more readily "observable" metric for red drum, that is very similar to sSPR when there are low levels of F on mature adults, is the escapement rate. Past assessments (Vaughan and Carmichael 2000) presented estimates of escapement through model age-3. During the most recent benchmark assessment (SEDAR 2009), it was determined that it may be more useful to encompass more of the immature portion of the stock in the escapement estimate, so escapement estimates through age-5 are presented in this assessment. Because there are a large number of adult age groups (ages 6-62 in the north and ages 6-41 in the south) assumed to have the same low level of F as for age-5 in the sSPR calculation, escapement rates are always higher than the sSPR. If there was no F on mature adults then escapement would equal sSPR levels. Static, or year-specific, escapement (sEsc) was defined as:

$$sEsc_y = e^{\sum_{a=1}^{T} -F_{y,a}}$$

where T is age-5. The cohort- specific escapement (tEsc), which defines the escapement rate for the cohort completing its final "escapement" age that year, is:

$$tEsc_y = e^{\sum_{a=1}^{T} -F_{y-T+a,a}}$$

2. Results

2.1. Northern Stock

The model with the lowest RSS from the data weighting hypotheses was the model with the total catch unity weighted, the indices unity weighted, the recreational harvest proportion-at-age data downweighted by 0.01, and the tagging data unity weighted (Table 11). This was the same model weighting that was chosen as the base model in SEDAR18. The fit of the model was reasonable overall and this model met all other fitting criteria. The fit was very good for the commercial catch data with very low RSS values and low SDSRs (Table 7 and Figures 1 and 2). The fit was not as good to the recreational catch data, particularly the recreational kept fleet which had a SDSR close to 2 and had poor fit in the 1990s. However, most recreational catch estimates were within the errors of the observed recreational data (Figure 1). The SDSR of the proportion-at-age data was low indicating good model fits (Table 7 and Figure 3). The index data were generally fit well (Figures 4 and 5), though all but the adult longline survey were overdispersed (SDSRs >2, Table 7). Most indices were estimated within the errors of the observed indices. The RSS values were highest for the North Carolina JAI and the MRIP indices due to the fitted model missing some of the peaks in the observed data. For the auxiliary tagging data, the fits were relatively good for age-1 and age-2 and not as good for age-3 and age-4 (Table 7 and Figure 6). The fit was very good to the full F of the release fishery (Table 7 and Figure 7).

Recruitment in the north was marked by large year classes in model years 1998, 2008, and 2012, corresponding to the 1997, 2007, and 2011 year classes (Table 12 and Figure 8). The 2012 recruitment was particularly large, approximately twice as large as any other between 1989 and 2013. As in SEDAR18, recruitment in the northern stock was estimated very precisely.

Total abundance in the northern stock shows a marked decline due to the decline in abundance of older ages (Table 13 and Figure 9). As with recruitment, the strong 2011 year class is evident in the estimates of age 1-3 abundance and total abundance in 2012 and 2013. Similar to SEDAR18, this marked decline is due to a decline in age 7^{+} abundance and may be an artifact of the assessment model, particularly the assumption of fixed selectivities for the live release fleet and the North Carolina longline survey time series being so short (only seven years).

The selectivities for each fleet and age for the three selectivity blocks are shown in Figure 10. For the kept fisheries (commercial gill net beach seine (GNBS), commercial other, and recreational harvest), peak selectivity occurred at age-2 across all selectivity blocks. The selectivity curves in the last selectivity block (1999-2013) are the narrowest and the kept selectivities are wider in earlier time blocks (broader slot range prior to 1992). The recreational live release fishery selectivities were fixed based on external tag-based estimates (Bacheler et al. 2008) but as with the kept fisheries, the selectivity in the most recent time block also peaked at age-2 before dropping to low levels.

F by year, age, and fleet are shown in Table 14 and the total F-at-age is shown in Table 15. The highest fleet specific F rates occur in the recreational harvest and commercial GNBS fleets (Figure 11). F rates are generally very low in the commercial other and recreational release fleets. Fs were particularly high in 1989 and 1990 before declining in 1991. The F rates have been generally low in all of the fleets with the exception of peaks as year classes have moved through the fisheries.

Correlation of model parameters with absolute values greater than 0.90 are in Table 16. All correlations above this threshold are between commercial F estimates and subsequent year commercial F estimates or prior year recruitment estimates.

2.1.1. Stock Status

Static and transitional escapement rates for ages 1-5 are shown in Table 17 and Figure 12. Escapement was low in the late 1980s and early 1990s and increased through the mid-1990s. Values have been fairly high and stable since around 2000, though there may be a slight decrease in the most recent years, particularly in 2012.

The sSPR increased throughout the 1990s (Table 18 and Figure 13). While the data is quite noisy, it appears to have been generally high in the 2000s and decreasing in recent years. In 2013, sSPR was estimated at 50.4% in the northern stock. Similar to the sSPR estimates, the average sSPR increased throughout the 1990s and peaked in 2005 before starting to decline (Table 18 and Figure 14). However, the 2011-2013 average sSPR is 43.8%, above the target (40%) and threshold (30%) values. Using ADMB's likelihood profile capabilities, the posterior probability density of the 2013 three year average sSPR was estimated. This estimation suggests that it is likely that the terminal year average sSPR estimate is above the management sSPR threshold of 30% (Figure 15).

2.1.2. Retrospective Analysis

In general, the model was very insensitive to removing years of data and estimates in recruitment and three year average sSPR were very consistent (Figure 16). The only exception was when the model only had data through 2010. In this model run, the recruitment estimates were slightly higher and the three year average sSPR was lower.

2.1.3. Sensitivity Analysis

In SEDAR18, the northern model was very sensitive to the inclusion of the tag-based F data and the TC felt that this necessitated a sensitivity run in this assessment. The removal of the tag-based F data did not affect the estimates of recruitment and resulted in slightly higher three year average sSPR estimates (Figure 17). The main effect the removal of the tagging data had was to increase the confidence intervals of the recruitment and three year average sSPR estimates. As the tagging data only span 1989-2004, it may be that the addition of nine years of data has lessened the impact the tagging data has on the model results.

Sensitivity analysis was conducted to determine the influence of each index of abundance on the model (Figure 18). Most of the model runs converged on a similar three year average sSPR value. The removal of the North Carolina IGNS age-1 index and the North Carolina JAI initially resulted in a lack of model convergence. Convergence was able to be achieved, however, by adjusting the bounds on the selectivity constraint parameters which changed the starting values of these parameters. When either the North Carolina IGNS age-1 or North Carolina JAI were removed, this resulted in lower sSPR values in the early part of the time series but similar sSPRs in the later part of the time series. The removal of the MRIP index, by comparison, gave similar three year average sSPR estimates in the early part of the time series but resulted in lower sSPR values at the end of the time series. The removal of the MRIP index was the only one of these model runs that resulted in the terminal year estimate of three year average sSPR to fall below the management threshold.

A sensitivity run was also conducted using iterative reweighting as suggested by the review panel in SEDAR18. The CVs for all indices except the North Carolina Longline survey and the F-at-age data for ages 2-4 had to be increased to achieve SDSRs below the upper limit suggested by Francis (2011). The adjustments are in Table 19. These adjustments resulted in a better fit to the recreational harvest and age-3 harvest F, particularly in the final selectivity period (after 1998). Conversely, the fit to the age-4 harvest F deteriorated in the final selectivity period (Figure 19). Both changes in fit to the F-at-age data indicate higher F on these ages in the final selectivity period (Figure 20), resulting in higher selectivity estimates and lower sSPR estimates than the base model. Changes in the three year average sSPR are most pronounced from 2009-2013, when they start to fluctuate around the target before falling below the target in the final two years (Figure 21). The estimates do not fall below the threshold. The reweighting acknowledges some process error due to interannual variability of the index catchabilities (i.e., increased input CVs), propagating additional uncertainty into the model estimates (Table 20).

2.2. Southern Stock

The model with the lowest RSS (Table 21) in the south had a very high index RSS value. As Francis (2011) recommends fitting the abundance indices well and this model improved the fit to the total catch and proportion-at-age data at the expense of the index data, this model was not selected as the best model. Models with the next lowest RSS values were evaluated and discarded for the following reasons: high (>700) index RSS, estimated selectivity constraints for ages 4 and 5^+ greater than 0.9 of the age-3 selectivity, and poor visual fit to the Florida live release catch. The remaining two models under consideration had the total catch and indices unity weighted and differed by how much the Georgia/South Carolina recreational discard proportion-at-age data were downweighted (0.1 vs. 0.001). As these models produced very similar results, the model with the proportion-at-age data downweighted to 0.1 was chosen as the preferred model as it was the preferred model used in SEDAR18 and the weighting was generally consistent with the northern model.

The fit of the preferred model was reasonable overall. The fit was very good for the catch data with very low RSS values and low SDSR values (Table 8 and Figures 22 and 23). All of the catch estimates were within the errors of the observed data (Figure 22). The SDSRs of the proportion-at-age data were also low indicating good model fits, though it was slightly higher for the Georgia/South Carolina release fleet (Table 8 and Figure 24). The index data were generally fit well (Figures 25 and 26) although most were overdispersed, particularly the South Carolina trammel net survey indices and the adult longline indices (Table 8). Most indices were estimated within the errors of the observed indices, though some peaks in the observed data were missed by the model.

The correlation of estimated values and parameters was explored using the correlation matrix output by ADMB. A large number of annual estimates of F for the fleets were strongly (>0.90) and positively correlated with annual F estimates from other years and fleets (Appendix C). The Florida recreational harvest fleet F and Florida discard fleet had the most correlations with other fleet and year specific Fs. There was also strong negative correlations between the recruitment estimates in 1989 and 1990 with various annual estimates of F, again particularly with the Florida fleets.

Estimated recruitment showed peaks in model years 1995, 2001, 2003, 2010 and 2013 (Table 22 and Figure 27). However, as in SEDAR18, abundance was very imprecisely estimated. Total abundance for the southern stock showed an upward trend and mirrored the trends seen in the ages 1-3 abundance (Table 23 and Figure 28). Age 4^+ abundance has been fairly stable and exhibits a slight upward trend.

The selectivities for each fleet and age for the various selectivity blocks are shown in Figure 29. Florida's recreational kept fishery had one selectivity block which peaked at age-3. Florida's recreational release fishery's selectivity was fixed based on tag-based estimates of selectivity from North Carolina (Bacheler et al. 2008). Georgia's kept fleet (commercial and recreational) peaked at age 1 for all time blocks. In the most recent selectivity period (2002-2013), the tail of the curve decreases more rapidly than in the 1989-1991 time block, likely due to the implementation of maximum size regulations. The selectivities for the South Carolina kept fleet was similar across all selectivity blocks with the main differences seen in the age-1 selectivity estimates. The Georgia/South Carolina release fleet selectivity peaked at age-1 in the 1989-1991 time period and stayed high through age-3 while the selectivity in the 1992-2013 time period was slightly lower for ages 1 and 2 and peaked at age-3.

F by year, age, and fleet are shown in Table 24 and the total F-at-age is shown in Table 25. The highest fleet specific F rates occur in the Florida and South Carolina harvest fleets (Figure 30). A large increase in annual F can be seen in the Florida harvest fleet in recent years, though slight increases can also be seen in the Florida and Georgia/South Carolina release fleets.

2.2.1. Stock Status

Static and transitional escapement for ages 1-5 are shown in Table 26 and Figure 31. Escapement has fluctuated mostly between 0.6 and 0.7 since the early part of the time series. Since 2005, however, there has been a slight decrease in static escapement, falling to the lowest value in the time series in terminal year 2013.

Both sSPR (Table 27 and Figure 32) and three year average sSPR (Table 27 and Figure 33) have been stable throughout the early part of the time series and show a slight decrease in recent years. However, as in SEDAR18, the asymptotic confidence bounds on these values are very large making any conclusions on stock status very uncertain. The terminal year three year sSPR for the southern stock is 53.5%, above both the target and threshold values. Using ADMB's likelihood profile capabilities, the posterior probability density of the 2013 three year average sSPR was estimated. This estimation suggests that it is likely that the terminal year average sSPR estimate is above the management sSPR threshold of 30% (Figure 34).

2.2.2. Retrospective Analysis

A five year retrospective analysis was conducted to see how recruitment and the three year average sSPR values changed as years of data were removed (Figure 35). Using the full time series (through 2013) resulted in lower estimates of recruitment and three year sSPR than any other terminal year. All other terminal year model runs using data through 2009-2012 converged on similar solutions.

2.2.3. Sensitivity Analyses

Indices were removed from the model individually to determine how sensitive the model estimates of three year sSPR were to the inclusion of certain indices (Figure 36). Removal of the Florida haul seine surveys resulted in higher three year sSPR values than the base run. Removal of the South Carolina trammel net survey (both ages-1 and 2) and the MRIP survey resulted in much lower estimates of three year average sSPR. Depending on which surveys were included, a very wide range of estimates for three year average sSPR were observed, though most of these point estimates were above the management threshold.

A sensitivity run was also conducted using iterative reweighting as suggested by the review panel in SEDAR18. The CVs for all indices which had SDSR values greater than those suggested by Francis (2011) were increased using the adjustments in Table 28. Following just one iteration, all index and proportion-at-age data had SDSR values around or less than 1 (Table 29) and within the recommended bounds. Additionally, the total standardized residual sum of squares and total negative log-likelihood were reduced and the visual fits of the Georgia/South Carolina release fleet proportion-at-age data were improved. This weighting, while fitting the observed data components better, did not improve the precision of the population estimates (i.e. total abundance, abundance at age, or sSPR). Three year average sSPR values were very similar between the base model and the iteratively reweighted model, with the iteratively re-weighted model estimating slightly higher sSPR (Figure 37). Total abundance estimates between the base run and the iteratively reweighted run were divergent in the early and late parts of the time series (Figure 38). The difference in the early part of the time series was primarily driven by the estimated age 7^+ abundance (Figure 39). This trend in the iteratively reweighted model shows a greater increase in total abundance as regulations were put in place in the early 1990s.

The M values used for the southern base model were from the SEDAR44 base runs and were estimated in SS3 with the SS3 age-2 M-at-age fixed based on external estimates. A sensitivity run was conducted using the M-at-age values from SEDAR18 to determine what effect this would have on the model results. The SEDAR18 M-at-age values were slightly higher than those estimated by SS3 for ages 1-4 and the same for ages 5-7^+. The model run using the SEDAR18 M-at-age values resulted in higher estimates of the three year average sSPR (Figure 40) and higher estimates of total abundance (Figure 41) when compared to the base model.

The weights-at-age used to calculate sSPR in the base model were also updated to match the values estimated by SS3 in SEDAR44. A sensitivity analysis was conducted using the SEDAR18 weights-at-age which were estimated using a spline. As spawning stock biomass was not calculated in this assessment, following the recommendations from SEDAR18, and sSPR is calculated as the ratio of fished spawning potential to unfished spawning potential, the change in the weights-at-age data did not change the three year average sSPR estimated when compared to the base model (Figure 40). Similarly, the estimates of total abundance did not change from the base model (Figure 41).

3. Discussion

The models presented here use essentially the same codes as were used in the previous benchmark assessment (SEDAR 2009) and, other than adding the infinite series correction, the main updates to the models were in the indices used, an updated maturity schedule and M vector for the southern stock, and updated weights-at-age. Additional exploration of the models was conducted based on the SEDAR18 reviewers' comments. These included using iterative reweighting and exploring the correlation of parameters. Iterative reweighting did not change the sSPR estimates for the southern stock much but did result in better fits to the observed data components and a trend in stock abundance that intuitively makes sense. The iterative reweighting of the northern stock model did give different results in the estimated three year average sSPR, estimating a lower terminal three year average sSPR value than the base model. However, the iterative reweighting did result in poorer fits to the F-at-age data for older fish after 1998, suggesting much higher selectivity than the base model even though harvest of fish greater than 27 inches was prohibited in North Carolina starting in 1999. Correlation analysis showed few strong correlations between parameter estimates in the northern model but a large number of correlations in the southern model. Reviewer comments from SEDAR18 suggested that this could show the model is overparameterized and future work should explore how the model could be simplified (e.g. reducing the number of fleets).

Most of the analyses completed in this assessment do indicate that both stocks are being fished above the threshold of 30% sSPR. The three year average sSPR point estimates from the base models for both stocks also indicate that both stocks are being fished above the target of 40% sSPR. However, the models do estimate trends in three year average sSPR in both stocks declining towards the target since about 2005. There are no apparent trends in recruitment estimates in either stock and the largest year class occurred in 2011 and 2009 in the northern and southern stocks, respectively.

One improvement in results from this assessment is the reduced reliance of the northern base model on the externally-derived F estimates. This indicates that the other data components in the base model agree with the F estimated in the Bacheler et al. 2008 tagging study, given the model configuration assumptions. It is important to note, however, that while the northern base model was less sensitive to the exclusion of the tagging data in the base model than it was in SEDAR18, similarly drastic changes were seen in the results when unity weights were used rather than the preferred model weighting. In contrast to SEDAR18 which estimated very large sSPRs when the tagging data were removed, the removal of the tagging data in the model with unity weights resulted in very low sSPRs. Nevertheless, the incorporation of tagging data directly into the model for both stocks, as recommended in SEDAR 18, should still be explored.

The inclusion of an adult index in the northern model and additional adult indices in the south addressed a particular shortcoming of the previous benchmark assessment. However, these indices have short time series, especially when compared to the life span of red drum, and will hopefully become more useful in the future. Despite improved information on mature fish through the new indices, the catch-at-age data are still too sparse to expand the age structure used in the model beyond an age-7 plus group and some of the concerns in the previous benchmark assessment remain in this assessment. The model still seems unable to provide realistic estimates of abundance of older ages. This was particularly true for the northern model which had very large age 7^{+} estimates starting in the late 1980s. These northern model estimates for ages 7^{+} also did not seem to track changes in regulation that would be expected, particularly the addition of a maximum harvest size in 1999. During SEDAR44, the year class information from the adult surveys were further explored and shown to track large year classes from the 1970s and 1980s well. Future work incorporating the age composition data for the adult indices into the SCA model could be useful.

Estimates of abundance and sSPR in the southern model continue to have very large confidence intervals. This uncertainty around the estimates makes it particularly difficult to reliably determine stock size or stock status in the south and as recommended by the reviewers in SEDAR18, the trends in abundance and sSPR are useful for only relative trends in the south.

Further work on the SCA models could be undertaken to possibly improve the models' stability and its ability to estimate abundance of mature fish. Initial work undertaken as a continuity analysis had focused on adapting the models to more closely resemble the SS3 models. The main change for this was to have the model estimate the selectivities for the release fleets rather than fixing them as was done in SEDAR18 for the northern model and for the Florida release fleet in the south. These runs, however, were found to be less stable and more sensitive to the weighting used, particularly in the south. For this reason, the SAS went back to using the original SEDAR18 codes, with the addition of the infinite series correction. However, this model configuration did show reasonable trends in the ages 7^{+} abundance estimates for the northern model and may be worth further consideration. Stability to this model could be increased by estimating only one set of selectivity constraints rather than different ones for kept versus released fish. Another possibility could be coding the selectivities using a parametric equation.

Fishery selectivities remain a major uncertainty of red drum assessments. Selectivities are constrained in the model by several assumptions and directly impact the model sSPR estimates. The Bacheler et al. 2008 tagging study was used to validate these assumptions and allow the model to estimate sSPR. Additionally, more reliable data on the age structure of the removals, particularly the recreational removals, may improve the models' ability to estimate selectivity and adult abundance.

There are some conflicts in the data that result in poor fits to some data points. For example, the indices in the northern model tend to disagree about the relative abundance in some years (i.e., 2001 year class). The MRIP and NC IGNS age-1 indices indicate high relative abundance of this year class, while the NC IGNS age-2 and NC JAI indices indicate low relative abundance of this year class. The model “smoothes” over this conflict by overestimating the NC IGNS age-2 and NC JAI indices and underestimating the NC IGNS age-1 and MRIP indices. These effects should be diminished by using the three year average sSPR for management, unless there is a consistent disagreement between the data sources. There may be some spatial effects that contribute to these conflicts, as the MRIP index is the only index that incorporates relative abundance information from states north of North Carolina and is the only index that spans the entire range of red drum in the south. Spatial dynamics should be an area of focus in future assessments, particularly if additional indices of abundance from states north of North Carolina become available.

4. Literature Cited

ASMFC. 2002. Amendment 2 to the Interstate Fishery Management Plan for Red Drum. ASMFC. Washington, D.C. 142 pp.

Bacheler, N.M., J.E. Hightower, L.M. Paramore, J.A. Buckel, and K.H. Pollock. 2008. Age-dependent tag return model to estimate mortality and selectivity of an estuarine-dependent fish with high rates of catch and release. Transaction of the American Fisheries Society 137: 1422-1432.

Francis, R.I.C.C. 2011. Data weighting in statistical fisheries stock assessment models. Canadian Journal of Fisheries and Aquatic Sciences 68: 1124-1138.

Lo, N.C.H., Jacobson, L.D. and Squire, J.L. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. *Canadian Journal of Fisheries and Aquatic Sciences*, 49: 2515-2526.

Lorenzen, K. 1996. The relationship between body weight and natural mortality in juvenile and adult fish: A comparison of natural ecosystems and aquaculture. J. Fish. Biol. 49:627-647.

Methot, Jr., R. D. and Wetzel, C.R. 2013. Stock Synthesis: A biological and statistical framework for fish stock assessment and fishery management. *Fisheries Research*. http://dx.doi.org/10.1016/j.fishres.2012.10.012

SEDAR. 2009. SEDAR18: Review Workshop Report, Atlantic Red Drum. SEDAR. North Charleston, SC.

SEDAR. 2015a. SEDAR 40 – Atlantic Menhaden Stock Assessment Report. SEDAR, North Charleston SC. 643 pp. available online at: http://www.sefsc.noaa.gov/sedar/Sedar_Workshops.jsp?WorkshopNum=40.

SEDAR. 2015b. SEDAR 44 – Atlantic Red Drum Stock Assessment Report. SEDAR, North Charleston SC. 890 pp. available online at: http://sedarweb.org/sedar-44.

SEDAR. 2016. Addendum II to the SEDAR 44 Red Drum Stock Assessment Report.

Vaughan, D.S. and J.T. Carmichael, 2000. Assessment of Atlantic red drum for 1999: northern and southern regions. NOAA Tech. Memo. NMFS-SEFSC-447.

5. Tables

Table 1. Indices used in the northern stock model.

Index	Years
NC Independent Gill Net Survey—Age 1	2001-2013
NC Independent Gill Net Survey—Age 2	2001-2013
NC Juvenile Abundance Index	1992-2013
MRFSS/MRIP Index	1991-2013
NC Longline Survey	2007-2013

Table 2. Indices used in the southern stock model.

Index	Years
FL Bagged Beach Seine Survey (YOY)	2002-2013
GA Gill Net Survey—Age 1	2003-2013
SC Stop Net Survey (YOY)	1989-1994
SC Trammel Net Survey—Age 1	1994-2013
SC Trammel Net Survey—Age 2	1994-2013
FL Haul Seine Survey—Age 2	1997-2013
FL Haul Seine Survey—Age 3	1997-2013
MRFSS/MRIP Index	1991-2013
SC 1 mile Longline Survey (Adult)	1994-2004
SC 1/3 mile Longline Survey	2007-2013
GA Longline Survey	2007-2013

Table 3. Selectivity blocks used in the northern stock model.

Fleet	Selectivity Block	Years
Commercial Gill Net and Beach Seine	1	1989-1991
Commercial Gill Net and Beach Seine	2	1992-1998
Commercial Gill Net and Beach Seine	3	1999-2013
Commercial Other Gears	1	1989-1991
Commercial Other Gears	2	1992-1998
Commercial Other Gears	3	1999-2013
Recreational Kept	1	1989-1991
Recreational Kept	2	1992-1998
Recreational Kept	3	1999-2013
Recreational Live Release	1	1989-1991
Recreational Live Release	2	1992-1998
Recreational Live Release	3	1999-2013

Table 4. Selectivity blocks used in the southern stock model.

Fleet	Selectivity Block	Years
FL Recreational Kept	1	1989-2013
GA Commercial/Recreational Kept	1	1989-1991
GA Commercial/Recreational Kept	2	1992-2001
GA Commercial/Recreational Kept	3	2002-2013
SC Commercial/Recreational Kept	1	1989-1993
SC Commercial/Recreational Kept	2	1994-2000
SC Commercial/Recreational Kept	3	2001-2013
FL Recreational Live Release	1	1989-2013
GA/SC Recreational Live Release	1	1989-1991
GA/SC Recreational Live Release	2	1992-2013

Table 5. Estimated parameters in the SCA models for red drum population dynamics in the northern stock. Parameters for each stock include those that describe fishing mortality: annual fully recruited F's (log_F) for each fishery, age 1-3 selectivities (log_sel) for each period of assumed constant selectivity, and age 4-5$^+$ selectivities as a proportion of age 3 selectivity (sel04, sel05). Abundance-estimate related parameters include recruitment (log_R), first-year abundance for ages 2-7$^+$ (log_initN), and index-of-abundance proportionality coefficients ('survey scalars' or log_q).

Northern stock

Population dynamic	Parameters estimated		Number
Fishing mortality			
Comm BS&GN	1989-2013 log_F's; 3 sets of age 1-3 log_sel's		34
Comm other	1989-2013 log_F's; 3 sets of age 1-3 log_sel's		34
Rec A+B1	1989-2013 log_F's; 3 sets of age 1-3 log_sel's		34
Rec B2	1989-2013 log_F's		25
Ages 4-5$^+$ sel	constant sel04 and sel05		2
		Total	129
Abundance			
recruitment	log_R 1989-2013		25
initial abundance	log_initN for ages 2-7$^+$		6
survey scalar	log_q's for five surveys		5
		Total	36
Grand Total			165

Table 6. Estimated parameters in the SCA models for red drum population dynamics in the northern stock. Parameters for each stock include those that describe fishing mortality: annual fully recruited F's (log_F) for each fishery, age 1-3 selectivities (log_sel) for each period of assumed constant selectivity, and age 4-5⁺ selectivities as a proportion of age 3 selectivity (sel04, sel05). Abundance-estimate related parameters include recruitment (log_R), first-year abundance for ages 2-7⁺ (log_initN), and index-of-abundance proportionality coefficients ('survey scalars' or log_q).

Southern stock

Population dynamic	Parameters estimated		Number
Fishing mortality			
FL rec A+B1	1989-2013 log_F's; 1 sets of age 1-3 log_sel's		28
GA rec A+B1	1989-2013 log_F's; 3 sets of age 1-3 log_sel's		34
SC rec A+B1	1989-2013 log_F's; 3 sets of age 1-3 log_sel's		34
FL rec B2	1989-2013 log_F's		25
GA/SC rec B2	1989-2013 log_F's; 2 sets of age 1-3 log_sel's		31
Ages 4-5⁺ sel	constant sel04 and sel05		2
		Total	154
Abundance			
recruitment	log_R 1989-2013		25
initial abundance	log_initN for ages 2-7⁺		6
survey scalar	log_q's for eleven surveys		11
		Total	42
Grand Total			196

Table 7. Likelihood components of the northern stock base model.

Components		N	TSS	RSS	NegLL	SDSR
Total Kill						
Comm GN & BS		25	84,705.83	0.12	-115.07	0.07
Comm Other		25	165,558.94	0.00	-115.13	0.01
Rec Kept		25	140.26	110.95	22.05	1.99
Rec Release		25	350.71	43.41	-7.77	1.31
	Totals	100	250,755.74	154.48	-215.92	
Proportion-at-age						
Comm GN & BS		175			359.92	0.08
Comm Other		175			130.07	0.32
Rec Kept		175			486.48	0.12
	Totals	525			976.47	
Indices of Abundance						
NC IGNS age 1		13	207.19	58.26	7.89	2.11
NC IGNS age 2		13	309.64	74.64	19.58	2.38
NC JAI age 1		22	333.08	262.87	98.61	3.45
MRIP ages 1-3		23	855.94	256.21	74.16	3.31
NC Adult Longline		7	4.49	7.08	-8.65	1.01
	Totals	78	1,710.34	659.05	191.58	
Auxiliary Observations						
F kept at age-1		16	840.21	14.83		0.99
F kept at age-2		16	293.06	22.09		0.97
F kept at age-3		16	298.33	315.49		4.59
F kept at age-4^+		16	1,816.75	380.74	247.91	5.03
Full F release		16	354.87	10.47	-25.18	0.81
	Totals	80	3,603.22	743.62	222.72	
Other Deviations						
Selectivities					57.99	
	Totals				57.99	
Grand Total					1,232.84	

Table 8. Likelihood components of the southern stock base model.

Components		N	TSS	RSS	NegLL	SDSR
Total Kill						
FL Rec		25	177.51	0.67	-43.80	0.16
GA Comm/Rec		25	116.15	0.32	-38.20	0.11
SC Comm/Rec		25	86.67	1.06	-32.81	0.20
FL Releases		25	198.77	0.07	-43.17	0.05
GA/SC Releases		25	310.38	0.03	-36.83	0.03
	Totals	125	889.47	2.15	-194.81	
Proportion-at-age						
FL Rec		175			547.00	0.13
GA Comm/Rec		175			593.21	0.89
SC Comm/Rec		175			913.69	0.54
GA/SC Releases		175			116.65	1.61
	Totals	700			2170.55	
Indices of Abundance						
FL Bagged Beach Seine Survey		12	26.43	16.76	-0.79	1.17
GA Gill Net Survey—Age 1		11	71.48	34.86	-0.49	1.78
SC Stop Net Survey		6	9.99	12.22	-2.58	1.40
SC Trammel Net Survey—Age 1		20	276.83	99.33	11.90	2.23
SC Trammel Net Survey—Age 2		20	253.44	100.13	12.56	2.24
FL Haul Seine Survey—Age 2		17	28.34	52.85	-2.82	1.76
FL Haul Seine Survey—Age 3		17	20.44	54.54	3.12	1.79
MRIP Index		23	411.08	76.53	-32.81	1.82
SC 1 mile Longline Survey (Adult)		11	44.97	46.95	6.06	2.06
SC 1/3 mile Longline Survey		7	34.19	32.82	2.27	2.15
GA Longline Survey		7	32.48	30.84	5.74	2.10
	Totals	151	1,209.65	557.82	2.14	
Other Deviations						
Selectivities					34.25	
	Totals				34.25	
	Grand Total				2,012.13	

Table 9. The external hypotheses (weights) used to evaluate 'best' model fit in the northern stock. The total catch fleets were the commercial gillnet and beach seine, the other commercial gears, the recreational landed (MRIP Type A+B1) catch, and the recreational live release. The first three of these were included in the proportion-at-age weights (the age composition of the live release fishery was implied from tagging estimates). The indices were the North Carolina independent gill net survey (IGNS) age 1 index, the IGNS age 2 index, the North Carolina juvenile abundance index, the MRFSS total catch rate index, and the North Carolina Longline survey. The tag-based F weights were used for the F-at-age estimates from the recreational landed fish and the fully recruited F's for the live release fishery.

Total Catch by fleet

H_o : default

1. 1. 1. 1.

H_{a1}: live release recreational total catch estimates are suspect

1. 1. 1. 0.1

H_{a2}: live release recreational total catch estimates are really suspect

1. 1. 1. 0.01

Proportion-at-age (excludes the live release fishery)

H_o: default

catch-at-age by fleet and year all year and all fleets 1.0

H_a: the recreational age composition data is less certain than commercial

commercial fleets are 1.0 and recreational fleet is 0.01

Indices of abundance

H_o: default

1. 1. 1. 1. 1.

H_{a1}: the MRIP index is best due to larger spatial coverage

1. 1. 1. 10. 1.

H_{a2}: the YOY indices are best due to scientific design and ease of capture

10. 1. 10. 1. 1.

Tagging based F (for kept F-at-age and then full F live release recreational)

H_o: default

1. 1.

H_a: both less accurate than catch-at-age model

0.1 0.1

Table 10. The external hypotheses (weights) used to evaluate 'best' model fit in the southern stock. The total catch fleets were the Florida recreational landed (MRIP Type A+B1) fishery, the Georgia recreational landed commercial fishery, the South Carolina recreational landed/commercial fishery, the Florida live release fishery, and the Georgia/South Carolina live release fishery. All but the Florida live release fishery (in order) were included in the proportion-at-age weights (the age composition of the Florida live release fishery was implied from tagging estimates). The indices were the Florida small seine survey, the Georgia monofilament gill net survey, the South Carolina stop net survey, the South Carolina age-1 trammel net survey, the South Carolina age-2 trammel net survey, the Florida age-2 haul seine survey, the Florida age-3 haul seine survey, the MRIP index, the South Carolina 1 mile longline survey, the South Carolina 1/3 mile longline survey, and the Georgia longline survey.

Total Catch by fleet

H_o : default

1. 1. 1. 1. 1.

H_{a1}: live release recreational total catch estimates are uncertain

1. 1. 1. 0.1 0.1

H_{a2}: live release recreational total catch estimates are really uncertain

1. 1. 1. 0.01 0.01

Proportion-at-age (excludes the Florida live release fishery)

H_o: default

catch-at-age by fleet and year all year and all fleets 1.0

H_{a1}: the live release recreational age composition data is less certain than other data

landed fisheries are 1.0 and recreational live release fleet is 0.1

H_{a2}: the live release recreational age composition data is much less certain than other data

landed fisheries are 1.0 and recreational live release fleet is 0.01

Indices of abundance

H_o: default

1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.

H_{a1}: the MRIP index is best due to larger areal coverage

1. 1. 1. 1. 1. 1. 1. 10. 1. 1. 1.

H_{a2}: the YOY indices are best due to scientific design and ease of capture

10. 10. 10. 10. 1. 1. 1. 1. 1. 1. 1.

Table 11. Total standardized residual sums of squares for the northern stock weighting hypotheses. Weighting combinations with no number entered failed to converge. Bolded value is the model weighting with the lowest RSS.

Tag Based F, H0			Total Catch Hypothesis			
		Indices H0		H0	Ha1	Ha2
		PAA	H0	1,657		2,434
			Ha1	**1,579**	1,605	2,096
			Total Catch Hypothesis			
		Indices Ha1		H0	Ha1	Ha2
		PAA	H0		2,481	3,340
			Ha1	1,948	2,091	2,506
			Total Catch Hypothesis			
		Indices Ha2		H0	Ha1	Ha2
		PAA	H0	1,966		3,855
			Ha1	2,133	2,586	3,264
Tag Based F, Ha1			Total Catch Hypothesis			
		Indices H0		H0	Ha1	Ha2
		PAA	H0			4,040
			Ha1	2,224	2,856	3,688
			Total Catch Hypothesis			
		Indices Ha1		H0	Ha1	Ha2
		PAA	H0	4,027	4,295	
			Ha1	3,720		
			Total Catch Hypothesis			
		Indices Ha2		H0	Ha1	Ha2
		PAA	H0	3,677	5,892	6,569
			Ha1	6,684		7,068

Table 12. Estimated recruitment with 95% confidence intervals (± 1.96 SE) for the northern stock.

Year	Est	LCI	UCI
1989	175,782	91,016	339,650
1990	145,801	101,709	208,812
1991	555,709	445,922	692,509
1992	591,845	479,008	731,285
1993	267,266	186,523	382,833
1994	499,319	414,934	600,850
1995	346,625	268,850	446,799
1996	211,928	164,861	272,257
1997	501,822	391,306	643,484
1998	934,718	817,685	1,069,109
1999	576,079	493,050	673,388
2000	161,781	124,285	210,388
2001	385,771	306,421	486,008
2002	689,002	586,950	809,270
2003	81,308	62,152	106,338
2004	450,449	379,043	535,232
2005	525,445	444,431	621,772
2006	642,422	545,198	756,599
2007	269,682	217,639	334,181
2008	928,198	801,591	1,075,010
2009	265,933	216,674	326,205
2010	310,519	250,976	384,164
2011	167,042	127,584	218,742
2012	1,899,308	1,670,928	2,157,791
2013	330,711	242,990	449,664

Table 13. Estimate beginning-of-the-year abundance of red drum ages 1 – 7^{+} in the northern stock during 1989-2013.

Northern	1	2	3	4	5	6	7^{+}	Total
1989	175,822	82,951	11,711	18,691	173,718	142,063	13,962,773	14,567,728
1990	145,733	18,145	2,401	1,712	15,325	160,129	13,130,891	13,474,335
1991	555,703	26,476	1,211	564	1,444	14,128	12,374,686	12,974,211
1992	591,855	301,275	12,391	779	505	1,332	11,543,832	12,451,969
1993	267,221	400,924	142,784	8,175	698	466	10,758,409	11,578,677
1994	499,313	162,768	141,719	81,594	7,263	644	10,018,501	10,911,802
1995	346,586	323,748	88,300	103,263	73,439	6,686	9,315,883	10,257,905
1996	211,860	241,719	193,478	67,241	93,286	67,684	8,678,335	9,553,604
1997	501,796	158,115	161,069	153,466	60,950	86,068	8,149,807	9,271,272
1998	934,984	350,391	89,925	116,860	138,314	56,205	7,670,214	9,356,892
1999	576,207	626,052	164,312	60,534	104,863	127,552	7,196,352	8,855,873
2000	161,703	448,337	375,572	140,491	55,033	96,584	6,812,266	8,089,987
2001	385,905	124,647	248,479	318,972	127,584	50,647	6,421,222	7,677,456
2002	689,203	288,104	46,575	201,779	288,823	117,377	6,013,468	7,645,328
2003	81,296	516,227	102,316	38,017	182,736	265,672	5,695,017	6,881,281
2004	450,418	64,147	320,701	88,766	34,611	168,419	5,546,430	6,673,493
2005	525,676	353,708	38,298	276,210	80,789	31,903	5,319,139	6,625,723
2006	642,259	409,233	215,033	32,910	251,084	74,376	4,975,518	6,600,414
2007	269,686	494,676	243,199	184,360	29,873	230,797	4,687,830	6,140,420
2008	928,288	207,130	274,639	206,355	167,328	27,476	4,567,248	6,378,463
2009	265,857	694,841	98,013	228,002	186,776	153,639	4,260,964	5,888,092
2010	310,509	207,585	460,355	85,152	207,266	171,826	4,100,645	5,543,338
2011	167,057	232,104	97,805	383,220	77,052	190,215	3,958,810	5,106,262
2012	1,898,819	130,108	138,828	84,186	348,348	70,925	3,855,730	6,526,945
2013	330,551	1,285,364	48,748	111,897	75,198	315,627	3,592,926	5,760,311

Table 14. Instantaneous fishing mortality, by fleet and age, for the northern stock.

	Commercial Gill net and Beach Seine					Commercial 'other' gear fishery				
	1	2	3	4	5	1	2	3	4	5
1989	0.699	1.358	0.658	0.039	0.000	0.142	0.238	0.184	0.011	0.000
1990	0.782	1.518	0.736	0.044	0.000	0.112	0.188	0.146	0.009	0.000
1991	0.107	0.208	0.101	0.006	0.000	0.041	0.069	0.053	0.003	0.000
1992	0.025	0.104	0.040	0.002	0.000	0.004	0.013	0.008	0.000	0.000
1993	0.041	0.167	0.065	0.004	0.000	0.005	0.018	0.011	0.001	0.000
1994	0.032	0.133	0.052	0.003	0.000	0.005	0.019	0.011	0.001	0.000
1995	0.038	0.158	0.062	0.004	0.000	0.010	0.035	0.021	0.001	0.000
1996	0.023	0.095	0.037	0.002	0.000	0.003	0.012	0.007	0.000	0.000
1997	0.011	0.044	0.017	0.001	0.000	0.003	0.011	0.007	0.000	0.000
1998	0.062	0.253	0.099	0.006	0.000	0.009	0.031	0.019	0.001	0.000
1999	0.024	0.222	0.035	0.002	0.000	0.001	0.006	0.004	0.000	0.000
2000	0.021	0.192	0.031	0.002	0.000	0.001	0.006	0.004	0.000	0.000
2001	0.032	0.290	0.046	0.003	0.000	0.001	0.006	0.004	0.000	0.000
2002	0.012	0.114	0.018	0.001	0.000	0.002	0.007	0.004	0.000	0.000
2003	0.007	0.066	0.010	0.001	0.000	0.001	0.005	0.003	0.000	0.000
2004	0.016	0.143	0.023	0.001	0.000	0.001	0.002	0.001	0.000	0.000
2005	0.018	0.162	0.026	0.002	0.000	0.001	0.005	0.003	0.000	0.000
2006	0.014	0.123	0.020	0.001	0.000	0.001	0.006	0.004	0.000	0.000
2007	0.019	0.173	0.027	0.002	0.000	0.002	0.009	0.005	0.000	0.000
2008	0.029	0.264	0.042	0.002	0.000	0.001	0.006	0.004	0.000	0.000
2009	0.012	0.106	0.017	0.001	0.000	0.001	0.005	0.003	0.000	0.000
2010	0.024	0.216	0.034	0.002	0.000	0.001	0.004	0.003	0.000	0.000
2011	0.011	0.104	0.016	0.001	0.000	0.001	0.005	0.003	0.000	0.000
2012	0.012	0.105	0.017	0.001	0.000	0.001	0.006	0.004	0.000	0.000
2013	0.014	0.131	0.021	0.001	0.000	0.002	0.010	0.006	0.000	0.000

Table 14 (con't). Instantaneous fishing mortality, by fleet and age, for the northern stock.

	Recreational Harvest					Recreational Live Release				
	1	2	3	4	5	1	2	3	4	5
1989	1.208	1.811	0.980	0.058	0.001	0.022	0.005	0.000	0.000	0.000
1990	0.575	0.862	0.467	0.028	0.000	0.037	0.008	0.000	0.000	0.000
1991	0.230	0.345	0.187	0.011	0.000	0.034	0.008	0.000	0.000	0.000
1992	0.144	0.492	0.267	0.016	0.000	0.016	0.008	0.001	0.000	0.000
1993	0.207	0.705	0.382	0.023	0.000	0.043	0.020	0.001	0.001	0.001
1994	0.081	0.276	0.150	0.009	0.000	0.115	0.054	0.004	0.003	0.003
1995	0.047	0.161	0.087	0.005	0.000	0.065	0.030	0.002	0.001	0.001
1996	0.047	0.161	0.087	0.005	0.000	0.019	0.009	0.001	0.000	0.000
1997	0.106	0.361	0.196	0.012	0.000	0.039	0.018	0.001	0.001	0.001
1998	0.096	0.326	0.177	0.011	0.000	0.035	0.016	0.001	0.001	0.001
1999	0.008	0.128	0.012	0.001	0.000	0.017	0.025	0.005	0.002	0.002
2000	0.015	0.229	0.022	0.001	0.000	0.023	0.034	0.007	0.003	0.003
2001	0.034	0.521	0.051	0.003	0.000	0.026	0.037	0.008	0.003	0.003
2002	0.048	0.746	0.073	0.004	0.000	0.027	0.039	0.008	0.003	0.003
2003	0.017	0.258	0.025	0.001	0.000	0.012	0.018	0.004	0.002	0.002
2004	0.014	0.224	0.022	0.001	0.000	0.011	0.016	0.003	0.001	0.001
2005	0.011	0.171	0.017	0.001	0.000	0.021	0.030	0.006	0.003	0.003
2006	0.014	0.214	0.021	0.001	0.000	0.032	0.047	0.010	0.004	0.004
2007	0.015	0.237	0.023	0.001	0.000	0.028	0.041	0.008	0.004	0.004
2008	0.019	0.289	0.028	0.002	0.000	0.041	0.060	0.012	0.005	0.005
2009	0.009	0.133	0.013	0.001	0.000	0.026	0.038	0.008	0.003	0.003
2010	0.022	0.337	0.033	0.002	0.000	0.045	0.065	0.014	0.006	0.006
2011	0.016	0.243	0.024	0.001	0.000	0.022	0.032	0.007	0.003	0.003
2012	0.034	0.531	0.052	0.003	0.000	0.143	0.209	0.043	0.019	0.019
2013	0.019	0.288	0.028	0.002	0.000	0.031	0.046	0.009	0.004	0.004

Table 15. Estimated age-1 to age-5 instantaneous fishing mortality for the northern stock during 1989-2013.

	Northern stock				
	1	2	3	4	5
1989	2.071	3.412	1.823	0.109	0.001
1990	1.506	2.577	1.349	0.081	0.001
1991	0.412	0.629	0.341	0.021	0.001
1992	0.189	0.617	0.316	0.019	0.001
1993	0.296	0.910	0.460	0.028	0.001
1994	0.233	0.482	0.217	0.015	0.003
1995	0.160	0.385	0.172	0.012	0.002
1996	0.093	0.276	0.132	0.008	0.001
1997	0.159	0.434	0.221	0.014	0.001
1998	0.201	0.627	0.296	0.018	0.001
1999	0.051	0.381	0.057	0.005	0.002
2000	0.060	0.460	0.063	0.006	0.003
2001	0.092	0.854	0.108	0.009	0.003
2002	0.089	0.905	0.103	0.009	0.004
2003	0.037	0.346	0.042	0.004	0.002
2004	0.042	0.386	0.049	0.004	0.001
2005	0.050	0.368	0.052	0.005	0.003
2006	0.061	0.390	0.054	0.007	0.004
2007	0.064	0.458	0.064	0.007	0.004
2008	0.090	0.618	0.086	0.010	0.005
2009	0.047	0.282	0.041	0.005	0.003
2010	0.091	0.623	0.083	0.010	0.006
2011	0.050	0.384	0.050	0.005	0.003
2012	0.190	0.852	0.116	0.023	0.019
2013	0.067	0.475	0.065	0.007	0.004

Table 16. Correlation coefficients between parameters with a correlation greater than 0.90 or less than -0.90 in the northern stock model.

Parameter 1	Parameter 2	Correlation
Comm Other F 1997	Comm Other F 1998	0.9074
Comm Other F 2000	Comm Other F 2001	0.9151
Comm Other F 2001	Comm Other F 2004	0.9107
Comm Other F 2004	Comm Other F 2010	0.914
Comm GNBS F 2013	Comm Other F 2013	0.942
Comm GNBS F 1999	Recruit 1998	-0.9225
Comm GNBS F 2000	Recruit 1999	-0.9157
Comm GNBS F 2003	Recruit 2002	-0.9389
Comm GNBS F 2005	Recruit 2004	-0.9309
Comm GNBS F 2007	Recruit 2006	-0.9045
Comm GNBS F 2009	Recruit 2008	-0.9611
Comm GNBS F 2011	Recruit 2010	-0.946

Table 17. sEsc, and tEsc (ages 1-5) with asymptotic SEs and CVs for the northern stock.

Year	sEsc			tEsc		
	Est	SE	CV	Est	SE	CV
1989	0.00	0.000	0.73			
1990	0.00	0.003	0.62			
1991	0.25	0.032	0.13			
1992	0.32	0.023	0.07			
1993	0.18	0.017	0.09	0.007	0.003	0.449
1994	0.39	0.018	0.05	0.084	0.018	0.213
1995	0.48	0.016	0.03	0.222	0.015	0.069
1996	0.60	0.023	0.04	0.265	0.016	0.062
1997	0.44	0.025	0.06	0.383	0.013	0.033
1998	0.32	0.017	0.05	0.465	0.012	0.026
1999	0.61	0.017	0.03	0.508	0.015	0.030
2000	0.55	0.019	0.03	0.436	0.017	0.040
2001	0.34	0.026	0.07	0.426	0.016	0.037
2002	0.33	0.037	0.11	0.518	0.014	0.027
2003	0.65	0.037	0.06	0.533	0.016	0.030
2004	0.62	0.044	0.07	0.360	0.024	0.067
2005	0.62	0.041	0.07	0.351	0.035	0.100
2006	0.60	0.055	0.09	0.610	0.031	0.051
2007	0.55	0.049	0.09	0.616	0.039	0.063
2008	0.45	0.043	0.10	0.622	0.036	0.057
2009	0.68	0.029	0.04	0.596	0.047	0.079
2010	0.44	0.038	0.09	0.540	0.042	0.077
2011	0.61	0.046	0.08	0.479	0.040	0.083
2012	0.30	0.087	0.29	0.620	0.024	0.039
2013	0.54	0.044	0.08	0.474	0.035	0.073

Table 18. Annual sSPR and three year sSPR with asymptotic SEs and CVs for the northern stock.

Year	sSPR			3 yr sSPR		
	Est	SE	CV	Est	SE	CV
1989	0.001	0.000	0.73			
1990	0.004	0.002	0.62			
1991	0.243	0.032	0.13	0.083	0.011	0.13
1992	0.316	0.022	0.07	0.188	0.013	0.07
1993	0.180	0.017	0.09	0.246	0.014	0.06
1994	0.369	0.018	0.05	0.288	0.012	0.04
1995	0.469	0.017	0.04	0.339	0.011	0.03
1996	0.596	0.023	0.04	0.478	0.012	0.02
1997	0.429	0.024	0.06	0.498	0.013	0.03
1998	0.313	0.017	0.05	0.446	0.013	0.03
1999	0.586	0.017	0.03	0.443	0.012	0.03
2000	0.525	0.019	0.04	0.475	0.011	0.02
2001	0.325	0.025	0.08	0.479	0.014	0.03
2002	0.311	0.035	0.11	0.387	0.018	0.05
2003	0.633	0.036	0.06	0.423	0.021	0.05
2004	0.602	0.043	0.07	0.515	0.025	0.05
2005	0.593	0.042	0.07	0.609	0.026	0.04
2006	0.556	0.055	0.10	0.584	0.030	0.05
2007	0.518	0.048	0.09	0.556	0.030	0.05
2008	0.408	0.041	0.10	0.494	0.031	0.06
2009	0.647	0.033	0.05	0.524	0.027	0.05
2010	0.403	0.037	0.09	0.486	0.025	0.05
2011	0.583	0.046	0.08	0.544	0.025	0.05
2012	0.228	0.071	0.31	0.405	0.034	0.08
2013	0.504	0.044	0.09	0.438	0.034	0.08

Table 19. Multiplicative weighting factors applied to input error in the northern stock assessment model to achieve SDSRs below the upper limit suggested by Francis (2011).

Data Set	Multiplicative Weighting Factor	SDSR Upper Limit	SDSR
NC Independent Gill Net Survey—Age 1	2.10	1.32	1.10
NC Independent Gill Net Survey—Age 2	2.42	1.32	1.11
NC Juvenile Abundance Index	3.44	1.25	1.02
MRFSS/MRIP Index	4.59	1.24	1.10
NC Longline Survey	1.00	1.45	1.02
Commercial GNBS	1.00	1.23	0.17
Commercial Other	1.00	1.23	0.63
Recreational Harvest	1.00	1.23	0.40
Harvest age-1 F	1.00	1.29	1.25
Harvest age-2 F	1.34	1.29	0.92
Harvest age-3 F	4.31	1.29	0.35
Harvest age-4+ F	8.99	1.29	1.25
Recreational Release Full F	1.00	1.29	0.83

Table 20. Annual sSPR and three year sSPR with asymptotic SEs and CVs for the northern stock iteratively reweighted model.

Year	sSPR			3 yr sSPR		
	Est	SE	CV	Est	SE	CV
1989	0.00	0.001	1.00			
1990	0.01	0.008	0.65			
1991	0.21	0.043	0.21	0.07	0.015	0.20
1992	0.34	0.036	0.11	0.19	0.019	0.10
1993	0.19	0.027	0.14	0.24	0.022	0.09
1994	0.39	0.027	0.07	0.30	0.020	0.06
1995	0.46	0.026	0.06	0.35	0.018	0.05
1996	0.59	0.034	0.06	0.48	0.019	0.04
1997	0.45	0.039	0.09	0.50	0.021	0.04
1998	0.35	0.027	0.08	0.47	0.021	0.05
1999	0.54	0.025	0.05	0.45	0.019	0.04
2000	0.46	0.028	0.06	0.45	0.018	0.04
2001	0.32	0.034	0.11	0.44	0.021	0.05
2002	0.23	0.047	0.20	0.33	0.025	0.07
2003	0.63	0.042	0.07	0.39	0.027	0.07
2004	0.61	0.054	0.09	0.49	0.032	0.07
2005	0.60	0.061	0.10	0.62	0.038	0.06
2006	0.56	0.067	0.12	0.59	0.045	0.08
2007	0.49	0.071	0.14	0.55	0.051	0.09
2008	0.38	0.060	0.16	0.48	0.052	0.11
2009	0.43	0.069	0.16	0.44	0.053	0.12
2010	0.33	0.062	0.19	0.38	0.053	0.14
2011	0.51	0.069	0.14	0.42	0.054	0.13
2012	0.18	0.065	0.37	0.34	0.049	0.14
2013	0.33	0.084	0.25	0.34	0.054	0.16

Table 21. Total standardized residual sums of squares for the southern stock weighting hypotheses. Weighting combinations with no number entered failed to converge. Bolded value is the model weighting with the lowest RSS and italicized number is the model chosen for the preferred base model run.

		Total Catch Hypothesis		
Indices H0		H0	Ha1	Ha2
PAA	H0	1,240	1,168	3,433
	Ha1	*1,210*	1,158	3,544
	Ha2	1,201	1,157	3,583
		Total Catch Hypothesis		
Indices Ha1		H0	Ha1	Ha2
PAA	H0	1,148	1,192	3,877
	Ha1	**850**	1,185	
	Ha2	879	1,273	5,340
		Total Catch Hypothesis		
Indices Ha2		H0	Ha1	Ha2
PAA	H0	951	1,110	7,678
	Ha1	964	2,177	7,872
	Ha2	972	2,200	7,638

Table 22. Estimated recruitment and associated bounds (± 1.96 asymptotic standard errors) for the southern stock.

Year	-1.96SE	Est	+1.96SE
1989	344,376	1,048,558	3,192,654
1990	371,890	1,051,206	2,971,397
1991	561,393	1,523,740	4,135,756
1992	515,633	1,490,653	4,309,360
1993	491,377	1,424,046	4,126,984
1994	666,042	1,794,613	4,835,483
1995	878,402	2,264,207	5,836,321
1996	409,570	1,125,957	3,095,393
1997	456,655	1,322,172	3,828,143
1998	383,079	1,132,098	3,345,642
1999	475,059	1,362,687	3,908,810
2000	326,621	869,824	2,316,427
2001	724,662	2,034,166	5,710,016
2002	592,228	1,690,145	4,823,466
2003	731,270	2,040,881	5,695,837
2004	654,140	1,740,266	4,629,779
2005	594,702	1,579,688	4,196,077
2006	411,877	1,111,477	2,999,394
2007	583,749	1,572,756	4,237,370
2008	632,733	1,782,988	5,024,308
2009	687,894	1,954,106	5,551,042
2010	1,001,036	2,597,568	6,740,375
2011	613,234	1,592,891	4,137,575
2012	386,594	1,011,298	2,645,473
2013	789,232	2,129,962	5,748,293

Table 23. Estimate beginning-of-the-year abundance of red drum ages 1 – 7$^+$ in the southern stock during 1989-2013.

Southern	1	2	3	4	5	6	7$^+$	Total
1989	1,048,558	667,100	329,375	372,344	1,897,098	739,802	1,978,164	7,032,441
1990	1,051,206	786,262	486,995	260,673	313,453	1,661,009	2,421,220	6,980,817
1991	1,523,740	782,510	571,367	380,634	218,212	274,489	3,632,240	7,383,191
1992	1,490,653	1,090,488	534,229	425,208	311,719	190,480	3,476,687	7,519,464
1993	1,424,046	1,123,202	805,684	419,783	356,809	272,840	3,272,935	7,675,298
1994	1,794,613	1,061,257	834,635	644,122	355,011	312,267	3,163,403	8,165,309
1995	2,264,207	1,320,017	763,425	649,999	538,370	310,337	3,096,904	8,943,259
1996	1,125,957	1,634,147	910,247	589,016	540,999	470,662	3,036,156	8,307,185
1997	1,322,172	850,826	1,187,885	709,402	492,459	473,203	3,125,147	8,161,094
1998	1,132,098	1,006,663	633,614	959,584	602,758	430,899	3,207,939	7,973,555
1999	1,362,687	883,239	774,331	510,834	814,602	527,504	3,245,033	8,118,230
2000	869,824	1,041,250	661,546	611,171	429,542	712,367	3,361,035	7,686,735
2001	2,034,166	643,012	741,464	499,364	503,726	374,996	3,621,658	8,418,385
2002	1,690,145	1,520,240	448,040	551,517	408,866	439,567	3,554,733	8,613,108
2003	2,040,881	1,297,397	1,137,316	355,412	464,794	357,654	3,560,681	9,214,135
2004	1,740,266	1,533,199	907,247	873,408	295,195	406,243	3,490,745	9,246,303
2005	1,579,688	1,300,071	1,097,895	712,426	732,747	258,004	3,471,215	9,152,046
2006	1,111,477	1,159,300	880,292	826,375	586,457	638,983	3,315,430	8,518,313
2007	1,572,756	837,538	841,933	684,975	690,456	512,353	3,518,857	8,658,868
2008	1,782,988	1,162,262	582,209	638,212	565,619	603,001	3,587,185	8,921,477
2009	1,954,106	1,301,874	782,505	434,644	523,403	493,766	3,726,439	9,216,736
2010	2,597,568	1,502,790	982,443	626,831	367,904	458,171	3,764,483	10,300,189
2011	1,592,891	1,880,033	1,006,489	739,477	515,979	321,067	3,755,472	9,811,408
2012	1,011,298	1,187,355	1,304,045	769,036	612,809	450,695	3,629,838	8,965,076
2013	2,129,962	764,333	822,511	976,881	631,668	534,995	3,630,363	9,490,714

Table 24. Instantaneous fishing mortality, by fleet and age, for the southern stock.

	FL Rec					GA Comm/Rec				
	1	2	3	4	5	1	2	3	4	5
1989	0.004	0.024	0.028	0.013	0.001	0.025	0.024	0.018	0.008	0.000
1990	0.005	0.029	0.034	0.015	0.001	0.035	0.033	0.024	0.011	0.001
1991	0.010	0.058	0.068	0.031	0.002	0.063	0.059	0.043	0.020	0.001
1992	0.009	0.049	0.058	0.026	0.001	0.035	0.024	0.011	0.005	0.000
1993	0.005	0.028	0.034	0.015	0.001	0.043	0.030	0.014	0.006	0.000
1994	0.009	0.048	0.057	0.026	0.001	0.048	0.034	0.015	0.007	0.000
1995	0.007	0.036	0.043	0.019	0.001	0.042	0.029	0.013	0.006	0.000
1996	0.010	0.057	0.067	0.030	0.002	0.025	0.017	0.008	0.004	0.000
1997	0.005	0.026	0.031	0.014	0.001	0.017	0.012	0.005	0.002	0.000
1998	0.008	0.045	0.054	0.024	0.001	0.012	0.008	0.004	0.002	0.000
1999	0.011	0.059	0.070	0.031	0.002	0.029	0.020	0.009	0.004	0.000
2000	0.016	0.087	0.103	0.046	0.002	0.050	0.035	0.016	0.007	0.000
2001	0.016	0.090	0.107	0.048	0.002	0.035	0.024	0.011	0.005	0.000
2002	0.010	0.053	0.063	0.028	0.001	0.030	0.027	0.006	0.003	0.000
2003	0.010	0.054	0.065	0.029	0.002	0.036	0.032	0.008	0.003	0.000
2004	0.008	0.044	0.052	0.024	0.001	0.046	0.041	0.010	0.004	0.000
2005	0.012	0.066	0.078	0.035	0.002	0.040	0.037	0.009	0.004	0.000
2006	0.010	0.056	0.066	0.030	0.002	0.032	0.029	0.007	0.003	0.000
2007	0.013	0.069	0.082	0.037	0.002	0.048	0.043	0.010	0.005	0.000
2008	0.012	0.068	0.081	0.037	0.002	0.051	0.046	0.011	0.005	0.000
2009	0.006	0.030	0.036	0.016	0.001	0.023	0.021	0.005	0.002	0.000
2010	0.010	0.056	0.067	0.030	0.002	0.056	0.050	0.012	0.005	0.000
2011	0.010	0.055	0.066	0.030	0.002	0.037	0.033	0.008	0.004	0.000
2012	0.014	0.079	0.095	0.042	0.002	0.022	0.019	0.005	0.002	0.000
2013	0.023	0.124	0.148	0.066	0.003	0.028	0.026	0.006	0.003	0.000

Table 24 (con't). Instantaneous fishing mortality, by fleet and age, for the southern stock.

	SC Comm/Rec					FL Releases				
	1	2	3	4	5	1	2	3	4	5
1989	0.048	0.094	0.042	0.019	0.001	0.006	0.009	0.002	0.001	0.001
1990	0.043	0.085	0.038	0.017	0.001	0.002	0.003	0.001	0.000	0.000
1991	0.037	0.072	0.032	0.014	0.001	0.019	0.028	0.006	0.002	0.002
1992	0.028	0.055	0.024	0.011	0.001	0.007	0.010	0.002	0.001	0.001
1993	0.028	0.055	0.025	0.011	0.001	0.011	0.017	0.003	0.001	0.001
1994	0.025	0.055	0.021	0.009	0.000	0.016	0.023	0.005	0.002	0.002
1995	0.051	0.114	0.043	0.019	0.001	0.013	0.019	0.004	0.002	0.002
1996	0.029	0.063	0.024	0.011	0.001	0.011	0.016	0.003	0.001	0.001
1997	0.032	0.070	0.026	0.012	0.001	0.015	0.022	0.005	0.002	0.002
1998	0.012	0.027	0.010	0.004	0.000	0.013	0.019	0.004	0.002	0.002
1999	0.011	0.025	0.009	0.004	0.000	0.015	0.022	0.005	0.002	0.002
2000	0.010	0.022	0.008	0.004	0.000	0.021	0.030	0.006	0.003	0.003
2001	0.008	0.045	0.019	0.008	0.000	0.021	0.031	0.006	0.003	0.003
2002	0.004	0.023	0.009	0.004	0.000	0.014	0.020	0.004	0.002	0.002
2003	0.014	0.077	0.032	0.014	0.001	0.014	0.021	0.004	0.002	0.002
2004	0.009	0.051	0.021	0.009	0.000	0.019	0.027	0.006	0.002	0.002
2005	0.012	0.069	0.028	0.013	0.001	0.029	0.043	0.009	0.004	0.004
2006	0.005	0.029	0.012	0.005	0.000	0.020	0.030	0.006	0.003	0.003
2007	0.009	0.049	0.020	0.009	0.000	0.018	0.027	0.006	0.002	0.002
2008	0.013	0.074	0.030	0.014	0.001	0.019	0.028	0.006	0.002	0.002
2009	0.007	0.038	0.015	0.007	0.000	0.010	0.014	0.003	0.001	0.001
2010	0.014	0.080	0.033	0.015	0.001	0.023	0.034	0.007	0.003	0.003
2011	0.013	0.074	0.030	0.014	0.001	0.019	0.027	0.006	0.002	0.002
2012	0.012	0.067	0.027	0.012	0.001	0.019	0.028	0.006	0.002	0.002
2013	0.012	0.068	0.028	0.012	0.001	0.034	0.050	0.010	0.004	0.004

Table 24 (con't). Instantaneous fishing mortality, by fleet and age, for the southern stock.

	GA/SC Releases				
	1	2	3	4	5
1989	0.004	0.004	0.004	0.002	0.000
1990	0.009	0.009	0.009	0.004	0.000
1991	0.006	0.006	0.006	0.003	0.000
1992	0.004	0.004	0.005	0.002	0.000
1993	0.006	0.007	0.008	0.004	0.000
1994	0.010	0.010	0.012	0.006	0.000
1995	0.013	0.013	0.017	0.007	0.000
1996	0.006	0.006	0.007	0.003	0.000
1997	0.005	0.005	0.006	0.003	0.000
1998	0.003	0.003	0.004	0.002	0.000
1999	0.003	0.003	0.003	0.002	0.000
2000	0.006	0.006	0.008	0.004	0.000
2001	0.010	0.011	0.013	0.006	0.000
2002	0.007	0.007	0.009	0.004	0.000
2003	0.012	0.013	0.016	0.007	0.000
2004	0.010	0.011	0.013	0.006	0.000
2005	0.016	0.016	0.020	0.009	0.000
2006	0.015	0.016	0.019	0.009	0.000
2007	0.015	0.015	0.019	0.009	0.000
2008	0.019	0.020	0.024	0.011	0.001
2009	0.018	0.018	0.022	0.010	0.001
2010	0.020	0.021	0.026	0.012	0.001
2011	0.015	0.016	0.020	0.009	0.000
2012	0.013	0.014	0.017	0.007	0.000
2013	0.017	0.018	0.022	0.010	0.001

Table 25. Estimated age-1 to age-5 instantaneous fishing mortality for the southern stock during 1989-2013.

	Southern stock				
	1	2	3	4	5
1989	0.088	0.155	0.094	0.042	0.003
1990	0.095	0.159	0.106	0.048	0.003
1991	0.135	0.222	0.155	0.070	0.006
1992	0.083	0.143	0.101	0.045	0.003
1993	0.094	0.137	0.084	0.038	0.003
1994	0.107	0.169	0.110	0.049	0.004
1995	0.126	0.212	0.119	0.054	0.004
1996	0.080	0.159	0.109	0.049	0.004
1997	0.073	0.135	0.073	0.033	0.004
1998	0.048	0.102	0.075	0.034	0.003
1999	0.069	0.129	0.097	0.043	0.004
2000	0.102	0.180	0.141	0.063	0.006
2001	0.091	0.201	0.156	0.070	0.006
2002	0.064	0.130	0.092	0.041	0.004
2003	0.086	0.198	0.124	0.056	0.005
2004	0.092	0.174	0.102	0.046	0.005
2005	0.109	0.230	0.144	0.065	0.007
2006	0.083	0.160	0.111	0.050	0.005
2007	0.102	0.204	0.137	0.061	0.005
2008	0.114	0.236	0.152	0.068	0.006
2009	0.063	0.122	0.082	0.037	0.003
2010	0.123	0.241	0.144	0.065	0.006
2011	0.094	0.206	0.129	0.058	0.005
2012	0.080	0.207	0.149	0.067	0.006
2013	0.115	0.286	0.214	0.096	0.009

Table 26. sEsc, and tEsc (ages 1-5) with asymptotic SEs and CVs for the southern stock.

Year	sEsc			tEsc		
	Est	SE	CV	Est	SE	CV
1989	0.683	0.184	0.270			
1990	0.663	0.193	0.291			
1991	0.556	0.223	0.401			
1992	0.687	0.175	0.254			
1993	0.701	0.164	0.234	0.637	0.197	0.309
1994	0.644	0.184	0.286	0.631	0.195	0.308
1995	0.597	0.250	0.418	0.660	0.180	0.273
1996	0.669	0.200	0.298	0.679	0.177	0.260
1997	0.728	0.153	0.210	0.647	0.193	0.298
1998	0.769	0.133	0.173	0.629	0.215	0.342
1999	0.710	0.156	0.219	0.673	0.187	0.278
2000	0.611	0.189	0.310	0.712	0.160	0.225
2001	0.592	0.204	0.344	0.711	0.158	0.223
2002	0.718	0.162	0.226	0.676	0.173	0.256
2003	0.626	0.189	0.301	0.637	0.184	0.288
2004	0.659	0.174	0.264	0.634	0.185	0.292
2005	0.574	0.204	0.356	0.672	0.176	0.262
2006	0.665	0.177	0.266	0.648	0.181	0.280
2007	0.600	0.191	0.318	0.632	0.185	0.293
2008	0.562	0.209	0.371	0.607	0.192	0.316
2009	0.737	0.148	0.201	0.620	0.190	0.307
2010	0.560	0.208	0.372	0.618	0.188	0.304
2011	0.611	0.203	0.332	0.613	0.189	0.309
2012	0.601	0.204	0.339	0.642	0.186	0.290
2013	0.487	0.234	0.482	0.601	0.202	0.336

Table 27. Annual sSPR and three year sSPR with asymptotic SEs and CVs for the southern stock.

Year	sSPR			3 yr sSPR		
	Est	SE	CV	Est	SE	CV
1989	0.665	0.193	0.290			
1990	0.647	0.201	0.312			
1991	0.527	0.232	0.441	0.613	0.204	0.332
1992	0.667	0.184	0.276	0.614	0.202	0.329
1993	0.680	0.174	0.256	0.625	0.195	0.311
1994	0.618	0.194	0.314	0.655	0.182	0.278
1995	0.574	0.258	0.449	0.624	0.203	0.325
1996	0.646	0.211	0.326	0.613	0.214	0.350
1997	0.705	0.165	0.233	0.642	0.205	0.320
1998	0.746	0.145	0.195	0.699	0.171	0.245
1999	0.684	0.168	0.245	0.712	0.158	0.222
2000	0.580	0.201	0.346	0.670	0.170	0.254
2001	0.560	0.215	0.384	0.608	0.193	0.317
2002	0.694	0.174	0.251	0.611	0.195	0.319
2003	0.601	0.199	0.331	0.618	0.195	0.315
2004	0.632	0.185	0.293	0.642	0.185	0.288
2005	0.540	0.215	0.398	0.591	0.198	0.336
2006	0.635	0.189	0.298	0.602	0.195	0.324
2007	0.572	0.201	0.352	0.582	0.201	0.345
2008	0.533	0.218	0.409	0.580	0.202	0.348
2009	0.716	0.158	0.221	0.607	0.191	0.315
2010	0.530	0.218	0.410	0.593	0.197	0.332
2011	0.583	0.214	0.367	0.610	0.196	0.321
2012	0.571	0.215	0.376	0.562	0.214	0.382
2013	0.449	0.242	0.538	0.535	0.222	0.416

Table 28. Multiplicative weighting factors applied to input error in the southern stock assessment model to achieve SDSRs below the upper limit suggested by Francis (2011).

Data Set	Multiplicative Weighting Factor	SDSR Upper Limit	SDSR
FL Bagged Seine Survey	1.00	1.34	1.19
GA Gill Net Survey	1.77	1.35	1.12
SC Stop Net Survey	1.00	1.49	1.12
SC Trammel Net Survey—Age 1	2.20	1.26	1.14
SC Trammel Net Survey—Age 2	2.23	1.26	1.14
FL Haul Seine Survey—Age 2	1.77	1.28	0.91
FL Haul Seine Survey—Age 3	1.80	1.28	0.96
MRFSS/MRIP Index	1.85	1.24	1.08
SC 1 mile Long Line Survey	2.11	1.35	1.34
SC 1/3 mile Long Line Survey	2.13	1.45	0.99
GA Long Line Survey	2.09	1.45	1.04

Table 29. Likelihood components of the southern red drum assessment model following iterative re-weighting.

Components		N	TSS	RSS	NegLL	SDSR
Total Kill						
FL Rec		25	177.51	0.12	-44.07	0.07
GA Comm/Rec		25	116.15	0.05	-38.33	0.05
SC Comm/Rec		25	86.67	0.23	-33.22	0.10
FL Releases		25	198.77	0.01	-43.20	0.02
GA/SC Releases		25	310.38	0.01	-36.84	0.02
	Totals	125	889.47	0.43	-195.67	
Proportion-at-age						
FL Rec		175			543.81	0.13
GA Comm/Rec		175			588.34	0.53
SC Comm/Rec		175			907.00	0.39
GA/SC Releases		175			103.30	0.88
	Totals	700			2142.45	
Indices of Abundance						
FL Bagged Beach Seine Survey		12	26.43	17.27	-0.54	1.19
GA Gill Net Survey—Age 1		11	23.61	13.75	-5.00	1.12
SC Stop Net Survey		6	9.99	7.93	-4.73	1.12
SC Trammel Net Survey—Age 1		20	58.97	25.91	-9.46	1.14
SC Trammel Net Survey—Age 2		20	53.16	25.92	-9.02	1.14
FL Haul Seine Survey—Age 2		17	9.32	14.25	-12.69	0.91
FL Haul Seine Survey—Age 3		17	6.67	15.79	-6.77	0.96
MRIP Index		23	120.34	26.83	-43.54	1.08
SC 1 mile Longline Survey (Adult)		11	10.66	19.93	0.31	1.34
SC 1/3 mile Longline Survey		7	7.76	6.91	-5.52	0.99
GA Longline Survey		7	8.17	7.64	-1.04	1.04
	Totals	151	335.06	182.11	-98.00	
Other Deviations						
Selectivities					37.90	
	Totals				37.90	
	Grand Total				1,886.68	

6. Figures

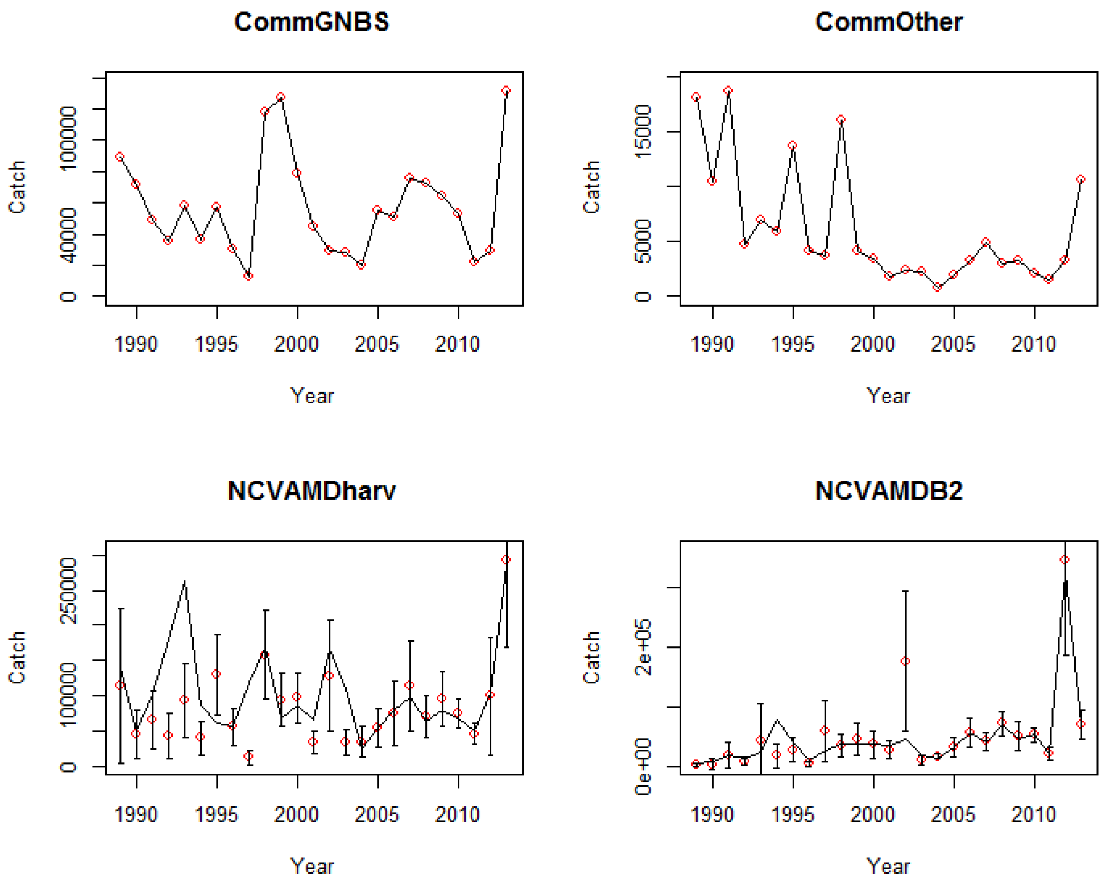


Figure 1. Observed (red circles) and model estimated (solid black line) catch, by fleet, for the northern stock. Error bars show 95% confidence intervals of observed values.

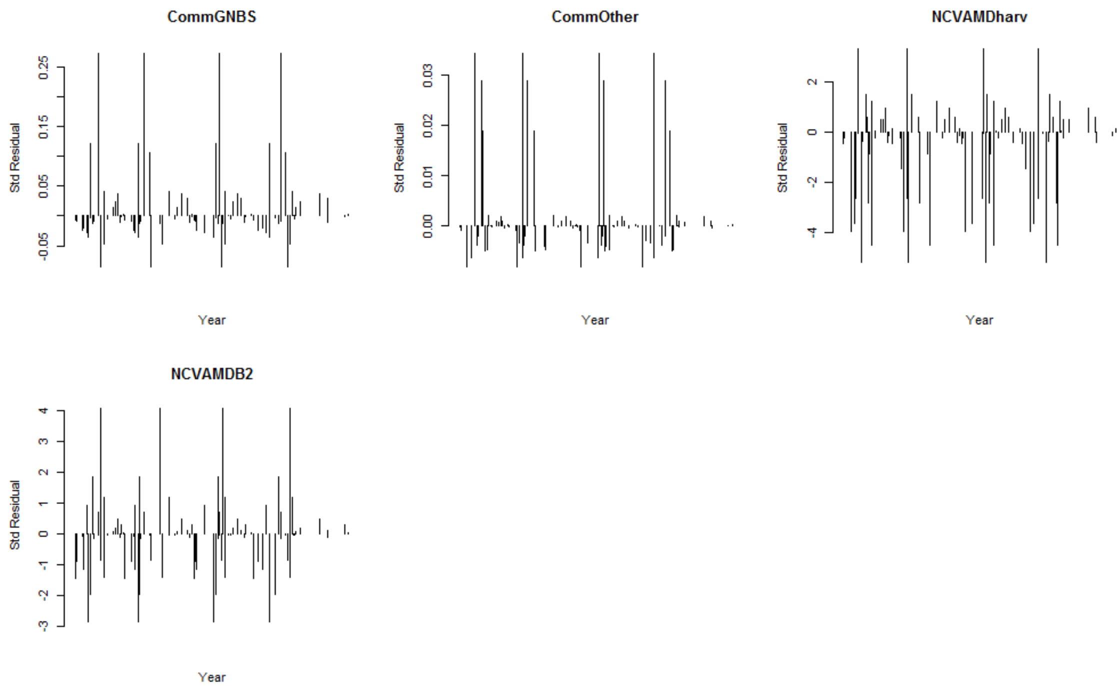


Figure 2. Standardized residuals for model fits to catch, by fleet and year, for the northern stock.

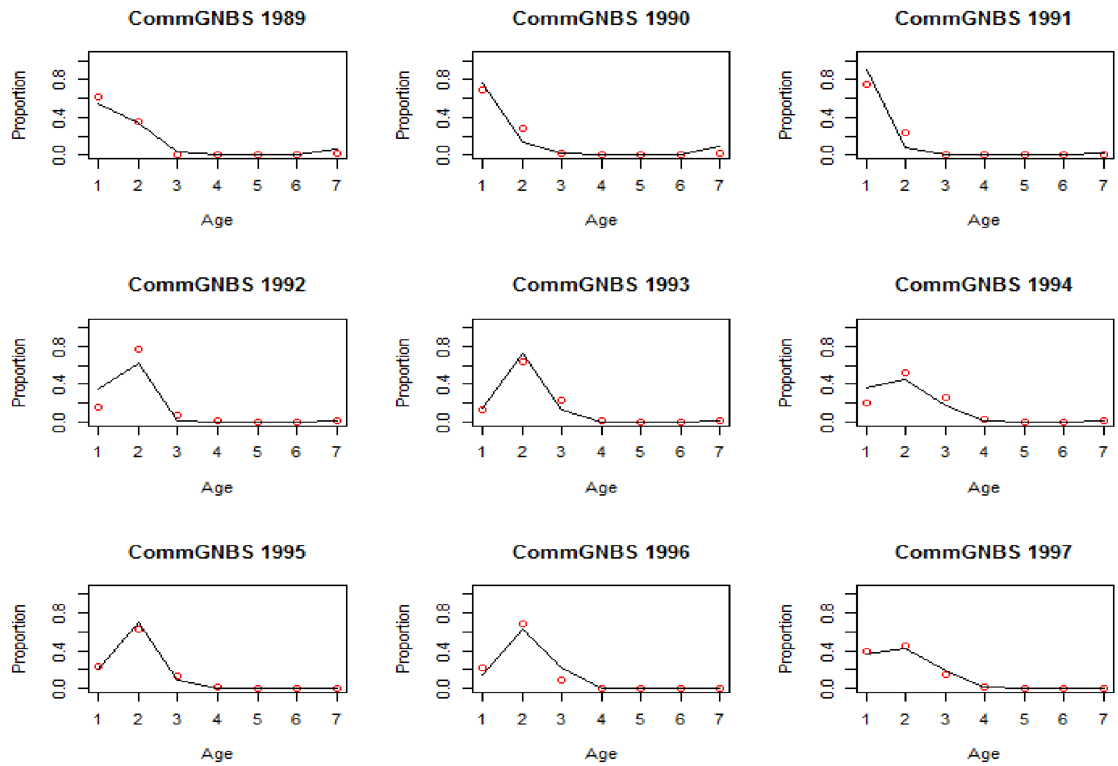


Figure 3. Northern model fits to the proportion-at-age data for each fleet and year. The recreational release fleet is not included as the selectivities were fixed based on external tagging data and the proportion-at-age data were not used in model fitting.

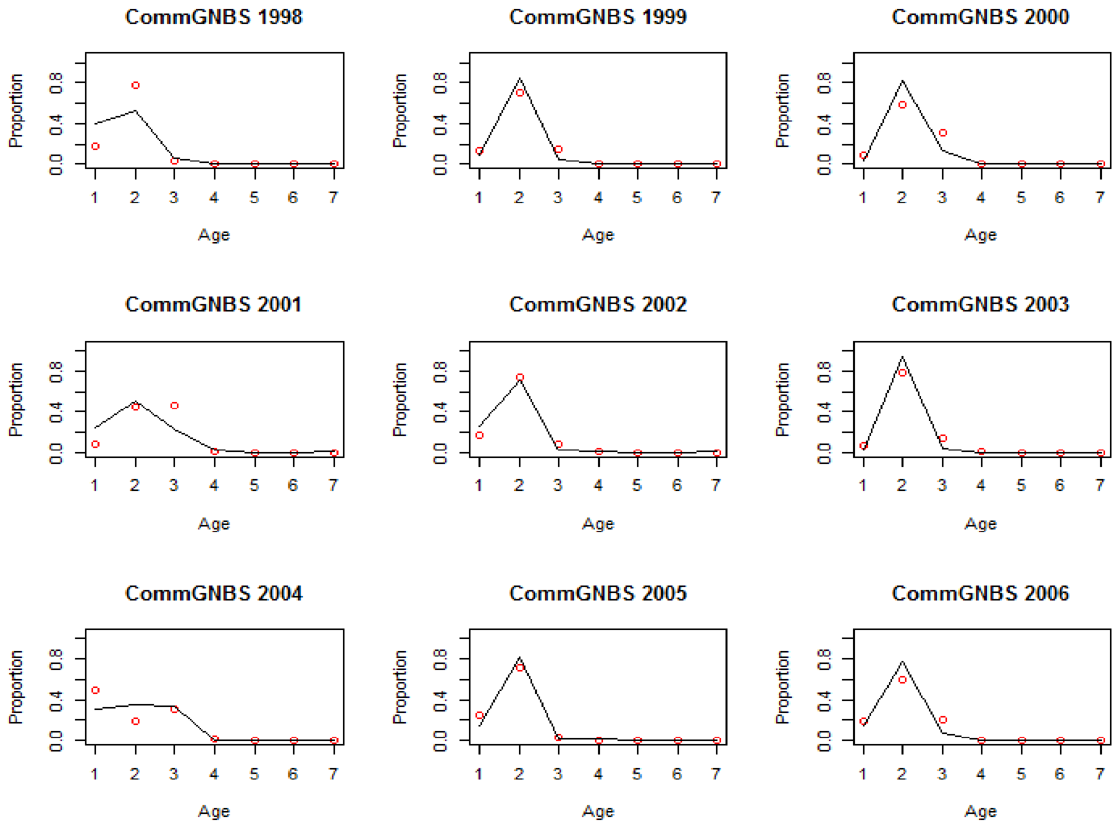


Figure 3 (con’t).

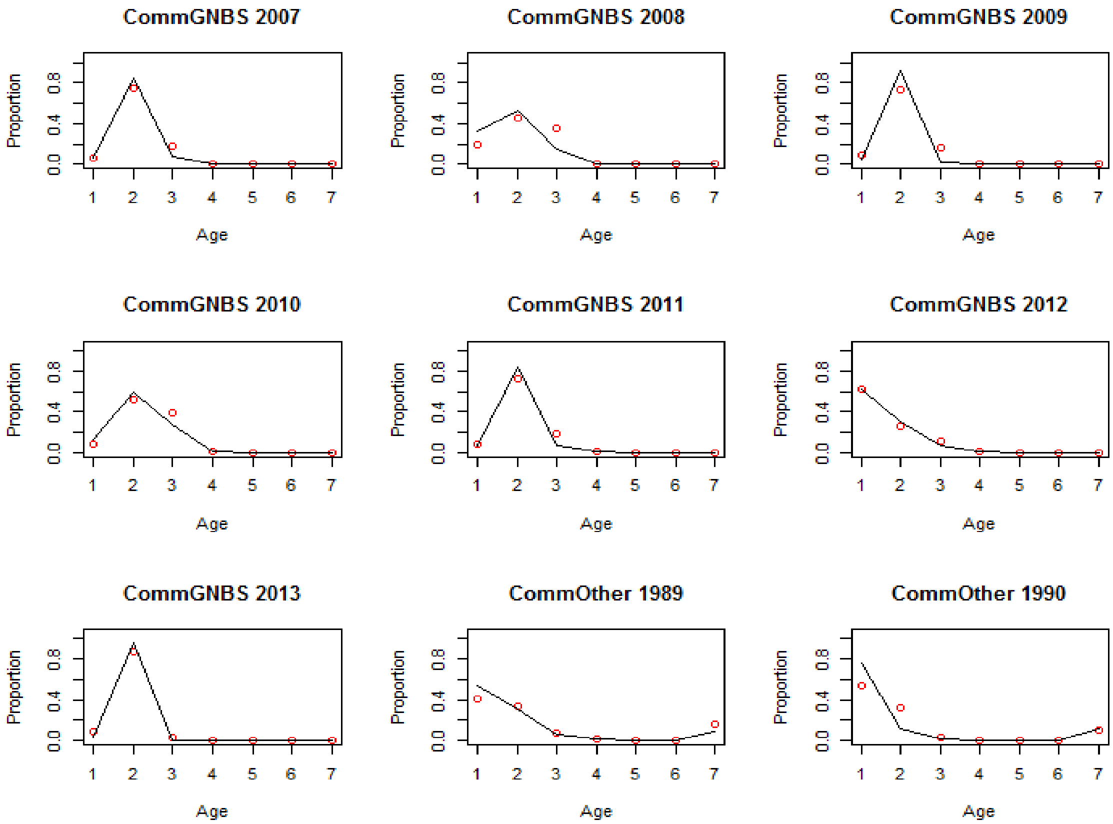


Figure 3 (con't).

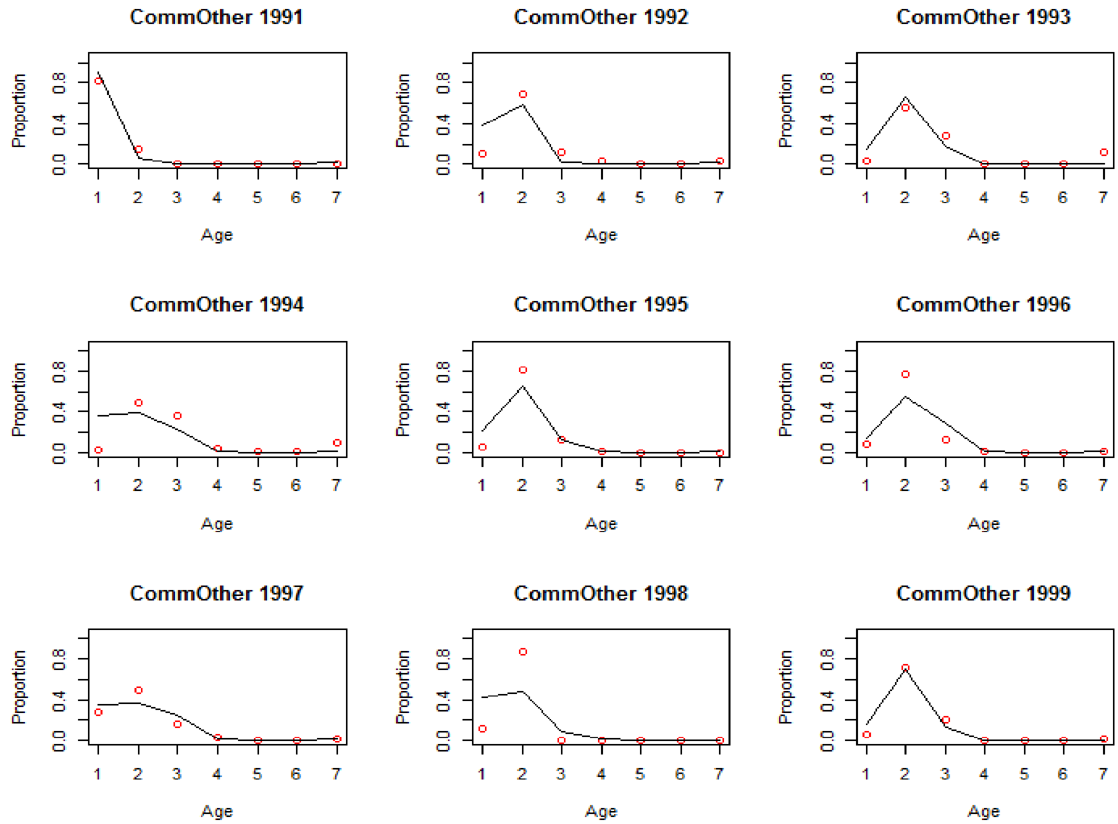


Figure 3 (con't).

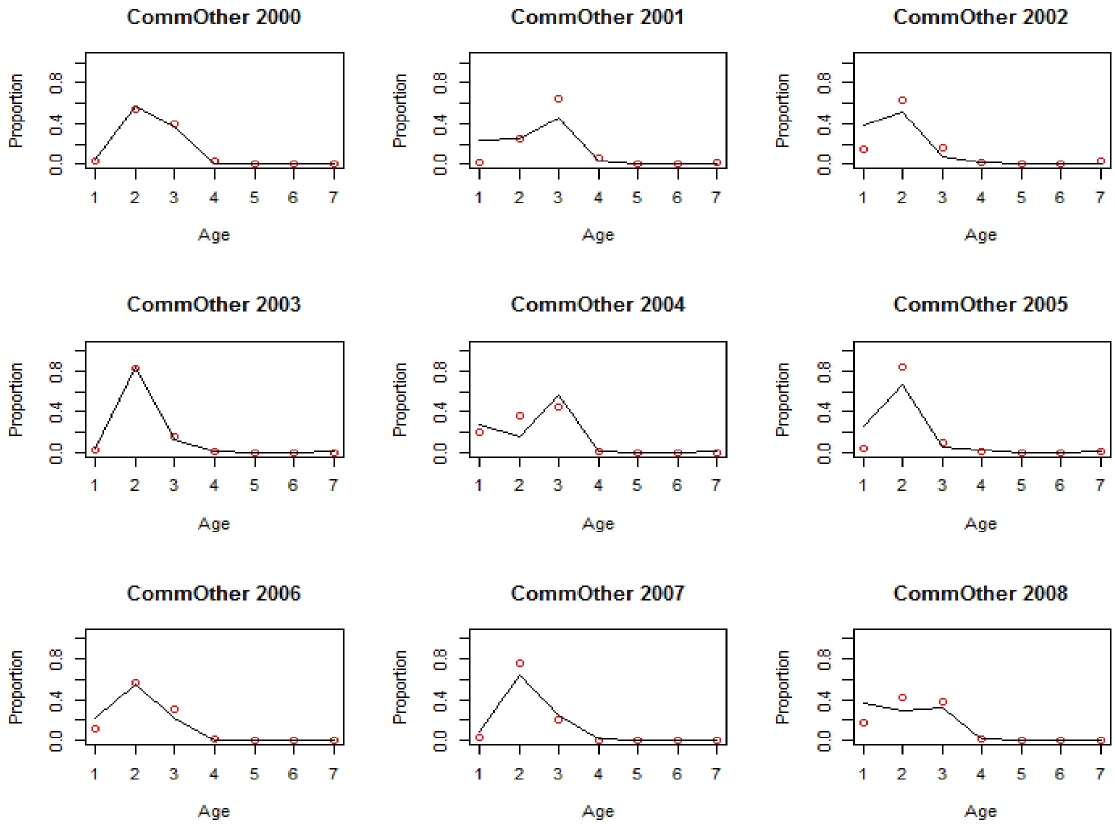


Figure 3 (con't).

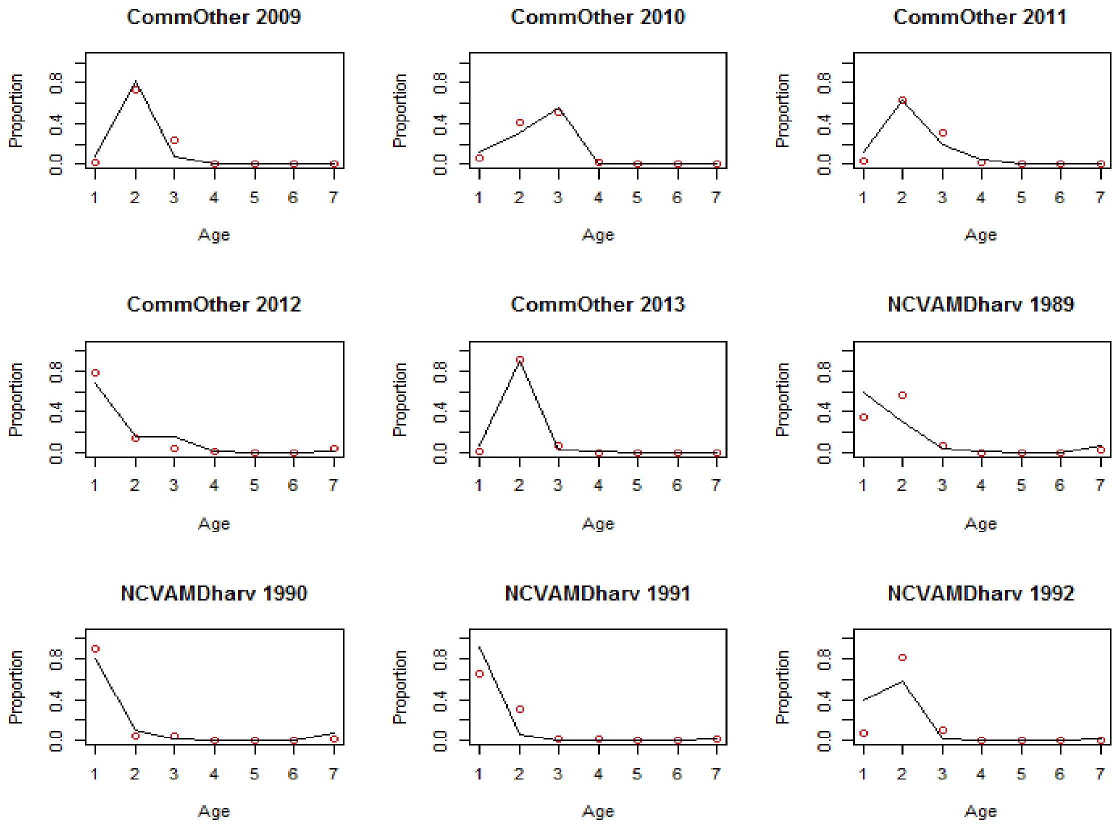


Figure 3 (con't).

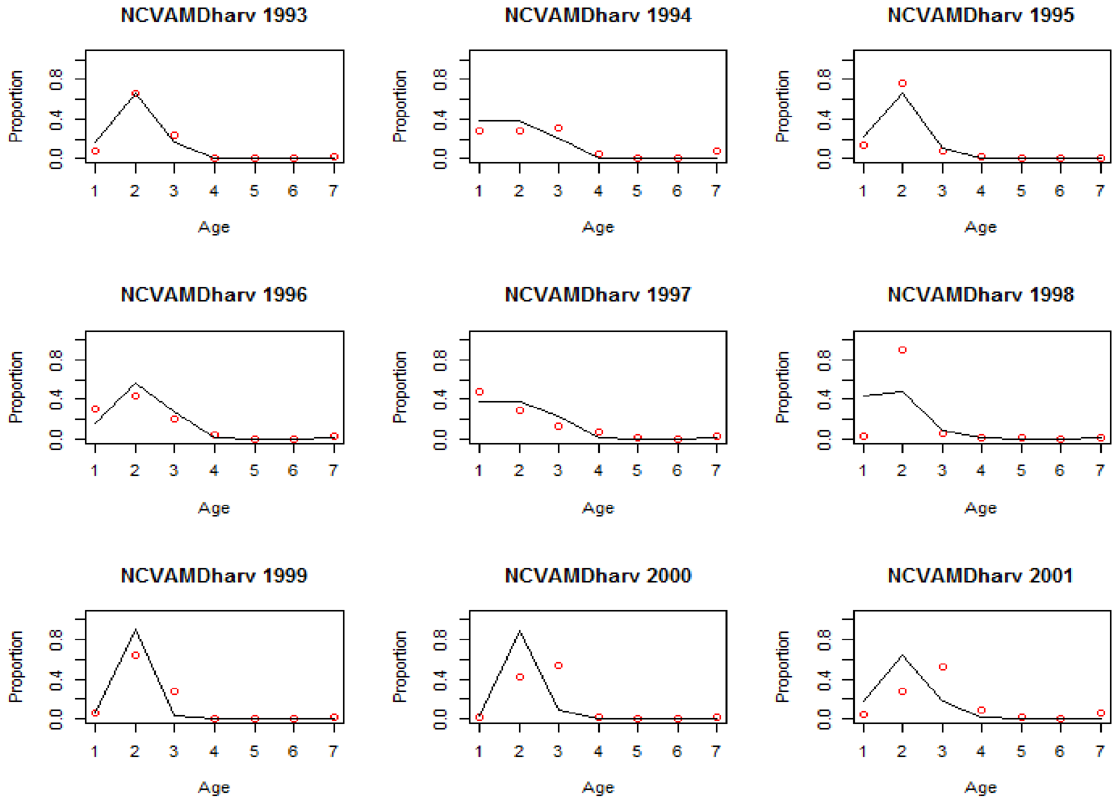


Figure 3 (con't).

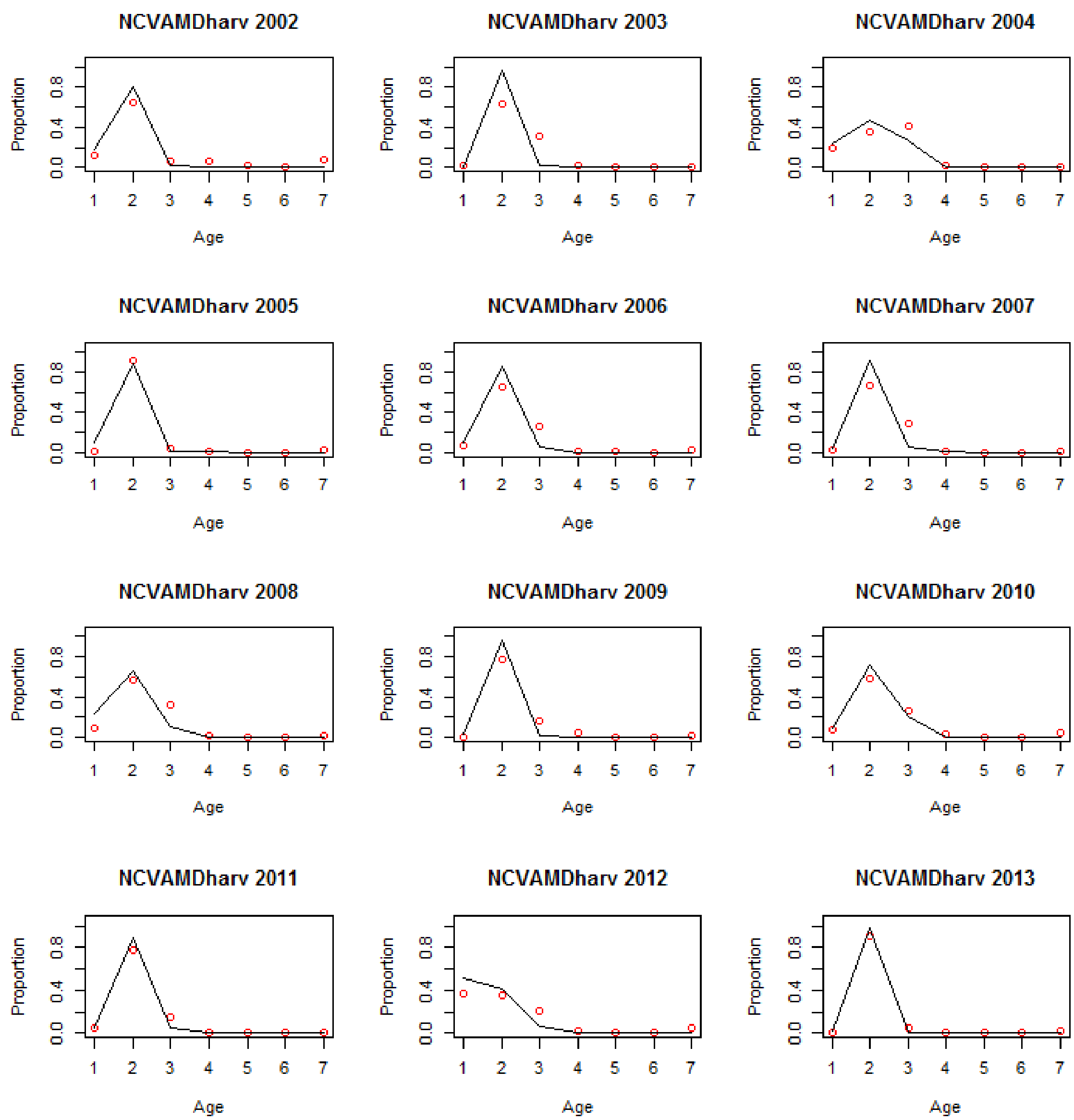


Figure 3 (con't).

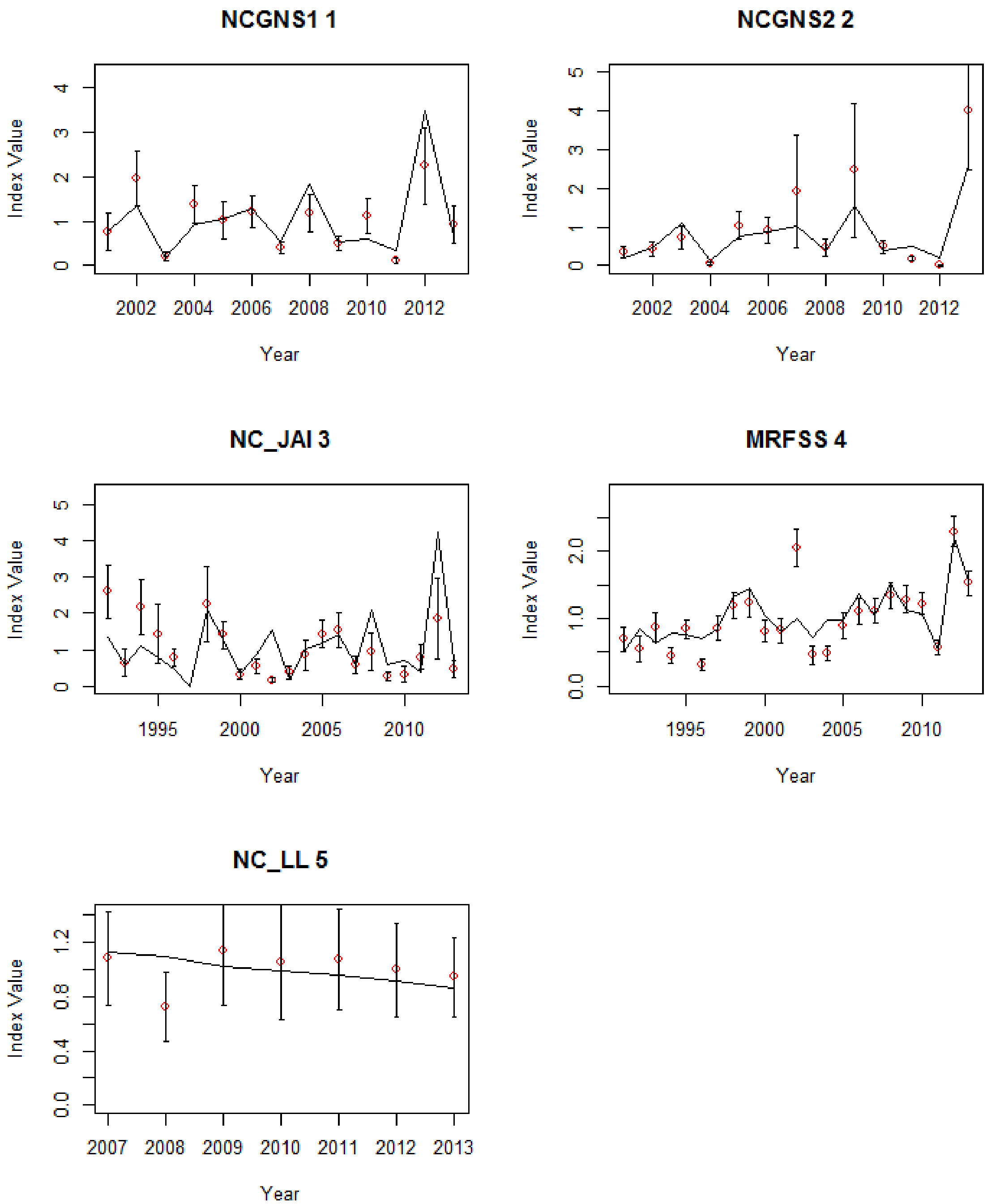


Figure 4. Observed (red circles) and model estimated (solid black line) indices of abundance for the northern stock. Error bars show 95% confidence intervals of observed values.

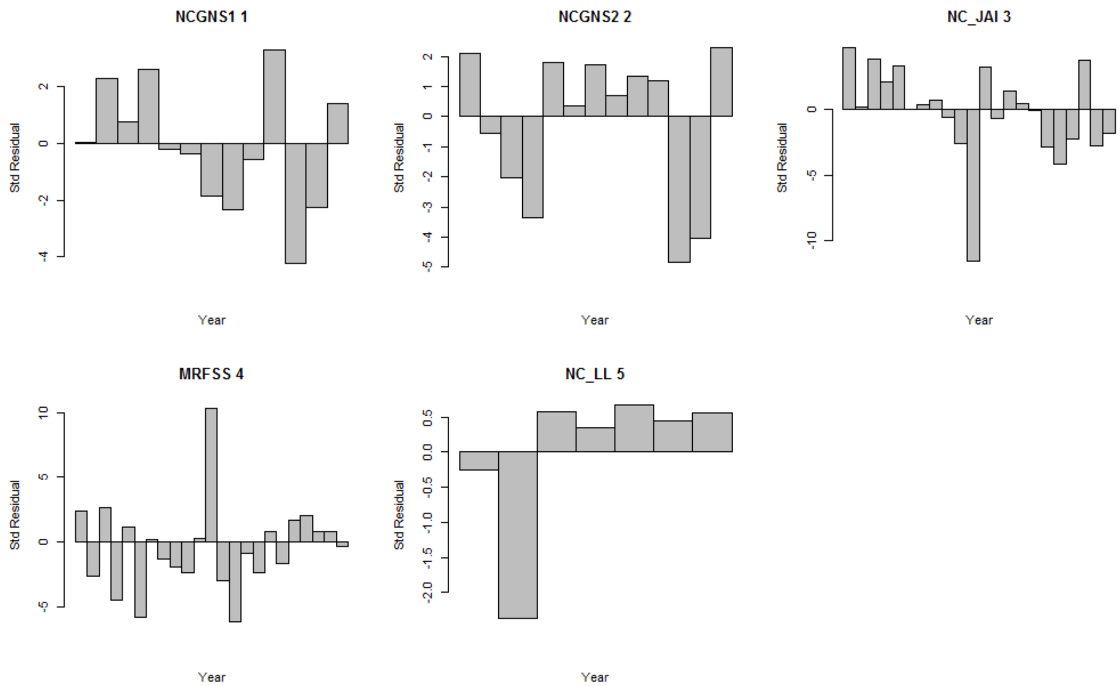


Figure 5. Standardized residuals for model fits to indices of abundance, by year, for the northern stock.

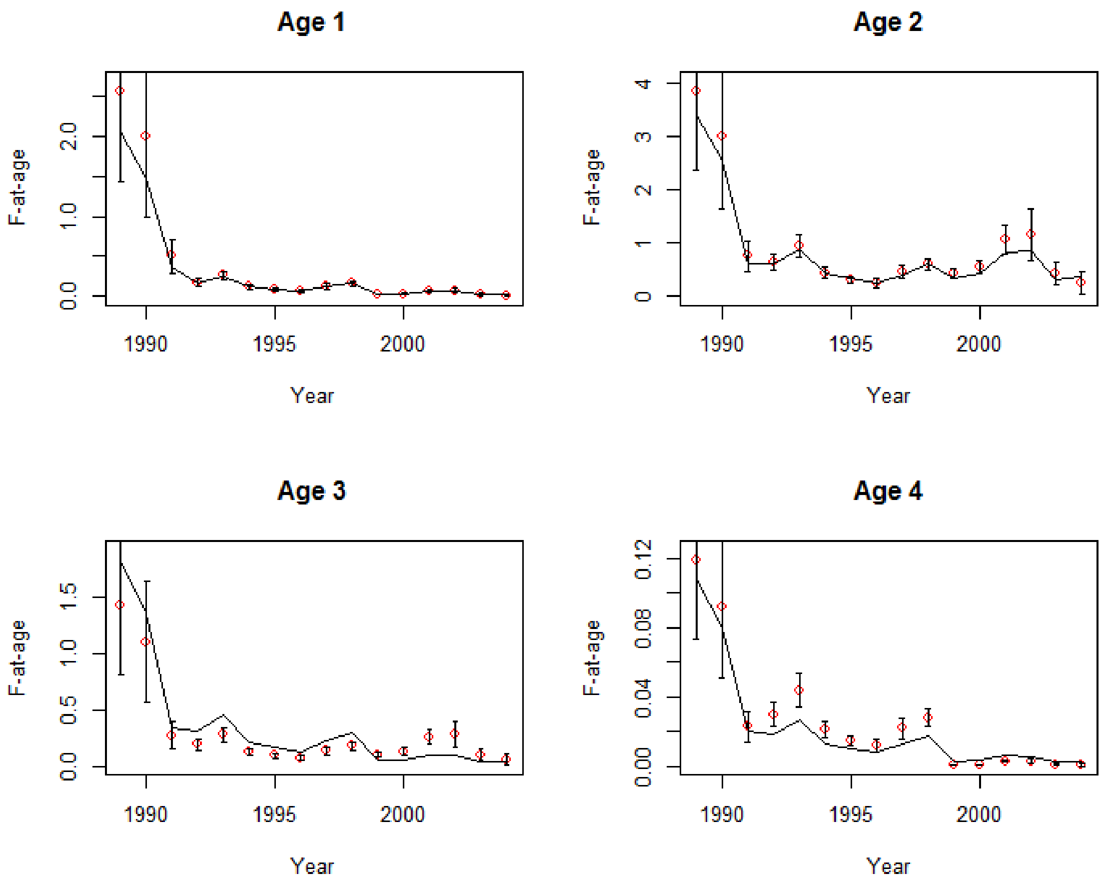


Figure 6. Observed (red circles) and model estimated (solid black line) F-at-age (ages 1-4) for the harvest fleets in the northern stock. Error bars show 95% confidence intervals of observed values.

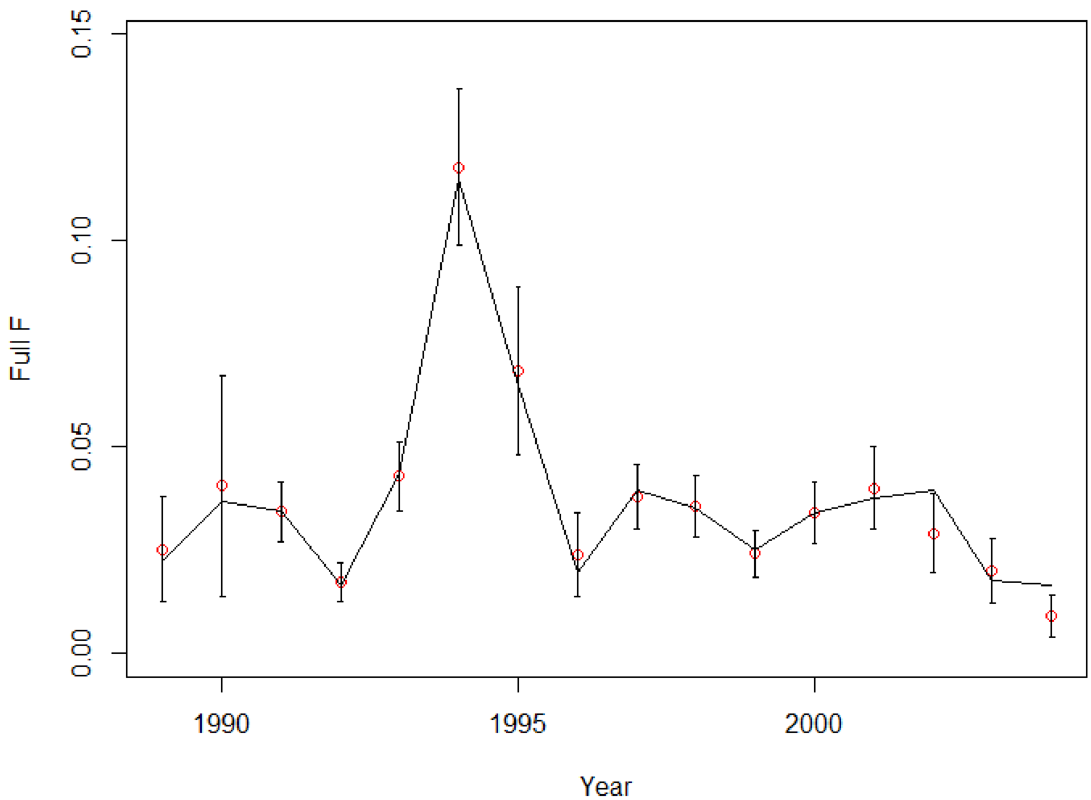


Figure 7. Observed (red circles) and model estimated (solid black line) full F for the recreational live release fleet in the northern stock. Error bars show 95% confidence intervals of observed values.

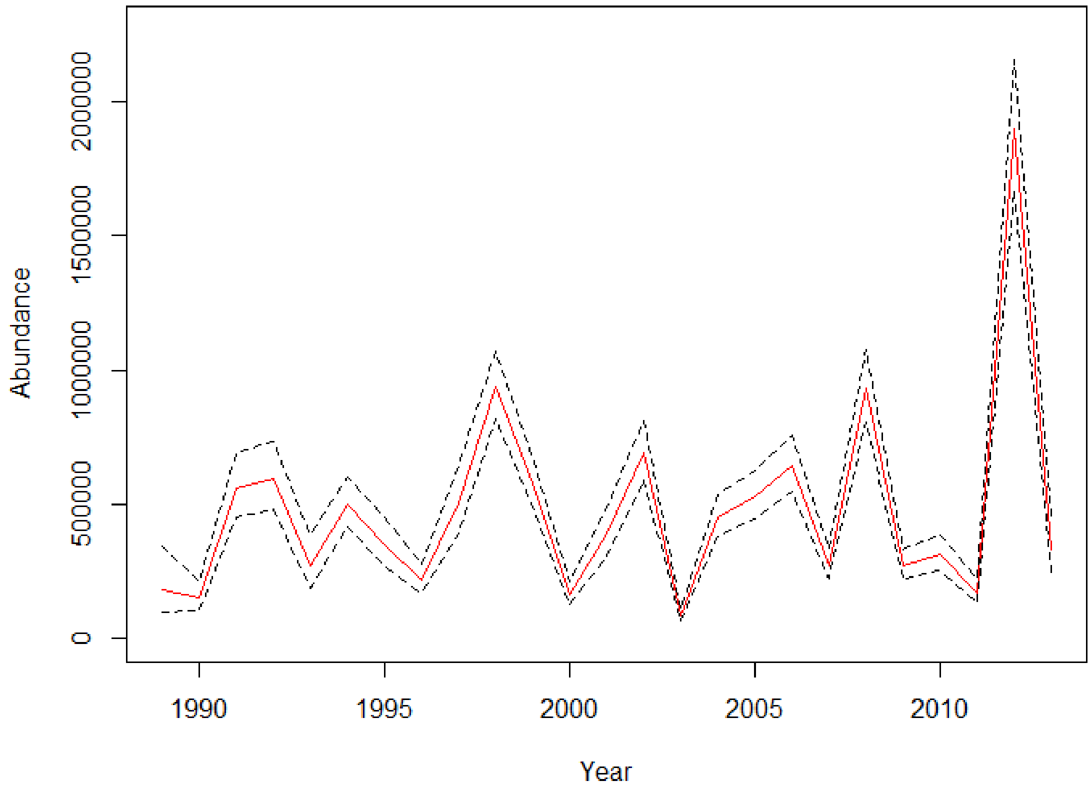


Figure 8. Predicted recruitment for the northern stock with 95% confidence intervals from asymptotic standard errors.

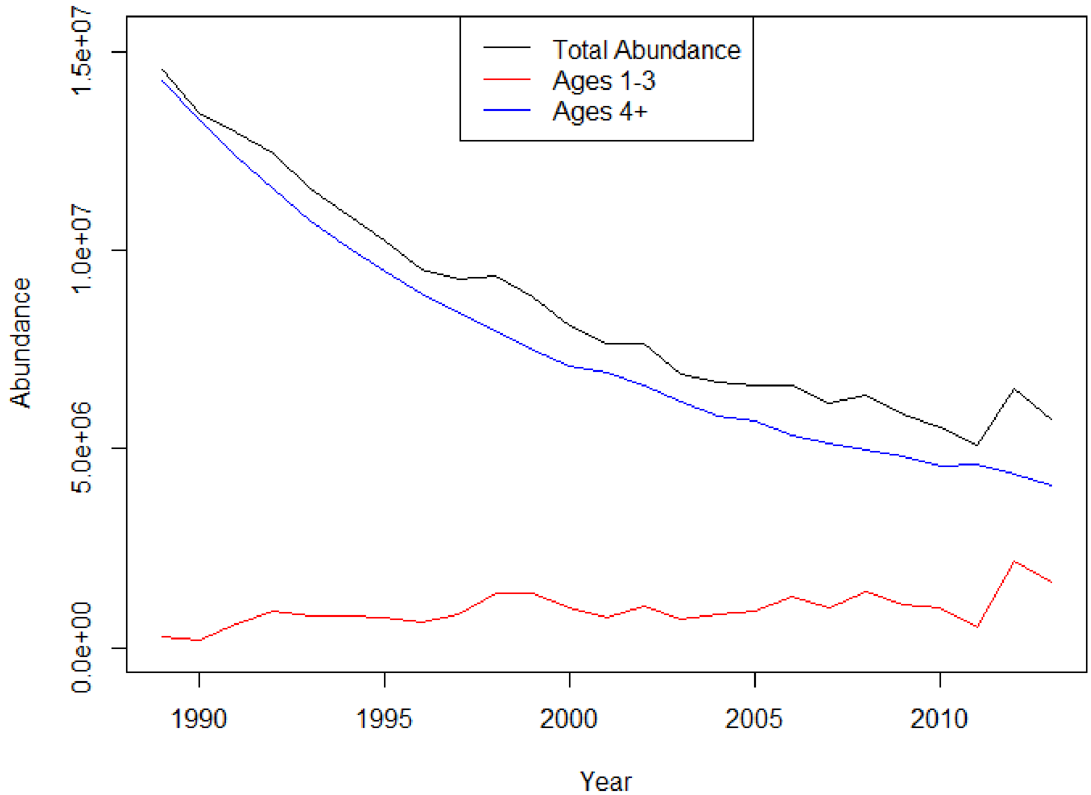


Figure 9. Abundance of red drum at various ages for the northern stock.

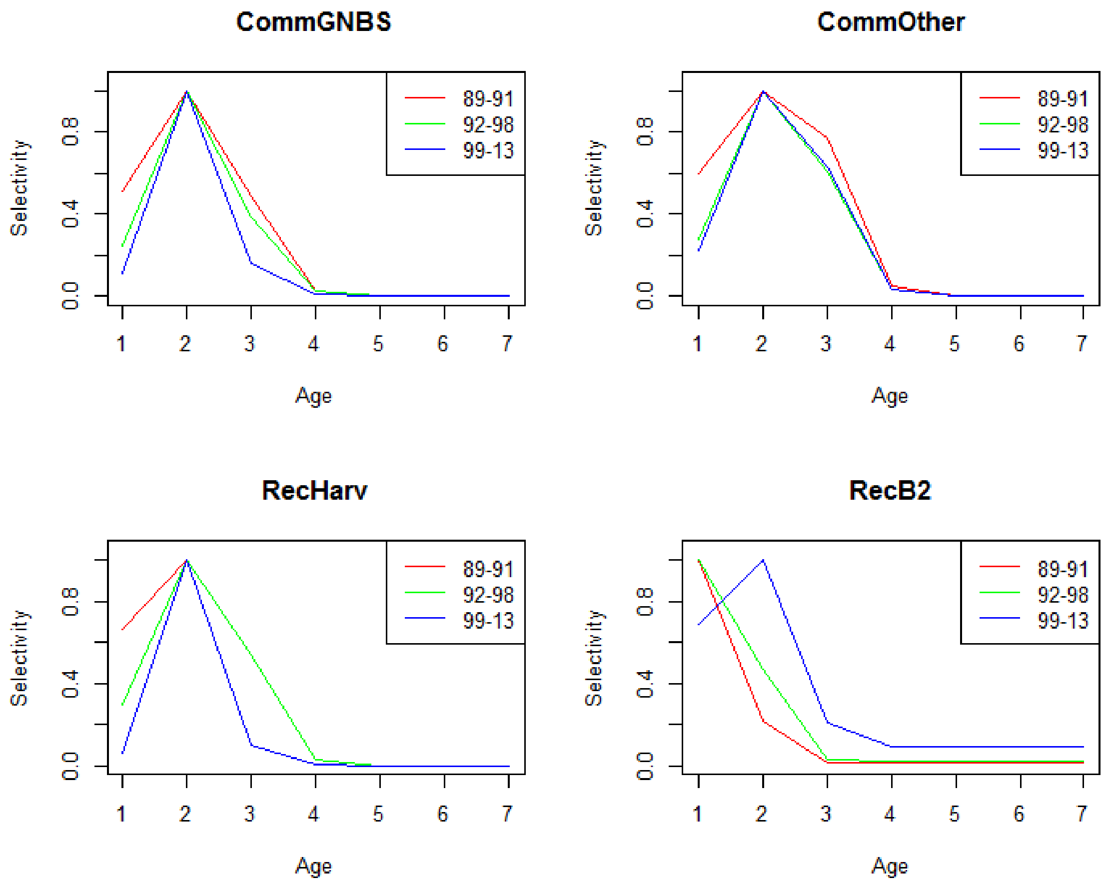


Figure 10. Selectivity curves for each fleet and selectivity block in the northern stock. The recreational live release selectivity is fixed based on external tagging analysis (Bacheler et al. 2008).

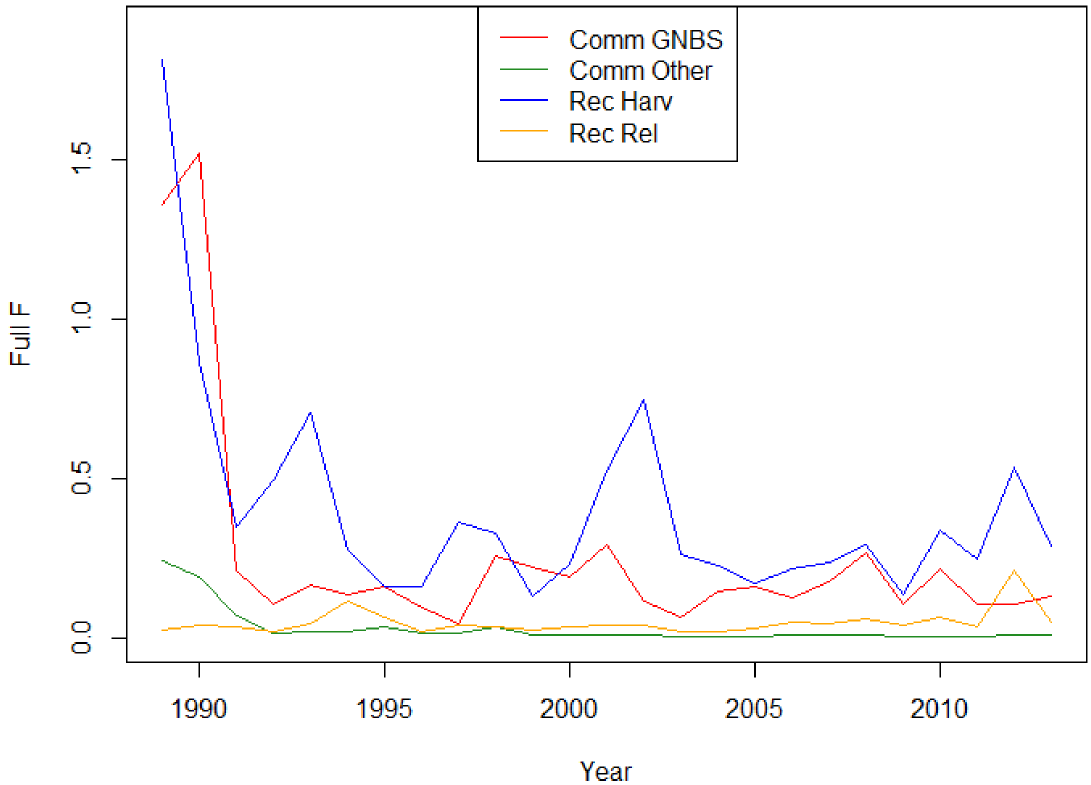


Figure 11. Fleet-specific annual fishing mortality for the northern stock.

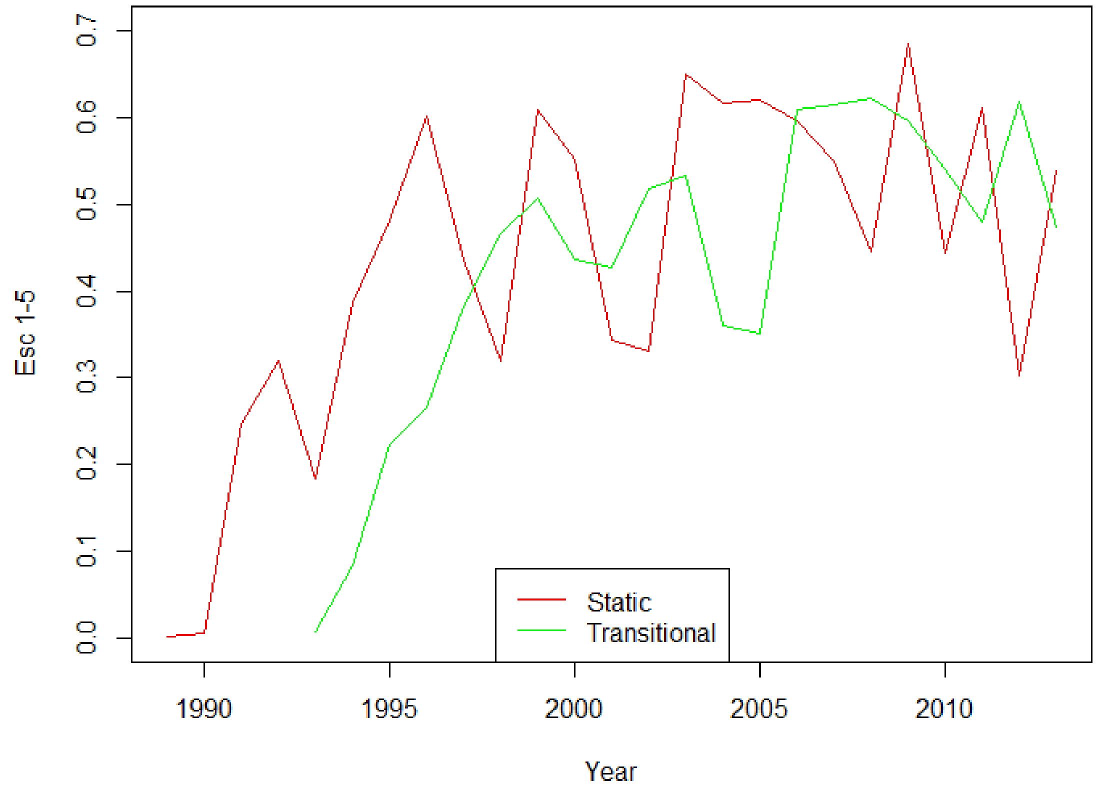


Figure 12. Estimates of static and transitional escapement for ages 1-5 for the northern stock.

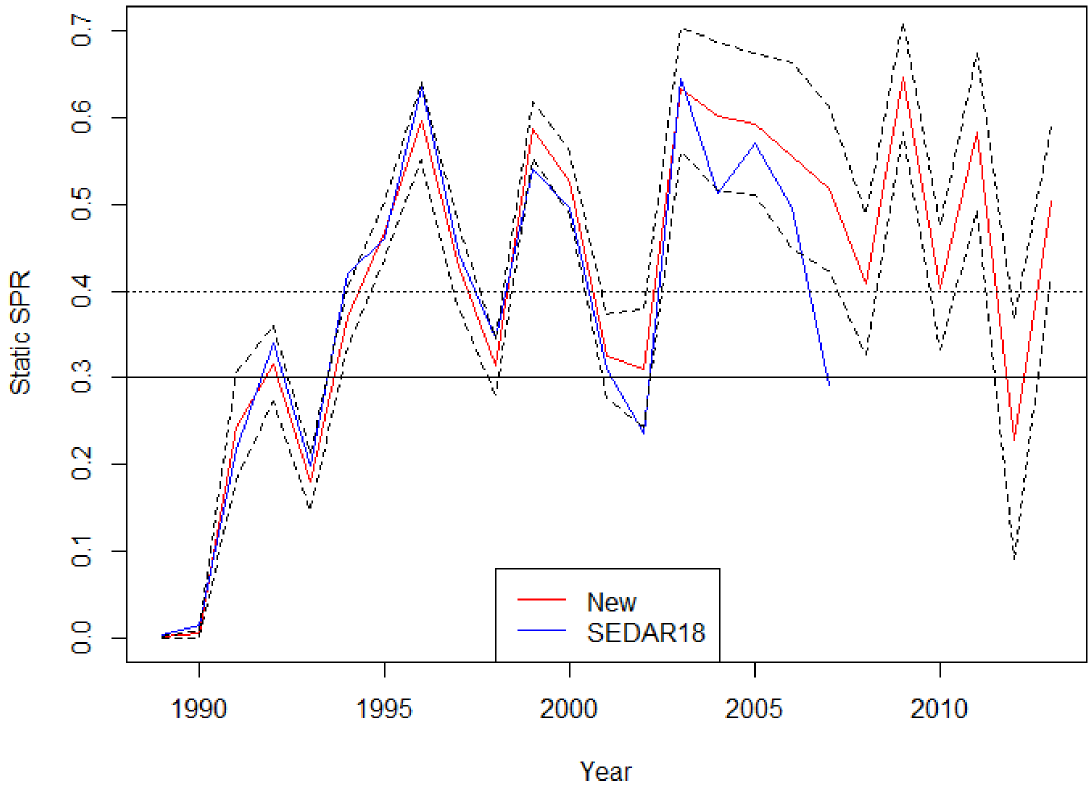


Figure 13. Annual sSPR estimates for the northern stock with 95% confidence intervals from asymptotic standard errors. Point estimates from the previous benchmark assessment (SEDAR18) are included for comparison. The target sSPR (dashed black line) is 40% and the threshold sSPR (solid black line) is 30%.

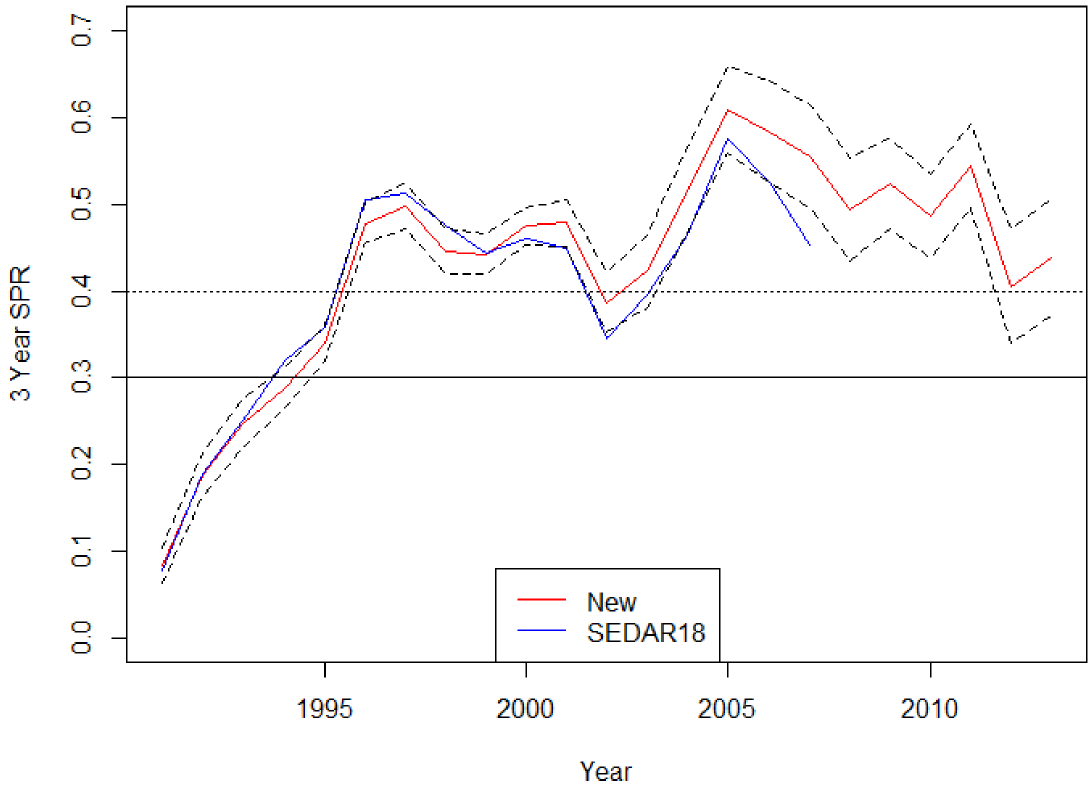


Figure 14. Three year average sSPR for the northern stock with 95% confidence intervals from asymptotic standard errors. Point estimates from the previous benchmark assessment (SEDAR18) are included for comparison. The target sSPR (dashed black line) is 40% and the threshold sSPR (solid black line) is 30%.

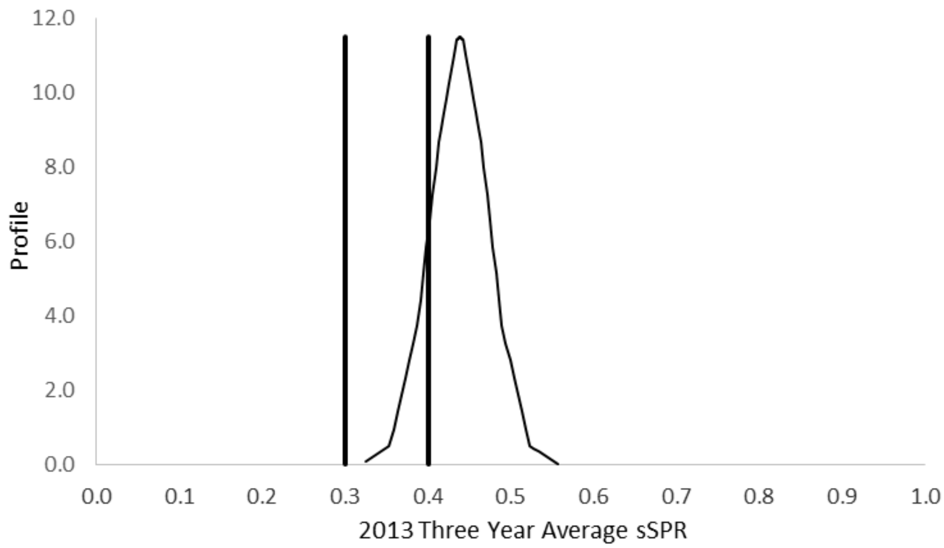


Figure 15. Estimated probability density function of the 2013 three year average sSPR for the northern stock. The target sSPR is 40% and the threshold sSPR is 30%.

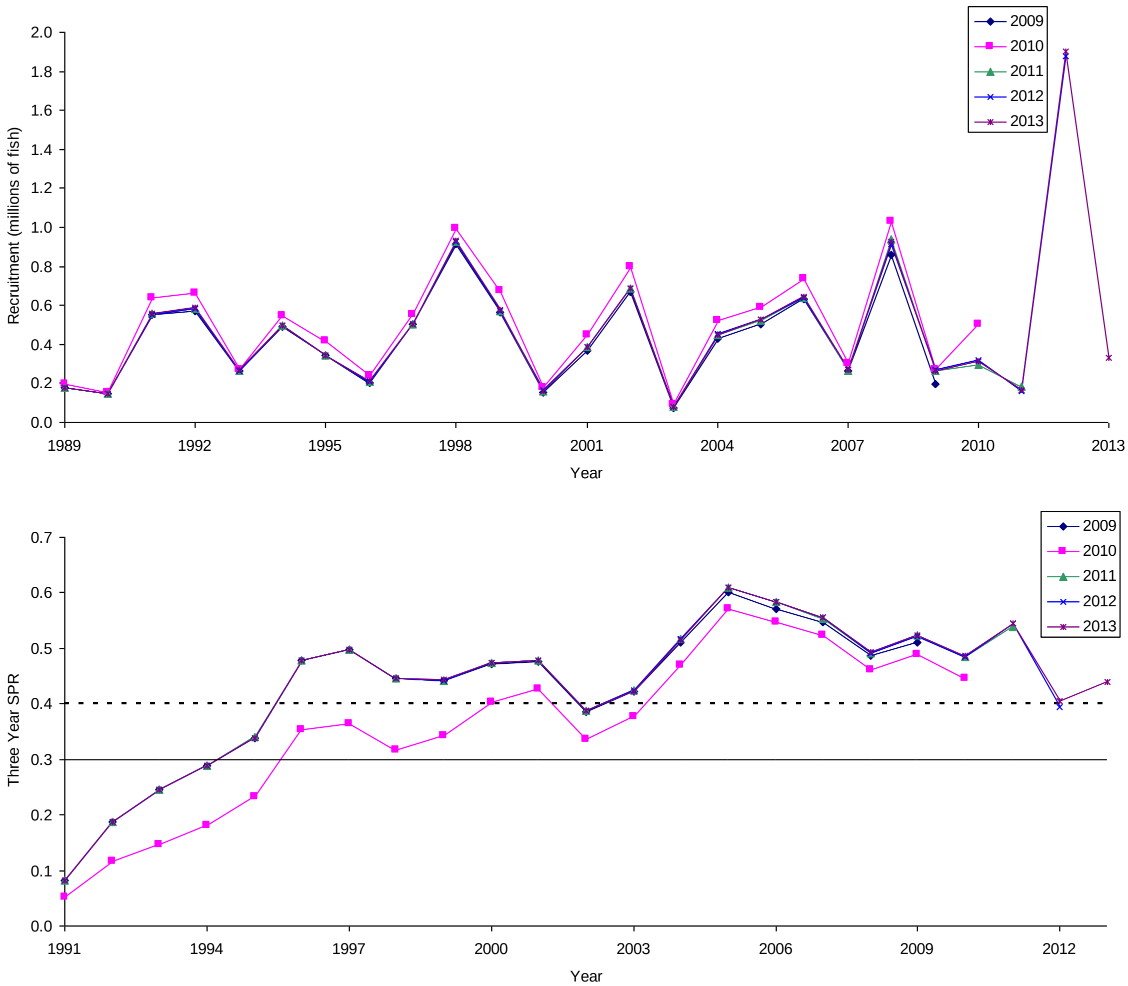
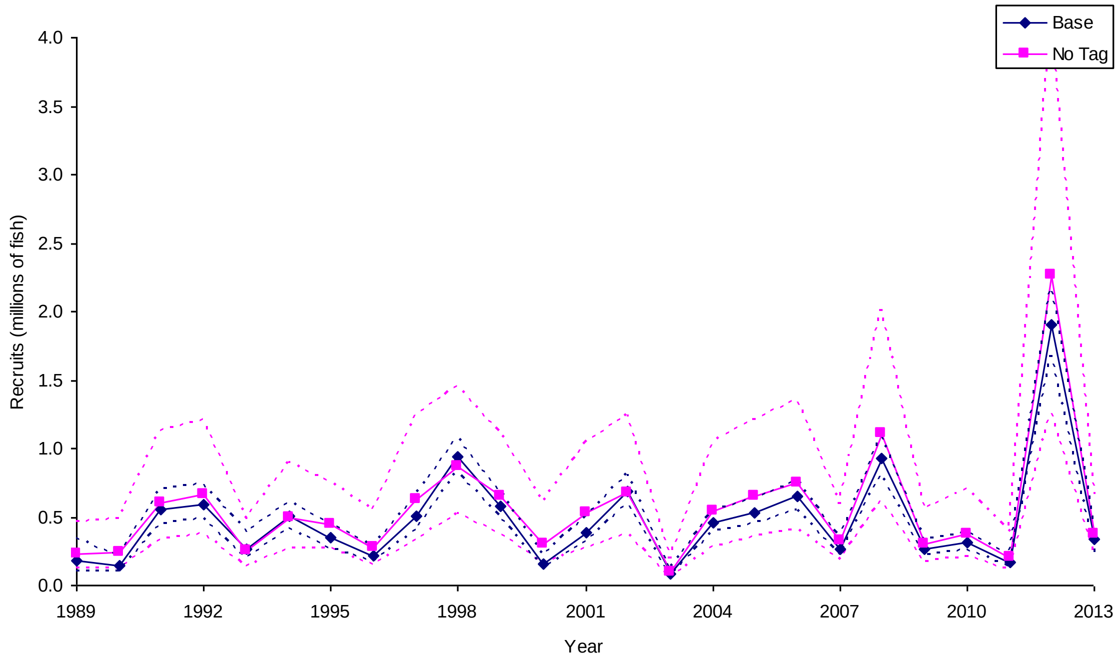


Figure 16. Five year retrospective analysis of the recruitment (top) and three year average sSPR (bottom) for the northern stock.



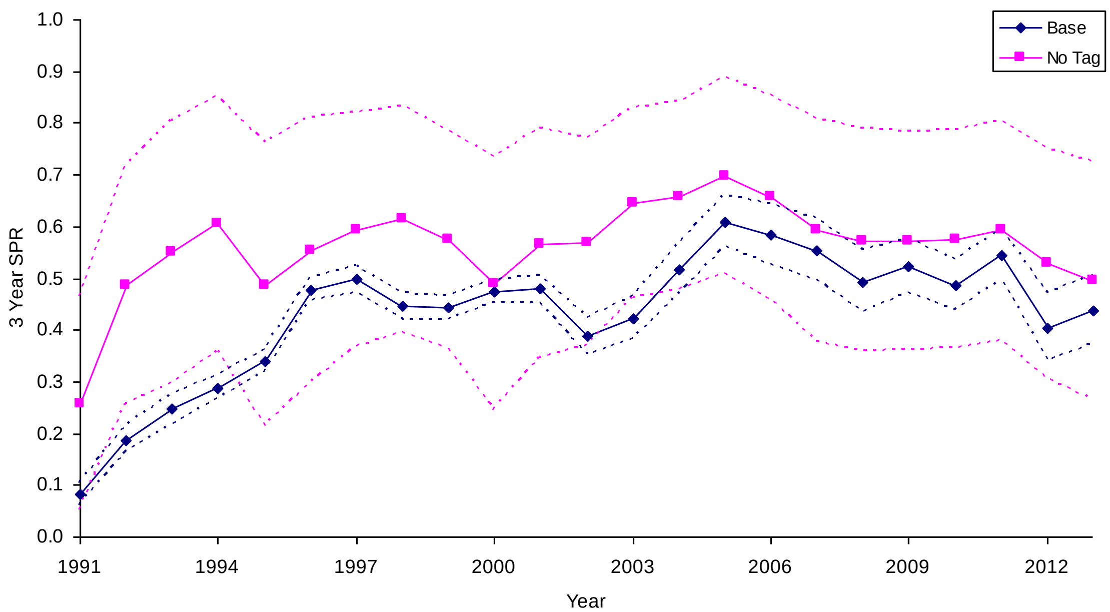


Figure 17. Comparison of the recruitment (top) and three year average sSPR (bottom) for the northern stock between the base model and when the tag-based F estimates (1989-2004) are removed.

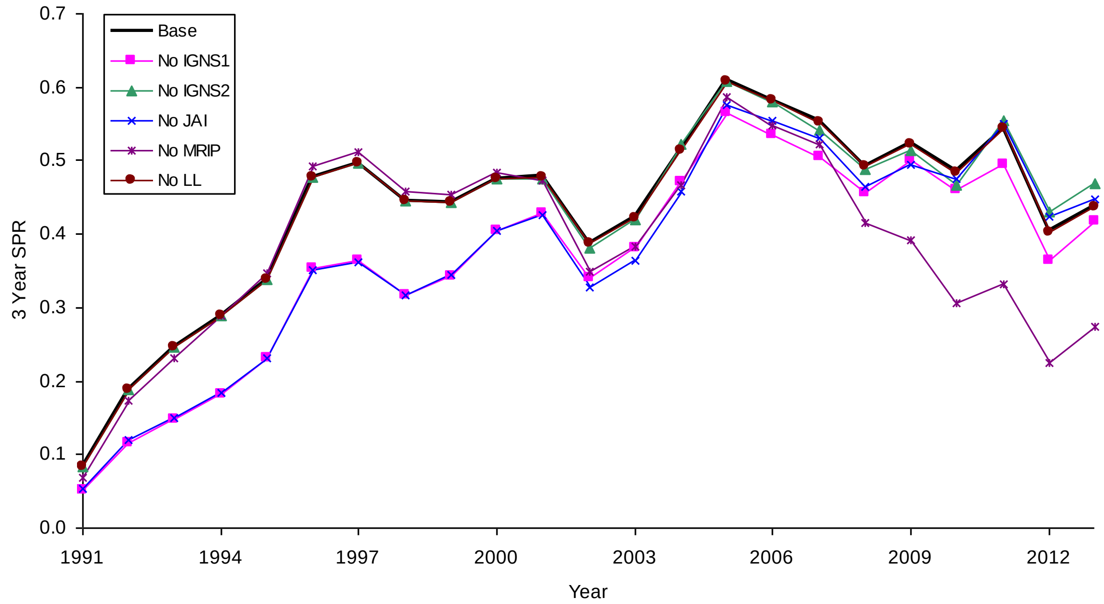


Figure 18. Comparison of the three year average sSPR for the northern stock when individual indices are removed.

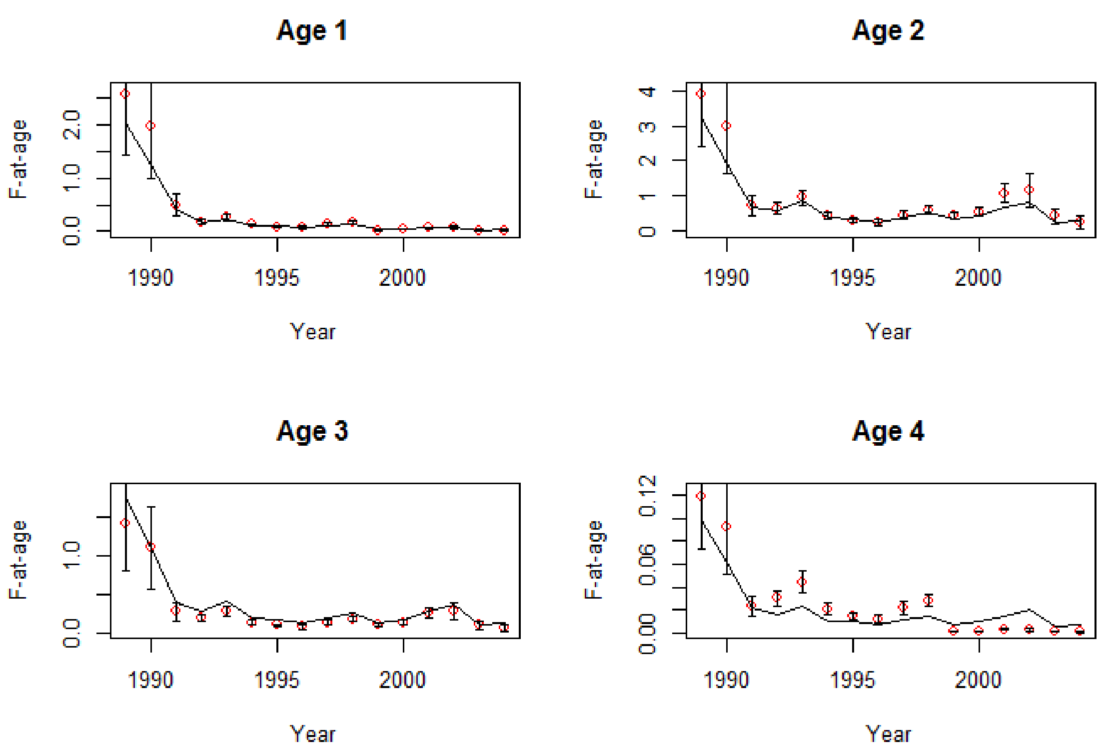


Figure 19. Observed (red circles) and model estimated (solid black line) F-at-age (ages 1-4) for the harvest fleets in the northern stock from the iteratively reweighted model. Error bars show 95% confidence intervals of observed values.

Figure 20. Comparison of the F-at-age for the northern stock for the base model and the iteratively reweighted model.

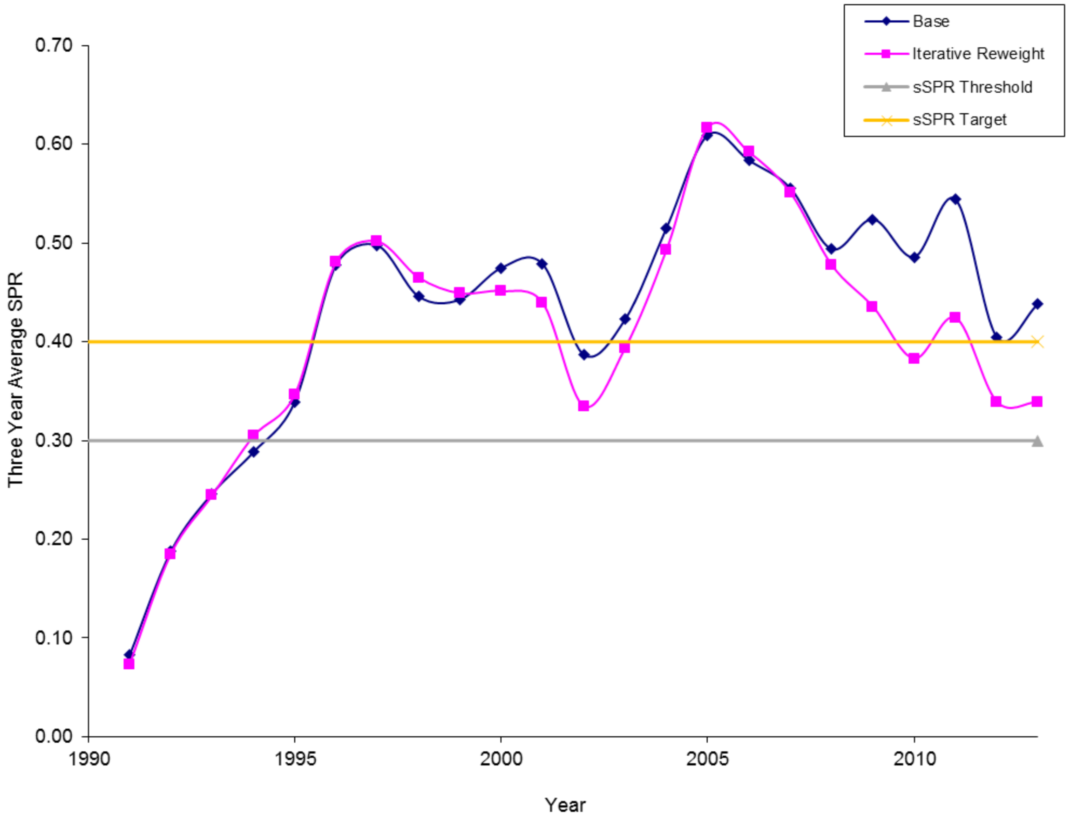


Figure 21. Comparison of the three year average sSPR for the northern stock for the base model and the iteratively reweighted model.

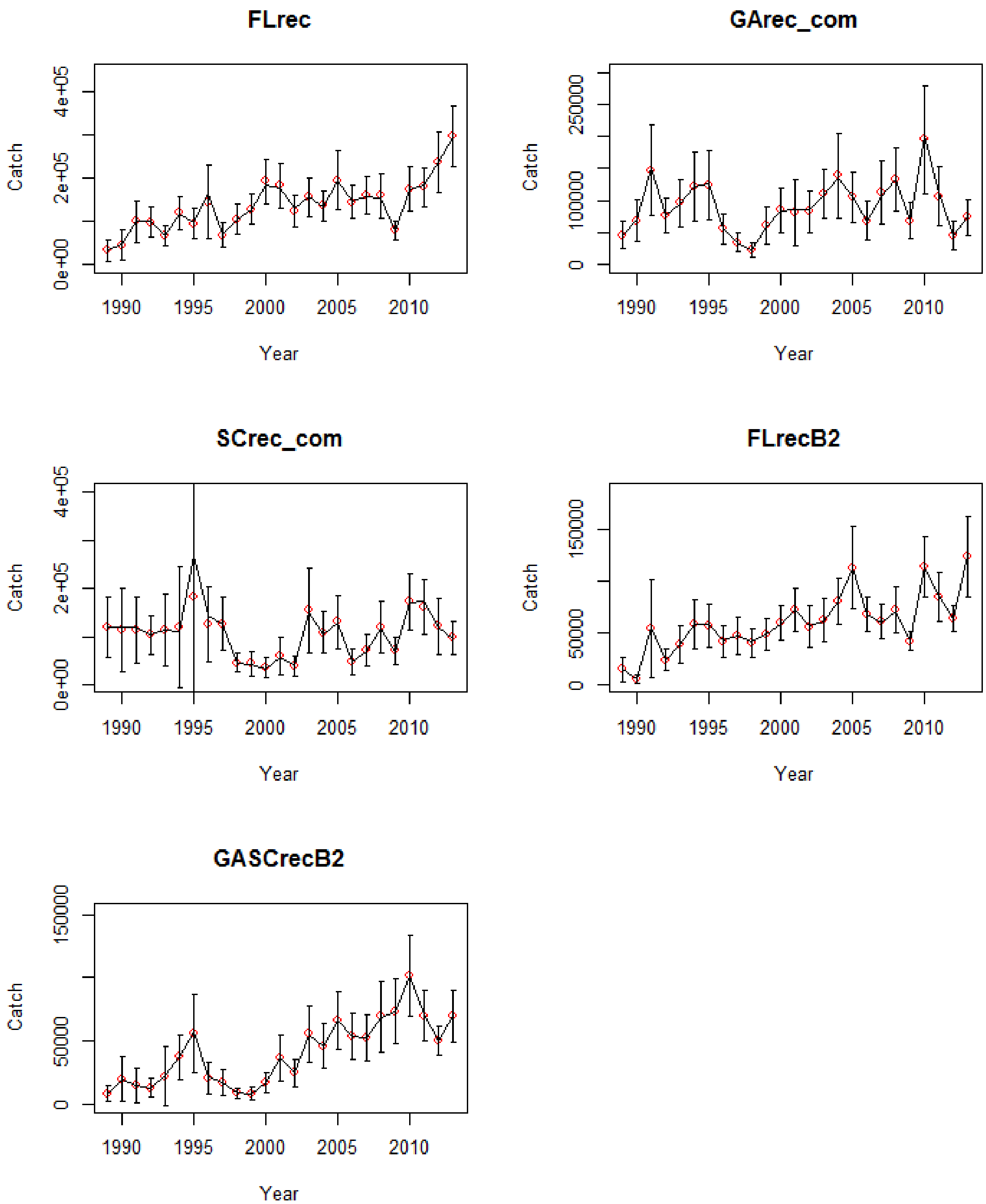


Figure 22. Observed (red circles) and model estimated (solid black line) catch, by fleet, for the southern stock. Error bars show 95% confidence intervals of observed values.

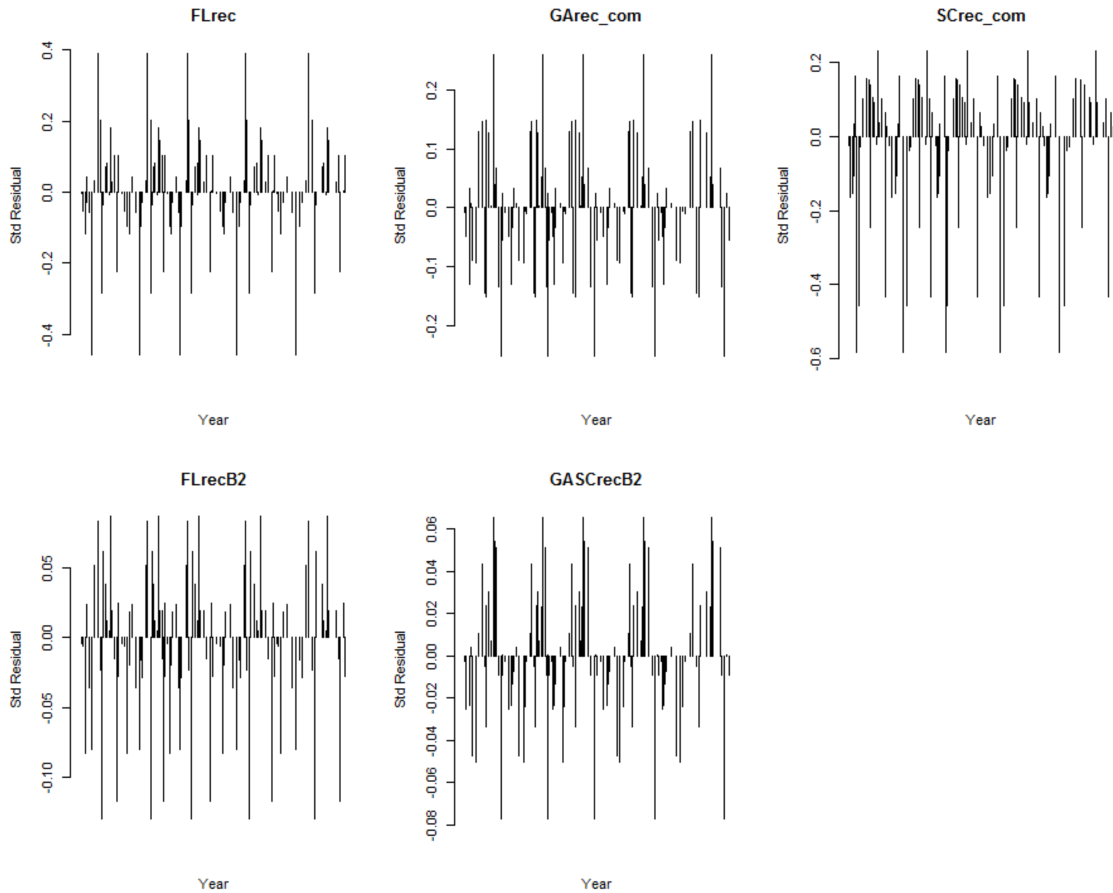


Figure 23. Standardized residuals for model fits to catch, by fleet and year, for the southern stock.

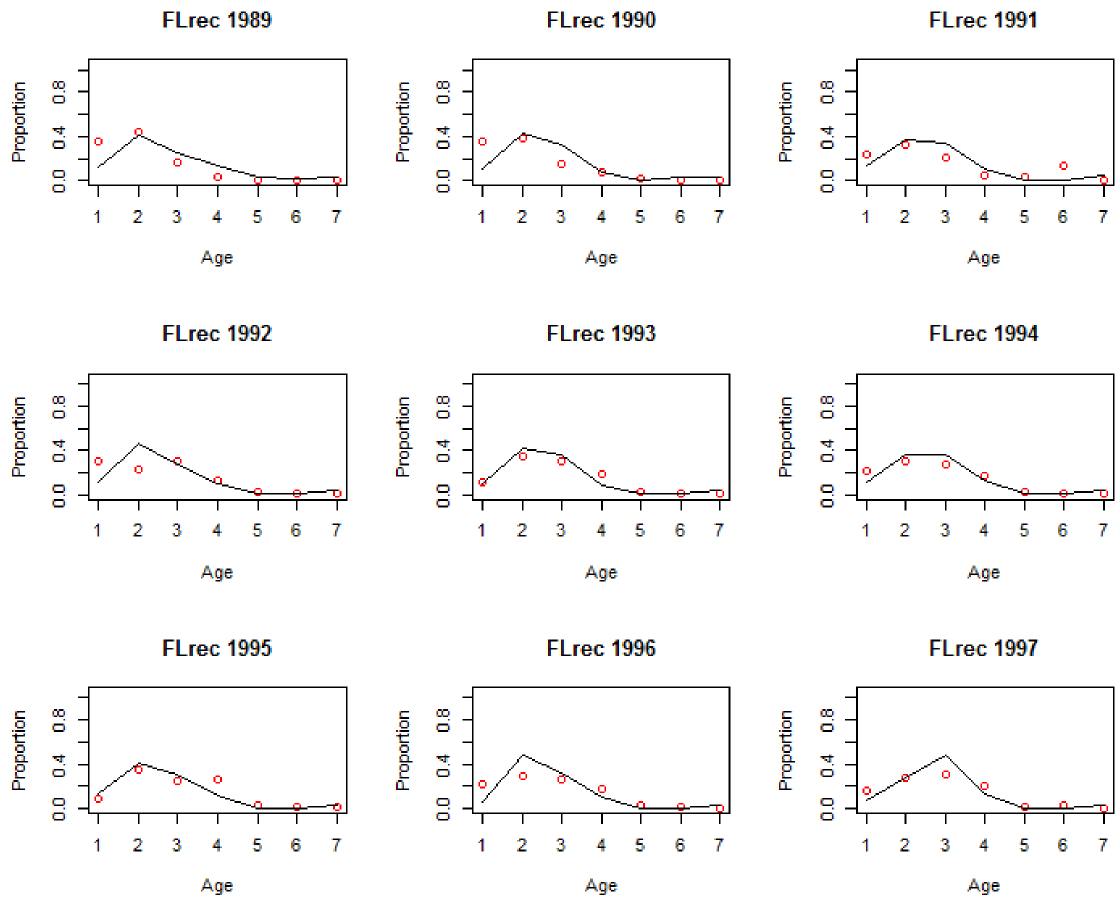


Figure 24. Southern model fits to the proportion-at-age data for each fleet and year. The Florida recreational release fleet is not included as the selectivity-at-age was fixed using tagging data from North Carolina and the proportion-at-age data was not used in model fitting.

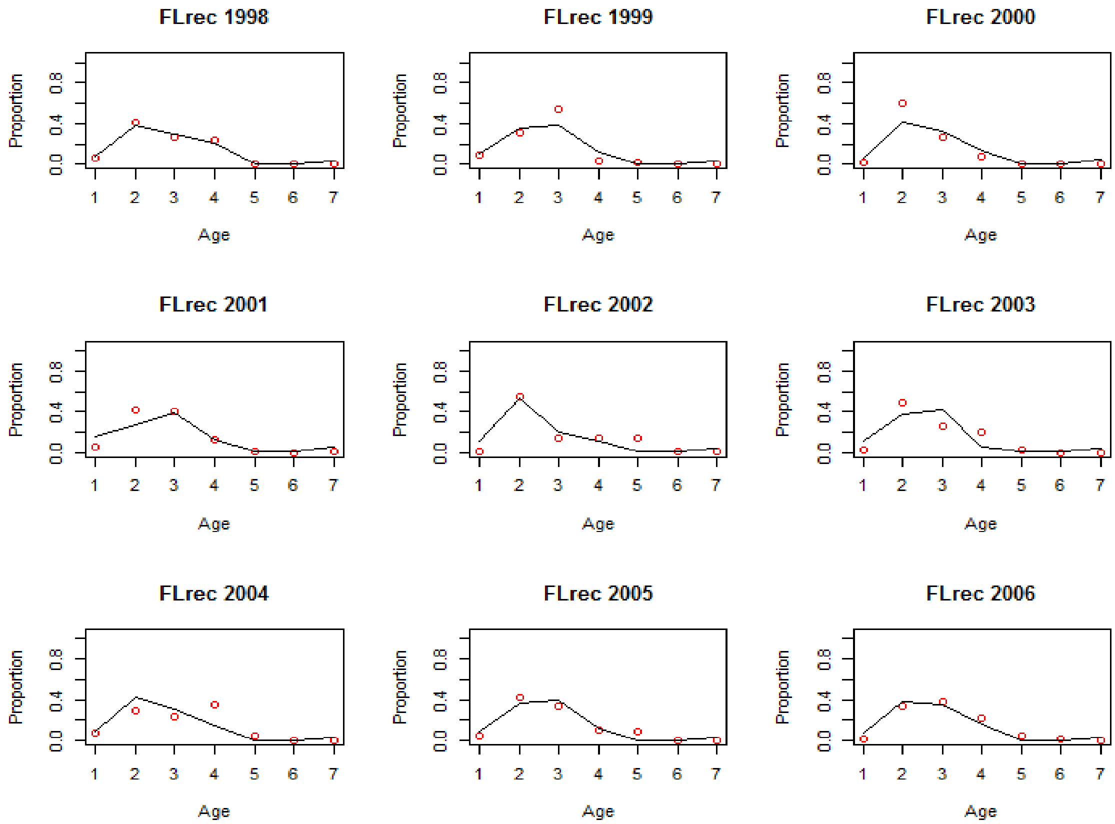


Figure 24 (con't).

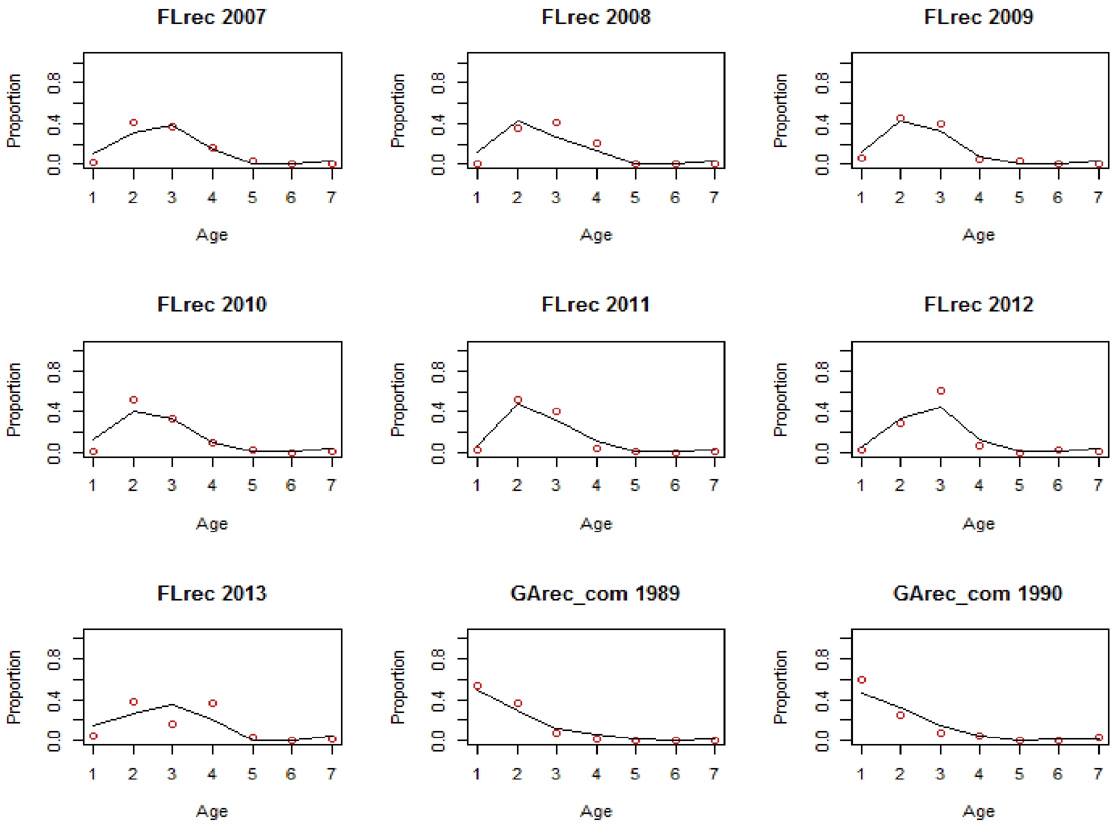


Figure 24 (con't).

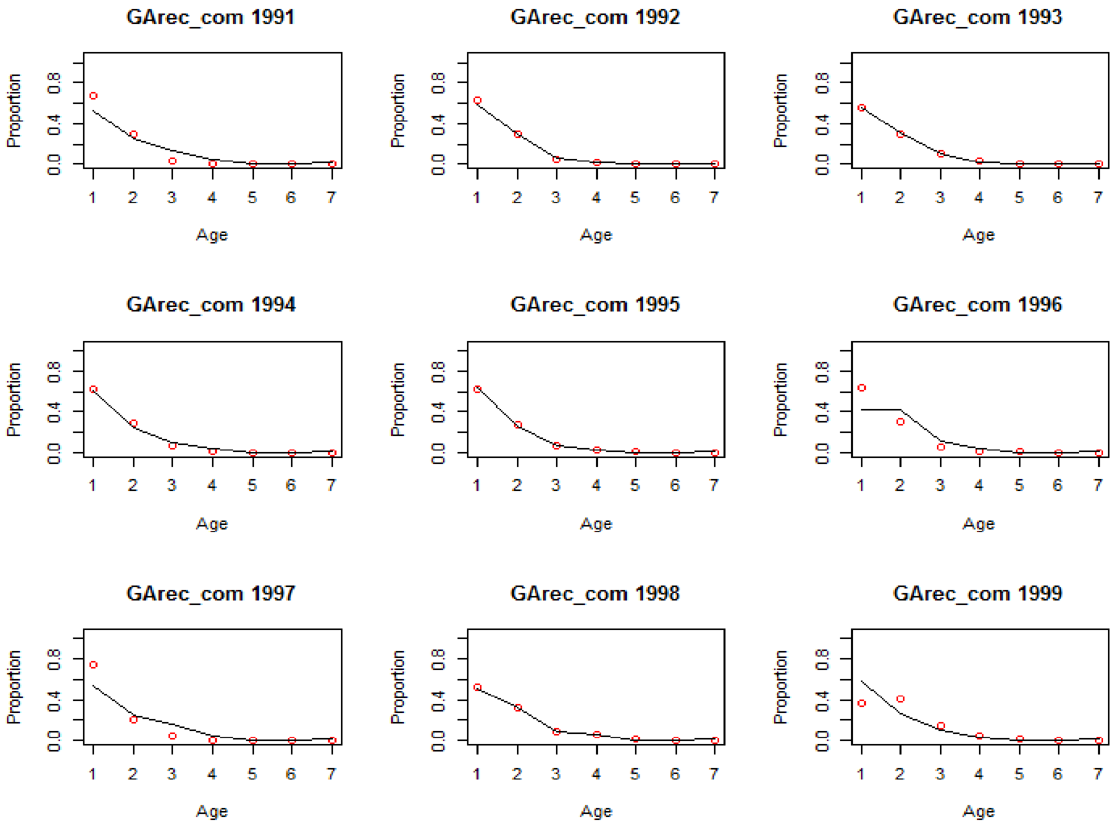


Figure 24 (con't).

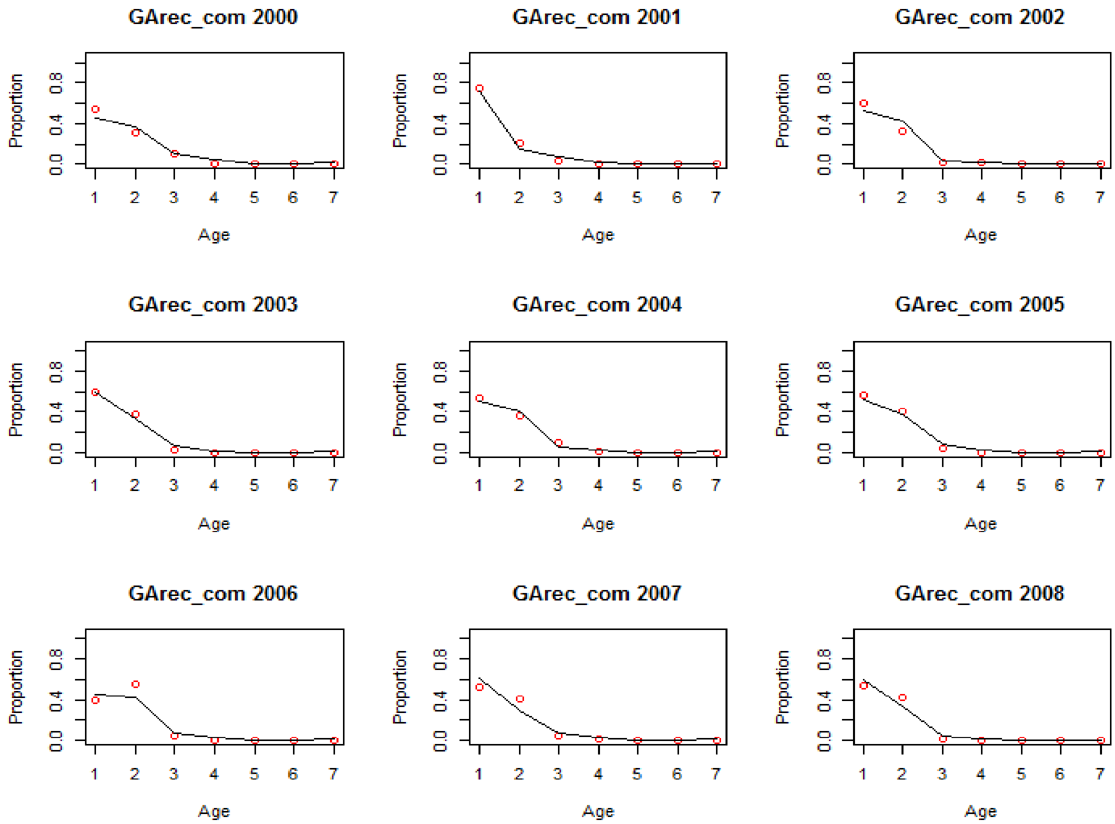


Figure 24 (con’t).

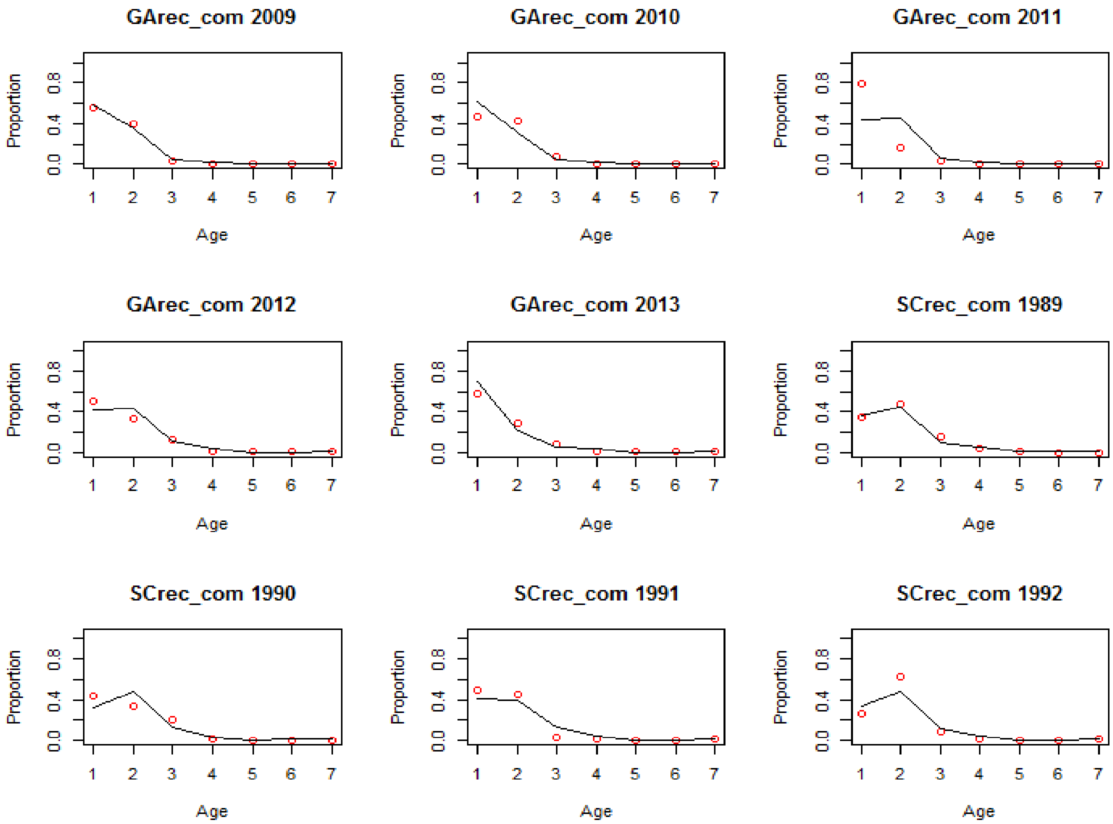


Figure 24 (con't).

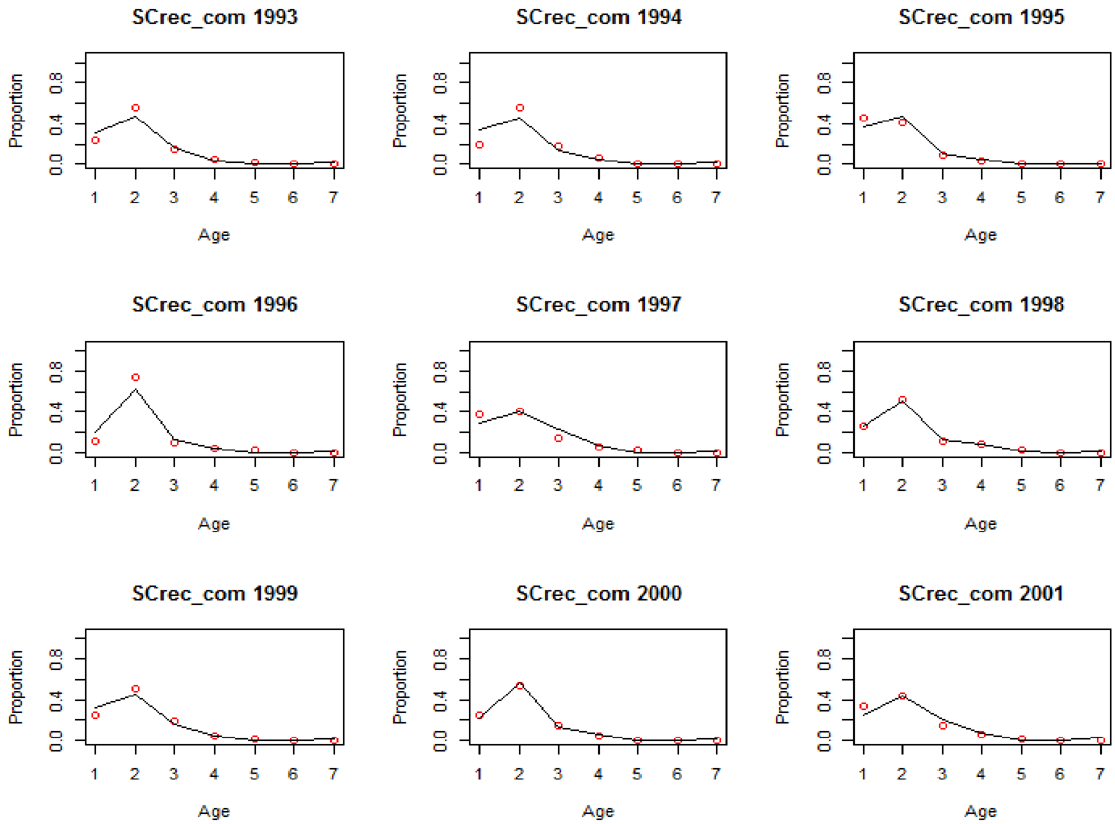


Figure 24 (con't).

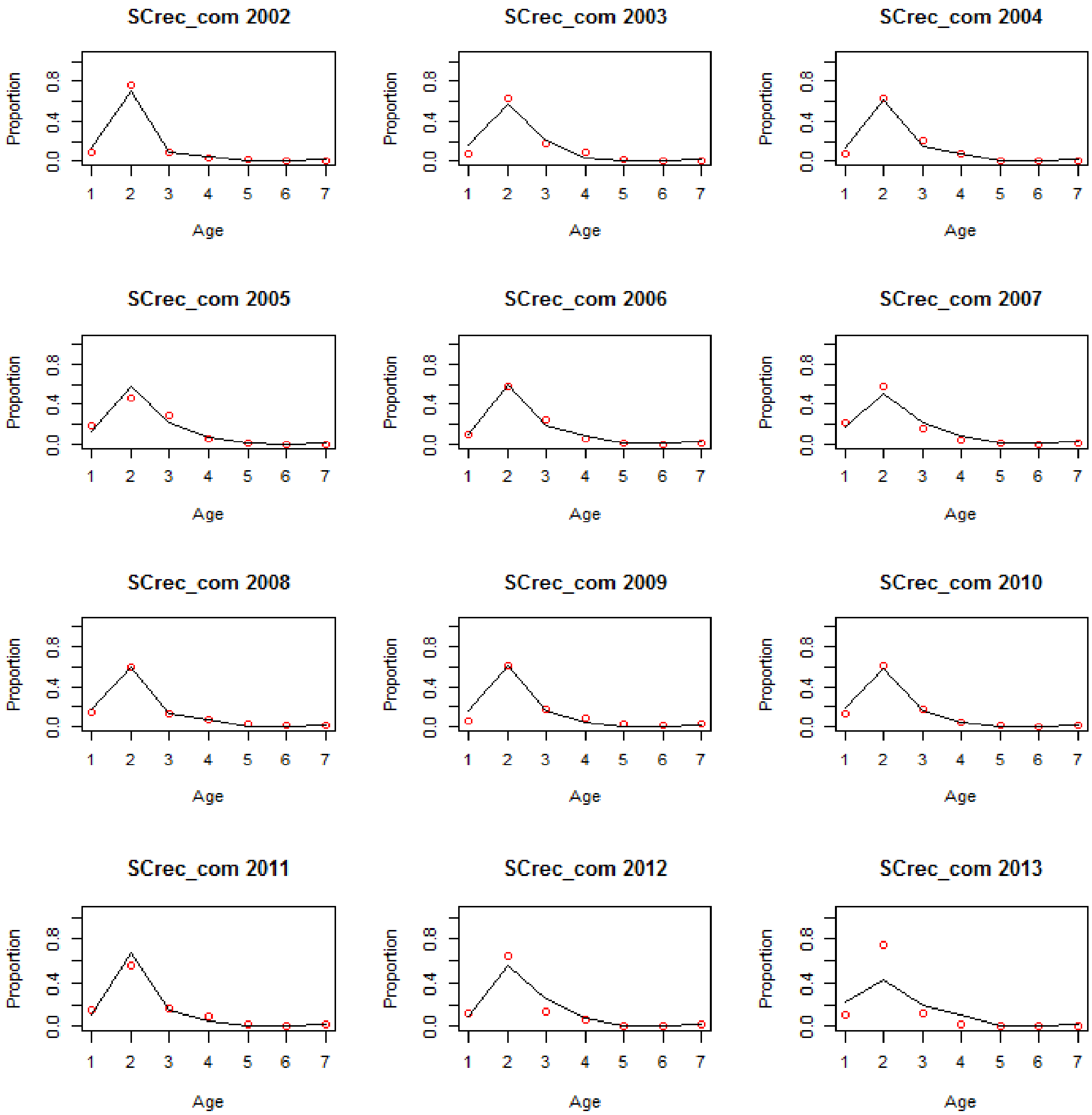


Figure 24 (con't).

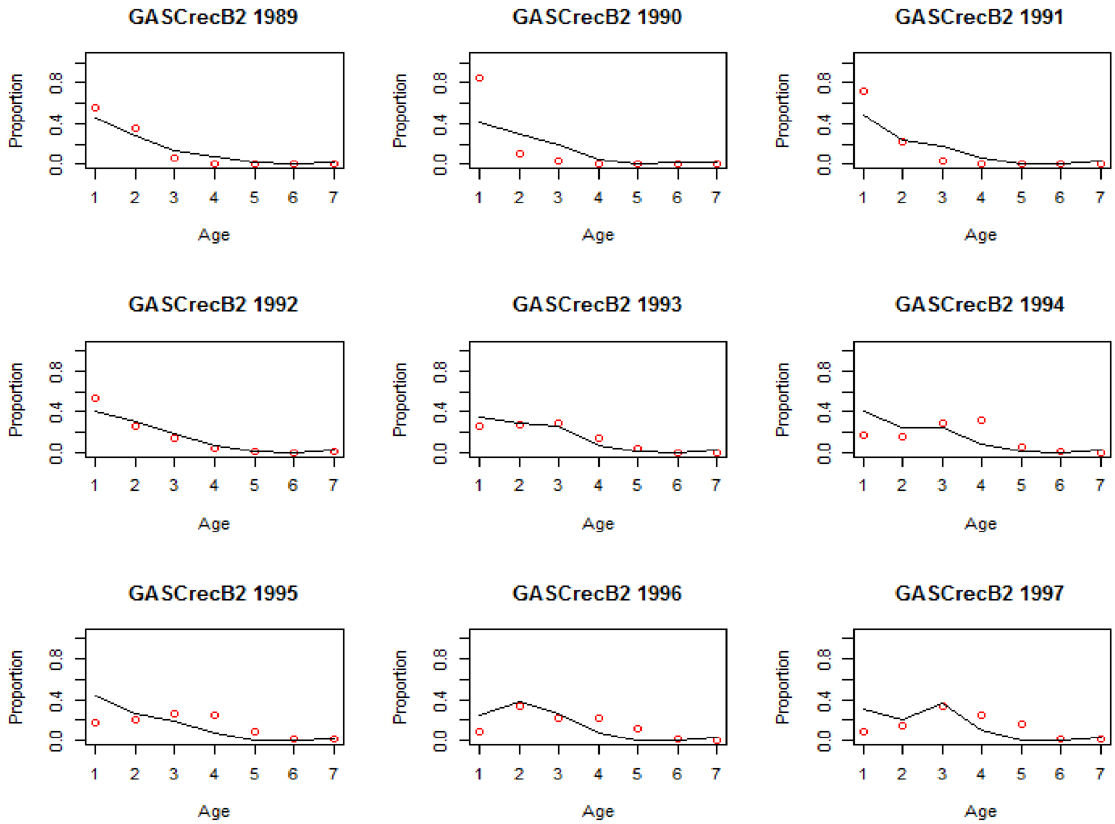


Figure 24 (con't).

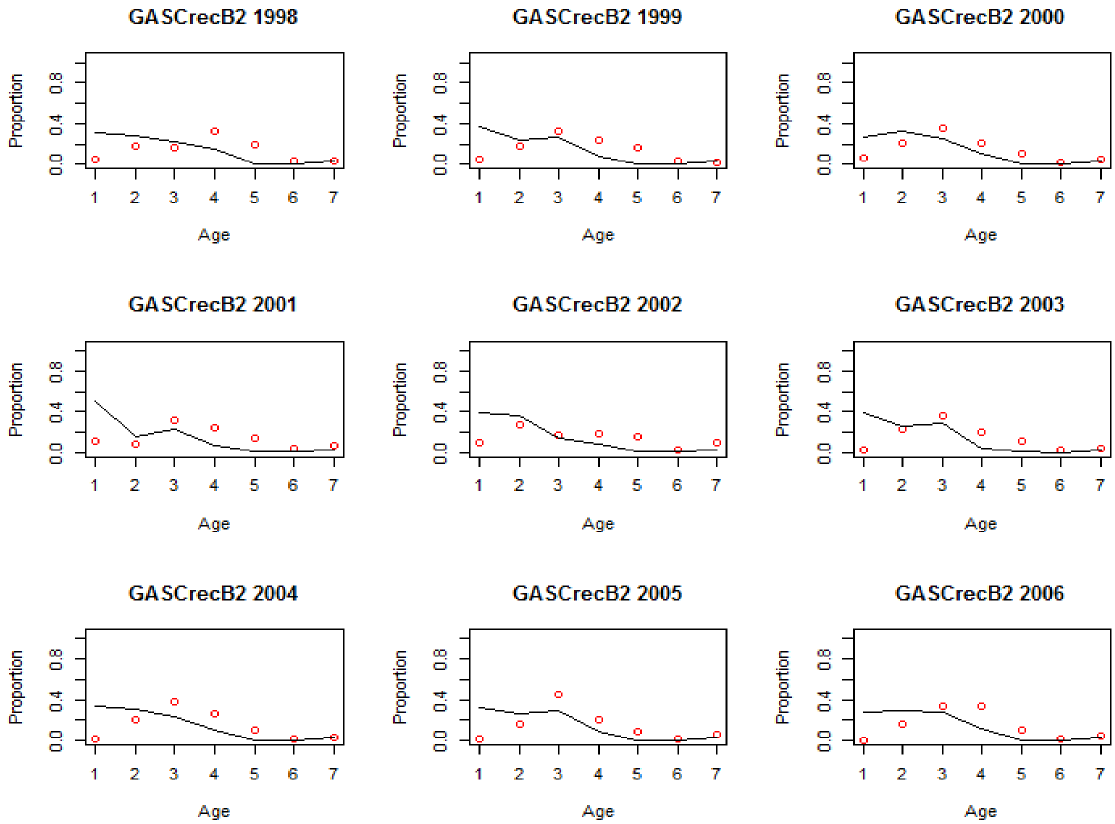


Figure 24 (con't).

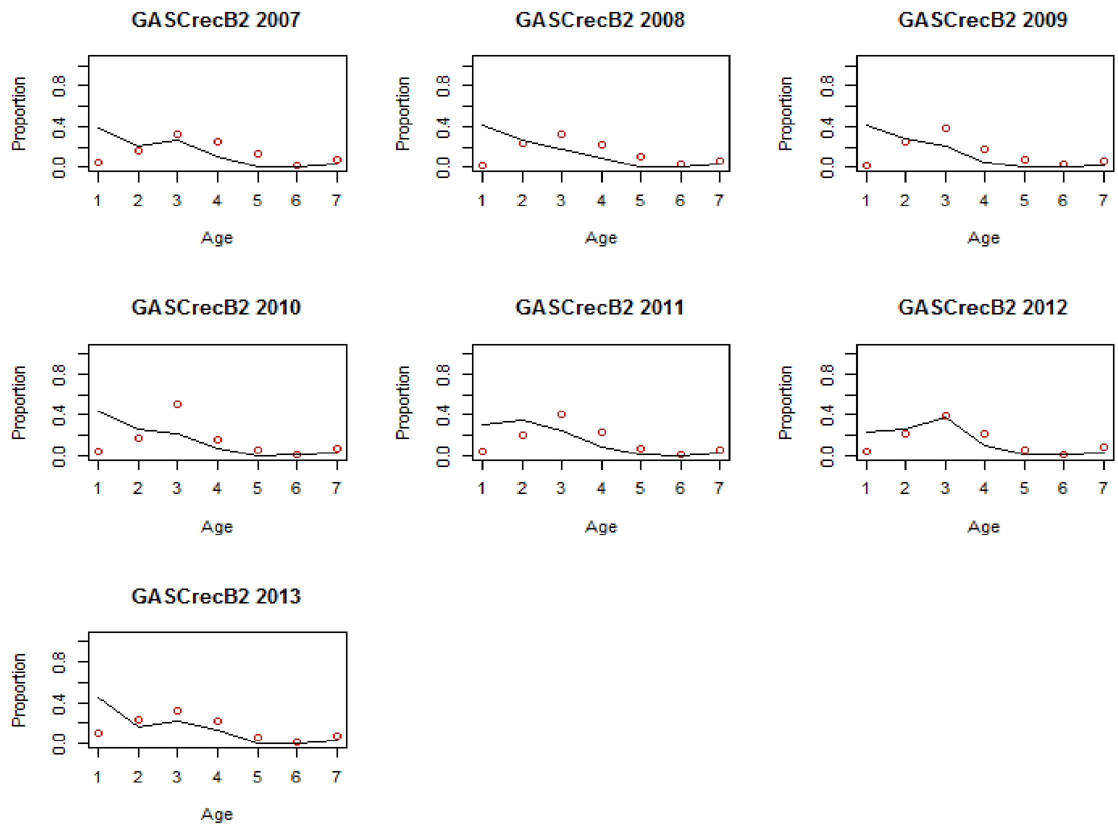


Figure 24 (con't).

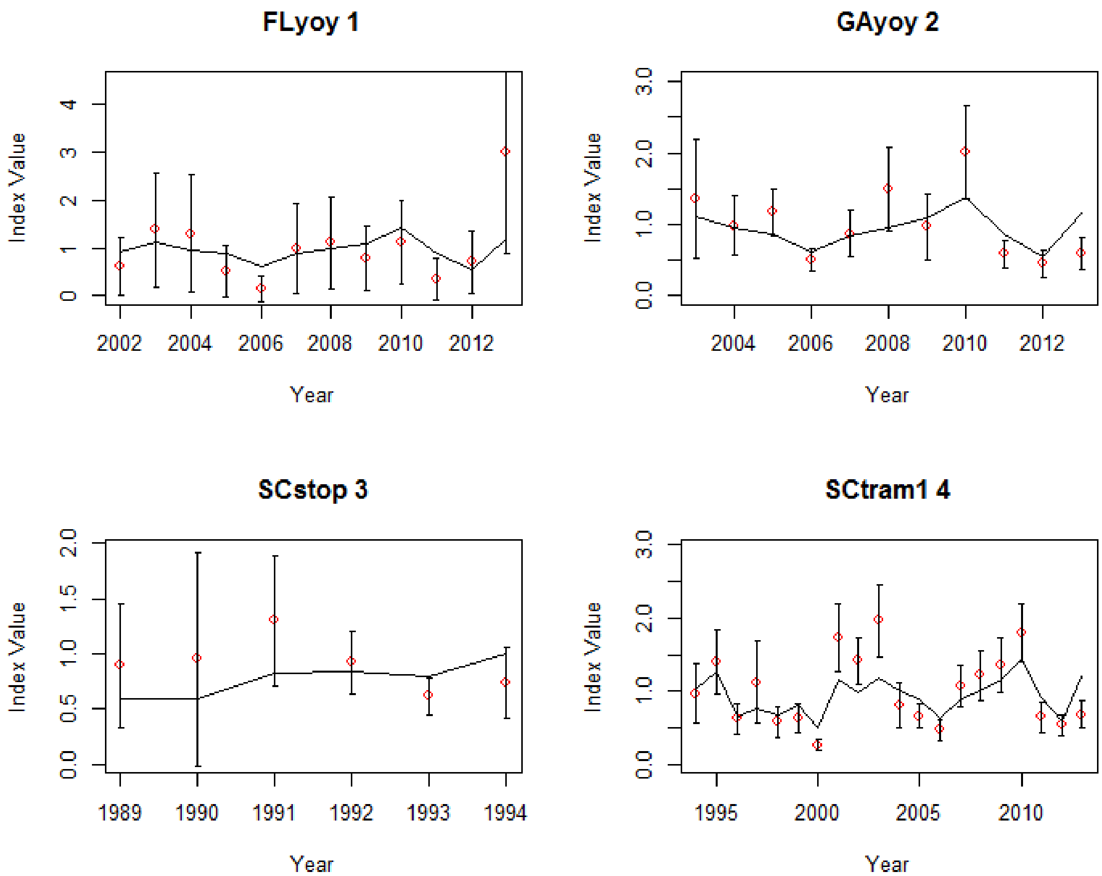


Figure 25. Observed (red circles) and model estimated (solid black line) indices of abundance for the southern stock. Error bars show 95% confidence intervals of observed values.

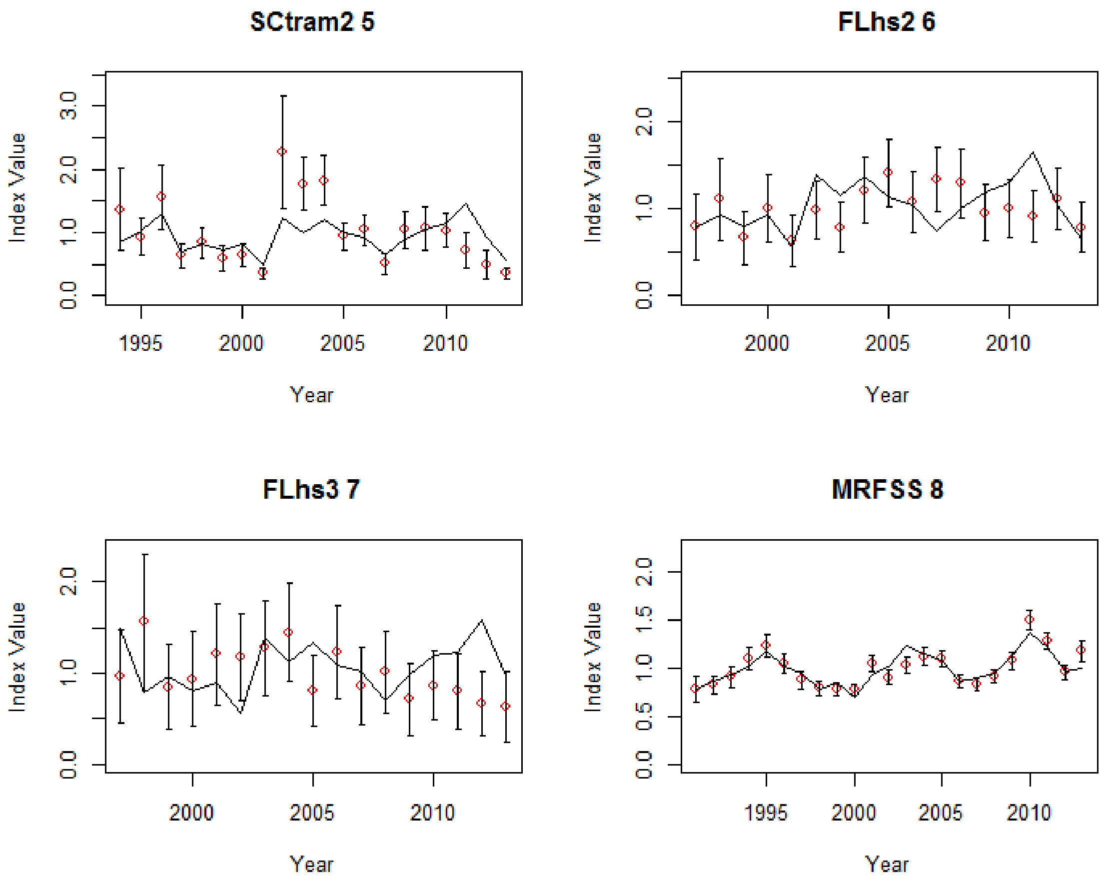


Figure 25 (con't). Index fits for the southern stock.

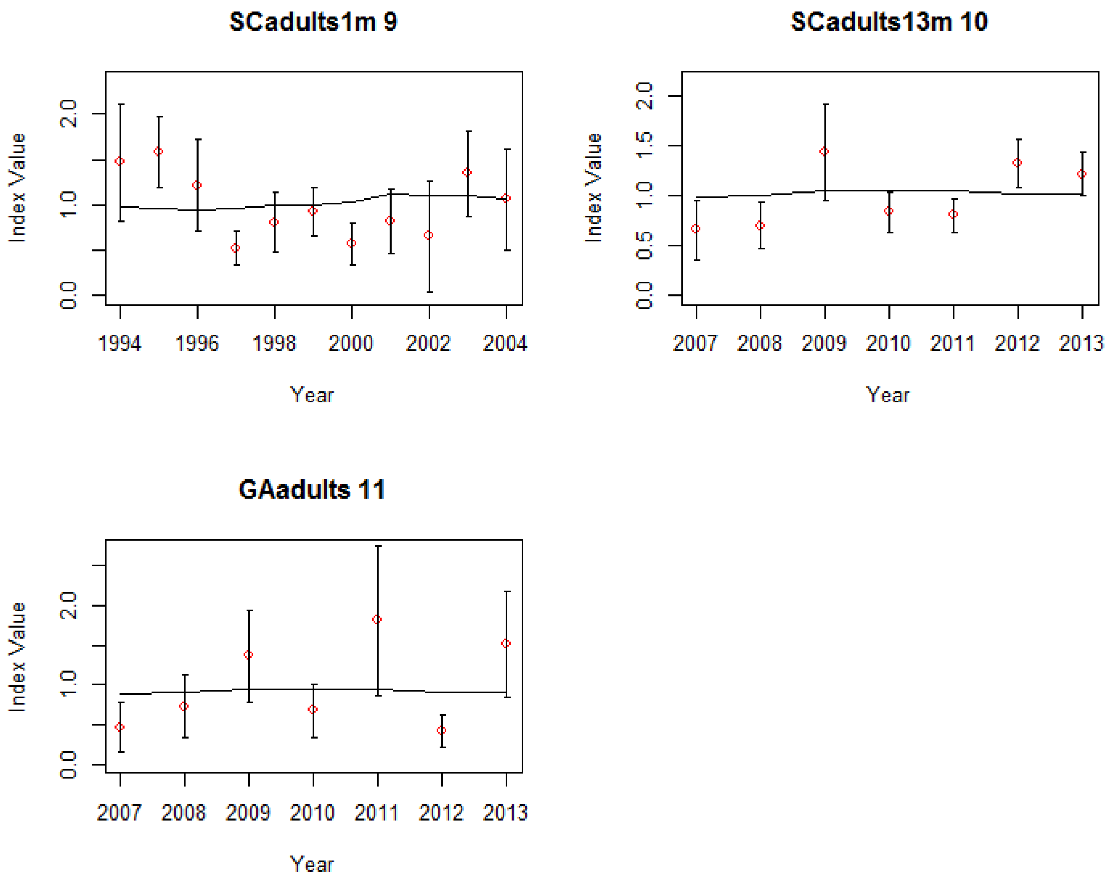


Figure 25 (con't). Index fits for the southern stock.

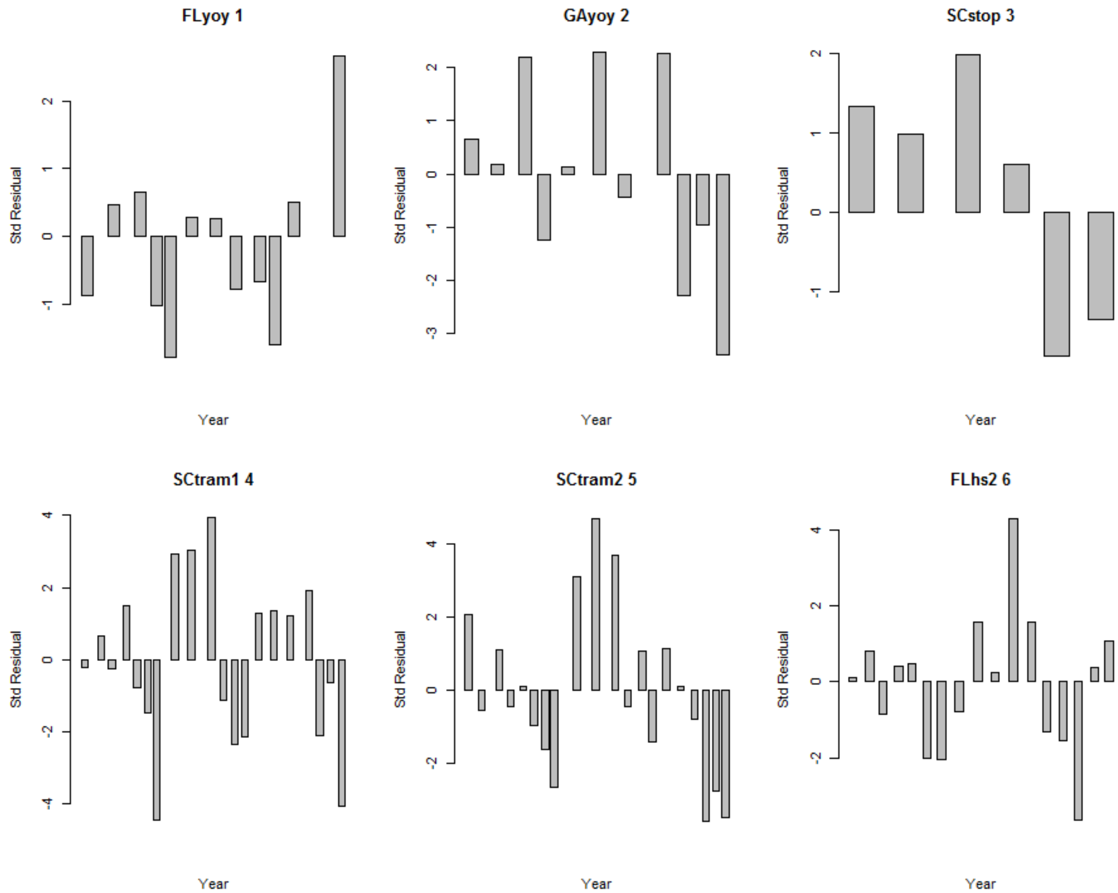


Figure 26. Standardized residuals for model fits to indices of abundance, by year, for the southern stock.

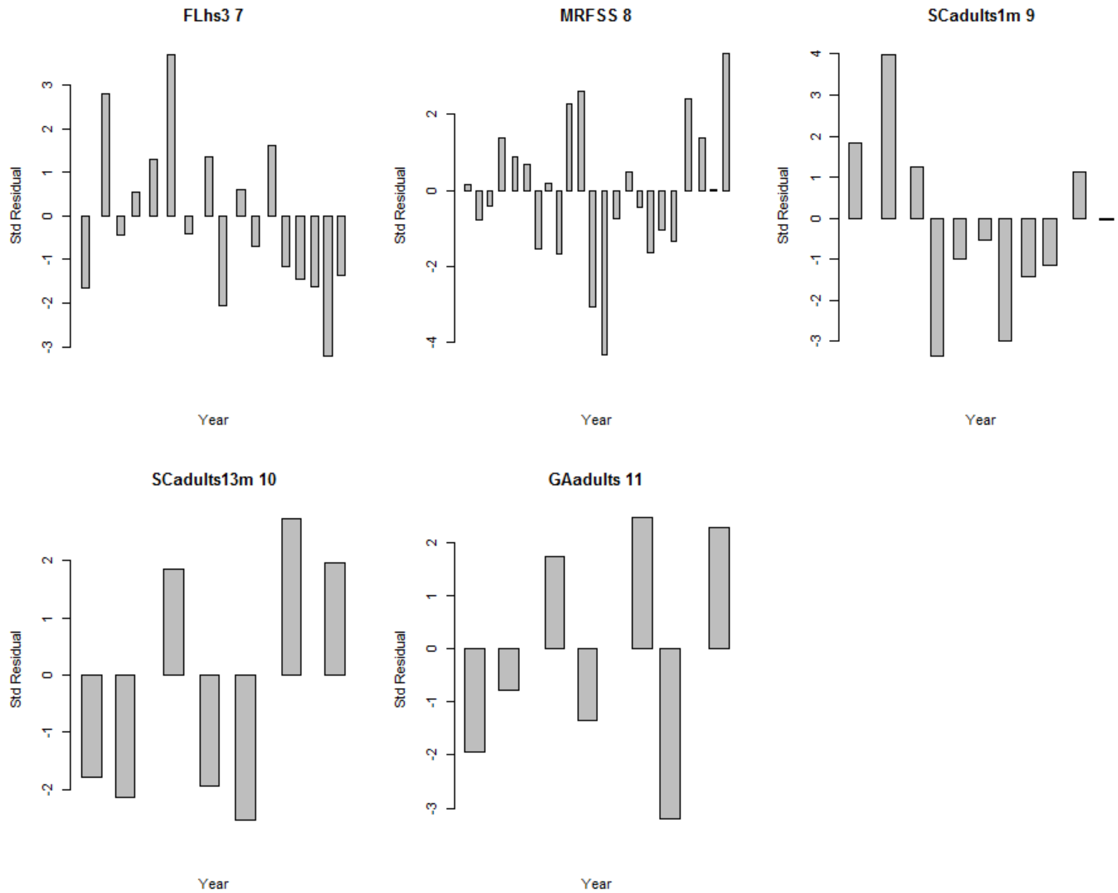


Figure 26 (con't). Standardized residuals for model fits to indices of abundance, by year, for the southern stock.

Figure 27. Predicted recruitment for the southern stock with 95% confidence intervals from asymptotic standard errors.

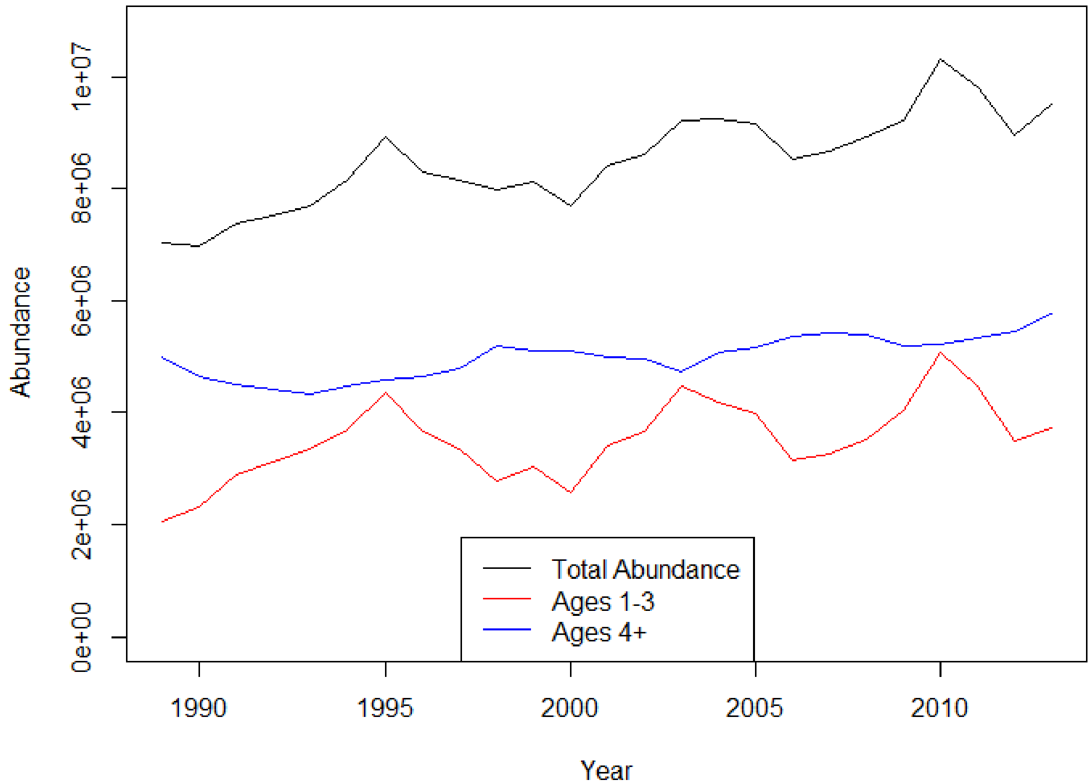


Figure 28. Abundance of red drum at various ages for the southern stock.

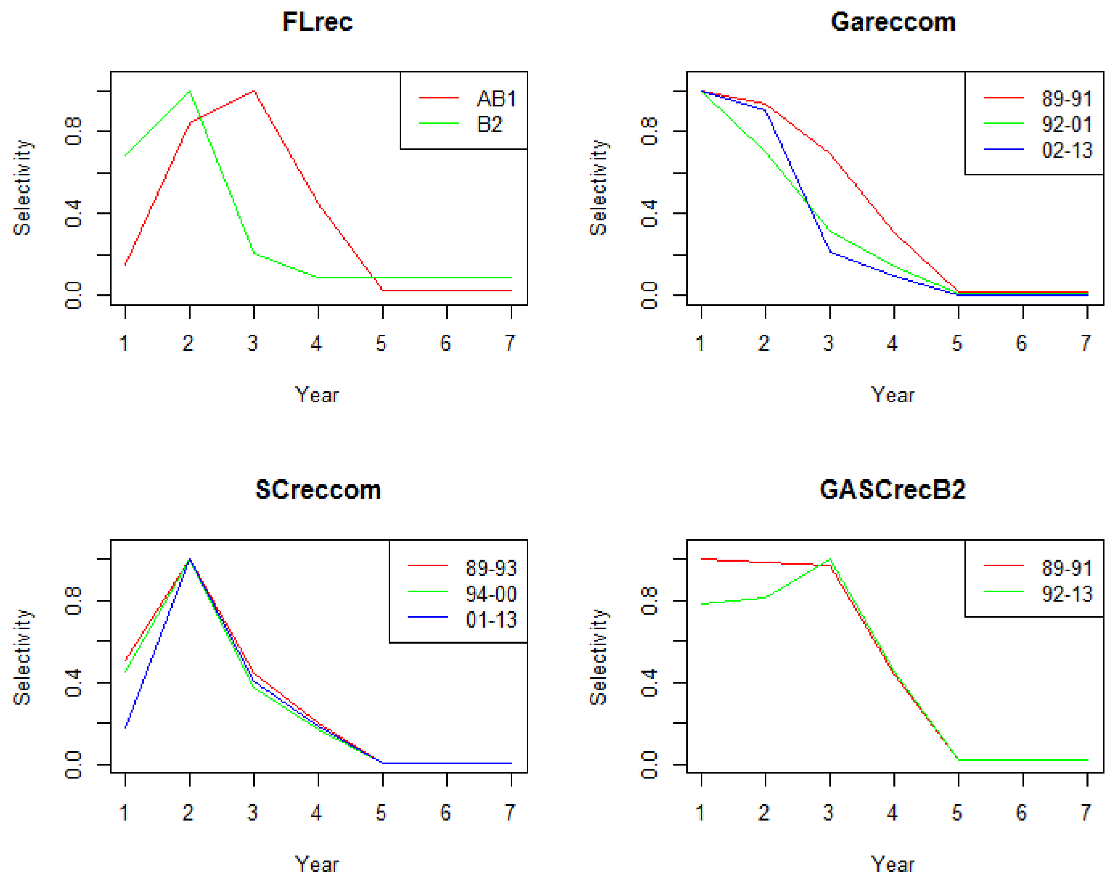


Figure 29. Selectivity curves for each fleet and selectivity block in the southern stock. The FL recreational live release selectivity is fixed based on external tagging analysis for North Carolina (Bacheler et al. 2008).

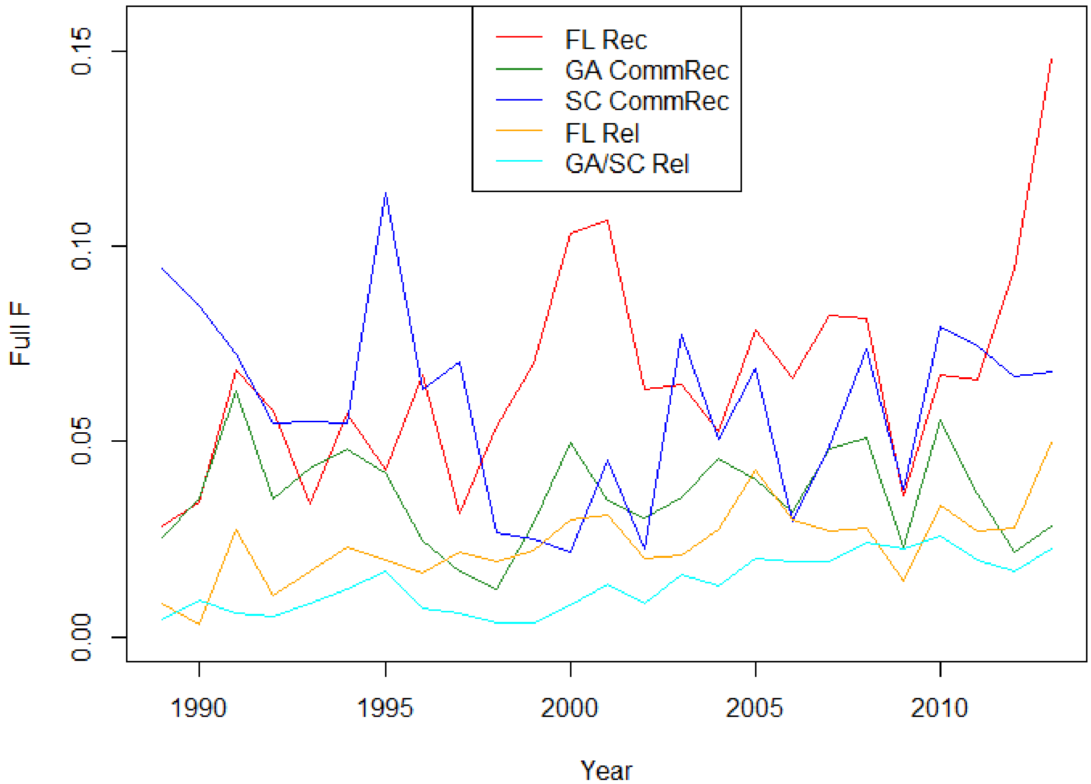


Figure 30. Fleet-specific annual fishing mortality for the southern stock.

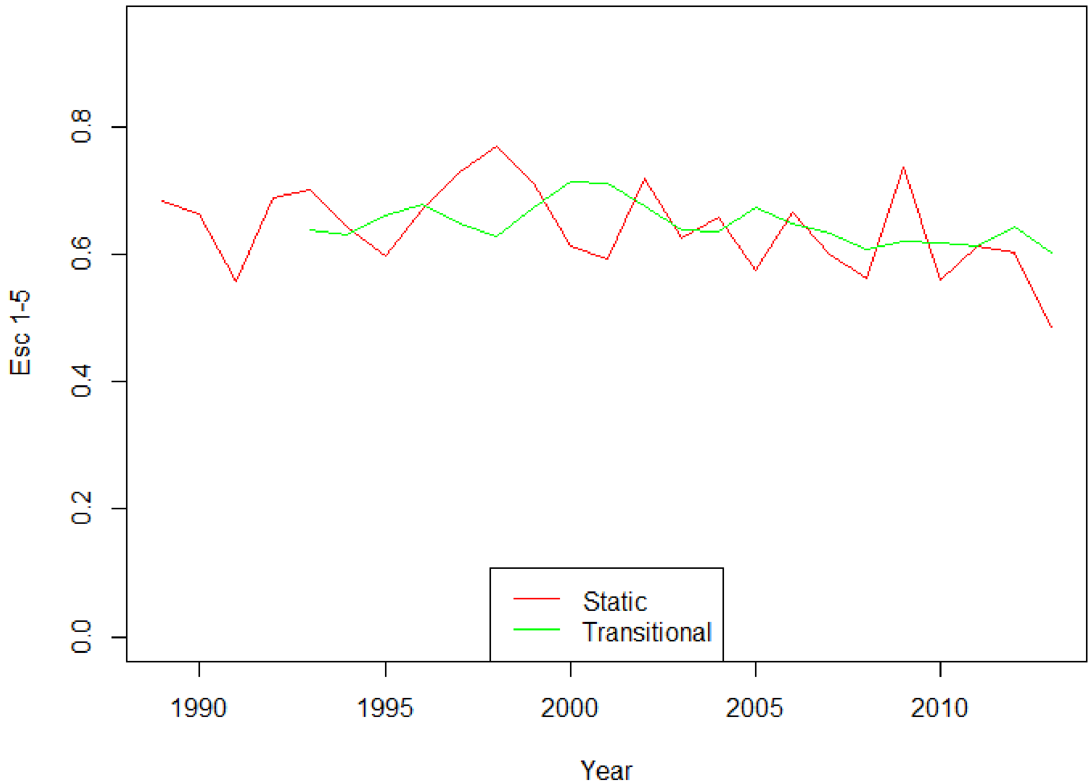


Figure 31. Estimates of static and transitional escapement for ages 1-5 for the southern stock.

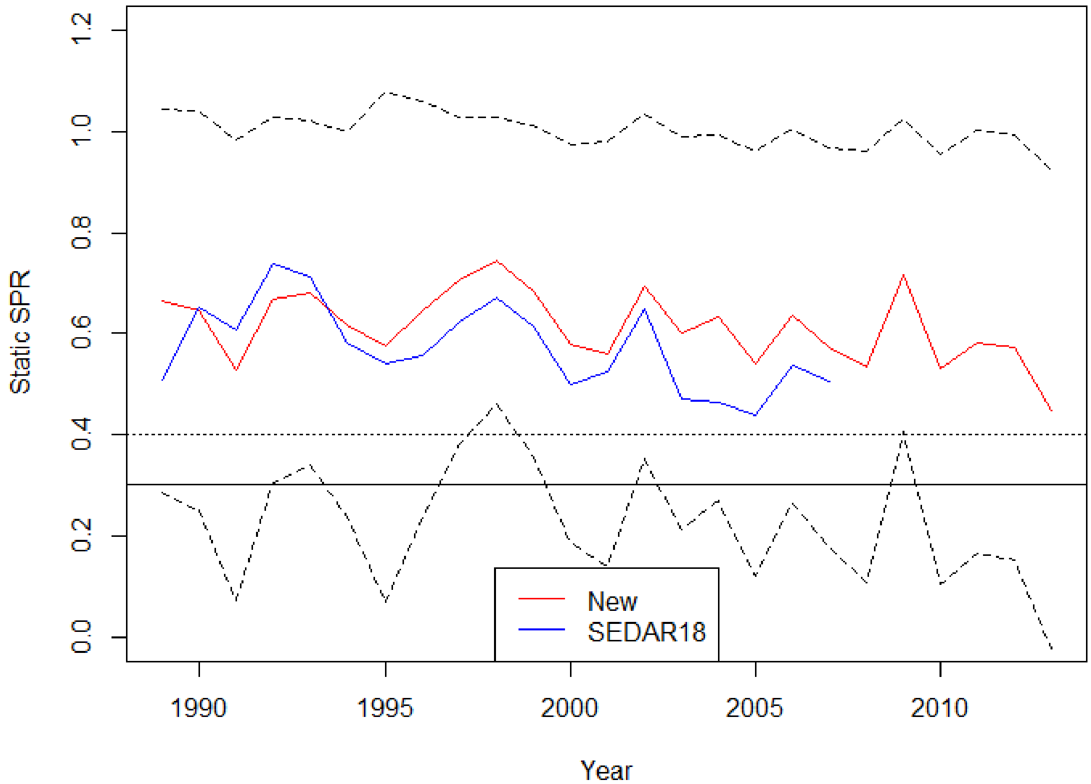


Figure 32. Annual sSPR estimates for the southern stock with 95% confidence intervals from asymptotic standard errors. Point estimates from the previous benchmark assessment (SEDAR18) are included for comparison. The target sSPR (dashed black line) is 40% and the threshold sSPR (solid black line) is 30%.

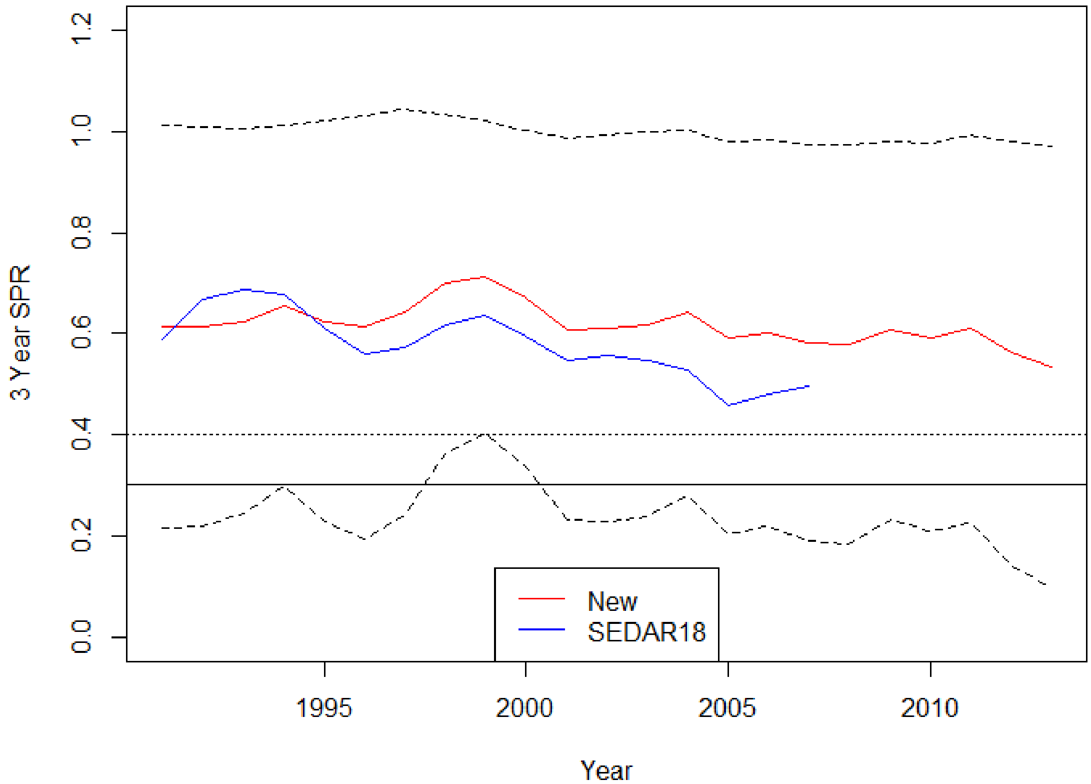


Figure 33. Three year average sSPR for the southern stock with 95% confidence intervals from asymptotic standard errors. Point estimates from the previous benchmark assessment (SEDAR18) are included for comparison. The target sSPR (dashed black line) is 40% and the threshold sSPR (solid black line) is 30%.

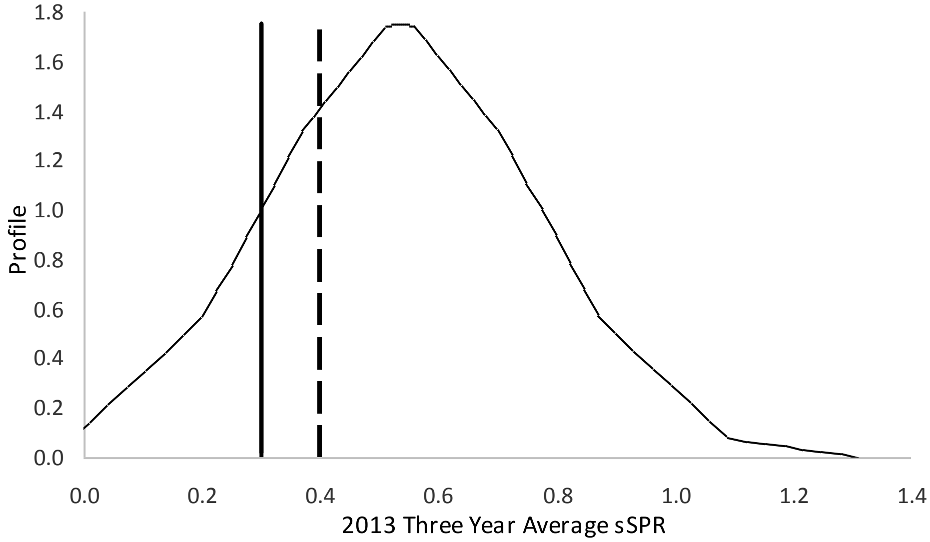


Figure 34. Estimated probability density function of the 2013 three year average sSPR for the southern stock. The target sSPR is 40% and the threshold sSPR is 30%.

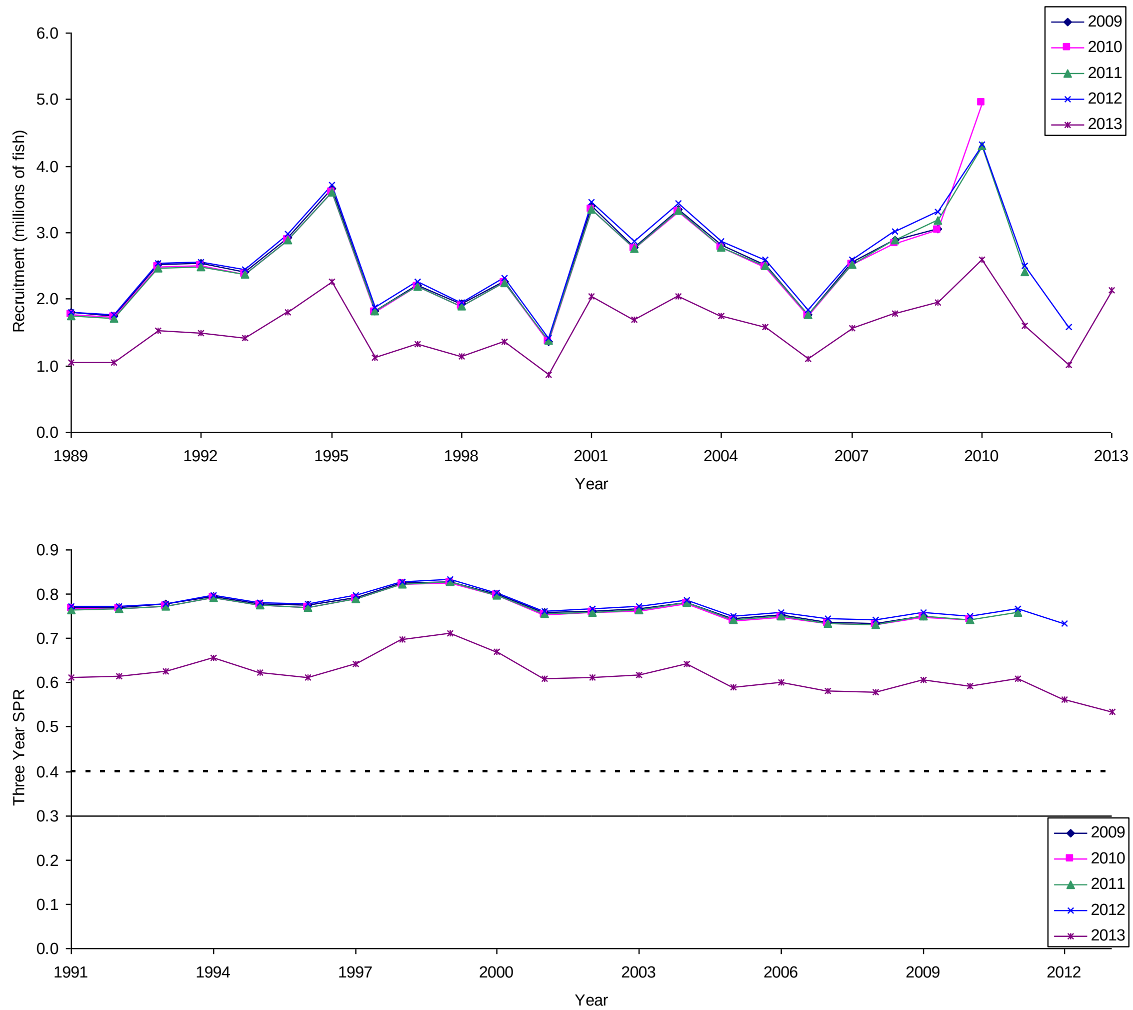


Figure 35. Five year retrospective analysis of the recruitment (top) and three year average sSPR (bottom) for the southern stock.

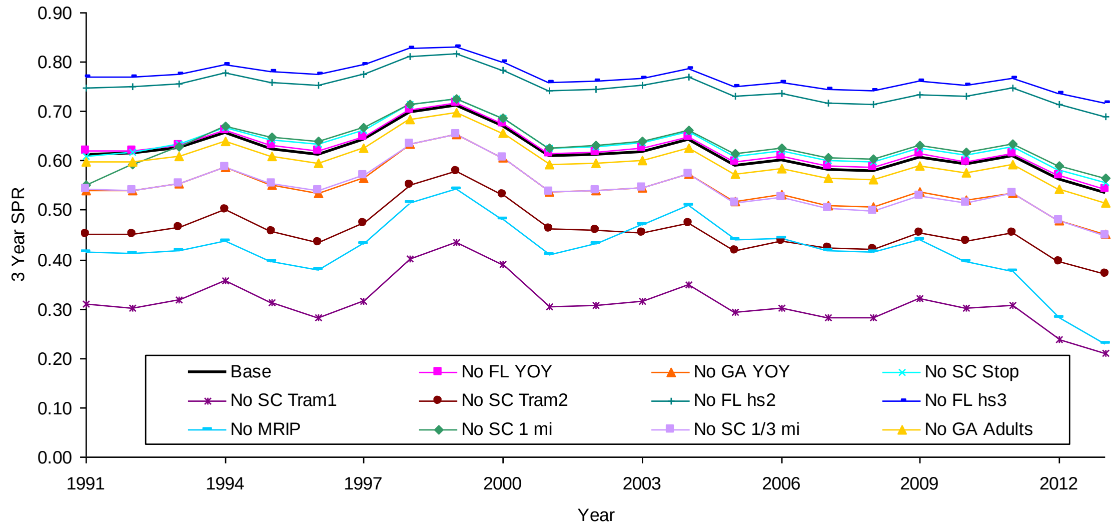


Figure 36. Comparison of the three year average sSPR for the southern stock when individual indices are removed.

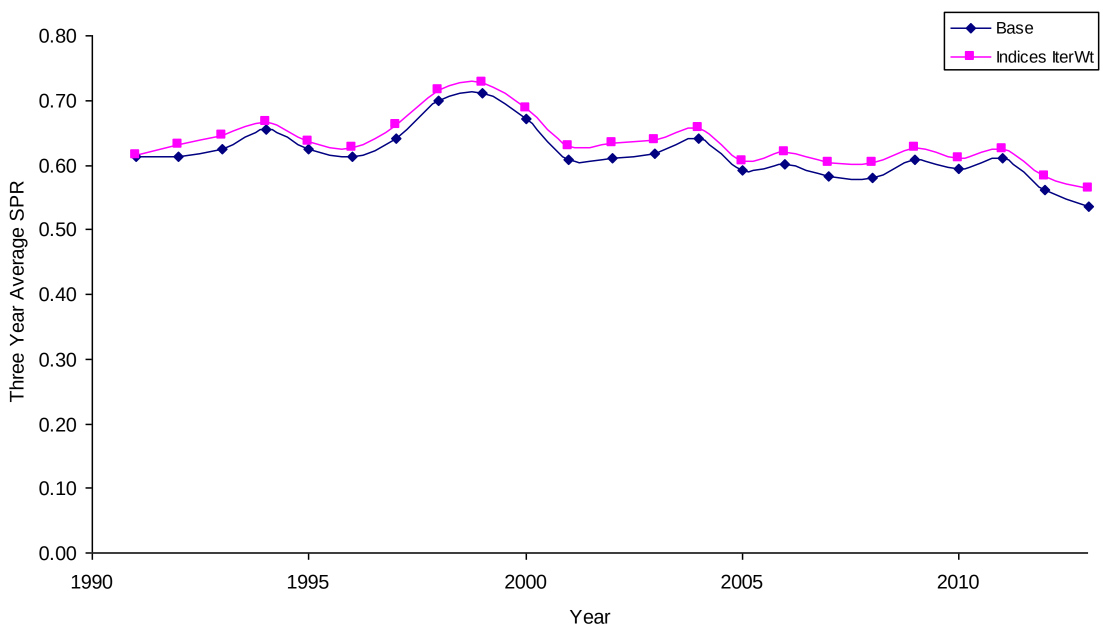


Figure 37. Comparison of the three year average sSPR for the southern stock for the base model and the iteratively reweighted model.

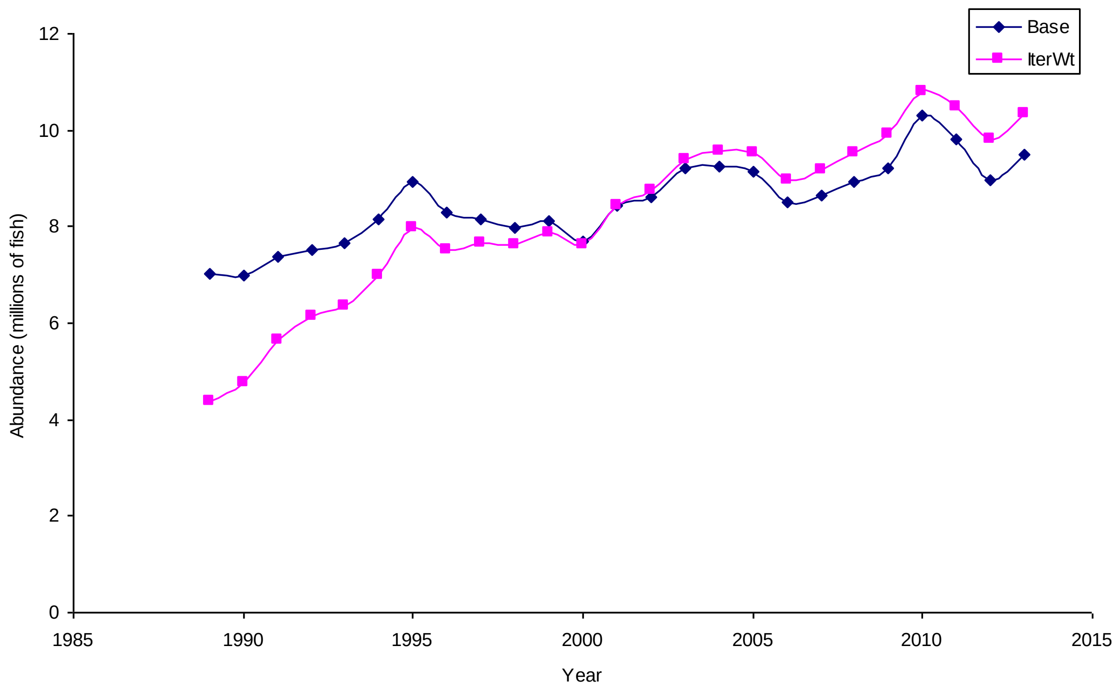


Figure 38. Comparison of the total abundance for the southern stock for the base model and the iteratively reweighted model.

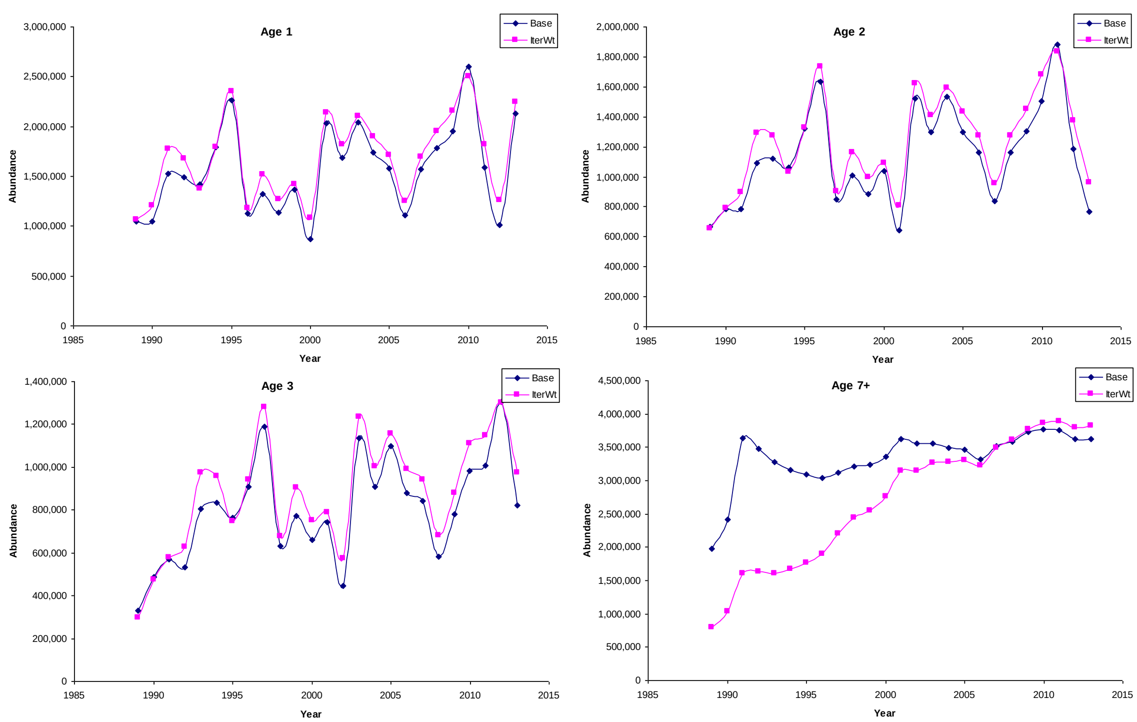


Figure 39. Comparison of the abundance for ages 1, 2, 3, and 7^{+} for the southern stock for the base model and the iteratively reweighted model.

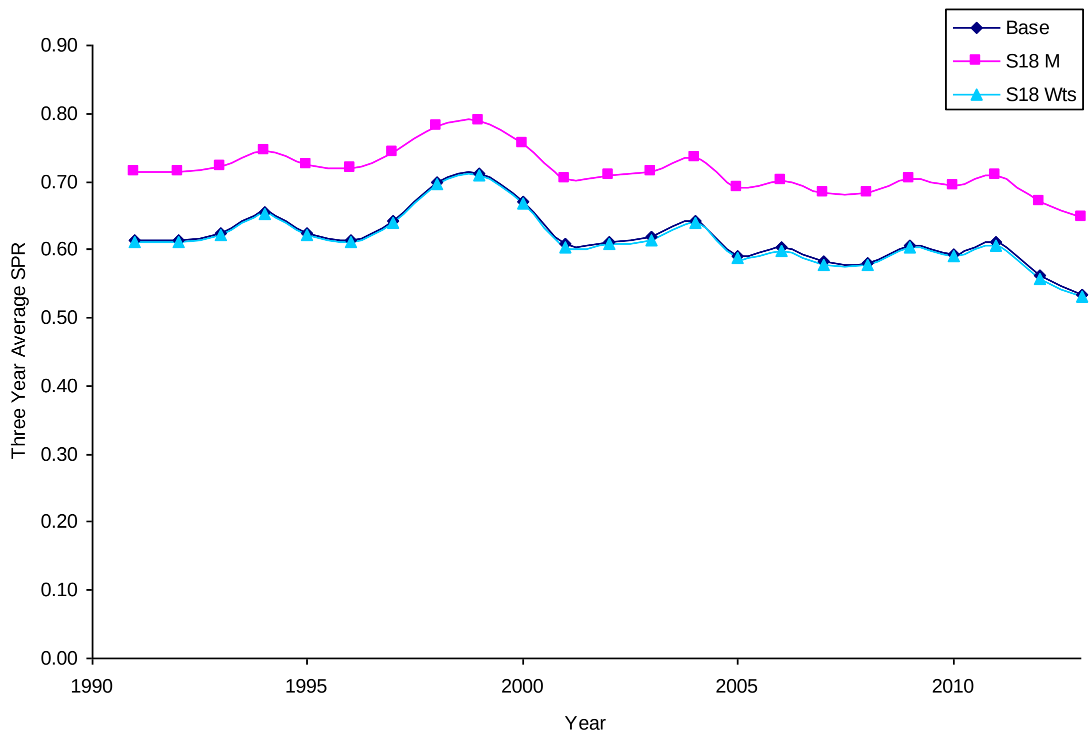


Figure 40. Comparison of the three year average sSPR for the southern stock for the base model, the model run using SEDAR18 estimates of M-at-age, and the model run using the SEDAR18 weights-at-age.

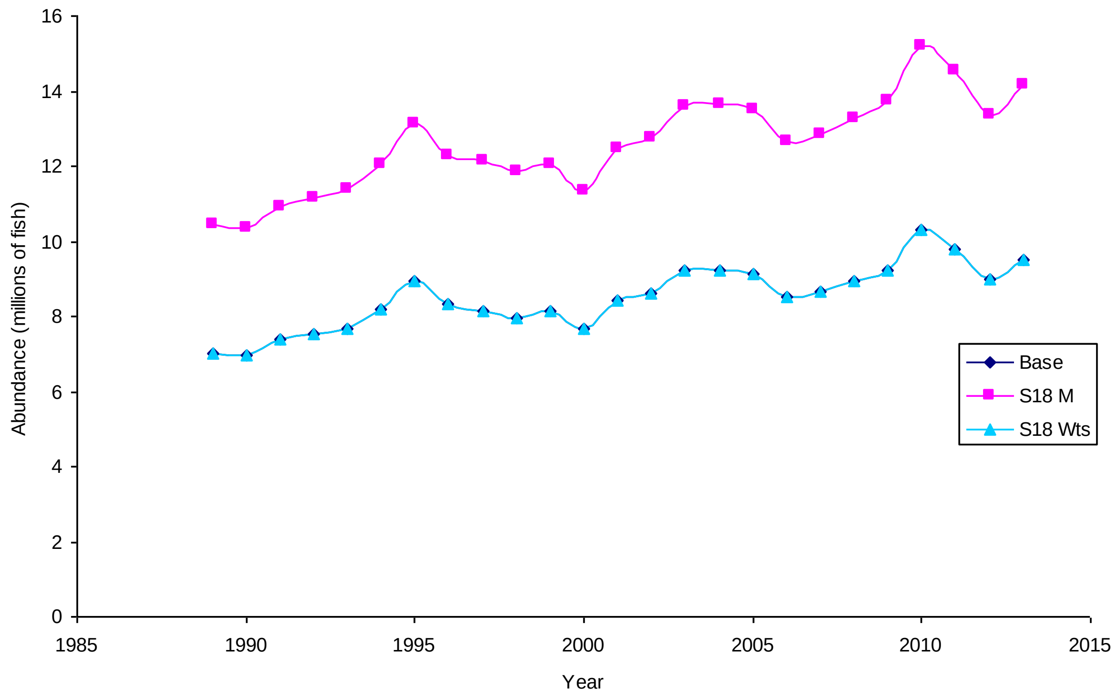


Figure 41. Comparison of the total abundance estimates for the southern stock for the base model, the model run using SEDAR18 estimates of M-at-age, and the model run using the SEDAR18 weights-at-age.

Appendix A. Model code and data inputs for the northern red drum stock assessment.

Model Code

```
TOP_OF_MAIN_SECTION
 //increase number of estimated parameters
 gradient_structure::set_NUM_DEPENDENT_VARIABLES(1000); // increasing number of parameters that can be
                      estimated to 1000 (default is 100 and must be changed if it will be exceeded)

DATA_SECTION   ////////////////////////////////////////////////////////////////////////
   !!USER_CODE ad_comm::change_datafile_name("n_base.dat");

//  init_int testing //toggle to turn on/off console output for testing, borrowed from spot code
 //////////// general dimensions and structural inputs ////////////
 // how many groups with separate fishing characteristics, fisheries?
  init_int nfleets

 // global first and last age used in the assesment
  init_int firstyr
   init_int lastyr


 // first and last years of catch data for each fishery
  init_ivector first_fyr(1,nfleets)
 init_ivector last_fyr(1,nfleets)

 // last year for tagging data
//  init_int last_tagyr

  // last year for tagging data likelihood
 //  init_int last_tag_likelihood

 // first and last age used in the assessment - last assumed plus group
  init_int firstage
   init_int lastage

 // last age that selectivity is estimated
  init_int last_sel_age

 // instantaneous natural mortality from firstage through lastage
  init_vector M(firstage,lastage)

 // selectivity blocks defined sequentially by fleet by year
  init_imatrix yr_sel_block(1,nfleets,first_fyr,last_fyr)

  //////////// observed data /////////////
 // total landed catch for each fleet each year and its CV
  init_matrix obs_tot_catch(1,nfleets,first_fyr,last_fyr)
   init_matrix tot_catch_CVs(1,nfleets,first_fyr,last_fyr)

  // error debugging tools
   //  !! cout << tot_catch_CVs << endl;
   // !! exit(4);
```

```
// observed selectivity for northern live-release fishery over two
// defined time period
 init_matrix B2_select(1,3,firstage,lastage)

// additional non-landed catch that is subject to the hook-and-line
// release mortality (rel_mort)
 init_matrix tot_B2catch(1,nfleets,first_fyr,last_fyr)
  init_number rel_mort

// observed proportion at age for all 'observed' landings and  sampled live-releases
// and number of fish sampled for age each year associated with these observed proportions
 init_3darray obs_prop_at_age(1,nfleets,first_fyr,last_fyr,firstage,lastage)
  init_matrix agedN(1,nfleets,first_fyr,last_fyr)

   init_matrix kept_Fatage(1989,2004,1,4)  // northern tagging total F-at-age for all kept fisheries, rec and comm
    init_matrix kept_F_CVs(1989,2004,1,4)   // tagging total F-at-age CV's for kept fisheries

 init_vector fullF_B2rec(1989,2004)     // fully recruited F for live-release fishery
  init_vector fullF_CVs(1989,2004)      // CV for fully recruited F for live-release fishery

   // error debugging tools
   //  !! cout << fullF_CVs << endl;
  //  !! exit(4);

// number of indices used for relative abundance
 init_int n_ndx
// first and last year for each index
 init_ivector first_syr(1,n_ndx)
  init_ivector last_syr(1,n_ndx)
// first and last age included in index
 init_ivector first_sage(1,n_ndx)
  init_ivector last_sage(1,n_ndx)
// midpoint month for the survey
 init_vector survey_month(1,n_ndx)
// relative abundance by index for each year available
// and coefficient of variation
 init_matrix survey_ndx(1,n_ndx,first_syr,last_syr)
  init_matrix survey_CVs(1,n_ndx,first_syr,last_syr)

// temporary penalty for keeping early-solution-search-F up
 init_number F_brake

      // !! cout << n_ndx << endl;
      // !! exit(99);

// the weights set associated with the total catches, proportion at age, indices, tagFs
 init_ivector wt_choice(1,4)

 // matrix showing three columns - for weight (lbs), proportion mature, and natural mortality
 // for every age in the fishes life
 init_matrix wt_mat_M62(1,62,1,3)

 //init_number rewgt
 //
 //    init_vector sdnr_adj_C(1,nfleets)
 //    init_vector sdnr_adj_ndx(1,n_ndx)
```

```
   //  !! cout << wt_mat_M62 << endl;
   //  !! exit(99);

// file names for the different weighting schemes referred to in wt_choice variable
  // total catch weights
 !!USER_CODE ad_comm::change_datafile_name("n0_TC.wts");
   init_matrix totcatch_wt(1,3,1,nfleets)

  // PAA wts
 !!USER_CODE ad_comm::change_datafile_name("n0_PAA.wts");
    init_3darray PAA_wt(1,2,1,nfleets-1,firstyr,lastyr)

  // Index wts
 !!USER_CODE ad_comm::change_datafile_name("n0_Ndx.wts");
   init_matrix indx_wt(1,3,1,n_ndx)

  // TagF wts
 !!USER_CODE ad_comm::change_datafile_name("n0_tagF.wts");
   init_matrix tagF_wt(1,2,1,2)
 ////////////////////////////////////////////////////////////////////////////////////

 // various statistics and manipulations of the input data
   ivector nselblocks(1,nfleets)
   int k
   number tot
   vector ave_obstC(1,nfleets)
   vector ave_obsNdx(1,n_ndx)
   matrix ave_obsPAA(1,nfleets,firstage,lastage)
   vector ave_obsFkept(1,4)
   number ave_obsFrelease
   matrix stdevPAA(1,nfleets,firstage,lastage)
LOCAL_CALCS
  for(ifleet=1;ifleet<=nfleets;ifleet++)
    {
    // how many 'selectivity blocks' are there for each fishery?
    nselblocks(ifleet) = yr_sel_block(ifleet,last_fyr(ifleet));
    }
     // special calculation for the norther rec live-release fisheries -- fleet=4 -- to calculate total kill
    for (iyr=first_fyr(4);iyr<=last_fyr(4);iyr++)
      {
      obs_tot_catch(4,iyr) = tot_B2catch(4,iyr) * (rel_mort);
      }

   // calculate various mean observed values to use in the total sum of squares [TSS = sum of squares
   //  for (mean-observed)/stdev(observed)], though this did not appear to be very helpful for
   //  'goodness of fit' evaluation where residual sum of squares [RSS = sum of squares for (observed-predicted)
   //   /stdev(observed)] was confounded by multidimensionaity of problem.

      // total catch
     for(ifleet=1;ifleet<=nfleets;ifleet++)
       {
       k = 0;
       tot=0;
      for (iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
         {
         k++;
         tot += log(obs_tot_catch(ifleet,iyr)+1e-6);
         }
```

```
      ave_obstC(ifleet) = tot/double(k);
     }

    // indices
  for (indx=1;indx<=n_ndx;indx++)
   {
    k = 0;
    tot=0;
   for(iyr=first_syr(indx);iyr<=last_syr(indx);iyr++)
    {
      if(survey_ndx(indx,iyr)>0)
       {
                        k++;
                        tot += log(survey_ndx(indx,iyr)+1.e-6);
        }
    }
   ave_obsNdx(indx) = tot/double(k);
  }

    //PAA -- this is a strech for 0.0-1.0 bound number      ---- remember fleet 4 doesn't count
for (ifleet=1;ifleet<=nfleets-1;ifleet++)
 {
  for (iage=firstage;iage<=lastage;iage++)
   {
    k = 0;
    tot=0;
   for (iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
     {
     k++;
     tot += obs_prop_at_age(ifleet,iyr,iage)+1.e-6;
     }
  ave_obsPAA(ifleet,iage) = tot/double(k);
   }
 }

 // what is the standard deviation of observed PAA across years for each fleet and age?
   for (ifleet=1;ifleet<=nfleets-1;ifleet++)
    {
     for (iage=firstage;iage<=lastage;iage++)
       {
        k = 0;
        tot=0;
        for (iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
          {
          k++;
          tot += square( obs_prop_at_age(ifleet,iyr,iage)-ave_obsPAA(ifleet,iage) );
          }
        stdevPAA(ifleet,iage) = sqrt( tot/(double(k)-1)  );
        }
    }

    // kept F-at-age
    for (iage=1;iage<=4;iage++)
     {
      k = 0;
      tot=0;
      for (iyr=1989;iyr<=2004;iyr++)
        {
```

```
        k++;
        tot += log(kept_Fatage(iyr,iage)+1.e-6);
        }
      ave_obsFkept(iage) = tot/double(k);
      }

   // Fully recruited Frelease

      k = 0;
      tot=0;
     for (iyr=1989;iyr<=2004;iyr++)
      {
      k++;
      tot += log(fullF_B2rec(iyr));
      }
      ave_obsFrelease = tot/double(k);
 END_CALCS


   // initialize various counters and temporary integers
   int sel_count
   int ifleet
   int iyr
   int iage
   int indx
   int i
   int j
   int ndx_n
   int PAA_n
   int PAA_n2
   int tC_n
   int kept_n
   int fullF_n

PARAMETER_SECTION  /////////////////////////////////////////////////////////////////////////////
 // NOTE: for convenience number of selectivities is hardwired -- does not include fleet=4, north live-release fishery
 //      when tag-based selectivity used is used /////////////////////////////not using tag-based selectivity for fleet 4
                      now //reverted back for continuity

    init_bounded_number sel04(-10.,10.,5)
    init_bounded_number sel05(-10.,10.,5)

    // init_bounded_number sel04b2(-10.,10.,5)
    // init_bounded_number sel05b2(-10.,10.,5)

  //----in get_selectivity function
 //Parameter: selectivities
  init_bounded_dev_vector fill_log_sel(1,27,-5,5,5)
    3darray log_sel(1,nfleets,1,nselblocks,firstage,lastage)
    matrix max_log_sel(1,nfleets,1,nselblocks)

 //----in get_mortality_rates function----
 //Parameter: fully recruited F's
  init_bounded_matrix log_Fmult(1,nfleets,first_fyr,last_fyr,-15,2,3)
    3darray log_Ffleet(1,nfleets,first_fyr,last_fyr,firstage,lastage)
    matrix Z(firstyr,lastyr,firstage,lastage)
    matrix tot_F(firstyr,lastyr,firstage,lastage)
```

```
//----in get_number_at_age function
//Parameters: median initial abundance ages 2-7+ and deviations from this for each age
//  init_bounded_number log_initN(8,25,1)
//  init_bounded_dev_vector log_initN_devs(firstage+1,lastage,-10,10,2)
   init_bounded_vector log_initN(firstage+1,lastage,2,18,1)

    matrix log_N(firstyr,lastyr,firstage,lastage)

 //Parameters: median recruitment by year and deviations from this for each year
// init_bounded_number log_R(8,25,1)
// init_bounded_dev_vector log_recruit_devs(firstyr,lastyr,-10,10,1)
//     vector log_recruits(firstyr,lastyr)
      init_bounded_vector log_recruits(firstyr,lastyr,5,18,1)

//----in calculate_catch function
    3darray C(1,nfleets,first_fyr,last_fyr,firstage,lastage)
    //matrix pred_catch(1,nfleets,first_fyr,last_fyr)
    sdreport_matrix pred_catch(1,nfleets,1989,2013) /////////////years have to be hard-wired for the sdreport for
                    some reason

//---- evaluate the objective function
        // indices
  //Parameter: catchability coefficient for each index
  matrix EffN(1,nfleets,first_fyr,last_fyr)
  matrix resid_ndx(1,n_ndx,first_syr,last_syr)
  matrix residmean_ndx(1,n_ndx,first_syr,last_syr)
       matrix resid_ndx2(1,n_ndx,first_syr,last_syr)
       matrix residmean_ndx2(1,n_ndx,first_syr,last_syr)
  matrix pred_ndx(1,n_ndx,first_syr,last_syr)
  vector stdev_ndx(1,n_ndx)
  vector neglogLL_ndx(1,n_ndx)
  number ndx_f
        // PAA
  3darray resid_PAA(1,nfleets,first_fyr,last_fyr,firstage,lastage)
  3darray residmean_PAA(1,nfleets,first_fyr,last_fyr,firstage,lastage)
       // fake residuals
       3darray resid_PAA2(1,nfleets,first_fyr,last_fyr,firstage,lastage)
       3darray residmean_PAA2(1,nfleets,first_fyr,last_fyr,firstage,lastage)
  vector stdev_PAA(1,nfleets-1)
  matrix neglogLL_PAA(1,nfleets,first_fyr,last_fyr)
  number PAA_f
        // total catch
  matrix resid_tC(1,nfleets,first_fyr,last_fyr)
  matrix residmean_tC(1,nfleets,first_fyr,last_fyr)
     matrix resid_tC2(1,nfleets,first_fyr,last_fyr)
     matrix residmean_tC2(1,nfleets,first_fyr,last_fyr)
  vector stdev_tC(1,nfleets)
  vector neglogLL_tC(1,nfleets)
          vector numerat(1,n_ndx)
          vector denomin(1,n_ndx)
          init_bounded_vector log_q_MLE(1,n_ndx,-18,-5,4)
  number tC_f
        //  kept F at age
  matrix pred_kept_Fatage(1989,2004,1,4)
  matrix resid_kept(1989,2004,1,4)
  matrix residmean_Fkept(1989,2004,1,4)
   matrix resid_kept2(1989,2004,1,4)
   matrix residmean_Fkept2(1989,2004,1,4)
```

```
  number stdev_kept
  vector neglogLL_kept(1989,2004)
  number kept_f
        //  fullF B2
  vector resid_fullF_B2(1989,2004)
  vector residmean_Frelease(1989,2004)
     vector resid_fullF_B22(1989,2004)
     vector residmean_Frelease2(1989,2004)
  number stdev_fullF
  number neglogLL_fullF
  number fullF_f

  // define some intermediate calculation
  number temp
  number temp2
  number avg_F
  number F_brake_penalty

    // Benchmark stuff
    // including spawning stock biomass under fishing and under no fishing,
    // spawning potential ratio, and various escapement estimates
    vector SSB_F(firstyr,lastyr)
    vector SSB_F0(firstyr,lastyr)
      number F_survival
      number F0_survival
    //vector escapement13(firstyr,lastyr)
   // vector escapement15(firstyr,lastyr)
      //transitional
    //   vector tEsc15(firstyr+4,lastyr)
     //  vector tEsc13(firstyr+2,lastyr)

   number Nu

  objective_function_value f

   sdreport_vector log_total_abundance(firstyr,lastyr)
   sdreport_vector log_N1(firstyr,lastyr)
   sdreport_vector log_N2(firstyr,lastyr)
   sdreport_vector log_N3(firstyr,lastyr)
   sdreport_vector log_Nplus(firstyr,lastyr)
   sdreport_vector expl13(firstyr,lastyr)
   sdreport_vector static_SPR(firstyr,lastyr)
   sdreport_vector three_yrSPR(firstyr+2,lastyr)
                         sdreport_vector escapement13(firstyr,lastyr)
   sdreport_vector escapement15(firstyr,lastyr)
                         sdreport_vector tEsc15(firstyr+4,lastyr)
   sdreport_vector tEsc13(firstyr+2,lastyr)

   likeprof_number three_yrSPR2013

PROCEDURE_SECTION /////////////////////////////////////////////////////////////////////////
 get_selectivities();
// if (testing==1) cout << "End get_selectivities()" << endl;
 get_mortality_rates();
// if (testing==1) cout << "End get_mortality_rates()" << endl;
 get_numbers_at_age();
// if (testing==1) cout << "End get_numbers_at_age()" << endl;
 calculate_catch();
```

```
// if (testing==1) cout << "End calculate_catch()" << endl;
 evaluate_the_objective_function();
//  if (testing==1) cout << "End evaluate_the_objective_function()" << endl;
//  if (testing==1) cout << "Procedure section completed first cycle, now exiting"<< endl;
//  if (testing==1) exit(1); //exit if in testing phase -- runs model at initial parameter values

   // static spawning potential ratio, and various escapement rate estimates
    // calculate spawning stock biomass per recruit with current year's fishing and without any F
     for(iyr=firstyr;iyr<=lastyr;iyr++)
      {
                    F_survival = mfexp( -1. * (wt_mat_M62(1,3)+tot_F(iyr,1)) );
                    F0_survival = mfexp(-1. * wt_mat_M62(1,3));
                     SSB_F(iyr) = wt_mat_M62(1,2)*wt_mat_M62(1,1)*F_survival;
                     SSB_F0(iyr) = wt_mat_M62(1,2)*wt_mat_M62(1,1)*F0_survival;

       for(iage=firstage+1;iage<=lastage;iage++)
        {

                     F_survival *= mfexp( -1.* (wt_mat_M62(iage,3)+tot_F(iyr,iage)) );
                     F0_survival *= mfexp(-1.* wt_mat_M62(iage,3));
          SSB_F(iyr) += wt_mat_M62(iage,2)*wt_mat_M62(iage,1)*F_survival;
                      SSB_F0(iyr) += wt_mat_M62(iage,2)*wt_mat_M62(iage,1)*F0_survival;
        }
       for(iage=lastage+1;iage<61;iage++)
        {
                     F_survival *= mfexp( -1.* (wt_mat_M62(iage,3)+tot_F(iyr,lastage)) );
                     F0_survival *= mfexp(-1.* wt_mat_M62(iage,3));
          SSB_F(iyr) += wt_mat_M62(iage,2)*wt_mat_M62(iage,1)*F_survival;
                      SSB_F0(iyr) += wt_mat_M62(iage,2)*wt_mat_M62(iage,1)*F0_survival;
        }
       //Infinite Series Correction added 7/19/16 (Mike Murphy's recommendation)
       F_survival *= mfexp(-1.* (wt_mat_M62(iage,3)+tot_F(iyr,lastage)))/(1.-mfexp(-
                    1.*(wt_mat_M62(iage+1,3)+tot_F(iyr,lastage))));
                     F0_survival *= mfexp(-1.* wt_mat_M62(iage,3))/(1.-mfexp(-1.*(wt_mat_M62(iage+1,3))));

       SSB_F(iyr) += wt_mat_M62(iage,2)*wt_mat_M62(iage,1)*F_survival;
                     SSB_F0(iyr) += wt_mat_M62(iage,2)*wt_mat_M62(iage,1)*F0_survival;

        // static SPR and static (year-specific) escapement rates
        static_SPR(iyr) = SSB_F(iyr)/SSB_F0(iyr);
        escapement13(iyr) = mfexp(-1.* tot_F(iyr,1)-tot_F(iyr,2)-tot_F(iyr,3));
        escapement15(iyr) = mfexp(-1.* tot_F(iyr,1)-tot_F(iyr,2)-tot_F(iyr,3)-tot_F(iyr,4)-tot_F(iyr,5));

         // transitional (yearclass-specific) escapement rates
         if(iyr>1992)
          {
           tEsc15(iyr) = mfexp( -1.* tot_F(iyr-4,1)-tot_F(iyr-3,2)-tot_F(iyr-2,3)-tot_F(iyr-1,4)-tot_F(iyr,5) );
          }
         if(iyr>1990)
          {
           tEsc13(iyr) = mfexp( -1.* tot_F(iyr-2,1)-tot_F(iyr-1,2)-tot_F(iyr,3) );
          }
     }

     log_total_abundance=log(rowsum(mfexp(log_N)));

    for(iyr=firstyr;iyr<=lastyr;iyr++)
      {
```

```
        log_N1(iyr) = log_N(iyr,1);
        log_N2(iyr) = log_N(iyr,2);
        log_N3(iyr) = log_N(iyr,3);
        log_Nplus(iyr) = log_N(iyr,7);
        // catch across fleets
         temp=0.;
         for(ifleet=1;ifleet<=nfleets;ifleet++)
          {
          temp += C(ifleet,iyr,1)+C(ifleet,iyr,2)+C(ifleet,iyr,3);
          }
        expl13(iyr) = temp/( mfexp(log_N1(iyr))+mfexp(log_N2(iyr))+mfexp(log_N3(iyr)) );
         if(iyr>1990)
          {
          three_yrSPR(iyr) = ( static_SPR(iyr-2)+static_SPR(iyr-1)+static_SPR(iyr) )/3.;
          }
        }

        three_yrSPR2013 = ( static_SPR(2013-2)+static_SPR(2013-1)+static_SPR(2013) )/3.;

//  outputMCMC();
    // cout <<  log_Nplus  << endl;
   //  exit(99);

   //////////////////////// Begin Population Dynamics Model ////////////////////////////
FUNCTION get_selectivities

 //----selectivity is not described parametrically but assumed constant above some maximum age
 //----the following simply fills out the array of candidate selectivities to be evaluated
 //----in the end it is standardized to the largest selectivity

  sel_count=0;  //remember first age is one;
  for (ifleet=1;ifleet<=nfleets-1;ifleet++)
       {
       for (i=1;i<=yr_sel_block(ifleet,last_fyr(ifleet));i++)
        {

          // fill log_sel matrix using bounded vector
          for (iage=firstage;iage<=last_sel_age;iage++)
           {
           sel_count++;
           log_sel(ifleet,i,iage) = fill_log_sel(sel_count);
           }
           max_log_sel(ifleet,i) = max(log_sel(ifleet,i));

          // standardize relative to this maximum
          for (iage=firstage;iage<=last_sel_age;iage++)
           {
           log_sel(ifleet,i,iage) =  log_sel(ifleet,i,iage)-max_log_sel(ifleet,i);
           }

            // Special: for red drum, we assume that the selectivity drops after last estimated age
           // if(ifleet<4)
           //    {
            log_sel(ifleet,i,last_sel_age+1) = log_sel(ifleet,i,last_sel_age)+log(1/(1+exp(-1.*sel04)));
            log_sel(ifleet,i,last_sel_age+2) = log_sel(ifleet,i,last_sel_age)+log(1/(1+exp(-1.*sel05)));
            //   }
            //if(ifleet==4)
            //   {
```

```
         // log_sel(ifleet,i,last_sel_age+1) = log_sel(ifleet,i,last_sel_age)+log(1/(1+exp(-1.*sel04b2)));
         // log_sel(ifleet,i,last_sel_age+2) = log_sel(ifleet,i,last_sel_age)+log(1/(1+exp(-1.*sel05b2)));
         //    }

        // selectivity for older ages is set equal to oldest-aged selectivity
        for (iage=last_sel_age+3;iage<=lastage;iage++)
         {
         log_sel(ifleet,i,iage) = log_sel(ifleet,i,last_sel_age+2);
         }
      }
     }

      // Special: for the northern live-release fishery selectivites are 'observed data'
      ifleet = 4; //////////////////////////////////////////////////commented out
      for (i=1;i<=yr_sel_block(ifleet,last_fyr(ifleet));i++) //////////////////////////////////////////////////commented out
       { //////////////////////////////////////////////////commented out
         for (iage=firstage;iage<=lastage;iage++)//////////////////////////////////////////////////commented out
         { //////////////////////////////////////////////////commented out
         log_sel(ifleet,i,iage) = log(B2_select(i,iage));   //////////////////////////////////////////////////commented out
          } //////////////////////////////////////////////////commented out
       } //////////////////////////////////////////////////commented out

    // use the B2's from tagging for 1998-2004

//   if(current_phase()==3)
//    {
//    cout << "no. fleets " << nfleets << endl;
 //   cout << " selblocks by year,fleet " << endl;
 //   cout << yr_sel_block << endl;
 //   cout << mfexp(log_sel) << endl;
//    exit(99);
//    }

FUNCTION get_mortality_rates

 //----age-specific fishing mortalities is derived using estimated selectivities and year-specific F----

 for (ifleet=1;ifleet<=nfleets;ifleet++)
  {
  // fill out the fleet-, year-, age-specific F's
  for (iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
    {
    for (iage=firstage;iage<=lastage;iage++)
     {
     log_Ffleet(ifleet,iyr,iage)=log_Fmult(ifleet,iyr)+log_sel(ifleet,yr_sel_block(ifleet,iyr),iage);
     }
    }
  }

 // --- calculate instantaneous total mortality for convenience later
 // allow for variable M with age

     // calculate the total fishing mortality across all fisheries each year
     //remember not all years have all fleets operating -- sum available F's
     tot_F=0.0;
    for (ifleet=1;ifleet<=nfleets;ifleet++)
      {
      for (iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
```

```
      {
      for (iage=firstage;iage<=lastage;iage++)
       {
       tot_F(iyr,iage) += mfexp(log_Ffleet(ifleet,iyr,iage));
       }
      }
     }

    // calculate Z's
   for (iyr=firstyr;iyr<=lastyr;iyr++)
    {
     Z(iyr) = M;
      for (iage=firstage;iage<=lastage;iage++)
       {
        Z(iyr,iage) += tot_F(iyr,iage);
       }
    }

  //  if(current_phase()==3)
  //  {
   // cout << "no. fleets " << nfleets << endl;
  //  cout << " selblocks by year,fleet " << endl;
  //  cout << yr_sel_block << endl;
  //  cout << Z << endl;
  //  cout << tot_F << endl;
  //  exit(99);
 //   }


FUNCTION get_numbers_at_age

   // This fills parameter estimates for initial N's or top row and
   // numbers-at-age-1 (recruits) or left column in N-at-age matrix

  // initial year's abundance for ages-2 to 7+
  //   for (iage=firstage+1;iage<=lastage;iage++)
  //   {
  //                    if (active(log_initN_devs))
  //                     {
  //    log_N(firstyr,iage)=log_initN+log_initN_devs(iage);
  //      }
  //    else
  //      {
  //    log_N(firstyr,iage)=log_initN;
  //      }
  //  }

     // initial year's abundance for ages-2 to 7+
   for (iage=firstage+1;iage<=lastage;iage++)
    {
      log_N(firstyr,iage)=log_initN(iage);
    }

   // all year's recruitment or beginning-of-the-year abundance of age-1
   // for (iyr=firstyr;iyr<lastyr;iyr++)
   //  {
   //                   if (active(log_recruit_devs))
    //                    {
```

```
   //     log_recruits(iyr) = log_R + log_recruit_devs(iyr);
   //     log_N(iyr,firstage) = log_recruits(iyr);
   //     }
   //   else
   //     {
   //     log_recruits(iyr) = log_R;
   //     log_N(iyr,firstage) =log_recruits(iyr);
   //     }

   for (iyr=firstyr;iyr<=lastyr;iyr++)
   {
      log_N(iyr,firstage) = log_recruits(iyr);
   }

   //----from these starting values project abundances forward in time and age----
   for (iyr=firstyr;iyr<lastyr;iyr++)
   {
     for (iage=firstage;iage<lastage;iage++)
      {
      log_N(iyr+1,iage+1)=log_N(iyr,iage)-Z(iyr,iage);
      }

  //----oldest age is a plus group so, in addition to the cohort survivors for last year
  //    need to add the last year's plus-group survivors
   log_N(iyr+1,lastage)=log( mfexp(log_N(iyr,lastage)-Z(iyr,lastage))+mfexp(log_N(iyr+1,lastage))  );
   }
  //----define recruitment in the final year, this is only informed if there is a yoy index to fit----
   //                   if (active(log_recruit_devs))
  //                      {
  //        log_recruits(lastyr) = log_R + log_recruit_devs(lastyr);
  //        log_N(lastyr,firstage) = log_recruits(lastyr);
  //        }
  //       else
  //        {
  //        log_recruits(lastyr) = log_R;
  //        log_N(lastyr,firstage) =log_recruits(lastyr);
  //        }
  /////////////////////////////// END POPULATION DYNAMICS MODEL ///////////////////////////////////////////////

  //  if(current_phase()==2)
  //   {
  //   cout << log_N << endl;
  //   exit(99);
  //   }



FUNCTION calculate_catch

  /////// for convenience need to calculate some terms to be used to calculate predicted proportion at age
  //----Use catch equation to calculate fleet-specific catch-at-age matrices----
  //    and total kill each year for each fleet
   pred_catch = 0.0;
   for (ifleet=1;ifleet<=nfleets;ifleet++)
     {
     for (iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
       {
       for (iage=firstage;iage<=lastage;iage++)
```

```
        {
        C(ifleet,iyr,iage) = (mfexp(log_Ffleet(ifleet,iyr,iage))/Z(iyr,iage))
                        * mfexp( log_N(iyr,iage) ) * ( 1.-mfexp(-1.*Z(iyr,iage)) );
        pred_catch(ifleet,iyr) +=  C(ifleet,iyr,iage);
        }
       }
      }

 //  if(current_phase()==2)
 //   {
 //   cout << pred_catch << endl;
 //   exit(99);
 //   }

 //////////////////////////////  OBSERVATION MODEL ///////////////////////////////////
FUNCTION evaluate_the_objective_function

 // Estimate effective sample size -- ignore fleet-4; northern rec live-release /////////////////////not ignoring fleet 4
 // useful in determining the 'goodness of fit' for the multinomial prediction of proportion at age in kill
   for (ifleet=1;ifleet<=nfleets;ifleet++)
    {
    for (iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
     {
     temp = 0.;
     temp2 = 0.;
      for (iage=firstage;iage<=lastage;iage++)
       {
      temp  += C(ifleet,iyr,iage)/(pred_catch(ifleet,iyr)+1.e-13)*( 1-C(ifleet,iyr,iage)
                                                /(pred_catch(ifleet,iyr)+1.e-13) );
      temp2 += square( obs_prop_at_age(ifleet,iyr,iage)-C(ifleet,iyr,iage)
                                               /(pred_catch(ifleet,iyr)+1.e-13) );
       }
    EffN(ifleet,iyr) = temp/temp2;
     }
    }

   // cout << EffN << endl;
  //  exit(99);

             // in the last phase a small penalty for a small F is added to objective
             // function, in earlier phases a much larger penalty keeps solution away
             // from infinitesimally small Fs
 F_brake_penalty = 0.;
 avg_F=sum(tot_F)/double(size_count(tot_F));
 if(last_phase())
  {
   F_brake_penalty += 1.e-6*square(log(avg_F/.2));
  }
  else
  {
   F_brake_penalty += F_brake*square(log(avg_F/.2));
  }

 ///////////// minimally 'regularize' the selectivities ////////////
//   f += sel_regularize*norm2(fill_log_sel);      /// how is the regularize number chosen?
  f += 5.*norm2(fill_log_sel);      /// how is the regularize number chosen?
```

```
// ----negative log Likelihood estimation for indices-----------------------------------------

 //  if(rewgt==1)
 //    {
 //         // cout << survey_CVs << endl;
 //    for(indx=1;indx<=n_ndx;indx++)
 //      {
 //      survey_CVs(ifleet) /= sdnr_adj_ndx(indx);
 //      }
 //       // cout << survey_CVs << endl;
 //       // exit(99);
 //    }

   ndx_f = 0;
   neglogLL_ndx = 0;
    for (indx=1;indx<=n_ndx;indx++)
     {
      ndx_n = 0;
      for(iyr=first_syr(indx);iyr<=last_syr(indx);iyr++)
       {
         if(survey_ndx(indx,iyr)>0)
           {
            // for aggregate indices, sum appropriate N estimates
            temp=0;
            for(iage=first_sage(indx);iage<=last_sage(indx);iage++)
            {
            temp += mfexp( log_N(iyr,iage)-Z(iyr,iage)*(survey_month(indx)/12.) );
            }

         ndx_n++;
         pred_ndx(indx,iyr) = mfexp(log_q_MLE(indx))*temp;
          // standardized residual
        resid_ndx(indx,iyr) = (   log(survey_ndx(indx,iyr)+1.e-6) - ( log_q_MLE(indx) + log(temp+1.e-6) )   )/
                              sqrt(log(pow(survey_CVs(indx,iyr),2)+1));
          // standardized residual from average -- for total sum of squares (dubious)
        residmean_ndx(indx,iyr) = (   log(survey_ndx(indx,iyr)+1.e-6) -  ave_obsNdx(indx)   )/
                              sqrt(log(pow(survey_CVs(indx,iyr),2)+1));

              // squared residuals///////////////////
        resid_ndx2(indx,iyr) = square(    (   log(survey_ndx(indx,iyr)+1.e-6) - ( log_q_MLE(indx) + log(temp+1.e-6) )   )/
                              sqrt(log(pow(survey_CVs(indx,iyr),2)+1))    );
        residmean_ndx2(indx,iyr) = square(  (   log(survey_ndx(indx,iyr)+1.e-6) -  ave_obsNdx(indx)   )/
                              sqrt(log(pow(survey_CVs(indx,iyr),2)+1))  );
             ///////////////////////////////////

          // negative log-likelihood for the lognormal distribution
        neglogLL_ndx (indx) +=  0.5*square( resid_ndx(indx,iyr) ) + log(sqrt(log(pow(survey_CVs(indx,iyr),2)+1)));
            }
       }
      stdev_ndx(indx) = sqrt(  sum(resid_ndx2(indx))/double(ndx_n));
      ndx_f += neglogLL_ndx(indx)*indx_wt(wt_choice(3),indx);
     }

     // if(current_phase()==2)
     //  if(last_phase())
     // {
     //  cout << survey_CVs << endl;
     //  cout << sdnr_adj_ndx << endl;
```

```
  //   cout << obs_prop_at_age(ifleet,iyr,iage) << endl;
  //   cout << agedN(ifleet,iyr)*(obs_prop_at_age(ifleet,iyr,iage)+1.e-6) << endl;
  //   cout << (1-(obs_prop_at_age(ifleet,iyr,iage)+1.e-6))  << endl;
  //   cout << obs_prop_at_age(ifleet,iyr,iage)+1.e-6 << endl;
  //   cout << C(ifleet,iyr,iage)/pred_catch(ifleet,iyr)+1.e-6 << endl;
  //   exit(99);
 //   }

//---Likelihood estimation for catch proportions-at-age ------------------------

 // cout << EffN << endl;
 // cout << agedN << endl;
 // exit(99);


 PAA_f = 0;
 neglogLL_PAA=0;
 PAA_n = 0;
 Nu=0;
 for (ifleet=1;ifleet<=nfleets-1;ifleet++)  // these were not observed for fleet=4, north rec live-release fishery
                        /////////////////////////////
  {
   PAA_n2=0;
  for (iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
    {


    Nu = agedN(ifleet,iyr);
 //   if(rewgt==1)
 //   {
 //    Nu = EffN(ifleet,iyr);
 //    }
 //   // cout << Nu << endl;
 //   // exit(99);

    for (iage=firstage;iage<=lastage;iage++)
     {
     PAA_n++;   // just overall number of observations counter
     PAA_n2++;
      // 'residual' in multinomial sense
     resid_PAA(ifleet,iyr,iage) = (obs_prop_at_age(ifleet,iyr,iage)+1.e-6)*log(
                     (C(ifleet,iyr,iage)/pred_catch(ifleet,iyr)+1.e-6)  );
     residmean_PAA(ifleet,iyr,iage) = (obs_prop_at_age(ifleet,iyr,iage)+1.e-6)*log( ave_obsPAA(ifleet,iage)+1.e-6  );

         // squared residuals//////////////////
     resid_PAA2(ifleet,iyr,iage) = square( ( (obs_prop_at_age(ifleet,iyr,iage)+1.e-6) -
                     (C(ifleet,iyr,iage)/pred_catch(ifleet,iyr)+1.e-6) ) /
                        sqrt(  Nu*(obs_prop_at_age(ifleet,iyr,iage)+1.e-6)*(1-(obs_prop_at_age(ifleet,iyr,iage)+1.e-6)) ) );
     residmean_PAA2(ifleet,iyr,iage) = square( ( (obs_prop_at_age(ifleet,iyr,iage)+1.e-6) -
                     (ave_obsPAA(ifleet,iage)+1.e-6))/
                         sqrt(  Nu*(obs_prop_at_age(ifleet,iyr,iage)+1.e-6)*(1-(obs_prop_at_age(ifleet,iyr,iage)+1.e-6)) ) );
         //////////////////////////////////


  //  if(current_phase()==3&iyr==1995&iage==2)
  //  {
  //   cout << resid_PAA2(ifleet,iyr,iage) << endl;
  //   cout << agedN(ifleet,iyr) << endl;
```

```
   //   cout << obs_prop_at_age(ifleet,iyr,iage) << endl;
   //   cout << agedN(ifleet,iyr)*(obs_prop_at_age(ifleet,iyr,iage)+1.e-6) << endl;
   //   cout << (1-(obs_prop_at_age(ifleet,iyr,iage)+1.e-6))  << endl;
   //   cout << obs_prop_at_age(ifleet,iyr,iage)+1.e-6 << endl;
   //   cout << C(ifleet,iyr,iage)/pred_catch(ifleet,iyr)+1.e-6 << endl;
    //  exit(99);
   //  }

        // negative log-likelihood for the multinomial distribution
      neglogLL_PAA(ifleet,iyr) -= resid_PAA(ifleet,iyr,iage)*agedN(ifleet,iyr);
      }
      PAA_f +=  PAA_wt(wt_choice(2),ifleet,iyr) * neglogLL_PAA(ifleet,iyr);
     }
    stdev_PAA(ifleet) = sqrt(  sum(resid_PAA2(ifleet))/double(PAA_n2));

   // if(current_phase()==1&ifleet==3)
   //  {
   //  cout << ifleet << endl;
   //  cout << resid_PAA(ifleet) << endl;
   //  exit(99);
   //  }
   }

   //  if(current_phase()==3)
   //  {
   //   cout << resid_PAA2 << endl;
   //   exit(99);
   //  }

// ----total catch kill -----------------------------------------

     tC_f = 0;
     neglogLL_tC = 0;
     tC_n=0;
     for(ifleet=1;ifleet<=nfleets;ifleet++)
      {
      for(iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
        {

 // if(rewgt==1)
 //    {
 //        //  cout << tot_catch_CVs << endl;
 //     tot_catch_CVs(ifleet,iyr) = tot_catch_CVs(ifleet,iyr)/sdnr_adj_C(ifleet);
 //         //  cout << tot_catch_CVs << endl;
 //         // exit(99);
 //     }

       tC_n++;  //just an overall total number of observations
         // standardized residual
       resid_tC(ifleet,iyr) = (  log(obs_tot_catch(ifleet,iyr)+1.e-6) - log(pred_catch(ifleet,iyr)+1.e-6)  )/
                              sqrt(log(pow(tot_catch_CVs(ifleet,iyr),2)+1));
         // standardized residual from average
       residmean_tC(ifleet,iyr) = (  log(obs_tot_catch(ifleet,iyr)+1.e-6) - ave_obstC(ifleet)  )/
                              sqrt(log(pow(tot_catch_CVs(ifleet,iyr),2)+1));

           // squared residuals//////////////////
       resid_tC2(ifleet,iyr) = square (    (  log(obs_tot_catch(ifleet,iyr)+1.e-6) - log(pred_catch(ifleet,iyr)+1.e-6)  )/
                              sqrt(log(pow(tot_catch_CVs(ifleet,iyr),2)+1))    );
```

```
      residmean_tC2(ifleet,iyr) = square(    (  log(obs_tot_catch(ifleet,iyr)+1.e-6) - ave_obstC(ifleet)  )/
                                  sqrt(log(pow(tot_catch_CVs(ifleet,iyr),2)+1))    );
         //////////////////////////////////

         // negative log-likelihood for the lognormal distribution
// neglogLL_tC (ifleet) +=  0.5*square( resid_tC(ifleet,iyr) ) +
                         log(sqrt(log(pow(tot_catch_CVs(ifleet,iyr)*sdsr_fleetC(ifleet),2)+1)));
 neglogLL_tC (ifleet) +=  0.5*square( resid_tC(ifleet,iyr) ) + log(sqrt(log(pow(tot_catch_CVs(ifleet,iyr),2)+1)));

      }

     tC_f += neglogLL_tC(ifleet)*totcatch_wt(wt_choice(1),ifleet);
     }

 //  if(current_phase()==2)
 //   {
 //   cout << neglogLL_tC << endl;
 //   cout << sdsr_fleetC << endl;
 //   exit(99);
 //   }

// tagging information on the catch at age for the kept fisheries
   // first need sum for the pooled predicted F-at-age for the kept fleets
    pred_kept_Fatage=0.0;
    for (ifleet=1;ifleet<=3;ifleet++)
     {
     for (iyr=1989;iyr<=2004;iyr++)
      {
      for (iage=1;iage<=4;iage++)
        {
       pred_kept_Fatage(iyr,iage) += mfexp(log_Ffleet(ifleet,iyr,iage));
        }
      }
     }

      kept_f = 0;
      kept_n=0;
      neglogLL_kept=0;
    for (iyr=1989;iyr<=2004;iyr++)
    {
    for (iage=1;iage<=4;iage++)
     {
     kept_n++;
        // standardized residual
     resid_kept(iyr,iage) = (  log(kept_Fatage(iyr,iage)) - log(pred_kept_Fatage(iyr,iage))  ) /
                               sqrt(log(pow(kept_F_CVs(iyr,iage),2)+1));
        // standardized residual from average
     residmean_Fkept(iyr,iage) = (  log(kept_Fatage(iyr,iage)) - ave_obsFkept(iage)  ) /
                               sqrt(log(pow(kept_F_CVs(iyr,iage),2)+1));

          // squared residuals//////////////////
     resid_kept2(iyr,iage) = square(    (  log(kept_Fatage(iyr,iage)) - log(pred_kept_Fatage(iyr,iage))  ) /
                               sqrt(log(pow(kept_F_CVs(iyr,iage),2)+1))   );
     residmean_Fkept2(iyr,iage) = square(    (  log(kept_Fatage(iyr,iage)) - ave_obsFkept(iage)  ) /
                               sqrt(log(pow(kept_F_CVs(iyr,iage),2)+1))    );
         //////////////////////////////////

         // negative log-likelihood for the lognormal distribution
```

```
      neglogLL_kept(iyr) +=  0.5*square( resid_kept(iyr,iage) ) + log(sqrt(log(pow(kept_F_CVs(iyr,iage),2)+1)));
      }
      kept_f += neglogLL_kept(iyr)*tagF_wt(wt_choice(4),1);
     }
     stdev_kept = sqrt(sum(resid_kept2)/double(kept_n));


 // tagging information on the full F for live release fishery
       fullF_f = 0;
       neglogLL_fullF=0;
       fullF_n=0;
    for (iyr=1989;iyr<=2004;iyr++)
     {
      fullF_n++;
           // standardized residual
      resid_fullF_B2(iyr) = (  log(fullF_B2rec(iyr)) - log_Fmult(4,iyr)  ) /
                                 sqrt(log(pow(fullF_CVs(iyr),2)+1));
          // standardized residual from average
      residmean_Frelease(iyr) = (  log(fullF_B2rec(iyr)) - ave_obsFrelease  ) /
                                 sqrt(log(pow(fullF_CVs(iyr),2)+1));

            // squared residuals//////////////////
      resid_fullF_B22(iyr) = square(    (  log(fullF_B2rec(iyr)) - log_Fmult(4,iyr)  ) /
                                 sqrt(log(pow(fullF_CVs(iyr),2)+1))    );
      residmean_Frelease2(iyr) = square(    (  log(fullF_B2rec(iyr)) - ave_obsFrelease  ) /
                                 sqrt(log(pow(fullF_CVs(iyr),2)+1))    );
           /////////////////////////////////

            // negative log-likelihood for the lognormal distribution
      neglogLL_fullF +=  0.5*square( resid_fullF_B2(iyr) ) + log(sqrt(log(pow(fullF_CVs(iyr),2)+1)));
      }
     fullF_f = neglogLL_fullF*tagF_wt(wt_choice(4),2);
   // cout << kept_f << endl;
   //  cout << fullF_f << endl;
   //exit(99);


     // full weighted estimate of sum of likelihoods
   f += ndx_f + PAA_f + tC_f + F_brake_penalty + kept_f + fullF_f;

  //  if(current_phase()==6)
  //   {
  //   cout << f << endl;
  //   exit(99);
  //   }

/////Removed by AG and used mcmc switch instead
//FUNCTION outputMCMC
  //--------------------------------------------------------------------------------
//   ofstream MCMCout1("MCMC1.out",ios::app);
//    MCMCout1 << three_yrSPR2013 << " " <<  static_SPR << endl;
//   MCMCout1.close();
//      ofstream MCMCout2("MCMC2.out",ios::app);
//       MCMCout2 <<  log_recruits   <<  " " << log_Fmult <<
//              endl;
//      MCMCout2.close();
//   ofstream MCMCout3("MCMC3.out",ios::app);
//       MCMCout3 << log_N2 << " " << log_N3 << " " << log_Nplus << " " << log_initN  << endl;
```

```
//      MCMCout3.close();

  if (mceval_phase()){
    ofstream sizeout("threeyr.out", ios::app);
    sizeout<<three_yrSPR2013<<endl;
  }

REPORT_SECTION
 report << "ALL INPUT DATA" << endl;
 report << nfleets << endl;
 report << endl;
 report << firstyr << "  " << lastyr << endl;
 report << endl;
 report << firstage << "  " << lastage << endl;
 report << endl;
 report << first_fyr << last_fyr << endl;
 report << endl;
 report << last_sel_age << endl;
 report << endl;
 report << M << endl;
 report << endl;
 report << yr_sel_block << endl;
 report << endl;
 report << obs_tot_catch << endl;
 report << endl;
 report << tot_catch_CVs << endl;
 report << endl;
 report << obs_prop_at_age << endl;
 report << endl;
 report << endl;
 report << n_ndx << endl;
 report << endl;
 report << first_syr << endl;
 report << endl;
 report << last_syr << endl;
 report << endl;
 report << survey_ndx << endl;
 report << endl;
 report << survey_CVs << endl;
 report << endl;
 report << kept_Fatage << endl;
 report << fullF_B2rec << endl;
 report << fullF_CVs << endl;
 report << endl;
 report << "unwted_obj_fnctn_fit " << endl;
 report << sum(neglogLL_ndx)+sum(neglogLL_PAA)+sum(neglogLL_tC)+sum(neglogLL_kept)+neglogLL_fullF
                              +F_brake_penalty+norm2(fill_log_sel)<< endl;
 report << "Objective_function_total" << endl;
 report << setw(15) << setprecision(5) << f << endl;
 report << "Index_part_wted"<< setw(15) << endl;
 report << setprecision(5) << ndx_f << setw(15) << setprecision(5) << double(ndx_n) << endl;
 report << "PAA_part_wted" << endl;
 report << setw(15) << setprecision(5) << PAA_f << setw(15) << setprecision(5) << double(PAA_n) << endl;
 report << "total_catch_part_wted" << endl;
 report << setw(15) << setprecision(5) << tC_f << setw(15) << setprecision(5) << double(tC_n) << endl;
 report << "Fkept_part_wted" << endl;
 report << setw(15) << setprecision(5) << kept_f << setw(15) << setprecision(5) << double(kept_n) << endl;
 report << "Ffull_rel_wted" << endl;
```

```
report << setw(15) << setprecision(5) << fullF_f << setw(15) << setprecision(5) << double(fullF_n) << endl;
report << "F_brake_penalty"  << endl;
report << F_brake_penalty << endl;
// report << "initN_devs" << norm2(log_initN_devs) << endl;
report << "log_selectivity_devs" << endl;
report << 5.*norm2(fill_log_sel) << endl;
//report << " log_recruit_devs = " << norm2(log_recruit_devs) << endl;
report << endl;
report << "Look at fits" << endl;
report << "Index  Year  Pred  Std_Resid Std_Residfrommean " << endl;
  for(indx=1;indx<=n_ndx;indx++)
   {
   for(iyr=first_syr(indx);iyr<=last_syr(indx);iyr++)
     {
    report << setw(5) << setprecision(0) << indx
          << setw(5) << setprecision(0) << iyr
          << setw(10) << setprecision(5) << pred_ndx(indx,iyr)
                                << setw(10) << setprecision(5) << resid_ndx(indx,iyr)
                                << setw(10) << setprecision(5) << residmean_ndx(indx,iyr) << endl;
     }
   }

report << "Index - neglogLL - Standard Deviation of Standardized Residuals (SDSR) -  Standardized Residual Sum of
                    Squares (SRSS) -  Total Standardized Residual Sum of Squares (TSRSS)" << endl;
   for(indx=1;indx<=n_ndx;indx++)
   {
                        stdev_ndx(indx) = std_dev(resid_ndx(indx));
                        report << setw(5) << setprecision(0) << indx
                                        << setw(15) << setprecision(5) << neglogLL_ndx(indx)
                                        << setw(10) << setprecision(5) << stdev_ndx(indx)
           << setw(10) << setprecision(5) << sum(resid_ndx2 (indx))
                                        << setw(10) << setprecision(5) << sum(residmean_ndx2 (indx)) << endl;
   }
report << endl;
report << " proportion at age " << endl;
   for(ifleet=1;ifleet<=nfleets;ifleet++)
    {
    for(iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
     {
      report << setw(5) << setprecision(0) << ifleet
           << setw(5) << setprecision(0) << iyr
           << setw(10) << setprecision(5) << C(ifleet,iyr)/pred_catch(ifleet,iyr) << endl;
     }
    }

 report << "Fleet - neglogLL - Standard Deviation of Standardized Residuals (SDSR)" << endl;
for (ifleet=1;ifleet<=nfleets-1;ifleet++) //fixed so that it only goes to nfleets-1, rather than nfleets
 {
                        report << setw(5) << setprecision(0) << ifleet
                                        << setw(15) << setprecision(5) << sum(neglogLL_PAA(ifleet))
                                        << setw(10) << setprecision(5) << stdev_PAA(ifleet) << endl;
 }

report << endl;

 report << "Fleet  Year  Pred  Std_Resid Std_Residfrommean " << endl;
  for(ifleet=1;ifleet<=nfleets;ifleet++)
   {
```

```
   for(iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
    {
      report.setf(ios::fixed, ios::floatfield);
                          report << setw(5) << setprecision(0) << ifleet
          << setw(10) << setprecision(0) << iyr
                                                  << setw(15) << setprecision(0) << pred_catch(ifleet,iyr)
                                                  << setw(15) << setprecision(5) << resid_tC(ifleet,iyr)
                                            << setw(15) << setprecision(5) << residmean_tC(ifleet,iyr) << endl;
    }
   }

report << "Fleet - neglogLL - Standard Deviation of Standardized Residuals (SDSR) -  Standardized Residual Sum of
                    Squares (SRSS) -  Total Standardized Residual Sum of Squares (TSRSS)" << endl;
   for(ifleet=1;ifleet<=nfleets;ifleet++)
    {
                         stdev_tC(ifleet) = std_dev(resid_tC(ifleet));
                         report << setw(5) << setprecision(0) << ifleet
                                                  << setw(15) << setprecision(5) << neglogLL_tC(ifleet)
                                                  << setw(15) << setprecision(5) << stdev_tC(ifleet)
          << setw(15) << setprecision(5) << sum(resid_tC2 (ifleet))
                                                  << setw(15) << setprecision(5) << sum(residmean_tC2 (ifleet)) << endl;
    }
report << endl;
  report << "Predicted FAA for harvest fisheries" << endl;
                    report << "Year Pred_FAA Std_Resid Std_Residfrommean" << endl;
   // for (iage=1;iage<=4;iage++)
   // {
    for (iyr=1989;iyr<=2004;iyr++)
     {
                    report << setw(5) << setprecision(0) << iyr
        // << setw(5) << setprecision(0) << iage
         << setw(15) << setprecision(5) << pred_kept_Fatage(iyr)
                                         << setw(10) << setprecision(5) << resid_kept(iyr)
                                         << setw(10) << setprecision(5) << residmean_Fkept(iyr) << endl;
    }
  //  }
report << "neglogLL - Standard Deviation of Standardized Residuals (SDSR) -  Standardized Residual Sum of Squares
                    (SRSS) -  Total Standardized Residual Sum of Squares (TSRSS)" << endl;
                    report << setw(15) << setprecision(5) << kept_f
                                                  << setw(10) << setprecision(5) << stdev_kept
                                                  << setw(15) << setprecision(5) << sum(resid_kept2)
                                                  << setw(15) << setprecision(5) << sum(residmean_Fkept2) << endl;

report << endl;
  report << "Full F Estimates for Release Fishery" << endl;
  report << "Year  Pred  Std_Resid Std_Residfrommean" << endl;
    for(iyr=1989;iyr<=2004;iyr++)
    {
     report << setw(5) << setprecision(0) << iyr
         << setw(15) << setprecision(5) << mfexp(log_Fmult(4,iyr))
                                                 << setw(15) << setprecision(5) << resid_fullF_B2(iyr)
                                            << setw(15) << setprecision(5) << residmean_Frelease(iyr) << endl;
    }

 report << "neglogLL - Standard Deviation of Standardized Residuals (SDSR) -  Standardized Residual Sum of Squares
                    (SRSS) -  Total Standardized Residual Sum of Squares (TSRSS)" << endl;
                    report << setw(15) << setprecision(5) << fullF_f
                       << setw(10) << setprecision(5) << std_dev(resid_fullF_B2)
```

```
       << setw(15) << setprecision(5) << sum(resid_fullF_B22)
        << setw(15) << setprecision(5) << sum(residmean_Frelease2) << endl;

report << "Predicted population dynamics" << endl;
report << "Abundance" << endl;
   for(iyr=firstyr;iyr<=lastyr;iyr++)
    {
     report << setw(5) << setprecision(0) << iyr
          << setw(15) << setprecision(9) << mfexp(log_N(iyr)) << endl;
     }
report << endl;
report << "F at age by fleet" << endl;
  for(ifleet=1;ifleet<=nfleets;ifleet++)
   {
   for(iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
    {
     report << setw(5) << setprecision(0) << ifleet
          << setw(5) << setprecision(0) << iyr
          << setw(10) << setprecision(5) << mfexp(log_Ffleet(ifleet,iyr))
          << setw(10) << setprecision(5) << EffN(ifleet,iyr) << endl;
     }
   }
 report << endl;
 report << "Check bounded values" << endl;
 report << "fill_log_sels" << endl;
 report << setw(5) << setprecision(4) << fill_log_sel << endl;
 report << endl;
 report << "log_Fmult" << endl;
 report << setw(5) << setprecision(4) << log_Fmult << endl;
 report << endl;
 report << "log_initN" << endl;
 report << setw(5) << setprecision(4) << log_initN << endl;
 report << endl;
 report << "log_recruits" << endl;
 report << setw(5) << setprecision(4) << log_recruits << endl;
 report << endl;
 report << "log_q_MLE" << endl;
 report << setw(5) << setprecision(4) << log_q_MLE << endl;
 report << endl;
 report << "selectivities" << endl;
     for (ifleet=1;ifleet<=nfleets;ifleet++)
         {
          for (i=1;i<=yr_sel_block(ifleet,last_fyr(ifleet));i++)
          {
             report << setw(5) << setprecision(0) << ifleet
                  << setw(5) << setprecision(0) << i
                  << setw(10) << setprecision(5) << mfexp(log_sel(ifleet,i)) << endl;
                          }
        }
  report << endl;
  report << "weighting scheme for this run" << endl;
  report << "TC wt" << setw(10) << setprecision(5) << totcatch_wt(wt_choice(1)) << endl;
  report << "PAA wt" << endl;
  report << setw(10) << setprecision(5) << PAA_wt(wt_choice(2)) << endl;
  report << "Index wt" << setw(10) << setprecision(5) << indx_wt(wt_choice(3)) << endl;
  report << "tagF wt" << setw(10) << setprecision(5) << tagF_wt(wt_choice(4)) << endl;
  report << "Fbrake" << setw(10) << setprecision(5) << F_brake << endl;
  report << endl;
```

```
   report << endl;
         for (iyr=firstyr;iyr<=lastyr;iyr++)
          {
                          report << setw(5) << setprecision(0) << iyr;
          for (iage=firstage;iage<=lastage;iage++)
           {
            report << setw(12) << setprecision(5) << tot_F(iyr,iage);
                           }
                          report << endl;
           }
   report << endl;

        report << " static SPR     " << setw(15) << setprecision(5) << static_SPR << endl;
        report << " 3 year SPR    " << setw(15) << setprecision(5) << three_yrSPR << endl;
       report << " escapement 1-3 " << setw(15) << setprecision(5) << escapement13 << endl;
       report << " escapement 1-5 " << setw(15) << setprecision(5) << escapement15 << endl;
       report << " t Esc 1-3 " << setw(15) << setprecision(5) << tEsc13 << endl;
       report << " t Esc 1-5 " << setw(15) << setprecision(5) << tEsc15 << endl;

       report << "selectivity constraint (4 and 5) =" << 1/(1+exp(-1.*sel04))
             << "   " << 1/(1+exp(-1.*sel05)) << endl;
      // report << "selectivity constraint for B2 (4 and 5) =" << 1/(1+exp(-1.*sel04b2))
            // << "   " << 1/(1+exp(-1.*sel05b2)) << endl;
    //     report << "selectivity regularize constant =" << sel_regularize << endl;
   // This report section actually gives SSB per recruit, not the SSB--need to multiply by N to get actual SSB
   // report << "SSB" << setw(15) << setprecision(2) << SSB_F << endl;



RUNTIME_SECTION
  convergence_criteria 1.0e-7
  maximum_function_evaluations 10000
```

Weights Files

```
#weights
#total catch by fleet
# Ha:default
#fleet1 fleet2 fleet3 fleet4
  1.    1.    1.    1.
# Ha:B2 rec total catch estimates are suspect
#fleet1 fleet2 fleet3 fleet4
  1.  1.    1.    0.1
# Ha:B2 rec total catch estimates are really suspect
#fleet1 fleet2 fleet3 fleet4
1.    1.    1.    0.01

#PAA weights
#Ha:default
#catch at age by fleet and year (excluding the B2 release fleet4)
#1989   1990   1991   1992   1993   1994   1995   1996   1997   1998   1999   2000   2001   2002   2003   2004
                2005   2006   2007  2008   2009   2010   2011   2012  2013
1      1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1  1     1     1     1
                1   1
1      1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1  1     1     1     1
                1   1
1      1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1  1     1     1     1
                1   1
```

```
#Ha:the B2 age compostion data is more uncertain than commercial age comp
#catch at age by fleet and year
#1989           1990      1991      1992      1993      1994      1995      1996      1997      1998      1999
                  2000      2001      2002      2003      2004      2005      2006      2007      2008      2009
                  2010      2011      2012      2013
1    1    1    1    1    1    1    1    1    1    1    1    1    1    1    1    1    1    1   1    1    1    1
                 1     1
1    1    1    1    1    1    1    1    1    1    1    1    1    1    1    1    1    1    1   1    1    1    1
                 1     1
0.01  0.01  0.01  0.01  0.01  0.01  0.01  0.01  0.01  0.01  0.01  0.01  0.01  0.01  0.01  0.01  0.01  0.01
                0.01 0.01  0.01  0.01  0.01  0.01   0.01

#weights
#Ha:default
# index weight
 1. 1. 1. 1. 1.
#Ha:the MRFSS index is best due to areal coverage
# index weight
 1. 1. 1. 10. 1.
#Ha:the yoy indexes are best due to scientific design and ease of capture
# index weight
 10. 1. 10. 1. 1.

#weights
#tagging based F (showing for keptF at age and then fullF B2rec)
# Ha: default
  1.  1.
# Ha: both less accurate
  0.1  0.1
```

<u>Input Data</u>

```
#Northern Stock 1989-2013 - Continuity
#
#Run in testing mode: runs model at initial values and output some values to console (0=off, 1=on)
# 0
# Defining two stockal commercial fisheries - gillnet+beachseine and other commercial gears
#
#fleets (1=VAMDNCcomGNBS, 2=VAMDNCcomSE, 3=NCVAMDrecAB1, 4=NCVAMDrecB2)
 4
# global first and last years used in assessment
 1989 2013
#
# first and last year for each fishing fleet
 1989 1989 1989 1989
 2013 2013 2013 2013
#
# Last year of tagging data
# 2004
#
# Last year tagging data in Likelihood for tag data F's
# 2004
#
#firstage lastage (same for all fleets)
 1 7
#
#last age selectivity estimated for
```

```
 3
#natural mortality - Lorenzen scaled to Hoenig method - average integer age M, plus group is average M from 7-62
                    ####Up to date#####
#  1   2   3   4   5   6   7
 0.20 0.13 0.10 0.09 0.08 0.08 0.07
#selectivity block -- only fleet1-3 used, fleet4(rec) uses tag-based input for selevtivity
#89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13
 1  1  1  2  2  2  2  2  2  2  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3
 1  1  1  2  2  2  2  2  2  2  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3
 1  1  1  2  2  2  2  2  2  2  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3
 1  1  1  2  2  2  2  2  2  2  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3
#
# total kill by fleet in numbers, except only A+B1 for fleet3 (rec) (1=VAMDNCcomGNBS, 2=VAMDNCcomSE,
                    3=NCVAMDrecAB1, 4=NCVAMDrecB2) ####Up to date####
#1989   1990   1991   1992   1993   1994   1995   1996   1997   1998   1999   2000   2001   2002   2003   2004
                    2005   2006   2007   2008   2009   2010   2011   2012   2013
89433               71307      49247      34984      57680      36232      56765      29778      12344      118100     127169
                       79076      44955      28847      28543      20459      54704      51010      75590      72838      64727
                       52651      22371      28999      131805
18043               10420      18756      4815       6916       5903       13767      4204       3732       16054      4166
                       3366       1787       2395       2216       755        2017       3346       4947       2926       3293
                       2081       1464       3306       10669
114512              46091      65963      43120      93873      40203      129545     55973      12468      157861     94168
                       97493      33538      128606     34184      35021      54574      75209      113195     71656      96213
                       75100      46098      99272      292194
0                   0  0          0          0          0          0          0          0          0          0          0
                       0          0          0          0          0          0          0          0          0          0
                       0          0          0

# CV's for total kill by fleet in numbers (assumed for commercial fleets, weighted average PSE from MRFSS AB1 north
                    stock for fleet 3 and B2 for fleet 4)) ####Up to date#####
#1989   1990   1991   1992   1993   1994   1995   1996   1997   1998   1999   2000   2001   2002   2003   2004
                    2005   2006   2007   2008   2009   2010   2011   2012   2013
0.01                0.01       0.01       0.01       0.01       0.01       0.01       0.01       0.01       0.01       0.01
                       0.01       0.01       0.01       0.01       0.01       0.01       0.01       0.01       0.01       0.01
                       0.01       0.01       0.01       0.01
0.01                0.01       0.01       0.01       0.01       0.01       0.01       0.01       0.01       0.01       0.01
                       0.01       0.01       0.01       0.01       0.01       0.01       0.01       0.01       0.01       0.01
                       0.01       0.01       0.01       0.01
0.487               0.376      0.316      0.375      0.289      0.297      0.224      0.238      0.455      0.203      0.206
                       0.188      0.240      0.314      0.264      0.330      0.254      0.314      0.289      0.212      0.209
                       0.139      0.170      0.426      0.214
0.880               1.401      0.592      0.438      0.705      0.569      0.369      0.408      0.452      0.272      0.294
                       0.312      0.279      0.341      0.377      0.160      0.249      0.224      0.187      0.138      0.248
                       0.114      0.232      0.234      0.173

#input B2 selectivity for rec northern stock by age (columns through last_sel_age) and select period (rows)
1.000   0.221   0.012   0.012   0.012   0.012   0.012
1.000   0.467   0.031   0.023   0.023   0.023   0.023
0.6840  1.0000  0.2070  0.0890  0.089   0.089   0.089

# total release by fleet ###Up to date####
#1989   1990   1991   1992   1993   1994   1995   1996   1997   1998   1999   2000   2001   2002   2003   2004
                    2005   2006   2007   2008   2009   2010   2011   2012   2013
 0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0
                    0     0
 0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0
                    0     0
```

0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0
21817 40539 230844 104580 552926 216398 341451 53221 726929 446907 576009
465834 349707 2204266 131752 215028 406892 709355 526917 895966 622927
666638 269027 4322513 876950

#release mortality
0.08

#proportion catch at age (age columns, year rows) by fleet ####Up to date####

#Age 1	2	3	4	5	6	7+
#	VAMDNCcomGNBS					
0.6101	0.3574	0.0080	0.0060	0.0006	0.0002	0.0176
0.6845	0.2761	0.0123	0.0057	0.0006	0.0003	0.0205
0.7452	0.2340	0.0089	0.0083	0.0007	0.0003	0.0028
0.1514	0.7658	0.0619	0.0079	0.0002	0.0000	0.0128
0.1326	0.6303	0.2307	0.0036	0.0003	0.0002	0.0024
0.1998	0.5184	0.2513	0.0210	0.0002	0.0002	0.0092
0.2278	0.6335	0.1299	0.0082	0.0002	0.0000	0.0003
0.2188	0.6805	0.0929	0.0068	0.0002	0.0001	0.0007
0.3872	0.4476	0.1516	0.0119	0.0004	0.0001	0.0012
0.1820	0.7724	0.0383	0.0066	0.0002	0.0000	0.0005
0.1401	0.7099	0.1443	0.0050	0.0001	0.0000	0.0005
0.0960	0.5858	0.3066	0.0110	0.0002	0.0001	0.0002
0.0806	0.4469	0.4648	0.0071	0.0002	0.0000	0.0004
0.1701	0.7446	0.0776	0.0054	0.0003	0.0001	0.0020
0.0666	0.7812	0.1468	0.0051	0.0001	0.0000	0.0002
0.4977	0.1823	0.3115	0.0082	0.0001	0.0000	0.0001
0.2476	0.7169	0.0334	0.0020	0.0000	0.0000	0.0001
0.1910	0.5953	0.2081	0.0055	0.0001	0.0000	0.0000
0.0595	0.7557	0.1793	0.0051	0.0001	0.0000	0.0003
0.1883	0.4569	0.3476	0.0070	0.0000	0.0000	0.0001
0.0877	0.7411	0.1641	0.0061	0.0006	0.0002	0.0001
0.0879	0.5165	0.3928	0.0028	0.0000	0.0000	0.0000
0.0823	0.7259	0.1876	0.0037	0.0000	0.0000	0.0005
0.6290	0.2559	0.1106	0.0039	0.0000	0.0000	0.0007
0.0879	0.8808	0.0302	0.0004	0.0000	0.0000	0.0007

#	VAMDNCcomSE					
0.4093	0.3411	0.0775	0.0109	0.0013	0.0016	0.1582
0.5385	0.3185	0.0331	0.0006	0.0017	0.0017	0.1059
0.8199	0.1524	0.0116	0.0048	0.0004	0.0001	0.0108
0.1137	0.6846	0.1172	0.0394	0.0052	0.0021	0.0379
0.0305	0.5583	0.2822	0.0007	0.0021	0.0034	0.1228
0.0221	0.4846	0.3531	0.0346	0.0035	0.0045	0.0975
0.0466	0.8145	0.1320	0.0062	0.0005	0.0001	0.0001
0.0804	0.7624	0.1335	0.0118	0.0020	0.0007	0.0092
0.2824	0.4990	0.1641	0.0253	0.0064	0.0023	0.0206
0.1175	0.8738	0.0042	0.0008	0.0015	0.0005	0.0017
0.0559	0.7119	0.2064	0.0053	0.0006	0.0009	0.0190
0.0295	0.5444	0.3934	0.0292	0.0020	0.0005	0.0010
0.0161	0.2589	0.6415	0.0570	0.0068	0.0020	0.0177
0.1450	0.6391	0.1634	0.0218	0.0025	0.0012	0.0271
0.0204	0.8279	0.1488	0.0029	0.0000	0.0000	0.0000
0.1959	0.3536	0.4418	0.0073	0.0000	0.0000	0.0013
0.0455	0.8456	0.0988	0.0060	0.0000	0.0000	0.0040
0.1186	0.5668	0.3074	0.0072	0.0000	0.0000	0.0000

0.0238	0.7545	0.2107	0.0057	0.0002	0.0001	0.0049
0.1793	0.4252	0.3783	0.0172	0.0000	0.0000	0.0000
0.0208	0.7377	0.2336	0.0078	0.0001	0.0000	0.0000
0.0570	0.4113	0.5108	0.0138	0.0000	0.0000	0.0071
0.0354	0.6271	0.3098	0.0252	0.0018	0.0006	0.0001
0.7800	0.1343	0.0434	0.0074	0.0004	0.0002	0.0343
0.0097	0.9193	0.0696	0.0014	0.0000	0.0000	0.0000

#NCVAMDrec	(just	A+B1	proportions)			
0.3490	0.5588	0.0741	0.0003	0.0001	0.0001	0.0177
0.8982	0.0414	0.0456	0.0017	0.0001	0.0004	0.0126
0.6630	0.3021	0.0114	0.0159	0.0000	0.0000	0.0075
0.0754	0.8133	0.1048	0.0009	0.0015	0.0006	0.0036
0.0780	0.6606	0.2391	0.0006	0.0006	0.0003	0.0209
0.2791	0.2770	0.3068	0.0511	0.0021	0.0002	0.0837
0.1384	0.7577	0.0741	0.0121	0.0095	0.0000	0.0083
0.3074	0.4285	0.1990	0.0420	0.0014	0.0000	0.0218
0.4781	0.2869	0.1206	0.0718	0.0143	0.0004	0.0278
0.0240	0.8992	0.0560	0.0044	0.0044	0.0014	0.0106
0.0567	0.6477	0.2810	0.0022	0.0011	0.0010	0.0103
0.0199	0.4162	0.5440	0.0072	0.0005	0.0001	0.0121
0.0395	0.2843	0.5299	0.0803	0.0098	0.0016	0.0546
0.1282	0.6402	0.0600	0.0700	0.0147	0.0047	0.0823
0.0207	0.6358	0.3090	0.0199	0.0064	0.0014	0.0067
0.1987	0.3612	0.4156	0.0180	0.0066	0.0000	0.0000
0.0130	0.9140	0.0401	0.0037	0.0014	0.0004	0.0275
0.0625	0.6441	0.2558	0.0165	0.0030	0.0003	0.0177
0.0267	0.6659	0.2828	0.0137	0.0012	0.0004	0.0092
0.0869	0.5749	0.3174	0.0080	0.0015	0.0002	0.0111
0.0046	0.7734	0.1571	0.0489	0.0005	0.0000	0.0155
0.0771	0.5899	0.2604	0.0261	0.0062	0.0004	0.0398
0.0497	0.7768	0.1532	0.0097	0.0055	0.0017	0.0035
0.3624	0.3524	0.2150	0.0164	0.0002	0.0001	0.0536
0.0094	0.9094	0.0550	0.0068	0.0010	0.0001	0.0184

#NCVAMD	B2	only				
0.6405	0.2368	0.0444	0.0059	0.0000	0.0008	0.0716
0.9651	0.0197	0.0000	0.0000	0.0000	0.0000	0.0152
0.8878	0.1122	0.0000	0.0000	0.0000	0.0000	0.0000
0.3898	0.6102	0.0000	0.0000	0.0000	0.0000	0.0000
0.3473	0.4596	0.0089	0.0000	0.0000	0.0000	0.1842
0.8833	0.1042	0.0054	0.0001	0.0000	0.0000	0.0071
0.6342	0.1809	0.0326	0.0026	0.0000	0.0000	0.1496
0.3101	0.3372	0.1171	0.0155	0.0000	0.0000	0.2200
0.8606	0.1303	0.0043	0.0025	0.0005	0.0002	0.0016
0.2554	0.6151	0.0157	0.0000	0.0003	0.0108	0.1028
0.2102	0.3803	0.1466	0.0623	0.0316	0.0112	0.1578
0.1624	0.4963	0.2175	0.0343	0.0066	0.0017	0.0812
0.0404	0.2448	0.2461	0.1863	0.0382	0.0013	0.2428
0.0214	0.1052	0.1129	0.2862	0.0695	0.0176	0.3873
0.0144	0.2747	0.3206	0.1281	0.0857	0.0271	0.1495
0.3366	0.1385	0.1918	0.0580	0.0144	0.0073	0.2535
0.0774	0.5525	0.0608	0.0374	0.0140	0.0039	0.2542
0.1273	0.5570	0.2126	0.0287	0.0089	0.0023	0.0631
0.0958	0.6672	0.1101	0.0605	0.0087	0.0027	0.0550
0.1255	0.4933	0.2845	0.0430	0.0020	0.0007	0.0510

0.0316	0.4971	0.2043	0.0660	0.0062	0.0004	0.1944
0.1124	0.2636	0.1531	0.1946	0.0534	0.0011	0.2219
0.1412	0.4107	0.2154	0.0740	0.0759	0.0224	0.0604
0.3195	0.3085	0.2631	0.0264	0.0004	0.0002	0.0819
0.0503	0.6476	0.1260	0.0394	0.0100	0.0007	0.1260

#number of ages that went into catch at age calcs by fleet and year (1=VAMDNCcomGNBS, 2=VAMDNCcomSE, 3=NCVAMDrecAB1, 4=NCVAMDrecB2) ###Updated on 7/18/16 to ESS North values scaled to range in the 6-1-15 Data Inputs File###

#1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004
2005 2006 2007 2008 2009 2010 2011 2012 2013

4 4 11 7 9 4 7 10 9 13 12 12
15 10 6 30 37 36 13 20 16 10
10 40 50

6 6 6 7 5 3 5 4 4 5 6 5
5 8 4 3 3 3 8 5 9 4
3 4 10

19 13 17 13 19 17 25 15 11 27 21
18 10 12 8 8 8 12 15 15 19
25 14 17 43

2 2 2 2 2 2 2 2 2 2 2 2
2 2 2 2 2 2 2 2 2 2
2 2 2

North stock information on F at age for age 1-4+, 1989-2004 total harvest)
#estimates

2.564	3.873	1.418	0.119
1.987	3.002	1.099	0.092
0.499	0.755	0.276	0.023
0.177	0.653	0.192	0.030
0.259	0.952	0.280	0.044
0.121	0.446	0.131	0.021
0.087	0.320	0.094	0.015
0.070	0.257	0.076	0.012
0.126	0.463	0.136	0.022
0.165	0.606	0.178	0.028
0.026	0.437	0.104	0.001
0.034	0.558	0.133	0.001
0.065	1.080	0.257	0.003
0.071	1.168	0.278	0.003
0.026	0.422	0.101	0.001
0.015	0.256	0.061	0.001

#CV's -- NOT CHANGED 2/22/15

0.226	0.196	0.220	0.196
0.254	0.228	0.249	0.228
0.224	0.194	0.218	0.194
0.123	0.121	0.127	0.121
0.113	0.110	0.116	0.110
0.117	0.114	0.120	0.114
0.103	0.100	0.107	0.100
0.171	0.170	0.174	0.170
0.142	0.140	0.145	0.140
0.097	0.094	0.102	0.094
0.116	0.116	0.118	0.116
0.114	0.113	0.116	0.113
0.129	0.128	0.130	0.128
0.208	0.208	0.209	0.208

0.257   0.256   0.257   0.256
0.412   0.411   0.412   0.411

#North stock information for release rec fishery,1989-2004 -- NOT CHANGED 2/22/15
#fully recruited F estimate
0.0250
0.0404
0.0342
0.0170
0.0427
0.1178
0.0683
0.0237
0.0377
0.0354
0.0240
0.0340
0.0398
0.0288
0.0197
0.0088

CV (corrected) -- NOT CHANGED 2/22/15
0.2622
0.3376
0.1073
0.1432
0.1015
0.0818
0.1534
0.2168
0.1045
0.1068
0.1191
0.1111
0.1287
0.1696
0.2000
0.2887

number of indices
1)NCIGNS1 2)NCIGNS2 3)NC JAI 4) MRFSS 5) NC longline
5

first year of surveys followed by last year of surveys
2001 2001 1992 1991 2007
2013 2013 2013 2013 2013

indices ages (indices in order by row showing begin, end ages)
1 2 1 1 7
1 2 1 3 7

middle of survey (months)
8 6 0 9 8

#observed index values across years (columns) ###Up to date###
1)NCIGNS1 2)NCIGNS2 3)NC JAI 4) MRFSS 5) NC longline

```
#1989       1990    1991    1992    1993    1994    1995    1996    1997    1998    1999
              2000    2001    2002    2003    2004    2005    2006    2007    2008    2009
              2010    2011    2012    2013

              0.7651  1.9537  0.2006  1.3743  1.0177  1.2183  0.3937  1.1960  0.4903  1.1069
              0.1114  2.2509  0.9211

              0.3328  0.4159  0.7336  0.0454  1.0285  0.9151  1.9209  0.4613  2.4654  0.4840
              0.1815  0.0076  4.0081
                      2.6006  0.6374  2.1752  1.4255  0.7932  -999    2.2572  1.4145  0.3159
              0.5396  0.1663  0.3840  0.8611  1.4301  1.5505  0.5919  0.9392  0.2722  0.3253
              0.8068  1.8603  0.4629
              0.6945  0.5513  0.8793  0.4522  0.8446  0.3178  0.8617  1.1888  1.2278  0.8180
              0.8227  2.0424  0.4612  0.4823  0.8978  1.1086  1.1130  1.3448  1.2850  1.2187
              0.5697  2.2926  1.5251

                                                      1.0797  0.7212  1.1359  1.0568  1.0726
              0.9934  0.9405

# estimated CV's for the index values - updated 4/9 from data input workbook
#1982  1983  1984  1985  1986  1987  1988  1989  1990  1991  1992  1993  1994  1995  1996  1997
            1998  1999  2000  2001  2002  2003  2004  2005  2006  2007  2008    2009    2010
              2011    2012    2013
                                                                      0.2816    0.1597  0.2593
              0.1568  0.2117  0.1524  0.1698  0.1801  0.1667  0.1812  0.2667  0.1947  0.2419

                                                                      0.2273    0.2182  0.2062
              0.3333  0.1765  0.1818  0.3898  0.2459  0.3589  0.1875  0.2083  1.000   0.1943

                                 0.1443       0.3062  0.1753  0.2909  0.1570  -999    0.2342
              0.1363  0.2257  0.1836  0.1941  0.2362  0.2458  0.1362  0.1558  0.2108  0.2784
              0.1902  0.3492  0.2064  0.3028  0.2645
                              0.1352  0.1725  0.1237  0.1264  0.0874  0.1377  0.1033  0.0810
              0.0837  0.1006  0.1092  0.0693  0.1489  0.1137  0.1092  0.0905  0.0839  0.0744
              0.0790  0.0684  0.0978  0.0502  0.0611

                                                                              0.1629  0.1786
              0.1812  0.2055  0.1774  0.1780  0.1572

#Fbrake level
 200.
# choice of weighting scheme
# TC, PAA, Ndx, tagF
  1.  2.  1.  1.
#
# weight, maturity, and natural mortality at age through age 62 - end year values (around spawning season)
            ###Updated 7/19/16 See Maturity Estimates file and emails with Jeff and Mike###
2.23        0.00    0.20
5.93        0.00    0.13
10.41       0.07    0.10
14.95       0.99    0.09
17.64       1.00    0.08
20.13       1.00    0.08
22.40       1.00    0.07
24.42       1.00    0.07
26.22       1.00    0.07
27.79       1.00    0.07
29.16       1.00    0.07
```

30.35	1.00	0.07
31.37	1.00	0.07
32.25	1.00	0.07
33.00	1.00	0.07
33.63	1.00	0.07
34.17	1.00	0.07
34.63	1.00	0.07
35.02	1.00	0.07
35.35	1.00	0.07
35.63	1.00	0.07
35.87	1.00	0.06
36.07	1.00	0.06
36.23	1.00	0.06
36.37	1.00	0.06
36.49	1.00	0.06
36.59	1.00	0.06
36.68	1.00	0.06
36.75	1.00	0.06
36.81	1.00	0.06
36.86	1.00	0.06
36.90	1.00	0.06
36.93	1.00	0.06
36.96	1.00	0.06
36.99	1.00	0.06
37.01	1.00	0.06
37.03	1.00	0.06
37.04	1.00	0.06
37.05	1.00	0.06
37.06	1.00	0.06
37.08	1.00	0.06
37.08	1.00	0.06
37.08	1.00	0.06
37.08	1.00	0.06
37.08	1.00	0.06
37.08	1.00	0.06
37.08	1.00	0.06
37.08	1.00	0.06
37.08	1.00	0.06
37.08	1.00	0.06
37.08	1.00	0.06
37.08	1.00	0.06
37.08	1.00	0.06
37.08	1.00	0.06
37.08	1.00	0.06
37.08	1.00	0.06
37.08	1.00	0.06
37.08	1.00	0.06
37.08	1.00	0.06
37.08	1.00	0.06
37.08	1.00	0.06

Appendix B. Model code and data inputs for the southern red drum stock assessment.

Model Code

```
TOP_OF_MAIN_SECTION
  //increase number of estimated parameters
  gradient_structure::set_NUM_DEPENDENT_VARIABLES(1000); // increasing number of parameters that can be
                      estimated to 1000 (default is 100 and must be changed if it will be exceeded)

DATA_SECTION ////////////////////////////////////////////////////////////////////
 //   !!USER_CODE ad_comm::change_datafile_name("so_base.dat");

      // all commented out sections in response to reviewer findings - MDM 8/21

 //////////// general dimensions and structural inputs ////////////
 // how many groups with separate fishing characteristics, fisheries?
 init_int nfleets

 // global first and last age used in the assesment
 init_int firstyr
 init_int lastyr

 // first and last years of catch data for each fishery
 init_ivector first_fyr(1,nfleets)
 init_ivector last_fyr(1,nfleets)

 // first and last age used in the assessment - last assumed plus group
 init_int firstage
 init_int lastage

 // last age that selectivity is estimated
 init_int last_sel_age

 // instantaneous natural mortality from firstage through lastage
 init_vector M(firstage,lastage)

 // selectivity blocks defined sequentially by fleet by year
 init_imatrix yr_sel_block(1,nfleets,first_fyr,last_fyr)

 //////////// observed data /////////////
 // total landed catch for each fleet each year and its CV
 init_matrix obs_tot_catch(1,nfleets,first_fyr,last_fyr)
 init_matrix tot_catch_CVs(1,nfleets,first_fyr,last_fyr)

 // observed selectivity for Florida live-release fishery over two
 // defined time period
 init_matrix B2_select(1,1,firstage,lastage)

 // additional non-landed catch that is subject to the hook-and-line
 // release mortality (rel_mort)
 init_matrix tot_B2catch(1,nfleets,first_fyr,last_fyr)
 init_number rel_mort
```

```
// observed proportion at age for all 'observed' landings and  sampled live-releases
// and number of fish sampled for age each year associated with these observed proportions
init_3darray obs_prop_at_age(1,nfleets,first_fyr,last_fyr,firstage,lastage)
init_matrix agedN(1,nfleets,first_fyr,last_fyr)

// number of indices used for relative abundance
init_int n_ndx
// first and last year for each index
init_ivector first_syr(1,n_ndx)
init_ivector last_syr(1,n_ndx)
// first and last age included in index
init_ivector first_sage(1,n_ndx)
init_ivector last_sage(1,n_ndx)
// midpoint month for the survey
init_vector survey_month(1,n_ndx)
// relative abundance by index for each year available
// and coefficient of variation
init_matrix survey_ndx(1,n_ndx,first_syr,last_syr)
init_matrix survey_CVs(1,n_ndx,first_syr,last_syr)

// temporary penalty for keeping early-solution-search-F up
init_number F_brake

// the weights set associated with the total catches, proportion at age and indices
init_ivector wt_choice(1,3)

 // matrix showing three columns - for weight (lbs), proportion mature, and natural mortality
 // for every age in the fishes life
 init_matrix wt_mat_M41(1,41,1,3)

      // error debugging tools
      //!! cout << F_brake << endl;
      //!! exit(4);

// file for the different weighting schemes referred to in wt_choice variable
   // total catch weights
!!USER_CODE ad_comm::change_datafile_name("s0_TC.wts");
    init_matrix totcatch_wt(1,3,1,nfleets)

   // PAA wts
!!USER_CODE ad_comm::change_datafile_name("s0_PAA.wts");
     init_3darray PAA_wt(1,3,1,nfleets,firstyr,lastyr)

   // Index wts
!!USER_CODE ad_comm::change_datafile_name("s0_Ndx.wts");
    init_matrix indx_wt(1,3,1,n_ndx)
  ////////////////////////////////////////////////////////////////////////////////////////

 // various statistics and manipulations of the input data
    ivector nselblocks(1,nfleets)
    int k
    number tot
    vector ave_obstC(1,nfleets)
    vector ave_obsNdx(1,n_ndx)
    matrix ave_obsPAA(1,nfleets,firstage,lastage)
    matrix stdevPAA(1,nfleets,firstage,lastage)
LOCAL_CALCS
   for(ifleet=1;ifleet<=nfleets;ifleet++)
```

```
  {
 // how many 'selectivity blocks' are there for each fishery?
  nselblocks(ifleet) = yr_sel_block(ifleet,last_fyr(ifleet));
  }

// special calculation for the B2 rec live-release fisheries -- fleet=5-6 -- to calculate total kill
 for(ifleet=4;ifleet<=nfleets;ifleet++)
  {
  for (iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
   {
   obs_tot_catch(ifleet,iyr) = tot_B2catch(ifleet,iyr) * (rel_mort);
   }
  }

// calculate various mean observed values to use in the total sum of squares [TSS = sum of squares
//  for (mean-observed)/stdev(observed)], though this did not appear to be very helpful for
//  'goodness of fit' evaluation where residual sum of squares [RSS = sum of squares for (observed-predicted)
//   /stdev(observed)] was confounded by multidimensionaity of problem.

 // total catch
  for(ifleet=1;ifleet<=nfleets;ifleet++)
    {
    k = 0;
    tot=0;
   for (iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
     {
     k++;
     tot += log(obs_tot_catch(ifleet,iyr)+1e-6);
     }
    ave_obstC(ifleet) = tot/double(k);
   }

  // indices
 for (indx=1;indx<=n_ndx;indx++)
 {
  k = 0;
  tot=0;
  for(iyr=first_syr(indx);iyr<=last_syr(indx);iyr++)
  {
    if(survey_ndx(indx,iyr)>0)
     {
                   k++;
                   tot += log(survey_ndx(indx,iyr)+1.e-6);
      }
  }
  ave_obsNdx(indx) = tot/double(k);
 }
  //PAA -- this is a strech for 0.0-1.0 bound number
for (ifleet=1;ifleet<=nfleets;ifleet++)
{
 for (iage=firstage;iage<=lastage;iage++)
  {
  k = 0;
  tot=0;
  for (iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
   {
   k++;
   tot += obs_prop_at_age(ifleet,iyr,iage)+1.e-6;
```

```
      }
   ave_obsPAA(ifleet,iage) = tot/double(k);
     }
  }

  // what is the standard deviation of observed PAA across years for each fleet and age?
    for (ifleet=1;ifleet<=nfleets;ifleet++)
    {
     for (iage=firstage;iage<=lastage;iage++)
      {
       k = 0;
       tot=0;
       for (iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
         {
         k++;
         tot += square( obs_prop_at_age(ifleet,iyr,iage)-ave_obsPAA(ifleet,iage) );
         }
       stdevPAA(ifleet,iage) = sqrt( tot/(double(k)-1)  );
       }
     }
 END_CALCS

   // initialize various counters and temporary integers
   int sel_count
   int ifleet
   int iyr
   int iage
   int indx
   int i
   int j
   int PAA_n
   int PAA_n2
   int tC_n
   int ndx_n

PARAMETER_SECTION  ////////////////////////////////////////////////////////////////////////////

     init_bounded_number sel04(-10,10.,5)
     init_bounded_number sel05(-10,10,5)

    // init_bounded_number sel04b2(-10,10.,5)
    // init_bounded_number sel05b2(-10.,10.,5)

  // NOTE: for convenience number of selectivities is hardwired -- ////////////////////////////////////changed to
                        include FL B2
  //      when tag-based selectivity used is used
  //----in get_selectivity function
  //Parameter: selectivities
   init_bounded_dev_vector fill_log_sel(1,30,-5,5,5)
    3darray log_sel(1,nfleets,1,nselblocks,firstage,lastage)
                        matrix max_log_sel(1,nfleets,1,nselblocks)

  //----in get_mortality_rates function----
  //Parameter: fully recruited F's
   init_bounded_matrix log_Fmult(1,nfleets,first_fyr,last_fyr,-15,2,3)
    3darray log_Ffleet(1,nfleets,first_fyr,last_fyr,firstage,lastage)
    matrix Z(firstyr,lastyr,firstage,lastage)
    matrix tot_F(firstyr,lastyr,firstage,lastage)
```

```
 //----in get_number_at_age function
 //Parameters: median initial abundance ages 2-7+ and deviations from this for each age
//   init_bounded_number log_initN(8,15,1)
//   init_bounded_dev_vector log_initN_devs(firstage+1,lastage,-10,10,2)
   init_bounded_vector log_initN(firstage+1,lastage,2,15,1)

    matrix log_N(firstyr,lastyr,firstage,lastage)

 //Parameters: median recruitment by year and deviations from this for each year
 //  init_bounded_number log_R(4,19,1)
 // init_bounded_dev_vector log_recruit_devs(firstyr,lastyr,-10,10,3)
 //     vector log_recruits(firstyr,lastyr)
                                ///// note hard-wired number of years - 1
     init_bounded_vector log_recruits(firstyr,lastyr,5,24,2)

 //----in calculate_catch function
    3darray C(1,nfleets,first_fyr,last_fyr,firstage,lastage)
    //matrix pred_catch(1,nfleets,first_fyr,last_fyr)
                     sdreport_matrix pred_catch(1,nfleets,1989,2013) /////////////years have to be hard-wired for the
                    sdreport for some reason

 //---- in evaluate the objective function
         // indices
  //Parameter: catchability coefficient for each index
  init_bounded_vector log_q_ndx(1,n_ndx,-19,-4,4)
    matrix EffN(1,nfleets,first_fyr,last_fyr)
    matrix resid_ndx(1,n_ndx,first_syr,last_syr)
    matrix residmean_ndx(1,n_ndx,first_syr,last_syr)
      matrix resid_ndx2(1,n_ndx,first_syr,last_syr)
      matrix residmean_ndx2(1,n_ndx,first_syr,last_syr)
    matrix pred_ndx(1,n_ndx,first_syr,last_syr)
                     //sdreport_matrix pred_ndx(1,n_ndx,1989,2013)
    vector stdev_ndx(1,n_ndx)
    number ndx_f
    vector neglogLL_ndx(1,n_ndx)
        // PAA
    3darray resid_PAA(1,nfleets,first_fyr,last_fyr,firstage,lastage)
       // fake residuals
      3darray resid_PAA2(1,nfleets,first_fyr,last_fyr,firstage,lastage)
      3darray residmean_PAA2(1,nfleets,first_fyr,last_fyr,firstage,lastage)
    vector stdev_PAA(1,nfleets)
    matrix neglogLL_PAA(1,nfleets,first_fyr,last_fyr)
    number PAA_f
        // total catch
    matrix resid_tC(1,nfleets,first_fyr,last_fyr)
    matrix residmean_tC(1,nfleets,first_fyr,last_fyr)
     matrix resid_tC2(1,nfleets,first_fyr,last_fyr)
     matrix residmean_tC2(1,nfleets,first_fyr,last_fyr)
    vector stdev_tC(1,nfleets)
    vector neglogLL_tC(1,nfleets)

   // define some intermediate calculation
   number temp
   number temp2
   number tC_f
   number avg_F
   number F_brake_penalty
```

```
  // Benchmark stuff
    // including spawning stock biomass under fishing and under no fishing,
    // spawning potential ratio, and various escapement estimates
      vector SSB_F(firstyr,lastyr)
      vector SSB_F0(firstyr,lastyr)
        number F_survival
        number F0_survival
      //vector escapement13(firstyr,lastyr)
      //vector escapement15(firstyr,lastyr)
        //transitional
        //vector tEsc15(firstyr+4,lastyr)
        //vector tEsc13(firstyr+2,lastyr)

  objective_function_value f

    sdreport_vector log_total_abundance(firstyr,lastyr)
    sdreport_vector log_N1(firstyr,lastyr)
    sdreport_vector log_N2(firstyr,lastyr)
    sdreport_vector log_N3(firstyr,lastyr)
    sdreport_vector log_Nplus(firstyr,lastyr)
    sdreport_vector expl13(firstyr,lastyr)
    sdreport_vector static_SPR(firstyr,lastyr)
    sdreport_vector three_yrSPR(firstyr+2,lastyr)
    sdreport_vector escapement13(firstyr,lastyr)
    sdreport_vector escapement15(firstyr,lastyr)
                        sdreport_vector tEsc15(firstyr+4,lastyr)
    sdreport_vector tEsc13(firstyr+2,lastyr)

    likeprof_number three_yrSPR2013

PROCEDURE_SECTION ///////////////////////////////////////////////////////////////////////////

get_selectivities();

                    // error debugging tools in PROCEDURE SECTIONS
                                        // cout << agedN << endl;
                                    // exit(4);

get_mortality_rates();

get_numbers_at_age();

calculate_catch();

evaluate_the_objective_function();

  // static spawning potential ratio, and various escapement rate estimates
    // calculate spawning stock biomass per recruit with current year's fishing and without any F
    for(iyr=firstyr;iyr<=lastyr;iyr++)
     {
                    F_survival = mfexp(-1. * (wt_mat_M41(1,3)+tot_F(iyr,1)) );
                    F0_survival = mfexp(-1. * wt_mat_M41(1,3));
                      SSB_F(iyr) = wt_mat_M41(1,2)*wt_mat_M41(1,1)*F_survival;
                      SSB_F0(iyr) = wt_mat_M41(1,2)*wt_mat_M41(1,1)*F0_survival;

      for(iage=firstage+1;iage<=lastage;iage++)
        {
```

```
                   F_survival *= mfexp(-1.* (wt_mat_M41(iage,3)+tot_F(iyr,iage)) );
                   F0_survival *= mfexp(-1.* wt_mat_M41(iage,3));
   SSB_F(iyr) += wt_mat_M41(iage,2)*wt_mat_M41(iage,1)*F_survival;
                    SSB_F0(iyr) += wt_mat_M41(iage,2)*wt_mat_M41(iage,1)*F0_survival;
  }
 for(iage=lastage+1;iage<40;iage++)
  {
                   F_survival *= mfexp(-1.* (wt_mat_M41(iage,3)+tot_F(iyr,lastage)) );
                   F0_survival *= mfexp(-1.* wt_mat_M41(iage,3));
   SSB_F(iyr) += wt_mat_M41(iage,2)*wt_mat_M41(iage,1)*F_survival;
                    SSB_F0(iyr) += wt_mat_M41(iage,2)*wt_mat_M41(iage,1)*F0_survival;
  }

  //Infinite series accumulation added for plus group (Mike's recommendation 7/12/16)
  F_survival *= mfexp(-1.* (wt_mat_M41(iage,3)+tot_F(iyr,lastage)))/(1.-mfexp(-
                  1.*(wt_mat_M41(iage+1,3)+tot_F(iyr,lastage))));
                   F0_survival *= mfexp(-1.* wt_mat_M41(iage,3))/(1.-mfexp(-1.*(wt_mat_M41(iage+1,3))));

   SSB_F(iyr) += wt_mat_M41(iage,2)*wt_mat_M41(iage,1)*F_survival;
                   SSB_F0(iyr) += wt_mat_M41(iage,2)*wt_mat_M41(iage,1)*F0_survival;

  // static SPR and static (year-specific) escapement rates
  static_SPR(iyr) = SSB_F(iyr)/SSB_F0(iyr);
  escapement13(iyr) = mfexp(-1.* tot_F(iyr,1)-tot_F(iyr,2)-tot_F(iyr,3));
  escapement15(iyr) = mfexp(-1.* tot_F(iyr,1)-tot_F(iyr,2)-tot_F(iyr,3)-tot_F(iyr,4)-tot_F(iyr,5));

   // transitional (yearclass-specific) escapement rates
   if(iyr>1992)
    {
     tEsc15(iyr) = mfexp( -1.* tot_F(iyr-4,1)-tot_F(iyr-3,2)-tot_F(iyr-2,3)-tot_F(iyr-1,4)-tot_F(iyr,5) );
    }
   if(iyr>1990)
    {
     tEsc13(iyr) = mfexp( -1.* tot_F(iyr-2,1)-tot_F(iyr-1,2)-tot_F(iyr,3) );
    }
}

log_total_abundance=log(rowsum(mfexp(log_N)));

for(iyr=firstyr;iyr<=lastyr;iyr++)
 {
  log_N1(iyr) = log_N(iyr,1);
  log_N2(iyr) = log_N(iyr,2);
  log_N3(iyr) = log_N(iyr,3);
  log_Nplus(iyr) = log_N(iyr,7);
  // catch across fleets
   temp=0.;
   for(ifleet=1;ifleet<=nfleets;ifleet++)
    {
    temp += C(ifleet,iyr,1)+C(ifleet,iyr,2)+C(ifleet,iyr,3);
    }
  expl13(iyr) = temp/( mfexp(log_N1(iyr))+mfexp(log_N2(iyr))+mfexp(log_N3(iyr)) );
   if(iyr>1990)
    {
    three_yrSPR(iyr) = ( static_SPR(iyr-2)+static_SPR(iyr-1)+static_SPR(iyr) )/3.;
    }
  }
```

```
        three_yrSPR2013 = ( static_SPR(2013-2)+static_SPR(2013-1)+static_SPR(2013) )/3.;

//  outputMCMC();

   //////////////////////// Begin Population Dynamics Model //////////////////////////////
FUNCTION get_selectivities

 //----selectivity is not described parametrically but assumed constant above some maximum age
 //----the following simply fills out the array of candidate selectivities to be evaluated
 //----in the end it is standardized to the largest selectivity

  sel_count=0;  //remember first age is one;
  for (ifleet=1;ifleet<=nfleets;ifleet++)
      {
       for (i=1;i<=yr_sel_block(ifleet,last_fyr(ifleet));i++)
        {

                        // Special: for the Florida live-release fishery selectivites are 'observed data' //////////////lines
                        below commented out if not estimating FL B2 selectivity
                        if(ifleet==4)
                          {
         for (iage=firstage;iage<=lastage;iage++)
           {
           log_sel(ifleet,i,iage) = log(B2_select(i,iage));
           }
        }
       else
        {
                          max_log_sel(ifleet,i)= -99.;
          // fill log_sel matrix using bounded vector
         for (iage=firstage;iage<=last_sel_age;iage++)
          {
          sel_count++;
          log_sel(ifleet,i,iage) = fill_log_sel(sel_count);
          // retain maximum selectivity within fleet and block of year
          if(log_sel(ifleet,i,iage)>max_log_sel(ifleet,i)) {max_log_sel(ifleet,i)=log_sel(ifleet,i,iage);}
          }

          // standardize relative to this maximum
         for (iage=firstage;iage<=last_sel_age;iage++)
          {
          log_sel(ifleet,i,iage) =  log_sel(ifleet,i,iage)-max_log_sel(ifleet,i);
          }

           // Special: for red drum, we assume that the selectivity drops after last estimated age
          // if(ifleet<4)
           // {
           log_sel(ifleet,i,last_sel_age+1) = log_sel(ifleet,i,last_sel_age)+log(1/(1+mfexp(-1.*sel04)));
           log_sel(ifleet,i,last_sel_age+2) = log_sel(ifleet,i,last_sel_age)+log(1/(1+mfexp(-1.*sel05)));
           // }
           // if(ifleet>=4)
           // {
          // log_sel(ifleet,i,last_sel_age+1) = log_sel(ifleet,i,last_sel_age)+log(1/(1+mfexp(-1.*sel04b2)));
          // log_sel(ifleet,i,last_sel_age+2) = log_sel(ifleet,i,last_sel_age)+log(1/(1+mfexp(-1.*sel05b2)));
          //  }

         // selectivity for older ages is set equal to oldest-aged selectivity
         for (iage=last_sel_age+3;iage<=lastage;iage++)
```

```
          {
          log_sel(ifleet,i,iage) = log_sel(ifleet,i,last_sel_age+2);
          }
        }
      }
    }


FUNCTION get_mortality_rates

 //----age-specific fishing mortalities are derived using estimated selectivities and year-specific F's----
 for (ifleet=1;ifleet<=nfleets;ifleet++)
  {
  // fill out the fleet-, year-, age-specific F's
  for (iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
   {
   for (iage=firstage;iage<=lastage;iage++)
    {
    log_Ffleet(ifleet,iyr,iage) = log_Fmult(ifleet,iyr)+log_sel(ifleet,yr_sel_block(ifleet,iyr),iage);
    }
   }
  }

 // --- calculate instantaneous total mortality for convenience later
 //     allow for variable M with age

     // calculate the total fishing mortality across all fisheries each year
     // remember not all fleets operate all year -- sum available F's
     tot_F=0.0;
    for (ifleet=1;ifleet<=nfleets;ifleet++)
     {
     for (iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
      {
      for (iage=firstage;iage<=lastage;iage++)
       {
       tot_F(iyr,iage) += mfexp(log_Ffleet(ifleet,iyr,iage));
       }
      }
     }

   // calculate Z's
   for (iyr=firstyr;iyr<=lastyr;iyr++)
    {
     Z(iyr) = M;
      for (iage=firstage;iage<=lastage;iage++)
       {
        Z(iyr,iage) += tot_F(iyr,iage);
       }
    }

FUNCTION get_numbers_at_age

  // This fills parameter estimates for initial N's or top row and
  // numbers-at-age-1 (recruits) or left column in N-at-age matrix

   // initial year's abundance for ages-2 to 7+
//    for (iage=firstage+1;iage<=lastage;iage++)
//     {
```

```
//                          if (active(log_initN_devs))
//                            {
 //      log_N(firstyr,iage)=log_initN+log_initN_devs(iage);
 //        }
 //      else
 //        {
 //      log_N(firstyr,iage)=log_initN;
 //        }
 //    }

      // initial year's abundance for ages-2 to 7+
    for (iage=firstage+1;iage<=lastage;iage++)
     {
       log_N(firstyr,iage)=log_initN(iage);
     }

    // all year's recruitment or beginning-of-the-year abundance of age-1
   //  for (iyr=firstyr;iyr<lastyr;iyr++)
   //   {
   //                       if (active(log_recruit_devs))
   //                         {
   //       log_recruits(iyr) = log_R + log_recruit_devs(iyr);
   //       log_N(iyr,firstage) = log_recruits(iyr);
   //       }
   //     else
   //       {
   //       log_recruits(iyr) = log_R;
   //       log_N(iyr,firstage) =log_recruits(iyr);
   //       }

     for (iyr=firstyr;iyr<=lastyr;iyr++)
     {
         log_N(iyr,firstage) = log_recruits(iyr);
     }

    //----from these starting values project abundances forward in time and age----
     for (iyr=firstyr;iyr<lastyr;iyr++)
     {
       for (iage=firstage;iage<lastage;iage++)
        {
        log_N(iyr+1,iage+1)=log_N(iyr,iage)-Z(iyr,iage);
        }

   //----oldest age is a plus group so, in addition to the cohort survivors for last year
    //    need to add the previous year's plus-group survivors
     log_N(iyr+1,lastage)=log( mfexp(log_N(iyr,lastage)-Z(iyr,lastage))+mfexp(log_N(iyr+1,lastage))  );
     }
   //----define recruitment in the final year, this is only informed if there is a yoy index to fit----
//                          if (active(log_recruit_devs))
//                            {
 //       log_recruits(lastyr) = log_R + log_recruit_devs(lastyr);
 //       log_N(lastyr,firstage) = log_recruits(lastyr);
 //       }
 //      else
 //        {
 //       log_recruits(lastyr) = log_R;
 //       log_N(lastyr,firstage) =log_recruits(lastyr);
 //        }
```

```
// //////////////////////////////// END POPULATION DYNAMICS MODEL ///////////////////////////////////////////////


FUNCTION calculate_catch

  /////// for convenience need to calculate some terms to be used to calculate predicted proportion at age
  //----Use catch equation to calculate fleet-specific catch-at-age matrices----
  //    and total kill each year for each fleet
    pred_catch = 0.0;
    for (ifleet=1;ifleet<=nfleets;ifleet++)
     {
     for (iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
      {
      for (iage=firstage;iage<=lastage;iage++)
       {
       C(ifleet,iyr,iage) = (mfexp(log_Ffleet(ifleet,iyr,iage))/Z(iyr,iage))
                     * mfexp( log_N(iyr,iage) ) * ( 1.-mfexp(-1.*Z(iyr,iage)) );
       pred_catch(ifleet,iyr) +=  C(ifleet,iyr,iage);
       }
      }
     }

 /////////////////////////////// OBSERVATION MODEL ///////////////////////////////////
FUNCTION evaluate_the_objective_function


 // Estimate effective sample size
 // useful in determining the 'goodness of fit' for the multinomial prediction of proportion at age in kill

   for (ifleet=1;ifleet<=nfleets;ifleet++)
    {
    for (iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
     {
     temp = 0.;
     temp2 = 0.;
      for (iage=firstage;iage<=lastage;iage++)
       {
      temp  += C(ifleet,iyr,iage)/(pred_catch(ifleet,iyr)+1.e-13)*( 1-C(ifleet,iyr,iage)
                                         /(pred_catch(ifleet,iyr)+1.e-13) );
      temp2 += square( obs_prop_at_age(ifleet,iyr,iage)-C(ifleet,iyr,iage)
                                         /(pred_catch(ifleet,iyr)+1.e-13) );
       }
    EffN(ifleet,iyr) = temp/temp2;
     }
    }

          // in the last phase a small penalty for a small F is added to objective
          // function, in earlier phases a much larger penalty keeps solution away
          // from infinitesimally small Fs
 F_brake_penalty = 0.;
 avg_F=sum(tot_F)/double(size_count(tot_F));
 if(last_phase())
  {
   F_brake_penalty += 1.e-6*square(log(avg_F/.2));
  }
  else
  {
   F_brake_penalty += F_brake * square(log(avg_F/.2));
```

```
}

    ///////////// minimally 'regularize' the selectivities ///////////
    f += 5. *norm2(fill_log_sel);



// ----negative log Likelihood estimation for indices-----------------------------------------

          // error debugging tools in PROCEDURE SECTIONS
          //    cout << wt_choice << endl;
                         //   exit(4);



  ndx_f = 0;
  neglogLL_ndx = 0;
  ndx_n = 0;
   for (indx=1;indx<=n_ndx;indx++)
    {
     for(iyr=first_syr(indx);iyr<=last_syr(indx);iyr++)
      {
        if(survey_ndx(indx,iyr)>0)
          {
          // for aggregate indices, sum appropriate N estimates
          temp=0;
          for(iage=first_sage(indx);iage<=last_sage(indx);iage++)
          {
          temp += mfexp( log_N(iyr,iage)-Z(iyr,iage)*(survey_month(indx)/12.) );
          }
       ndx_n++; // how many index data points
       pred_ndx(indx,iyr) = mfexp(log_q_ndx(indx))*temp;
        // standardized residual
       resid_ndx(indx,iyr) = (   log(survey_ndx(indx,iyr)+1.e-6) - ( log_q_ndx(indx) + log(temp+1.e-6) )   )/
                         sqrt(log(pow(survey_CVs(indx,iyr),2)+1));
        // standardized residual from average -- for total sum of squares (dubious)
       residmean_ndx(indx,iyr) = (   log(survey_ndx(indx,iyr)+1.e-6) -  ave_obsNdx(indx)   )/
                         sqrt(log(pow(survey_CVs(indx,iyr),2)+1));

            // squared residuals//////////////////
       resid_ndx2(indx,iyr) = square(  ( log(survey_ndx(indx,iyr)+1.e-6) - ( log_q_ndx(indx) + log(temp+1.e-6) ) )/
                         sqrt(log(pow(survey_CVs(indx,iyr),2)+1))    );
       residmean_ndx2(indx,iyr) = square(  ( log(survey_ndx(indx,iyr)+1.e-6) -  ave_obsNdx(indx) )/
                         sqrt(log(pow(survey_CVs(indx,iyr),2)+1))   );
           //////////////////////////////////

        // negative log-likelihood for the lognormal distribution
       neglogLL_ndx (indx) +=  0.5*square( resid_ndx(indx,iyr) ) + log(sqrt(log(pow(survey_CVs(indx,iyr),2)+1)));
          }
       }
     ndx_f += neglogLL_ndx(indx)*indx_wt(wt_choice(3),indx);
    }

                              // error debugging tools in PROCEDURE SECTIONS
                                               //cout << agedN << endl;
                                          //exit(4);

//---Likelihood estimation for catch proportions-at-age ------------------------
  PAA_f = 0;
```

```
 neglogLL_PAA = 0;
 PAA_n2=0;
 for (ifleet=1;ifleet<=nfleets;ifleet++)
  {
   PAA_n = 0;
   for (iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
    {
     // these were not observed for fleet=5; Florida rec live-release fishery ////////////////////////comment out
                    below
                    if(ifleet==4) {PAA_f +=0;}
                           else
                           {
    for (iage=firstage;iage<=lastage;iage++)
     {
     PAA_n2++;
     PAA_n++;
      // 'residual' in multinomial sense
     resid_PAA(ifleet,iyr,iage) = (obs_prop_at_age(ifleet,iyr,iage)+1.e-6)*log(
                    (C(ifleet,iyr,iage)/pred_catch(ifleet,iyr)+1.e-6)  );

           // squared residuals//////////////////
     resid_PAA2(ifleet,iyr,iage) = square( ( (obs_prop_at_age(ifleet,iyr,iage)+1.e-6) -
                    (C(ifleet,iyr,iage)/pred_catch(ifleet,iyr)+1.e-6) ) /
                                 sqrt(  agedN(ifleet,iyr)*(obs_prop_at_age(ifleet,iyr,iage)+1.e-6)*(1-
                    (obs_prop_at_age(ifleet,iyr,iage)+1.e-6)) ) );
     residmean_PAA2(ifleet,iyr,iage) = square( ( (obs_prop_at_age(ifleet,iyr,iage)+1.e-6) -
                    (ave_obsPAA(ifleet,iage)+1.e-6))/
                                 sqrt(  agedN(ifleet,iyr)*(obs_prop_at_age(ifleet,iyr,iage)+1.e-6)*(1-
                    (obs_prop_at_age(ifleet,iyr,iage)+1.e-6)) ) );
          ///////////////////////////////////

        // negative log-likelihood for the multinomial distribution
     neglogLL_PAA(ifleet,iyr) -= resid_PAA(ifleet,iyr,iage)*agedN(ifleet,iyr);
     }
            PAA_f +=  PAA_wt(wt_choice(2),ifleet,iyr) * neglogLL_PAA(ifleet,iyr);
            }
    }

      // dubious standard deviation for standardzed residuals -- rather, use effective sample size
                    ///////////////comment out below
                    if(ifleet==4) { stdev_PAA(ifleet)=0;}
                           else
                           {
             stdev_PAA(ifleet) = sqrt(  sum(resid_PAA2(ifleet))/double(PAA_n));
                           }
  }


// ----total catch kill -----------------------------------------
    tC_f = 0;
    tC_n = 0;
    neglogLL_tC = 0;
    for(ifleet=1;ifleet<=nfleets;ifleet++)
     {
     for(iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
      {
      tC_n++;
         // standardized residual
```

```
        resid_tC(ifleet,iyr) = (  log(obs_tot_catch(ifleet,iyr)+1.e-6) - log(pred_catch(ifleet,iyr)+1.e-6)  )/
                                    sqrt(log(pow(tot_catch_CVs(ifleet,iyr),2)+1));
          // standardized residual from average
        residmean_tC(ifleet,iyr) = (  log(obs_tot_catch(ifleet,iyr)+1.e-6) - ave_obstC(ifleet)  )/
                                    sqrt(log(pow(tot_catch_CVs(ifleet,iyr),2)+1));

            // squared residuals//////////////////
        resid_tC2(ifleet,iyr) = square (  ( log(obs_tot_catch(ifleet,iyr)+1.e-6) - log(pred_catch(ifleet,iyr)+1.e-6) )/
                                    sqrt(log(pow(tot_catch_CVs(ifleet,iyr),2)+1))   );
        residmean_tC2(ifleet,iyr) = square(   ( log(obs_tot_catch(ifleet,iyr)+1.e-6) - ave_obstC(ifleet) )/
                                    sqrt(log(pow(tot_catch_CVs(ifleet,iyr),2)+1))  );
           //////////////////////////////////

           // negative log-likelihood for the lognormal distribution
       neglogLL_tC (ifleet) +=  0.5*square( resid_tC(ifleet,iyr) ) + log(sqrt(log(pow(tot_catch_CVs(ifleet,iyr),2)+1)));
        }
      tC_f += neglogLL_tC(ifleet)*totcatch_wt(wt_choice(1),ifleet);
      }

      ////////////////////////// End of Observation Model ///////////////////////////////

   // objective function sum of likelihoods -- F_brake is near zero and could be dropped in last phase
   f += ndx_f + PAA_f + tC_f + F_brake_penalty;

 ////Removed by AG and used mcmc switch instead
//FUNCTION outputMCMC
  //-------------------------------------------------------------------------------------
//   ofstream MCMCout1("MCMC1.out",ios::app);
//    MCMCout1 << three_yrSPR2013 << " " <<  static_SPR << endl;
//   MCMCout1.close();
//     ofstream MCMCout2("MCMC2.out",ios::app);
//       MCMCout2 <<  log_recruits   <<  " " << log_Fmult <<
//              endl;
//      MCMCout2.close();
//    ofstream MCMCout3("MCMC3.out",ios::app);
//       MCMCout3 << log_N2 << " " << log_N3 << " " << log_Nplus << " " << log_initN  << endl;
//      MCMCout3.close();

   if (mceval_phase()){
     ofstream sizeout("threeyr.out", ios::app);
     sizeout<<three_yrSPR2013<<endl;
   }


REPORT_SECTION
  report << " Dump ALL INPUT DATA to verify correct read" << endl;
  report << nfleets << endl;
  report << endl;
  report << firstyr << "  " << lastyr << endl;
  report << endl;
  report << firstage << "  " << lastage << endl;
  report << endl;
  report << first_fyr << last_fyr << endl;
  report << endl;
  report << last_sel_age << endl;
  report << endl;
  report << M << endl;
  report << endl;
```

```
report << yr_sel_block << endl;
report << endl;
report << obs_tot_catch << endl;
report << endl;
report << tot_catch_CVs << endl;
report << endl;
report << obs_prop_at_age << endl;
report << endl;
report << n_ndx << endl;
report << endl;
report << first_syr << endl;
report << endl;
report << last_syr << endl;
report << endl;
report << survey_ndx << endl;
report << endl;
report << survey_CVs << endl;
report << endl;
report << endl;
report << "unwted_obj_fnctn_fit " << endl;
report << sum(neglogLL_ndx)+sum(neglogLL_PAA)+sum(neglogLL_tC)+F_brake_penalty+norm2(fill_log_sel)<< endl;
report << "Objective_function_total" << endl;
report << setw(15) << setprecision(5) << f << endl;
report << "Index_part_wted" << endl;
report << setw(15) << setprecision(5) << ndx_f << setw(15) << setprecision(5) << double(ndx_n) << endl;
report << "PAA_part_wted" << endl;
report << setw(15) << setprecision(5) << PAA_f << setw(15) << setprecision(5) << double(PAA_n2) << endl;
report << "total_catch_part_wted" << endl;
report << setw(15) << setprecision(5) << tC_f << setw(15) << setprecision(5) << double(tC_n) << endl;
report << "F_brake_penalty"  << endl;
report << setw(15) << F_brake_penalty << endl;
//report << "initN_devs" << setw(15) << norm2(log_initN_devs) << endl;
report << "log_selectivity_devs" << endl;
report << setw(15) << 5.*norm2(fill_log_sel) << endl;
//report << "log_recruit_devs" << norm2(log_recruit_devs) << endl;
report << endl;
report << "Look at fits" << endl;
report << "Index  Year  Pred  Std_Resid Std_Residfrommean" << endl;
 for(indx=1;indx<=n_ndx;indx++)
   {
   for(iyr=first_syr(indx);iyr<=last_syr(indx);iyr++)
    {
    report << setw(5) << setprecision(0) << indx
         << setw(5) << setprecision(0) << iyr
         << setw(10) << setprecision(5) << pred_ndx(indx,iyr)
                                        << setw(10) << setprecision(5) << resid_ndx(indx,iyr)
                                        << setw(10) << setprecision(5) << residmean_ndx(indx,iyr) << endl;
     }
   }

report << "Index - neglogLL - Standard Deviation of Standardized Residuals (SDSR) -  Standardized Residual Sum of
                    Squares (SRSS) -  Total Standardized Residual Sum of Squares (TSRSS)" << endl;
   for(indx=1;indx<=n_ndx;indx++)
    {
                        stdev_ndx(indx) = std_dev(resid_ndx(indx));
                        report << setw(5) << setprecision(0) << indx
                                                 << setw(15) << setprecision(5) << neglogLL_ndx(indx)
                                                 << setw(10) << setprecision(5) << stdev_ndx(indx)
```

```
            << setw(10) << setprecision(5) << sum(resid_ndx2 (indx))
                                                    << setw(10) << setprecision(5) << sum(residmean_ndx2 (indx)) << endl;
     }

report << endl;
report << " proportion at age " << endl;
   for(ifleet=1;ifleet<=nfleets;ifleet++)
     {
     for(iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
       {
       report << setw(5) << setprecision(0) << ifleet
            << setw(5) << setprecision(0) << iyr
            << setw(10) << setprecision(5) << C(ifleet,iyr)/pred_catch(ifleet,iyr) << endl;
       }
     }

 report << "Fleet - neglogLL - Standard Deviation of Standardized Residuals (SDSR)" << endl;
for (ifleet=1;ifleet<=nfleets;ifleet++)
 {
                         report << setw(5) << setprecision(0) << ifleet
                                                    << setw(15) << setprecision(5) << sum(neglogLL_PAA(ifleet))
                                                    << setw(10) << setprecision(5) << stdev_PAA(ifleet) << endl;
  }

report << endl;

report << "Fleet  Year  Pred  Std_Resid Std_Residfrommean " << endl;
  for(ifleet=1;ifleet<=nfleets;ifleet++)
    {
    for(iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
     {
        report.setf(ios::fixed, ios::floatfield);
                          report << setw(5) << setprecision(0) << ifleet
            << setw(10) << setprecision(0) << iyr
                                                    << setw(15) << setprecision(0) << pred_catch(ifleet,iyr)
                                                    << setw(10) << setprecision(5) << resid_tC(ifleet,iyr)
                                             << setw(10) << setprecision(5) << residmean_tC(ifleet,iyr) << endl;
     }
    }

report << "Fleet - neglogLL - Standard Deviation of Standardized Residuals (SDSR) -  Standardized Residual Sum of
                      Squares (SRSS) -  Total Standardized Residual Sum of Squares (TSRSS)" << endl;
   for(ifleet=1;ifleet<=nfleets;ifleet++)
    {
                         stdev_tC(ifleet) = std_dev(resid_tC(ifleet));
                         report << setw(5) << setprecision(0) << ifleet
                                                    << setw(15) << setprecision(5) << neglogLL_tC(ifleet)
                                                    << setw(10) << setprecision(5) << stdev_tC(ifleet)
            << setw(10) << setprecision(5) << sum(resid_tC2 (ifleet))
                                                    << setw(10) << setprecision(5) << sum(residmean_tC2 (ifleet)) << endl;
     }

report << endl;
report << "Predicted population dynamics" << endl;
report << "Abundance" << endl;
   for(iyr=firstyr;iyr<=lastyr;iyr++)
     {
      report << setw(5) << setprecision(0) << iyr
```

```
          << setw(15) << setprecision(9) << mfexp(log_N(iyr)) << endl;
      }
report << endl;
report << "F at age by fleet" << endl;
  for(ifleet=1;ifleet<=nfleets;ifleet++)
   {
   for(iyr=first_fyr(ifleet);iyr<=last_fyr(ifleet);iyr++)
    {
     report << setw(5) << setprecision(0) << ifleet
          << setw(5) << setprecision(0) << iyr
          << setw(10) << setprecision(5) << mfexp(log_Ffleet(ifleet,iyr))
          << setw(10) << setprecision(5) << EffN(ifleet,iyr) << endl;
     }
   }
 report << endl;
 report << "Check bounded values" << endl;
 report << "fill_log_sels" << endl;
 report << setw(5) << setprecision(0) << fill_log_sel << endl;
 report << endl;
 report << "log_Fmult" << endl;
 report << setw(5) << setprecision(0) << log_Fmult << endl;
 report << endl;
 report << "log_initN" << endl;
 report << setw(5) << setprecision(0) << log_initN << endl;
 report << endl;
 report << "log_recruits" << endl;
 report << setw(5) << setprecision(0) << log_recruits << endl;
 report << endl;
 report << "log_q_ndx" << endl;
 report << setw(5) << setprecision(0) << log_q_ndx << endl;
 report << endl;
 report << "selectivities" << endl;
    for (ifleet=1;ifleet<=nfleets;ifleet++)
        {
         for (i=1;i<=yr_sel_block(ifleet,last_fyr(ifleet));i++)
          {
            report << setw(5) << setprecision(0) << ifleet
                 << setw(5) << setprecision(0) << i
                 << setw(10) << setprecision(5) << mfexp(log_sel(ifleet,i)) << endl;
                          }
        }
  report << endl;
  report << "weighting scheme for this run" << endl;
  report << "TC wt" << setw(10) << setprecision(5) << totcatch_wt(wt_choice(1)) << endl;
  report << "PAA wt" << endl;
  report << setw(10) << setprecision(5) << PAA_wt(wt_choice(2)) << endl;
  report << "Index wt" << setw(10) << setprecision(5) << indx_wt(wt_choice(3)) << endl;
  report << "Fbrake" << setw(10) << setprecision(5) << F_brake << endl;

  report << endl;
  report << "Total F estimates by year and age" << endl;
       for (iyr=firstyr;iyr<=lastyr;iyr++)
        {
                       report << setw(5) << setprecision(0) << iyr;
        for (iage=firstage;iage<=lastage;iage++)
         {
          report << setw(10) << setprecision(5) << tot_F(iyr,iage);
                          }
```

```
                        report << endl;
         }
   report << endl;


       report << " static SPR     " << setw(15) << setprecision(5) << static_SPR << endl;
       report << " 3 year SPR    " << setw(15) << setprecision(5) << three_yrSPR << endl;
       report << " escapement 1-3 " << setw(15) << setprecision(5) << escapement13 << endl;
       report << " escapement 1-5 " << setw(15) << setprecision(5) << escapement15 << endl;
       report << " t Esc 1-3 " << setw(15) << setprecision(5) << tEsc13 << endl;
       report << " t Esc 1-5 " << setw(15) << setprecision(5) << tEsc15 << endl;

       report << "sel constraint estimates (4 and 5)=" << 1/(1+mfexp(-1.*sel04)) << "   " << 1/(1+mfexp(-1.*sel05)) <<
                    endl;
       //report << "selectivity constraint for B2 (4 and 5) =" << 1/(1+mfexp(-1.*sel04b2))
        //     << "   " << 1/(1+mfexp(-1.*sel05b2)) << endl;

       // report << "SSB" << SSB_F(iyr) << endl;
```

Weights Files

```
#weights
#total catch by fleet
# Ha:default
#fleet1 fleet2 fleet3 fleet4 fleet5
 1.    1.    1.    1.    1.
# Ha:B2 rec total catch estimates are suspect
#fleet1 fleet2 fleet3 fleet4 fleet5
 1.    1.    1.    0.1   0.1
# Ha:B2 rec total catch estimates are really suspect
#fleet1 fleet2 fleet3 fleet4 fleet5
 1.    1.    1.    0.01    0.01

#weights
#Ha:default
#catch at age by fleet and year
#1989   1990   1991   1992   1993   1994   1995   1996   1997   1998   1999   2000   2001   2002   2003   2004
                    2005   2006   2007   2008   2009   2010   2011   2012   2013
1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
                    1   1
1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
                    1   1
1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
                    1   1
0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
                    0   0
1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
                    1   1
#Ha:the B2 age compostion data is very uncertain
#catch at age by fleet and year
#1989   1990   1991   1992   1993   1994   1995   1996   1997   1998   1999   2000   2001   2002   2003   2004
                    2005   2006   2007   2008   2009   2010   2011   2012   2013
1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
                    1   1
1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
                    1   1
1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
                    1   1
```

0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0
0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1
0.1 0.1 0.1 0.1 0.1
#Ha:the B2 age compostion data is very,very uncertain
#catch at age by fleet and year
#1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004
2005 2006 2007 2008 2009 2010 2011 2012 2013
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0
0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001
0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001

#weights
#Ha:default
index weight
1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
#Ha:the MRFSS index is best due to areal coverage
index weight
1. 1. 1. 1. 1. 1. 1. 10. 1. 1. 1.
#Ha:the yoy indexes are best due to scientifically design and ease of capture
index weight
10. 10. 10. 10. 1. 1. 1. 1. 1. 1. 1.

Input Data

#Southern Stock 1989-2013 - Continuity
#
Defining 5 fleets with each state's (FL,GA,SC) having A+B1 rec, and FLrec B2 fishery then combined GASC B2
no commercial landings from southern stock during model period
#fleets (1=FLrecharv,2=GArecharv,3=SCrecharv,4)FL recB2,5)GA/SC recB2)
5
global first and last years used in assessment
1989 2013
#
first and last year for each fishing fleet
1989 1989 1989 1989 1989
2013 2013 2013 2013 2013
#
#firstage lastage (same for all fleets)
1 7
#
#last age selectivity estimated for
3
#natural mortality///////////////////////////using mid year M-at-age estimated with SS3 SSVB growth estimates and
an average from age 7-42 for plus group M, updated 7/7/16
1 2 3 4 5 6 7
0.20 0.16 0.14 0.13 0.13 0.12 0.11

#
#selectivity block by fleet (each row is a fleet;1=FLrec,2=Garec/com,3=SCrec/com,4)FL recB2,5)GA/SC recB2)

```
#89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13
 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
 1 1 1 2 2 2 2 2 2 2 2 2 2 3 3 3 3 3 3 3 3 3 3 3 3
 1 1 1 1 1 2 2 2 2 2 2 2 2 3 3 3 3 3 3 3 3 3 3 3 3
 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
#
# total kill by fleet in numbers ( ONLY A+B1 for recs -- 1=FLrec,2=Garec/com,3=SCrec/com,4)FL recB2,5)GA/SC recB2 )
#1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004
        2005 2006 2007 2008 2009 2010 2011 2012 2013
 32985        45209   99336   98176   66971   119696  95198   144798  69369   105163  128499
                193962  182701  124550  156213  136728  195550  145860  161427  159246  79635
                175828  180001  238191  297527
 46346        69122   146835  76290   96151   121655  124357  55991   35337   23449   61662
                85222   81656   83356   110621  138893  105655  68813   113237  133107  68857
                194826  106962  45766   73827
 119686       113270  112968  103249  113460  119561  183302  124906  125771  45791   43140
                35425   59147   39694   154111  107803  130655  48703   72261   119471  70326
                172708  161503  121068  97386
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
        0 0
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
        0 0
#
# CV's for landings or releases depending on fishery ///////////////////////////////////////////////used weighted
        average for SC/GA B2 fleet PSE
#1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004
        2005 2006 2007 2008 2009 2010 2011 2012 2013
 0.396        0.386   0.240   0.181   0.184   0.163   0.187   0.298   0.214   0.173   0.141
                0.136   0.142   0.155   0.147   0.128   0.177   0.130   0.140   0.168   0.146
                0.145   0.128   0.149   0.121
 0.234        0.236   0.245   0.182   0.193   0.223   0.223   0.220   0.202   0.229   0.245
                0.212   0.317   0.201   0.178   0.242   0.187   0.228   0.220   0.187   0.205
                0.218   0.220   0.259   0.194
 0.267        0.386   0.309   0.199   0.332   0.542   0.728   0.316   0.226   0.212   0.308
                0.294   0.343   0.273   0.294   0.206   0.216   0.282   0.234   0.227   0.198
                0.174   0.182   0.244   0.182
 0.427        0.365   0.451   0.229   0.238   0.209   0.184   0.188   0.194   0.175   0.160
                0.145   0.150   0.183   0.169   0.140   0.181   0.123   0.138   0.159   0.109
                0.132   0.140   0.100   0.162
 0.382        0.455   0.456   0.269   0.520   0.240   0.277   0.305   0.308   0.218   0.277
                0.238   0.254   0.220   0.200   0.191   0.173   0.175   0.175   0.203   0.176
                0.158   0.146   0.113   0.147

#
#input B2 selectivity for rec northern stock by age (columns through last_sel_age) and year (rows) -- look to see - this
        is used for Florida
0.684 1.000 0.207 0.089 0.089 0.089 0.089

# total release by fleet (B2's)
#1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004
        2005 2006 2007 2008 2009 2010 2011 2012 2013
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
        0 0
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
        0 0
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
        0 0
```

179873 71680 670400 296862 486498 720918 712927 522494 585029 506364 602572
739877 894528 698270 772792 1006814 1405967 847269 758684 889550 521659
1414115 1051143 799428 1541541
110822 250878 190598 168079 282091 468140 702511 265743 213601 117663 110762
221074 460384 313503 697313 580145 828116 676242 662781 865960 918827
1270102 878072 633855 872099

#
#release mortality
0.08
#
#proportion catch at age (age columns, year rows) by fleet ###Up to date###

#Age 1	2	3	4	5	6	7+
#	FLrec	(AB1	prop	at	age)	
0.3616	0.4382	0.1604	0.0347	0.0027	0.0005	0.0019
0.3481	0.3911	0.1524	0.0773	0.0130	0.0087	0.0094
0.2337	0.3253	0.2123	0.0548	0.0280	0.1409	0.0050
0.2953	0.2336	0.2964	0.1335	0.0222	0.0106	0.0084
0.1178	0.3457	0.2965	0.1863	0.0279	0.0140	0.0118
0.2173	0.2975	0.2676	0.1738	0.0230	0.0117	0.0090
0.0925	0.3459	0.2454	0.2621	0.0315	0.0109	0.0117
0.2220	0.2960	0.2669	0.1750	0.0230	0.0111	0.0059
0.1559	0.2811	0.3043	0.2054	0.0209	0.0321	0.0003
0.0643	0.4179	0.2629	0.2312	0.0115	0.0017	0.0104
0.0874	0.3149	0.5517	0.0311	0.0140	0.0002	0.0007
0.0253	0.6080	0.2729	0.0789	0.0100	0.0032	0.0019
0.0471	0.4122	0.4087	0.1253	0.0028	0.0004	0.0036
0.0098	0.5500	0.1409	0.1405	0.1428	0.0038	0.0122
0.0298	0.4844	0.2639	0.1970	0.0246	0.0000	0.0003
0.0751	0.2907	0.2304	0.3529	0.0480	0.0009	0.0019
0.0382	0.4292	0.3403	0.1010	0.0845	0.0014	0.0054
0.0116	0.3281	0.3786	0.2188	0.0499	0.0119	0.0011
0.0198	0.4068	0.3687	0.1635	0.0329	0.0047	0.0037
0.0118	0.3578	0.4100	0.2132	0.0027	0.0024	0.0022
0.0576	0.4535	0.4003	0.0479	0.0374	0.0002	0.0031
0.0162	0.5242	0.3374	0.0989	0.0181	0.0006	0.0046
0.0218	0.5131	0.4038	0.0392	0.0120	0.0008	0.0093
0.0224	0.2836	0.6048	0.0620	0.0011	0.0196	0.0065
0.0447	0.3750	0.1638	0.3677	0.0359	0.0019	0.0111

#GArec	(AB1	prop	at	age)		
0.5403	0.3716	0.0766	0.0087	0.0025	0.0003	0.0000
0.6002	0.2500	0.0768	0.0391	0.0055	0.0026	0.0259
0.6753	0.2894	0.0298	0.0049	0.0005	0.0001	0.0000
0.6326	0.2925	0.0510	0.0169	0.0043	0.0015	0.0013
0.5539	0.2984	0.0996	0.0357	0.0076	0.0019	0.0029
0.6185	0.2929	0.0745	0.0120	0.0016	0.0002	0.0002
0.6288	0.2714	0.0728	0.0195	0.0051	0.0010	0.0013
0.6356	0.3019	0.0516	0.0075	0.0029	0.0004	0.0001
0.7443	0.2073	0.0426	0.0043	0.0011	0.0002	0.0002
0.5217	0.3153	0.0895	0.0531	0.0139	0.0028	0.0037
0.3681	0.4127	0.1487	0.0421	0.0194	0.0040	0.0050
0.5513	0.3172	0.1139	0.0090	0.0053	0.0010	0.0024
0.7426	0.2145	0.0315	0.0051	0.0034	0.0008	0.0021
0.6091	0.3290	0.0236	0.0136	0.0106	0.0028	0.0114
0.5968	0.3733	0.0289	0.0004	0.0003	0.0001	0.0003
0.5416	0.3535	0.0917	0.0090	0.0022	0.0005	0.0016

0.5615	0.4025	0.0351	0.0009	0.0000	0.0000	0.0000
0.3961	0.5489	0.0503	0.0029	0.0011	0.0002	0.0006
0.5287	0.4080	0.0412	0.0098	0.0065	0.0014	0.0045
0.5418	0.4297	0.0193	0.0036	0.0028	0.0007	0.0021
0.5662	0.4011	0.0287	0.0016	0.0012	0.0002	0.0008
0.4772	0.4307	0.0790	0.0057	0.0034	0.0008	0.0032
0.7995	0.1661	0.0309	0.0019	0.0007	0.0002	0.0007
0.4997	0.3319	0.1319	0.0132	0.0103	0.0026	0.0105
0.5829	0.2873	0.0797	0.0169	0.0138	0.0035	0.0159

#SCrec	(AB1	prop	at	age)		
0.3381	0.4715	0.1488	0.0380	0.0035	0.0000	0.0002
0.4344	0.3397	0.2036	0.0208	0.0014	0.0000	0.0000
0.4954	0.4475	0.0342	0.0089	0.0020	0.0000	0.0119
0.2596	0.6299	0.0847	0.0139	0.0024	0.0002	0.0094
0.2323	0.5547	0.1543	0.0429	0.0123	0.0000	0.0035
0.1900	0.5570	0.1834	0.0635	0.0056	0.0004	0.0001
0.4526	0.4074	0.0972	0.0357	0.0067	0.0002	0.0000
0.1056	0.7362	0.0957	0.0421	0.0187	0.0014	0.0003
0.3679	0.4079	0.1361	0.0590	0.0258	0.0016	0.0016
0.2622	0.5202	0.1094	0.0820	0.0231	0.0014	0.0016
0.2497	0.5066	0.1835	0.0428	0.0142	0.0019	0.0013
0.2530	0.5378	0.1514	0.0498	0.0070	0.0005	0.0005
0.3426	0.4432	0.1461	0.0557	0.0094	0.0013	0.0017
0.0903	0.7676	0.0917	0.0282	0.0147	0.0021	0.0054
0.0724	0.6331	0.1789	0.0979	0.0159	0.0011	0.0007
0.0786	0.6265	0.2121	0.0745	0.0079	0.0004	0.0000
0.1834	0.4619	0.2833	0.0594	0.0092	0.0012	0.0016
0.0976	0.5810	0.2499	0.0541	0.0075	0.0017	0.0083
0.2119	0.5801	0.1486	0.0390	0.0126	0.0014	0.0063
0.1505	0.6027	0.1276	0.0757	0.0235	0.0088	0.0113
0.0640	0.6176	0.1702	0.0809	0.0298	0.0118	0.0256
0.1312	0.6114	0.1810	0.0487	0.0116	0.0014	0.0147
0.1450	0.5657	0.1631	0.0867	0.0205	0.0037	0.0154
0.1216	0.6487	0.1429	0.0562	0.0116	0.0023	0.0167
0.1054	0.7476	0.1233	0.0177	0.0027	0.0004	0.0029

# FLrec	B2	age	comp ###From Mike's input files for code estimating B2 selectivity			
0.6036	0.3137	0.0580	0.0242	0.0003	0.0000	0.0002
0.8021	0.1368	0.0393	0.0207	0.0005	0.0000	0.0006
0.6854	0.2405	0.0488	0.0056	0.0147	0.0039	0.0011
0.4988	0.1978	0.1806	0.0893	0.0171	0.0096	0.0068
0.2711	0.1912	0.2439	0.2167	0.0427	0.0156	0.0188
0.1723	0.1719	0.2224	0.3205	0.0618	0.0255	0.0257
0.1007	0.1790	0.2152	0.3831	0.0671	0.0244	0.0305
0.1081	0.2169	0.2609	0.2996	0.0649	0.0270	0.0227
0.1098	0.1443	0.2921	0.3393	0.0470	0.0633	0.0041
0.0395	0.2101	0.1677	0.4696	0.0537	0.0154	0.0439
0.1019	0.1276	0.4209	0.1127	0.2175	0.0043	0.0149
0.0450	0.2339	0.2286	0.2751	0.1130	0.0327	0.0717
0.0461	0.1397	0.4724	0.1819	0.0474	0.0123	0.1002
0.0286	0.2119	0.1568	0.2264	0.1754	0.0409	0.1599
0.2986	0.4115	0.1621	0.0558	0.0640	0.0005	0.0074
0.0825	0.2688	0.1468	0.3857	0.0710	0.0143	0.0308
0.0110	0.1705	0.2706	0.1664	0.2676	0.0235	0.0905
0.1691	0.2466	0.2563	0.1727	0.0629	0.0561	0.0363
0.0329	0.1900	0.2273	0.2926	0.1403	0.0424	0.0745

0.0126	0.1108	0.2219	0.4355	0.0799	0.0735	0.0658
0.1055	0.2968	0.3219	0.1175	0.0910	0.0044	0.0630
0.0257	0.2649	0.3784	0.2115	0.0521	0.0074	0.0600
0.0174	0.2436	0.4255	0.1152	0.1080	0.0071	0.0832
0.0191	0.2099	0.4241	0.1209	0.0151	0.1218	0.0891
0.1242	0.2258	0.0811	0.3866	0.0714	0.0243	0.0865

#	SCrec+GArec		B2	age	comp	
0.5652	0.3518	0.0674	0.0117	0.0034	0.0004	0.0001
0.8506	0.1121	0.0353	0.0019	0.0000	0.0000	0.0000
0.7264	0.2235	0.0401	0.0084	0.0012	0.0003	0.0002
0.5343	0.2594	0.1427	0.0422	0.0158	0.0023	0.0033
0.2640	0.2730	0.2888	0.1359	0.0340	0.0020	0.0022
0.1682	0.1617	0.2897	0.3156	0.0564	0.0062	0.0022
0.1807	0.1969	0.2640	0.2513	0.0872	0.0117	0.0083
0.0919	0.3296	0.2230	0.2170	0.1236	0.0117	0.0033
0.0886	0.1400	0.3355	0.2510	0.1586	0.0134	0.0129
0.0494	0.1789	0.1692	0.3302	0.1996	0.0321	0.0405
0.0449	0.1769	0.3221	0.2385	0.1644	0.0294	0.0238
0.0567	0.2063	0.3535	0.2075	0.1130	0.0209	0.0422
0.1160	0.0873	0.3090	0.2445	0.1464	0.0331	0.0637
0.0911	0.2778	0.1646	0.1798	0.1538	0.0300	0.1028
0.0198	0.2301	0.3629	0.1945	0.1178	0.0294	0.0456
0.0146	0.2043	0.3724	0.2566	0.1068	0.0183	0.0269
0.0162	0.1574	0.4506	0.2097	0.0920	0.0208	0.0533
0.0054	0.1564	0.3407	0.3375	0.0951	0.0210	0.0439
0.0434	0.1606	0.3187	0.2563	0.1300	0.0185	0.0725
0.0213	0.2339	0.3200	0.2282	0.1035	0.0337	0.0594
0.0151	0.2460	0.3882	0.1848	0.0758	0.0275	0.0626
0.0330	0.1695	0.5076	0.1597	0.0564	0.0096	0.0642
0.0371	0.2010	0.4052	0.2275	0.0647	0.0122	0.0522
0.0368	0.2147	0.3864	0.2145	0.0574	0.0119	0.0783
0.0957	0.2287	0.3162	0.2139	0.0614	0.0116	0.0724

assumed ages sampled by fleet and year(1=FLrec,2=Garec/com,3=SCrec/com,4=B2FL, 5=B2GA/SC)###needs to be updated with FL logbook and SC tag lengths ESS###Updated with ESS scaled to range from ESS-South worksheet of data inputs file 7/8/16

#1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004
2005 2006 2007 2008 2009 2010 2011 2012 2013

4 4 6 7 9 12 11 13 8 12 22 25
25 20 19 18 18 22 19 18 15 20
20 22 15

8 4 5 11 8 7 7 7 20 25 21 23
27 42 47 41 28 20 22 47 50 44
37 23 36

11 11 15 21 26 12 22 45 37 36 31
38 31 47 38 43 31 31 27 35 37
45 47 38 17

2 2 2 2 2 2 2 2 2 2 2 2
2 2 2 2 2 2 2 2 2 2
2 2 2

2 2 2 3 3 2 5 3 3 2 3 2
2 2 2 2 2 2 2 2 2 2
2 2 2

number of indices

```
# YOY's: 1)FL 2)GA 3)SC stop net 4)SC trammel age 1 ; subadult: 5)SC trammel age 2 6)FL hs 2 7)FL hs 3 8) MRFSS 9) SC
        adults 1m 10) SC adults 1/3m 11) GA adults
 11
# first year of surveys followed by last year of surveys
 2002 2003 1989 1994 1994 1997 1997 1991 1994 2007 2007
 2013 2013 1994 2013 2013 2013 2013 2013 2004 2013 2013
# indices ages (indices in order by row showing begin, end ages)
 1  1  1  1  2 2 3 1  7  7  7
 1  1  1  1  2 2 3 3  7  7  7
#
# middle of survey (months) ###Month is divided by 12 in the model code, changed inputs to month
 0 6 10 10 6 6 6 6 11 11 11
#
#observed index values across years (columns)
# YOY's: 1)FL 2)GA 3)SC stop net 4)SC trammel age 1 ; subadult: 5)SC trammel age 2 6)FL hs 2 7)FL hs 3 8) MRFSS 9) SC
        adults 1m 10) SC adults 1/3m 11) GA adults (2006 taken out based on Carolyns recommendation)
        ##Up to date###

#1989 1990    1991    1992    1993    1994    1995    1996    1997    1998    1999    2000    2001    2002    2003    2004
        2005    2006    2007    2008    2009    2010    2011    2012    2013

        0.615   1.377   1.299   0.525   0.156   0.990   1.102   0.784   1.114   0.339
        0.703   2.999

                1.360   0.987   1.170   0.501   0.872   1.504   0.971   2.014   0.583
        0.450   0.590
0.895   0.952   1.300   0.926   0.616   0.740


                                0.972   1.407   0.625   1.123   0.585   0.630   0.269
        1.736   1.415   1.965   0.809   0.666   0.472   1.067   1.217   1.366   1.799
        0.648   0.538   0.689
                                1.369   0.931   1.555   0.636   0.836   0.595   0.654
        0.361   2.274   1.770   1.820   0.943   1.041   0.505   1.044   1.069   1.028
        0.713   0.493   0.361
                                                        0.793   1.106   0.660   1.003
        0.631   0.977   0.782   1.207   1.405   1.080   1.338   1.286   0.949   0.993
        0.902   1.106   0.782
                                                        0.960   1.561   0.847   0.934
        1.203   1.182   1.275   1.446   0.804   1.232   0.862   1.009   0.712   0.863
        0.805   0.667   0.638
        0.790   0.829   0.914   1.101   1.238   1.056   0.877   0.796   0.790   0.778
        1.047   0.904   1.032   1.123   1.106   0.862   0.834   0.918   1.079   1.498
        1.287   0.964   1.180
                                1.468   1.584   1.219   0.528   0.812   0.928   0.573
        0.822   0.658   1.346   1.063


                                                0.662   0.706   1.440   0.839   0.806
        1.325   1.221

                                                0.471   0.735   1.366   0.681   1.810
        0.424   1.513

# estimated CV's for the index values
#1989 1990    1991    1992    1993    1994    1995    1996    1997    1998    1999    2000    2001    2002    2003    2004
        2005    2006    2007    2008    2009    2010    2011    2012    2013
```

0.50471 0.44332 0.48500 0.52666 0.89699 0.48697 0.44755 0.43174 0.39482 0.65788
0.47564 0.36162

0.31100 0.21900 0.14510 0.15720 0.19270 0.19880 0.24420 0.16420 0.17570
0.22250 0.19820
0.31797 0.51984 0.23095 0.15577 0.14313 0.22177

0.21319 0.16071 0.17599 0.25375 0.18534 0.16223 0.13920
0.13539 0.11711 0.13012 0.19139 0.12737 0.14720 0.13571 0.13936 0.13925 0.11130
0.16576 0.14116 0.13825
0.24178 0.15945 0.16790 0.15624 0.15480 0.18321 0.13762
0.12147 0.20198 0.12012 0.11147 0.11585 0.11812 0.17775 0.14307 0.16283 0.13335
0.20091 0.22807 0.13122
0.24497 0.21514 0.23188 0.19717
0.23551 0.17502 0.18733 0.16025 0.14182 0.16656 0.14029 0.15918 0.17153 0.17061
0.16589 0.16222 0.18549
0.27004 0.24465 0.28354 0.28356
0.23540 0.20569 0.20967 0.18945 0.24866 0.21223 0.25106 0.22837 0.27964 0.22216
0.26134 0.27085 0.30849
0.08596 0.06025 0.06203 0.05426 0.04836 0.04993 0.05209 0.05061 0.04387 0.04203
0.03983 0.04157 0.04187 0.04133 0.03920 0.04043 0.04278 0.04134 0.04088 0.03450
0.03405 0.03878 0.04509
0.22664 0.12721 0.21235 0.18073 0.20313 0.14434 0.20007
0.21702 0.47246 0.17901 0.26679

0.22820 0.16702 0.17198 0.12044 0.10686
0.09519 0.09293

0.33333 0.26818 0.21516 0.25000 0.26568
0.24409 0.22517

#Fbrake level, eliminates low F/high N bias in early phases of solution
2000.
choice of weighting scheme
TC, PAA, Ndx
1. 2. 1.
weight(lbs), maturity, and M at age through age 41, input as end year weight, end year maturity, end year M, M and Wt based on SSVB growth estimates from SS3 and maturity updated (updated 7/8/16)

2.18	0.00	0.20
5.43	0.02	0.16
9.07	0.09	0.14
12.48	0.36	0.13
15.38	0.77	0.13
17.71	0.95	0.12
19.51	0.99	0.12
20.88	1.00	0.12
21.89	1.00	0.12
23.60	1.00	0.11
24.23	1.00	0.11
24.47	1.00	0.11
24.55	1.00	0.11
24.58	1.00	0.11
24.59	1.00	0.11
24.60	1.00	0.11
24.60	1.00	0.11

24.60	1.00	0.11
24.60	1.00	0.11
24.60	1.00	0.11
24.60	1.00	0.11
24.60	1.00	0.11
24.60	1.00	0.11
24.60	1.00	0.11
24.60	1.00	0.11
24.60	1.00	0.11
24.60	1.00	0.11
24.60	1.00	0.11
24.60	1.00	0.11
24.60	1.00	0.11
24.60	1.00	0.11
24.60	1.00	0.11
24.60	1.00	0.11
24.60	1.00	0.11
24.60	1.00	0.11
24.60	1.00	0.11
24.60	1.00	0.11
24.60	1.00	0.11
24.60	1.00	0.11
24.60	1.00	0.11
24.60	1.00	0.11

Appendix C. Correlation coefficents between parameters with a correlation greater than 0.90 or less than -0.90 in the southern stock model.

Parameter 1	Parameter 2	Correlation	Parameter 1	Parameter 2	Correlation
FL Rec F 1991	FL Rec F 1992	0.92	FL Rec F 1992	FL B2 F 2001	0.94
FL Rec F 1991	FL Rec F 1993	0.91	FL Rec F 1993	FL B2 F 2001	0.94
FL Rec F 1992	FL Rec F 1994	0.94	FL Rec F 1994	FL B2 F 2001	0.94
FL Rec F 1991	FL Rec F 1994	0.92	FL Rec F 1995	FL B2 F 2001	0.94
FL Rec F 1992	FL Rec F 1995	0.94	FL Rec F 1996	FL B2 F 2001	0.90
FL Rec F 1993	FL Rec F 1996	0.94	FL Rec F 1997	FL B2 F 2001	0.93
FL Rec F 1991	FL Rec F 1995	0.91	FL Rec F 1998	FL B2 F 2001	0.94
FL Rec F 1992	FL Rec F 1995	0.94	FL Rec F 1999	FL B2 F 2001	0.95
FL Rec F 1993	FL Rec F 1995	0.94	FL Rec F 2000	FL B2 F 2001	0.95
FL Rec F 1994	FL Rec F 1995	0.94	FL Rec F 2001	FL B2 F 2001	0.95
FL Rec F 1992	FL Rec F 1996	0.90	FL Rec F 2002	FL B2 F 2001	0.95
FL Rec F 1993	FL Rec F 1996	0.90	FL Rec F 2003	FL B2 F 2001	0.95
FL Rec F 1994	FL Rec F 1996	0.91	FL Rec F 2004	FL B2 F 2001	0.95
FL Rec F 1995	FL Rec F 1996	0.90	FL Rec F 2005	FL B2 F 2001	0.94
FL Rec F 1991	FL Rec F 1997	0.90	FL Rec F 2006	FL B2 F 2001	0.95
FL Rec F 1992	FL Rec F 1997	0.93	FL Rec F 2007	FL B2 F 2001	0.95
FL Rec F 1993	FL Rec F 1997	0.93	FL Rec F 2008	FL B2 F 2001	0.94
FL Rec F 1994	FL Rec F 1997	0.93	FL Rec F 2009	FL B2 F 2001	0.95
FL Rec F 1995	FL Rec F 1997	0.93	FL Rec F 2010	FL B2 F 2001	0.95
FL Rec F 1991	FL Rec F 1998	0.91	FL Rec F 2011	FL B2 F 2001	0.95
FL Rec F 1992	FL Rec F 1998	0.94	FL Rec F 2012	FL B2 F 2001	0.95
FL Rec F 1993	FL Rec F 1998	0.94	FL Rec F 2013	FL B2 F 2001	0.95
FL Rec F 1994	FL Rec F 1998	0.94	GA Rec F 1992	FL B2 F 2001	0.92
FL Rec F 1995	FL Rec F 1998	0.94	GA Rec F 1993	FL B2 F 2001	0.91
FL Rec F 1996	FL Rec F 1998	0.90	GA Rec F 1997	FL B2 F 2001	0.91
FL Rec F 1997	FL Rec F 1998	0.93	GA Rec F 2002	FL B2 F 2001	0.91
FL Rec F 1991	FL Rec F 1999	0.92	GA Rec F 2003	FL B2 F 2001	0.92
FL Rec F 1992	FL Rec F 1999	0.95	GA Rec F 2005	FL B2 F 2001	0.91
FL Rec F 1993	FL Rec F 1999	0.95	GA Rec F 2008	FL B2 F 2001	0.92
FL Rec F 1994	FL Rec F 1999	0.95	GA Rec F 2009	FL B2 F 2001	0.91
FL Rec F 1995	FL Rec F 1999	0.95	GA Rec F 2013	FL B2 F 2001	0.91
FL Rec F 1996	FL Rec F 1999	0.91	SC Rec F 1992	FL B2 F 2001	0.92
FL Rec F 1997	FL Rec F 1999	0.94	SC Rec F 1997	FL B2 F 2001	0.91
FL Rec F 1998	FL Rec F 1999	0.95	SC Rec F 1998	FL B2 F 2001	0.91
FL Rec F 1991	FL Rec F 2000	0.92	SC Rec F 2004	FL B2 F 2001	0.92
FL Rec F 1992	FL Rec F 2000	0.95	SC Rec F 2005	FL B2 F 2001	0.91
FL Rec F 1993	FL Rec F 2000	0.95	SC Rec F 2007	FL B2 F 2001	0.90
FL Rec F 1994	FL Rec F 2000	0.95	SC Rec F 2008	FL B2 F 2001	0.91
FL Rec F 1995	FL Rec F 2000	0.95	SC Rec F 2009	FL B2 F 2001	0.93
FL Rec F 1996	FL Rec F 2000	0.91	SC Rec F 2010	FL B2 F 2001	0.93
FL Rec F 1997	FL Rec F 2000	0.94	SC Rec F 2011	FL B2 F 2001	0.93
FL Rec F 1998	FL Rec F 2000	0.95	SC Rec F 2012	FL B2 F 2001	0.90
FL Rec F 1999	FL Rec F 2000	0.96	SC Rec F 2013	FL B2 F 2001	0.93
FL Rec F 1991	FL Rec F 2001	0.92	FL B2 F 1992	FL B2 F 2001	0.91
FL Rec F 1992	FL Rec F 2001	0.95	FL B2 F 1993	FL B2 F 2001	0.91
FL Rec F 1993	FL Rec F 2001	0.95	FL B2 F 1994	FL B2 F 2001	0.92
FL Rec F 1994	FL Rec F 2001	0.95	FL B2 F 1995	FL B2 F 2001	0.93
FL Rec F 1995	FL Rec F 2001	0.95	FL B2 F 1996	FL B2 F 2001	0.93
FL Rec F 1996	FL Rec F 2001	0.91	FL B2 F 1997	FL B2 F 2001	0.93
FL Rec F 1997	FL Rec F 2001	0.94	FL B2 F 1998	FL B2 F 2001	0.94
FL Rec F 1998	FL Rec F 2001	0.95	FL B2 F 1999	FL B2 F 2001	0.94
FL Rec F 1999	FL Rec F 2001	0.96	FL B2 F 2000	FL B2 F 2001	0.95
FL Rec F 2000	FL Rec F 2001	0.96	FL Rec F 1991	FL B2 F 2002	0.90
FL Rec F 1991	FL Rec F 2002	0.92	FL Rec F 1992	FL B2 F 2002	0.93
FL Rec F 1992	FL Rec F 2002	0.95	FL Rec F 1993	FL B2 F 2002	0.93

Parameter 1	Parameter 2	Correlation	Parameter 1	Parameter 2	Correlation
FL Rec F 1993	FL Rec F 2002	0.94	FL Rec F 1994	FL B2 F 2002	0.93
FL Rec F 1994	FL Rec F 2002	0.95	FL Rec F 1995	FL B2 F 2002	0.93
FL Rec F 1995	FL Rec F 2002	0.94	FL Rec F 1997	FL B2 F 2002	0.92
FL Rec F 1996	FL Rec F 2002	0.91	FL Rec F 1998	FL B2 F 2002	0.93
FL Rec F 1997	FL Rec F 2002	0.93	FL Rec F 1999	FL B2 F 2002	0.94
FL Rec F 1998	FL Rec F 2002	0.95	FL Rec F 2000	FL B2 F 2002	0.94
FL Rec F 1999	FL Rec F 2002	0.96	FL Rec F 2001	FL B2 F 2002	0.94
FL Rec F 2000	FL Rec F 2002	0.96	FL Rec F 2002	FL B2 F 2002	0.94
FL Rec F 2001	FL Rec F 2002	0.96	FL Rec F 2003	FL B2 F 2002	0.94
FL Rec F 1991	FL Rec F 2003	0.92	FL Rec F 2004	FL B2 F 2002	0.94
FL Rec F 1992	FL Rec F 2003	0.95	FL Rec F 2005	FL B2 F 2002	0.93
FL Rec F 1993	FL Rec F 2003	0.95	FL Rec F 2006	FL B2 F 2002	0.94
FL Rec F 1994	FL Rec F 2003	0.95	FL Rec F 2007	FL B2 F 2002	0.94
FL Rec F 1995	FL Rec F 2003	0.95	FL Rec F 2008	FL B2 F 2002	0.93
FL Rec F 1996	FL Rec F 2003	0.91	FL Rec F 2009	FL B2 F 2002	0.94
FL Rec F 1997	FL Rec F 2003	0.94	FL Rec F 2010	FL B2 F 2002	0.94
FL Rec F 1998	FL Rec F 2003	0.95	FL Rec F 2011	FL B2 F 2002	0.94
FL Rec F 1999	FL Rec F 2003	0.96	FL Rec F 2012	FL B2 F 2002	0.94
FL Rec F 2000	FL Rec F 2003	0.96	FL Rec F 2013	FL B2 F 2002	0.94
FL Rec F 2001	FL Rec F 2003	0.96	GA Rec F 1992	FL B2 F 2002	0.91
FL Rec F 2002	FL Rec F 2003	0.96	GA Rec F 1993	FL B2 F 2002	0.90
FL Rec F 1991	FL Rec F 2004	0.92	GA Rec F 2002	FL B2 F 2002	0.90
FL Rec F 1992	FL Rec F 2004	0.95	GA Rec F 2003	FL B2 F 2002	0.91
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FL Rec F 1998	FL Rec F 2004	0.95	SC Rec F 2004	FL B2 F 2002	0.91
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FL Rec F 2000	FL Rec F 2004	0.96	SC Rec F 2009	FL B2 F 2002	0.91
FL Rec F 2001	FL Rec F 2004	0.96	SC Rec F 2010	FL B2 F 2002	0.92
FL Rec F 2002	FL Rec F 2004	0.96	SC Rec F 2011	FL B2 F 2002	0.92
FL Rec F 2003	FL Rec F 2004	0.96	SC Rec F 2013	FL B2 F 2002	0.92
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FL Rec F 1992	FL Rec F 2005	0.94	FL B2 F 1994	FL B2 F 2002	0.91
FL Rec F 1993	FL Rec F 2005	0.94	FL B2 F 1995	FL B2 F 2002	0.92
FL Rec F 1994	FL Rec F 2005	0.94	FL B2 F 1996	FL B2 F 2002	0.92
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FL Rec F 1996	FL Rec F 2005	0.90	FL B2 F 1998	FL B2 F 2002	0.93
FL Rec F 1997	FL Rec F 2005	0.93	FL B2 F 1999	FL B2 F 2002	0.93
FL Rec F 1998	FL Rec F 2005	0.94	FL B2 F 2000	FL B2 F 2002	0.94
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FL Rec F 2001	FL Rec F 2005	0.95	FL Rec F 1992	FL B2 F 2003	0.93
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FL Rec F 1997	FL Rec F 2006	0.94	FL Rec F 2003	FL B2 F 2003	0.94

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FL Rec F 2006	FL Rec F 2007	0.96	SC Rec F 2005	FL B2 F 2003	0.91
FL Rec F 1991	FL Rec F 2008	0.91	SC Rec F 2008	FL B2 F 2003	0.90
FL Rec F 1992	FL Rec F 2008	0.94	SC Rec F 2009	FL B2 F 2003	0.92
FL Rec F 1993	FL Rec F 2008	0.94	SC Rec F 2010	FL B2 F 2003	0.93
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FL Rec F 1996	FL Rec F 2008	0.90	FL B2 F 1992	FL B2 F 2003	0.91
FL Rec F 1997	FL Rec F 2008	0.93	FL B2 F 1993	FL B2 F 2003	0.90
FL Rec F 1998	FL Rec F 2008	0.94	FL B2 F 1994	FL B2 F 2003	0.91
FL Rec F 1999	FL Rec F 2008	0.95	FL B2 F 1995	FL B2 F 2003	0.92
FL Rec F 2000	FL Rec F 2008	0.95	FL B2 F 1996	FL B2 F 2003	0.92
FL Rec F 2001	FL Rec F 2008	0.95	FL B2 F 1997	FL B2 F 2003	0.92
FL Rec F 2002	FL Rec F 2008	0.95	FL B2 F 1998	FL B2 F 2003	0.93
FL Rec F 2003	FL Rec F 2008	0.95	FL B2 F 1999	FL B2 F 2003	0.93
FL Rec F 2004	FL Rec F 2008	0.96	FL B2 F 2000	FL B2 F 2003	0.94
FL Rec F 2005	FL Rec F 2008	0.94	FL B2 F 2001	FL B2 F 2003	0.94
FL Rec F 2006	FL Rec F 2008	0.96	FL B2 F 2002	FL B2 F 2003	0.93
FL Rec F 2007	FL Rec F 2008	0.95	FL Rec F 1991	FL B2 F 2004	0.91
FL Rec F 1991	FL Rec F 2009	0.92	FL Rec F 1992	FL B2 F 2004	0.94
FL Rec F 1992	FL Rec F 2009	0.95	FL Rec F 1993	FL B2 F 2004	0.94
FL Rec F 1993	FL Rec F 2009	0.95	FL Rec F 1994	FL B2 F 2004	0.95
FL Rec F 1994	FL Rec F 2009	0.95	FL Rec F 1995	FL B2 F 2004	0.94
FL Rec F 1995	FL Rec F 2009	0.95	FL Rec F 1996	FL B2 F 2004	0.91
FL Rec F 1996	FL Rec F 2009	0.91	FL Rec F 1997	FL B2 F 2004	0.93
FL Rec F 1997	FL Rec F 2009	0.94	FL Rec F 1998	FL B2 F 2004	0.94
FL Rec F 1998	FL Rec F 2009	0.95	FL Rec F 1999	FL B2 F 2004	0.95
FL Rec F 1999	FL Rec F 2009	0.96	FL Rec F 2000	FL B2 F 2004	0.95
FL Rec F 2000	FL Rec F 2009	0.96	FL Rec F 2001	FL B2 F 2004	0.95
FL Rec F 2001	FL Rec F 2009	0.96	FL Rec F 2002	FL B2 F 2004	0.95
FL Rec F 2002	FL Rec F 2009	0.96	FL Rec F 2003	FL B2 F 2004	0.95
FL Rec F 2003	FL Rec F 2009	0.96	FL Rec F 2004	FL B2 F 2004	0.96
FL Rec F 2004	FL Rec F 2009	0.96	FL Rec F 2005	FL B2 F 2004	0.94

Parameter 1	Parameter 2	Correlation	Parameter 1	Parameter 2	Correlation
FL Rec F 2005	FL Rec F 2009	0.95	FL Rec F 2006	FL B2 F 2004	0.96
FL Rec F 2006	FL Rec F 2009	0.96	FL Rec F 2007	FL B2 F 2004	0.95
FL Rec F 2007	FL Rec F 2009	0.96	FL Rec F 2008	FL B2 F 2004	0.94
FL Rec F 2008	FL Rec F 2009	0.95	FL Rec F 2009	FL B2 F 2004	0.95
FL Rec F 1991	FL Rec F 2010	0.92	FL Rec F 2010	FL B2 F 2004	0.95
FL Rec F 1992	FL Rec F 2010	0.95	FL Rec F 2011	FL B2 F 2004	0.96
FL Rec F 1993	FL Rec F 2010	0.95	FL Rec F 2012	FL B2 F 2004	0.95
FL Rec F 1994	FL Rec F 2010	0.95	FL Rec F 2013	FL B2 F 2004	0.96
FL Rec F 1995	FL Rec F 2010	0.95	GA Rec F 1992	FL B2 F 2004	0.92
FL Rec F 1996	FL Rec F 2010	0.91	GA Rec F 1993	FL B2 F 2004	0.92
FL Rec F 1997	FL Rec F 2010	0.94	GA Rec F 1996	FL B2 F 2004	0.90
FL Rec F 1998	FL Rec F 2010	0.95	GA Rec F 1997	FL B2 F 2004	0.91
FL Rec F 1999	FL Rec F 2010	0.96	GA Rec F 2002	FL B2 F 2004	0.91
FL Rec F 2000	FL Rec F 2010	0.96	GA Rec F 2003	FL B2 F 2004	0.92
FL Rec F 2001	FL Rec F 2010	0.96	GA Rec F 2005	FL B2 F 2004	0.92
FL Rec F 2002	FL Rec F 2010	0.96	GA Rec F 2008	FL B2 F 2004	0.92
FL Rec F 2003	FL Rec F 2010	0.96	GA Rec F 2009	FL B2 F 2004	0.91
FL Rec F 2004	FL Rec F 2010	0.96	GA Rec F 2010	FL B2 F 2004	0.90
FL Rec F 2005	FL Rec F 2010	0.95	GA Rec F 2011	FL B2 F 2004	0.90
FL Rec F 2006	FL Rec F 2010	0.96	GA Rec F 2013	FL B2 F 2004	0.91
FL Rec F 2007	FL Rec F 2010	0.96	SC Rec F 1992	FL B2 F 2004	0.92
FL Rec F 2008	FL Rec F 2010	0.95	SC Rec F 1997	FL B2 F 2004	0.91
FL Rec F 2009	FL Rec F 2010	0.96	SC Rec F 1998	FL B2 F 2004	0.92
FL Rec F 1991	FL Rec F 2011	0.93	SC Rec F 2004	FL B2 F 2004	0.92
FL Rec F 1992	FL Rec F 2011	0.95	SC Rec F 2005	FL B2 F 2004	0.92
FL Rec F 1993	FL Rec F 2011	0.95	SC Rec F 2007	FL B2 F 2004	0.90
FL Rec F 1994	FL Rec F 2011	0.96	SC Rec F 2008	FL B2 F 2004	0.91
FL Rec F 1995	FL Rec F 2011	0.95	SC Rec F 2009	FL B2 F 2004	0.93
FL Rec F 1996	FL Rec F 2011	0.92	SC Rec F 2010	FL B2 F 2004	0.94
FL Rec F 1997	FL Rec F 2011	0.94	SC Rec F 2011	FL B2 F 2004	0.93
FL Rec F 1998	FL Rec F 2011	0.95	SC Rec F 2012	FL B2 F 2004	0.90
FL Rec F 1999	FL Rec F 2011	0.96	SC Rec F 2013	FL B2 F 2004	0.93
FL Rec F 2000	FL Rec F 2011	0.96	FL B2 F 1992	FL B2 F 2004	0.92
FL Rec F 2001	FL Rec F 2011	0.96	FL B2 F 1993	FL B2 F 2004	0.91
FL Rec F 2002	FL Rec F 2011	0.96	FL B2 F 1994	FL B2 F 2004	0.92
FL Rec F 2003	FL Rec F 2011	0.96	FL B2 F 1995	FL B2 F 2004	0.93
FL Rec F 2004	FL Rec F 2011	0.97	FL B2 F 1996	FL B2 F 2004	0.93
FL Rec F 2005	FL Rec F 2011	0.95	FL B2 F 1997	FL B2 F 2004	0.93
FL Rec F 2006	FL Rec F 2011	0.97	FL B2 F 1998	FL B2 F 2004	0.94
FL Rec F 2007	FL Rec F 2011	0.96	FL B2 F 1999	FL B2 F 2004	0.94
FL Rec F 2008	FL Rec F 2011	0.96	FL B2 F 2000	FL B2 F 2004	0.95
FL Rec F 2009	FL Rec F 2011	0.96	FL B2 F 2001	FL B2 F 2004	0.95
FL Rec F 2010	FL Rec F 2011	0.96	FL B2 F 2002	FL B2 F 2004	0.94
FL Rec F 1991	FL Rec F 2012	0.92	FL B2 F 2003	FL B2 F 2004	0.94
FL Rec F 1992	FL Rec F 2012	0.95	FL Rec F 1991	FL B2 F 2005	0.90
FL Rec F 1993	FL Rec F 2012	0.95	FL Rec F 1992	FL B2 F 2005	0.93
FL Rec F 1994	FL Rec F 2012	0.95	FL Rec F 1993	FL B2 F 2005	0.93
FL Rec F 1995	FL Rec F 2012	0.95	FL Rec F 1994	FL B2 F 2005	0.93
FL Rec F 1996	FL Rec F 2012	0.91	FL Rec F 1995	FL B2 F 2005	0.93
FL Rec F 1997	FL Rec F 2012	0.94	FL Rec F 1997	FL B2 F 2005	0.92
FL Rec F 1998	FL Rec F 2012	0.95	FL Rec F 1998	FL B2 F 2005	0.93
FL Rec F 1999	FL Rec F 2012	0.96	FL Rec F 1999	FL B2 F 2005	0.94
FL Rec F 2000	FL Rec F 2012	0.96	FL Rec F 2000	FL B2 F 2005	0.94
FL Rec F 2001	FL Rec F 2012	0.96	FL Rec F 2001	FL B2 F 2005	0.94
FL Rec F 2002	FL Rec F 2012	0.96	FL Rec F 2002	FL B2 F 2005	0.93

Parameter 1	Parameter 2	Correlation	Parameter 1	Parameter 2	Correlation
FL Rec F 2003	FL Rec F 2012	0.96	FL Rec F 2003	FL B2 F 2005	0.94
FL Rec F 2004	FL Rec F 2012	0.96	FL Rec F 2004	FL B2 F 2005	0.94
FL Rec F 2005	FL Rec F 2012	0.95	FL Rec F 2005	FL B2 F 2005	0.93
FL Rec F 2006	FL Rec F 2012	0.96	FL Rec F 2006	FL B2 F 2005	0.94
FL Rec F 2007	FL Rec F 2012	0.96	FL Rec F 2007	FL B2 F 2005	0.94
FL Rec F 2008	FL Rec F 2012	0.95	FL Rec F 2008	FL B2 F 2005	0.93
FL Rec F 2009	FL Rec F 2012	0.96	FL Rec F 2009	FL B2 F 2005	0.94
FL Rec F 2010	FL Rec F 2012	0.96	FL Rec F 2010	FL B2 F 2005	0.94
FL Rec F 2011	FL Rec F 2012	0.96	FL Rec F 2011	FL B2 F 2005	0.94
FL Rec F 1991	FL Rec F 2013	0.93	FL Rec F 2012	FL B2 F 2005	0.94
FL Rec F 1992	FL Rec F 2013	0.95	FL Rec F 2013	FL B2 F 2005	0.94
FL Rec F 1993	FL Rec F 2013	0.95	GA Rec F 1992	FL B2 F 2005	0.91
FL Rec F 1994	FL Rec F 2013	0.96	GA Rec F 1993	FL B2 F 2005	0.90
FL Rec F 1995	FL Rec F 2013	0.95	GA Rec F 2002	FL B2 F 2005	0.90
FL Rec F 1996	FL Rec F 2013	0.92	GA Rec F 2003	FL B2 F 2005	0.91
FL Rec F 1997	FL Rec F 2013	0.94	GA Rec F 2005	FL B2 F 2005	0.90
FL Rec F 1998	FL Rec F 2013	0.95	GA Rec F 2008	FL B2 F 2005	0.91
FL Rec F 1999	FL Rec F 2013	0.96	GA Rec F 2013	FL B2 F 2005	0.90
FL Rec F 2000	FL Rec F 2013	0.96	SC Rec F 1992	FL B2 F 2005	0.91
FL Rec F 2001	FL Rec F 2013	0.96	SC Rec F 1998	FL B2 F 2005	0.90
FL Rec F 2002	FL Rec F 2013	0.96	SC Rec F 2004	FL B2 F 2005	0.91
FL Rec F 2003	FL Rec F 2013	0.96	SC Rec F 2005	FL B2 F 2005	0.90
FL Rec F 2004	FL Rec F 2013	0.97	SC Rec F 2009	FL B2 F 2005	0.91
FL Rec F 2005	FL Rec F 2013	0.95	SC Rec F 2010	FL B2 F 2005	0.92
FL Rec F 2006	FL Rec F 2013	0.97	SC Rec F 2011	FL B2 F 2005	0.92
FL Rec F 2007	FL Rec F 2013	0.96	SC Rec F 2013	FL B2 F 2005	0.92
FL Rec F 2008	FL Rec F 2013	0.96	FL B2 F 1992	FL B2 F 2005	0.90
FL Rec F 2009	FL Rec F 2013	0.96	FL B2 F 1994	FL B2 F 2005	0.91
FL Rec F 2010	FL Rec F 2013	0.96	FL B2 F 1995	FL B2 F 2005	0.92
FL Rec F 2011	FL Rec F 2013	0.97	FL B2 F 1996	FL B2 F 2005	0.92
FL Rec F 2012	FL Rec F 2013	0.97	FL B2 F 1997	FL B2 F 2005	0.92
FL Rec F 1992	GA Rec F 1992	0.91	FL B2 F 1998	FL B2 F 2005	0.93
FL Rec F 1993	GA Rec F 1992	0.92	FL B2 F 1999	FL B2 F 2005	0.93
FL Rec F 1994	GA Rec F 1992	0.92	FL B2 F 2000	FL B2 F 2005	0.94
FL Rec F 1995	GA Rec F 1992	0.91	FL B2 F 2001	FL B2 F 2005	0.93
FL Rec F 1997	GA Rec F 1992	0.90	FL B2 F 2002	FL B2 F 2005	0.92
FL Rec F 1998	GA Rec F 1992	0.91	FL B2 F 2003	FL B2 F 2005	0.93
FL Rec F 1999	GA Rec F 1992	0.92	FL B2 F 2004	FL B2 F 2005	0.94
FL Rec F 2000	GA Rec F 1992	0.92	FL Rec F 1991	FL B2 F 2006	0.92
FL Rec F 2001	GA Rec F 1992	0.92	FL Rec F 1992	FL B2 F 2006	0.95
FL Rec F 2002	GA Rec F 1992	0.92	FL Rec F 1993	FL B2 F 2006	0.95
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FL Rec F 1995	GA Rec F 1993	0.91	FL Rec F 2008	FL B2 F 2006	0.95
FL Rec F 1998	GA Rec F 1993	0.91	FL Rec F 2009	FL B2 F 2006	0.96
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FL Rec F 1999	GA Rec F 1996	0.90	FL B2 F 1998	FL B2 F 2006	0.95
FL Rec F 2000	GA Rec F 1996	0.90	FL B2 F 1999	FL B2 F 2006	0.95
FL Rec F 2001	GA Rec F 1996	0.90	FL B2 F 2000	FL B2 F 2006	0.96
FL Rec F 2003	GA Rec F 1996	0.90	FL B2 F 2001	FL B2 F 2006	0.95
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FL Rec F 1995	GA Rec F 1993	0.91	FL Rec F 2008	FL B2 F 2006	0.95
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FL Rec F 2011	GA Rec F 1998	0.90	GA Rec F 1995	FL B2 F 2007	0.90
FL Rec F 2013	GA Rec F 1998	0.90	GA Rec F 1996	FL B2 F 2007	0.90
FL Rec F 2000	GA Rec F 2000	0.90	GA Rec F 1997	FL B2 F 2007	0.91
FL Rec F 2001	GA Rec F 2000	0.90	GA Rec F 2000	FL B2 F 2007	0.90
FL Rec F 2004	GA Rec F 2000	0.90	GA Rec F 2002	FL B2 F 2007	0.92
FL Rec F 2006	GA Rec F 2000	0.90	GA Rec F 2003	FL B2 F 2007	0.92
FL Rec F 2007	GA Rec F 2000	0.90	GA Rec F 2005	FL B2 F 2007	0.92
FL Rec F 2009	GA Rec F 2000	0.90	GA Rec F 2008	FL B2 F 2007	0.92
FL Rec F 2010	GA Rec F 2000	0.90	GA Rec F 2009	FL B2 F 2007	0.91
FL Rec F 2011	GA Rec F 2000	0.90	GA Rec F 2010	FL B2 F 2007	0.90
FL Rec F 2012	GA Rec F 2000	0.90	GA Rec F 2011	FL B2 F 2007	0.90
FL Rec F 2013	GA Rec F 2000	0.91	GA Rec F 2013	FL B2 F 2007	0.92
FL Rec F 1992	GA Rec F 2002	0.90	SC Rec F 1992	FL B2 F 2007	0.92
FL Rec F 1993	GA Rec F 2002	0.90	SC Rec F 1997	FL B2 F 2007	0.91
FL Rec F 1994	GA Rec F 2002	0.91	SC Rec F 1998	FL B2 F 2007	0.92
FL Rec F 1995	GA Rec F 2002	0.90	SC Rec F 2004	FL B2 F 2007	0.92
FL Rec F 1998	GA Rec F 2002	0.91	SC Rec F 2005	FL B2 F 2007	0.92
FL Rec F 1999	GA Rec F 2002	0.92	SC Rec F 2007	FL B2 F 2007	0.91
FL Rec F 2000	GA Rec F 2002	0.92	SC Rec F 2008	FL B2 F 2007	0.91
FL Rec F 2001	GA Rec F 2002	0.92	SC Rec F 2009	FL B2 F 2007	0.93
FL Rec F 2002	GA Rec F 2002	0.91	SC Rec F 2010	FL B2 F 2007	0.94
FL Rec F 2003	GA Rec F 2002	0.92	SC Rec F 2011	FL B2 F 2007	0.94
FL Rec F 2004	GA Rec F 2002	0.92	SC Rec F 2012	FL B2 F 2007	0.90
FL Rec F 2005	GA Rec F 2002	0.91	SC Rec F 2013	FL B2 F 2007	0.93
FL Rec F 2006	GA Rec F 2002	0.92	FL B2 F 1992	FL B2 F 2007	0.92
FL Rec F 2007	GA Rec F 2002	0.92	FL B2 F 1993	FL B2 F 2007	0.91
FL Rec F 2008	GA Rec F 2002	0.91	FL B2 F 1994	FL B2 F 2007	0.92
FL Rec F 2009	GA Rec F 2002	0.92	FL B2 F 1995	FL B2 F 2007	0.93
FL Rec F 2010	GA Rec F 2002	0.92	FL B2 F 1996	FL B2 F 2007	0.94
FL Rec F 2011	GA Rec F 2002	0.92	FL B2 F 1997	FL B2 F 2007	0.93
FL Rec F 2012	GA Rec F 2002	0.92	FL B2 F 1998	FL B2 F 2007	0.94
FL Rec F 2013	GA Rec F 2002	0.92	FL B2 F 1999	FL B2 F 2007	0.95
FL Rec F 1992	GA Rec F 2003	0.91	FL B2 F 2000	FL B2 F 2007	0.95
FL Rec F 1993	GA Rec F 2003	0.91	FL B2 F 2001	FL B2 F 2007	0.95
FL Rec F 1994	GA Rec F 2003	0.92	FL B2 F 2002	FL B2 F 2007	0.94

Parameter 1	Parameter 2	Correlation	Parameter 1	Parameter 2	Correlation
FL Rec F 1995	GA Rec F 2003	0.91	FL B2 F 2003	FL B2 F 2007	0.94
FL Rec F 1997	GA Rec F 2003	0.90	FL B2 F 2004	FL B2 F 2007	0.95
FL Rec F 1998	GA Rec F 2003	0.91	FL B2 F 2005	FL B2 F 2007	0.94
FL Rec F 1999	GA Rec F 2003	0.92	FL B2 F 2006	FL B2 F 2007	0.96
FL Rec F 2000	GA Rec F 2003	0.92	FL Rec F 1991	FL B2 F 2008	0.91
FL Rec F 2001	GA Rec F 2003	0.92	FL Rec F 1992	FL B2 F 2008	0.93
FL Rec F 2002	GA Rec F 2003	0.92	FL Rec F 1993	FL B2 F 2008	0.93
FL Rec F 2003	GA Rec F 2003	0.92	FL Rec F 1994	FL B2 F 2008	0.94
FL Rec F 2004	GA Rec F 2003	0.93	FL Rec F 1995	FL B2 F 2008	0.93
FL Rec F 2005	GA Rec F 2003	0.92	FL Rec F 1996	FL B2 F 2008	0.90
FL Rec F 2006	GA Rec F 2003	0.93	FL Rec F 1997	FL B2 F 2008	0.93
FL Rec F 2007	GA Rec F 2003	0.92	FL Rec F 1998	FL B2 F 2008	0.94
FL Rec F 2008	GA Rec F 2003	0.92	FL Rec F 1999	FL B2 F 2008	0.95
FL Rec F 2009	GA Rec F 2003	0.92	FL Rec F 2000	FL B2 F 2008	0.95
FL Rec F 2010	GA Rec F 2003	0.92	FL Rec F 2001	FL B2 F 2008	0.95
FL Rec F 2011	GA Rec F 2003	0.93	FL Rec F 2002	FL B2 F 2008	0.94
FL Rec F 2012	GA Rec F 2003	0.92	FL Rec F 2003	FL B2 F 2008	0.95
FL Rec F 2013	GA Rec F 2003	0.93	FL Rec F 2004	FL B2 F 2008	0.95
FL Rec F 1992	GA Rec F 2005	0.91	FL Rec F 2005	FL B2 F 2008	0.94
FL Rec F 1993	GA Rec F 2005	0.91	FL Rec F 2006	FL B2 F 2008	0.95
FL Rec F 1994	GA Rec F 2005	0.91	FL Rec F 2007	FL B2 F 2008	0.95
FL Rec F 1995	GA Rec F 2005	0.91	FL Rec F 2008	FL B2 F 2008	0.94
FL Rec F 1998	GA Rec F 2005	0.91	FL Rec F 2009	FL B2 F 2008	0.95
FL Rec F 1999	GA Rec F 2005	0.92	FL Rec F 2010	FL B2 F 2008	0.95
FL Rec F 2000	GA Rec F 2005	0.92	FL Rec F 2011	FL B2 F 2008	0.95
FL Rec F 2001	GA Rec F 2005	0.92	FL Rec F 2012	FL B2 F 2008	0.95
FL Rec F 2002	GA Rec F 2005	0.91	FL Rec F 2013	FL B2 F 2008	0.95
FL Rec F 2003	GA Rec F 2005	0.92	GA Rec F 1992	FL B2 F 2008	0.92
FL Rec F 2004	GA Rec F 2005	0.92	GA Rec F 1993	FL B2 F 2008	0.91
FL Rec F 2005	GA Rec F 2005	0.91	GA Rec F 1997	FL B2 F 2008	0.91
FL Rec F 2006	GA Rec F 2005	0.92	GA Rec F 2002	FL B2 F 2008	0.91
FL Rec F 2007	GA Rec F 2005	0.92	GA Rec F 2003	FL B2 F 2008	0.92
FL Rec F 2008	GA Rec F 2005	0.91	GA Rec F 2005	FL B2 F 2008	0.91
FL Rec F 2009	GA Rec F 2005	0.92	GA Rec F 2008	FL B2 F 2008	0.92
FL Rec F 2010	GA Rec F 2005	0.92	GA Rec F 2009	FL B2 F 2008	0.91
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FL Rec F 2013	GA Rec F 2005	0.92	SC Rec F 1997	FL B2 F 2008	0.91
FL Rec F 2013	GA Rec F 2007	0.90	SC Rec F 1998	FL B2 F 2008	0.91
FL Rec F 1992	GA Rec F 2008	0.91	SC Rec F 2004	FL B2 F 2008	0.92
FL Rec F 1993	GA Rec F 2008	0.91	SC Rec F 2005	FL B2 F 2008	0.91
FL Rec F 1994	GA Rec F 2008	0.92	SC Rec F 2008	FL B2 F 2008	0.91
FL Rec F 1995	GA Rec F 2008	0.91	SC Rec F 2009	FL B2 F 2008	0.92
FL Rec F 1997	GA Rec F 2008	0.90	SC Rec F 2010	FL B2 F 2008	0.93
FL Rec F 1998	GA Rec F 2008	0.91	SC Rec F 2011	FL B2 F 2008	0.93
FL Rec F 1999	GA Rec F 2008	0.92	SC Rec F 2013	FL B2 F 2008	0.93
FL Rec F 2000	GA Rec F 2008	0.92	FL B2 F 1992	FL B2 F 2008	0.91
FL Rec F 2001	GA Rec F 2008	0.92	FL B2 F 1993	FL B2 F 2008	0.91
FL Rec F 2002	GA Rec F 2008	0.92	FL B2 F 1994	FL B2 F 2008	0.92
FL Rec F 2003	GA Rec F 2008	0.92	FL B2 F 1995	FL B2 F 2008	0.93
FL Rec F 2004	GA Rec F 2008	0.93	FL B2 F 1996	FL B2 F 2008	0.93
FL Rec F 2005	GA Rec F 2008	0.91	FL B2 F 1997	FL B2 F 2008	0.93
FL Rec F 2006	GA Rec F 2008	0.93	FL B2 F 1998	FL B2 F 2008	0.93
FL Rec F 2007	GA Rec F 2008	0.92	FL B2 F 1999	FL B2 F 2008	0.94
FL Rec F 2008	GA Rec F 2008	0.91	FL B2 F 2000	FL B2 F 2008	0.94

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FL Rec F 2009	GA Rec F 2008	0.92	FL B2 F 2001	FL B2 F 2008	0.94
FL Rec F 2010	GA Rec F 2008	0.92	FL B2 F 2002	FL B2 F 2008	0.93
FL Rec F 2011	GA Rec F 2008	0.93	FL B2 F 2003	FL B2 F 2008	0.94
FL Rec F 2012	GA Rec F 2008	0.92	FL B2 F 2004	FL B2 F 2008	0.95
FL Rec F 2013	GA Rec F 2008	0.93	FL B2 F 2005	FL B2 F 2008	0.93
FL Rec F 1992	GA Rec F 2009	0.90	FL B2 F 2006	FL B2 F 2008	0.95
FL Rec F 1993	GA Rec F 2009	0.90	FL B2 F 2007	FL B2 F 2008	0.95
FL Rec F 1994	GA Rec F 2009	0.91	FL Rec F 1991	FL B2 F 2009	0.92
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FL Rec F 2002	GA Rec F 2009	0.91	FL Rec F 1997	FL B2 F 2009	0.94
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Parameter 1	Parameter 2	Correlation	Parameter 1	Parameter 2	Correlation
FL Rec F 2009	GA Rec F 2008	0.92	FL B2 F 2001	FL B2 F 2008	0.94
FL Rec F 2010	GA Rec F 2008	0.92	FL B2 F 2002	FL B2 F 2008	0.93
FL Rec F 2011	GA Rec F 2008	0.93	FL B2 F 2003	FL B2 F 2008	0.94
FL Rec F 2012	GA Rec F 2008	0.92	FL B2 F 2004	FL B2 F 2008	0.95
FL Rec F 2013	GA Rec F 2008	0.93	FL B2 F 2005	FL B2 F 2008	0.93
FL Rec F 1992	GA Rec F 2009	0.90	FL B2 F 2006	FL B2 F 2008	0.95
FL Rec F 1993	GA Rec F 2009	0.90	FL B2 F 2007	FL B2 F 2008	0.95
FL Rec F 1994	GA Rec F 2009	0.91	FL Rec F 1991	FL B2 F 2009	0.92
FL Rec F 1995	GA Rec F 2009	0.90	FL Rec F 1992	FL B2 F 2009	0.95
FL Rec F 1998	GA Rec F 2009	0.90	FL Rec F 1993	FL B2 F 2009	0.95
FL Rec F 1999	GA Rec F 2009	0.91	FL Rec F 1994	FL B2 F 2009	0.96
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FL Rec F 2001	GA Rec F 2009	0.91	FL Rec F 1996	FL B2 F 2009	0.91
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FL Rec F 2007	GA Rec F 2009	0.91	FL Rec F 2002	FL B2 F 2009	0.96
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FL Rec F 2001	GA Rec F 2010	0.90	FL Rec F 2011	FL B2 F 2009	0.97
FL Rec F 2002	GA Rec F 2010	0.90	FL Rec F 2012	FL B2 F 2009	0.96
FL Rec F 2003	GA Rec F 2010	0.90	FL Rec F 2013	FL B2 F 2009	0.97
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FL Rec F 2007	GA Rec F 2011	0.90	GA Rec F 2009	FL B2 F 2009	0.92
FL Rec F 2009	GA Rec F 2011	0.90	GA Rec F 2010	FL B2 F 2009	0.91
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FL Rec F 1999	GA Rec F 2013	0.92	SC Rec F 2008	FL B2 F 2009	0.92
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FL Rec F 2007	GA Rec F 2013	0.92	FL B2 F 1994	FL B2 F 2009	0.93
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FL Rec F 2009	GA Rec F 2013	0.92	FL B2 F 1996	FL B2 F 2009	0.94
FL Rec F 2010	GA Rec F 2013	0.92	FL B2 F 1997	FL B2 F 2009	0.94
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FL Rec F 2012	GA Rec F 2013	0.91	FL B2 F 1999	FL B2 F 2009	0.95
FL Rec F 2013	GA Rec F 2013	0.92	FL B2 F 2000	FL B2 F 2009	0.96
FL Rec F 1992	SC Rec F 1992	0.91	FL B2 F 2001	FL B2 F 2009	0.96
FL Rec F 1993	SC Rec F 1992	0.91	FL B2 F 2002	FL B2 F 2009	0.95
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FL Rec F 2013	SC Rec F 1997	0.92	GA Rec F 2005	FL B2 F 2010	0.92
FL Rec F 1992	SC Rec F 1998	0.91	GA Rec F 2008	FL B2 F 2010	0.92
FL Rec F 1993	SC Rec F 1998	0.91	GA Rec F 2009	FL B2 F 2010	0.91
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FL Rec F 2004	SC Rec F 1998	0.92	SC Rec F 2007	FL B2 F 2010	0.91
FL Rec F 2005	SC Rec F 1998	0.91	SC Rec F 2008	FL B2 F 2010	0.91
FL Rec F 2006	SC Rec F 1998	0.92	SC Rec F 2009	FL B2 F 2010	0.93
FL Rec F 2007	SC Rec F 1998	0.92	SC Rec F 2010	FL B2 F 2010	0.94
FL Rec F 2008	SC Rec F 1998	0.91	SC Rec F 2011	FL B2 F 2010	0.94
FL Rec F 2009	SC Rec F 1998	0.92	SC Rec F 2012	FL B2 F 2010	0.91
FL Rec F 2010	SC Rec F 1998	0.92	SC Rec F 2013	FL B2 F 2010	0.93
FL Rec F 2011	SC Rec F 1998	0.92	FL B2 F 1992	FL B2 F 2010	0.92
FL Rec F 2012	SC Rec F 1998	0.92	FL B2 F 1993	FL B2 F 2010	0.91
FL Rec F 2013	SC Rec F 1998	0.92	FL B2 F 1994	FL B2 F 2010	0.93
FL Rec F 2004	SC Rec F 2002	0.90	FL B2 F 1995	FL B2 F 2010	0.93
FL Rec F 2006	SC Rec F 2002	0.90	FL B2 F 1996	FL B2 F 2010	0.94
FL Rec F 2011	SC Rec F 2002	0.90	FL B2 F 1997	FL B2 F 2010	0.93
FL Rec F 2013	SC Rec F 2002	0.90	FL B2 F 1998	FL B2 F 2010	0.94
FL Rec F 1992	SC Rec F 2004	0.91	FL B2 F 1999	FL B2 F 2010	0.95
FL Rec F 1993	SC Rec F 2004	0.91	FL B2 F 2000	FL B2 F 2010	0.95
FL Rec F 1994	SC Rec F 2004	0.92	FL B2 F 2001	FL B2 F 2010	0.95
FL Rec F 1995	SC Rec F 2004	0.91	FL B2 F 2002	FL B2 F 2010	0.94
FL Rec F 1997	SC Rec F 2004	0.90	FL B2 F 2003	FL B2 F 2010	0.94
FL Rec F 1998	SC Rec F 2004	0.91	FL B2 F 2004	FL B2 F 2010	0.95
FL Rec F 1999	SC Rec F 2004	0.92	FL B2 F 2005	FL B2 F 2010	0.94
FL Rec F 2000	SC Rec F 2004	0.92	FL B2 F 2006	FL B2 F 2010	0.96
FL Rec F 2001	SC Rec F 2004	0.92	FL B2 F 2007	FL B2 F 2010	0.95
FL Rec F 2002	SC Rec F 2004	0.92	FL B2 F 2008	FL B2 F 2010	0.95
FL Rec F 2003	SC Rec F 2004	0.92	FL B2 F 2009	FL B2 F 2010	0.96
FL Rec F 2004	SC Rec F 2004	0.93	FL Rec F 1991	FL B2 F 2011	0.91
FL Rec F 2005	SC Rec F 2004	0.91	FL Rec F 1992	FL B2 F 2011	0.94
FL Rec F 2006	SC Rec F 2004	0.93	FL Rec F 1993	FL B2 F 2011	0.94
FL Rec F 2007	SC Rec F 2004	0.92	FL Rec F 1994	FL B2 F 2011	0.95
FL Rec F 2008	SC Rec F 2004	0.91	FL Rec F 1995	FL B2 F 2011	0.94
FL Rec F 2009	SC Rec F 2004	0.92	FL Rec F 1996	FL B2 F 2011	0.91
FL Rec F 2010	SC Rec F 2004	0.92	FL Rec F 1997	FL B2 F 2011	0.93
FL Rec F 2011	SC Rec F 2004	0.93	FL Rec F 1998	FL B2 F 2011	0.94
FL Rec F 2012	SC Rec F 2004	0.92	FL Rec F 1999	FL B2 F 2011	0.95
FL Rec F 2013	SC Rec F 2004	0.93	FL Rec F 2000	FL B2 F 2011	0.95
FL Rec F 1992	SC Rec F 2005	0.91	FL Rec F 2001	FL B2 F 2011	0.95
FL Rec F 1993	SC Rec F 2005	0.91	FL Rec F 2002	FL B2 F 2011	0.95
FL Rec F 1994	SC Rec F 2005	0.91	FL Rec F 2003	FL B2 F 2011	0.95
FL Rec F 1995	SC Rec F 2005	0.91	FL Rec F 2004	FL B2 F 2011	0.96
FL Rec F 1998	SC Rec F 2005	0.91	FL Rec F 2005	FL B2 F 2011	0.94
FL Rec F 1999	SC Rec F 2005	0.92	FL Rec F 2006	FL B2 F 2011	0.96
FL Rec F 2000	SC Rec F 2005	0.92	FL Rec F 2007	FL B2 F 2011	0.95
FL Rec F 2001	SC Rec F 2005	0.92	FL Rec F 2008	FL B2 F 2011	0.94
FL Rec F 2002	SC Rec F 2005	0.91	FL Rec F 2009	FL B2 F 2011	0.95

Parameter 1	Parameter 2	Correlation	Parameter 1	Parameter 2	Correlation
FL Rec F 2003	SC Rec F 2005	0.92	FL Rec F 2010	FL B2 F 2011	0.95
FL Rec F 2004	SC Rec F 2005	0.92	FL Rec F 2011	FL B2 F 2011	0.96
FL Rec F 2005	SC Rec F 2005	0.91	FL Rec F 2012	FL B2 F 2011	0.95
FL Rec F 2006	SC Rec F 2005	0.92	FL Rec F 2013	FL B2 F 2011	0.96
FL Rec F 2007	SC Rec F 2005	0.92	GA Rec F 1992	FL B2 F 2011	0.92
FL Rec F 2008	SC Rec F 2005	0.91	GA Rec F 1993	FL B2 F 2011	0.92
FL Rec F 2009	SC Rec F 2005	0.92	GA Rec F 1994	FL B2 F 2011	0.90
FL Rec F 2010	SC Rec F 2005	0.92	GA Rec F 1995	FL B2 F 2011	0.90
FL Rec F 2011	SC Rec F 2005	0.92	GA Rec F 1996	FL B2 F 2011	0.90
FL Rec F 2012	SC Rec F 2005	0.92	GA Rec F 1997	FL B2 F 2011	0.91
FL Rec F 2013	SC Rec F 2005	0.92	GA Rec F 2002	FL B2 F 2011	0.92
FL Rec F 1999	SC Rec F 2007	0.90	GA Rec F 2003	FL B2 F 2011	0.92
FL Rec F 2000	SC Rec F 2007	0.91	GA Rec F 2005	FL B2 F 2011	0.92
FL Rec F 2001	SC Rec F 2007	0.91	GA Rec F 2008	FL B2 F 2011	0.92
FL Rec F 2002	SC Rec F 2007	0.90	GA Rec F 2009	FL B2 F 2011	0.91
FL Rec F 2003	SC Rec F 2007	0.90	GA Rec F 2010	FL B2 F 2011	0.90
FL Rec F 2004	SC Rec F 2007	0.91	GA Rec F 2011	FL B2 F 2011	0.90
FL Rec F 2006	SC Rec F 2007	0.91	GA Rec F 2013	FL B2 F 2011	0.92
FL Rec F 2007	SC Rec F 2007	0.91	SC Rec F 1992	FL B2 F 2011	0.92
FL Rec F 2009	SC Rec F 2007	0.91	SC Rec F 1997	FL B2 F 2011	0.91
FL Rec F 2010	SC Rec F 2007	0.90	SC Rec F 1998	FL B2 F 2011	0.92
FL Rec F 2011	SC Rec F 2007	0.91	SC Rec F 2004	FL B2 F 2011	0.92
FL Rec F 2012	SC Rec F 2007	0.90	SC Rec F 2005	FL B2 F 2011	0.92
FL Rec F 2013	SC Rec F 2007	0.91	SC Rec F 2007	FL B2 F 2011	0.90
FL Rec F 1992	SC Rec F 2008	0.90	SC Rec F 2008	FL B2 F 2011	0.91
FL Rec F 1993	SC Rec F 2008	0.90	SC Rec F 2009	FL B2 F 2011	0.93
FL Rec F 1994	SC Rec F 2008	0.91	SC Rec F 2010	FL B2 F 2011	0.94
FL Rec F 1995	SC Rec F 2008	0.90	SC Rec F 2011	FL B2 F 2011	0.94
FL Rec F 1998	SC Rec F 2008	0.90	SC Rec F 2012	FL B2 F 2011	0.90
FL Rec F 1999	SC Rec F 2008	0.91	SC Rec F 2013	FL B2 F 2011	0.93
FL Rec F 2000	SC Rec F 2008	0.91	FL B2 F 1992	FL B2 F 2011	0.92
FL Rec F 2001	SC Rec F 2008	0.91	FL B2 F 1993	FL B2 F 2011	0.91
FL Rec F 2002	SC Rec F 2008	0.91	FL B2 F 1994	FL B2 F 2011	0.92
FL Rec F 2003	SC Rec F 2008	0.91	FL B2 F 1995	FL B2 F 2011	0.93
FL Rec F 2004	SC Rec F 2008	0.92	FL B2 F 1996	FL B2 F 2011	0.93
FL Rec F 2005	SC Rec F 2008	0.90	FL B2 F 1997	FL B2 F 2011	0.93
FL Rec F 2006	SC Rec F 2008	0.92	FL B2 F 1998	FL B2 F 2011	0.94
FL Rec F 2007	SC Rec F 2008	0.91	FL B2 F 1999	FL B2 F 2011	0.94
FL Rec F 2008	SC Rec F 2008	0.91	FL B2 F 2000	FL B2 F 2011	0.95
FL Rec F 2009	SC Rec F 2008	0.92	FL B2 F 2001	FL B2 F 2011	0.95
FL Rec F 2010	SC Rec F 2008	0.91	FL B2 F 2002	FL B2 F 2011	0.94
FL Rec F 2011	SC Rec F 2008	0.92	FL B2 F 2003	FL B2 F 2011	0.94
FL Rec F 2012	SC Rec F 2008	0.91	FL B2 F 2004	FL B2 F 2011	0.95
FL Rec F 2013	SC Rec F 2008	0.92	FL B2 F 2005	FL B2 F 2011	0.94
FL Rec F 1992	SC Rec F 2009	0.92	FL B2 F 2006	FL B2 F 2011	0.96
FL Rec F 1993	SC Rec F 2009	0.92	FL B2 F 2007	FL B2 F 2011	0.95
FL Rec F 1994	SC Rec F 2009	0.92	FL B2 F 2008	FL B2 F 2011	0.95
FL Rec F 1995	SC Rec F 2009	0.92	FL B2 F 2009	FL B2 F 2011	0.96
FL Rec F 1997	SC Rec F 2009	0.91	FL B2 F 2010	FL B2 F 2011	0.95
FL Rec F 1998	SC Rec F 2009	0.92	FL Rec F 1991	FL B2 F 2012	0.93
FL Rec F 1999	SC Rec F 2009	0.93	FL Rec F 1992	FL B2 F 2012	0.95
FL Rec F 2000	SC Rec F 2009	0.93	FL Rec F 1993	FL B2 F 2012	0.95
FL Rec F 2001	SC Rec F 2009	0.93	FL Rec F 1994	FL B2 F 2012	0.96
FL Rec F 2002	SC Rec F 2009	0.93	FL Rec F 1995	FL B2 F 2012	0.95
FL Rec F 2003	SC Rec F 2009	0.93	FL Rec F 1996	FL B2 F 2012	0.92

Parameter 1	Parameter 2	Correlation	Parameter 1	Parameter 2	Correlation
FL Rec F 2003	SC Rec F 2005	0.92	FL Rec F 2010	FL B2 F 2011	0.95
FL Rec F 2004	SC Rec F 2005	0.92	FL Rec F 2011	FL B2 F 2011	0.96
FL Rec F 2005	SC Rec F 2005	0.91	FL Rec F 2012	FL B2 F 2011	0.95
FL Rec F 2006	SC Rec F 2005	0.92	FL Rec F 2013	FL B2 F 2011	0.96
FL Rec F 2007	SC Rec F 2005	0.92	GA Rec F 1992	FL B2 F 2011	0.92
FL Rec F 2008	SC Rec F 2005	0.91	GA Rec F 1993	FL B2 F 2011	0.92
FL Rec F 2009	SC Rec F 2005	0.92	GA Rec F 1994	FL B2 F 2011	0.90
FL Rec F 2010	SC Rec F 2005	0.92	GA Rec F 1995	FL B2 F 2011	0.90
FL Rec F 2011	SC Rec F 2005	0.92	GA Rec F 1996	FL B2 F 2011	0.90
FL Rec F 2012	SC Rec F 2005	0.92	GA Rec F 1997	FL B2 F 2011	0.91
FL Rec F 2013	SC Rec F 2005	0.92	GA Rec F 2002	FL B2 F 2011	0.92
FL Rec F 1999	SC Rec F 2007	0.90	GA Rec F 2003	FL B2 F 2011	0.92
FL Rec F 2000	SC Rec F 2007	0.91	GA Rec F 2005	FL B2 F 2011	0.92
FL Rec F 2001	SC Rec F 2007	0.91	GA Rec F 2008	FL B2 F 2011	0.92
FL Rec F 2002	SC Rec F 2007	0.90	GA Rec F 2009	FL B2 F 2011	0.91
FL Rec F 2003	SC Rec F 2007	0.90	GA Rec F 2010	FL B2 F 2011	0.90
FL Rec F 2004	SC Rec F 2007	0.91	GA Rec F 2011	FL B2 F 2011	0.90
FL Rec F 2006	SC Rec F 2007	0.91	GA Rec F 2013	FL B2 F 2011	0.92
FL Rec F 2007	SC Rec F 2007	0.91	SC Rec F 1992	FL B2 F 2011	0.92
FL Rec F 2009	SC Rec F 2007	0.91	SC Rec F 1997	FL B2 F 2011	0.91
FL Rec F 2010	SC Rec F 2007	0.90	SC Rec F 1998	FL B2 F 2011	0.92
FL Rec F 2011	SC Rec F 2007	0.91	SC Rec F 2004	FL B2 F 2011	0.92
FL Rec F 2012	SC Rec F 2007	0.90	SC Rec F 2005	FL B2 F 2011	0.92
FL Rec F 2013	SC Rec F 2007	0.91	SC Rec F 2007	FL B2 F 2011	0.90
FL Rec F 1992	SC Rec F 2008	0.90	SC Rec F 2008	FL B2 F 2011	0.91
FL Rec F 1993	SC Rec F 2008	0.90	SC Rec F 2009	FL B2 F 2011	0.93
FL Rec F 1994	SC Rec F 2008	0.91	SC Rec F 2010	FL B2 F 2011	0.94
FL Rec F 1995	SC Rec F 2008	0.90	SC Rec F 2011	FL B2 F 2011	0.94
FL Rec F 1998	SC Rec F 2008	0.90	SC Rec F 2012	FL B2 F 2011	0.90
FL Rec F 1999	SC Rec F 2008	0.91	SC Rec F 2013	FL B2 F 2011	0.93
FL Rec F 2000	SC Rec F 2008	0.91	FL B2 F 1992	FL B2 F 2011	0.92
FL Rec F 2001	SC Rec F 2008	0.91	FL B2 F 1993	FL B2 F 2011	0.91
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FL Rec F 2004	SC Rec F 2008	0.92	FL B2 F 1996	FL B2 F 2011	0.93
FL Rec F 2005	SC Rec F 2008	0.90	FL B2 F 1997	FL B2 F 2011	0.93
FL Rec F 2006	SC Rec F 2008	0.92	FL B2 F 1998	FL B2 F 2011	0.94
FL Rec F 2007	SC Rec F 2008	0.91	FL B2 F 1999	FL B2 F 2011	0.94
FL Rec F 2008	SC Rec F 2008	0.91	FL B2 F 2000	FL B2 F 2011	0.95
FL Rec F 2009	SC Rec F 2008	0.92	FL B2 F 2001	FL B2 F 2011	0.95
FL Rec F 2010	SC Rec F 2008	0.91	FL B2 F 2002	FL B2 F 2011	0.94
FL Rec F 2011	SC Rec F 2008	0.92	FL B2 F 2003	FL B2 F 2011	0.94
FL Rec F 2012	SC Rec F 2008	0.91	FL B2 F 2004	FL B2 F 2011	0.95
FL Rec F 2013	SC Rec F 2008	0.92	FL B2 F 2005	FL B2 F 2011	0.94
FL Rec F 1992	SC Rec F 2009	0.92	FL B2 F 2006	FL B2 F 2011	0.96
FL Rec F 1993	SC Rec F 2009	0.92	FL B2 F 2007	FL B2 F 2011	0.95
FL Rec F 1994	SC Rec F 2009	0.92	FL B2 F 2008	FL B2 F 2011	0.95
FL Rec F 1995	SC Rec F 2009	0.92	FL B2 F 2009	FL B2 F 2011	0.96
FL Rec F 1997	SC Rec F 2009	0.91	FL B2 F 2010	FL B2 F 2011	0.95
FL Rec F 1998	SC Rec F 2009	0.92	FL Rec F 1991	FL B2 F 2012	0.93
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FL Rec F 2000	SC Rec F 2009	0.93	FL Rec F 1993	FL B2 F 2012	0.95
FL Rec F 2001	SC Rec F 2009	0.93	FL Rec F 1994	FL B2 F 2012	0.96
FL Rec F 2002	SC Rec F 2009	0.93	FL Rec F 1995	FL B2 F 2012	0.95
FL Rec F 2003	SC Rec F 2009	0.93	FL Rec F 1996	FL B2 F 2012	0.92

Parameter 1	Parameter 2	Correlation	Parameter 1	Parameter 2	Correlation
FL Rec F 2004	SC Rec F 2009	0.93	FL Rec F 1997	FL B2 F 2012	0.94
FL Rec F 2005	SC Rec F 2009	0.92	FL Rec F 1998	FL B2 F 2012	0.95
FL Rec F 2006	SC Rec F 2009	0.93	FL Rec F 1999	FL B2 F 2012	0.96
FL Rec F 2007	SC Rec F 2009	0.93	FL Rec F 2000	FL B2 F 2012	0.96
FL Rec F 2008	SC Rec F 2009	0.92	FL Rec F 2001	FL B2 F 2012	0.96
FL Rec F 2009	SC Rec F 2009	0.93	FL Rec F 2002	FL B2 F 2012	0.96
FL Rec F 2010	SC Rec F 2009	0.93	FL Rec F 2003	FL B2 F 2012	0.96
FL Rec F 2011	SC Rec F 2009	0.93	FL Rec F 2004	FL B2 F 2012	0.97
FL Rec F 2012	SC Rec F 2009	0.93	FL Rec F 2005	FL B2 F 2012	0.95
FL Rec F 2013	SC Rec F 2009	0.93	FL Rec F 2006	FL B2 F 2012	0.97
GA Rec F 1992	SC Rec F 2009	0.90	FL Rec F 2007	FL B2 F 2012	0.96
GA Rec F 2003	SC Rec F 2009	0.90	FL Rec F 2008	FL B2 F 2012	0.96
GA Rec F 2008	SC Rec F 2009	0.90	FL Rec F 2009	FL B2 F 2012	0.96
SC Rec F 2004	SC Rec F 2009	0.90	FL Rec F 2010	FL B2 F 2012	0.96
FL Rec F 1992	SC Rec F 2010	0.93	FL Rec F 2011	FL B2 F 2012	0.97
FL Rec F 1993	SC Rec F 2010	0.93	FL Rec F 2012	FL B2 F 2012	0.96
FL Rec F 1994	SC Rec F 2010	0.93	FL Rec F 2013	FL B2 F 2012	0.97
FL Rec F 1995	SC Rec F 2010	0.92	GA Rec F 1992	FL B2 F 2012	0.93
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FL Rec F 2006	SC Rec F 2010	0.94	GA Rec F 2005	FL B2 F 2012	0.93
FL Rec F 2007	SC Rec F 2010	0.94	GA Rec F 2006	FL B2 F 2012	0.90
FL Rec F 2008	SC Rec F 2010	0.93	GA Rec F 2007	FL B2 F 2012	0.91
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FL Rec F 2011	SC Rec F 2010	0.94	GA Rec F 2010	FL B2 F 2012	0.91
FL Rec F 2012	SC Rec F 2010	0.94	GA Rec F 2011	FL B2 F 2012	0.91
FL Rec F 2013	SC Rec F 2010	0.94	GA Rec F 2013	FL B2 F 2012	0.93
GA Rec F 1992	SC Rec F 2010	0.91	SC Rec F 1992	FL B2 F 2012	0.93
GA Rec F 1993	SC Rec F 2010	0.90	SC Rec F 1997	FL B2 F 2012	0.92
GA Rec F 2002	SC Rec F 2010	0.90	SC Rec F 1998	FL B2 F 2012	0.93
GA Rec F 2003	SC Rec F 2010	0.91	SC Rec F 2002	FL B2 F 2012	0.91
GA Rec F 2005	SC Rec F 2010	0.90	SC Rec F 2004	FL B2 F 2012	0.93
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GA Rec F 2013	SC Rec F 2010	0.90	SC Rec F 2007	FL B2 F 2012	0.92
SC Rec F 1992	SC Rec F 2010	0.91	SC Rec F 2008	FL B2 F 2012	0.92
SC Rec F 1998	SC Rec F 2010	0.90	SC Rec F 2009	FL B2 F 2012	0.94
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SC Rec F 2008	SC Rec F 2010	0.90	SC Rec F 2012	FL B2 F 2012	0.92
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FL Rec F 1992	SC Rec F 2011	0.92	FL B2 F 1992	FL B2 F 2012	0.93
FL Rec F 1993	SC Rec F 2011	0.92	FL B2 F 1993	FL B2 F 2012	0.92
FL Rec F 1994	SC Rec F 2011	0.93	FL B2 F 1994	FL B2 F 2012	0.93
FL Rec F 1995	SC Rec F 2011	0.92	FL B2 F 1995	FL B2 F 2012	0.94
FL Rec F 1997	SC Rec F 2011	0.92	FL B2 F 1996	FL B2 F 2012	0.95
FL Rec F 1998	SC Rec F 2011	0.93	FL B2 F 1997	FL B2 F 2012	0.94
FL Rec F 1999	SC Rec F 2011	0.94	FL B2 F 1998	FL B2 F 2012	0.95

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FL Rec F 2004	SC Rec F 2009	0.93	FL Rec F 1997	FL B2 F 2012	0.94
FL Rec F 2005	SC Rec F 2009	0.92	FL Rec F 1998	FL B2 F 2012	0.95
FL Rec F 2006	SC Rec F 2009	0.93	FL Rec F 1999	FL B2 F 2012	0.96
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FL Rec F 2009	SC Rec F 2009	0.93	FL Rec F 2002	FL B2 F 2012	0.96
FL Rec F 2010	SC Rec F 2009	0.93	FL Rec F 2003	FL B2 F 2012	0.96
FL Rec F 2011	SC Rec F 2009	0.93	FL Rec F 2004	FL B2 F 2012	0.97
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GA Rec F 2003	SC Rec F 2009	0.90	FL Rec F 2008	FL B2 F 2012	0.96
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SC Rec F 2004	SC Rec F 2009	0.90	FL Rec F 2010	FL B2 F 2012	0.96
FL Rec F 1992	SC Rec F 2010	0.93	FL Rec F 2011	FL B2 F 2012	0.97
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FL Rec F 2013	SC Rec F 2010	0.94	GA Rec F 2013	FL B2 F 2012	0.93
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FL Rec F 1994	SC Rec F 2011	0.93	FL B2 F 1994	FL B2 F 2012	0.93
FL Rec F 1995	SC Rec F 2011	0.92	FL B2 F 1995	FL B2 F 2012	0.94
FL Rec F 1997	SC Rec F 2011	0.92	FL B2 F 1996	FL B2 F 2012	0.95
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FL Rec F 1999	SC Rec F 2011	0.94	FL B2 F 1998	FL B2 F 2012	0.95

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FL Rec F 2000	SC Rec F 2011	0.94	FL B2 F 1999	FL B2 F 2012	0.96
FL Rec F 2001	SC Rec F 2011	0.94	FL B2 F 2000	FL B2 F 2012	0.96
FL Rec F 2002	SC Rec F 2011	0.93	FL B2 F 2001	FL B2 F 2012	0.96
FL Rec F 2003	SC Rec F 2011	0.94	FL B2 F 2002	FL B2 F 2012	0.95
FL Rec F 2004	SC Rec F 2011	0.94	FL B2 F 2003	FL B2 F 2012	0.95
FL Rec F 2005	SC Rec F 2011	0.93	FL B2 F 2004	FL B2 F 2012	0.96
FL Rec F 2006	SC Rec F 2011	0.94	FL B2 F 2005	FL B2 F 2012	0.95
FL Rec F 2007	SC Rec F 2011	0.94	FL B2 F 2006	FL B2 F 2012	0.97
FL Rec F 2008	SC Rec F 2011	0.93	FL B2 F 2007	FL B2 F 2012	0.96
FL Rec F 2009	SC Rec F 2011	0.94	FL B2 F 2008	FL B2 F 2012	0.96
FL Rec F 2010	SC Rec F 2011	0.94	FL B2 F 2009	FL B2 F 2012	0.97
FL Rec F 2011	SC Rec F 2011	0.94	FL B2 F 2010	FL B2 F 2012	0.96
FL Rec F 2012	SC Rec F 2011	0.94	FL B2 F 2011	FL B2 F 2012	0.96
FL Rec F 2013	SC Rec F 2011	0.94	FL Rec F 1991	FL B2 F 2013	0.91
GA Rec F 1992	SC Rec F 2011	0.91	FL Rec F 1992	FL B2 F 2013	0.93
GA Rec F 1993	SC Rec F 2011	0.90	FL Rec F 1993	FL B2 F 2013	0.93
GA Rec F 2003	SC Rec F 2011	0.91	FL Rec F 1994	FL B2 F 2013	0.94
GA Rec F 2005	SC Rec F 2011	0.90	FL Rec F 1995	FL B2 F 2013	0.93
GA Rec F 2008	SC Rec F 2011	0.91	FL Rec F 1997	FL B2 F 2013	0.92
GA Rec F 2013	SC Rec F 2011	0.90	FL Rec F 1998	FL B2 F 2013	0.93
SC Rec F 1992	SC Rec F 2011	0.90	FL Rec F 1999	FL B2 F 2013	0.94
SC Rec F 1998	SC Rec F 2011	0.90	FL Rec F 2000	FL B2 F 2013	0.94
SC Rec F 2004	SC Rec F 2011	0.91	FL Rec F 2001	FL B2 F 2013	0.94
SC Rec F 2005	SC Rec F 2011	0.90	FL Rec F 2002	FL B2 F 2013	0.94
SC Rec F 2009	SC Rec F 2011	0.92	FL Rec F 2003	FL B2 F 2013	0.94
SC Rec F 2010	SC Rec F 2011	0.92	FL Rec F 2004	FL B2 F 2013	0.95
FL Rec F 1999	SC Rec F 2012	0.90	FL Rec F 2005	FL B2 F 2013	0.93
FL Rec F 2000	SC Rec F 2012	0.90	FL Rec F 2006	FL B2 F 2013	0.95
FL Rec F 2001	SC Rec F 2012	0.90	FL Rec F 2007	FL B2 F 2013	0.94
FL Rec F 2002	SC Rec F 2012	0.90	FL Rec F 2008	FL B2 F 2013	0.94
FL Rec F 2003	SC Rec F 2012	0.90	FL Rec F 2009	FL B2 F 2013	0.94
FL Rec F 2004	SC Rec F 2012	0.91	FL Rec F 2010	FL B2 F 2013	0.94
FL Rec F 2006	SC Rec F 2012	0.91	FL Rec F 2011	FL B2 F 2013	0.95
FL Rec F 2007	SC Rec F 2012	0.90	FL Rec F 2012	FL B2 F 2013	0.94
FL Rec F 2009	SC Rec F 2012	0.90	FL Rec F 2013	FL B2 F 2013	0.95
FL Rec F 2010	SC Rec F 2012	0.90	GA Rec F 1992	FL B2 F 2013	0.92
FL Rec F 2011	SC Rec F 2012	0.91	GA Rec F 1993	FL B2 F 2013	0.91
FL Rec F 2012	SC Rec F 2012	0.91	GA Rec F 1997	FL B2 F 2013	0.91
FL Rec F 2013	SC Rec F 2012	0.91	GA Rec F 2002	FL B2 F 2013	0.91
FL Rec F 1992	SC Rec F 2013	0.92	GA Rec F 2003	FL B2 F 2013	0.92
FL Rec F 1993	SC Rec F 2013	0.92	GA Rec F 2005	FL B2 F 2013	0.91
FL Rec F 1994	SC Rec F 2013	0.93	GA Rec F 2008	FL B2 F 2013	0.91
FL Rec F 1995	SC Rec F 2013	0.92	GA Rec F 2009	FL B2 F 2013	0.90
FL Rec F 1997	SC Rec F 2013	0.91	GA Rec F 2013	FL B2 F 2013	0.91
FL Rec F 1998	SC Rec F 2013	0.92	SC Rec F 1992	FL B2 F 2013	0.91
FL Rec F 1999	SC Rec F 2013	0.93	SC Rec F 1997	FL B2 F 2013	0.91
FL Rec F 2000	SC Rec F 2013	0.93	SC Rec F 1998	FL B2 F 2013	0.91
FL Rec F 2001	SC Rec F 2013	0.93	SC Rec F 2004	FL B2 F 2013	0.91
FL Rec F 2002	SC Rec F 2013	0.93	SC Rec F 2005	FL B2 F 2013	0.91
FL Rec F 2003	SC Rec F 2013	0.93	SC Rec F 2008	FL B2 F 2013	0.90
FL Rec F 2004	SC Rec F 2013	0.94	SC Rec F 2009	FL B2 F 2013	0.92
FL Rec F 2005	SC Rec F 2013	0.92	SC Rec F 2010	FL B2 F 2013	0.93
FL Rec F 2006	SC Rec F 2013	0.94	SC Rec F 2011	FL B2 F 2013	0.93
FL Rec F 2007	SC Rec F 2013	0.93	SC Rec F 2013	FL B2 F 2013	0.93
FL Rec F 2008	SC Rec F 2013	0.92	FL B2 F 1992	FL B2 F 2013	0.91

Parameter 1	Parameter 2	Correlation	Parameter 1	Parameter 2	Correlation
FL Rec F 2009	SC Rec F 2013	0.93	FL B2 F 1993	FL B2 F 2013	0.91
FL Rec F 2010	SC Rec F 2013	0.93	FL B2 F 1994	FL B2 F 2013	0.92
FL Rec F 2011	SC Rec F 2013	0.94	FL B2 F 1995	FL B2 F 2013	0.93
FL Rec F 2012	SC Rec F 2013	0.93	FL B2 F 1996	FL B2 F 2013	0.93
FL Rec F 2013	SC Rec F 2013	0.94	FL B2 F 1997	FL B2 F 2013	0.93
GA Rec F 1992	SC Rec F 2013	0.90	FL B2 F 1998	FL B2 F 2013	0.93
GA Rec F 2003	SC Rec F 2013	0.90	FL B2 F 1999	FL B2 F 2013	0.94
GA Rec F 2008	SC Rec F 2013	0.90	FL B2 F 2000	FL B2 F 2013	0.94
SC Rec F 1992	SC Rec F 2013	0.90	FL B2 F 2001	FL B2 F 2013	0.94
SC Rec F 2004	SC Rec F 2013	0.91	FL B2 F 2002	FL B2 F 2013	0.93
SC Rec F 2005	SC Rec F 2013	0.90	FL B2 F 2003	FL B2 F 2013	0.93
SC Rec F 2009	SC Rec F 2013	0.91	FL B2 F 2004	FL B2 F 2013	0.94
SC Rec F 2010	SC Rec F 2013	0.92	FL B2 F 2005	FL B2 F 2013	0.93
SC Rec F 2011	SC Rec F 2013	0.92	FL B2 F 2006	FL B2 F 2013	0.95
FL Rec F 1992	FL B2 F 1992	0.91	FL B2 F 2007	FL B2 F 2013	0.94
FL Rec F 1993	FL B2 F 1992	0.91	FL B2 F 2008	FL B2 F 2013	0.94
FL Rec F 1994	FL B2 F 1992	0.91	FL B2 F 2009	FL B2 F 2013	0.95
FL Rec F 1995	FL B2 F 1992	0.91	FL B2 F 2010	FL B2 F 2013	0.95
FL Rec F 1998	FL B2 F 1992	0.91	FL B2 F 2011	FL B2 F 2013	0.94
FL Rec F 1999	FL B2 F 1992	0.92	FL B2 F 2012	FL B2 F 2013	0.95
FL Rec F 2000	FL B2 F 1992	0.92	GA/SC B2 F 1998	GA/SC B2 F 2002	0.90
FL Rec F 2001	FL B2 F 1992	0.92	GA/SC B2 F 1994	GA/SC B2 F 2003	0.90
FL Rec F 2002	FL B2 F 1992	0.91	GA/SC B2 F 1998	GA/SC B2 F 2003	0.91
FL Rec F 2003	FL B2 F 1992	0.92	GA/SC B2 F 2002	GA/SC B2 F 2003	0.91
FL Rec F 2004	FL B2 F 1992	0.92	GA/SC B2 F 1994	GA/SC B2 F 2004	0.90
FL Rec F 2005	FL B2 F 1992	0.91	GA/SC B2 F 1998	GA/SC B2 F 2004	0.91
FL Rec F 2006	FL B2 F 1992	0.92	GA/SC B2 F 2000	GA/SC B2 F 2004	0.90
FL Rec F 2007	FL B2 F 1992	0.92	GA/SC B2 F 2002	GA/SC B2 F 2004	0.91
FL Rec F 2008	FL B2 F 1992	0.91	GA/SC B2 F 2003	GA/SC B2 F 2004	0.92
FL Rec F 2009	FL B2 F 1992	0.92	FL Rec F 2004	GA/SC B2 F 2005	0.90
FL Rec F 2010	FL B2 F 1992	0.92	FL Rec F 2006	GA/SC B2 F 2005	0.90
FL Rec F 2011	FL B2 F 1992	0.92	FL Rec F 2011	GA/SC B2 F 2005	0.90
FL Rec F 2012	FL B2 F 1992	0.92	FL Rec F 2013	GA/SC B2 F 2005	0.90
FL Rec F 2013	FL B2 F 1992	0.92	FL B2 F 2006	GA/SC B2 F 2005	0.90
SC Rec F 2010	FL B2 F 1992	0.90	FL B2 F 2009	GA/SC B2 F 2005	0.91
SC Rec F 2011	FL B2 F 1992	0.90	FL B2 F 2012	GA/SC B2 F 2005	0.91
FL Rec F 1992	FL B2 F 1993	0.90	GA/SC B2 F 1992	GA/SC B2 F 2005	0.90
FL Rec F 1993	FL B2 F 1993	0.90	GA/SC B2 F 1994	GA/SC B2 F 2005	0.91
FL Rec F 1994	FL B2 F 1993	0.91	GA/SC B2 F 1998	GA/SC B2 F 2005	0.92
FL Rec F 1995	FL B2 F 1993	0.90	GA/SC B2 F 2000	GA/SC B2 F 2005	0.91
FL Rec F 1998	FL B2 F 1993	0.90	GA/SC B2 F 2001	GA/SC B2 F 2005	0.90
FL Rec F 1999	FL B2 F 1993	0.91	GA/SC B2 F 2002	GA/SC B2 F 2005	0.92
FL Rec F 2000	FL B2 F 1993	0.91	GA/SC B2 F 2003	GA/SC B2 F 2005	0.93
FL Rec F 2001	FL B2 F 1993	0.91	GA/SC B2 F 2004	GA/SC B2 F 2005	0.93
FL Rec F 2002	FL B2 F 1993	0.91	FL Rec F 1999	GA/SC B2 F 2006	0.90
FL Rec F 2003	FL B2 F 1993	0.91	FL Rec F 2000	GA/SC B2 F 2006	0.90
FL Rec F 2004	FL B2 F 1993	0.92	FL Rec F 2001	GA/SC B2 F 2006	0.90
FL Rec F 2005	FL B2 F 1993	0.90	FL Rec F 2003	GA/SC B2 F 2006	0.90
FL Rec F 2006	FL B2 F 1993	0.92	FL Rec F 2004	GA/SC B2 F 2006	0.91
FL Rec F 2007	FL B2 F 1993	0.91	FL Rec F 2006	GA/SC B2 F 2006	0.91
FL Rec F 2008	FL B2 F 1993	0.91	FL Rec F 2007	GA/SC B2 F 2006	0.90
FL Rec F 2009	FL B2 F 1993	0.91	FL Rec F 2009	GA/SC B2 F 2006	0.90
FL Rec F 2010	FL B2 F 1993	0.91	FL Rec F 2010	GA/SC B2 F 2006	0.90
FL Rec F 2011	FL B2 F 1993	0.92	FL Rec F 2011	GA/SC B2 F 2006	0.91
FL Rec F 2012	FL B2 F 1993	0.91	FL Rec F 2012	GA/SC B2 F 2006	0.90

Parameter 1	Parameter 2	Correlation	Parameter 1	Parameter 2	Correlation
FL Rec F 2013	FL B2 F 1993	0.92	FL Rec F 2013	GA/SC B2 F 2006	0.91
FL Rec F 1992	FL B2 F 1994	0.91	FL B2 F 2004	GA/SC B2 F 2006	0.90
FL Rec F 1993	FL B2 F 1994	0.91	FL B2 F 2006	GA/SC B2 F 2006	0.91
FL Rec F 1994	FL B2 F 1994	0.92	FL B2 F 2007	GA/SC B2 F 2006	0.90
FL Rec F 1995	FL B2 F 1994	0.91	FL B2 F 2009	GA/SC B2 F 2006	0.91
FL Rec F 1997	FL B2 F 1994	0.90	FL B2 F 2010	GA/SC B2 F 2006	0.90
FL Rec F 1998	FL B2 F 1994	0.91	FL B2 F 2011	GA/SC B2 F 2006	0.90
FL Rec F 1999	FL B2 F 1994	0.92	FL B2 F 2012	GA/SC B2 F 2006	0.91
FL Rec F 2000	FL B2 F 1994	0.92	GA/SC B2 F 1994	GA/SC B2 F 2006	0.91
FL Rec F 2001	FL B2 F 1994	0.92	GA/SC B2 F 1998	GA/SC B2 F 2006	0.92
FL Rec F 2002	FL B2 F 1994	0.92	GA/SC B2 F 2000	GA/SC B2 F 2006	0.91
FL Rec F 2003	FL B2 F 1994	0.92	GA/SC B2 F 2001	GA/SC B2 F 2006	0.90
FL Rec F 2004	FL B2 F 1994	0.93	GA/SC B2 F 2002	GA/SC B2 F 2006	0.92
FL Rec F 2005	FL B2 F 1994	0.91	GA/SC B2 F 2003	GA/SC B2 F 2006	0.92
FL Rec F 2006	FL B2 F 1994	0.93	GA/SC B2 F 2004	GA/SC B2 F 2006	0.93
FL Rec F 2007	FL B2 F 1994	0.92	GA/SC B2 F 2005	GA/SC B2 F 2006	0.94
FL Rec F 2008	FL B2 F 1994	0.92	FL B2 F 2012	GA/SC B2 F 2007	0.90
FL Rec F 2009	FL B2 F 1994	0.92	GA/SC B2 F 1994	GA/SC B2 F 2007	0.91
FL Rec F 2010	FL B2 F 1994	0.92	GA/SC B2 F 1998	GA/SC B2 F 2007	0.92
FL Rec F 2011	FL B2 F 1994	0.93	GA/SC B2 F 2000	GA/SC B2 F 2007	0.91
FL Rec F 2012	FL B2 F 1994	0.92	GA/SC B2 F 2001	GA/SC B2 F 2007	0.90
FL Rec F 2013	FL B2 F 1994	0.93	GA/SC B2 F 2002	GA/SC B2 F 2007	0.92
SC Rec F 2009	FL B2 F 1994	0.90	GA/SC B2 F 2003	GA/SC B2 F 2007	0.93
SC Rec F 2010	FL B2 F 1994	0.91	GA/SC B2 F 2004	GA/SC B2 F 2007	0.93
SC Rec F 2011	FL B2 F 1994	0.91	GA/SC B2 F 2005	GA/SC B2 F 2007	0.93
SC Rec F 2013	FL B2 F 1994	0.90	GA/SC B2 F 2006	GA/SC B2 F 2007	0.93
FL Rec F 1992	FL B2 F 1995	0.92	GA/SC B2 F 1994	GA/SC B2 F 2008	0.90
FL Rec F 1993	FL B2 F 1995	0.92	GA/SC B2 F 1998	GA/SC B2 F 2008	0.91
FL Rec F 1994	FL B2 F 1995	0.93	GA/SC B2 F 2002	GA/SC B2 F 2008	0.91
FL Rec F 1995	FL B2 F 1995	0.92	GA/SC B2 F 2003	GA/SC B2 F 2008	0.92
FL Rec F 1997	FL B2 F 1995	0.92	GA/SC B2 F 2004	GA/SC B2 F 2008	0.92
FL Rec F 1998	FL B2 F 1995	0.92	GA/SC B2 F 2005	GA/SC B2 F 2008	0.93
FL Rec F 1999	FL B2 F 1995	0.93	GA/SC B2 F 2006	GA/SC B2 F 2008	0.92
FL Rec F 2000	FL B2 F 1995	0.93	GA/SC B2 F 2007	GA/SC B2 F 2008	0.92
FL Rec F 2001	FL B2 F 1995	0.93	GA/SC B2 F 1992	GA/SC B2 F 2009	0.90
FL Rec F 2002	FL B2 F 1995	0.93	GA/SC B2 F 1994	GA/SC B2 F 2009	0.91
FL Rec F 2003	FL B2 F 1995	0.93	GA/SC B2 F 1998	GA/SC B2 F 2009	0.92
FL Rec F 2004	FL B2 F 1995	0.94	GA/SC B2 F 2000	GA/SC B2 F 2009	0.91
FL Rec F 2005	FL B2 F 1995	0.92	GA/SC B2 F 2001	GA/SC B2 F 2009	0.90
FL Rec F 2006	FL B2 F 1995	0.94	GA/SC B2 F 2002	GA/SC B2 F 2009	0.92
FL Rec F 2007	FL B2 F 1995	0.93	GA/SC B2 F 2003	GA/SC B2 F 2009	0.93
FL Rec F 2008	FL B2 F 1995	0.93	GA/SC B2 F 2004	GA/SC B2 F 2009	0.93
FL Rec F 2009	FL B2 F 1995	0.93	GA/SC B2 F 2005	GA/SC B2 F 2009	0.94
FL Rec F 2010	FL B2 F 1995	0.93	GA/SC B2 F 2006	GA/SC B2 F 2009	0.93
FL Rec F 2011	FL B2 F 1995	0.94	GA/SC B2 F 2007	GA/SC B2 F 2009	0.93
FL Rec F 2012	FL B2 F 1995	0.93	GA/SC B2 F 2008	GA/SC B2 F 2009	0.93
FL Rec F 2013	FL B2 F 1995	0.94	GA/SC B2 F 1992	GA/SC B2 F 2010	0.91
GA Rec F 1992	FL B2 F 1995	0.91	GA/SC B2 F 1994	GA/SC B2 F 2010	0.91
GA Rec F 2003	FL B2 F 1995	0.91	GA/SC B2 F 1995	GA/SC B2 F 2010	0.90
GA Rec F 2008	FL B2 F 1995	0.90	GA/SC B2 F 1998	GA/SC B2 F 2010	0.92
SC Rec F 1992	FL B2 F 1995	0.90	GA/SC B2 F 2000	GA/SC B2 F 2010	0.91
SC Rec F 1998	FL B2 F 1995	0.90	GA/SC B2 F 2001	GA/SC B2 F 2010	0.91
SC Rec F 2004	FL B2 F 1995	0.90	GA/SC B2 F 2002	GA/SC B2 F 2010	0.93
SC Rec F 2009	FL B2 F 1995	0.91	GA/SC B2 F 2003	GA/SC B2 F 2010	0.93
SC Rec F 2010	FL B2 F 1995	0.92	GA/SC B2 F 2004	GA/SC B2 F 2010	0.93

Parameter 1	Parameter 2	Correlation	Parameter 1	Parameter 2	Correlation
SC Rec F 2011	FL B2 F 1995	0.92	GA/SC B2 F 2005	GA/SC B2 F 2010	0.94
SC Rec F 2013	FL B2 F 1995	0.91	GA/SC B2 F 2006	GA/SC B2 F 2010	0.94
FL B2 F 1994	FL B2 F 1995	0.91	GA/SC B2 F 2007	GA/SC B2 F 2010	0.94
FL Rec F 1992	FL B2 F 1996	0.92	GA/SC B2 F 2008	GA/SC B2 F 2010	0.93
FL Rec F 1993	FL B2 F 1996	0.92	GA/SC B2 F 2009	GA/SC B2 F 2010	0.94
FL Rec F 1994	FL B2 F 1996	0.93	FL Rec F 2000	GA/SC B2 F 2011	0.90
FL Rec F 1995	FL B2 F 1996	0.92	FL Rec F 2001	GA/SC B2 F 2011	0.90
FL Rec F 1997	FL B2 F 1996	0.92	FL Rec F 2004	GA/SC B2 F 2011	0.90
FL Rec F 1998	FL B2 F 1996	0.93	FL Rec F 2006	GA/SC B2 F 2011	0.90
FL Rec F 1999	FL B2 F 1996	0.93	FL Rec F 2007	GA/SC B2 F 2011	0.90
FL Rec F 2000	FL B2 F 1996	0.94	FL Rec F 2009	GA/SC B2 F 2011	0.90
FL Rec F 2001	FL B2 F 1996	0.94	FL Rec F 2010	GA/SC B2 F 2011	0.90
FL Rec F 2002	FL B2 F 1996	0.93	FL Rec F 2011	GA/SC B2 F 2011	0.91
FL Rec F 2003	FL B2 F 1996	0.93	FL Rec F 2012	GA/SC B2 F 2011	0.90
FL Rec F 2004	FL B2 F 1996	0.94	FL Rec F 2013	GA/SC B2 F 2011	0.91
FL Rec F 2005	FL B2 F 1996	0.93	FL B2 F 2006	GA/SC B2 F 2011	0.90
FL Rec F 2006	FL B2 F 1996	0.94	FL B2 F 2009	GA/SC B2 F 2011	0.91
FL Rec F 2007	FL B2 F 1996	0.94	FL B2 F 2010	GA/SC B2 F 2011	0.90
FL Rec F 2008	FL B2 F 1996	0.93	FL B2 F 2012	GA/SC B2 F 2011	0.91
FL Rec F 2009	FL B2 F 1996	0.94	GA/SC B2 F 1992	GA/SC B2 F 2011	0.91
FL Rec F 2010	FL B2 F 1996	0.93	GA/SC B2 F 1994	GA/SC B2 F 2011	0.92
FL Rec F 2011	FL B2 F 1996	0.94	GA/SC B2 F 1995	GA/SC B2 F 2011	0.90
FL Rec F 2012	FL B2 F 1996	0.93	GA/SC B2 F 1998	GA/SC B2 F 2011	0.93
FL Rec F 2013	FL B2 F 1996	0.94	GA/SC B2 F 1999	GA/SC B2 F 2011	0.90
GA Rec F 1992	FL B2 F 1996	0.91	GA/SC B2 F 2000	GA/SC B2 F 2011	0.92
GA Rec F 1993	FL B2 F 1996	0.90	GA/SC B2 F 2001	GA/SC B2 F 2011	0.91
GA Rec F 2003	FL B2 F 1996	0.91	GA/SC B2 F 2002	GA/SC B2 F 2011	0.93
GA Rec F 2005	FL B2 F 1996	0.90	GA/SC B2 F 2003	GA/SC B2 F 2011	0.93
GA Rec F 2008	FL B2 F 1996	0.91	GA/SC B2 F 2004	GA/SC B2 F 2011	0.94
SC Rec F 1992	FL B2 F 1996	0.90	GA/SC B2 F 2005	GA/SC B2 F 2011	0.95
SC Rec F 1998	FL B2 F 1996	0.90	GA/SC B2 F 2006	GA/SC B2 F 2011	0.94
SC Rec F 2004	FL B2 F 1996	0.91	GA/SC B2 F 2007	GA/SC B2 F 2011	0.94
SC Rec F 2005	FL B2 F 1996	0.90	GA/SC B2 F 2008	GA/SC B2 F 2011	0.93
SC Rec F 2009	FL B2 F 1996	0.91	GA/SC B2 F 2009	GA/SC B2 F 2011	0.94
SC Rec F 2010	FL B2 F 1996	0.92	GA/SC B2 F 2010	GA/SC B2 F 2011	0.95
SC Rec F 2011	FL B2 F 1996	0.92	FL Rec F 1992	GA/SC B2 F 2012	0.92
SC Rec F 2013	FL B2 F 1996	0.92	FL Rec F 1993	GA/SC B2 F 2012	0.92
FL B2 F 1992	FL B2 F 1996	0.90	FL Rec F 1994	GA/SC B2 F 2012	0.92
FL B2 F 1994	FL B2 F 1996	0.91	FL Rec F 1995	GA/SC B2 F 2012	0.92
FL B2 F 1995	FL B2 F 1996	0.92	FL Rec F 1997	GA/SC B2 F 2012	0.91
FL Rec F 1992	FL B2 F 1997	0.92	FL Rec F 1998	GA/SC B2 F 2012	0.92
FL Rec F 1993	FL B2 F 1997	0.92	FL Rec F 1999	GA/SC B2 F 2012	0.93
FL Rec F 1994	FL B2 F 1997	0.93	FL Rec F 2000	GA/SC B2 F 2012	0.93
FL Rec F 1995	FL B2 F 1997	0.92	FL Rec F 2001	GA/SC B2 F 2012	0.93
FL Rec F 1997	FL B2 F 1997	0.91	FL Rec F 2002	GA/SC B2 F 2012	0.93
FL Rec F 1998	FL B2 F 1997	0.93	FL Rec F 2003	GA/SC B2 F 2012	0.93
FL Rec F 1999	FL B2 F 1997	0.93	FL Rec F 2004	GA/SC B2 F 2012	0.93
FL Rec F 2000	FL B2 F 1997	0.93	FL Rec F 2005	GA/SC B2 F 2012	0.92
FL Rec F 2001	FL B2 F 1997	0.93	FL Rec F 2006	GA/SC B2 F 2012	0.93
FL Rec F 2002	FL B2 F 1997	0.93	FL Rec F 2007	GA/SC B2 F 2012	0.93
FL Rec F 2003	FL B2 F 1997	0.93	FL Rec F 2008	GA/SC B2 F 2012	0.92
FL Rec F 2004	FL B2 F 1997	0.94	FL Rec F 2009	GA/SC B2 F 2012	0.93
FL Rec F 2005	FL B2 F 1997	0.92	FL Rec F 2010	GA/SC B2 F 2012	0.93
FL Rec F 2006	FL B2 F 1997	0.94	FL Rec F 2011	GA/SC B2 F 2012	0.94
FL Rec F 2007	FL B2 F 1997	0.93	FL Rec F 2012	GA/SC B2 F 2012	0.93

Parameter 1	Parameter 2	Correlation	Parameter 1	Parameter 2	Correlation
FL Rec F 2008	FL B2 F 1997	0.93	FL Rec F 2013	GA/SC B2 F 2012	0.94
FL Rec F 2009	FL B2 F 1997	0.93	GA Rec F 1992	GA/SC B2 F 2012	0.90
FL Rec F 2010	FL B2 F 1997	0.93	GA Rec F 2003	GA/SC B2 F 2012	0.90
FL Rec F 2011	FL B2 F 1997	0.94	GA Rec F 2008	GA/SC B2 F 2012	0.90
FL Rec F 2012	FL B2 F 1997	0.93	SC Rec F 2004	GA/SC B2 F 2012	0.90
FL Rec F 2013	FL B2 F 1997	0.94	SC Rec F 2009	GA/SC B2 F 2012	0.91
GA Rec F 1992	FL B2 F 1997	0.91	SC Rec F 2010	GA/SC B2 F 2012	0.91
GA Rec F 2003	FL B2 F 1997	0.91	SC Rec F 2011	GA/SC B2 F 2012	0.92
GA Rec F 2008	FL B2 F 1997	0.90	SC Rec F 2013	GA/SC B2 F 2012	0.91
SC Rec F 1992	FL B2 F 1997	0.90	FL B2 F 1994	GA/SC B2 F 2012	0.90
SC Rec F 1998	FL B2 F 1997	0.90	FL B2 F 1995	GA/SC B2 F 2012	0.91
SC Rec F 2004	FL B2 F 1997	0.90	FL B2 F 1996	GA/SC B2 F 2012	0.91
SC Rec F 2009	FL B2 F 1997	0.91	FL B2 F 1997	GA/SC B2 F 2012	0.91
SC Rec F 2010	FL B2 F 1997	0.92	FL B2 F 1998	GA/SC B2 F 2012	0.92
SC Rec F 2011	FL B2 F 1997	0.92	FL B2 F 1999	GA/SC B2 F 2012	0.92
SC Rec F 2013	FL B2 F 1997	0.91	FL B2 F 2000	GA/SC B2 F 2012	0.93
FL B2 F 1994	FL B2 F 1997	0.91	FL B2 F 2001	GA/SC B2 F 2012	0.93
FL B2 F 1995	FL B2 F 1997	0.92	FL B2 F 2002	GA/SC B2 F 2012	0.91
FL B2 F 1996	FL B2 F 1997	0.92	FL B2 F 2003	GA/SC B2 F 2012	0.92
FL Rec F 1991	FL B2 F 1998	0.90	FL B2 F 2004	GA/SC B2 F 2012	0.93
FL Rec F 1992	FL B2 F 1998	0.93	FL B2 F 2005	GA/SC B2 F 2012	0.91
FL Rec F 1993	FL B2 F 1998	0.93	FL B2 F 2006	GA/SC B2 F 2012	0.93
FL Rec F 1994	FL B2 F 1998	0.94	FL B2 F 2007	GA/SC B2 F 2012	0.93
FL Rec F 1995	FL B2 F 1998	0.93	FL B2 F 2008	GA/SC B2 F 2012	0.92
FL Rec F 1997	FL B2 F 1998	0.92	FL B2 F 2009	GA/SC B2 F 2012	0.94
FL Rec F 1998	FL B2 F 1998	0.93	FL B2 F 2010	GA/SC B2 F 2012	0.93
FL Rec F 1999	FL B2 F 1998	0.94	FL B2 F 2011	GA/SC B2 F 2012	0.93
FL Rec F 2000	FL B2 F 1998	0.94	FL B2 F 2012	GA/SC B2 F 2012	0.94
FL Rec F 2001	FL B2 F 1998	0.94	FL B2 F 2013	GA/SC B2 F 2012	0.92
FL Rec F 2002	FL B2 F 1998	0.94	GA/SC B2 F 1992	GA/SC B2 F 2012	0.91
FL Rec F 2003	FL B2 F 1998	0.94	GA/SC B2 F 1994	GA/SC B2 F 2012	0.92
FL Rec F 2004	FL B2 F 1998	0.94	GA/SC B2 F 1995	GA/SC B2 F 2012	0.90
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FL Rec F 2006	FL B2 F 1998	0.94	GA/SC B2 F 1998	GA/SC B2 F 2012	0.94
FL Rec F 2007	FL B2 F 1998	0.94	GA/SC B2 F 1999	GA/SC B2 F 2012	0.91
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GA Rec F 2002	FL B2 F 1998	0.90	GA/SC B2 F 2009	GA/SC B2 F 2012	0.95
GA Rec F 2003	FL B2 F 1998	0.91	GA/SC B2 F 2010	GA/SC B2 F 2012	0.95
GA Rec F 2005	FL B2 F 1998	0.91	GA/SC B2 F 2011	GA/SC B2 F 2012	0.96
GA Rec F 2008	FL B2 F 1998	0.91	FL Rec F 2004	GA/SC B2 F 2013	0.90
GA Rec F 2009	FL B2 F 1998	0.90	FL Rec F 2006	GA/SC B2 F 2013	0.90
GA Rec F 2013	FL B2 F 1998	0.90	FL Rec F 2011	GA/SC B2 F 2013	0.90
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SC Rec F 1997	FL B2 F 1998	0.90	FL B2 F 2006	GA/SC B2 F 2013	0.90
SC Rec F 1998	FL B2 F 1998	0.91	FL B2 F 2009	GA/SC B2 F 2013	0.90
SC Rec F 2004	FL B2 F 1998	0.91	FL B2 F 2012	GA/SC B2 F 2013	0.91
SC Rec F 2005	FL B2 F 1998	0.91	GA/SC B2 F 1992	GA/SC B2 F 2013	0.91

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SC Rec F 2010	FL B2 F 1998	0.93	GA/SC B2 F 1998	GA/SC B2 F 2013	0.92
SC Rec F 2011	FL B2 F 1998	0.92	GA/SC B2 F 1999	GA/SC B2 F 2013	0.90
SC Rec F 2013	FL B2 F 1998	0.92	GA/SC B2 F 2000	GA/SC B2 F 2013	0.91
FL B2 F 1992	FL B2 F 1998	0.91	GA/SC B2 F 2001	GA/SC B2 F 2013	0.91
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FL B2 F 1994	FL B2 F 1998	0.91	GA/SC B2 F 2003	GA/SC B2 F 2013	0.93
FL B2 F 1995	FL B2 F 1998	0.92	GA/SC B2 F 2004	GA/SC B2 F 2013	0.94
FL B2 F 1996	FL B2 F 1998	0.92	GA/SC B2 F 2005	GA/SC B2 F 2013	0.94
FL B2 F 1997	FL B2 F 1998	0.92	GA/SC B2 F 2006	GA/SC B2 F 2013	0.94
FL Rec F 1991	FL B2 F 1999	0.91	GA/SC B2 F 2007	GA/SC B2 F 2013	0.94
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GA Rec F 2003	FL B2 F 1999	0.92	FL Rec F 2013	Recruit 1989	-0.93
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GA Rec F 2013	FL B2 F 1999	0.91	SC Rec F 2011	Recruit 1989	-0.91
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SC Rec F 1998	FL B2 F 1999	0.91	FL B2 F 1996	Recruit 1989	-0.91
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Atlantic States Marine Fisheries Commission

Atlantic Red Drum Stock Assessment

Review Panel Report of the Statistical Catch-at-Age Model

Dr. Paul Rago and Dr. Matthew Cieri (Reviewers)

January 2017

Acknowledgements
The review panel thanks members of the Red Drum Assessment Team (AT) and the many different scientists associated with preparation of the assessment reports we have reviewed. The previous reviewers for SEDAR 44 are also thanked for their lucid summaries. Finally we thank the ASMFC staff for their guidance and support, particularly for initiating a webinar meeting with members of the AT in December 2016.

Executive Summary

Overall the Statistical Catch-at-Age Stock Assessment Report and the SEDAR 44 Data Workshop Report together have met each of the terms of reference. The AT performed their work well, especially given the difficulties red drum life-history and exploitation patterns create for stock assessment analyses.

Examination of the assessment results, as well as corroborating information from the independent indices, suggest that both the Northern and Southern stocks appear to be above their management targets and limits as approved in the FMP.

However, there is a high degree of uncertainty associated with these assessments. The lack of good fishery-dependent and -independent data on the oldest and most fecund age classes, coupled with sensitivity to weightings and initial conditions suggest an overall scaling problem with both regions' assessments. The wide confidence limits in the South and the unrealistic decline in abundance over the time series in the North suggest fundamental assessment and data issues. Given the life-history and pattern of exploitation, it is unclear how these issues can be easily resolved. Certainly further work, as outlined below and highlighted by the AT, is needed.

Given the critical dependency of overfishing status determination on the F estimates for older fish, and the difficulties of estimating F when population size is indeterminate, the assessment only gives a rough measure of stock status. While there are no major signals to suggest the stocks are in trouble, it should be recognized that even small changes in the fishing mortality on age 5 and older fish could lead to rapid overfishing.

Theoretically, the Spawning Potential Ratio (SPR) analysis measures exploitation in an equilibrium context. By that measure, a small increase in F on older fish would lead to an immediate determination of overfishing. In practice, the stock dynamics would depend on the true population size of older fish. Since population size is highly uncertain, and in the North equilibrium is highly improbable, any management changes should be carefully considered. More specifically, measures that might increase fishing mortality rates on older fish should be avoided until the estimates can be verified. Moreover, the assessment cannot provide information on the potential population limits for recruitment failure as scale of the most fecund portion of the population is uncertain.

As a final note, it is important to recognize that the same concerns that were identified with the SS3 model formulation underlie the application of SCA models to the stocks. Despite its nominally less complex analytical structure, the data conflicts and instability of estimates remain in SCA, as in SS3 formulations. These issues would likewise confound any age structured modeling approach. It suggests that the overall problem is one of data and the pattern of exploitation which informs model approaches, rather than the approach itself.

Nonetheless, the SEDAR 44 recommendations to work from a simple model and gradually increase complexity remain valid. Such a process is in and of itself, a major task as model identification relies heavily on deeper insights developed over years of experience by the lead data and assessment analysts. Moreover, there is no guarantee that such a process can derive an optimal model if the underlying causes cannot be identified. More often than not, the problems lie in the data themselves. By that measure the AT and other groups assessing red drum are well poised to move forward because they have a strong understanding of the underlying data.

Evaluation of Terms of Reference (TOR)

1. Evaluate the thoroughness of data collection and the presentation and treatment of fishery-dependent and fishery-independent data in the assessment, including the following but not limited to:

a. Presentation of data source variance (e.g., standard errors).

The assessment team did an excellent job of summarizing the available data and characterizing the underlying sources of uncertainty. Methods for estimating sampling variance followed accepted methods. For major programs, such as the MRIP, measures of uncertainty followed estimates obtained from official sources. Differences often exist between sample variances and variances implied as data are used in analytical models. These differences are often expressed as "effective sample size". The authors used modern and accepted methods for estimating effective sampling size. It should be noted that these methods (e.g., the Francis method) are conditional on the analytical model used and the data ensemble included in it. Thus, these approaches are objective methods for subjectively estimating the information content of data.

b. Justification for inclusion or elimination of available data sources

The SEDAR 44 Data Workshop Report provided extraordinary details on the advantages and limitations of available data sets. One important feature of their data analyses was development of objective approaches for looking for both internal and external consistency with other data sources. Testing for the ability to follow a year class over multiple years is especially useful for eliminating indices that may be tracking availability to the sampling area rather than true abundance. We affirm the conclusions of the SEDAR panel that the process for reducing the 23 indices for the Northern stock to 5 indices and the 25 indices to 11 for the Southern stock was well done.

The general premise that data sets with "some information" should be included to improve model fit should be applied with caution. Adding marginally informative data streams can increase uncertainty of parameter estimates, as weighting of data sources ultimately undermines the application of likelihood theory in the model and is often ad hoc. This concern is not restricted to the red drum assessment and is in fact, commonly applied in fisheries assessments. While additional data streams can stabilize model performance and improve determination of status, it incurs a cost of stretching the underlying theory and underestimating the uncertainty of the results.

c. Consideration of data strengths and weaknesses (e.g., temporal and spatial scale, gear selectivities, aging accuracy, sample size)

As noted above, the AT conducted a detailed evaluation of the myriad data sets available. For the purposes of the SCA assessment, no major changes in data sources or indices estimation occurred. This is consistent with the Terms of Reference given to the AT.

d. Calculation and/or standardization of abundance indices

The analyses of the MRIP data to develop species clusters to improve estimation of the likely trips for red drum by Murphy (SEDAR44-DW12) was novel, thorough, and well done.

Assembling region or state specific abundance indices for smaller and younger fish into a coherent measure of trend is a vexing problem for many assessments of coastal stocks on the East Coast. Habitat, sampling design, and gear differences among indices are compounded by inter-annual variations in availability. Fig. 5.7.4 (pg. 139 in SEDAR 44 report) provides an excellent illustration of this challenge.

e. Estimation of discards and size composition of discards.

One potential concern is the use of the ratio estimator to hindcast historical discards. While this is an appropriate approach given the lack of data, these estimates will likely be sensitive to changes in management. Other than a cautious note about discards, this term of reference was handled very well by the AT via the Data Workshop.

2. Evaluate the definition of stock structure used in the assessment. Is the definition appropriate given the biology and management of red drum?

Stock structure decisions in stock assessments always reflect a mixture of biological and management considerations. Practical considerations such as differences among fleets, user groups, or jurisdictions among areas often are equally important or supersede purely biological determinations. For red drum there appears to be sufficient evidence of a genetic difference between the Northern and Southern stocks. Life history differences also support the genetic distinction. Fortuitously, the boundary also corresponds to changes in ecosystems and management jurisdictions near North Carolina. Mixing of stocks in this area is common for many species owing to its oceanographic conditions. Such localized mixing is relatively unimportant for stock assessments, but should be recognized.

3. Evaluate the methods and models used to estimate population parameters (e.g., F, biomass, abundance) and biological reference points, including but not limited to:

a. ***Evaluate the choice and justification of the preferred model(s). Was the most appropriate model (or model averaging approach) chosen given available data and life history of red drum?***

The AT did an excellent job of evaluating alternative hypotheses. The approach was rigorous and well executed. Within the constraints of using the SCA model and not altering its configuration drastically, the authors rendered multiple hypotheses into a manageable subset and then examined the joint effects of multiple data weightings. Methods for consideration of alternative data weighting schemes for each stock (Tables 9 and 10) and the results (Tables 11 and 21) are exceptionally lucid and well crafted.

The AT also addressed key life history information appropriately for each stock. Differences in maturation rates, natural mortality, longevity, and growth are well described. How adjacent stocks could have such dramatically different population trajectories, as implied by the model fits, received less attention from the AT. Seeking model formulations that are more consistent with each other could help improve the overall fit of both models.

One possible avenue for future exploration would be to examine a model that can fit both age and length composition data, similar to what was recently developed for Cobia using the Beaufort Assessment Model (BAM). Care would need to be taken however to ensure that appropriate weightings were given in the likelihood profile to ensure that undo weights were not assigned to the catch data.

b. Evaluate model parameterization and specification (e.g., choice of CVs, effective sample sizes, likelihood weighting schemes, calculation/specification of M, stock-recruitment relationship, choice of time-varying parameters, plus group treatment).

A critical, if not *the* critical assumption, in the modeling process is the implementation of domed shaped stock-recruitment relationship. As a result, the assessment model consists of two independent populations; an immature but heavily exploited younger group, and a reproductive but minimally exploited plus group. The plus group is essentially unbounded, as catches of fish older than age 6 are uncommon or low. When parametric selectivity curves are employed, the modeled F approaches zero, so that the dynamics of the plus group are governed almost entirely by the assumed level of F of those ages. This is clearly seen in the estimation of age 7+ group in the Northern Stock. Differences between the model estimates and a simple exponential decay curve can be demonstrated, as shown in the following section.

In the Southern Stock the plus group seems to be more consistent with the population biology. For both stocks however, the abundances of age 7+ red drum are very high. This leads to a large fraction of total biomass being essentially static and unavailable to exploitation.

Overall, the externally estimated parameters were handled well. One possible suggestion for natural mortality, in future work, would be to examine Charnov et al. (2013) which examined the descending trend of M at age in light of maturation, as opposed to survival at maximum age (which can be difficult in exploited populations).

Most importantly, the inability to establish scale (i.e., population abundance) in the model outputs is a major problem for the assessment. In theory the rate of change in abundance indices by age class can inform F estimates. It is not clear how much of the F estimate is reliant on the age compositions vs. the relationship between total catches and relative abundance indices. The best model fit for the Northern Stock fully weights the information for the tag based info, the indices of abundance, and total catch, and down weights the recreational age composition relative to the commercial fishery (Table 11). In contrast, the best model for the Southern Stock does not distinguish between the weighting on total catch for commercial and recreational, places a high weight on the MRIP relative abundance index, and also down weights the age composition of live release recreational catch.

4. Evaluate the diagnostic analyses performed, including but not limited to:

a. Sensitivity analyses to determine model stability and potential consequences of major model assumptions.

The model is highly sensitive to weightings applied to various likelihood components. Generally such sensitivity is symptomatic of conflicting information within the model wherein abundance indices suggest a pattern inconsistent with total catch or age/length compositions. Neither catch time series nor survey indices reveal high abundances of large fish. This leads to estimation of a dome shaped selectivity pattern wherein the size of the population in the plus group is essentially unverifiable. One might call such populations cryptic. This would be merely an intellectual curiosity if it were not a critical component of status determination.

If this were not an "intermediate" assessment, more could be done to explore model performance. Likelihood profile analyses would be helpful for several parameters. An important starting point would be the age-specific F estimates. Given the importance of the estimated F on the oldest fish, it would be valuable to conduct a profile analysis of estimated F for each stock. Such an approach might reveal a broader confidence interval than suggested by the asymptotic errors. More importantly, profile analysis would be valuable to examine the effects on population size and SPR for each fixed value of F in the likelihood profile. The multi-fleet structure of the SCA model might make this computation more difficult because aggregate age specific F is a composite estimate of commercial and recreational fleets. We defer to the lead analysts on how best to implement a reasonable approach.

Further examination of simple parametric relationships for the calculation of SPR would also be useful. A sensitivity analysis of SPR to F on the oldest ages is shown below. At low Fs, SPR reference points will be highly sensitive to the implied biomass in the plus groups. To illustrate this effect, the biomass in the plus group to the total population at equilibrium can be estimated from the parameters for the sSPR.

One effect of the domed-selectivity pattern in the Northern Stock is that the dynamics of the plus group are essentially uncoupled from the age 1 to 4 red drum. A simple illustration of this effect can be demonstrated by noting the trajectory of the plus group from 1989 to 2013. In the model estimates the trajectory is

Model based 7+ Abundance estimate in 1989 =13,962,773; abundance in 2013 = 3,592,926 (Table 13, p. 32).
The annual instantaneous rate of change Z = -ln(3592926/13962773)/(2013-1989)=0.06.

Using this, one can compute the predicted population size for the 7+ group as

N7+_pred(1990)=N7+_model(1989)*exp(-0.06)
….
N7+_pred(t+1)=N7+_pred(t)*exp(-0.06)

This synthetic trajectory, which excludes the effect of recruitment of age 6 fish to the 7+ group, looks surprisingly similar to the actual model predictions shown in Figure 1.

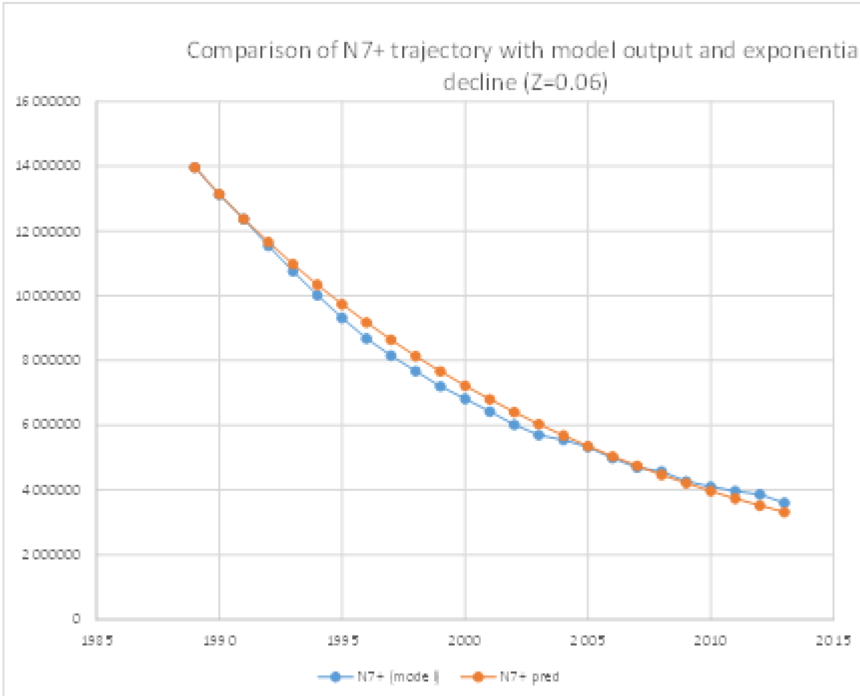

Figure 1. Comparison of SCA model output (blue dots) with predicted estimate based on simple exponential decay of the 1989 abundance estimate at Z=0.06.

This suggests that the exponential decline in 7+ is consistent with a total Z of about 0.06 which is the value used for M in the North. F on 7+ fish is minimal throughout the time series. Incoming recruitment of age 6 fish has relatively little influence on the trajectory but there is some improvement after 2010 as age 6 fish began to increase. The numerical fraction of the plus group to the total population ranges from 96% in 1989 to 62% in 2013. In contrast, the Southern Stock fluctuates around 39% without trend. The expected fraction of a population above 6 years old in a population with Z=0.06 is 0.69. This is just the sum N(a) from a=7 to 62 divided by sum N(a) from a=1 to 62. Hence the average fraction of the population in the 7+ (2011-2013) of 66% is about equal to that expected in an equilibrium population.

Another way of examining the “uncoupling” effect is to consider the ratio of the population numbers in the plus group to the average numbers of recruits (i.e., age 6) to the plus group. In 1989, for the Northern Stock the ratio of the plus group to average age 6 is 132.8. By 2013, this ratio decreases to 34.2. The overall ratio across all years is 69.5. If these numbers are true it would suggest that the initial plus group size is the consequence of a much higher historical average recruitment. Since that hypothetical epoch the stock must have had a reduced recruitment stanza. An alternative hypothesis to the dome is that the larger fish have died.

In contrast, the Southern Stock relationship between the size of the plus group and age 6 recruits reveals an overall ratio of 6.8 and a slightly increasing trend from 1989 (4.1) to 2013 (7.4). Such a pattern is more consistent with the underlying biology and the hypothesized efficacy of management measures. It is difficult to develop a plausible explanation for these differences between stocks. While the model estimates for the Southern Stock are less precise, they have, at least by this metric, greater biological plausibility.

While the above analysis is preliminary it highlights a major concern; that the abundance estimate for age 7+ in the Northern Stock in 1989 is probably an artifact. The model estimates a very high initial population which allows it to minimize the differences between observed and predicted catches, and reduce the effects of incoming recruitment on the subsequent stock dynamics.

Comparison between the estimate of SPR in the SEDAR 18 formulation and the base model reveals large differences in Figure 2 (i.e., Figure 14 from the Assessment Report).

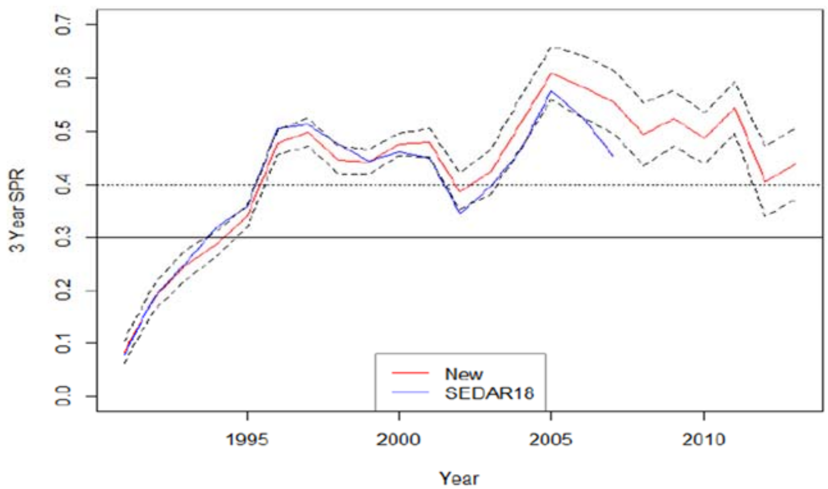

Figure 14. Three year average sSPR for the northern stock with 95% confidence intervals from asymptotic standard errors. Point estimates from the previous benchmark assessment (SEDAR18) are included for comparison. The target sSPR (dashed black line) is 40% and the threshold sSPR (solid black line) is 30%.

Figure 2. Taken from the assessment report.

This suggest that cumulative changes in the SCA assessment vs. SEDAR 18 have had a large impact on the population's trajectory. Given this and if there is time, a full continuity run, or an update of the previous model approach through 2014, is suggested. This would highlight the potential uncertainty for managers.

b. Retrospective analysis

The retrospective pattern in the assessment is particularly interesting as it reveals an apparent bifurcation of estimates with the 2010 peel in the Northern Stock and 2012 and earlier peels in the Southern Stock (Figure 3 and 4) (i.e., Figures 16 and 35, respectively, from the Assessment Report). Because these changes must be due to changes in F, it would be useful to examine the changes in age-specific F estimates for each stock.

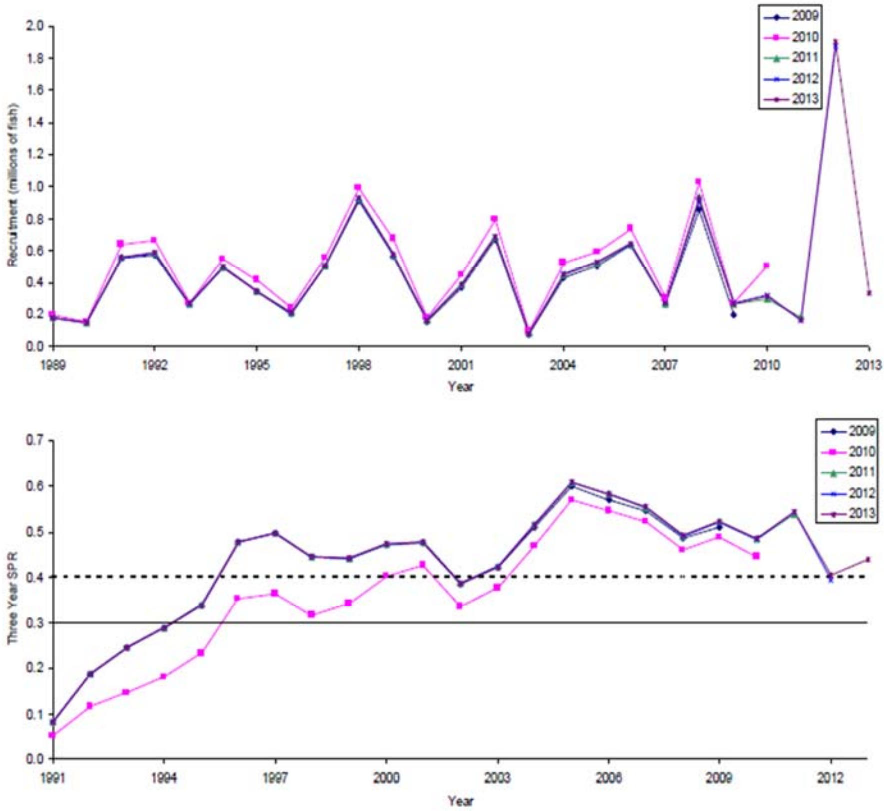

Figure 16. Five year retrospective analysis of the recruitment (top) and three year average sSPR (bottom) for the northern stock.

Figure 3. Taken from the assessment report.

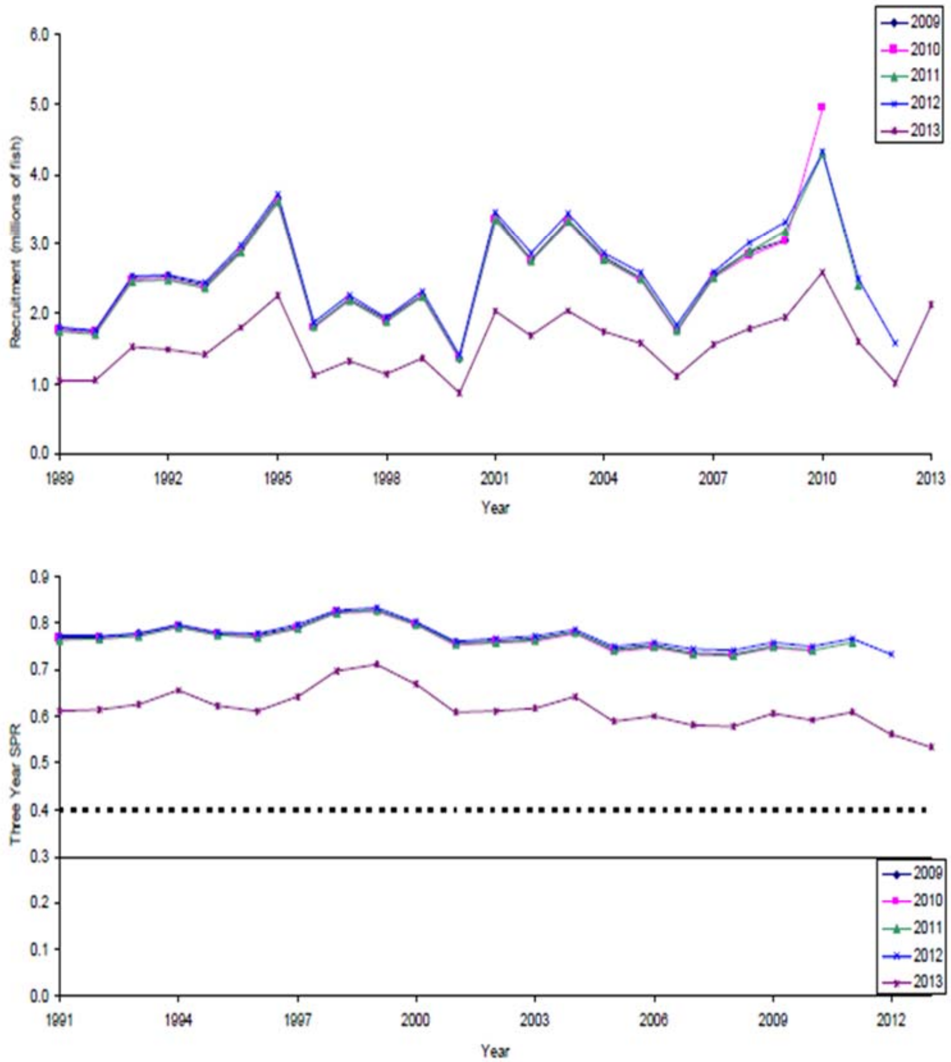

Figure 35. Five year retrospective analysis of the recruitment (top) and three year average sSPR (bottom) for the southern stock.

Figure 4. Taken from the assessment report.

The pattern in the North again highlights the sensitivity of the plus group to changes in the data, particularly with the 2010 peel. This can have implications on potential reference points. For the South, an explanation of the 2013 peel is warranted but again highlights the difficulty the SCA model has in defining population scale appropriately. In both stocks the sensitivity analyses suggest that scale is sensitive to assumptions, and poorly defined.

5. Evaluate the methods used to characterize uncertainty in estimated parameters. Ensure that the implications of uncertainty in technical conclusions are clearly stated.

The AT provides estimates of key parameters using asymptotic errors for all and MCMC for some. Both measures of uncertainty probably underestimate the true variance, as acknowledged by the AT.

The high correlation among parameters is expected given the relatively high apparent ratio of parameters to data. It is not clear why 0.9 is chosen as a cutoff for presentation. As a general consideration, it would be helpful to develop some functional equivalents to "condition indices", a metric used in general linear models to identify poorly specified models. Condition indices are functions of the eigen values and vectors of the design matrix.

6. Recommend best estimates of exploitation from the assessment for use in management, if possible, or specify alternative estimation methods.

Increasing trends in several indices suggests management measures may be working. However, the conclusion that stocks are above B_{msy}, or proxies, are tenuous given initial condition effects on plus groups. In the North this suggests that age 4+ abundance is declining throughout the time series. Overall, both stocks appear to be above management targets and limits, though the wide confidence intervals in the South, as well as model performance, suggest a higher degree of uncertainty surrounding stock status.

A relative F approach, though simplistic, may be more useful for examining trends given the model's inability to rectify scale. This approach would examine the ratio of catch to some function of the time series of relative abundance indices and could be either year-specific, or calculated as a moving average.

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

A possible alternative is to look at cohort specific SPR. This would limit overfishing definition to completed cohorts from 1989 to 2009. Estimates for cohorts from 2010 to 2013 could be obtained by assuming that the Fs estimated for 2013 continue onward for those cohorts.

The reference points as a whole would benefit from further testing. Static SPR is useful for measuring overfishing but its implementation is compromised by the same factors that led to rejection of biomass determination. If biomass and abundance estimates are unreliable due to problems in resolving scale, one cannot then conclude that the F estimates are reliable. This occurs because the catches are fixed. The Fs are conditional on the ability to generally match the catch based on the estimated abundance indices.

The biological reference points should be evaluated with respect to varying assumptions about the magnitude of F on the plus group. The effect of increasing F(7+) from 0.004 to 0.04 will have a dramatic impact on the current state of the resource (Figure 5 and 6). As a simple illustration we examined the effects of increasing F on the age 4 to 7 range from 0.009 to 0.214 in the South and from 0.004 to 0.065 in the North. The upper bounds correspond to the respective F estimates on age 3 fish in each area. The lower bounds correspond to the F estimates on age 5 fish in the terminal year.

For the northern stock, increasing F from 0.004 to 0.04 drops SPR below 30%.

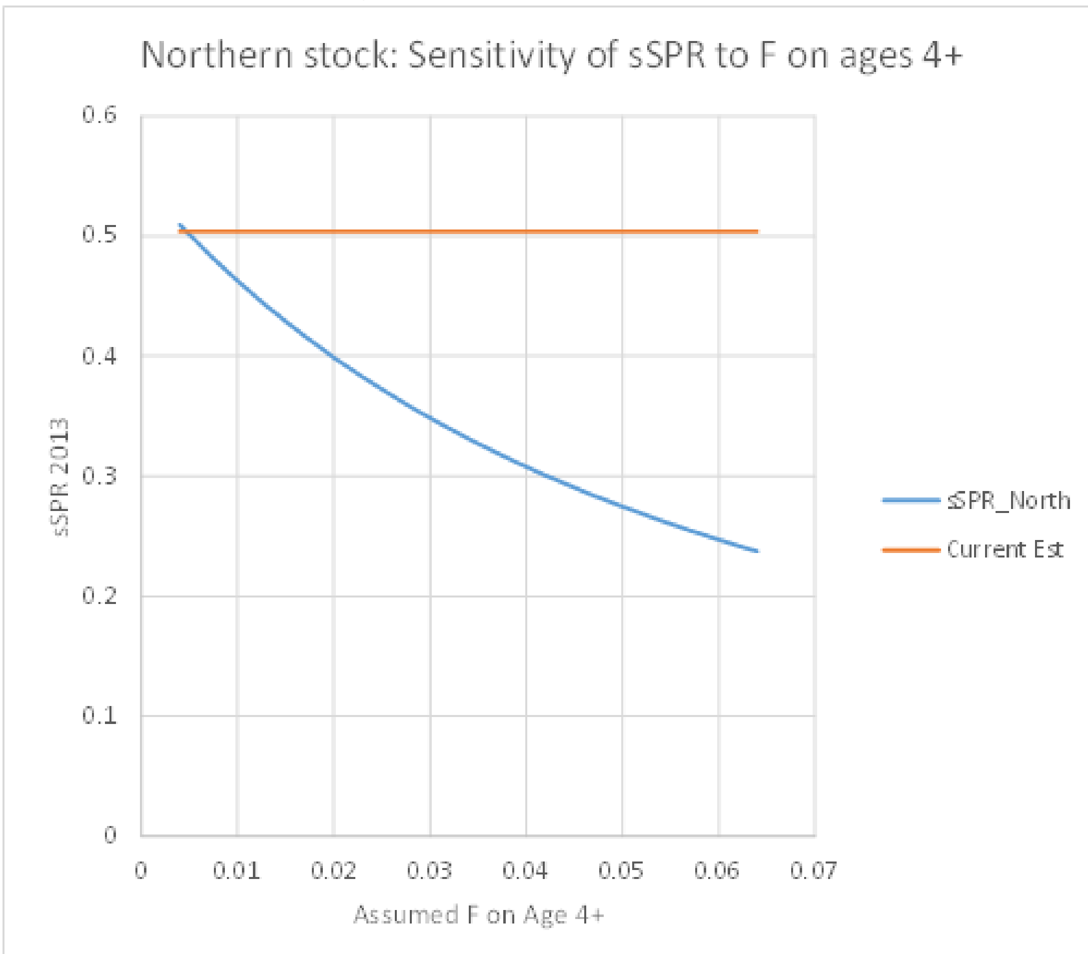

Figure 5. Sensitivity analysis of the current estimate of SPR in the Northern Stock to variation in the assumed fishing mortality estimate on ages 4 and older.

The southern stock is slightly less sensitive but increases in F to 0.06 are sufficient to drive SPR below 30% (Figure 6). Thus the status determination is highly sensitive to the estimated composite F on ages 4 and older. In the vicinity of Fs of about half the estimated M, the stock status can sharply decline. If the current level of recruitment is in fact dependent on an extended age structure implied by the low Z on adults older than 7, resource persistence is conditional on maintenance of minimal harvest of older red drum.

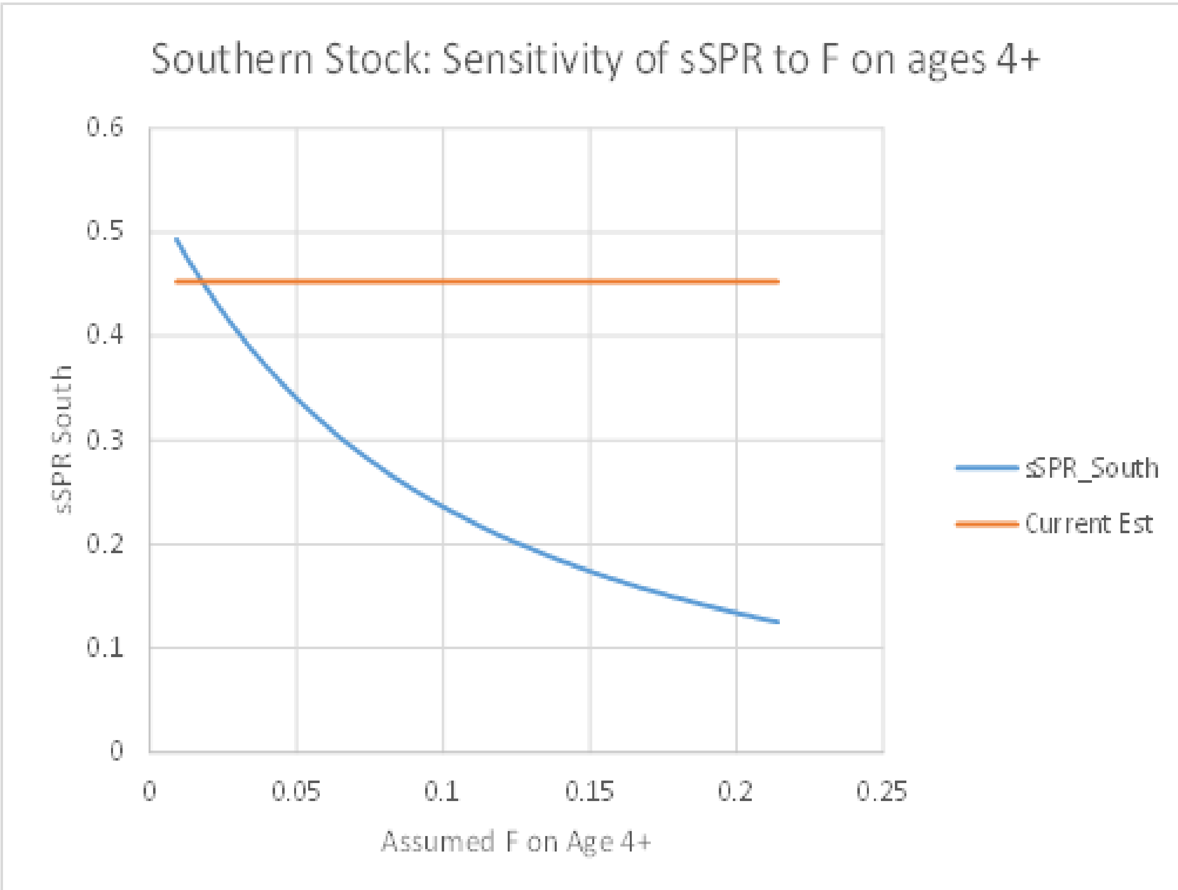

Figure 6. Sensitivity analysis of the current estimate of SPR in the Southern Stock to variation in the assumed fishing mortality estimate on ages 4 and older.

For the southern stock the fraction of sSPR in the 7+ group is 0.82 under current fishing mortality and 0.84 when F is assumed to be zero. For the Northern Stock the fraction of sSPR in the 7+ group is 0.8 under current fishing mortality and the same when F is assumed to be zero. For either stock, most of the SPR is in the plus group, and is therefore relatively unaffected by the F estimates on younger fish. The primary factor is the estimated F on age 7 fish, which is uncertain.

The ability to resolve differences in age specific Fs of less than 0.01 is problematic in any stock assessment. Differences between the current estimate and true value of F of less than 0.04 would lead to an estimate of overfishing in the Northern Stock; differences of less than 0.06 would lead to an estimate of overfishing in the South.

Thus, caution should be applied when examining stock status relative to current reference points. Any biomass or abundance based targets and limits would suffer from difficulties this approach has to estimating scale of the population, particularly, for the plus group. Further, SPR as a benchmark cannot get at minimum stock size needed for sustainable recruitment.

References

ASMFC. 2016. Red Drum Statistical Catch-at-Age Model Stock Assessment Report. November 2016. Arlington, VA.

Murphy, M. 2014. Relative indices of abundance for Red drum (Sciaenops ocellatus) inhabiting inland waters along the Atlantic coast based on 1991-2013 angler catch rate data. SEDAR-DW12.

SEDAR. 2015. SEDAR 44 – Red Drum Section III: Review Workshop. SEDAR, North Charleston SC. 890 pp. available online at: http://sedarweb.org/sedar-44.

SEDAR. 2015. SEDAR 44 – Atlantic Red Drum Stock Assessment Report. SEDAR, North Charleston SC. 890 pp. available online at: http://sedarweb.org/sedar-44.

Charnov, E. L., H. Gislason, and J. G. Pope. 2013. Evolutionary assembly rules for fish life histories. Fish Fish. 14:212–224

SEDAR, 2013. SEDAR 28: South Atlantic Cobia Stock Assessment Report. SEDAR, North Charleston, SC 29405. Available at http://sedarweb.org/docs/sar/S28_SAR_SACobia_WithAddendumFinal_5.16.2013.pdf

2016 REVIEW OF THE
ATLANTIC STATES MARINE FISHERIES COMMISSION
FISHERY MANAGEMENT PLAN FOR

SPOT
(Leiostomus xanthurus)

2015 FISHING YEAR

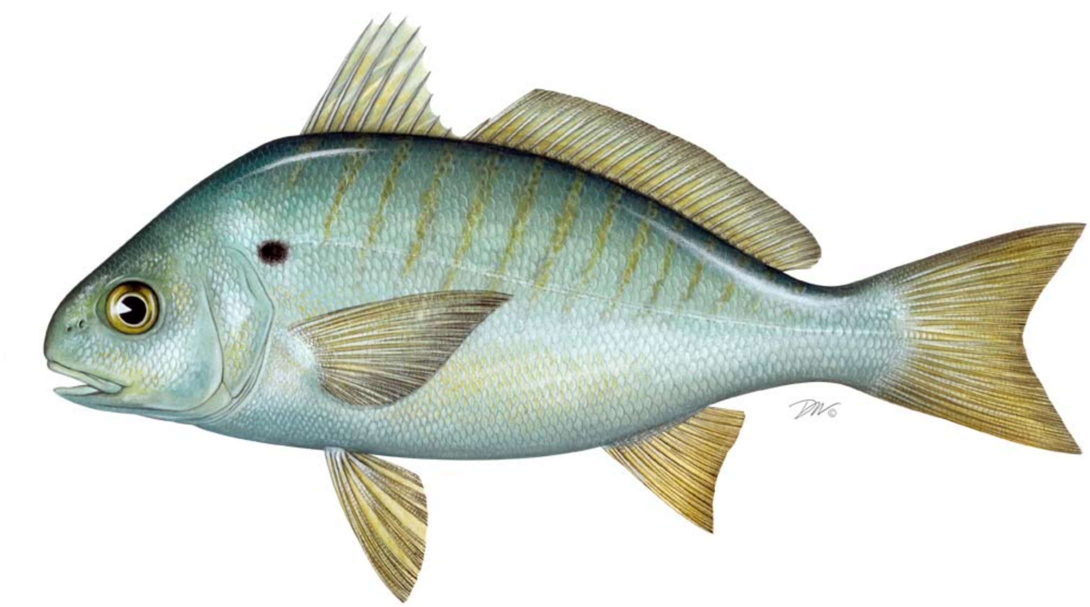

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Table of Contents

I. Status of the Fishery Management Plan

Date of FMP Approval: October 1987; Omnibus Amendment August 2011

Management Area: The Atlantic coast distribution of the resource from Delaware through Florida

Active Boards/Committees: South Atlantic State/Federal Fisheries Management Board; Spot Plan Review Team; South Atlantic Species Advisory Panel; Omnibus Amendment Plan Development Team

The Fishery Management Plan (FMP) for Spot was adopted in 1987 and includes the states from Delaware through Florida (ASMFC 1987). In reviewing the early plans created under the Interstate Fisheries Management Plan process, the ASMFC found the Spot FMP to be in need of evaluation and possible revision. A Wallop-Breaux grant from the U.S. Fish and Wildlife Service was provided to conduct a comprehensive data collection workshop for spot. The October 1993 workshop at the Virginia Institute of Marine Science was attended by university and state agency representatives from six states. Presentations on fishery-dependent and fishery-independent data, population dynamics, and bycatch reduction devices were made and discussed. All state reports and a set of recommendations were included in the workshop report (Kline and Speir 1993).

Subsequent to the workshop and independent of it, the South Atlantic State/Federal Fisheries Management Board (Management Board) reviewed the status of several plans in order to define the compliance issues to be enforced under the Atlantic Coastal Fisheries Cooperative Management Act (ACFCMA). The Management Board found recommendations in the plan to be vague and perhaps no longer valid, and recommended that an amendment be prepared to the Spot FMP to define the management measures necessary to achieve the goals of the FMP. In their final schedule for compliance under the ACFCMA, the ISFMP Policy Board adopted the finding that the FMP does not contain any management measures that states are required to implement. In August 2009, the Management Board expanded the initiated amendment to the Spanish Mackerel FMP to include Spot and Spotted Seatrout, creating the Omnibus Amendment for Spot, Spotted Seatrout and Spanish Mackerel. The goal of the Omnibus Amendment was to update all three plans with requirements specified under the Atlantic Coastal Fisheries Cooperative Management Act (1993) and the Interstate Fishery Management Program Charter (1995). In August 2011, the Management Board approved the Omnibus Amendment for Spot, Spotted Seatrout, and Spanish Mackerel. This Amendment did not set specific management measures for Spot but it did align management of the species with the requirements of ACFCMA.

In August 2014, the Board approved Addendum I to the Omnibus Amendment. The Addendum establishes use of a Traffic Light Analysis (TLA) to evaluate fisheries trends and develop state-specified management actions (e.g., bag limits, size restrictions, time and area closures, and gear restrictions) when harvest and abundance thresholds are exceeded for two consecutive years.

II. Status of the Stock

A stock assessment for spot is in progress and will be submitted to the South Atlantic Management Board in 2017. As an assessment is currently in progress, a TLA was not conducted for spot in 2016.

Traffic Light Approach
As part of the requirements under the 2011 Omnibus Amendment, for years in-between benchmark stock assessments, the Spot PRT was tasked with conducting annual monitoring analysis. These trigger exercises compared five data sources to the 10^{th} percentile of the data sets' time series. If two terminal values of the five data sources (at least one of which must be fishery independent) fell below the 10^{th} percentile, the Management Board would be prompted to consider management action.

In August 2014, the Board approved Addendum I to the Omnibus Amendment. The Addendum established the Traffic Light Approach (TLA) as the new precautionary management framework to evaluate fishery trends and develop management actions. The TLA framework replaces the management trigger stipulated in the Omnibus Amendment after concern that the triggers were limited in their ability to illustrate long-term declines or increases in stock abundance. In contrast, the TLA is a statistically-robust way to incorporate multiple data sources (both fishery-independent and -dependent) into a single, easily understood metric for management advice. It is an effective method to illustrate long-term trends in the fishery.

The TLA was originally developed as a management tool for data poor fisheries. The name comes from assigning a color (red, yellow, or green) to categorize relative levels of population indicators. When a population characteristic improves, the proportion of green in the given year increases. Harvest and abundances thresholds of 30% and 60% red were established in Addendum I, representing moderate and significant concern for the fishery. If thresholds for both population characteristics achieve or exceed a threshold for a two year period, then management action is enacted.

Analysis of the composite harvest index showed a general decline beginning in 2005 (Figure 1). This decline was driven mostly by the decline in commercial landings rather than the recreational harvest. The composite harvest index did not trip in 2013-2014. However, this index did trip in 2012-2013 with an average red percentage of 38%.

The TLA composite abundance index for adult spot (NMFS and SEAMAP surveys) was run using the 1989-2014 time period since that was when the two surveys overlapped (Figure 1). The TLA composite characteristic did trigger in 2014 with a mean red proportion for 2013-2014 of 43.5%. This reflects the drop in annual catch levels in both indexes for the last two years. During past years, the index would have tripped most years from 1989 to 2004 given the proportions of red in the index above the 30% threshold.

Overall, management triggers were not tripped in 2014 since both population characteristics (harvest and abundance) were not above the 30% threshold for the 2013-2014 time period. Nonetheless, the analysis shows that there are declining trends in the fishery independent indices for spot.

III. Status of the Fishery

Total landings of spot from NJ to FL in 2015 are estimated at 4.44 million pounds, a decrease of nearly 4,000,000 lbs from 2014 and roughly 2.8 million lbs less than the average of the last 10 years (7,189,579) (Tables 1 and 3). The recreational fishery harvested slightly more than the commercial fishery (51% and 49% respectively, by pounds). Although, historical commercial harvests were larger than recreational harvests, over the last 10 years proportions of commercial and recreational harvests have been almost equal (51% and 49% respectively, by pounds).
Commercial spot landings have ranged between 1.37 and 14.52 million pounds from 1950-2015 (Figure 2), with the 2015 landings (2.16 million pounds) being less than half of 2014 landings. Coastwide, gillnets were used to capture 47% of commercially harvested spot (Table 2). Virginia landed approximately 72% of the commercial harvest (by pounds) in 2015, followed by North Carolina with 17% of the harvest. Spot are a major component of Atlantic coast scrap landings (NCDMF 2001). A scrap fishery is one in which fish species that are unmarketable as food, due to size or palatability, are sold unsorted, usually as bait. The largest bycatch component for spot comes from the South Atlantic shrimp trawl fishery.

The recreational harvest of spot along the Atlantic coast from 1981 to 2015 has varied between 3.6 and 20.1 million fish (or 1.7 and 6.9 million pounds; Tables 3 and 4). There was an increasing trend in the recreational harvest from a low in 1999 of 1.6 million fish to 15.9 million fish in 2007. Since then, harvest has generally declined, with a 2015 harvest of 6.1 million fish, down 2.6 million fish from 2014 (Figure 3). Anglers in South Carolina were responsible for 52% of the total number of fish harvested in 2015, followed by anglers in North Carolina (17.8%) and Virginia (14.3%). Many anglers are known to catch spot to use as bait, as well as for other recreational purposes. The estimated number of spot released annually by recreational anglers has varied between 1.9 and 11.2 million fish, with 2015 releases estimated at 2.49 million fish.

IV. Status of Assessment Advice

A formal stock assessment of spot has not been completed. The 1987 FMP recognized the lack of biological and fisheries data necessary for a stock assessment and effective management of the resource.

The Spot Plan Review Team evaluated the adequacy of data for assessment purposes in 2012, and reported the following:

- Commercial landings data appear adequate for a spot assessment; however, discard data are limited. The level of commercial biological sampling is on par with other species having assessments performed.
- The adequacy of recreational harvest and harvest length data is comparable to other species which rely primarily on MRIP data. Limited discard length data are available and discard mortality rates are unknown; however, less recreational discarding of spot occurs than for many other species, potentially due to its use as a bait fish.
- The number, time series, and distribution of fishery-independent indices appear adequate for stock assessment purposes. Biological data appear ample from several surveys, although reproductive data are limited. Further, the amount and representativeness of samples from each survey has not been investigated in detail.

- Additional investigation into the quality and quantity of commercial, recreational, and indices data for a spot stock assessment would need to take place through a data workshop (this occurred in 2015).

In 2014, the PRT recommended that the Board initiate a coastwide assessment for spot. This assessment is currently underway and is expected to be completed in 2017.

V. Status of Research and Monitoring

Catch and effort data are collected by the commercial and recreational statistics programs conducted by the states and the National Marine Fisheries Service (NMFS). Biological characterization data from fishery landings are also available from several states. Specifically, age data are now available from Maryland, Virginia, North Carolina, and South Carolina. Recruitment indices are available from surveys in Delaware, Maryland, Virginia, North Carolina, and South Carolina. Adult or aggregate (mix of juvenile and older spot) relative abundance indices are available from New Jersey, Delaware, North Carolina, South Carolina, and SEAMAP (covering North Carolina through Florida). These surveys, in addition to the Northeast Fisheries Science Center Bottom Trawl Survey, the Northeast Area Monitoring and Assessment Program (NEAMAP), the Chesapeake Bay Multispecies Monitoring and Assessment Program (ChesMMAP), and the Chesapeake Bay Fishery-Independent Multispecies Survey (CHESFIMS), collect a variety of biological data elements.

Below is a description of the fishery dependent sampling conducted by states.

<u>Maryland:</u> Maryland conducts an onboard commercial pound net survey on the Potomac River and the Chesapeake Bay, sampling once per week from May through September and collecting length and age data.

<u>Virginia:</u> Virginia's Marine Resources Commission collects biological data from Virginia's commercial and recreational fisheries, with total length, weight, sex, and age measured whenever possible. The fish are aged by examining otoliths, which is done by Old Dominion University's Center for Quantitative Fisheries Ecology.

<u>North Carolina:</u> Commercial fishing activity is monitored through fishery-dependent sampling conducted under Title III of the Interjurisdictional Fisheries Act and has been ongoing since 1982. Data collected in this program allows the size distribution of spot to be characterized by gear/fishery. Further sub-sampling is conducted to procure samples for age determination (whole otoliths), sex ratio, reproductive condition, and weight.

<u>South Carolina:</u> Fishery dependent data related to Spot has been available primarily through the SCDNR State Finfish Survey (SFS), the National Marine Fisheries Service's Marine Recreational Information Program (MRIP), and a SCDNR-managed mandatory trip reporting system for licensed charterboat operators.

<u>Georgia:</u> The Marine Sportfish Carcass Recovery Project, a partnership with recreational anglers along the Georgia coast, was used to collect biological data from finfish. In 2015, a total of 3,696 fish carcasses were donated through this program. Spot were not present in the list of donated species for 2015.

Below is a description of fishery independent sampling conducted by states.

New Jersey: The New Jersey Bureau of Marine Fisheries conducts an Ocean Trawl Survey, Delaware River Seine Survey, and Delaware Bay Trawl Survey. Respective indices of abundance (GM) for the three surveys in 2015 were: 0.63, 0.02, and 0.19 (2014 values were: 0.31, 0.01, and 0.06, respectively).

Delaware: Annual relative abundance estimates (number/nautical mile) of spot in Delaware are monitored through the Division's adult ground fish bottom trawl survey. The relative abundance of spot decreased to 3.39 (#/nm) and was the lowest estimate of abundance since 2004. The Division monitors juvenile fish abundance through a 16-ft bottom trawl survey which has been conducted annually since 1980. Separate spot young of the year (YOY) indices are generated for the Delaware Estuary (Bay and River) and Delaware's "Inland Bays" (Indian River and Rehoboth Bays). YOY spot recruitment, 0.42 per tow (geometric mean), increased in 2015 relative to 2014 for the Delaware Estuary and was below the time series mean and median. The Inland Bays YOY index increased to 2.46 per tow, and remained below the time series mean in 2015.

Maryland: Maryland conducted a fisheries independent gill net survey on the Choptank River once per week from June 6, 2015 to August 27, 2015, with the exception of the second week in July. Experimental monofilament gill nets with stretched mesh sizes of 2.5, 3.0, 3.5 and 4.0 inches were set at four randomly selected locations within the sampling area. The 2.5 inch mesh captured the majority of spot in each year from 2013-2015, accounting for 73 - 95% of the catch annually. Fish in 200 and 210 mm length bins accounted for over 60 % of the length frequency distributions in 2013 and 2014. The distribution shifted toward larger fish in 2015, with only 24% of captured fish in the 200 and 210 mm length groups.

Finfish collected by Maryland's Chesapeake Bay Blue Crab Trawl Survey have been enumerated since 1980, (Davis et al.1995). The spot Chesapeake Bay juvenile index (JI) has been variable throughout the time series. The index increased to 16.4 in 2012, which is near the 24 year time series mean of 17.7 fish per tow, but decreased to the time series low of 0.29 fish per tow in 2015. A second JI was derived from the Striped Bass Juvenile Seine Survey (JSS). The 2015 geometric mean (GM) catch per haul was 0.06, the second lowest value of the 49-year time series. A 4.9-m semi-balloon otter trawl has also been used to sample Maryland's Atlantic coastal bays since 1972. The 2015 GM of 2.74 spot per hectare was an increase from very low values in 2013 and 2014, but was still below the 27 year time series mean of 9.48. The final juvenile index is derived from the coastal bays seine survey. The 2015 GM catch per haul was 4.59, an increase from the previous year but still below the time series mean of 7.83.

Virginia: The Virginia Institute of Marine Science (VIMS) has been conducting a monthly juvenile trawl survey since 1955 to monitor the abundance and seasonal distribution of finfish and invertebrates in the Chesapeake Bay and its tributaries. An index of age-0 spot abundance is available from 1988 up to 2015, with sampling coming from tributaries of the Chesapeake Bay (fixed and random sites) as well as the bay itself (random sites). The average index value is 13.83, and the 2015 value was the lowest in the time series.

North Carolina: North Carolina has no current fishery-independent monitoring programs specifically for spot. However, the NCDMF has conducted a stratified random trawl survey in

Pamlico Sound (Pamlico Sound Survey, Program 195) since 1987 to obtain juvenile abundance indices (JAI) for several economically important species, including spot. The 2015 spot JAI (mean number of individuals/tow) was 405.48, a slight decline from the 2014 JAI of 410.64.

South Carolina: While Spot are not necessarily a specifically targeted species for SCDNR monitoring programs or projects, they are a common component species of four fishery independent monitoring efforts conducted by the SCDNR. The Southeast Area Monitoring and Assessment – South Atlantic Program (SEAMAP-SA) is a shallow water (15 to 30 ft depth) trawl survey that monitors status and trends of numerous coastal species within the South Atlantic Bight seasonally (spring, summer and fall) from Cape Canaveral, FL to Cape Hatteras, NC. The annual stratified mean catch per tow in weight for the entire survey in 2015 was 12.3 kg/tow, a 9.2% decline from 2014 (13.5 kg/tow). The second survey is an inshore estuarine trammel net survey conducted by the SCDNR. In 2015, CPUE increased slightly (10.1%) from 2014, and remained below the long-term mean for a sixth year. The third survey was an electroshock survey conducted in low salinity brackish and tidal freshwater portions of different South Carolina estuaries. The CPUE in 2015 (4.4 ± 0.55 fish per set) declined from 2014 by 70% and was the lowest annual CPUE on record for the survey. The fourth survey is the South Carolina Estuarine and Coastal Assessment Program (SCECAP). The CPUE declined in 2015 from 2014 to the lowest value in the time series (6.9 fish per hectare) and remained well below the series long term mean.

Georgia: Spot are occasionally observed during the red drum gillnet survey and the trammel net survey. Lengths of captured spot were recorded and then fish were released. During 2015, 150 trammel and 216 gill net sets captured 171 and 452 spot, respectively. Average fork length of spot in trammel nets was 205 mm and in the gillnet survey was 197 mm. The 2015 geometric means (#/net set) from both trammel and gill nets (0.54 and 0.89) were greater than those of 2014 (0.31 and 0.25, respectively). The monthly Ecological Monitoring Survey (EMS) samples estuarine finfish from a total of 42 stations, distributed amongst 6 estuaries, from January to December. Average fork length of spot captured in this survey was 134 mm. The 2015 geometric mean (4.41 fish/standard 15 minute trawl) was lower than the 2014 geometric mean (5.12 fish/standard 15 minute trawl), but greater than the average of the last five years.

Florida: The FWC-FWRI's FIM program initiated surveys on estuarine, bay and coastal systems of the Florida Atlantic at northern Indian River Lagoon in 1990, southern Indian River Lagoon in 1997, and northeast Florida (Jacksonville study area) in 2001. Indices of abundance (IOAs) data for juvenile (YOY) spot (<30 mm standard length, SL) were available from 21.3-m seine and 6.1-m trawl samples. IOAs for YOY and sub-adult/adult spot have been low and showed little variations; except in 2010 and 2011.

VI. Status of Management Measures and Issues

The FMP for Spot identified two management measures for implementation: 1) promote the development and use of bycatch reduction devices through demonstration and application in trawl fisheries, and 2) promote increases in yield per recruit through delaying entry to spot fisheries to age one and older.

Considerable progress has been made in developing bycatch reduction devices (BRDs) and evaluating their effectiveness. Proceedings from a 1993 spot and croaker workshop summarized much of the experimental work on bycatch reduction, and many states have conducted subsequent testing. For example, North Carolina Division of Marine Fisheries (NCDMF) conducted research on the four main gear types (shrimp trawl, flynet, long haul seine, and pound net) responsible for the bulk of the scrap fish landings in order to reduce the catch of small fish. State testing of shrimp trawl BRDs achieved finfish reductions of 50-70% with little loss of shrimp, although total bycatch numbers relative to shrimp fishery effort are still unknown. The Virginia Marine Resources Commission investigated the use of culling panels in pound nets and long haul seines to release small croaker, spot, and weakfish. The Potomac River Fisheries Commission (PRFC) also investigated the use of culling panels in pound nets, finding that the panels allowed the release of 28% of captured spot less than six inches in length.

Following favorable testing, devices have been made mandatory or recommended in several state fisheries. The use of BRDs is required in all penaeid shrimp trawl fisheries in the South Atlantic. The PRFC recommends the use of culling panels in pound nets and allows those nets with panels to keep one bushel of bycatch of flounder and weakfish. In North Carolina, escapement panels have been required in the bunt nets of long haul seines in an area south and west of Bluff Shoals in the Pamlico Sound since April 1999. However, evaluation of the beneficial effects of BRDs to spot stocks continues to need further study.

General gear restrictions, such as minimum mesh sizes or area trawling bans, have helped protect some age classes of spot. However, only Georgia has implemented a spot creel limit (25 fish, both recreational and commercial, except for shrimp trawlers).

Omnibus Amendment (Interstate)

In August 2011, the Management Board approved the development of an amendment to the Spot FMP to address three issues: compliance measures, consistency with federal management in the exclusive economic zone, and alignment with Commission standards. The updated FMP's objectives are to: (1.) Increase the level of research and monitoring on spot bycatch in other fisheries, in order to complete a coastwide stock assessment (2.) Manage the Spot fishery stock to maintain the spawning stock biomass above the target biomass levels. (3.) Develop research priorities that will further refine the spot management program to maximize the biological, social, and economic benefits derived from the spot population. The Omnibus Amendment does not require specific fishery management measures in either the recreational or commercial fisheries for states within the management unit.

Addendum I

In August 2014, the Board approved Addendum I which establishes a new management framework (i.e., Traffic Light Approach) to evaluate fisheries trends and develop state-specified management actions (i.e., bag limits, size restrictions, time & area closures, and gear restrictions) when harvest and abundance thresholds are exceeded over two years. Management measures would remain in place for two years.

Recent Changes in State Regulations

<u>North Carolina:</u> There are no direct restrictions on the commercial harvest of spot within coastal, joint, or inland waters of North Carolina. There are however numerous indirect restrictions that effect the commercial harvest and bycatch of spot in North Carolina. Changes to such restrictions for 2015 include: Gill net restrictions for Internal Coastal Waters pertaining to area closures/openings, gear modifications

and attendance rules to avoid interactions with endangered species and requiring the use of an additional BRD for shrimp trawlers (Proclamation SH-2-2015).

De minimis Guidelines

A state qualifies for *de minimis* status if its past 3-years' average of the combined commercial and recreational catch is less than 1% of the past 3-years' average of the coastwide combined commercial and recreational catch. Those states that qualify for *de minimis* are not required to implement any monitoring requirements, none of which are included in the plan.

De Minimis Requests

Georgia requests *de minimis* status. The PRT notes that Georgia meets the requirements of *de minimis*.

VII. Implementation of FMP Compliance Requirements for 2015

All states within the management unit have submitted compliance reports for the 2015 fishing year. The PRT found no compliance issues.

VIII. Recommendations of the Plan Review Team

<u>Management and Regulatory Recommendation</u>
The Spot PRT will continue to monitor the fishery through the Traffic Light Approach.

<u>Research and Monitoring Recommendations</u>
High Priority
- State monitoring and reporting on the extent of unutilized bycatch and fishing mortality on fish less than age-1 in fisheries that take significant numbers of spot.
- Evaluate the effects of mandated bycatch reduction devices on spot catch in those states with significant commercial harvests.
- Continue monitoring long-term changes in spot abundance, growth rates, and age structure.
- Continue monitoring of juvenile spot populations in major nursery areas.
- Improve spot catch and effort statistics from the commercial and recreational fisheries, along with size and age structure of the catch, in order to develop production models.
- Conduct age validation studies.
- Cooperatively develop criteria for aging spot otoliths and scales.
- Develop catch-at-age matrices for recreational and commercial fisheries.
- Determine the effect that anthropogenic perturbations may be having on growth, survival, and recruitment.

Medium Priority
- Cooperatively develop a yield-per-recruit analysis.
- Develop stock identification methods and investigate the degree of mixing between state stocks during the annual fall migration.
- Determine migratory patterns through tagging studies.
- Determine the onshore vs. offshore components of the spot fishery.

IX. References

Atlantic States Marine Fisheries Commission (ASMFC). 1987. Fishery Management Plan for Spot. Washington (DC): ASMFC. Fisheries Management Report #11. 90 p.

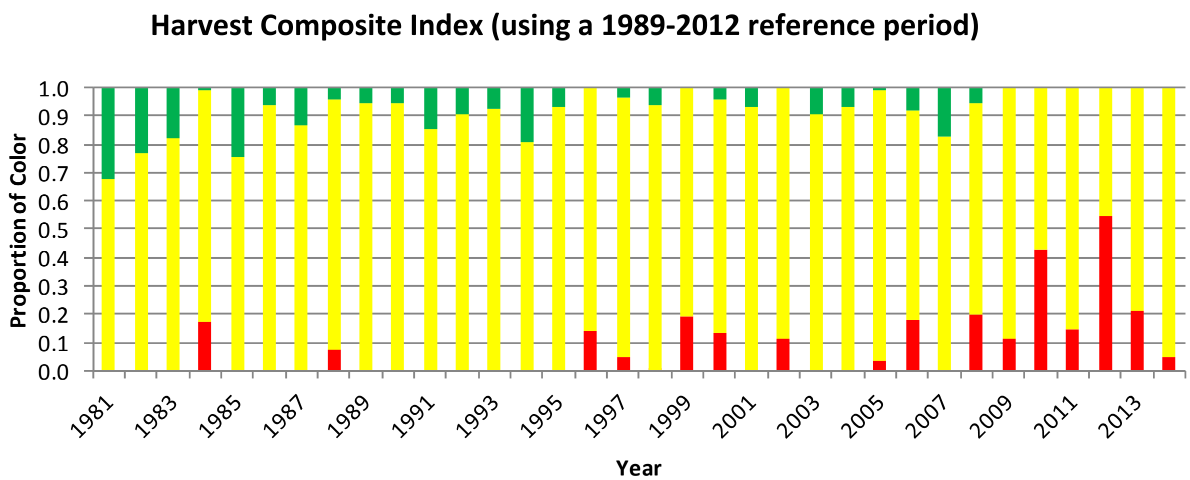
Kline LL, Speir H (editors). 1993. Proceedings of a Workshop on Spot (*Leiostomus xanthurus*) and Atlantic Croaker (*Micropogonias undulatus*). Washington (DC): Atlantic States Marine Fisheries Commission. Special Report #25. 175 p.

NCDMF. 2001. Assessment of North Carolina commercial finfisheries, 1997–2000. Final Report, North Carolina Department of Environment and Natural Resources, Division of Marine Fisheries, Award Number NA 76 FI 0286, 1-3.

Spot Plan Review Team (PRT). 2012. Spot Data Availability and Stock Monitoring Report, 2009. Washington (DC): Atlantic States Marine Fisheries Commission. Report to the South Atlantic State-Federal Fisheries Management Board. 85 p.

X. Figures

Figure 1: Traffic Light Approach for spot, 2014. Top figure shows the harvest composite index and the bottom figure shows the abundance composite index.



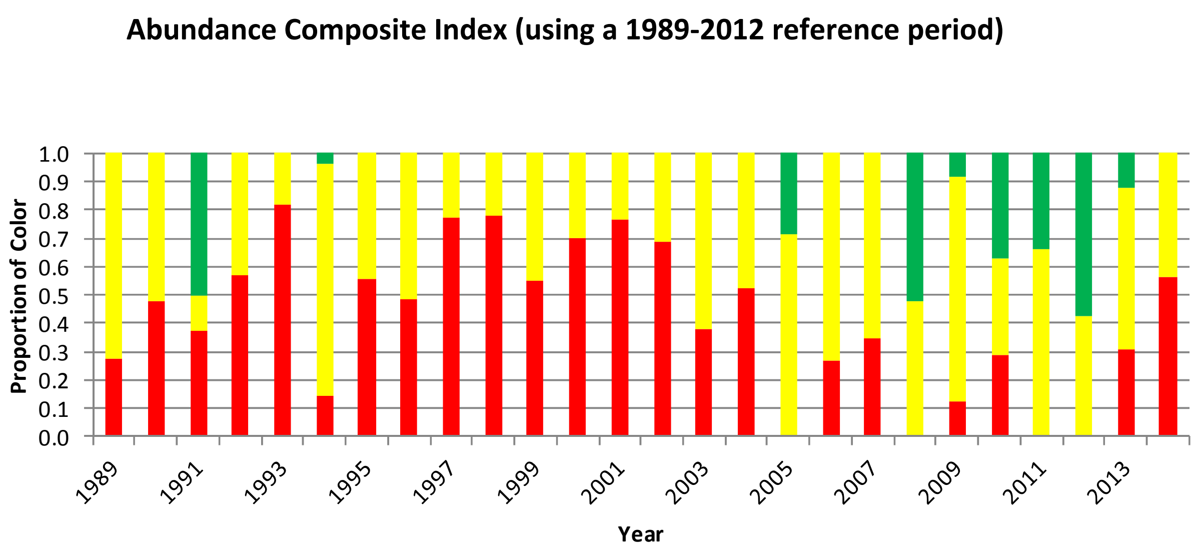


Figure 2: Spot commercial and recreational landings (pounds), 1950-2015.
(Recreational landings available from 1981-present; see Tables 1 and 3 for state-by-state values and data sources)

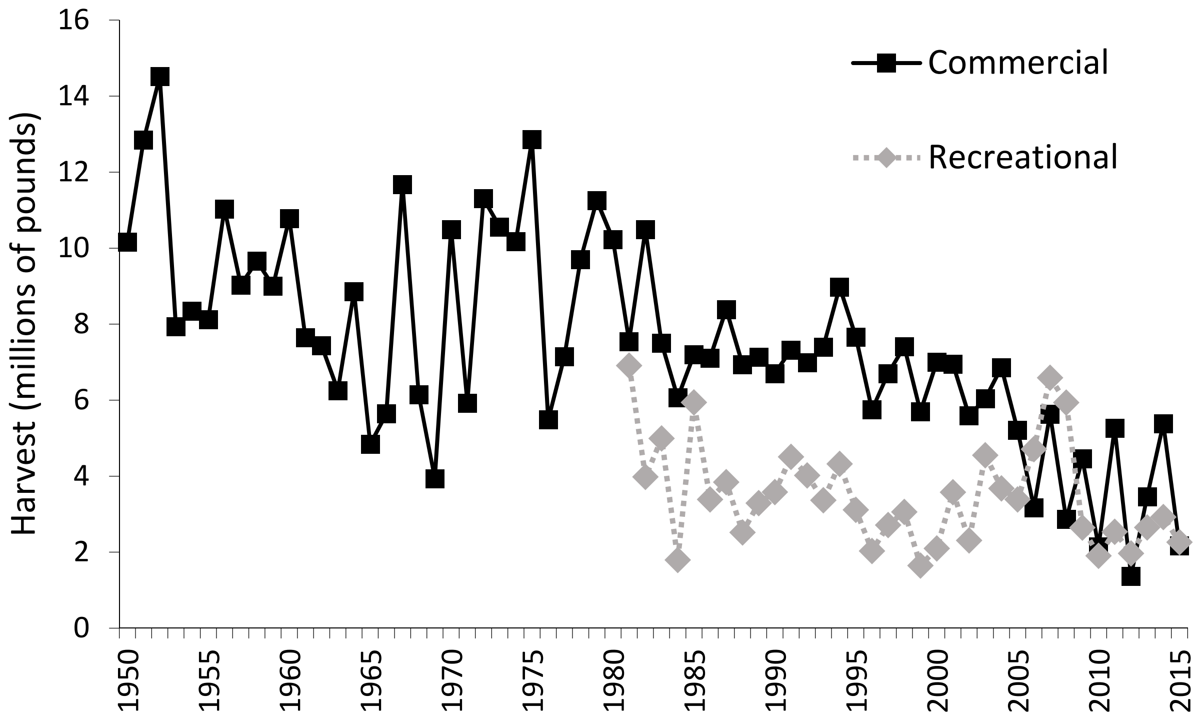
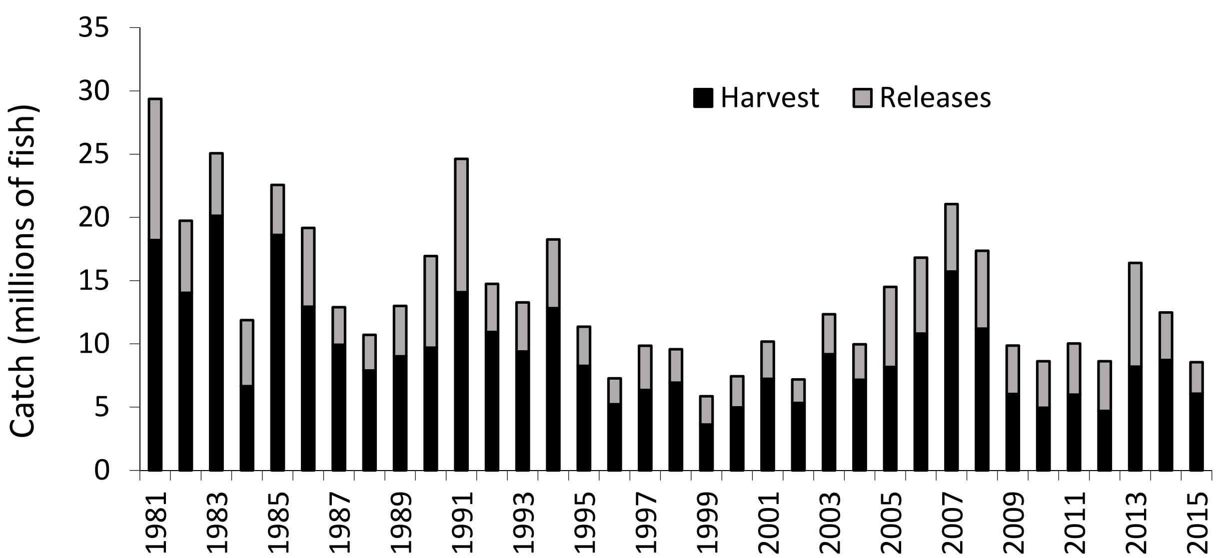


Figure 3. Spot recreational harvest and releases (numbers of fish), 1981-2015
(See Tables 4 and 5 for state-by-state values and data source)



XI. Tables

Table 1. Commercial landings (pounds) by state, and estimated value (ex-vessel), 1981-2015 [Source: NMFS Fisheries Statistics Division (queried 12/19/2016) & State Compliance Reports (received 11/01/2016)]. Starred values are confidential.

Year	NY	NJ	DE	MD	PRFC	VA	NC	SC	GA	FL	**Total**
1981		6,000	11,100	14,200	49,899	1,025,800	3,511,574	127,384	7,721	2,798,881	7,552,559
1982		1,800	2,500	6,200	45,946	1,017,100	4,918,763	62,562	292	4,431,239	10,486,402
1983		800		129,400	347,416	1,567,900	2,952,295	240,096		2,266,296	7,504,203
1984		100		43,200	165,524	735,200	3,481,920	130,265		1,508,552	6,064,761
1985		2,400	17,200	7,700	19,912	1,561,739	4,043,843	142,755		1,399,819	7,195,368
1986		6,600	86,400	104,400	148,004	1,839,500	3,354,191	655,378	124	918,875	7,113,472
1987		15,900	140,100	251,800	291,964	3,721,100	2,806,041	220,553	1,528	943,713	8,392,699
1988		1,600	38,700	58,000	53,865	1,985,500	3,080,258	376,221	644	1,344,276	6,939,064
1989		8,200	29,000	115,800	90,920	2,468,100	3,254,473	31,472	361	1,144,639	7,142,965
1990		9,039	24,900	127,882	145,535	1,630,735	3,455,460	39,957	43	1,275,729	6,709,280
1991		54,433	236,200	216,035	147,355	2,539,340	3,047,305	31,787		1,051,532	7,323,987
1992		102,213	95,000	331,837	226,335	2,497,622	2,826,138	171,959	261	740,048	6,991,413
1993	63	10,900	22,000	182,198	88,988	3,349,399	2,672,164	251,225	1,276	826,322	7,404,535
1994		31,408	100,400	166,246	181,127	4,269,402	2,937,355	288,241		1,002,887	8,977,066
1995	22	30,151	62,000		177,780	3,622,954	3,006,885	209,132	247	558,087	7,667,258
1996	318	1,149		256,711	101,670	2,982,083	2,290,040	60,574		56,423	5,748,968
1997	189	6,175	35,686	120,331	134,591	3,465,507	2,627,977	87,170		227,097	6,704,723
1998	579	27,582	140,363	225,937	117,580	4,277,256	2,397,025	63,912		161,205	7,411,439
1999		7,822	51,534	223,463	108,326	2,961,890	2,262,213	9,393		72,973	5,697,614
2000	939	13,852	32,290	176,946	120,642	3,764,679	2,829,818	8,519		57,946	7,005,631
2001	160	20,034	78,272	283,488	176,546	3,248,212	3,093,921	12,950		33,056	6,946,639
2002	5,737	1,326	13,780	138,640	140,776	3,062,211	2,184,076	23,151		20,586	5,590,283
2003	35	6,003	77,031	184,437	227,430	3,471,484	2,043,421	17,181		9,337	6,036,359
2004	98	1,652	58,502		131,605	4,338,082	2,317,215	1,876		12,792	6,861,822
2005	435	769	155,299	114,987	95,350	3,102,816	1,714,518	10,468		21,156	5,215,798
2006	2,959	3,646	7,522	34,018	40,777	1,695,985	1,364,797	5,691		22,502	3,177,897
2007	1,080	4,474	61,637	389,514	70,514	4,327,887	879,135	6,357		14,317	5,637,154
2008	650	1,942	32,496	123,571	29,835	1,976,661	737,293	1,492		9,181	2,863,714
2009	317	34,063	60,671	521,958	63,470	3,910,221	1,006,550	22,557		22,057	4,456,467
2010	447	6,048	59,800	589,560	44,025	1,023,948	572,345	3,957		13,438	2,143,898
2011	159	54,890	81,868	612,391	60,106	3,741,879	936,993	12,162		33,879	5,272,523
2012	90,141	9,935	17,752	101,677	14,563	613,337	489,708	541		36,591	1,374,245
2013	156,752	48,324	73,191	262,692	41,286	2,084,551	768,621	2,446		31,249	3,469,112
2014	2,113	29,683	107,139	320,804	148,908	3,983,384	766,245	5,917	*	16,747	5,381,160
2015	901	355	3,546	88,117	86,972	1,577,765	377,358	1,619		27,969	2,164,602

Table 2. Commercial landings (pounds) by gear, 2015

[Source: NMFS Fisheries Statistics Division (queried 12/19/2016)]

Gear	Landings (lbs)	Percent of Total
Gill nets	1,565,746	80.4%
Haul Seins	111,182	5.7%
Pound Net	133067	6.8%
Trawl	5,698	0.3%
Other	132,819	6.8%
Total	1,948,512	

Table 3. Recreational harvest (pounds) by state, 1981-2015
[Source: State Compliance Reports (received 11/01/2016)]

Year	NY	NJ	DE	MD	VA	NC	SC	GA	FL	**Total**
1981	20,348	6,175	8,047	554,986	4,625,985	1,193,537	144,600	50,734	311,406	6,915,818
1982		85,446	19,281	656,245	1,563,396	1,093,047	313,177	20,199	236,027	3,986,818
1983			4,017	354,788	2,520,125	1,630,882	293,161	28,023	167,294	4,998,290
1984		3,768	5,714	361,850	404,533	650,386	169,346	81,758	122,585	1,799,940
1985	3,415	4,255		193,266	1,955,039	3,120,532	441,808	13,071	213,042	5,944,428
1986	1,327	2,114	3,836	1,139,871	1,205,158	536,443	455,836	23,369	25,360	3,393,314
1987				1,545,691	1,336,387	690,653	226,701	14,601	32,835	3,846,868
1988		84,941	1,876	80,547	720,609	802,320	632,868	14,645	184,602	2,522,408
1989	132	606	10,368	633,150	1,400,728	929,188	288,591	7,798	23,254	3,293,815
1990		5,644	11,821	791,264	2,103,751	613,904	50,525	6,259	1,737	3,584,905
1991		19,528	48,100	634,894	2,729,698	727,463	245,661	1,786	107,256	4,514,386
1992		8,788	36,799	724,279	2,278,309	403,775	397,677	6,978	167,845	4,024,450
1993	315	2,264	844	636,032	951,766	812,810	461,447	109,317	396,632	3,371,427
1994	7,198	20,364	34,795	676,687	1,217,036	1,842,360	469,518	2,687	57,234	4,327,879
1995		1,186	22,919	485,682	1,067,637	1,247,995	242,973	7,701	42,851	3,118,944
1996		10,966	789	294,404	492,982	710,086	494,448	5,445	26,953	2,036,073
1997		8,609	50,781	401,275	1,263,447	722,868	254,794	2,072	13,962	2,717,808
1998			36,658	631,422	866,619	1,249,543	228,502	2,088	47,196	3,062,028
1999			10,886	272,292	244,499	646,662	391,402	2,275	84,511	1,652,527
2000	130,649	46,244	32,968	600,302	252,885	893,835	128,669	1,402	14,129	2,101,083
2001			20,110	629,861	523,202	1,773,671	346,878	1,720	284,706	3,580,148
2002			10,870	336,660	829,972	984,898	140,164	2,857	7,840	2,313,261
2003			14,386	1,690,502	875,729	1,714,158	227,821	5,710	26,504	4,554,810
2004			6,919	442,100	1,136,261	1,846,688	245,991	721	3,338	3,682,018
2005		14,546	68,075	658,077	1,375,629	1,103,830	158,407	917	12,751	3,392,232
2006		28,971	38,010	991,142	1,926,940	978,181	745,772	1,166	6,067	4,716,249
2007	952	0	74,531	1,282,803	3,237,069	1,378,993	605,024	2,346	12,899	6,594,617
2008	0	23,157	42,078	618,172	1,828,398	671,916	2,731,815	4,292	21,041	5,940,869
2009	0	1,882	48,465	802,395	829,245	354,375	589,027	2,493	22,169	2,650,051
2010		212,616	74,641	447,575	563,423	260,757	322,885	214	28,033	1,910,144
2011		755	52,120	314,032	1,101,847	411,243	596,679	171	62,657	2,539,504
2012		104,028	21,558	253,103	410,777	230,259	933,684	91	19,090	1,972,590
2013	6,099	118,685	107,330	280,842	1,336,913	460,928	301,307	1,614	42,267	2,655,985
2014		6,477	210,001	404,080	1,276,043	704,445	157,258	3,968	165,159	2,944,135
2015		0	3,274	187,061	378,959	395,268	1,166,210	575	134,445	2,265,792

Table 4. Recreational harvest (numbers) by state, 1981-2015
[Source: State Compliance Reports (received 11/01/2016)]

Year	NY	NJ	DE	MD	VA	NC	SC	GA	FL	**Total**
1981	44,278	28,006	17,508	948,931	11,662,684	4,023,934	562,750	124,057	799,226	18,211,374
1982		387,582	82,094	2,864,603	4,526,847	4,124,465	1,230,253	84,153	735,398	14,035,395
1983			14,464	1,600,362	12,059,247	4,880,268	970,747	112,123	488,029	20,125,240
1984		8,501	15,553	904,793	1,489,795	2,758,366	724,925	363,841	396,402	6,662,176
1985	15,494	12,692		1,028,391	5,491,918	8,789,391	2,355,044	62,338	861,700	18,616,968
1986	3,824	9,587	12,178	3,789,796	4,229,191	2,646,049	2,007,386	137,782	96,803	12,932,596
1987				3,180,704	3,864,151	2,129,146	599,807	79,487	73,833	9,927,128
1988		348,593	2,360	277,964	2,028,768	2,558,322	1,951,157	57,786	663,681	7,888,631
1989	602	1,128	45,853	1,154,314	3,714,855	2,924,299	1,078,570	34,977	67,506	9,022,104
1990		25,927	44,362	2,120,655	5,354,294	1,986,601	142,271	17,730	7,252	9,699,092
1991		88,393	138,113	1,841,555	8,820,075	2,317,095	598,290	10,281	269,628	14,083,430
1992		20,443	90,053	1,671,897	6,317,539	1,271,416	1,190,757	25,788	357,678	10,945,571
1993	1,168	7,788	3,263	1,880,043	2,836,534	2,057,440	1,437,809	228,606	946,757	9,399,408
1994	19,275	144,589	92,352	1,761,701	3,395,503	5,929,269	1,329,997	9,587	137,067	12,819,340
1995		2,949	51,695	1,099,658	2,731,242	3,329,981	875,189	27,842	140,231	8,258,787
1996		23,954	955	591,300	1,109,237	2,007,071	1,423,352	14,131	64,337	5,234,337
1997		20,148	126,089	713,657	3,328,144	1,440,661	680,842	5,471	31,987	6,346,999
1998			96,389	1,327,259	2,023,756	2,865,190	489,068	6,788	120,389	6,928,839
1999			19,911	655,289	569,250	1,308,167	801,785	5,578	264,233	3,624,213
2000	498,470	281,481	65,952	1,389,505	527,259	1,924,108	246,290	2,950	40,908	4,976,923
2001	0	0	51,096	1,088,997	1,056,365	3,650,711	735,551	3,681	652,976	7,239,377
2002	0	0	22,013	690,515	1,601,837	2,586,313	393,597	6,987	25,907	5,327,169
2003	0	0	30,166	3,300,595	1,441,002	3,796,556	524,513	11,523	84,686	9,189,041
2004	0	0	17,494	867,589	1,717,416	3,825,768	729,851	1,563	6,790	7,166,471
2005	0	46,795	150,772	1,788,679	2,781,973	3,012,872	358,550	3,199	23,796	8,166,636
2006	0	68,168	110,607	2,895,783	3,584,930	2,978,506	1,170,611	1,761	7,990	10,818,356
2007	1,813	0	176,997	3,615,346	8,203,377	3,078,346	605,024	6,529	30,184	15,717,616
2008	0	132,472	133,996	1,892,116	4,398,472	1,843,343	2,731,815	8,903	58,732	11,199,849
2009	0	6,720	128,799	2,064,326	2,146,607	1,056,346	589,027	17,948	25,391	6,035,164
2010	0	650,260	214,180	1,164,091	1,669,843	834,561	322,885	851	94,671	4,951,342
2011	0	1,370	150,650	912,704	2,967,029	1,207,335	596,680	968	152,329	5,989,065
2012	39,912	627,664	65,555	766,145	1,350,153	784,272	1,001,664	348	65,598	4,701,311
2013	13,294	326,956	248,346	945,972	4,332,620	1,464,592	732,413	6,573	132,204	8,202,970
2014		13,062	344,930	1,254,029	3,908,724	2,111,880	466,106	15,620	608,814	8,723,165
2015		0	10,277	524,079	867,365	1,081,083	3,157,322	36,684	391,653	6,068,463

Table 5. Recreational releases (numbers) by state, 1981-2015
[Source: State Compliance Reports (received 11/01/2016)]

Year	NY	NJ	DE	MD	VA	NC	SC	GA	FL	**Total**
1981		25,740	1,502	1,331,316	8,905,412	735,408	82,035	5,975	64,344	11,151,732
1982		974,847	5,061	1,677,415	1,618,065	806,851	366,650	44,091	205,387	5,698,367
1983		57,556		1,114,795	2,715,522	634,107	192,240	39,798	186,615	4,940,633
1984			13,260	1,150,599	2,607,693	952,816	346,003	17,897	130,493	5,218,761
1985	22,220	2,979		735,873	2,051,793	429,914	515,106	17,316	170,060	3,945,261
1986		79,712		2,720,343	2,250,794	816,204	331,290	20,863	10,351	6,229,557
1987			1,104	248,973	1,736,228	593,937	304,127	28,434	57,437	2,970,240
1988		110,698	4,501	716,258	762,504	995,806	110,498	16,951	110,003	2,827,219
1989		4,503	40,193	730,580	2,519,034	524,897	138,834	1,630	22,425	3,982,096
1990		14,504	10,120	1,811,434	4,441,195	921,849	13,709	4,079	30,937	7,247,827
1991		91,991	59,770	2,123,582	7,041,156	946,564	100,666	14,629	168,284	10,546,642
1992		1,324	12,553	493,597	2,091,001	841,163	279,044	16,791	64,738	3,800,211
1993			35,987	1,573,486	1,374,950	528,449	130,055	47,667	185,226	3,875,820
1994	8,140	160,380	53,078	1,037,498	2,142,198	1,363,884	320,921	22,434	335,647	5,444,180
1995		22,162	14,195	253,827	1,166,428	1,035,361	331,781	9,799	268,765	3,102,318
1996	7,178	39,448	1,128	208,897	577,847	924,204	212,920	5,329	65,083	2,042,034
1997		21,512	88,751	1,316,341	1,365,809	450,663	245,349	990	18,102	3,507,517
1998		12,542	75,985	633,914	900,352	650,157	307,480	12,286	58,264	2,650,980
1999			15,789	618,742	339,988	633,112	86,894	10,675	530,849	2,236,049
2000	157,991	16,633	30,522	1,080,310	502,923	481,995	115,682	17,376	54,388	2,457,820
2001		2,040	13,139	577,417	968,976	1,143,695	154,077	11,714	74,232	2,945,290
2002	2,127	3,331	27,220	501,111	481,765	671,669	103,914	20,038	44,584	1,855,759
2003		39,049	13,273	670,382	933,842	1,132,992	231,612	31,055	106,918	3,159,123
2004			39,998	383,292	882,136	1,257,887	210,215	12,536	9,427	2,795,491
2005		5,772	157,445	2,135,086	2,456,981	1,334,559	183,819	25,117	41,773	6,340,552
2006		65,244	92,864	1,355,280	1,371,751	2,588,647	496,870	3,774	21,755	5,996,185
2007	535	119,976	44,455	1,618,690	2,156,839	1,197,005	151,481	17,600	26,675	5,333,256
2008		1,166,532	98,304	1,737,665	1,487,665	1,322,408	188,746	25,908	128,942	6,156,170
2009		7,691	140,014	632,595	1,457,588	1,222,053	326,065	10,486	40,890	3,837,382
2010		191,745	72,216	1,155,003	1,155,882	871,054	166,679	562	57,924	3,671,065
2011		1,370	66,661	296,513	2,245,221	1,000,566	222,623	9,766	196,294	4,039,014
2012	37634	477938	60,334	919,896	1,145,960	759,081	142,093	3,968	373,916	3,920,820
2013	332	746,878	214,067	2,621,931	2,226,300	1,314,199	957,781	8,623	110,865	8,200,976
2014		15,323	78,691	565,679	1,173,748	890,831	427,049	27,224	575,251	3,753,796
2015		0	11,404	242,912	509,194	708,122	744,532	34,884	238,078	2,489,126