Atlantic States Marine Fisheries Commission

Coastal Sharks Management Board

May 1, 2018
9:00 – 11:00 a.m.
Arlington, Virginia

Draft Agenda

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

1. Welcome/Call to Order (*R. Miller)* 9:00 a.m.
2. Board Consent 9:00 a.m.
   - Approval of Agenda
   - Approval of Proceedings from October 2017
3. Public Comment 9:05 a.m.
4. Review North Atlantic Shortfin Mako Stock Assessment, NOAA Fisheries Highly Migratory Species (HMS) Emergency Rule Measures, and Amendment 11 (*K. Brewster-Geisz*) 9:15 a.m.
   - Technical Committee Report (*K. Rootes-Murdy*)
   - Discuss Possible Board Comment to HMS on Amendment 11 (*K. Rootes-Murdy*)
   - Discuss Potential Management Response (*K. Rootes-Murdy*) **Possible Action**
5. Review SEDAR 54 Sandbar Shark Stock Assessment (*K. Brewster-Geisz*) 10:00 a.m.
   - Technical Committee Report (*K. Rootes-Murdy*)
6. Update on Endangered Species Act Status of Oceanic Whitetip Shark (*C. Young*) 10:30 a.m.
   - Technical Committee Report (*K. Rootes-Murdy*)
7. Consider Approval of 2016 and 2017 FMP Review and State Compliance Reports (*K. Rootes-Murdy*) **Action** 10:50 a.m.
8. Other Business/Adjourn 11:00 a.m.

The meeting will be held at the Westin Crystal City, 1800 S. Eads Street, Arlington, Virginia; 703.486.1111

MEETING OVERVIEW

Coastal Sharks Management Board Meeting
May 1, 2018
9:00 – 11:00 a.m.
Arlington, Virginia

Chair: Roy Miller (DE) Assumed Chairmanship: 5/2017	Vice Chair: Pat Geer	Law Enforcement Committee Representative: Greg Garner/ Chrisolm Frampton
Coastal Shark Technical Committee Chair: Brent Frazier (SC)	Coastal Shark Advisory Panel Chair: Lewis Gillingham (VA)	Previous Board Meeting: October 2017
Voting Members: ME, MA, RI, CT, NY, NJ, DE, MD, VA, NC, SC, GA, FL, NMFS, USFWS (15 votes)		

2. Board Consent

- Approval of Agenda
- Approval of Proceedings from October 2017

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

4. Review North Atlantic Shortfin Mako Stock Assessment, NOAA Fisheries Emergency Rule Measures, and Amendment 11 (9:15-10:00 a.m.) Possible Action

Background

- The 2017 ICCAT stock assessment on North Atlantic shortfin mako indicates that the resource is overfished and overfishing is occurring. In response to the results, NOAA Fisheries has implemented emergency rule measures to reduce landings by approximately 72-79 percent. (**Briefing Materials**)
- NOAA Fisheries has also began scoping on an Amendment to rebuild the stock by 2040. (**Briefing Materials**)
- The Technical Committee met to review the stock assessment, review the emergency rule measures, and provide recommendations to the Board on potential action. (**Briefing Materials**)

Presentations

- North Atlantic shortfin mako shark stock assessment, NOAA Fisheries Emergency Rule Measures and Scoping Document for Amendment 11 by K. Brewster-Geisz
- Technical Committee Report by K. Rootes-Murdy
- Potential Management Response Options by K. Rootes-Murdy

Board Actions for Consideration at this Meeting

- Potential Management Response to 2017 Stock Assessment and Emergency Rule Measures

5. Review SEDAR 54 Sandbar Shark Stock Assessment (10:00-10:30 a.m.)

Background

- SEDAR 54 was completed in fall 2017. The results of the assessment indicate that sandbar sharks remain overfished but overfishing isn't occurring. (**Briefing Materials**)
- The Technical Committee was tasked with reviewing the assessment results and providing recommendations to the Board (**Briefing Materials**)

Presentations

- SEDAR 54 Assessment results by K. Brewster-Geisz
- Technical Committee Report by K. Rootes-Murdy

6. Update on Endangered Species Act Status of Oceanic Whitetip Shark (10:30-10:50 a.m.)

Background

- NOAA Fisheries initiated a status review in 2015 based on a petition to list Oceanic Whitetip Sharks as either threatened or endangered. Based on their review, NOAA Fisheries has determined that the resource has a moderate risk of extinction is proposed to be listed as threatened under the Endangered Species Act (ESA). (**Briefing Materials**)
- The Technical Committee was tasked with reviewing this status update and providing recommendations to the Board (**Briefing Materials**)

Presentations

- Update on ESA Status of Oceanic Whitetip Shark by C. Young
- Technical Committee Report by K. Rootes-Murdy

7. Consider Approval of 2016 and 2017 FMP Review and State Compliance (1:50-2:10 p.m.) Final Action

Background

- State compliance reports are due August 1.
- The Plan Review Team reviewed each state report and drafted the 2016 and 2017 combined FMP Review. (**Briefing Materials**)

Presentations

- Overview of the 2016 and 2017 Fishery Management Plan Review by K. Rootes-Murdy

Board Actions for Consideration at this Meeting

- Accept the 2016 and 2017 Fishery Management Plan Review and approve *de minimis* requests

8. **Other Business/Adjourn**

DRAFT PROCEEDINGS OF THE

ATLANTIC STATES MARINE FISHERIES COMMISSION

COASTAL SHARKS MANAGEMENT BOARD

The Marriott Norfolk Waterside
Norfolk, Virginia
October 17, 2017

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

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INDEX OF MOTIONS

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

2. **Approval of proceedings of May 2017 by consent** (Page 1).

3. **Move to approve the 2018 coastal sharks specifications via an email vote after NOAA Fisheries publishes the final rule for the 2018 Atlantic Shark Commercial Fishing season** (Page 15). Motion by Rob O'Reilly; second by Tom Baum. Motion carried (Page 15).

4. **Move to elect Mr. Pat Geer as Vice-chair to the Coastal Sharks Board** (Page 15). Motion by Spud Woodward; second by Robert Boyles. Motion carried (Page 15).

5. **Motion to adjourn** by consent (Page 16).

ATTENDANCE

Board Members

Pat Keliher, ME (AA)
Rep. Sarah Peake, MA (LA)
Dan McKiernan, MA, proxy for D. Pierce (AA)
Jason McNamee, RI, proxy for J. Coit (AA)
Eric Reid, RI, proxy for Sen. Sosnowski (LA)
Colleen Giannini, CT, proxy for M. Alexander (AA)
Lance Stewart, CT (GA)
John Maniscalco, NY, proxy for J. Gilmore (AA)
Sen. Phil Boyle, NY (LA)
Emerson Hasbrouck, NY (GA)
Tom Fote, NJ (GA)
Tom Baum, NJ, proxy for L. Herrighty (AA)
Adam Nowalsky, NJ, proxy for Asm. Andrzejczak (LA)
Craig Pugh, DE, proxy for Rep. Carson (LA)
Stew Michels, DE, proxy for D. Saveikis (GA)
Roy Miller, DE (GA)
Ed O'Brien, MD, proxy for Del. Stein (LA)
Mike Luisi, MD, proxy for D. Blazer (AA)
Rachel Dean, MD (GA)
Rob O'Reilly, VA, proxy for J. Bull (AA)
Cathy Davenport, VA (GA)
Kyle Schick, VA, proxy for Sen. Stuart (LA)
Michelle Duval, NC, proxy for B. Davis (AA)
Doug Brady, NC (GA)
David Bush, NC, proxy for Rep. Steinburg (LA)
Robert Boyles, Jr., SC (AA)
Malcolm Rhodes, SC (GA)
Pat Geer, GA, proxy for Rep. Nimmer (LA)
Spud Woodward, GA (AA)
Nancy Addison, GA (GA)
Rep. Thad Altman, FL (LA)
James Estes, FL, proxy for J. McCawley (AA)
Karyl Brewster-Geisz, NOAA

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

Ex-Officio Members

Doug Messeck, Law Enforcement Representative

Staff

Robert Beal
Toni Kerns
Kirby Rootes-Murdy
Jessica Kuesel
Caitlin Starks

Guests

Sign-In Sheet Not Distributed

The Coastal Sharks Management Board of the Atlantic States Marine Fisheries Commission convened in the Hampton Roads Ballroom V of the Marriott Waterside Hotel, Norfolk, Virginia, October 17, 2017, and was called to order at 1:03 o'clock p.m. by Chairman Roy W. Miller.

CALL TO ORDER

CHAIRMAN ROY W. MILLER: I think we should go ahead and call the Coastal Shark Management Board to order. I'm Roy Miller; serving as Chair. I'm from the state of Delaware, so welcome to the Shark Board meeting this afternoon.

APPROVAL OF AGENDA

CHAIRMAN MILLER: You have an agenda, are there any additions or corrections to the agenda? Seeing none; I'm assuming it's approved.

APPROVAL OF PROCEEDINGS

CHAIRMAN MILLER: The proceedings from the May, 2017 meeting that were the most recent meeting of the Shark Board. Are there any additions or corrections to those proceedings? Seeing none; I'll assume they're approved as they are printed before you.

PUBLIC COMMENT

CHAIRMAN MILLER: At this time I would like to call on Public Comment. As is our custom, this would be for items not specifically on our agenda. There is one person who would like to offer public comment; would you please step forward, and say your name please, and your affiliation?

MS. KATIE WESTFALL: Hi, yes this is actually for an item that is on the agenda. Will that be after the agenda item is addressed? Okay, I'll hold off then.

CHAIRMAN MILLER: That would be the best time to address it then. Just remind me when we get to your agenda item.

FINAL RULE FOR HIGHLY MIGRATORY SPECIES AMENDMENT 5B (DUSKY SHARKS)

CHAIRMAN MILLER: All right next on our agenda, we're going to go over the Final Rule for Highly Migratory Species Amendment 5b (Dusky Sharks). To lead off this discussion concerning the review of the final rule and NOAA Fisheries Request for Complementary Measures, I'm going to call on Karyl Brewster-Geisz. Karyl.

REVIEW FINAL RULE AND NOAA FISHERIES REQUEST FOR COMPLEMENTARY MEASURES

MS. KARYL BREWSTER-GEISZ: For those of you who don't know me, I work for NOAA Fisheries in the Highly Migratory Species Management Division. If you remember last spring, I gave a presentation about the final rule and requested for complementary measures then. I believe the Commission decided to think about it, review what the states wanted, and then we are at the stage now where NOAA Fisheries at least is hoping for the Commission to take on and implement some complementary measures for Amendment 5b.

I have a very quick presentation where I will explain the background of Amendment 5b, what we finalized, the implementation status of those measures, and then our request for complementary measures. If you remember, this is all regarding dusky sharks. It is a ridgeback shark found along the coast.

The stock assessment found they were overfished and experiencing overfishing, and a mortality reduction of 12 percent was needed to end overfishing immediately, and an additional reduction, so total reduction of 35 percent is needed to rebuild the stock by 2107. That is not a typo, it's not 2017, and it is 90 years from now, 2107. We have a bit of work to do to reduce fishing mortality by 35 percent. Our final rule published last April, and then I presented that to the Commission in May. One of the final measures we had was requiring that all recreational permit holders obtain a shark endorsement; and this shark endorsement would allow you to fish for and catch and land sharks, not just dusky sharks but any sharks.

This will be required as of January. It is something that you can get when you apply for your HMS angling, HMS charter headboat, or a couple other permits. You watch a video that is up on our web page. You can look for it on YouTube or Vimeo or any of the other places. It's about two minutes long, it goes through how to identify dusky sharks and other ridgeback sharks, how to safe handle and release them, so you do not injure the shark, nor do you injure yourself.

It also talks about the circle hook requirements and the recreational regulations. In addition to the shark endorsement, we have updated our shark identification placard. If you remember, this is on waterproof, tear proof paper for anyone. We hand it out to tournaments who request it. Anyone can get them. I have a couple copies up here.

We created a prohibited shark identification placard that has the prohibited species, particularly ridgeback sharks, which is what we're focusing on, and on the back has handling and release techniques. We also updated our careful catch and release guide; and this guide goes through how to release not just sharks, but other HMS, including billfish and tunas and swordfish.

All of this is underway, and we've been getting really good response so far on the placards, the careful catch and release guide, the video, we've undergone beta testing for the quiz that people will need to take to take the shark endorsement. We've made some tweaks to the video so the new video will be available with the quiz.

Those tweaks were more focusing on the safety requirements. You do not have to use a dehooker, but we do ask everybody to release the shark with a minimum amount of gear. The other measure we have for the recreational fishery is requiring circle hooks. The circle hook requirement is for anywhere south of Chatham, Massachusetts.

That is pretty much the northernmost range of dusky sharks. Some of the research particularly that by Angel Willey and Mark Sampson in Maryland showed that circle-hooks do have a very positive impact on fishing mortality; it reduces it by quite a lot. We have really begun outreach on this, and it is all in our outreach materials.

Commercially we are requiring that all fishermen with a limited access permit and pelagic longline gear, need to release sharks that they are not planning on keeping by using a dehooker, or by cutting the gangion less than three feet from the hook. Again, all of our pelagic longline fishermen are trained in how to use a dehooker; but if they deem it unsafe to do so, given the activity of the shark, they need to cut it with a minimum amount of gear.

This minimum amount of gear is more of a commonsense effort to try to minimize fishing mortality; so that shark when it's released has the opportunity to survive, thus reducing fishing mortality. We also implemented how to do this and how to identify sharks for commercial fishermen; by having a new shark segment in our safe handling and identification release workshops. These workshops were already required. We are not including a new segment on shark identification. We have increased dusky shark outreach and awareness tremendously; we've included some more commercial outreach materials, and require all pelagic longline, bottom longline, and shark gillnet fishermen to abide by dusky shark fleet communication and relocation protocol.

What this means is if they catch a dusky shark they need to let other vessels in the area know there are dusky sharks in the area; and they need to move one nautical mile, once they pull up their gear, to try to get away from the sharks. This is the same requirement we have when it comes to marine mammals and sea turtles; so we again felt this was a commonsense measure, to try to move away from the dusky sharks.

Then the last alternative we have for them is requiring the circle hooks in bottom longline gear. We already require circle hooks for sea turtles in the pelagic longline fishery. Now we will be requiring it in the bottom longline fishery as well. This slide, I'm not expecting you to be able to read it. It is just a summary of all of that.

All of these measures are already in effect, some of those commercial measures, or will be in effect come January 1st. Then this is our request that you help us with the outreach and education, and provide links to some of our materials or create your own materials; that you collaborate on the development of best practices for the handling and release of sharks when shore or pier fishing.

Again, all of our handling and release is from the vessels; because we are in federal waters. We're really looking to the states to drive the development of best practices up and down the coast, so all fishermen know how to release sharks when they catch them from that pier or on the beach. We're also asking the states to consider requiring circle hooks in your various hook-and-line fisheries.

This could be your recreational fisheries, but it could also be some of your commercial hand gear or commercial short lines. We are asking that you require fishermen to maximize gear removal before releasing sharks. This doesn't mean they have to use dehookers, but maybe just cutting with the least amount of gear as possible remaining on the shark. Then also consider cooperative research with us to improve estimates of duskies.

We talked a lot about that at the Technical Committee last time, have had some conversations with various states. I think we're moving forward somewhat on that. If you haven't started thinking about it, it would be good. Again, all of these measures we implemented are needed; in order to reduce fishing mortality on dusky sharks by 35 percent. We really need all of the states to help with this; in order to end overfishing and rebuild this species. Thank you.

CHAIRMAN MILLER: Thank you, Karyl. Are there questions or comments relative to Karyl's report; in the back, Pat?

MR. PAT GEER: Karyl, thank you very much for that. I'm just kind of curious. How have the measures that have been in place since June been received by the commercial fishery? I mean they have about four months so far. What are you hearing from the commercial sector?

MS. BREWSTER-GEISZ: The commercial sector has not come back saying that these are unreasonable requests. They are already taking the course in the workshops. They've been doing that since June. For the most part it's good. We've gotten some questions back from the workshop; so we might be making some changes to that presentation that they give. As far as I know things are going well with the commercial fleet and the measures that are already in effect.

CHAIRMAN MILLER: Are there any other questions or comments? David Bush.

MR. DAVID E. BUSH, JR.: Thank you for your presentation. A quick question for you, on the previous slide I think it was where it said these final measures will end overfishing. Is that based on what is already, or what has already been implemented, and anything the states do above and beyond that is additional, or is this with the assumption that the states will have complementary measures?

MS. BREWSTER-GEISZ: To end overfishing we needed a 12 percent reduction in fishing mortality; and we felt that the commercial measures that are already in place, or went into place on June 5th, would have achieved the 12 percent. We also believe that with the states onboard, we can reach that 35 percent that is needed to rebuild the stock.

CHAIRMAN MILLER: Are there any other questions?

LAW ENFORCEMENT COMMITTEE REPORT

CHAIRMAN MILLER: We'll proceed to the next item; and that is the Law Enforcement Committee Report, and for that I'm going to call on Doug Messeck from Delaware; who is representing the Law Enforcement Committee today. Doug.

MR. DOUG MESSECK: I'll be breezing over real quickly – and thank you for the opportunity to come here and speak to you all today – will be the memo from a conference call that we had several months back. What we reviewed and we discussed were some of the implementations that we're going to go over.

Under the federal waters the LEC did agree that the online training video and questions had merit; but it would provide some difficulty to enforce. What we are recommending at this time is continue using this as an outreach and educational tool, and also extend this over to enforcement officers up and down the coast, so that they also have the training in being able to identify the sharks.

The possession requirement of carrying some certification, if you have that onboard, individual person that would be adequate for enforcement purposes; but it would have to be something that is consistent amongst all the states so that we would know what we're looking for in the federal waters. Discussion of implementation into the state waters on this.

It was our recommendation that this somehow be combined to the HMS permit; so that when you received your HMS permit you took the online training, and then that became part of the general HMS that was distributed. However, we did realize that would not take into account the shore fishermen and the beach anglers and the peer anglers; who do make up a large part of this.

As far as the recreational for the non-offset and non-stainless with the circle hook requirements, that does prove very difficult for enforcement purposes, because it comes down to targeting. It will take a lot of personnel hours to sit there to watch these folks; to know exactly what they're fishing for and being able to ascertain that yes they are targeting sharks, they are catching them, and they are doing this. That will be very time consuming, very hard to enforce. Several states already have circle hook requirements in for striped bass. They are effective; but they are very time consuming, and they are hard to enforce. Once a person leaves that area, if they have the sharks onboard and they have left that area, at that point you're not able to ascertain beyond a reasonable doubt that they did in fact catch those fish under the J hook or the circle hooks.

Once they've left the fishing area then enforcement is going to end at that point. The commercial circle hook requirements would be not a problem for enforcement, because they are in that directed fishery. They're going to be out there and their gear is more concise and more contained, so it would be no problem to the commercial end of it.

The gear removal, the LEC had very strong recommendations for the potential safety of the fishermen; that they be granted leeway with personal safety being the biggest factor. We feel that the use of certain gear should not be required, but to require having the gear onboard is easily enforceable, but you have to have the leeway, as far as those persons using that whether or not it is safe for that fisherman to release that fish.

CHAIRMAN MILLER: Thank you for those comments, Doug. Are there any questions for Doug? Michelle.

DR. MICHELLE DUVAL: Thank you for the Law Enforcement Committee report, Doug. I was a little bit confused when the Law Enforcement Committee was discussing the online training course. I was having difficulty understanding if the Law Enforcement Committee was recommending that the states require that the online training course be taken; and that the federal permit, in other words the federal endorsement for recreational fishing be required by the states as well. It just wasn't clear to me if you all were recommending that or not.

MR. MESSECK: For the federal waters with taking the course and the online, and then printing out some type of certificate and having it onboard the boat, we were in support of that; although we wanted to see it more educational based with going out there rather than requiring it, because of the enforceability issues.

We have to have something onboard that shows it is unique to that fisherman that they have it, and then a fisherman that comes out of say Maryland, who is fishing off of New Jersey waters. They may encounter different jurisdictions t that we have something that is consistent throughout the states. But it was enforceable that on the federal level, if they were in the federal waters and they had some type of certificate that was printed out to that person that would be easily enforceable.

As far as coming back into the states that is where our recommendation was that an addendum be made to the HMS, so that this way it covered both state and federal waters, rather than each individual state trying to come up with their own regulations that may be different as you go up and down the coast. Our main goal in all this was to have the highest level of consistency.

CHAIRMAN MILLER: Are there any other questions or comments regarding enforcement? Emerson.

MR. EMERSON C. HASBROUCK: My question is looking for some clarification. I thought, and perhaps incorrectly that anybody who had an HMS permit had to abide by those HMS requirements; regardless of the fishery, whether they were fishing in federal or state water under that federal HMS permit. Is that correct or not correct?

MR. MESSECK: For the HMS for the tunas it is requirement that you're in state or federal waters. For the sharks there is that exemption in there. If you're fishing strictly in state waters then you do not have to have the possession of the HMS permit.

CHAIRMAN MILLER: Karyl, did you want to comment on that?

MS. BREWSTER-GEISZ: Yes, thank you. I just wanted to clarify. If you have a HMS permit, yes you are required to follow the federal regulations regardless of whether you are in state waters or federal waters, unless the state has more restrictive regulations. If you are only fishing in state waters, and you never go into the federal waters, then you are correct that you only need that for tunas; which we manage all the way to the shore. But for sharks you do not need a federal permit.

CHAIRMAN MILLER: Eric.

MR. ERIC REID: It is just the comment about being able to get a permit online. I think that's a pretty interesting solution, maybe? I'm a shark dealer. I have to physically go to a class so I can ID sharks. I'm handling them; they're dead when I get them, so maybe it's a handling thing. But I have to physically go to a class.

Every three years when I have to renew, I have to go back to a class. I just think it's interesting that the recreational guys can go online and print out a certificate; and I've got to drag my butt to class every three years. I don't know if you can change that. It doesn't have anything to do with dusky sharks; but it has permitting in general. I've talked about that before, but I don't seem to get anywhere, Mr. Chairman.

CHAIRMAN MILLER: Do you have any comment to that, Karyl?

MS. BREWSTER-GEISZ: Yes, we do require that all of our shark dealers go to a class every three years; where they have hands-on instructions for seeing the sharks in those, because what the shark dealers are doing, they need to be clear and identify every shark to species on their dealer reports, which is critical for our quota monitoring purposes.

Some of our shark species have pretty small quotas; and we need to make sure we're getting the correct identifications. The shark fishermen, there are thousands of them compared to hundreds of the dealers. We would love to be able to require that all shark fishermen when they go out fishing get that hands on requirement; but it's just not possible for the recreational fishery, where you're talking about 20 or 30,000 people going, some of them just going out once for a weekend.

We are requiring this video now; which shows some of the main features, particularly of the species that are important or critically important at the moment, and those are the ridgebacks. Those of you who will remember, I believe it was the Edisto tournament in South Carolina, where fishermen clearly landed ridgeback sharks. It's because they were not aware of the regulations and how to identify ridgeback shark, let alone whether or not those were duskies or sandbars or silky or any of the other ridgeback sharks. We're trying to, in our endorsement video, trying to point out those indications of what you should not be landing. We do not intend for all the recreational fishermen to become shark experts.

Shark dealers however, they have a commercial stake in this. They should be experts. We are considering other ways. We have heard comment like yours before that it's every three years; shark identification doesn't change that frequently. Maybe we should change it. We're considering things like that; but at the moment this is where we stand.

CHAIRMAN MILLER: Thank you for that clarification, Karyl. Okay, Eric?

MR. REID: Thank you, Mr. Chairman; I won't take any more time.

CHAIRMAN MILLER: Are there any other hands. Tom Fote.

MR. THOMAS P. FOTE: Karyl, have you thought about through the Chair, have you thought about doing a video for the surf fishermen? I've noticed in the last couple years there are a lot of clubs that actually have where they meet at night and they all shark fish. Everything is released, nothing is kept.

But the handling of how you handle sharks in the surf, it would be nice to basically be able to send them to a site, and when I see one of the clubs scheduling some night like this. I say why don't you all go look at the video before you basically do that? It's becoming very popular. I mean guys do it.

They basically have big gear, like they were doing it for the last 30 years they were catching a lot of brown sharks in the bays and things like that. But all those sharks are really released; but it would be nice if you had a handling video that we could basically show to them, because as we tried in New Jersey, as we demonstrated with summer flounder, we're trying to promote how you handle fish and release them carefully.

MS. BREWSTER-GEISZ: Thanks, we would actually love to do a handling and release video. One of the problems we've had with the video we have now for the sharks is some of the anglers, particularly those up off of New England that handle some of our big blue sharks and mako sharks, say that the sharks we're showing in the video are a little too relaxed.

They are not the type of sharks they see. They see sharks that are all over the place; struggling to get out. They are having trouble getting us video of that to put it in. I would urge you that if you have any video that you would like us to do, get us a request. But then also, if you have the video itself, we would love to have it to be able to use.

MR. FOTE: These guys shoot videos of everything they do nowadays. If we put out a release and ask some of the clubs, basically when you're doing this if you shoot a video, please get it into us. We want to use it as a training video to look at. Of course you have to use circle hooks, you've got to be abiding by the laws if you do that. We need some instruction. If you help me write up something like that I can get to a bunch of clubs that do that; and maybe it would help in obtaining footage.
CHAIRMAN MILLER: John.

MR. JOHN MANISCALCO: I would just second the need for that kind of handling video. New York State is also seeing an increase in shore fishing for prohibited species like sandbar, sand tiger and that kind of thing. Any positive outreach would be helpful.

CHAIRMAN MILLER: I would just add that although I'm not aware of a video generated by Delaware, I think they're the only state that has regulations with regard to recreational release of sharks. We'll get into that summary of the states, how the states react to releasing sharks, and what guidance they provide in a minute. But I just thought I would throw that in here now. Are there any further questions or comments on this?

TECHNICAL COMMITTEE REPORT

CHAIRMAN MILLER: Seeing none; I'm going to call on Kirby for a report of the Technical Committee; in their review of these federal measures, Kirby.

MR. KIRBY ROOTES-MURDY: As mentioned, I'm going to go through the Technical Committee report. First is just some brief background. As you all know, the last time the Board met was in May, 2017, and there was a request for the Board to consider cooperative research with NOAA Fisheries to improve the estimates of dusky and other sharks caught in state waters.

The Technical Committee met via conference call on June 2, to discuss the provisions of Amendment 5b. I will note that I was not on that call; Karyl was. She might back me up if I misspeak on any of these points that were raised by the Technical Committee. For Amendment 5b, NOAA Fisheries is interested in trying to collect additional fishery dependent data for future stock assessments; as Karyl mentioned.

Currently the shark dependent data, they are pulling that from five commercial vessels that have 100 percent observer coverage in federal waters. Regarding the gear, they're using bottom line and they're limited to no more than 300 hooks. What that means is that for each trip fishermen can make two sets only; the first no more than 150 hooks can be set, and then on the second set no more than 300 hooks.

Fishermen must keep all dead sharks; that's unless they are prohibited species or the fishing season is closed, and the fishermen are allowed to fish for and sell sandbar sharks. Some of the challenges that the Technical Committee raised regarding extending research into state waters were the following.

Fishing for sandbar sharks is prohibited in state waters for many states; and current bottom line gear length may exceed the requirements of short lines that are used to fish for sharks in state waters. Fishermen many times can keep over their commercial retention limits, as well as fishing for coastal sharks based on a quota other than the aggregated, large, coastal sharks quota is also a problem. What we mean by that is that the season may be closed for other large coastal shark fishermen.

The group discussed the language also in Section 4.3.82 regarding the display and research permits of the coastal sharks FMP. As noted in the document, a state may grant exemptions from the seasonal closure, quota, possession limit, gear restrictions, and prohibited species restrictions contained in the FMP through a state display, or through a research permit system. Then states also required NMFS to apply for a research permit; which is not automatically or always easily obtained. Next we have a couple of state-specific notes. First was from Georgia. Although it's allowed in the coastal sharks FMP, longlines and gillnets are not allowed in state waters. No current, commercial fishery is currently taking place, and therefore there was not a need for fishery independent data collection. Over 17 plus seasons of fishery independent data collection, and no documented dusky sharks have been found in Georgia's territorial waters.

Five species though have been encountered; and those are Atlantic sharpnose, bonnethead, blacknose, blacktip, and sandbar sharks. Other state notes were with regards to North Carolina. There were two main concerns that were raised regarding shark research in state waters. The first is that North Carolina has a scientific permit application that requires applicants to be affiliated with a research institution.

The second is that accurate reporting of research landings versus commercial landings is somewhat of a problem. Currently there is one North Carolina fisherman who participates, and is not affiliated with a research institution. NOAA Fisheries is in turn responsible for the scientific permit, though legally they are not.

From my understanding the application issue would need to be resolved before the landings issue could be addressed. Highly Migratory Species Division of NOAA will have further discussions with the state of North Carolina on this; and maybe Karyl can speak to that if any progress has been made on that.

Then lastly, if there is a potential fix regarding the commercial research landings, HMS could ask the fishermen to sign an agreement that lets HMS forward the landings data to North Carolina. This would then allow North Carolina to accurately depict commercial and research landings on North Carolina's trip ticket system.

Wrapping up additional state notes, we have South Carolina, and Virginia and Florida. For South Carolina that state will allow a research fishery in state waters, if the individual has a South Carolina scientific research permit. Virginia and Florida there was a request made on that call about an allowable gear type in state waters; if they could allow research fishery in state waters. I have not heard word back on that as of yet, maybe Rob can speak to that.

Regarding Florida, they currently have a ban on longline gear and gillnets in state waters. That will not be lifted for shark research. Last, as noted in the TC report, NOAA has a shark tagging program, and there were some questions on angler participation in that program. South Carolina currently has anglers required to have a scientific research permit to tag a fish.

Florida requires a special activity license for all fish tagging. Massachusetts, Maryland, North Carolina and Georgia, do not require anglers participating in a cooperative tagging effort to have a scientific research permit. With that I will take any questions as best I can. Thank you.

REVIEW STATE FEEDBACK

CHAIRMAN MILLER: Are there any questions for Kirby? I'm going to call on Kirby again to provide state feedback on the review. That was through the auspices of a poll, and Kirby will tell us about it.

MR. ROOTES-MURDY: I'll go through this pretty quickly; just as background, as you're aware there were questions posed to the states following the May board meeting. I'm going to walk through the summary of that feedback that we got from the states. Just to be clear, we received feedback. We set a deadline of May 31, and we got feedback from the states of New York south through Florida. They provided responses to those questions. We didn't hear anything from the states north of New York up through Massachusetts or the state of Maine that I'm aware of. The three questions that were asked were, and a number of them had subcomponents, and I can get into those if there are follow up questions.

But the three questions were; does your state have communication materials currently to address best practices when fishing for sharks from shore or piers? The second question is; does your state require circle hooks when fishing for sharks or other species? The third was; does your state have measures to maximize gear removal before releasing sharks?

That's either release using a dehooker, or cutting the gangion line less than three feet from the hook. Question one; in terms of the responses they were nearly split. Four were yes, five were no, some qualified those answers. Nearly all were in favor of the sub-question of requiring communication materials.

Many are not interested in making it mandatory. Many noted that the Commission and/or NOAA should help with developing those materials, and material information should be consistent if implemented across all the states. Regarding question two, does your state require circle hooks?

Predominantly it was a no for most states. That would be New York through Delaware, North Carolina, and Georgia through Florida. New Jersey, Delaware, North Carolina and Florida all require circle hooks for other specific species. Maryland, Virginia and South Carolina regulate short lines for the commercial fishery.

There was a sub-question about whether the Commission should require circle hooks. This was fairly evenly split, in terms of two were against three were for, and four states either didn't answer or were neutral on the question. The last main question was does your state have measures to maximize gear removal?

A majority of the states do not, only three states currently have these measures or similar measures in place; and that's New York, Delaware, and Virginia. Just to note, the state specific responses were included in your meeting materials, so please look through that if you have specific questions on an individual state. But with that I will take any questions on my summary.

CHAIRMAN MILLER: John then Michelle.

MR. MANISCALCO: Just a note. I believe New York State does have a circle hook requirement for sharks.

MR. ROOTES-MURDY: Thank you, John, I'll make that noted. Sorry.

CHAIRMAN MILLER: Michelle.

DR. DUVAL: In terms of circle hooks, I mean we do require, in addition to what was noted in the survey. I mean we do require the use of circle hooks for the short lines for the coastal shark's fishery for the commercial sector of the coastal shark's fishery. Then also in our proclamation, which has the force and effect of rule. We do have language that is very similar to Delaware's regulation on the books; where it states it is unlawful to fail to return all sharks not meeting harvest requirements to the water in a manner that ensures the highest likelihood of survival, which I think is very similar to what Delaware has on the books right now. I just wanted to make those two notes.

CHAIRMAN MILLER: Thank you for those additions. Are there any other comments or questions on the poll that was distributed and described by Kirby? Jay.

MR. JASON McNAMEE: I will first start by apologizing to Kirby. I have an e-mail crafted up. It's well within the realm of possibility that I just never hit send. I'm guessing it is past relevance at this point, but if not I would be happy to send it to you. To cut to the chase, I don't think Rhode Island would have tipped the balance in either direction in the poll, for the answers you have already. But I just mostly wanted to apologize for not responding.

MR. ROOTES-MURDY: Thank you, Jay. Just to that. If folks have questions on Rhode Island's requirements or answer to those, then you can direct those to Jay and he can answer them in this meeting.

CHAIRMAN MILLER: Are there any other comments or questions?

CONSIDER COMPLEMENTARY MANAGEMENT MEASURES FOR STATE WATERS

CHAIRMAN MILLER: The last item under this subheading would be to Consider Complementary Management Measures for State Waters. We list possible action for that agenda item. Are there any recommendations from the Board? It doesn't have to be in the form of a motion yet, but any comments or recommendations? Dr. Duval.

DR. DUVAL: It sounds like, just from my reading of all of the survey responses that most states were in favor of or amendable to including links on their websites to educational outreach materials that would link directly to the HMS website, in terms of the educational video online. I think just in terms of making that a requirement.

I'm not so sure we would necessarily support making it a requirement or a compliance requirement. My sense, and other states can speak up is that most folks were amendable to including that information on their website. I do agree with the states that indicated, in terms of providing additional outreach materials for shore or peer-based-recreational fishing for sharks.

We would probably look to the Commission and HMS to take a coordinated approach to developing those materials, just to make sure that there is a consistent educational message going out to all anglers, with regard to best practices and safe handling of those sharks. I do have some other comments on the research fishery, and complementing that in state waters, but I'll hold off and maybe just tackle these things one thing at a time.

CHAIRMAN MILLER: Is there any response either to Michelle's comments or any comments on this particular topic or suggestions? Rob O'Reilly.

MR. ROB O'REILLY: The correspondence here with Michelle is pretty much the same. The outreach is really good. I see from the survey that maybe some states are hoping to be provided the information. But certainly that's supportable, putting as a requirement based on the feedback that I heard from the Advisor, at least the director of the Advisory Committee is that all along most of the states were not looking for that. I think that probably my comments are very similar, and I won't wait to talk about the research part. But I know that Kirby asked me about that earlier and mentioned that I might address that. I think other than longline, Kirby, I think that is probably the gear that is prohibited, so just wanted to add that now if I may.

CHAIRMAN MILLER: In thinking about this prior to the meeting, I decided there are three possible courses of action. Obviously the default is doing nothing additional. A second course of action would be as Michelle suggested, having voluntary access to the educational materials that link on state's websites linking to the federal guidance in this regard.

Then the third option would be some sort of mandatory compliance. Thus far the only comments that I've heard from anyone, and Robert, I'll get to you in just a second, would be for the second alternative, namely voluntary compliance with perhaps a common message available. Robert.

MR. ROBERT H. BOYLES, JR.: The state of South Carolina has long adopted a policy of complementary management; specifically for sharks in state waters, for a variety of reasons. I must point out to the Board however, that our Legislature has been very, very clear in terms of recreational angling requirements.

I should preface this to say that we have required a saltwater recreational fishing license since the early 1990s. We were one of the first states to do so on the east coast, but I would like to read from the South Carolina Code. "However, no federal recreational angling permit, or federal charterboat headboat permit is required for the taking or possession of sharks in the water of the state."

Our General Assembly has made a very, very strong policy statement with regard to federal permitting requirements in state waters. Insofar as I represent the state of South Carolina, and given South Carolina's history, vis-a-vis federalism, I think it would just be helpful for the Board to make note of that. But having said that I think the idea of complementary management measures, both from ease of the compliance, as well as making accessible those educational materials is very important.

CHAIRMAN MILLER: Are there any other comments or suggestions? Do the states feel they have sufficient guidance at this point to press forward with this issue? Michelle.

DR. DUVAL: Well I'm not shy. Again, we don't have any problem with providing links to the materials that HMS has produced on our website. You know we would be happy to do so. I think perhaps receiving, if that link could be e-mailed directly to us, we just want to make sure that we're providing the appropriate link to those materials. Then as I said, we are absolutely supportive of additional materials that would assist anglers who are fishing from peers or from shore.

Our concern is just that whatever we are linking to everybody is linking to the same information; so that it is a consistent educational message. I think from North Carolina's perspective we have no problem moving forward; and providing links on our website to the videos that the Highly Migratory Species Division has already produced.

CHAIRMAN MILLER: Assuming this is the path forward for us, Karyl. Could you provide the exact links to everyone, to every coastal state to make sure that in our educational materials they reach the right source?

MS. BREWSTER-GEISZ: Yes, we are actually putting the video, along with our questions, up on our permit web page for educational purposes. Anybody can go to the permit web page and see the video and take the questions. That will happen when we make the switch over to issuing 2018 permits; so that should be November timeframe.

Anyone will be able to watch the video, take the questions. The answers to the questions have links to all of our materials. The question that I have for all of you actually is I'm hearing some messages that you would like consistent, or at least some of the states would like consistent shore and peer-based best practices, which I'm all in favor for. The question is more of, is that really what I'm hearing and how do we start that process?

CHAIRMAN MILLER: Yes the question is who will tailor made this advice for shore and peer fishing? Obviously we're not going to resolve that just at this particular juncture. But certainly Karyl can provide the linkage to the federal websites, at least for vessels fishing in internal waters for sharks. It will be up to the states to provide links to that information, provided in our education and outreach materials.

I'm not hearing any consensus or any suggestions even, towards making that mandatory. But it appears to be a voluntary compliance measure. Are there any differing opinions on that or is everyone pretty much on the same page that it should be voluntary? I'm seeing some heads nod for the voluntary. Does anyone feel otherwise on that? All right thank you. Michelle, I think you wanted to raise another issue as well. Did you not?

DR. DUVAL: Yes, just I think a couple things. I think one of the other questions that was raised was, and I think that NOAA Fisheries has requested complementary measures for is the use of circle hooks when fishing for sharks. As I indicated that is already a requirement for the commercial fishery in North Carolina, when fishing on coastal sharks within state waters.

That is already a requirement of our proclamation. We do have concerns, which for folks who read through the materials would have seen, with regard to having a circle hook requirement for recreational fishermen. I think this is reflective of what the Law Enforcement Committee pointed out, the issue is determining targeting.

Our concern was also that anglers are likely to be much more receptive to a positive encouragement to use circle hooks as part of best handling practices when fishing for certain species, as opposed to making this a mandatory compliance element. I just wanted to reiterate that is where North Carolina stands on the circle hook issue. We would prefer to provide positive encouragement, rather than making that a mandatory requirement within state waters.

I think the folks who are fishing, engaged in directed fishing for sharks in federal waters. Those are folks who are really shark fishermen. That is what they plan to go out and do, and I think for a lot of anglers fishing within state waters, they are not looking necessarily to target sharks. I'm not saying everybody, but they're not necessarily looking to target sharks. If they happen to pull up a shark, and are faced with a compliance of having to use a circle hook. We're just concerned that that is actually going to have a negative impact, in terms of angler attitude. Thank you, it sounds like Robert wants to speak to that point, and then I'll come back to the research permit.

CHAIRMAN MILLER: All right, I'll call on Robert.

MR. BOYLES: Dr. Duval said it very, very well. I mean in addition to sharks there are a number of species that we're watching now that we are developing and have developed best practices for. Circle hooks are a very, very big part of that; leader lengths, fixed weights, those kinds of things, in the red drum fishery for instance.

We already have a very vibrant outreach campaign now, and certainly think that this is in keeping. I agree with Dr. Duval's comments. You are concerned about targeting, specifically recreational fishermen fishing in state waters could be out shark fishing, could be out red drum fishing, it could be flounder fishing.

I think it makes it puts our Law Enforcement Division in a very difficult spot, in terms of looking at those violations. The last thing I would like to say is you know we have found a good success, in terms of engaging the recreational anglers as partners in stewardship and conservation with these voluntarily measures, as opposed to mandatory measures.

CHAIRMAN MILLER: Are there any further comments? I take it, by the fact that no one has additional comments that there is no one that feels that circle hooks, for instance, should be mandatory in state waters for fishing for sharks. But that no one would oppose any given jurisdiction from providing additional outreach materials recommending circle hooks when fishing for sharks. Is that a fair summarization of the general feelings of the Board?

I'm not seeing any negative responses, so I'll take that as a positive. Have we covered everything on this particular agenda item? Is there anything further we need to take care of? There was a public comment, and I think it was on this agenda item. Would you come forward and identify yourself, Katie? Thank you.

MS. WESTFALL: Good afternoon, my name is Katie Westfall; I'm the Senior Manager of Highly Migratory Species Advocacy at the Environmental Defense Fund, and a member of the Coastal Sharks Advisory Panel. I appreciate the opportunity to provide public comment today on this agenda item, and strongly support the Commission adopting complementary management measures to Highly Migratory Species Amendment 5b, which aims to end the overfishing of dusky sharks, and rebuild their population.

It sounded like there was interest in voluntary measures; but specifically I would like to strongly encourage the Commission to require that anglers fishing for sharks obtain a shark endorsement, including the completion of online shark identification and fishing regulation training course. As you know, at least 19 shark species are prohibited in both the federal fishery and according to the ASMFC Coastal Shark Plan, including dusky sharks.

Unfortunately, many sharks caught intentionally and accidentally in recreational fisheries fall into this prohibited group. Over the past decade on the east coast alone, 1.2 million prohibited sharks were caught in both state and federal waters, along with an additional 17.5 million sharks that were reported as unidentified; because anglers either did not or could not identify at the species level. While some of these sharks will survive after release, many will die after being mistakenly landed or mishandled, because anglers do not know fishing regulations, safe handle and release practices, or how to identify the species. The landing of dusky sharks, for example, has been prohibited since 2000, but overfishing continues.

Recreational fishing in state and federal waters represents the largest source of interactions with dusky sharks by an order of magnitude, highlighting the need for increased stewardship by anglers. For a species like dusky sharks, which is prohibited due to its vulnerable life history characteristics, even low levels of mortality harm that population and hamper recovery efforts.

Recent research suggests that anglers themselves under appreciate the impact they can have with catch and release fishing; and at the same time studies indicate that education efforts that train fishermen to safely handle and release sharks, can reduce the amount of mortality that occurs after release.

It's particularly important that the Commission takes action to adopt complementary measures to this endorsement; because tens of thousands of individuals fish for sharks from boats, peers, and shorelines on the east coast. Indeed, this estimate may be low by an order of magnitude, as these numbers are not currently known.

As noted in a recent study, it's also important to recognize that land-based-shark fishing has the potential to cause more stress to sharks as they're dragged over rough terrain onto the shore without the buoyant support of water. This type of handling makes sharks more susceptible to injury, and less likely to survive if released.

Requiring an endorsement and related training would increase the ability of anglers to correctly identify dusky and other prohibited sharks, comply with regulations, and safely handle and release these sharks. Thus, adopting this measure would aid in the rebuilding of the dusky shark population.

Further, these measures would help to improve the data for the recreational sector in state waters, as it would increase the chances that anglers are correctly identifying shark species. It would also help to identify the universe of fishermen who are targeting sharks, which could provide a population to sample from, in order to improve recreational estimates for dusky and other sharks.

In addition to the shark endorsement, we recommend that states expand outreach and educational efforts to recreational fishermen in state waters, which could include trainings and workshops. In order to implement such an effort, at a minimal cost states could use the NMFS produced outreach materials that we talked about today.

In addition to those materials, it was heartening to hear the support for the development of shore-based fishing best handling practices, as that is currently missing. Thank you very much for the opportunity to comment on this important issue, and for your consideration of the recreational shark endorsement.

SET 2018 SPECIFICATIONS

CHAIRMAN MILLER: Are there any questions or comments to direct to Katie, before she walks back? Seeing none; thank you very much. All right, we'll move on to the next to the last agenda item, and that is set the 2018 Specifications for shark fishing. I'm going to call on Kirby, initially to tee that up for us.

MR. ROOTES-MURDY: I'm going to actually pass it down to Karyl; who has a PowerPoint ready for it.

MS. BREWSTER-GEISZ: I will be really fast on this. This is in regard to our proposed rule for quotas, opening days, retention limits for the 2018 Atlantic shark commercial fishing season. I am focusing only on the Atlantic Region. We issued a proposed rule in August. Real short summary, this proposed rule proposes the exact same thing that we implemented in 2017.

The exact same quotas all around, which means that Atlantic smoothhound sharks, which is essentially smooth dogfish in the Atlantic, has an increase, because they under harvested the quota. Everybody else has the base quota that we have set up. We are proposing opening all shark management groups on January 1.

We are proposing that the large coastal retention limit be 25 sharks other than sandbar per vessel per trip. If the quota is going really fast at the beginning of the year, we would reduce the retention limit, probably to about three. That's what we did this year. Come July 15 or so, we will increase it back up to 36, is what we proposed.

This is pretty much exactly the same that we did this year. Except for a couple modifications in the retention limit, it's the same that we did in 2016; both in 2016 and 2017 the large coastal fishery continued through the entire year. We are not expecting it to close at this point. Comment period ended on September 21. We did not receive any comments opposed to this. We did not receive any comments from any of the states.

We had a couple comments from people generally about shark fishing, some people who don't like shark fishing at all, and wanted us to close all commercial fisheries, and some people who were supportive of having quotas but were concerned about the enforcement. Other than that all the comments we received were in favor of what we proposed for the Atlantic. We are working on the final rule. Here are all the numbers in a really small font, so I'm not going to read it to you. You can look at it on your own.

CHAIRMAN MILLER: Are there any questions for Karyl? Seeing none; I'll look to the Board for a possible motion. Rob O'Reilly.

MR. O'REILLY: Thank you, Karyl, and as I stated last year, it's really important that over time NOAA has been able to allow other states to enjoy the fishery. That's certainly the case in Virginia. We're very happy about that. With the variable possession limits that's made all the difference, and after July 15, we are able to pursue some sharks, which is good.

Thank you again, and my motion is move to approve the 2018 Coastal Shark Specifications via an e-mail vote after the NOAA Fisheries

publishes the final rule for the 2018 Atlantic Shark Commercial Fishery Season. This is not a precedent, this has happened before where we've had the e-mail vote.

CHAIRMAN MILLER: Does anyone care to offer a second? First hand I saw, is that Tom Baum? Tom. **Is there any discussion on the motion? Seeing none; are we ready for a vote? Is there a need to caucus? Is there any opposition to approving this motion? Seeing none; I assume it's approved as offered. Thank you.**

ELECT VICE-CHAIR

CHAIRMAN MILLER: The last agenda item is we need to elect a Vice-Chair. Does anyone have a suggestion? Spud.

MR. A.G. SPUD WOODWARD: I would like to nominate Patrick Geer for Vice-Chair of the Coastal Sharks Board.

CHAIRMAN MILLER: **Is there a second? Robert. Are there any further nominations? Seeing none; congratulations, Pat. You're the new Vice-Chair. (Applause)**

OTHER BUSINESS

CHAIRMAN MILLER: All right, is there any other business to come before the Shark Board? Michelle.

DR. DUVAL: Sorry, not to go back to a previous issue, but I just wanted to make a quick comment on the shark research fishery, and the request by HMS to develop cooperative research opportunities in state waters. I know we struggled with this in North Carolina a little bit, because of our regulations, and it is in regulation that we do require a scientific or academic institution to be the holder of that permit, just so that we do not have individuals applying to do "research".

We just want to make sure that there is valid, scientific research being done. I don't anticipate that those regulations will change, so we're going to have to try to work towards some solution. But because we do want to support those types of research activities in state waters where we can, you know I did note that we do have one individual who participates in that fishery right now.

There was a researcher from the Northeast Fishery Science Center, I think a Mr. Milliken who did obtain one of our Scientific and Educational Collection Permits, in order to work with this individual. Perhaps Karyl and HMS staff can look into that and a similar solution can be found.

CHAIRMAN MILLER: Thank you for that suggestion and the comment, Michelle. Is there anything further for the good of the Shark Board? Toni.

MS. TONI KERNS: Not necessarily for the Shark Board, but I did want to make an introduction, who I haven't even made myself an introduction yet. Some of you may remember Najih Lazar; he used to work for the state of Rhode Island, and now he is at the University of Rhode Island, Coastal Resources Center. He is here with a delegation of folks from Ghana; including their Deputy Minister and their Director of Fisheries. They are here to learn about the Commission and our process.

They too have a fisheries commission that they are working to get together to work on rebuilding their fishery resources. They're here to just learn about our process. They will be here tonight with us at the annual dinner. I don't know if you gentlemen want to stand up so folks can see you, or just say hello. Please make sure folks introduce yourselves, (Applause) and let them know how our Commission works. That is it. I think we'll start Eel on time at 2:30.

ADJOURNMENT

CHAIRMAN MILLER: Welcome, and if there is nothing further, I guess we're adjourned.

(Whereupon the meeting adjourned at 2:10
o’clock p.m. on October 17, 2017)

REPORT OF THE 2017 ICCAT SHORTFIN MAKO ASSESSMENT MEETING

(Madrid, Spain 12-16 June 2017)

1. Opening, adoption of Agenda and meeting arrangements

The meeting was held at the ICCAT Secretariat in Madrid, June 12 to 16, 2017. Dr Enric Cortés (USA), the Species Group ("the Group") rapporteur and meeting Chairman, opened the meeting and welcomed participants. Dr Miguel Neves dos Santos (ICCAT Assistant Executive Secretary) addressed the Group on behalf of the ICCAT Executive Secretary, welcomed the participants and wished them the best for this important assessment. The Chairman proceeded to review the Agenda which was adopted with minor changes (**Appendix 1**).

The List of Participants is included in **Appendix 2**. The List of Documents presented at the meeting is attached as **Appendix 3**. The abstracts of all SCRS documents presented at the meeting are included in **Appendix 4**. The following served as rapporteurs:

Sections	*Rapporteur*
Items 1, 7 and 8	P. de Bruyn
Item 2	J. Fernández Costa, E. Cortés, R. Coelho, D. Macias, M. Byrne, P. De Bruyn
Item 3	D. Courtney, B. Babcock, H. Winker, H. O'Farrell, D. Die, D. Parker
Item 4	D. Courtney, B. Babcock, H. Winker, H. O'Farrell, D. Parker, E. Cortés, M. Kai, P. de Bruyn
Item 5	B. Babcock, H. O'Farrell.
Item 6	E. Cortés, G. Diaz, A. Domingo

2. Summary of available data submitted by the assessment data deadline (30 April 2017)

2.1 Stock identity

No new information was presented on stock structure.

2.2 Catches

The Secretariat stated that very little Task I or II information had been received since the data preparatory meeting in March. The major change was the receipt of Task I catches from South Africa for the southern stock. This submission filled an important gap in the catch series for the southern stock.

Document SCRS/2017/110 provided updates on the alternative hypothesis for the reconstruction of time series of catches for north and south Atlantic stocks of shortfin mako shark. It was noted that the reconstruction of shark catch time series is important for stock assessments, as the nominal catch data on sharks is usually limited. The estimation method is based on ratios of shark catches to catches of the main target species obtained from observer programs, literature reviews, and/or personal communications.

The Group noted that these estimated catches were significantly higher than the official Task I catches (**Figure 1**), particularly for the historic time series. It was acknowledged that the Task I data, particularly in the early part of the time series, are highly uncertain due to the lack of reporting of shark captures during that period. The estimation presented here provides a potentially more realistic representation of the captures for the early years of exploitation. It was thus recommended that these estimations be used in an alternative model run for each of the models.

It was also questioned whether trade data had ever been used to estimate total catches for shortfin makos. It was noted that fin trade data had been used in the past for blue sharks (Anon, 2016), but that these estimates were only valid until 2012 (due to the trade data collected) and also were dependent on the ICCAT Effdis data used in their estimation, which is currently under revision.

2.3 Indices of abundance

Document SCRS/2017/108 provided standardized CPUEs for the shortfin mako shark from the Spanish surface longline fleet targeting swordfish in the North and South Atlantic Ocean over the period 1990-2015. Standardization was based on GLM analysis of trip data. A base case and two sensitivity analyses (GLM and MIXED procedure) were carried out. Area was identified to be the most relevant factor explaining the CPUE variability in all models. The base case explained between 40-46% of CPUE variability. All tested scenarios showed very similar and stable trends in general CPUE over time in the North and South Atlantic stocks during the 26 years analyzed.

The Group discussed the use in the model of the variable "type of trip" (ratio) defined as the percentage of swordfish in relation with the total of swordfish plus blue shark catches. The Group suggested the use of clusters in the analysis instead of the ratio to avoid redundancy in the model. Researchers of EU-Portugal, whose fleet is similar to the EU-Spain fleet, carried out an analysis of clusters in their fleet and, they obtained the same results using clusters as when using ratios. Furthermore, the clusters showed the same redundancy in the model. Taking into account the previous considerations, and the history of the EU-Spain fishery, the authors consider that the ratio is a good indicator for the criteria of the skipper targeting swordfish and/or blue shark during a fishing trip.

A question was raised about the number of zero catches and the authors indicated that there was a low proportion of trips with zero catches (mean values of 2.8% and 4.3% for the North and South Atlantic stocks, respectively). In addition, the zero catch trips showed a stable trend over time. The Group welcomed this update to the EU-Spain North and South LL CPUE series and recommended that they be considered for the assessment models.

SCRS/P/2017/017 presented a new standardized CPUE data time series for shortfin mako shark caught by the South African large pelagic shark longline fleet for the Group to review. The majority of these catches occur in an area that straddles the ICCAT/IOTC 20 degree boundary, which is a known juvenile aggregation area. Given the uncertainty regarding regional assignment of this boundary stock, the Group suggested that the standardized CPUE indices should not be included in the assessment of the South Atlantic shortfin mako shark.

2.4 Biology

Document SCRS/2017/111 presented the results of the age and growth Project for the North Atlantic within the ICCAT-SRDCP - Shark Research and Data Collection Programme. Ageing from vertebrae and growth models were presented for the North Atlantic. A 2-parameter von Bertalanffy growth model provided the most biological reasonable estimates, especially for females. The difference in growth parameters between males and females was noted, with males having almost double the growth rate of females.

Additionally, preliminary plots of the integrated growth analysis using both tag-recapture data and age readings was shown (work done in cooperation between ICCAT and IATTC scientists). For this analysis the ICCAT conventional tag data are being used. It was noted that for this model it is not possible to have sex-specific parameters, because of the current structure of the ICCAT tagging dataset (sex data currently not available). The Group acknowledged the work done so far and encouraged the continuity of this integrated growth analysis.

Document SCRS/2017/126 presented estimates of maximum population growth rate and steepness for shortfin makos in the North and South Atlantic Ocean. A dual life table/Leslie matrix approach was carried out to obtain estimates of productivity (r_{max}), net reproductive rate (R_0), generation time (μ_1), and steepness derived analytically. Natural mortality at age was obtained from the minimum of five estimates obtained through different life history invariant methods to approximate maximum population growth rate.

It was noted that productivity estimates from the North Atlantic are different from those in the South, with the South having higher estimated r_{max}. Regarding mortality, the estimated mortality rates of males and females are very different in the younger ages. It was discussed that mortality should be the same for males and females up to the age at maturity for males, because length at age up to approximately age 8 is similar for males and females and feeding grounds are probably similar. It was further discussed that because the objective is to approximate ideal conditions and a maximum density-dependent response to obtain r_{max}, use of a Lorenzen or similar size-specific life history invariant method to predict mortality results in extremely low or even negative values of r_{max}. Therefore, it was thought that making mortality rates of males equal to those of females as described in the paper was the best approach to produce credible estimates of r_{max}.

SSB_{MSY}/SB_0 and steepness were obtained analytically from the life table/Leslie matrix approach. The inflection point was translated into the shape parameter for the generalised Pella Tomlinson surplus production function by (SCRS/2017/P/020 and SCRS/2017/135):

$$\frac{SB_{MSY}}{SB_0} = m^{\left(-\frac{1}{m-1}\right)}$$

2.5 Length compositions

The results provided at the data preparatory meeting (Coelho *et al.*, in press) were used for the stock assessments. EU-Spain provided additional length composition data (2009-2015) that was also used.

It was noted in presentation SCRS/2017/P/017 that the majority of length-frequency data from South Africa came from the Indian Ocean, and not the Atlantic.

The full description of the use of the size data is in Section 4 of the report.

2.6 Other relevant data

The presentation SCRS/P/2017/022 provided updated results of a study presented at the data preparatory meeting that quantified fishing mortality of satellite-tagged shortfin makos in the western North Atlantic. The update included 11 additional individuals and an additional year of tracking data. The updated results were similar to those reported previously, with ca. 28% of tagged sharks harvested and F = 0.32 (0.19 – 0.53). It was noted that results may not be representative of the entire stock because the study was limited to immature sharks only tracked within the western North Atlantic. It was suggested to compare fishing mortality rates from stock synthesis over the ages of the sharks that were tagged. The presentation also included movement and behavior data for satellite-tagged sharks which highlighted low spatial overlap of sharks tagged off the northeast coast of the U.S., and off the Yucatán Peninsula in Mexico. Behavioral analysis of these sharks indicated two distinct core areas of intensive use corresponding to the mid-Atlantic Bight and the western edge of the Yucatán Channel.

Document SCRS/2017/129 reported on anomalously high landings of mako sharks relative to blue sharks reported by 21 E.U. longline fishing vessels in 2008. The authors suggested that the high mako landings may have been a result of misreporting where swordfish were reported as makos.

The Group raised a number of concerns with this hypothesis. Firstly, it was noted that swordfish quotas were not reached in 2008, and it was therefore unlikely that fishers would disguise swordfish landings as makos. Secondly, available ICCAT landing data did not indicate a noticeable spike in mako landings during this time period. It was therefore suggested by the Group that these perceived anomalies are likely artefacts of data reporting and fleet behavior. Reasons for this include that landings were reported in weight (kg) which may not be a reasonable proxy for numbers of individuals landed (i.e. several large makos would weigh more than many small blue sharks). The Group advised caution when interpreting landing data as long-range boats may employ strategies that do not allow the direct relation of landings to trips.

Document SCRS/2017/130 reported spatially explicit mako shark landings of two longline vessels during a 16 year period (1997-2012). The presentation described CPUE changed over time for the two vessels, as well as where the vessels fished in relation to shark densities described by satellite tagging data.

The possibility of using habitat selection results derived from satellite tracking data in the North Atlantic to predict distributions of sharks in the data-poor South Atlantic was discussed, to which the Group noted that ICCAT is currently engaged in several satellite tagging studies. The Group suggested that interpreting any change in CPUE should be considered in relation to changes in gear and fishing methodology.

3. Methods and other data relevant to the assessment

3.1 Production models

Bayesian Surplus Production Model (BSP)

Babcock and Cortés (in press) (which updated the same document presented at the data preparatory meeting) presented a comparison of Bayesian Surplus Production (BSP) model software applications. The paper applied both the BSP1 software (without process error) and the BSP2 software (with process error), and two independent MCMC software packages, JAGS and Stan, to the data from the 2012 mako shark assessment for the North Atlantic to determine whether the results are consistent. The authors also used the SIR and MCMC algorithms from the LearnBayes R library to fit the same function with both algorithms. Although all the modeling approaches give fairly consistent posteriors for r, the posteriors of K were somewhat different. This may be because there is a long period of catches with no CPUE data, or because the catch and CPUE data are not consistent with each other. The lack of information in the data may cause the model to be sensitive to minor differences in how the model is configured.

The 2012 shortfin mako assessment used the BSP VisualBASIC software that does not include process error (BSP1, Babcock and Cortés (in press)). As a continuity run, the same software was used with similar settings, applied to the updated data for both the North and South Atlantic (**Appendix 5**). Because the models did not adequately capture the trends in the CPUE indices, the version of the VisualBASIC software that includes process error (BSP2) was also applied. Finally, a model was coded with similar priors and assumptions to the BSP models in JAGS; this model will be referred to as JAGS2-BSP.

For the BSP1, BSP2, and BSP2-JAGS runs, catches were either the catches from the data preparatory meeting (C1), starting in 1950 in the north and 1971 in the south, or the alternative estimated catch series (C2) based on ratios (SCRS/2017/110), starting in 1971. The prior for the starting biomass ratio B0/K was lognormal with a mean of 1 and log-sd of 0.2 for the southern runs, and for the northern runs starting in 1950. For the northern runs starting in 1971, the mean was 0.85, with the same log-sd. The CPUE series in the north were US-Log, JPLL-N, POR-LL-N, ESP-LL-N, and CH-TA-LLN. In the south the CPUE series were UR-LL-Log, JPLL-S, BR-LL, UR-LL-Obs, ESP-LL-S, and CH-TA-LLS. The observation error standard deviation was estimated as a single parameter for the BSP1 runs (equal weighting). It was estimated separately for each series in the BSP2 and BSP2-JAGS runs. In all cases, the prior for K was uniform on log(K) between 0.001 and 5 million. The prior for r was calculated by converting updated ranges for r (SCRS/2017/126) into informative lognormal distributions following the approach outlined in (SCRS/2017/135), which resulted in a mean of 0.0254 and log-sd of 0.434 in the North Atlantic and a mean of 0.052 and log-sd of 0.275 in the South Atlantic. For the North Atlantic, we used either the Schaefer model, or the generalized production model as implemented in BSP1 with a shape parameter of 5 ($B_{MSY}/K=0.67$) (McAllister *et al.*, 2000). For the South Atlantic, only the Schaefer model was used.

To evaluate the relative impact of the priors, catches and CPUE data on the model outputs, a post-model pre-data run was conducted with BSP2-JAGS (model with priors and catch data but without CPUEs), and also fitted the model to each index separately.

Projections were implemented within the BSP2-JAGS model with fixed TACS from 0 to 4,000 t in increments of 500 t, with a time horizon of 50 years (approximately 2 generations; SCRS/2017/126). The projections set the catch in 2016 and 2017 equal to the catch in 2015, and catches from 2018 forward were equal to the TAC. The biomass relative to K was projected forward using random draws from the process error equation within the JAGS MCMC algorithm.

Just Another Bayesian Biomass Assessment (JABBA) model

In addition to BSP1, BSP2, and BSP2-JAGS runs, the recently developed Bayesian State-Space Surplus Production Model R to JAGS interface framework, JABBA, was applied to the North Atlantic (NA) and South Atlantic (SA) shortfin mako shark catch and CPUE data series (SCRS/2017/135). JABBA represents a further development of the modeling framework applied in the 2016 ICCAT South Atlantic blue shark assessment (Carvalho and Winker, 2015), the 2017 North Pacific blue shark assessment (Kai *et al.*, 2017) and the 2017 Mediterranean Albacore assessment. The inbuilt options include: (1) automatic fitting of multiple CPUE time series and associated standard errors, (2) estimating or fixing the process variance, (3) optional estimation of additional observation variance for individual or grouped CPUE time series and (4) specifying a Fox, Schaefer or Pella-Tomlinson production function by setting the inflection point B_{MSY}/K and converting this ratio into a shape parameter m.

For the JABBA runs, the same lognormal r and intitial biomass depletion ($\varphi = B_1/K$) priors as for the other BSP model versions were used. All catchability parameters were formulated as uninformative uniform priors, while the process variance and observation variance were implemented by assuming inverse-gamma priors (SCRS/2017/135). To incorporate available standard errors of the year-effect estimated from the standardization models, an additional variance approach for the observation error variance was adopted.

Monitoring the trace and applying Gelman and Rubin (1992) and Heidelberger and Welch (1983) diagnostics suggested that convergence of the MCMC samples to the posterior distribution was achieved after only 100,000 iterations, sampled with a thinning rate of 10 with a burn-in period of 20,000 for each of the two chains.

As additional model performance diagnostics, a jackknife procedure and prediction-validation was applied, including a visual inspection of the retrospective patterns for the C1 catch series runs for the North and South Atlantic. For the jackknife, the Group focused on the relative influence of individual CPUE series by dropping one CPUE at a time and predicting CPUE and the stock status (B / B_{MSY} and H / H_{MSY}) trajectories where H = C/B as defined in SCRS/2017/135. It is used interchangeably in this case with F for surplus production models. For the prediction-validation, the last ten years of CPUE observations were iteratively excluded, the model was refitted and projected forward until the final year 2015. During each backward-iteration, all CPUE observations were removed simultaneously for the respective year. The retrospectives were visualized by only showing projections for the next year instead of projecting all the way forward to the final year 2015.

3.2 Other methods

Catch-only Monte-Carlo method CMSY

Typical production models use time series of catch and fitting of abundance indices to estimate productivity. Instead, the CMSY method uses catch and productivity to estimate biomass, exploitation rate, MSY, and related fisheries reference points as well as the resilience of the species from catch data. In doing so, CMSY provides an alternative assessment tool for situations where CPUE indices are not available or potentially unreliable. Assuming underlying population dynamics of the Schaefer Model, probable ranges of parameters r and K are filtered with a Monte-Carlo algorithm to detect 'viable' r-K pairs. As such, CMSY builds on the concepts of the Catch-MSY method of Martell and Froese (2013), but the main achievement of CMSY compared with the Catch-MSY method lies in overcoming the problems created by a triangular, rather than ellipsoid, distribution of the viable r-k pairs as a result of the Monte-Carlo filtering procedure. Other improvements include adding estimation of biomass and exploitation rates as standard CMSY output and the implementation of a Bayesian state-space Schaefer surplus production model (CMSY.BSM) as a routine tool within the CMSY software (Froese *et al.*, 2016).

For the purpose of this assessment, an "ICCAT-friendly" version (CMSY_ICCATv2.R) was developed for the original CMSY R code by Froese *et al.* (2016) to facilitate comparison of CMSY results with outputs of conventionally used Bayesian surplus production models. Among the newly implemented features are: (1) a plot comparing normalized trends of CMSY biomass projection to observed and predicted CPUE from the CMSY.BSM, (2) plots comparing CMSY distributions for K, r, $Bcur/B_{MSY}$ and $Fcur/F_{MSY}$ to the corresponding posteriors from the CMSY.BSM, as well as priors for K an r and (3) a Kobe-type biplot that allows comparing the CMSY and CMSY.BSM trajectories of the ratios F/F_{MSY} (y-axis) over B/B_{MSY} (x-axis).

For the purpose of comparability, the same r ranges as for the BSP models were used. The CMSY framework allows setting depletion priors (B/K) for the start, middle and end of the time series, which are mainly required for CMSY. The same informative B / K uniform prior range for the first year as Bstart / K = 0.85-0.99 was assumed and vaguely to moderately informative prior ranges for the intermediate Bint / K = 0.3 - 0.9 and final year 2015 Bend / K = 0.1 - 0.8. The only difference between the North and South Atlantic was the setting of the intermediate year to 1990 and 1995, respectively. For the C2 catch time series the authors only adjusted Bstart / K = 0.6-0.99 to allow more flexibility.

3.3 Length-based age-structured models: Stock Synthesis

A length-based age-structured statistical model was implemented with Stock Synthesis (Methot and Wetzel, 2013) version 3.24U (SS3; e.g. Methot, 2015) for the North Atlantic shortfin mako stock. A sex-specific model was implemented to allow for observed sex-specific differences in length and maturity at age. A two-stage data weighting approach was implemented (Francis 2011) to iteratively tune (re-weight) variance adjustment factors for the different fleet-specific data sets (relative abundance indices and length frequency distributions of the catch) used in the model. This approach was previously investigated for North Atlantic blue shark (Courtney *et al.*, 2017). Available time series for 1950-2015 of catch, relative abundance, relative abundance coefficients of variation, and length composition data considered for use in the SS3 model runs were assigned to twelve modelled fleets of catch and six modelled surveys of relative abundance. The catch series used corresponds to C1. During the meeting C2 was used as a sensitivity. Length composition data by sex in 10 cm bins were available for four modelled fleets (Japan LL, Chinse Taipei LL, USA LL, and Venezuela LL) and a length composition for combined sexes was used for one modelled fleet (EU España + Portugal LL). Catch for the remaining five fleets and relative abundance for all surveys were assigned to one of the available length compositions indentified above. Life history inputs were obtained from data first assembled at the 2014 Intersessional meeting of the Shark Species Group (Anon., 2015), and revised during the 2016 Intersessional Meeting of the Shark Species Group (Anon., 2017) and the 2017 Shortfin Mako Shark Data Preparatory Meeting (Anon. (in press)). The model considered age groups zero to 30+. Mean length at each age was assumed to follow a normal distribution and the CV of the mean length at age was assumed to be a linear function of length. Maturity was assumed to change with age. The resulting pup production varied between age groups and was also a function of the length of the mating and gestation cycles. Model convergence was based on whether or not the Hessian inverted, although other convergence diagnostics were also evaluated. Uncertainty in estimated and derived parameters was obtained from asymptotic standard errors calculated from the maximum likelihood estimates of parameter variances at the converged solution. More details of the implementation of SS3 for North Atlantic shortfin mako can be found in SCRS/2017/125.

Natural mortality and stock-recruitment relationship

The Group discussed the plausibility of males having approximately two times higher natural mortality (M) schedules than females at lower ages. The M schedules were assumed, in part, because the estimate of growth completion rate, k, of males was almost double that of females. However, the different M schedules at lower ages are implausible because the length at lower ages of males and females are very similar, especially until both sexes reach maturity. Therefore the Group assumed that males and females have the same M schedules until the age at maturity. The length-at-age of males and females differs after reaching maturity. However, the M schedules of males and females are likely to be only slightly different after reaching maturity because of the large size reached by mature shortfin makos. Furthermore, the original M schedules of females derived from life history invariant methods are almost constant at age and the biological parameters of females are more crucial than those of males in population modeling. Therefore the Group assumed that both males and females have approximately the same M (0.08) for all ages.

The Group discussed the applicability and parameterization of the Low Fecundity Spawner Recruitment (LFSR) developed by Taylor *et al.* (2013) to the stock-recruitment (SR) relationships of shortfin mako in the North Atlantic. The LFSR is a survival based SR function and the equation can produce a variety of SR relationships and pre-recruit survival against pups or spawning biomass. The shape of SR-relationships is governed by two parameters, Sfrac and Beta. The former represents the reduction in mortality as a fraction of –log (unfished recruitment over unfished spawning biomass) and the latter controls the shape of the density-dependent relationship between spawning depletion and pre-recruit survival. The LFSR can produce the same SR relationships as those with the Beverton-Holt (BH) model and the two parameters of the LFSR from the value of steepness (Taylor *et al.* 2013) can be compared. Document SCRS/2017/132 concluded that the LFSR is more suitable for shortfin mako sharks than the BH model because the LFSR can produce a pre-recruit survival against pups or spawning biomass with an increase in survival occurring fastest closer to the unfished equilibrium (convex decreasing survival). In contrast, the pre-recruit survival of the BH model increases fastest at low spawning output (concave decreasing survival). After discussions, the Group decided, although not unanimously, that the concave decreasing survival is less likely for shortfin mako (with survival decreasing fastest at low stock size) and it may be more reasonable for shortfin mako to expect that offspring survival would decrease fastest due to competition when the population approaches unfished biomass level (Beta > 1). The Group then selected parameters of the LFSR (Sfrac=0.171, Beta=3) from two convex decreasing survival curves (Beta=2 and 3) proposed by Document SCRS/2017/132. Based on the comparisons of the likelihood computed by the SS model, the fitting of the model (Beta=3) to the data was slightly better.

4. Stock status results

4.1 Production models

North Atlantic

BSP

For the North Atlantic, all the continuity analysis models in BSP1 converged adequately with percent maximum weight less than 0.5% and similar values of the log(weights) and log(likelihood*priors). All BSP1 results had high K values and were fairly optimistic about current status (**Appendix 5**). However, this model did not fit the abundance trends and was therefore not considered reliable to provide management advice.

When process error was added to the models for the North Atlantic using the BSP2 model, the mode of the posterior distribution was able to track the changes in CPUE indices throughout the time series (**Appendix 5**). These models were not able to converge on the complete posterior distribution, as the percent maximum weight was greater than 0.5% even after 36 million SIR draws. Therefore this model was not considered reliable to provide management advice either.

The North Atlantic BSP2-JAGS model runs all converged adequately, with Gelman-Rubin diagnostics near 1 and effective number of parameters greater than 100 (**Table 1**). The four models were consistent in finding that the mean of current biomass is below B_{MSY} and mean H is above H_{MSY} (**Table 1, Figure 2**). These models all closely tracked the trend in the CPUE series. Although the CVs are wide, current stock status is mostly predicted to be overfished with overfishing occurring (**Figure 3**).

In the diagnostic runs (**Table 2, Figure 4**), the post-model pre-data run caused the population to crash implying that the priors were somewhat pessimistic given the amount of catch that has been removed. When the indices were fitted separately, they were fairly consistent in finding a biomass decline in the 1990s, followed by an increase, but they varied in their estimate of current stock status.

Additional sensitivity analyses done with BSP2-JAGS are presented in **Appendix 5**.

JABBA

Stock depletion (B/K) and status estimates (B / B_{MSY} and H / H_{MSY}) are provided together with the model parameter estimates in **Table 3**. All scenarios consistently predict biomass depletion at close to 50% below B_{MSY} for the final assessment year, 2015, with the range of associated 95% credibility intervals falling entirely below B_{MSY}. The results are therefore similar to the BSP2-JAGS results for the North Atlantic. The estimated H / H_{MSY} trajectories would imply that sustainable harvest rates were already exceeded prior to the 1990s and in 2015 are approximately three to four times higher than sustainable levels.

The jackknife procedure demonstrated that the Schaefer C1 catch run for the North Atlantic (SCRS/2017/135) was fairly insensitive to dropping any one CPUE series at a time as this resulted in hardly discernable effects on the predicted CPUE and stock status trajectories of B / B_{MSY} and H / H_{MSY} (**Figure 5**). The retrospective pattern for the North Atlantic model appeared robust and indicates that the JABBA would have been able to accurately determine the current stock status based on CPUE from 2010 (**Figure 6**).

The prediction validation for the North Atlantic C1 catch scenario suggests that the prediction capacity of JABBA is sufficiently robust to adequately forecast the stock status over time periods of up to eight years, with high accuracy possible over a period of three years (**Figure 7**).

South Atlantic

BSP

The BSP1 continuity runs in the South Atlantic estimated a trajectory where the biomass increased with increasing CPUE (**Appendix 5**). These results are similar to what was found in the 2012 Shortfin Mako Stock Assessment and Ecological Risk Assessment Meeting (Anon., 2013). The BSP2 runs were unable to converge. As the BSP1 model did not fit the abundance trends and the BSP2 model did not converge, neither of these models were considered reliable to provide management advice.

The BSP2-JAGS runs estimated a slightly decreasing biomass trend in the 1970s, before increasing to track the increasing trend in the indices (**Table 4, Figure 8**). The informative prior on B_0/K is probably preventing the model from estimating a lower value of B_0/K. However, the credible intervals are very wide, implying that the trend is very uncertain. At the mean, the population is above B_{MSY}, but the two models disagree on whether the mean harvest rate relative to H_{MSY} is above 1 (**Table 4**).

JABBA

South Atlantic CPUE data were highly variable, and the model was unable to accurately fit the Japanese and Brazilian indices for the South Atlantic shortfin mako stock resulting in considerable noise for the C1 catch series fit (**Figure 9**). In general, the estimated H /H_{MSY} trajectories for South Atlantic JABBA runs show a steadily increasing but fluctuating trend, which started to become unsustainable in the 1990s, peaked around 2005, and then showed a slight decline, but remained unsustainable, in the final year 2015 (**Figure 10**).

The B/B_{MSY} and H/H_{MSY} trajectories for the JABBA model are illustrated by means of Kobe plots for the South Atlantic C1 scenario (**Figure 10**). Contrary to population theory, the trajectory of the South Atlantic stock reveals a clockwise pattern (**Figure 11**) moving from an underexploited state to a recovery as a result of decreasing biomass under sustainable fishing, which is followed by a short period of overfishing before a biomass rebuilding phase during the recent period of unsustainable harvest rate above H_{MSY}. The resulting stock status posterior for 2015 is therefore implausible, with 8% support for an overfished state (red), 3.7% for a sustainable stock (green) and 88.3% (yellow) of the posterior pairs falling within the area of unsustainable harvesting ($H / H_{MSY} > 1$ and $B / B_{MSY} > 1$), despite an extended recent period of biomass increase. This pattern points towards a severe contradiction between the state process in the form of catch and resilience (r) information and the observation process in the form of CPUE data.

The jackknife validation procedure applied to the C1 run for the South Atlantic indicated that removing the Uruguay LL Obs data had the strongest effect on the estimate of B / B_{MSY} with the results being more pessimistic. H / H_{MSY} was fairly insensitive to dropping any of the available CPUE time series (**Figure 12**). The diagnostics revealed a strong retrospective pattern that affected B / B_{MSY}, but again to a lesser extent, H / H_{MSY} (**Figure 13**). Such patterns are undesirable, and the South Atlantic diagnostics highlight the poor performance with regards to the robustness of estimates and forward projections of B / B_{MSY} and H / H_{MSY} estimates in the JABBA model.

4.2 Other methods

South Atlantic

CMSY

The Group first explored the performance of CMSY for the North Atlantic as a proof of concept to be applied to the South Atlantic. Comparisons between CMSY and the CMSY.BSM fitted to U.S. logbook LL CPUE and North Atlantic catch data (1950-2015) showed general agreement for the 2015 estimates of H/H_{MSY} and B/B_{MSY} (**Figure 14**). The estimated trajectories also showed similar trends, albeit with some intermittent divergences in the B/B_{MSY} trajectory. The similarity between CMSY, CMSY.BSM and JABBA for the C1 catch series further corroborates that the North Atlantic CPUE indices can be consistently described by these three modelling frameworks.

Although the CMSY and CMSY.BSM estimates of r and K are more similar for the South Atlantic (**Figure 10**) than for the North Atlantic, the 2015 estimates of H / H_{MSY} and B / B_{MSY} were in poor agreement. The CMSY results suggest that the South Atlantic stock status is as pessimistic as that of the North Atlantic. The strong discrepancy between the fitted models and CMSY, which is independent of CPUE, further highlights that the CPUE-driven stock status estimates for the South Atlantic should be treated with caution. There was agreement between the process error model stock estimates for North Atlantic and the catch-only method CMSY, but strong discrepancies between CMSY and fitted models for South Atlantic. It is therefore likely that the poor fit in the South Atlantic can be attributed to the apparent contradiction between the observation process (i.e. CPUE) and process equation, which is informed by the catch and resilience (*r*).

The CMSY model B/B_{MSY} and H /H_{MSY} trajectories are illustrated by means of Kobe plots for the South Atlantic. C1 and C2 scenarios are illustrated in **Figures 15 and 16**, as well as **Table 5**. The results for CMSY scenario 1 is more pessimistic than that of scenario 2, with scenario 1 indicating that the South Atlantic shortfin mako stock is in an overfished state whereas scenario 2 indicates it is a little above MSY. Both scenarios indicate the stock is currently experiencing overfishing, with scenario 1 indicating strong overfishing and scenario 2 indicating that H is just above H_{MSY}.

4.3 Stock Synthesis

North Atlantic

Three Stock Synthesis model runs were evaluated. Comparisons of stock status indicator trajectories between the three model runs are provided in **Figure 17**. Stock Synthesis model run 1 represented the original model presented to the Group as described in (SCRS/2017/125). The Kobe plot for this model is presented in **Figure 18**. The Stock Synthesis model was updated (Stock Synthesis model run 2) to set natural mortality for males equal to that for females (**Figure 19**). The Group recommended evaluating four Stock Synthesis model runs using the LFSR relationship. Three Stock Synthesis model runs using the LFSR relationship were developed by fixing the Beta parameter at values of 1, 2, and 3, and then solving analytically for the LFSR sfrac parameter values (0.212, 0.176, and 0.171, respectively) which correspond to the original steepness value (0.345) of the BH stock-recruitment relationship used in Stock Synthesis. An additional model run was developed by solving for the LFSR Beta (0.642) and sfrac (0.263) parameter values simultaneously with an optimization routine which correspond to the original steepness value (0.345) of the BH stock-recruitment relationship used in Stock Synthesis. Based on a Group recommendation, the Stock Synthesis model was updated (Stock Synthesis model run 3) to replace the BH stock recruitment relationship with the LFSR relationship using Beta = 3 and sfrac = 0.171 (**Figure 20**). Model results are presented below for model run 3, which the Group considered to be the base run for Stock Synthesis (**Tables 6-8**).

Five model sensitivities were also evaluated as summarized below. Model sensitivity 1 evaluated model sensitivity to uncertainty in *catch* data. Model run 1 was modified by replacing the catch data series (C1:1950-2015) in the model with an alternative catch data series (C2: 1971-2015). Initial fishing mortality was estimated in 1971 by assuming that catch prior to 1971 was equal to the average total alternative catch for the years 1971-1980, and estimating one additional parameter in the model for the initial fishing mortality necessary to remove the historic catch annually. It was noted that the same Stock Synthesis model (model run 1) was not able to estimate initial fishing mortality with the original catch series (C1) when truncated from 1971-2015. It was noted that the ability to estimate initial fishing mortality with the alternative catch data (C2) indicates that the higher alternative catch data early in the time series may be consistent with the other data in the model. In other words, the model sensitivity analysis provided support for higher historic catch. However, the Group discussed that the alternative catch data may not be appropriate at this time for use in the model because of insufficient time to evaluate the SS3 fits to this alternate catch series.

Model sensitivity 2 evaluated model sensitivity to uncertainty in *length-based selectivity*. Model run 2 was modified by replacing the double normal length-based selectivity curves estimated in the model with logistic selectivity consistent with the previous assessment conducted for North Atlantic shortfin mako (Anon., 2013). The previous assessment used empirically derived logistic selectivity at age for roughly the same fleets using available length composition data.

It was noted that results from the sensitivity run 2 showed a different pattern in the modelled population's response to fishing pressure than the results obtained from model runs 1, 2, and 3. In particular, under the sensitivity analysis, the annual spawning stock size appeared to fluctuate slightly over time in response to changes in stock size which resulted from observed changes in fishing pressure and estimated recruitment. In contrast, under model runs 1, 2, and 3 (**Figure 17**) the annual spawning stock size appeared to decrease monotonically over time as if under equilibrium and did not fluctuate in response to observed changes in fishing pressure and estimated recruitment. It was noted that because of the combination of low natural mortality and dome-shaped selectivity in model run 2, there was a large proportion of the modelled population numbers at higher ages (both mature male and mature female) present, in particular the age 30+ age bin. That is consistent with the observation that the body weight of the mature sharks is much higher than that of most of the sharks available to the fishery. Mature sharks are not harvested due to the assumptions of the selectivity curves and the length data. Consequently, the mature biomass at older ages and the 30+ age sharks declined gradually over time only in response to natural mortality and most of the mature fish including the spawner biomass remained, contributing to the recruitment.

It was noted that the model runs 1, 2, and 3 with dome-shaped selectivity appeared to result in hyper stability of spawning stock size (e.g. **Figures 18-20**), i.e. under fishing mortality with dome-shaped selectivity on immature animals, few recruits reach reproductive age and growth overfishing is occurring. The spawning stock then only appears to be stable because the mature sharks are not selected. The Group noted that this is problematic for the management implementation because under this scenario the spawning stock size would not be expected to respond to a reduction in fishing mortality on immature sized animals until after those immature animals mature and contribute to the reproduction, which could be many years.

In contrast, model sensitivity 2, which assumed asymptotic selectivity, did not appear to have a hyper stable spawning stock size, which is more consistent with the expectation of a stock that responds directly to fishing pressure. However, it was noted that the asymptotic selectivity scenario fits to both relative abundance and length composition were very poor. Consequently a lot of work would be needed to identify plausible causes of the poor fit to each data set and to recommend ways of addressing them either in the model, by adding more structure to the model or externally to the model, for example by reformulating the data as was proposed for the bluefin shark assessment (Anon., 2016). It was noted that in an effort to fit the available data expediently for the current assessment, dome-shaped selectivity was allowed based on estimation of the selectivity parameters, which allowed the shape of the selectivity curve at lengths greater than the peak in selectivity to be estimated based on fits to the length composition data.

Model sensitivity 3 continued the evaluation of model sensitivity to uncertainty in *length-based selectivity*. Model sensitivity 3 modified the selectivity for fleet 4 (U.S. LL) to allow the shape of the selectivity curve at lengths greater than the peak in selectivity to be estimated based on fits to the length composition data. The length frequency of sharks caught by the U.S. LL is centered at a smaller size than the other fleets, and this scenario resulted in dome-shaped selectivity for fleet 4 (and all fleets which mirrored the selectivity of fleet 4) and imposed asymptotic selectivity for all other fleets. However, the results of this scenario were similar to the poor fits to relative abundance and length composition as obtained in model sensitivity 2, and was therefore not pursued further.

Model sensitivity 4 evaluated model sensitivity to the *CV in the distribution of length at age*. Model run 2 was modified to estimate the CV for L_{Amin} (female and male). A concern raised by the Group was that the current CVs were based only on uncertainty in the length at age data and did not account for other sources of uncertainty especially for the youngest ages. The Group suggested that the CV for L_{Amin} (female and male) should probably be larger in order to account for this uncertainty in the model. However, the estimated values for the CV of L_{Amin} (0.034 for young females and 0.095 for young males) were smaller than those obtained from the data (0.093 for females and 0.097 for males). This did not seem plausible and was not pursued further.

Model sensitivity 5 evaluated model sensitivity to *stage 2 estimation of effective sample size (effN) for length composition data*. Model run 2 was modified by replacing the eff*N* for length composition obtained with the Francis method with the eff*N* for length composition obtained with the McAllister and Ianelli method. Both methods are defined in the cited references provided in SCRS/2017/125 and were presented and discussed in detail at the 2016 Intersessional Meeting of the Shark Species Group (Anon., 2017), and based on the material presented at that meeting both methods appear reasonable. However, because the two approaches use different methods to arrive at the eff*N*, the resulting values for eff*N* differ. In this case, the eff*N* values obtained from the McAllister and Ianelli method (using the harmonic mean) were higher than those obtained using the Francis method (gave more weight to the length data in the model likelihood). An evaluation of the model likelihood indicated that this also resulted in a relatively worse fit to the abundance indices. This result suggests that there is conflict in the data when used in the assessment (i.e. increasing the weight given to one data set in the model likelihood resulted in worse fit to another data set). The Group suggested that when there is data conflict in an assessment model, then it is important not to let the fit to length composition reduce the fit to the indices. Consequently the Group recommended using the relatively lower eff*N* provided by the Francis method.

General comments on the Stock Synthesis model

Although several misspecifications and uncertainties might be included in the current model setting, the current base model of SS3 converged reasonably well and produced reasonable results for the available fishery and biological data. In consideration of the biological and fisheries characteristics (i.e. age- and sex-specific growth, sex-specific mature size, fecundity proportional to body length, low-fecundity stock recruitment relationship, lower natural mortality through all the age classes, and all fleets are only selecting immature sharks and the availability and vulnerability is different by sexes) of shortfin makos, the results of the sex- and age-specific structured model (SS) may in the future be more suitable to provide the management advice than production type models (BSPM) once the model has been fully explored.

It is worth noting that high values of F (>0.20) were obtained with SS3 starting in 1993. These values are consistent with those estimated from satellite tagging data for shortfin makos of similar lengths and ages. Specifically, the F value derived from tagging (SCRS/P/2017/022) for the period 2013-2016 was 0.33 (0.19-0.56 95% CI) and the F values estimated in SS3 for 2013-2015 ranged from 0.21 to 0.25.

4.4 Synthesis of assessment results

Considerable progress was made since the last assessment on the integration of new data sources (in particular size data and sex-specific information) and modelling approaches (in particular model structure). Uncertainty in data inputs and model configuration were explored through sensitivity analysis. The production models in the South had difficulty fitting the increasing trends in the CPUE series combined with increasing catches. The results obtained from these models for this region were implausible as there is conflict between the data and the model assumptions. Management advice was thus based on the CMSY model in the South. The results are summarized below.

North Atlantic

For the North Atlantic stock, scenarios with the BSP2-JAGS estimated that the stock was both overfished (B_{2015}/B_{MSY}=0.63 to 0.85) and that overfishing was occurring (H_{2015}/H_{MSY}=1.93 to 3.58). The probability of the stock being overfished and experiencing overfishing was 82.1 – 97.8% (Kobe red zone: **Figure 21**). The JABBA model indicated that the stock was both overfished (B_{2015}/B_{MSY}=0.57 to 0.76) and that overfishing was occurring (H_{2015}/H_{MSY}=3.75 to 4.37), resulting in a 92.6 – 99.9% probability of being in an overfished state and still experiencing overfishing (**Figure 21**). Estimates obtained with the final SS3 run predicted that the stock was probably overfished (SSF_{2015}/SSF_{MSY}=0.95, where SSF is spawning stock fecundity) and that overfishing was occurring (F_{2015}/F_{MSY}=4.38, CV=0.11) with a probability of 56.1% of being overfished and experiencing overfishing (**Figure 21**). The Kobe phase plots for the individual model runs in the North Atlantic are provided in **Figure 22**, while the combined Kobe phase plot is provided in **Figure 23**. The combined probability from all the models of being in an overfished state while still experiencing overfishing was 90% (**Figure 24**). CMSY was only used as a proof of concept in the North (and the results were similar to the production models) and so the results are not presented here.

The models agree that the northern stock was overfished and was undergoing overfishing. The results obtained in this evaluation are not comparable with those obtained in the last assessment in 2012 because the input data and model structures have changed significantly. The catch time series are different (they now start in 1950 vs. 1971 in the 2012 assessment) and were derived using different assumptions; the CPUE series have been decreasing since 2010 (the last year in the 2012 assessment models)); some of the biological inputs have changed and are now sex specific; and additional length composition data became available. Additionally, in 2012 only the BSP1 production model and a catch-free age-structured production model were used. This updated assessment represents a significant improvement in our understanding of current stock status for North Atlantic shortfin mako.

South Atlantic

For the South Atlantic stock, scenarios with the BSP2-JAGS estimated that the stock was not overfished (B_{2015}/B_{MSY}=1.69 to 1.75) but that overfishing may be occurring (F_{2015}/F_{MSY}=0.86 to 1.07). For the BSP2-JAGS model, estimates from the 2 runs indicated a 0.3-1.4% probability of the stock being overfished and overfishing occurring (red quadrant in Kobe plot), a 29-47.4% probability of the stock not being overfished but overfishing occurring, or alternatively, the stock being overfished but overfishing not occurring (yellow quadrants in Kobe plot), and a 52.3-69.6% probability of the stock not being overfished and overfishing not occurring (green quadrant in Kobe plot) (**Figure 25**). In the JABBA model Kobe plot the South Atlantic stock trajectory reveals a clockwise pattern moving from an underexploited state to a recovery as a result of decreasing biomass under sustainable fishing, which is followed by a short period of overfishing, which is implausible. The model results were therefore not considered for management advice. Model estimates obtained for the CMSY model indicate that the stock could be overfished (B_{2015}/B_{MSY}= 0.65 to 1.12) and that overfishing is likely occurring (F_{2015}/F_{MSY}=1.02 to 3.67). Considering catch scenarios C1 and C2, model estimates from the CMSY model indicated a 23-89% probability of the stock being overfished and overfishing occurring (red quadrant in Kobe plot), a 11-48% probability of the stock not being overfished but overfishing occurring, or alternatively, the stock being overfished but overfishing not occurring (yellow quadrants in Kobe plot), and only a 0-29% probability of the stock not being overfished and overfishing not occurring (green quadrant in Kobe plot) (**Figure 25**). The combined model results indicate a probability of 19% that the stock is both overfished and experiencing overfishing (**Figure 26**). The Group considers the stock status results for the South Atlantic to be highly uncertain. Despite this uncertainty, it is not possible to discount that in recent years the stock may have been at, or already below, B_{MSY} and that fishing mortality is already exceeding F_{MSY}. The Kobe phase plots for the individual model runs in the South Atlantic are provided in **Figure 27**, while the combined Kobe phase plot is provided in **Figure 28**.

5. Projections

Projections were only carried out for BSP2-JAGS models in the North Atlantic. No projections were conducted for the South Atlantic due to the uncertainty of stock status explained above.

The BSP2-JAGS model projections indicated that current catch levels (C1 = 3,600 t, and C2 = 4,750 t, mean of the last 5 years) in the North Atlantic will cause continued population decline. According to the more optimistic C1 and C2 catch series Schaefer model projections, catches would need to be 1000 t or lower to prevent further population declines (**Figure 29 a and b**). For the corresponding generalized production models, catches would also have to be reduced to below 1000 t to prevent further population declines (**Figure 29 c and d**). Overall, this implies reductions in catches in the order of 72-79%. Kobe II matrices showing the probabilities of $F<F_{MSY}$, $B>B_{MSY}$, and $B>B_{MSY}$ + $F<F_{MSY}$ (green quadrant of the Kobe plot) under different constant catch levels are shown in **Table 9**.

Although in terms of SSF the current stock size for SS3 appears more optimistic than the aggregated biomass dynamic models, the future outlook is probably more pessimistic. This is because the juveniles are being removed beginning at age at first capture and so are not reaching maturity. It can be anticipated that spawning stock size will decline for many years after fishing pressure has been reduced until the recruits reach maturity.

6. Recommendations

6.1 Research and statistics

- The Group noted the importance of having the sex information on the conventional tagging database. Such data are usually reported for sharks, but currently are not available in the ICCAT database. Therefore, the Group recommends that the Secretariat revises the conventional tagging database to include this field and make it available in the cases where such information was reported.
- The Group recommends to focus research efforts on identifying pupping grounds to increase our knowledge of shortfin mako reproductive behaviour which could lead to improved scientific advice.
- The Group recommends further research on the implications of priors and error structure in Bayesian surplus production models.
- The Group reiterates the recommendations from the Data Preparatory Meeting http://iccat.int/Documents/Meetings/Docs/2017_SMA_DATA_PREP_ENG.pdf
- The Group emphasizes that identification of a robust TAC in the future will require developing projections in SS3 in addition to those undertaken using production models.

6.2 Management

- For the North Atlantic stock, projections were based on the production modelling approach only (BSP2-JAGS), which indicated that catches would need to be reduced to 1,000 t or lower to prevent further population declines. However, taking into consideration the timeline for stock rebuilding based on this approach, it should be noted that for a TAC of 1,000 t the probability of being in the Kobe plot green zone ($F<F_{MSY}$ and $B>B_{MSY}$) (**Table 9**) is estimated to be only 25% by 2040.
- The Group indicated that releasing animals brought to the vessel alive could be a potentially effective measure to reduce fishing mortality as studies indicate post-release survival is likely to be about 70%. Following best practices to correctly handle and release live specimens could therefore further increase post-release survival. However, at this time the Group does not have enough information to assess if the adoption of live releases alone will be enough to reduce landings to 1,000 t or less and stop further stock decline.

- For the South Atlantic stock, given the uncertainty in stock status and considering the large fluctuations in catch, the Group recommends that until this uncertainty is reduced, catch levels should not exceed the average catch in the last five years (2,854 t with scenario C1 or 2,933 t with scenario C2), or about 2,900 t.
- Given the limited time available for discussing management recommendations, the Group decided to continue discussing them at the Shark Species Group meeting in September.

7. Other matters

There were no other matters.

8. Adoption of the report and closure

The report was partially adopted by the Group and the meeting was adjourned. Sections 4.1, 4.4, and 6.2 of the report were later adopted by correspondence.

References

Anonymous. 2013. Report of the 2012 Shortfin Mako Stock Assessment and Ecological Risk Assessment Meeting (*Olhão, Portugal - June 11-18, 2012*). ICCAT. Col. Vol. Sci. Papers. 69 (4): 1427-1570.

Anonymous. 2015. 2014 Intersessional Meeting of the Sharks Species Group (*Piriapolis, Uruguay, 10-1 March 2014*) Col. Vol. Sci. Pap. 71(6): 2458-2550.

Anonymous. 2016. Report of the 2015 Bluefin Shark Stock Assessment (*Oceanário de Lisboa, Lisbon, Portugal – 27-31 July 2015*). Col. Vol. Sci. Pap. 72(4): 866-1019.

Anonymous. 2017. Report of the 2016 Intersessional Meeting of the Shark Species Group (*Madeira, Portugal – April 25 to 29, 2016*). ICCAT. Col. Vol. Sci. Pap. 73(8): 2759-2809.

Anonymous. (in press). Report of the 2017 Shortfin Mako Shark Data Preparatory Meeting (*Madrid, Spain – March 28 to 31, 2017*). Document SCRS/2017/002: p 52.

Babcock, E. and Cortes, E. (in press). Bayesian surplus production models for shortfin mako sharks: are the results consistent when using different software packages? SCRS/2017/055: 9 p.

Coelho R., Domingo A., Courtney D., Cortés E., Arocha F., Liu K-M., Yokawa K., Yasuko S., Hazin F., Rosa D. and Lino P.G. (in press). A revision of the shortfin mako shark size distribution in the Atlantic using observer data from the main pelagic longline fleets. Document SCRS/2017/048: 17 p.

Courtney, D., Cortés, E., Zhang, X. and Carvalho, F. 2017. Stock synthesis model sensitivity to data weighting: an example from preliminary model runs previously conducted for north Atlantic blue shark. ICCAT. Col. Vol. Sci. Papers. 73(8): 2860-2890.

Francis, R.I.C.C. 2011. Data weighting in statistical fisheries stock assessment models. Can. J. Fish. Aquat. Sci. 68:1124-138.

Froese, R., Demirel, N., Coro, G., Kleisner, K.M. and Winker, H. 2016. Estimating fisheries reference points from catch and resilience. Fish 83: 506–526, doi:10.1111/faf.12190.

Gelman, A. and Rubin, D.B. 1992. Inference from Iterative Simulation Using Multiple Sequences. Statistical Science 7: 457-472.

Heidelberger, P. and Welch, P.D. 1983. Simulation Run Length Control in the Presence of an Initial Transient.

Kai, M., Carvalho, F., Yokoi, H., Kanaiwa, M., Takahashi, N., Brodziak, J., Sippel, T., Kohin, S., 2017. Stock assessment for the north Pacific blue shark (*Prionace glauca*) using Bayesian State-space Surplus Production Model (No. ISC/17/SHARKWG-1/4).

Martell, S., and Froese, R. 2013. A simple method for estimating MSY from catch and resilience. 505: 504–514. doi:10.1111/j.1467-2979.2012.00485.x.

McAllister, M.K., Babcock, E.A., Pikitch, E.K. and Prager, M.H. 2000. Application of a non-equilibrium generalized production model to South and North Atlantic swordfish: combining Bayesian and demographic methods for parameter estimation. ICCAT. Col. Vol. Sci. Papers. 51(5): 1523-1550.

Methot, R.D. 2015. User manual for Stock Synthesis model version 3.24s, Updated February 11, 2015. NOAA Fisheries, Seattle, WA.

Methot, R.D. and Wetzel, C.R. 2013. Stock synthesis: A biological and statistical framework for fish stock assessment and fishery management. Fish. Res. 142:86–99.

Taylor, I.G., Gertseva, V., Methot, R.D., Maunder, M.N. 2013. A stock- recruitment relationship based on pre-recruit survival, illustrated with application to spiny dogfish shark. Fish. Res. 142, 15–21.

Table 1. North Atlantic BSP2-JAGS model runs. Rhat is the Gelman-Rubin diagnostic, n.eff is the effective number of parameters (Values are means and CVs are in parentheses).

Parameter	**1N C1**	**2N C2**	**3N C1 generalized**	**4N C2 generalized**
Rhat	1.02	1.01	1.01	1.01
n.eff	160	230	320	160
K(1000)	154.29(0.29)	246.95(0.32)	125.11(0.37)	214.03(0.35)
r	0.04(0.54)	0.03(0.47)	0.04(0.58)	0.03(0.48)
Bo/BMSY	1.82(0.13)	1.68(0.16)	1.36(0.13)	1.28(0.15)
B2015/BMSY	0.85(0.2)	0.75(0.21)	0.78(0.23)	0.63(0.24)
H2015/HMSY	2.97(0.47)	3.58(0.45)	1.93(0.48)	2.41(0.44)

Table 2. North Atlantic BSP2-JAGS diagnostic runs **(**Values are means and CVs are in parentheses).

Parameter	**5N pmpd**	**6N index 1**	**7N index 2**	**8N index 3**	**9N index 4**	**10N index 5**
Rhat	3.17	1.03	1.01	1.01	1.02	1.01
n.eff	3	74	1200	460	810	330
K(1000)	221.65(2.91)	231.3(0.58)	694.27(1.06)	394.83(1.32)	873.6(0.93)	363.71(1.43)
r	0.03(0.46)	0.03(0.5)	0.03(0.46)	0.03(0.46)	0.03(0.45)	0.03(0.47)
Bo/Bmsy	1.82(0.13)	1.85(0.12)	1.79(0.14)	1.8(0.13)	1.78(0.14)	1.82(0.13)
Bcur/Bmsy	0.29(2.21)	0.95(0.26)	1.58(0.27)	1.13(0.43)	1.92(0.27)	0.98(0.61)
Hcur/Hmsy	14977(0.9)	2.75(0.53)	0.99(0.91)	2.9(1.06)	0.58(0.87)	6.83(2.05)

Table 3. Stock depletion and status estimates, together with model parameters, for the JABBA model applied to the North Atlantic shortfin mako for catch scenarios C1 and C2.

(A) Base-case catch time series (C1)

	NA.Schaefer.C1			NA.Pella.C1		
Estimates	Median	2.50%	97.50%	Median	2.50%	97.50%
K	137365.3	79046.5	247732.8	123223.9	70840.1	260386.8
r	0.032	0.013	0.098	0.074	0.029	0.204
σ	0.09	0.063	0.134	0.089	0.063	0.134
H_{MSY}	0.016	0.006	0.049	0.015	0.006	0.041
B_{MSY}	68682.6	39523.2	123866.4	82558.3	47461.9	174455.6
MSY	1146.8	445.8	2523.1	1287.3	526.3	2863.5
B_{1950}/K	0.746	0.554	0.994	0.781	0.575	0.989
B_{2015}/K	0.381	0.257	0.545	0.414	0.276	0.586
$B_{2015}/B_{\mathrm{MSY}}$	0.763	0.514	1.090	0.618	0.412	0.874
$H_{2015}/H_{\mathrm{MSY}}$	3.749	1.465	10.582	4.128	1.606	11.414

(B) Alternative catch time series (C2)

	NA.Schaefer.C2			NA.Pella.C2		
Estimates	Median	2.50%	97.50%	Median	2.50%	97.50%
K	187530.6	113905.0	351652.0	172713.1	100950.1	348444.0
r	0.030	0.012	0.073	0.076	0.030	0.203
σ	0.10	0.063	0.145	0.095	0.063	0.141
H_{MSY}	0.015	0.006	0.036	0.015	0.006	0.04
B_{MSY}	93765.3	56952.5	175826.0	115715.4	67635.2	233452.7
MSY	1440.3	559.0	3337.5	1831.6	727.9	4193.5
B_{1950}/K	0.834	0.605	1.024	0.844	0.573	1.04
B_{2015}/K	0.344	0.215	0.518	0.384	0.236	0.569
$B_{2015}/B_{\mathrm{MSY}}$	0.689	0.430	1.036	0.573	0.352	0.849
$H_{2015}/H_{\mathrm{MSY}}$	4.379	1.608	12.374	4.167	1.571	11.414

Table 4. South Atlantic BSP2-JAGS model runs (Values are means and CVs are in parentheses).

Parameter	**11S C1**	**12S C2**	**13S pmpd**
Rhat	1.01	1.01	1
n.eff	160	200	1000
K(1000)	121.94(0.39)	139.76(0.38)	137.7(0.36)
r	0.06(0.27)	0.06(0.27)	0.06(0.27)
Bo/Bmsy	1.48(0.18)	1.48(0.18)	1.47(0.18)
Bcur/Bmsy	1.75(0.19)	1.69(0.19)	1.69(0.19)
Hcur/Hmsy	1.07(0.46)	0.86(0.44)	0.86(0.43)

Table 5. Stock depletion and status estimates, together with model parameters, for the C_{MSY} model applied to the South Atlantic shortfin mako for catch scenarios C1 and C2.

	CMSY.SA.C1			CMSY.SA.C2		
Estimates	Median	2.50%	97.50%	Median	2.50%	97.50%
K	66067.715	42003.174	103919.360	129096.863	64563.960	258131.624
r	0.069	0.053	0.089	0.069	0.053	0.089
H_{MSY}	0.034	0.026	0.045	0.034	0.026	0.045
B_{MSY}	33033.857	21001.587	51959.680	64548.431	32281.980	129065.812
MSY	1.132	0.778	1.649	2.213	0.950	5.157
B_{2015}/K	0.324	0.109	0.527	0.562	0.141	0.784
B_{2015}/B_{MSY}	0.647	0.218	1.053	1.125	0.282	1.569
H_{2015}/H_{MSY}	3.666	2.252	10.867	1.024	0.734	4.088

Table 6. Stock Synthesis model run 3 estimates of ending year (2015) stock status relative to maximum sustainable yield (MSY), including spawning stock fecundity (SSF_{2015}), fishing mortality (F_{2015}, calculated as the sum of continuous F obtained for each fleet), and recruits (R_{2015}), along with equilibrium SSF (SSF_0) and R (R_0), maximum sustainable yield (MSY), SSF at MSY (SSF_{MSY}), F at MSY (F_{MSY}) and the ratios SSF_{2015}/SSF_{MSY} and F_{2015}/F_{MSY}. Asymptotic standard errors (SE) calculated from the maximum likelihood estimates of parameter variances at the converged solution and CV based on the SE (where available) are also provided for the parameter estimates.

Ending year (2015) stock status relative to MSY reference points	Estimate	SE	CV
SSF_{2015} (1,000s)	558	50	9%
F_{2015}	0.247	---	---
R_{2015} (1,000s)	140	12	8%
SSF_0	1,126	52	5%
R_0	220	10	5%
MSY (t)	1,004	33.29	3%
SSF_{MSY}	586	27	5%
F_{MSY}	0.056	0.002	4%
SSF_{2015}/SSF_{MSY}	0.952	---	---
F_{2015}/F_{MSY}	4.379	0.49	11%

Table 7. Stock Synthesis model run 3 annual estimates of total biomass (B), spawning stock fecundity (SSF), recruits (R), total fishing mortality (F, calculated as the sum of continuous F obtained for each fleet).

Year	B (t)	SSF ((1,000s)	R (1,000s)	F
Virg		1,126	220	
Init		1,126	220	
1950	277,435	1,126	220	0.004
1951	277,310	1,126	220	0.002
1952	277,212	1,126	220	0.002
1953	277,107	1,126	220	0.003
1954	276,976	1,126	220	0.001
1955	276,915	1,126	220	0.002
1956	276,831	1,126	220	0.001
1957	276,769	1,126	220	0.002
1958	276,656	1,125	220	0.002
1959	276,557	1,125	220	0.003
1960	276,434	1,125	220	0.002
1961	276,343	1,125	220	0.004
1962	276,166	1,125	220	0.006
1963	275,925	1,125	220	0.003
1964	275,790	1,124	220	0.005
1965	275,580	1,124	220	0.004
1966	275,401	1,123	220	0.008
1967	275,090	1,123	220	0.007
1968	274,794	1,122	220	0.009
1969	274,415	1,122	220	0.009
1970	274,025	1,121	220	0.008
1971	273,658	1,120	220	0.012
1972	273,136	1,120	220	0.011
1973	272,622	1,119	220	0.011
1974	272,116	1,118	220	0.015
1975	271,408	1,117	220	0.018
1976	270,577	1,116	220	0.009
1977	270,118	1,115	220	0.014
1978	269,469	1,114	220	0.013
1979	268,894	1,112	220	0.013
1980	268,392	1,111	220	0.019
1981	267,625	1,109	220	0.030
1982	266,213	1,107	220	0.034
1983	264,546	1,104	220	0.038
1984	262,899	1,102	219	0.040
1985	260,775	1,099	182	0.087
1986	255,945	1,095	169	0.120
1987	250,774	1,091	167	0.124
1988	245,659	1,086	170	0.112
1989	240,574	1,081	186	0.083

Table 7. Continued.

Year	B (t)	SSF (1,000s)	R (1,000s)	F
1990	236,134	1,077	179	0.102
1991	231,458	1,071	176	0.106
1992	226,733	1,065	167	0.151
1993	220,930	1,058	166	0.201
1994	213,765	1,050	160	0.200
1995	206,865	1,040	144	0.276
1996	197,888	1,028	143	0.352
1997	188,682	1,014	177	0.273
1998	181,327	1,000	229	0.289
1999	174,051	983	223	0.235
2000	168,455	966	266	0.199
2001	163,695	946	264	0.206
2002	159,188	925	191	0.234
2003	154,592	902	283	0.260
2004	150,071	877	311	0.239
2005	146,061	850	312	0.220
2006	142,810	822	233	0.203
2007	139,983	792	177	0.224
2008	136,671	762	190	0.197
2009	133,790	731	210	0.241
2010	129,881	700	162	0.268
2011	125,502	669	145	0.224
2012	121,963	639	141	0.285
2013	117,478	610	151	0.251
2014	113,706	583	145	0.212
2015	110,638	558	140	0.247

Table 8. Stock Synthesis model run 3 annual estimates of total fishing mortality (F, calculated as the sum of continuous F obtained for each fleet) relative to fishing mortality at MSY (F/F_{MSY}) and spawning stock fecundity (SSF 1,000s) relative to spawning stock fecundity at MSY (SSF/SSF_{MSY}).

Year	F/F_{MSY}	SSF/SSF_{MSY}
1950	0.064	1.921
1951	0.043	1.921
1952	0.043	1.921
1953	0.053	1.921
1954	0.013	1.921
1955	0.027	1.921
1956	0.017	1.921
1957	0.044	1.921
1958	0.037	1.921
1959	0.049	1.921
1960	0.032	1.921
1961	0.078	1.920
1962	0.107	1.920
1963	0.047	1.919
1964	0.087	1.919
1965	0.069	1.918
1966	0.138	1.917
1967	0.124	1.916
1968	0.164	1.915
1969	0.163	1.914
1970	0.148	1.913
1971	0.205	1.912
1972	0.197	1.911
1973	0.202	1.910
1974	0.259	1.908
1975	0.315	1.907
1976	0.167	1.905
1977	0.249	1.903
1978	0.231	1.901
1979	0.222	1.898
1980	0.330	1.896
1981	0.532	1.893
1982	0.598	1.889
1983	0.666	1.885
1984	0.702	1.880
1985	1.549	1.875
1986	2.128	1.868
1987	2.199	1.861
1988	1.979	1.854
1989	1.466	1.846

Table 8. Continued.

Year	F/F_{MSY}	SSF/SSF_{MSY}
1990	1.813	1.838
1991	1.869	1.828
1992	2.670	1.818
1993	3.556	1.806
1994	3.542	1.791
1995	4.887	1.775
1996	6.227	1.755
1997	4.828	1.731
1998	5.126	1.707
1999	4.170	1.679
2000	3.525	1.648
2001	3.653	1.615
2002	4.143	1.579
2003	4.599	1.540
2004	4.228	1.497
2005	3.892	1.451
2006	3.589	1.403
2007	3.964	1.353
2008	3.493	1.301
2009	4.268	1.248
2010	4.748	1.195
2011	3.971	1.142
2012	5.054	1.091
2013	4.444	1.042
2014	3.763	0.995
2015	4.379	0.952

Table 9. Kobe II risk matrix giving the probability that the fishing mortality will be below the fishing mortality rate at MSY (top), the probability that the biomass will exceed the level that will produce MSY (middle), and the two combined (bottom) based on BSP2-JAGS results for North Atlantic shortfin mako.

Probability that $F<F_{MSY}$

TAC (t)	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
500	0	0	75	75	74	75	75	74	75	75	74	76	75	75	75	75	76	76	76	74	75	74	75	75	75
1000	0	0	30	31	32	32	32	31	32	33	34	35	35	35	36	35	35	36	38	37	38	38	38	38	38
1500	0	0	11	11	10	11	11	13	13	13	14	14	14	14	14	14	15	14	15	15	16	16	16	16	16
2000	0	0	2	2	3	4	4	4	4	4	4	5	5	4	4	5	5	5	5	6	5	6	6	6	6
2500	0	0	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
3500	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
4000	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

Probability that $B>B_{MSY}$

TAC (t)	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
0	7	7	6	8	10	13	16	19	21	24	27	29	31	33	36	38	41	42	43	45	46	47	50	52	54
500	5.8	5	4	6	9	10	12	14	15	16	19	20	21	23	24	25	27	28	29	31	30	32	33	35	35
1000	6	5	6	7	9	9	10	13	13	14	16	17	18	20	21	21	22	24	23	25	25	25	25	26	27
1500	6	6	6	7	8	8	10	10	11	11	12	12	12	13	13	14	15	15	16	16	17	17	16	16	16
2000	6	5	5	6	7	7	7	8	8	8	9	9	9	8	8	9	9	9	8	9	9	9	9	9	9
2500	6	6	6	6	7	7	7	6	6	6	7	6	6	7	7	6	7	6	6	6	6	6	6	6	6
3000	6	6	5	7	6	5	5	6	5	5	5	5	5	4	4	4	4	3	3	3	3	3	3	3	3
3500	6	5	6	6	6	5	5	5	5	5	5	3	3	3	3	2	2	2	2	2	2	2	2	2	2
4000	6	5	6	5	4	4	3	3	2	2	2	2	2	1	1	1	1	1	1	1	1	0	0	0	0

Probability of being in the green zone ($F<F_{MSY}$ and $B>B_{MSY}$)

TAC (t)	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
0	0	0	6	8	11	13	16	19	21	24	27	29	31	33	36	38	41	42	43	45	46	47	50	52	54
500	0	0	4	6	9	10	12	14	15	16	19	20	21	23	24	25	27	27	29	31	30	32	33	35	35
1000	0	0	5	6	8	8	9	10	11	12	15	15	15	17	19	19	20	22	21	23	23	23	23	24	25
1500	0	0	3	3	4	5	5	6	7	7	7	8	8	9	9	10	10	10	11	11	12	12	12	12	12
2000	0	0	0	1	2	2	2	3	3	2	3	3	3	3	3	4	4	4	4	5	4	5	5	5	5
2500	0	0	0	0	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2
3000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
3500	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
4000	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

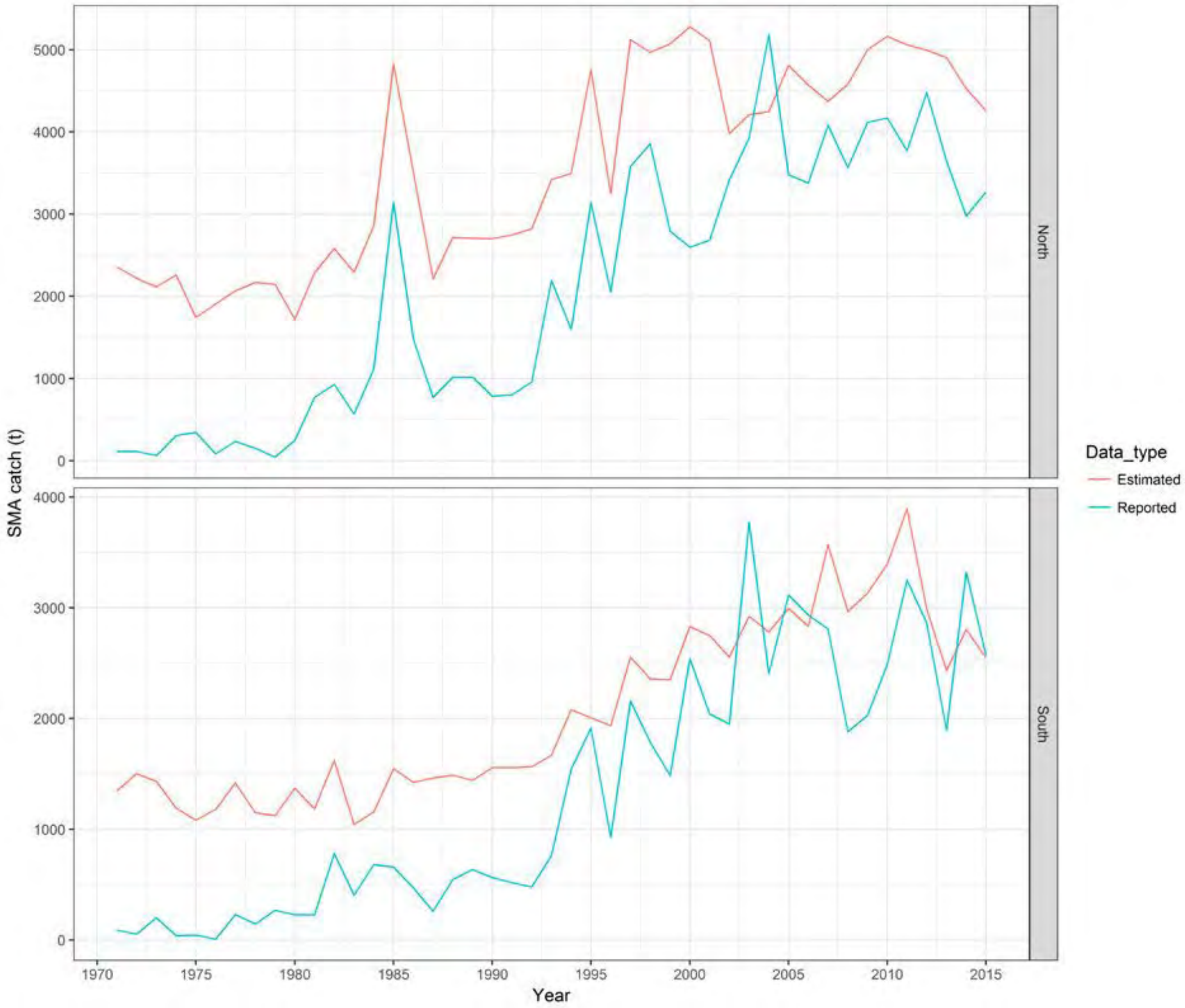


Figure 1. Time series of reported (Task I) and estimated shortfin mako shark (SMA) catches, between 1971 and 2015, for the North and South Atlantic stocks.

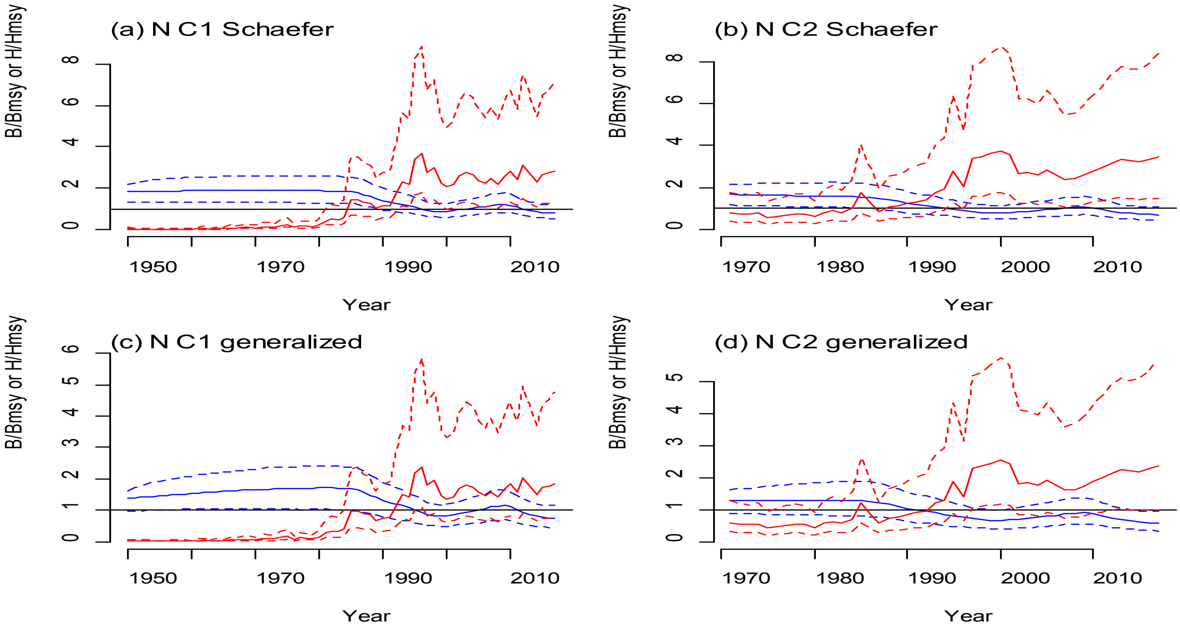


Figure 2. North Atlantic BSP2-JAGS biomass (blue) and harvest rate (red) histories for (a) C1 Schaefer, (b) C2 Schaefer, (c) C1 generalized production model, and (d) C2 generalized production model.

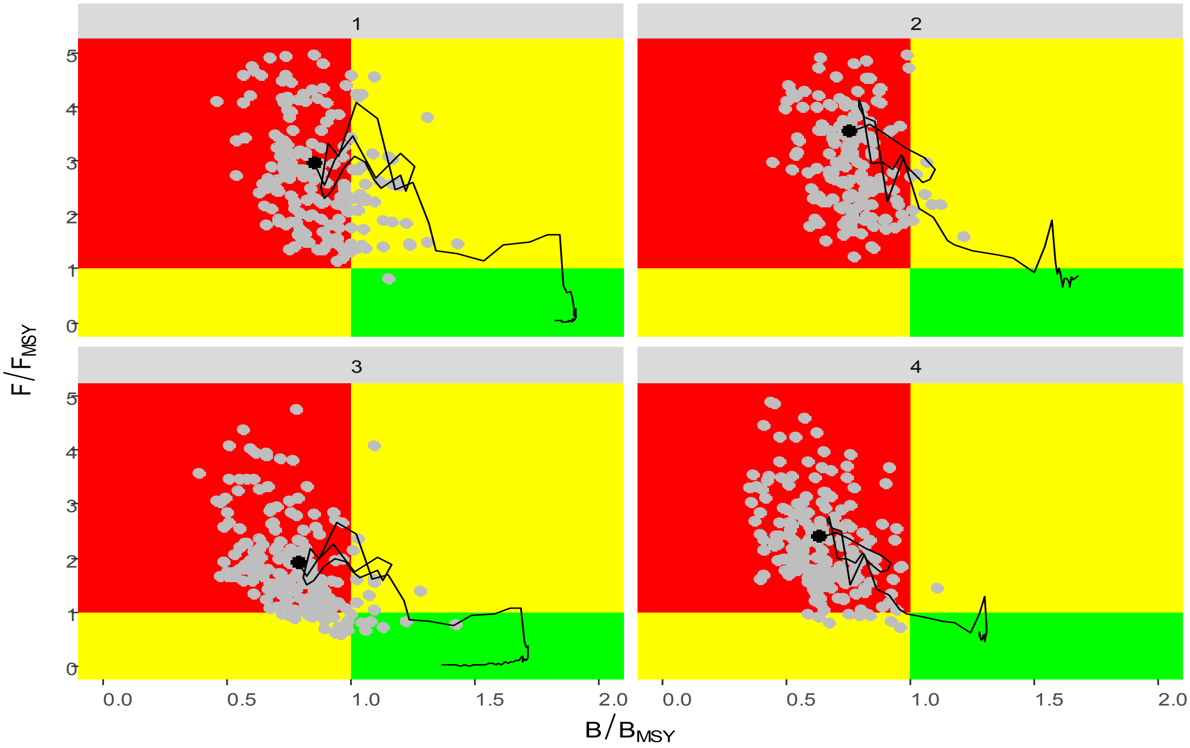


Figure 3. Kobe plots for BSP2-JAGS in the North Atlantic, for (a) C1 Schaefer, (b) C2 Schaefer, (c) C1 generalized production model, and (d) C2 generalized production model. Each point represents an MCMC draw. The solid black dot denotes current (2015) stock status.

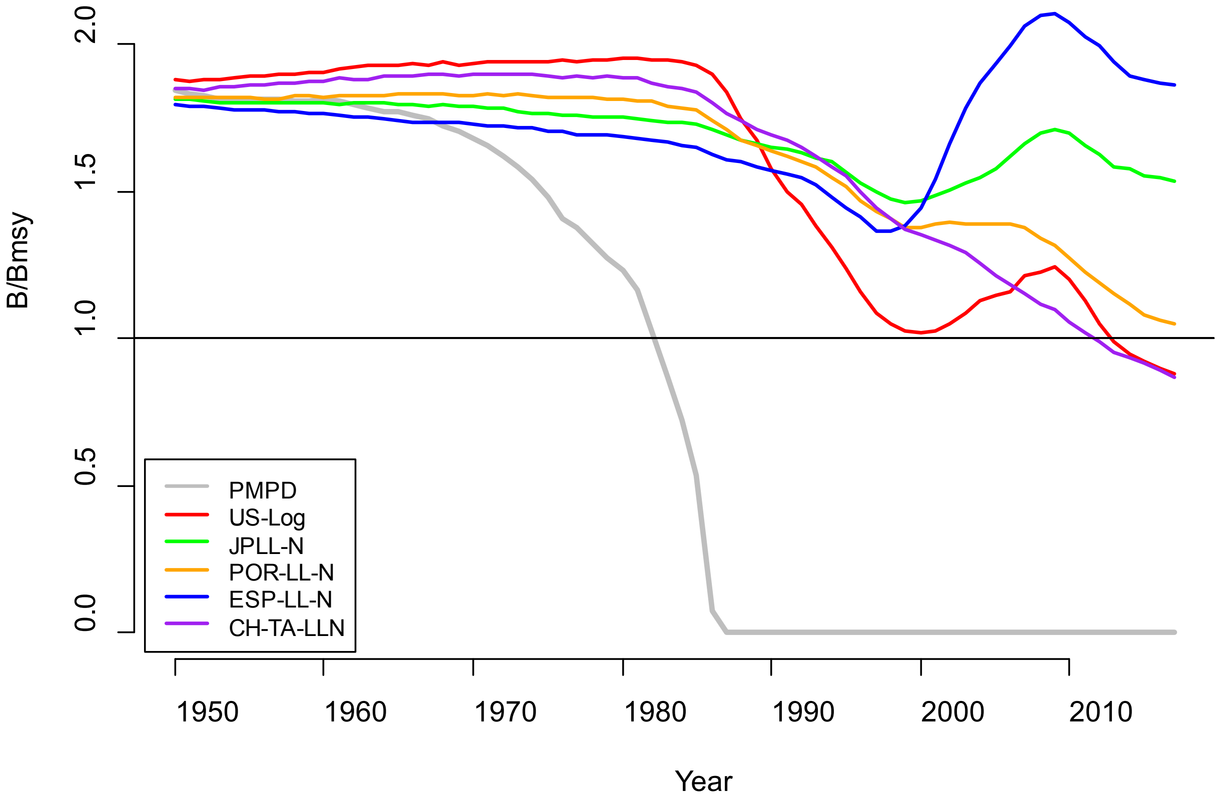


Figure 4. North Atlantic BSP2-JAGS diagnostic model runs, including post-model pre-data (PMPD), and each index of abundance fitted separately.

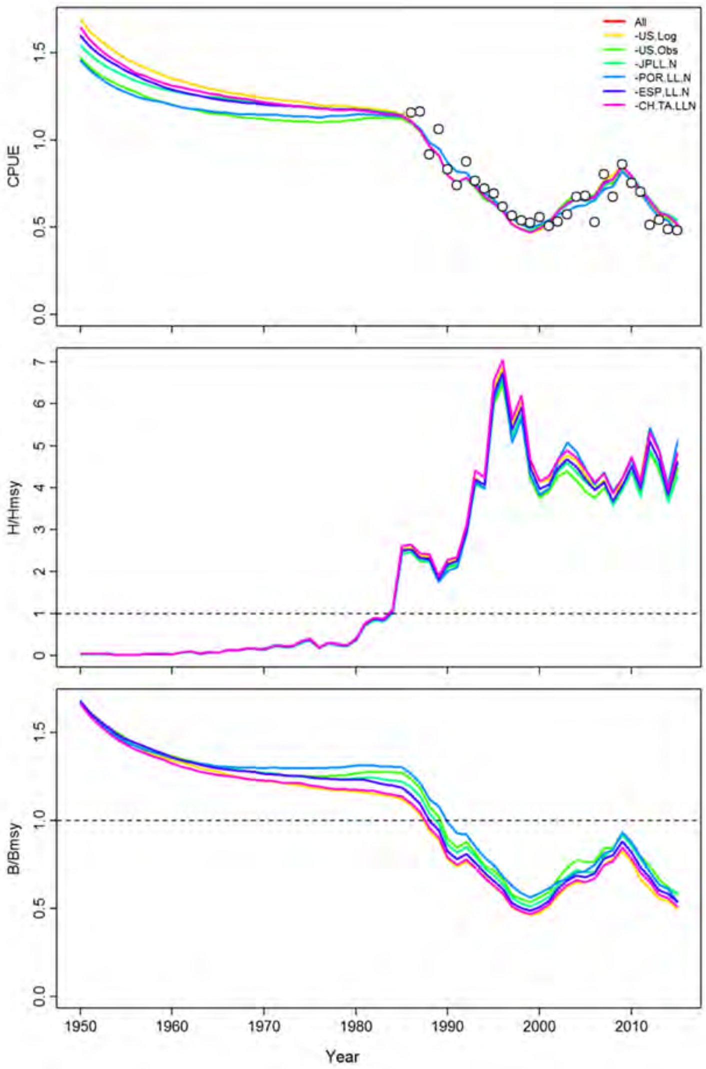


Figure 5. Jackknife diagnostics with respect to the CPUE series, F/F$_{MSY}$ and B/B$_{MSY}$ over time for the North Atlantic C1 scenario, with open circles illustrating the US LL CPUE.

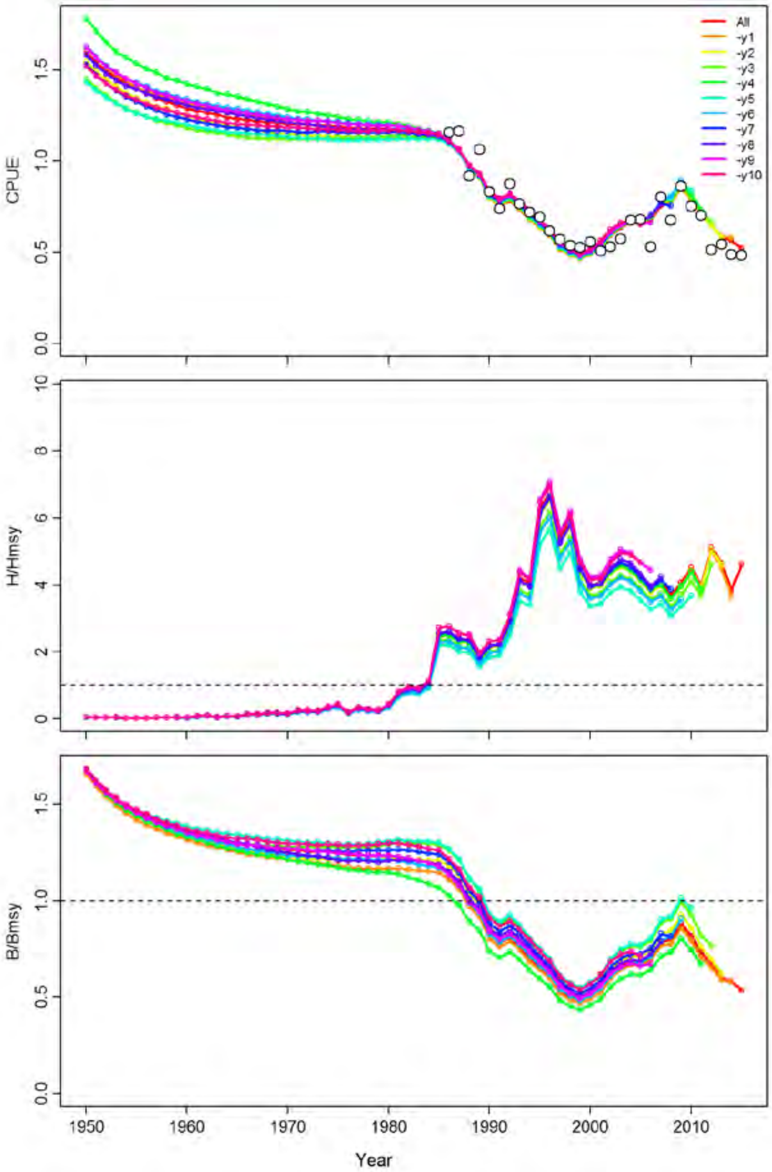


Figure 6. Retrospective diagnostics with respect to the CPUE series, F/F_{MSY} and B/B_{MSY} over time for the North Atlantic C1 scenario, with open circles illustrating the US LL CPUE.

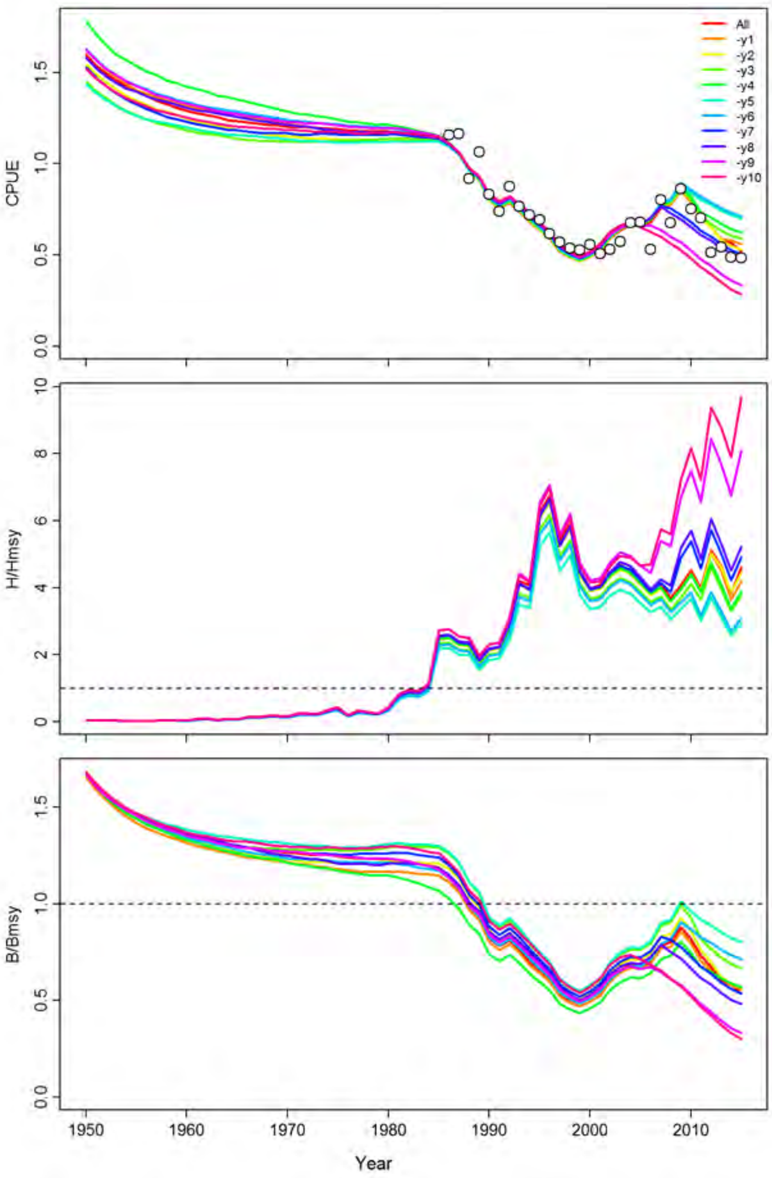


Figure 7. Cross-validation prediction diagnostics with respect to the CPUE series, F/F_{MSY} and B/B_{MSY} over time for the North Atlantic C1 scenario, with open circles illustrating the US LL CPUE.

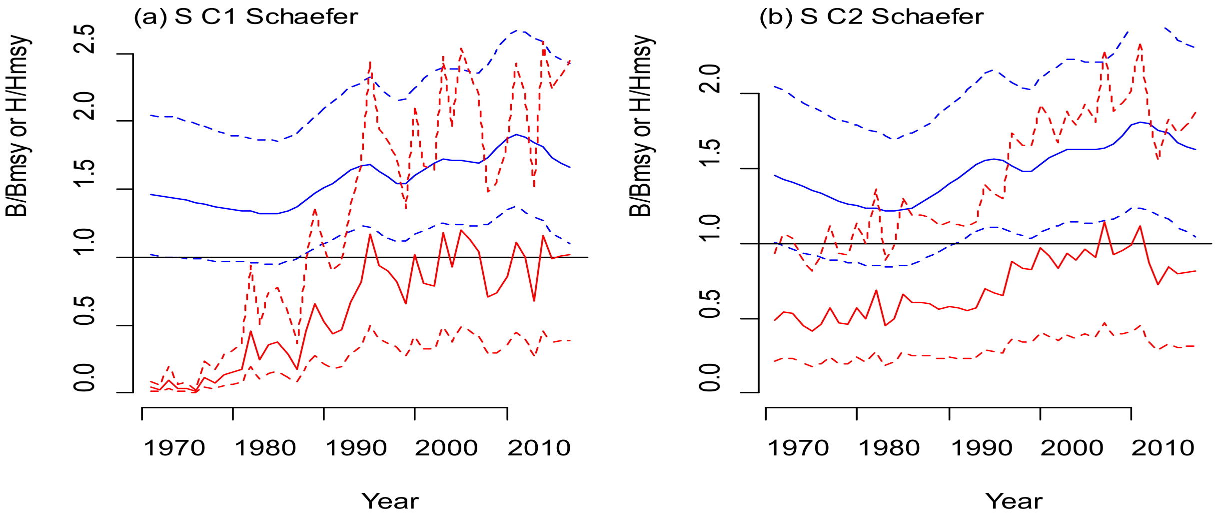


Figure 8. South Atlantic BSP2-JAGS biomass (blue) and harvest rate (red) histories for (a) C1 catch Schaefer, and (b) C2 catch Schaefer.

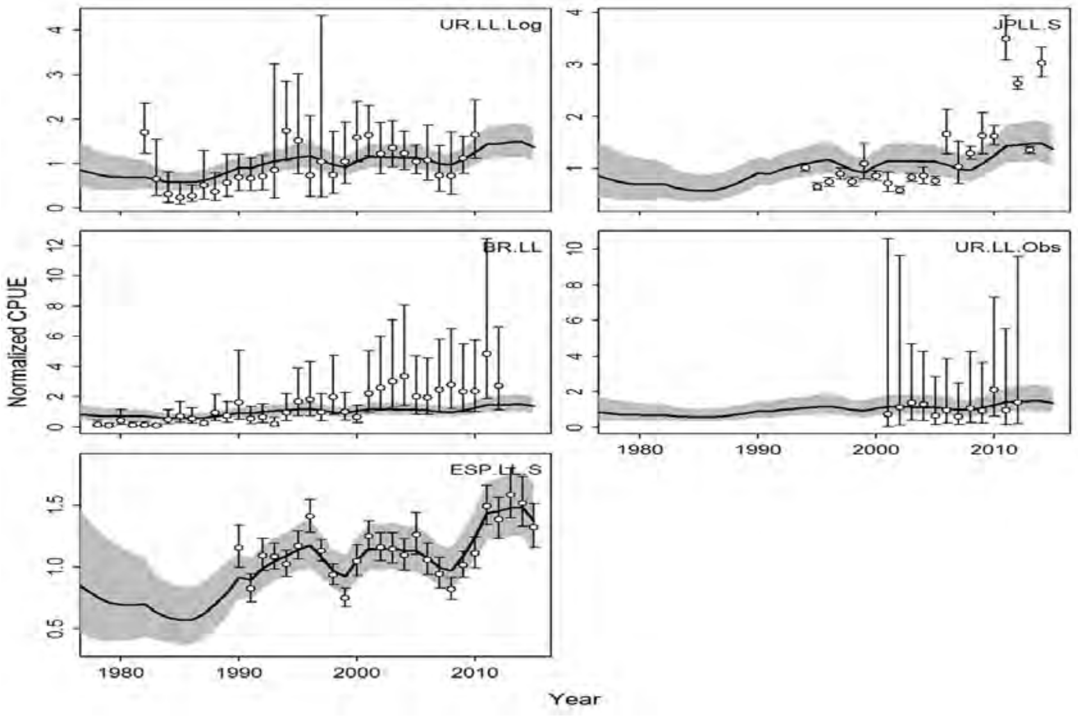


Figure 9. Time-series of observed (circle) and predicted (solid line) catch per unit effort (CPUE) for the shortfin mako shark in the South Atlantic C1 scenario using JABBA. Shaded grey area indicates 95% C.I.

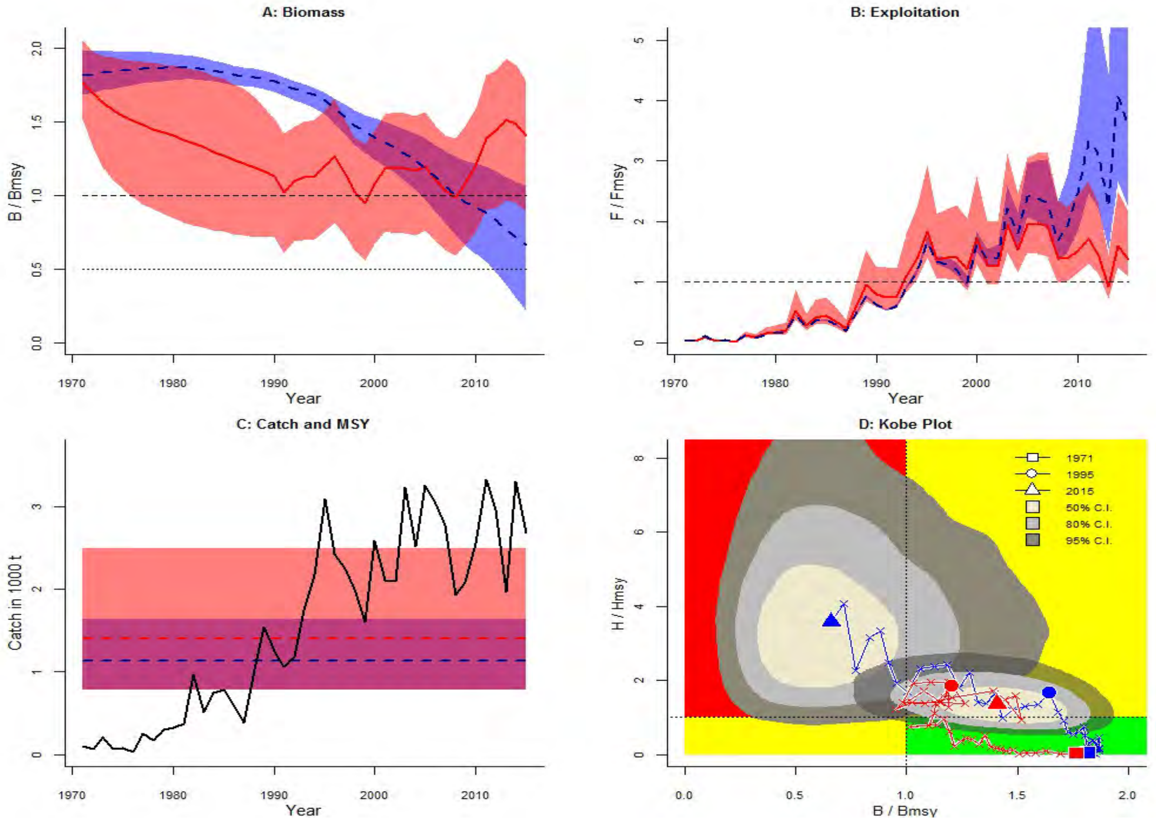


Figure 10. Comparison of CMSY (blue) and CMSY_BSM (red) for South Atlantic SMA scenario C1 showing the trajectories of (A) predicted B / B_{MSY}, (B) predicted F / F_{MSY}, (C) catches superimposing the MSY region (95% CIs), and (D) Kobe plot with uncertainty for the final year illustrated by kernel densities. Note that F is used here interchangeably with harvest rate H = C/B.

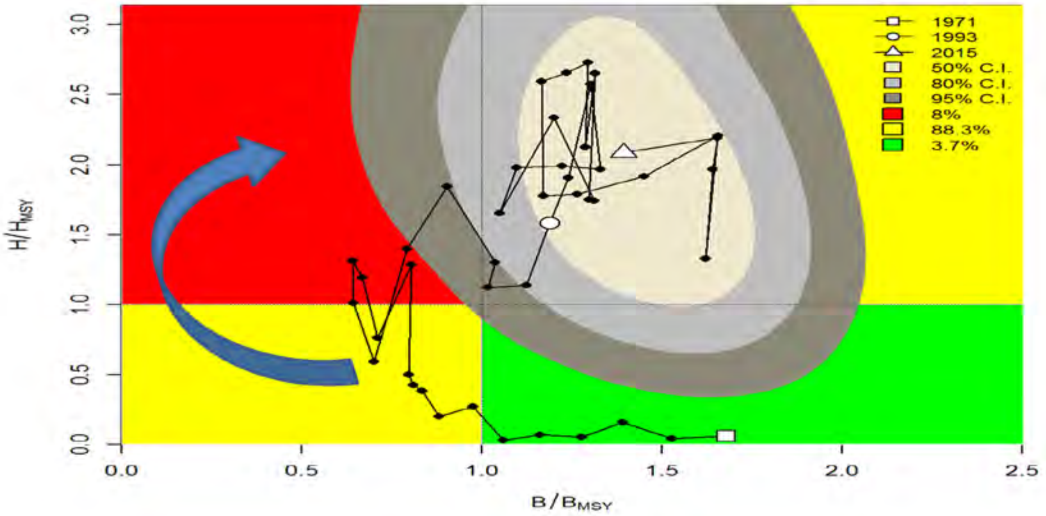


Figure 11. Kobe diagram showing the estimated trajectories (1971-2015) of B/B_{MSY} and H/H_{MSY} for the C1 scenario for the South Atlantic shortfin mako shark stock assessment with the JABBA model. The South Atlantic stock reveals a clockwise pattern moving from an underexploited state to a recovery as result of decreasing biomass under sustainable fishing, which is followed by a short period of overfishing, which is somewhat biologically implausible and ambiguous. This erroneous trend can be attributed to the apparent contradiction between the observation process (i.e. CPUE) and process equation, as both CPUE and biomass trends increase.

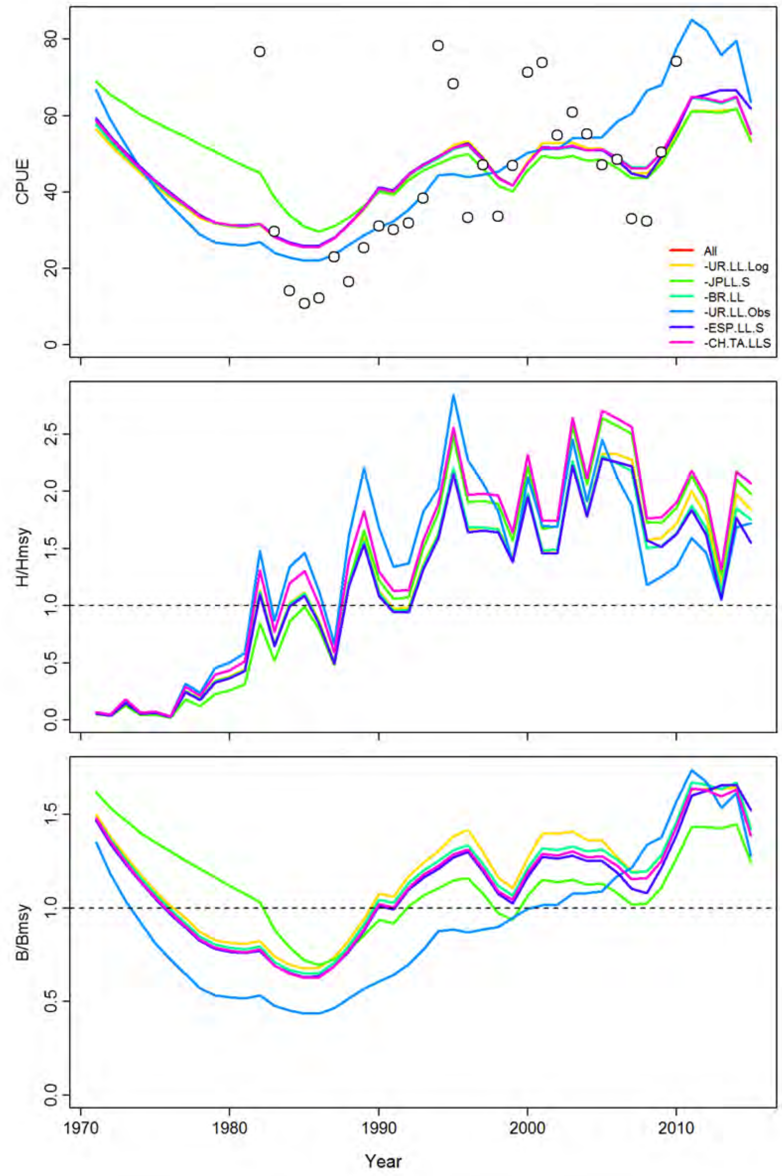


Figure 12. Jackknife diagnostics of the JABBA model with respect to the CPUE series, F/F$_{MSY}$ and B/B$_{MSY}$ over time for the South Atlantic C1 scenario, with open circles illustrating the Brazilian LL CPUE.

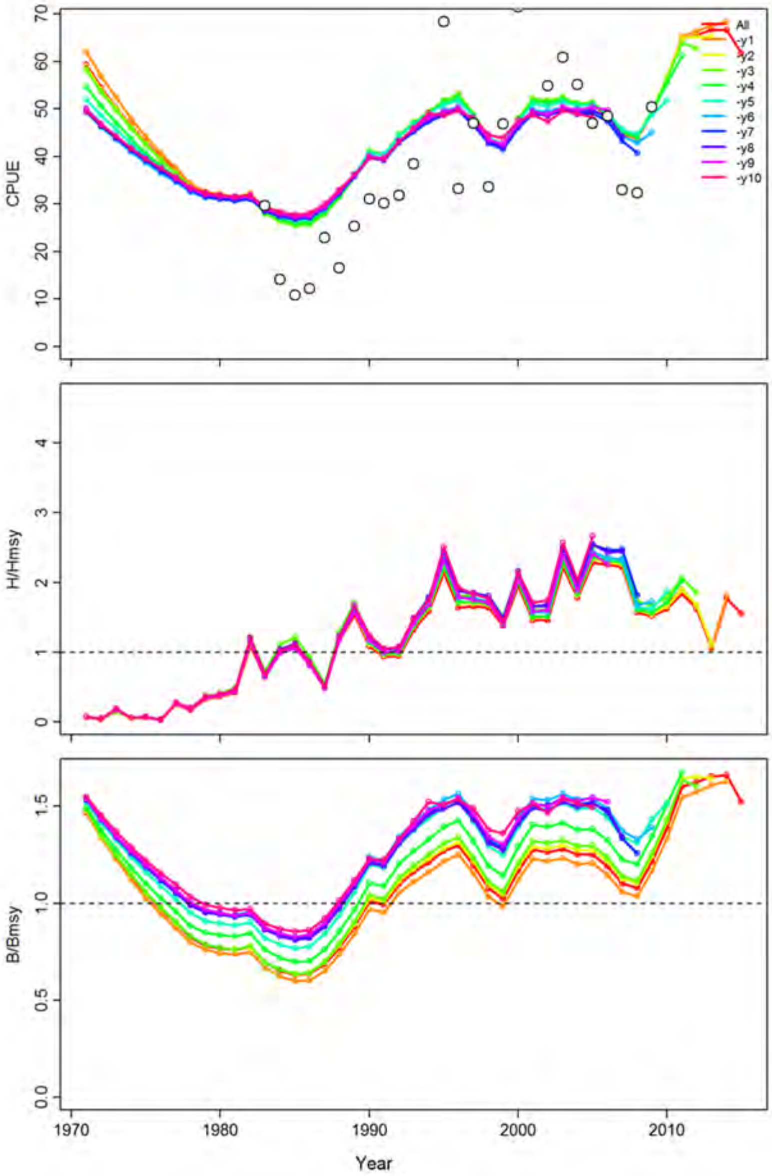


Figure 13. Retrospective diagnostics of the JABBA model with respect to the CPUE series, F/F_{MSY} and B/B_{MSY} over time for the South Atlantic C1 scenario, with open circles illustrating the Brazilian LL CPUE.

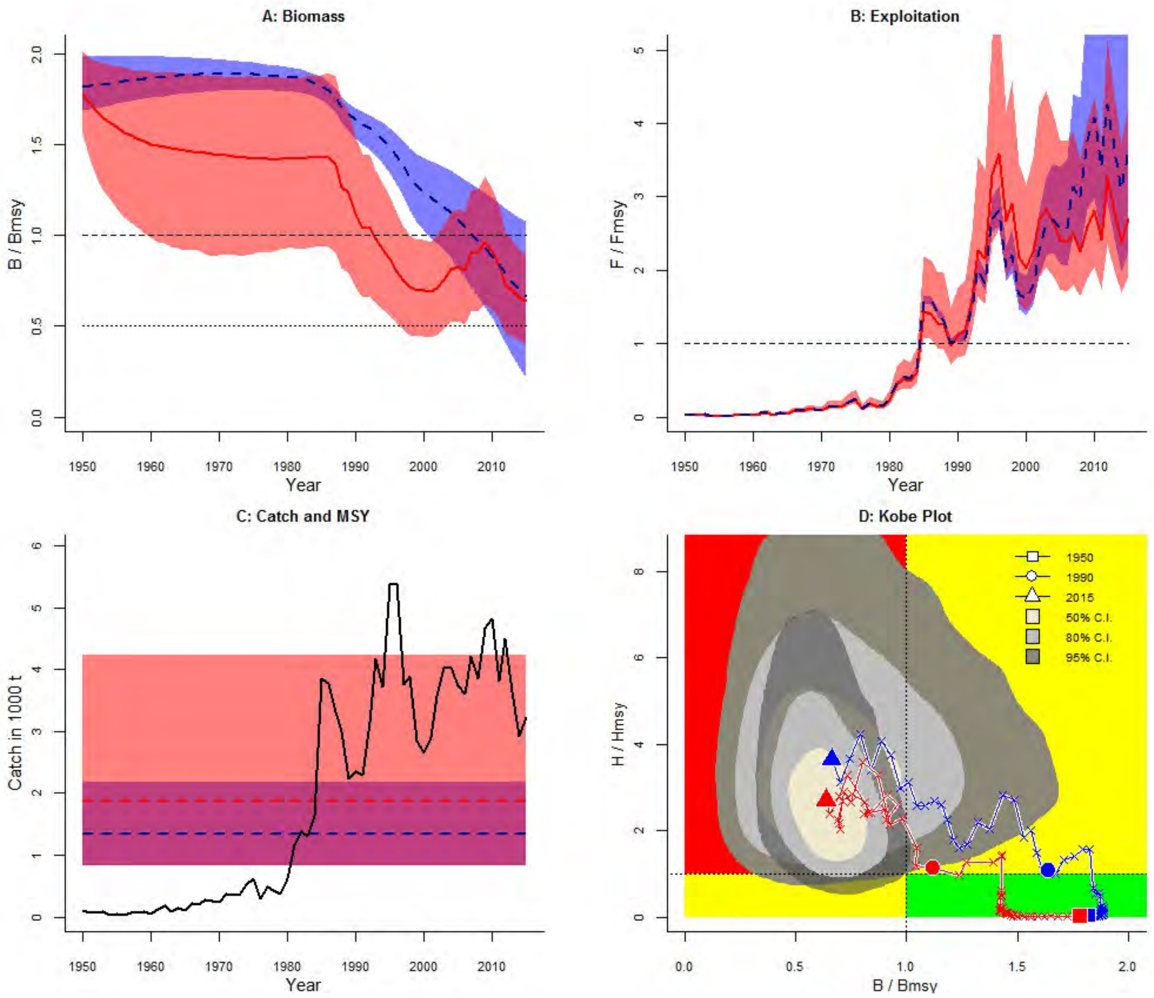


Figure 14. Comparison of CMSY (blue) and CMSY_BSM (red) for North Atlantic SMA scenario C1 showing the trajectories of (A) predicted B / B_{MSY}, (B) predicted F / F_{MSY}, (C) catches superimposing the MSY region (95% CIs), and (D) Kobe plot with uncertainty for the final year illustrated by kernel densities. Note that F is used here interchangeably with harvest rate H = C/B.

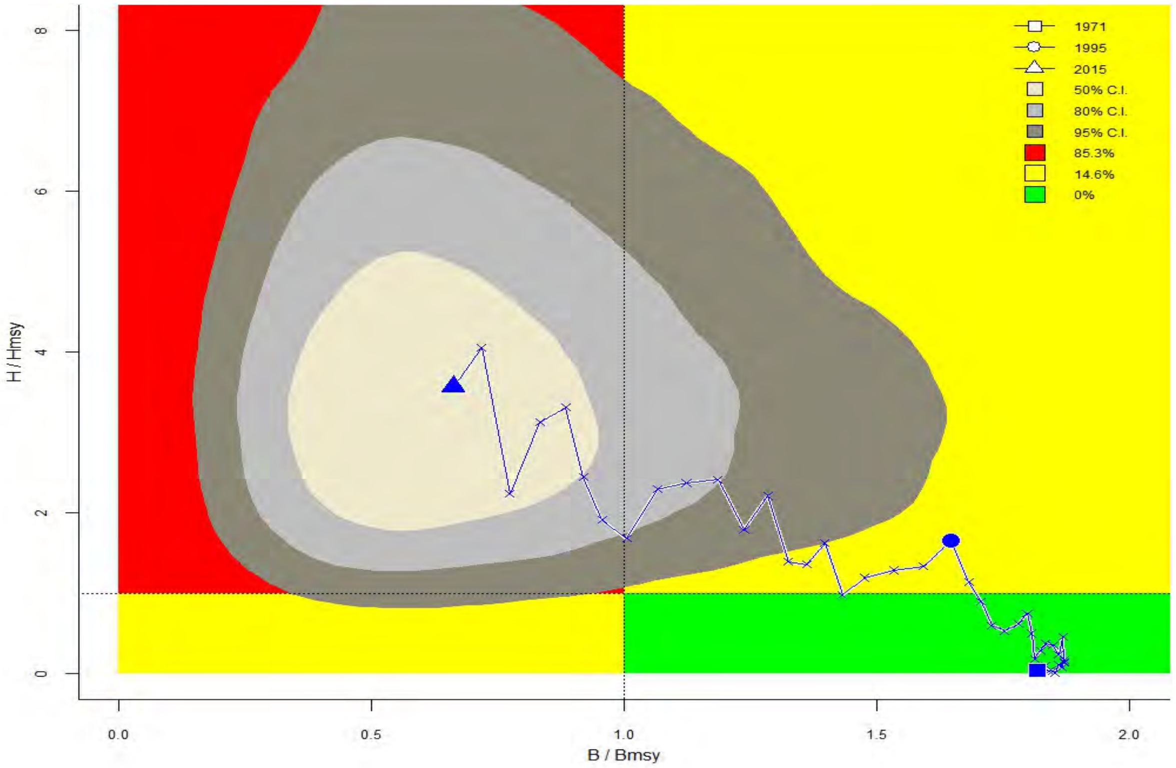


Figure 15. Kobe plot for C_{MSY} assessment results for South Atlantic SMA scenario C1 with uncertainty for the final year illustrated by kernel densities.

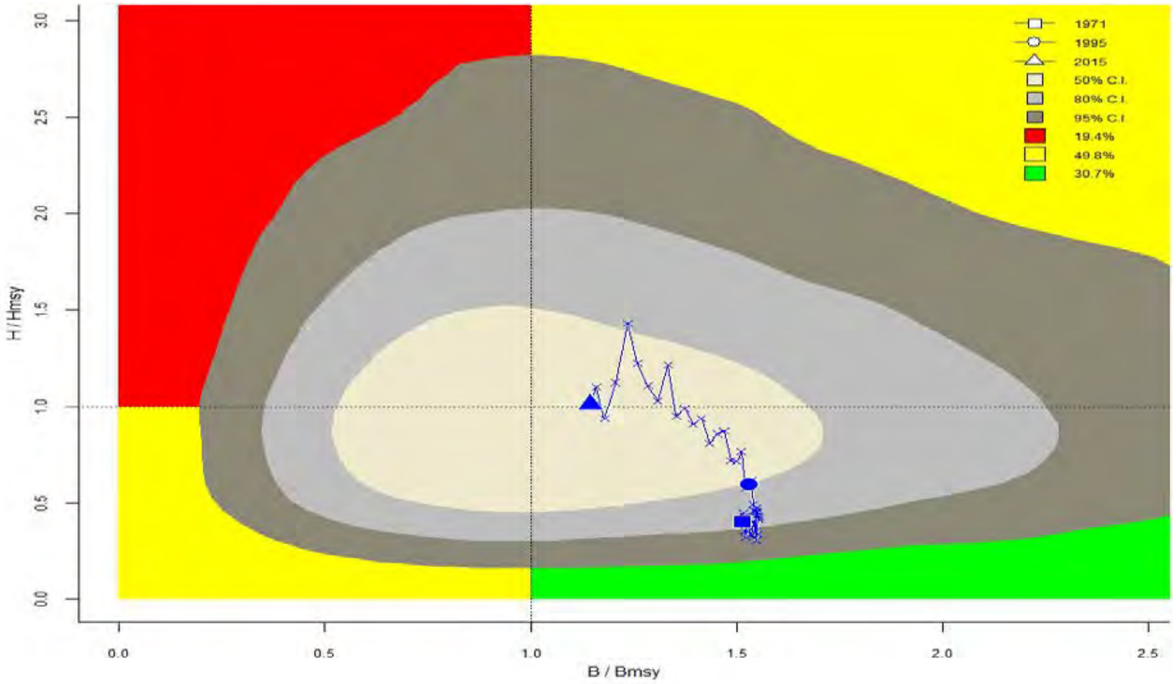
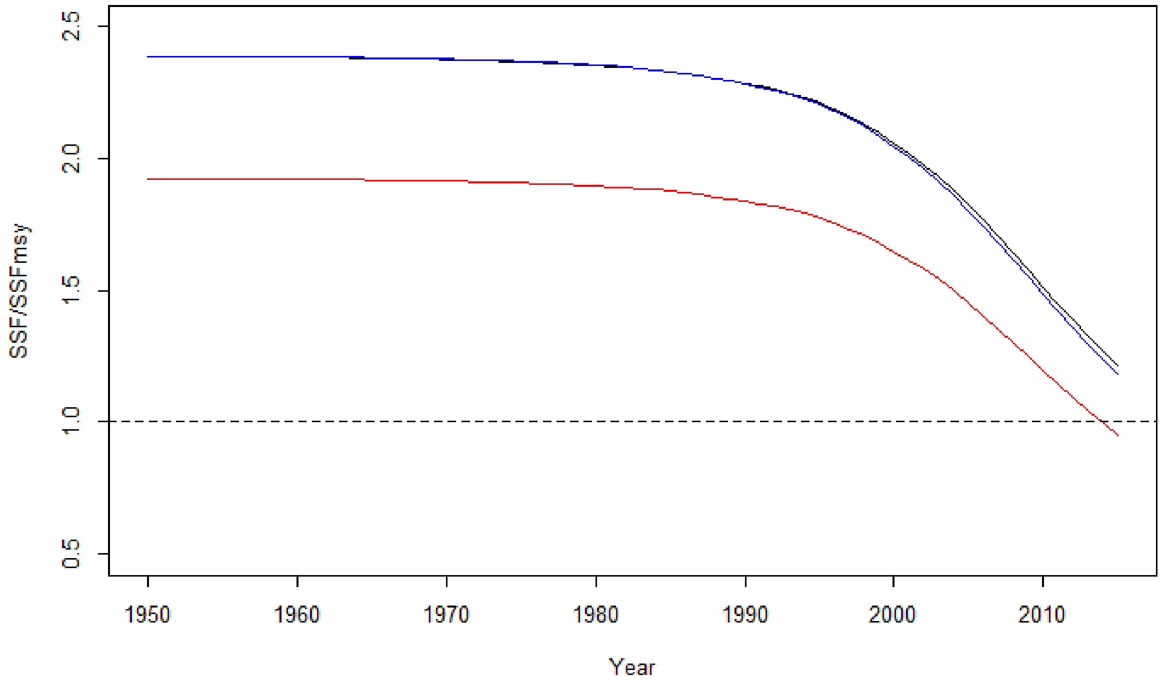


Figure 16. Kobe plot for CMSY assessment results for South Atlantic SMA scenario C2 with uncertainty for the final year illustrated by kernel densities.



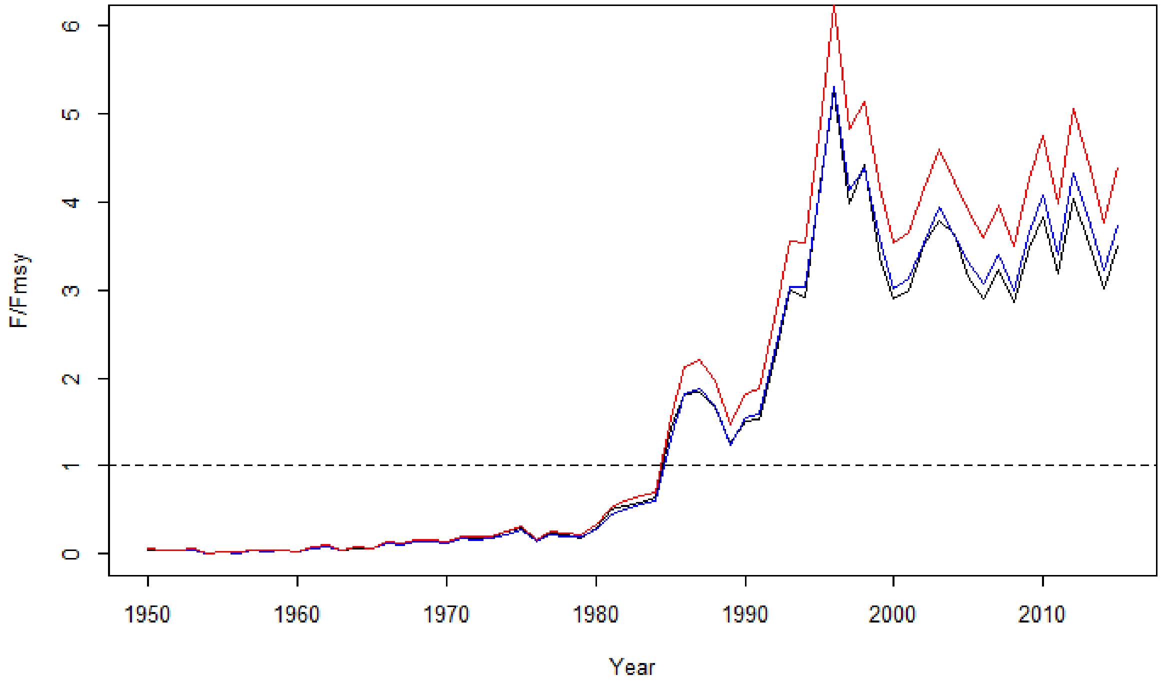


Figure 17. SSF/SSF$_{MSY}$ and F/F$_{MSY}$ for Stock Synthesis model run 1 (black), model run 2 (blue), and model run 3 (red) relative to the values at MSY (stippled line).

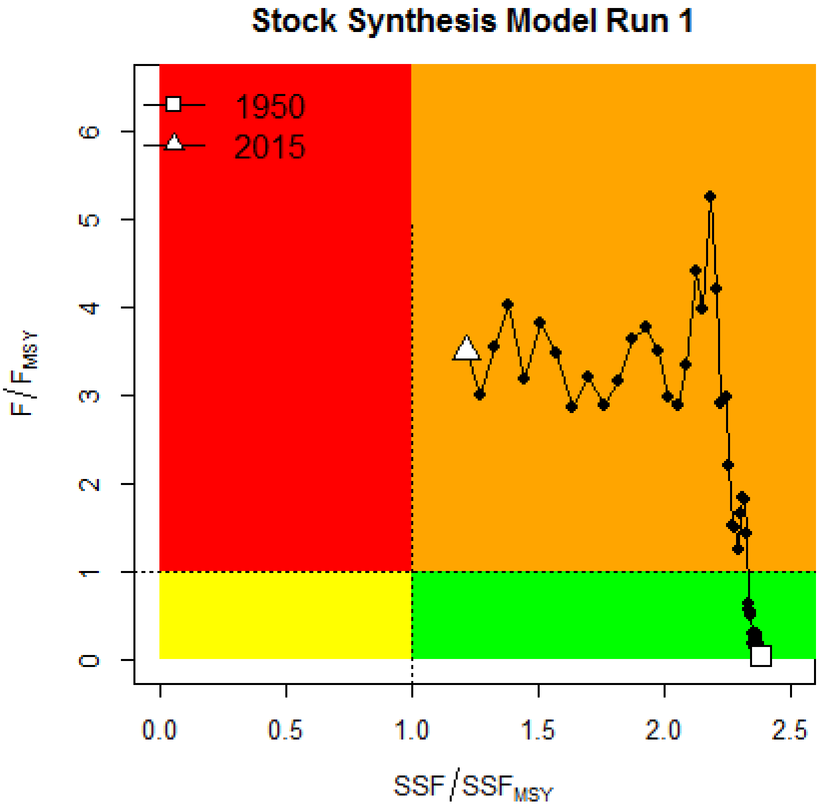


Figure 18. Kobe plot (SSF/SSF$_{MSY}$ and F/F$_{MSY}$) for Stock Synthesis model run 1 relative to the values at MSY (stippled lines).

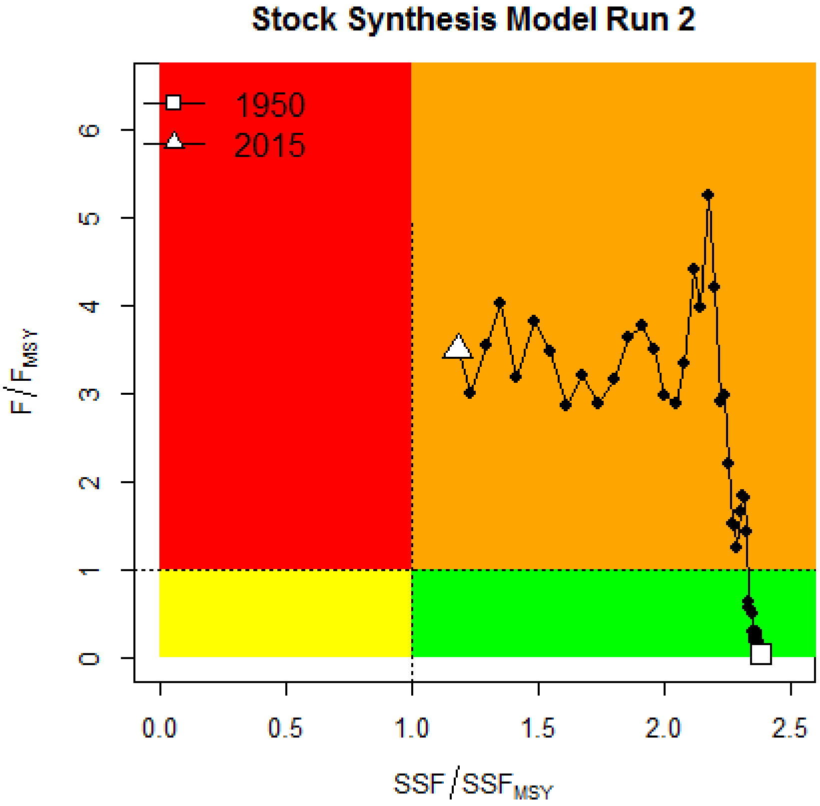


Figure 19. Kobe plot (SSF/SSF$_{MSY}$ and F/F$_{MSY}$) for Stock Synthesis model run 2 relative to the values at MSY (stippled lines).

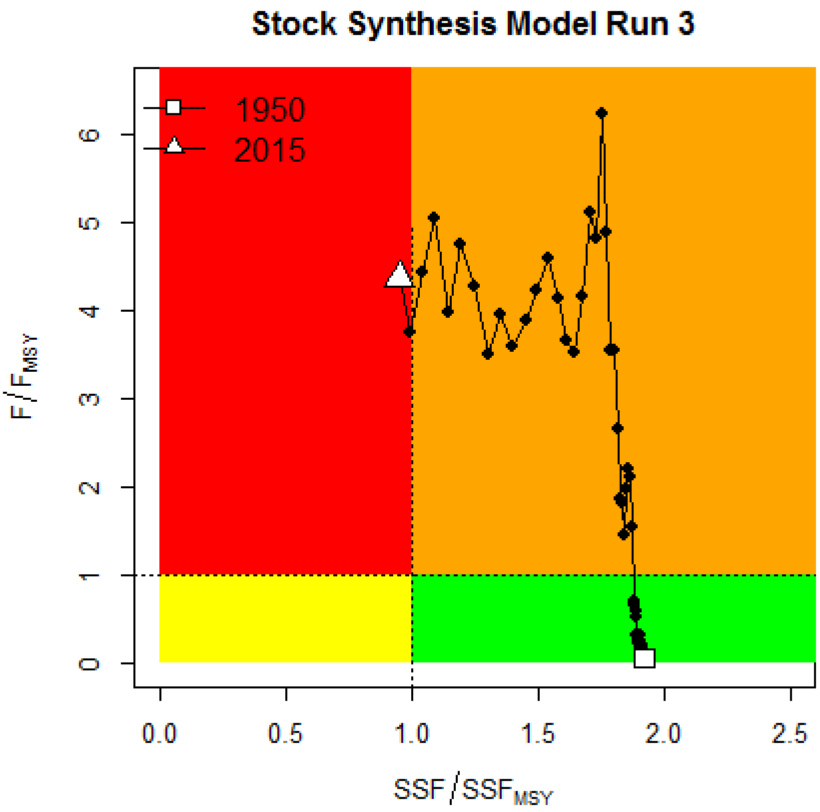


Figure 20. Kobe plot (SSF/SSF$_{MSY}$ and F/F$_{MSY}$) for Stock Synthesis model run 3 relative to the values at MSY (stippled lines).

```
  Method         Run       red   yellow green
1     SS           1 56.07287 43.92713   0.0
2    BSP           1 82.10000 17.50000   0.4
3    BSP           2 92.30000  7.70000   0.0
4    BSP           3 97.80000  2.20000   0.0
5    BSP           4 97.30000  2.50000   0.2
6  Jabba     Pella 1 99.90000  0.10000   0.0
7  Jabba     Pella 2 99.30000  0.60000   0.1
8  Jabba Schaefer 1 92.60000  7.40000   0.0
9  Jabba Schaefer 2 95.80000  4.20000   0.0
```

Figure 21. Kobe Pie Chart for the individual runs in the North Atlantic. From left to right, models are: SS=Stock Synthesis; BSP1=BSP2JAGS, Catch 1, Schaefer; BSP2= BSP2JAGS, Catch 1, Schaefer; BSP3= BSP2JAGS, Catch2, Generalized; BSP4=BSP2JAGS, Catch 2, Generalized; JABBA Pella, with Catch 1; JABBA Pella with Catch 2; JABBA Schaefer with Catch 1; JABBA Schaefer with Catch 2.

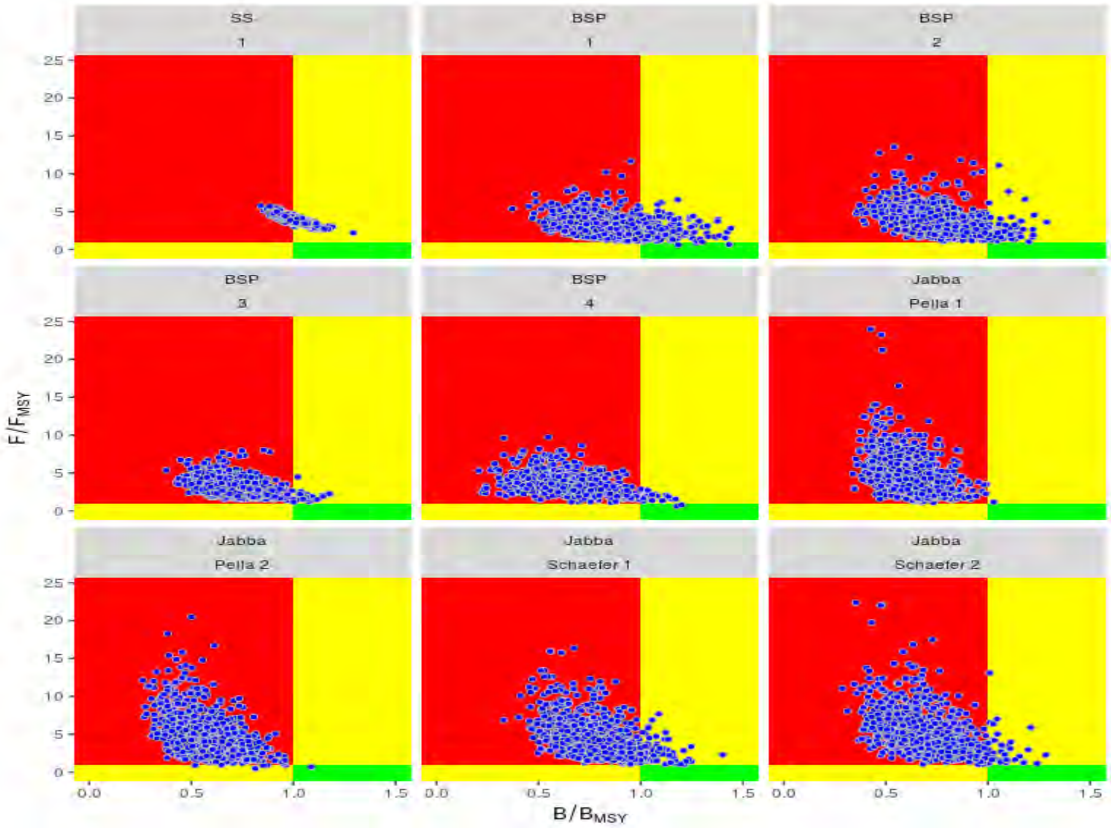


Figure 22. Kobe phase plots for the individual model runs in the North Atlantic. See Figure 21 caption for a description of the models.

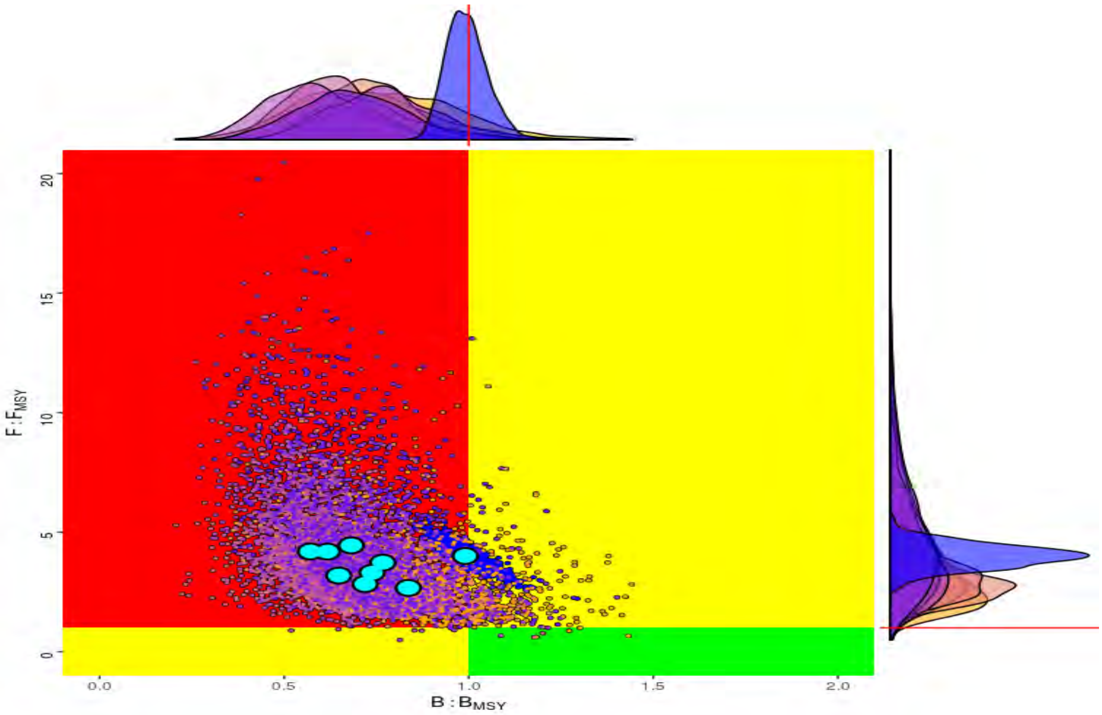


Figure 23. Kobe phase plot for North Atlantic shortfin mako showing current status (2015) based on all assessment models used. Large points show the medians for each assessment scenario; small points show the individual simulations. Marginal distributions are also shown.

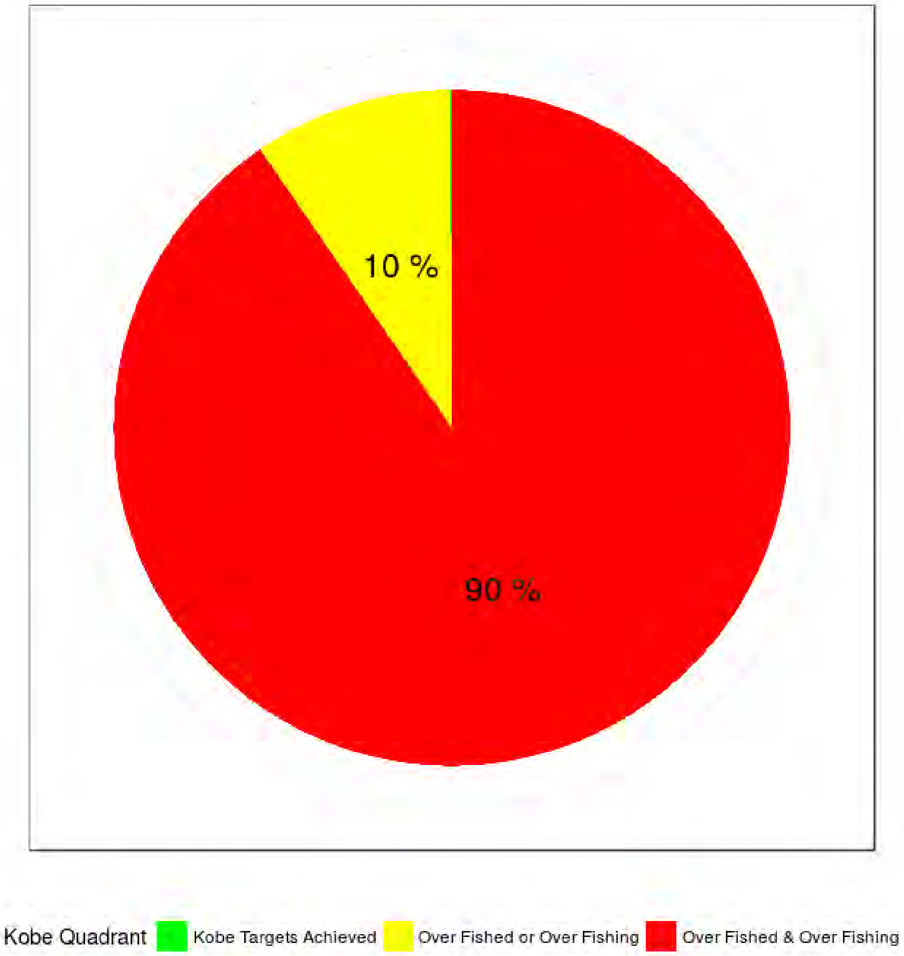
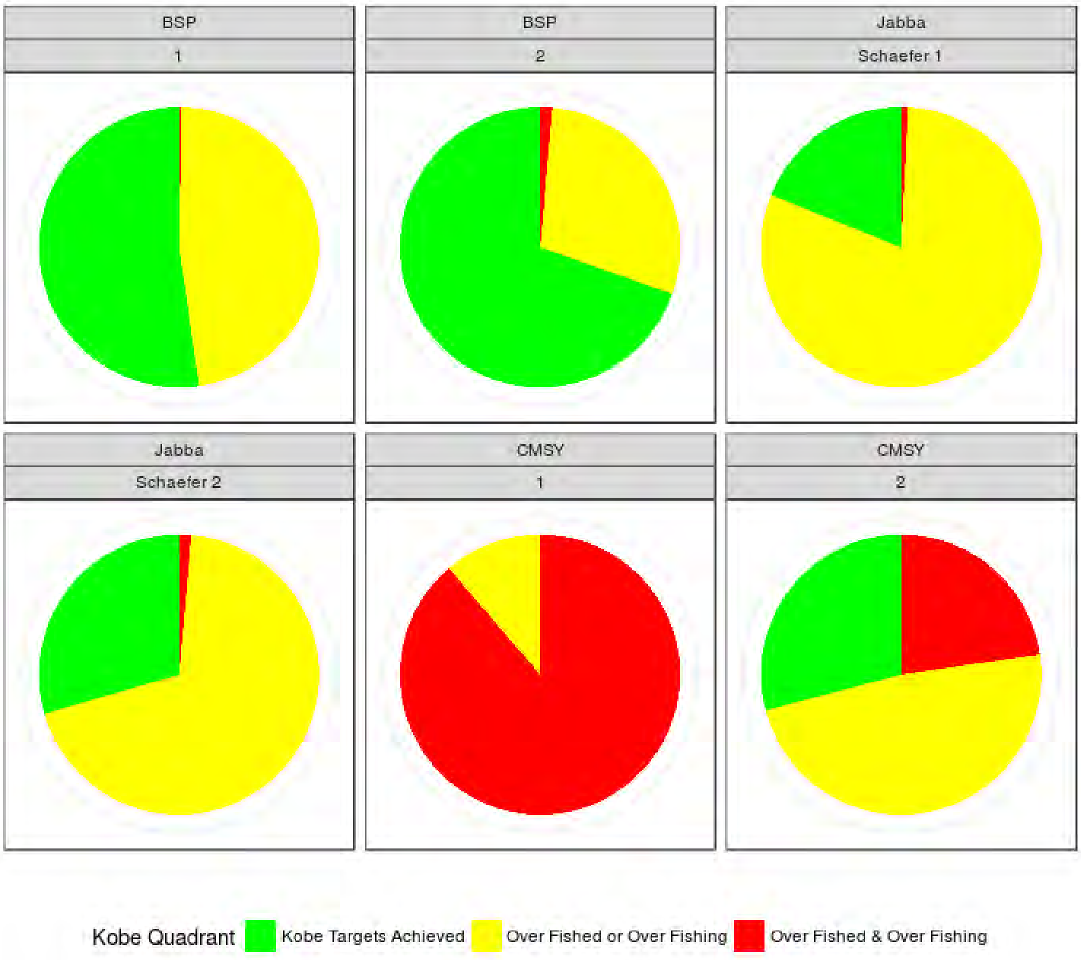


Figure 24. Kobe Pie Chart for the combined runs in the North Atlantic.



```
  Method         Run  red yellow green
1    BSP           1  0.3   47.4  52.3
2    BSP           2  1.4   29.0  69.6
3  Jabba Schaefer 1  0.8   80.3  18.9
4  Jabba Schaefer 2  1.4   69.1  29.5
5   CMSY           1 88.7   11.2   0.1
6   CMSY           2 22.7   48.2  29.1
```

Figure 25. Kobe Pie Chart for the individual runs in the South Atlantic. From left to right, models are: BSP1=BSP2JAGS, Catch 1, Schaefer; BSP2= BSP2JAGS, Catch 2, Schaefer; JABBA Schaefer with Catch 1; JABBA Schaefer with Catch 2; CMSY with Catch 1; CMSY with Catch 2.

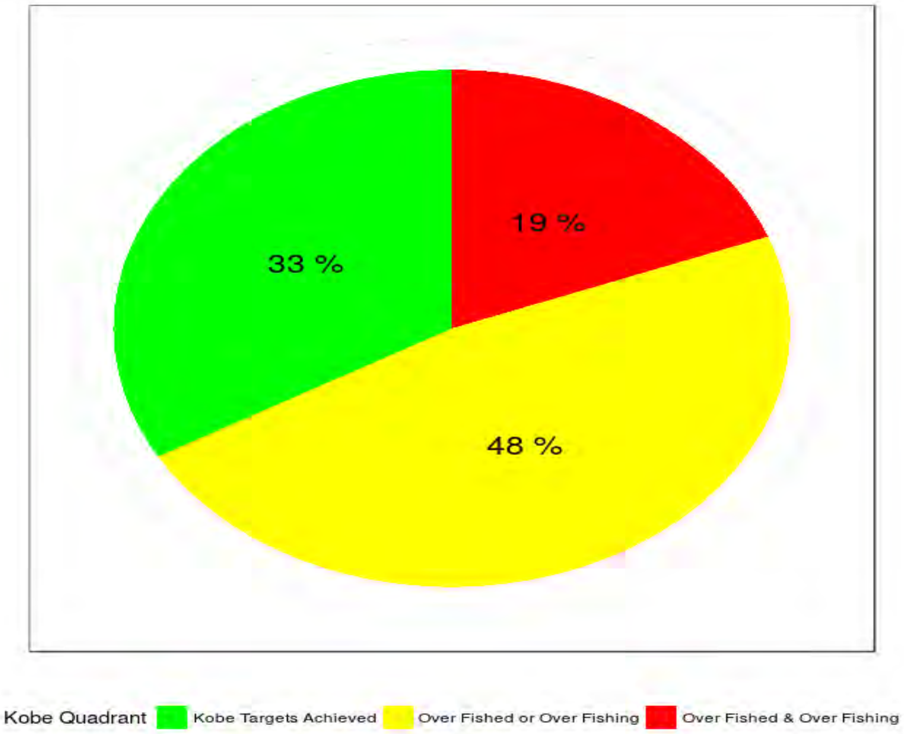


Figure 26. Kobe Pie Chart for the combined runs in the South Atlantic.

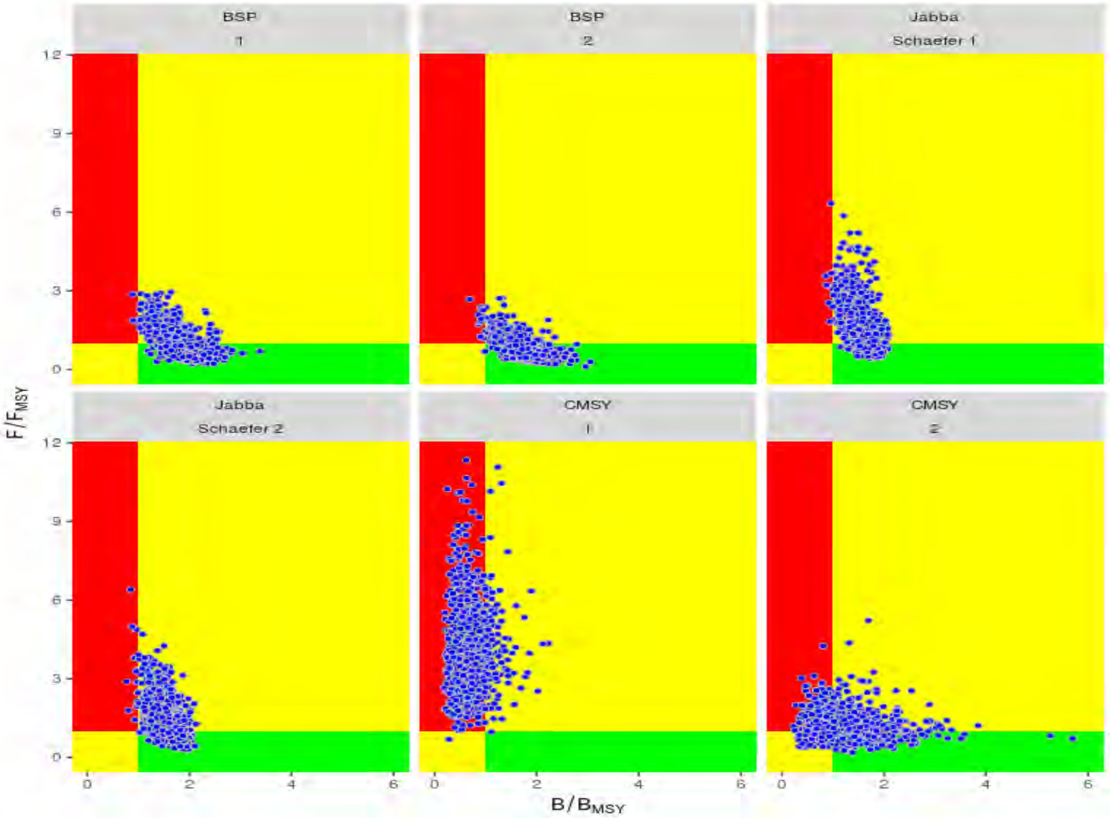


Figure 27. Kobe phase plots for the individual model runs in the South Atlantic. See Figure 25 caption for a description of the models.

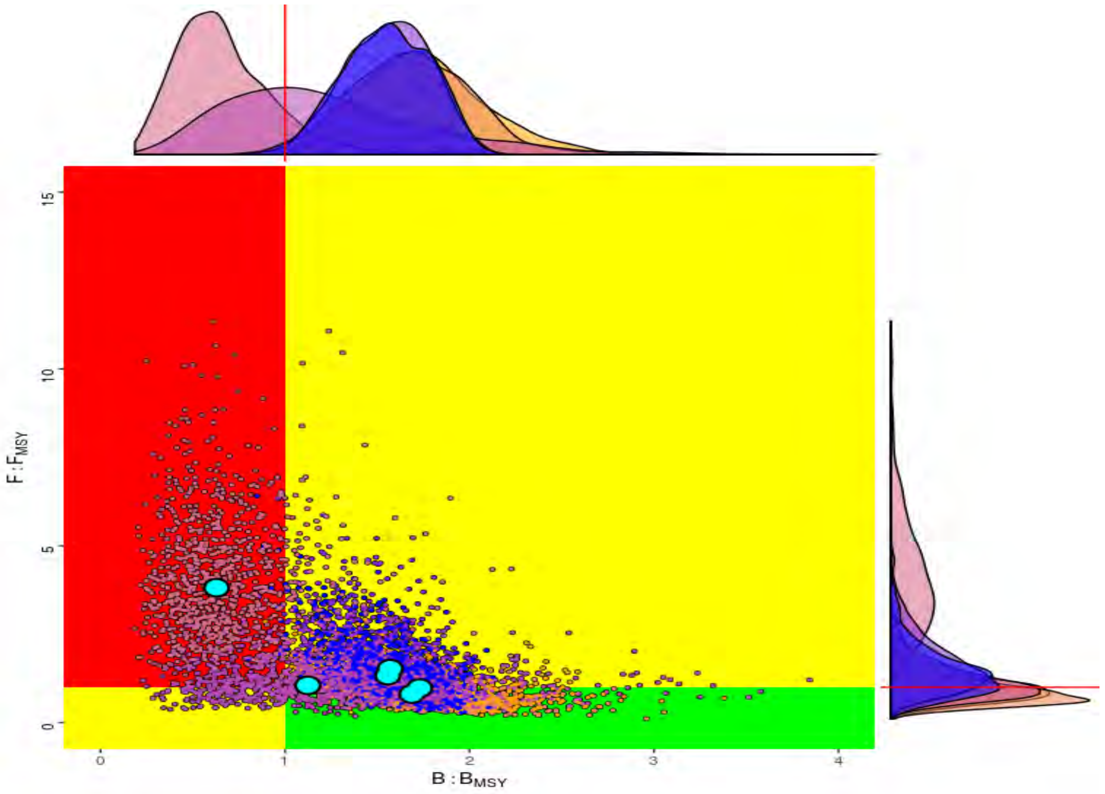


Figure 28. Kobe phase plot for South Atlantic, large points show the medians for each assessment scenario, small points show the individual simulations, marginal distributions are also shown.

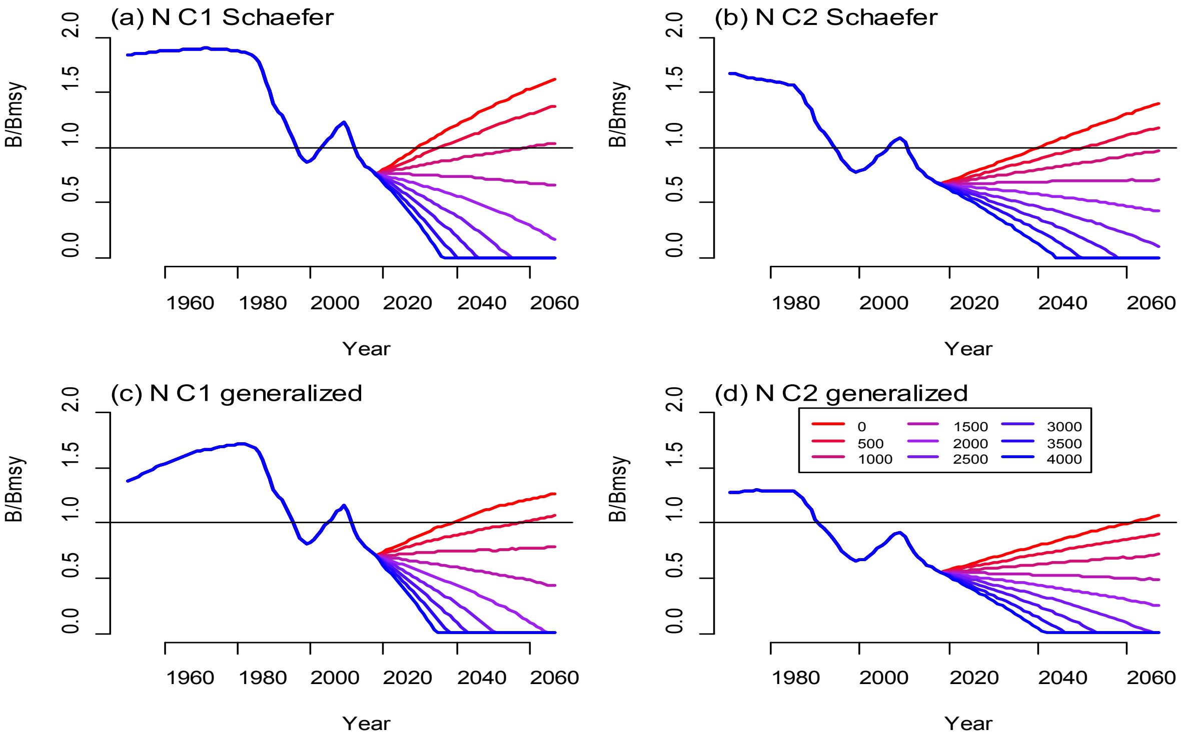


Figure 29. Median TAC projections (0 – 4000 t) from BSP2-JAGS North Atlantic for JAGS fits for (a) C1 Schaefer, (b) C2 Schaefer, (c) C1 generalized production model, and (d) C2 generalized production model.

Appendix 1

Agenda

1. Opening, adoption of Agenda and meeting arrangements
2. Summary of available data submitted by the assessment data deadline (30 April, 2017)
    - 2.1 Stock identity
    - 2.2 Catches
    - 2.3 Indices of abundance
    - 2.4 Biology
    - 2.5 Length compositions
    - 2.6 Other relevant data
3. Methods and other data relevant to the assessment
    - 3.1 Production models
    - 3.2 Other methods
    - 3.3 Length-based age-structured models: Stock Synthesis
4. Stock status results
    - 4.1 Production models
    - 4.2 Other methods
    - 4.3 Stock Synthesis
    - 4.4 Synthesis of assessment results
5. Projections
6. Recommendations
    - 6.1 Research and statistics
    - 6.2 Management
7. Other matters
8. Adoption of the report and closure

Appendix 2

List of Participants

CONTRACTING PARTIES

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Appendix 3

List of Papers and Presentations

Reference	Title	Authors
SCRS/2017/108	Updated standardized catch rates of shortfin mako (*Isurus oxyrinchus*) caught by the Spanish surface longline fishery targeting swordfish in the Atlantic ocean during the period 1990-2015	Fernández-Costa J., García-Cortés B., Ramos-Cartelle A. and Mejuto J.
SCRS/2017/110	An alternative hypothesis for the reconstruction of time series of catches for North and South Atlantic stocks of shortfin mako shark	Coelho R. and Rosa D.
SCRS/2017/111	Age and growth of shortfin mako in the North Atlantic, with revised parameters for consideration to use in the stock assessment	Rosa D., Mas F., Mathers A., Natanson L.J., Domingo A., Carlson J. and Coelho R.
SCRS/2017/125	Stock synthesis (SS3) model runs conducted for North Atlantic shortfin mako shark	Courtney D., Cortés E. and Zhang X.
SCRS/2017/126	Estimates of maximum population growth rate and steepness for shortfin makos in the North and South Atlantic Ocean	Cortes E.
SCRS/2017/129	Anomalous ratios of blue and shortfin mako shark landings from individual north-Atlantic longline fishing vessels	Queiroz N., Mucientes G., Sousa L.L., Sims D.W.
SCRS/2017/130	Highly spatially resolved catch records of shortfin mako in the Central North Atlantic	Queiroz N., Mucientes G., Sousa L.L., Sims D.W.
SCRS/2017/132	Proposal of implementation of low-fecundity spawner-recruitment relationship for shortfin mako in the North Atlantic	Kai M. and Carvalho F.
SCRS/2017/135	Initial stock assessment results for the North and South Atlantic shortfin mako (*Isurus oxyrinchus*) using a Bayesian Surplus Production Model and the Catch-Resilience method CMSY	Winker H, Carvalho F., Sharma R., Parker D. and Kerwath S.
SCRS/P/2017/017	Fishing the RFMO boundary: South African shortfin mako data	Winker H., Kerwath S. and Parker D.
SCRS/P/2017/020	Linking age-structured (SS3) and surplus production models	Winker H. and Carvalho F.
SCRS/P/2017/021	CMSY and a fitted SPMs: Lessons learned from Mediterranean albacore with application to South Atlantic shortfin mako	Winker H. and Parker D.
SCRS/P/2017/022	Using Satellite Telemetry to Quantify Fisheries Interaction and Survival of Shortfin Mako Sharks	Byrne M.

Appendix 4

SCRS Document Abstracts

SCRS/2017/108 – Standardized catches per unit of effort (in number and weight) were obtained for the shortfin mako (*Isurus oxyrinchus*) using General Linear Modeling procedures based on trip data from the Spanish surface longline fleet targeting swordfish in the North and South Atlantic Ocean over the period 1990-2015. A base case and two GLM sensitivity analyses were carried out including a MIXED procedure. Area was identified to be the most relevant factor in explaining CPUE variability in all cases. The base case models explained between 40-46% of CPUE variability. The comparison of the standardized CPUEs obtained from the base case and the two sensitivity models show a very similar and stable general trend over time regardless of the model used for the North Atlantic stock. The base case and sensitivity analysis using a mixed model also show very similar trends over time in the case of the South Atlantic stock. All scenarios tested suggest overall stable CPUE trends or a slightly increase trend, in the North and South Atlantic stocks, respectively, during the 26-year period analyzed.

SCRS/2017/110 – The reconstruction of shark catch time series is particularly important for stock assessments, as the nominal catch data on sharks is usually very limited and a major source of uncertainty. This document provides an alternative hypothesis for the reconstruction of shark catches in the Atlantic (ICCAT fisheries) based on a method developed for the EUPOA-Sharks (EU Plan of Action for Sharks). The estimation method is based on ratios of sharks:main species catches, obtained from observer programs, literature revision and/or personnel communications. In this paper we present the average estimations by fleet/métier for the Atlantic (2000-2015) as well as time series for 1971-2015. A specific estimation for shortfin mako by stock is also presented. In this specific case, the main differences in the declared vs. estimated catches are more relevant in the earlier years of the series, which is consistent with more underreporting and lack of species specific information in the earlier years. These time series (North and South stocks) can be considered for use as alternative catch histories in the 2017 ICCAT SMA stock assessment.

SCRS/2017/111 – The shortfin mako, *Isurus oxyrinchus* (Lamnidae), is regularly caught as bycatch in pelagic longline fisheries and is among the most vulnerable sharks to this fishery. The age and growth of *I. oxyrinchus* was studied along a wide North Atlantic region. Data from 375 specimens ranging in size from 57 to 366 cm fork length (FL) for females and 52 to 279 cm FL for males were analysed. Growth models were fitted using the von Bertalanffy growth equation re-parameterised to calculate L0, instead of t0, and a modification of this equation using the known size at birth. Growth models were compared using the Akaike information criterion (AIC) and Bayesian Information Criterion (BIC). The von Bertalanffy growth equation with fixed L0 (size at birth = 63 cm FL) seemed to adequately model growth in this species, with resulting growth parameters of Linf = 241.8 cm FL, k = 0.136 year-1 for males and Linf = 350.3 cm FL, k = 0.064 year-1 for females. This study adds to knowledge of the vital life-history parameters of shortfin mako in the Atlantic Ocean, which can be used in future stock assessments for producing scientific advice to promote the management and conservation of this species.

SCRS/2017/125 – Stock Synthesis model runs were conducted for the North Atlantic shortfin mako shark based on the available catch, CPUE, length composition, and life history data compiled by the Shark Working Group. A sex-specific model was implemented in order to allow for observed differences in growth between sexes. Beverton-Holt stock-recruitment was assumed. The steepness of the stock recruitment relationship and natural mortality at age were fixed at independently estimated values. A two-stage data weighting approach was implemented to iteratively tune (re-weight) variance adjustment factors for fleet-specific relative abundance indices (CPUE) externally to the model (Stage 1) and fleet-specific size data distributions (length composition) within the Stock Synthesis model (Stage 2). Ending year (2015) stock status relative to maximum sustainable yield (MSY) reference points obtained from the final SS3 model run following the two stage data weighting approach indicated that the fishing mortality rate in 2015 was above the fishing mortality rate at maximum sustainable yield (F_2015/F_MSY = 3.7) and that F_2015/F_MSY first exceeded 1.0 in 1985. The final SS3 model run also indicated that spawning stock size in 2015, calculated here as spawning stock fecundity (SSF, 1,000s), was very close to being below the spawning stock size at MSY (SSF_2015/SSF_MSY = 1.005).

SCRS/2017/126 – Maximum population growth rates and steepness values of the Beverton-Holt stock-recruitment relationship were computed for North and South Atlantic stocks of shortfin mako (*Isurus oxyrinchus*) based on the biological information provided at the 2017 Shortfin Mako Data Preparatory meeting and soon thereafter. I used a dual life table/Leslie matrix approach to obtain estimates of productivity (r_{max}), net reproductive rate (R_0), generation time (μ_1), and derived steepness analytically. To encompass a plausible range of biological values, I considered parameters from the von Bertalanffy growth function obtained in a recently completed study by the Shark Species Group and those from a previous study for the North Atlantic, and from two published studies for the South Atlantic. I also considered a female size vs. litter size relationship or constant fecundity. Finally, natural mortality at age was obtained from the minimum of five estimates obtained through different life history invariant methods to approximate a maximum population growth rate. Estimated productivity ranged from r_{max}=0.031 to 0.060 yr^{-1} for the North Atlantic stock and from r_{max}=0.066 to 0.123 yr^{-1} for the South Atlantic stock. Analytically derived values of steepness corresponding to these productivities ranged from h=0.34 to 0.52 for the North Atlantic stock and h=0.44 to 0.72 for the South Atlantic stock. These estimates can be used to formulate informative priors of r_{max} and h in production and age-structured stock assessment models, respectively.

SCRS/2017/129 – Here we examine the verified landings of shortfin mako and blue sharks made by 21 individual European longline fishing vessels in 2008. Catches of shortfin mako typically comprise 3–13% of blue shark catches in the same longline or gill-net fishery, hence large deviations from this ratio may represent overreporting of mako landings that can affect scientific stock assessments. For the 21 vessels operating in the North Atlantic in 2008 the catches of shortfin mako were between 27.8 and 6481 % of blue shark catches. The average of mako was 725 % (± 1611.2 S.D.) of blue shark catches. Considering only 9 vessels for which the percentage was less than 100, the catches of mako were on average 48.6 % (± 18.9 S.D.) of blue shark catches. Although some discarding of blues may have affected the higher percentage makos observed, it seems likely that the majority of blue shark catches were retained and implies that the excess 'mako' could have been a regulated species such as swordfish. The scale of this problem prior to 2013 may already have affected data used in assessing shortfin mako populations in the Atlantic.

SCRS/2017/130 – Here we examine highly-spatially resolved catch records of individual shortfin mako detailed in personal logbooks from two longline-vessel captains over a 16 year period. Logbooks comprised data recording time, location (latitude/longitude), water temperature, gear type and setting practice (exact hook number, type, depth) and numbers of sharks and total biomass per species captured on each longline set. Results show median fishing trip duration increased from 29 days pre-2005 to 37 post-2005, with fishing areas expanded spatially by as much as 5º further west and between 2o and 20º further south from pre- to post-2005, together with a general shift in density distribution of sets. The expansion overlapped key areas of shark habitat use not previously exploited by those vessels, resulting in CPUE and biomass of shortfin mako being generally higher at the expanding edges of the core fishing areas post-2005. Whether fishing patterns responded to lower biomass of shortfin mako being available within higher use shark habitat remains an open question, but our results argue for detailed spatially-referenced catch data to be analysed in relation to new telemetry of oceanic shark space-use and fishing vessel movements to obtain a greater understanding of how CPUE varies through time.

SCRS/2017/132 – This document paper presents the short review of low-fecundity spawner-recruitment relationship (LFSR) to give a motivation of the implementation of the LFSR in the stock synthesis model. The parameter values of the LFSR are also computed using the preliminary value of the steepness for shortfin mako in the North Atlantic.

SCRS/2017/135 – We present results of two alternative stock assessment modeling frameworks applied to the North Atlantic (NA) and South Atlantic (SA) shortfin mako shark catch and CPUE data series. First we applied a Bayesian State-Space Surplus Production Model (Just Another Bayesian Biomass Assessment: JABBA), which estimates process variance and additional observation variance simultaneously and was fitted to primary catch time series and all provided standardized CPUE time series for the NA and SA. Based on the JABBA base-case fits, the MSY estimate for North Atlantic base-case was 1134.1 metric tons (479.9 – 3324.5 95% C.I.) and at 1130.5 metric tons (325.3 – 2274.1 95% C.I.) for the South Atlantic. Stock status trajectory of over time showed a typical anti-clockwise pattern for the NA shortfin mako shark stock status moving from underexploited through a period of unsustainable fishing, leading to a 99% posterior probability of being over-exploited in 2015. In contrast, the South Atlantic stock reveals a clockwise pattern moving from an underexploited state to a recovery as result of decreasing biomass under sustainable fishing, which is followed by a short period of overfishing. For the SA shortfin mako shark population, the resulting stock status posterior for 2015 therefore appears somewhat implausible and ambiguous. Model diagnostics in for evaluating forecasting, retrospective patterns and sensitivity to dropping on CPUE series at a time (jackknife) indicated overall good performance for the NA stock, but highlighted that stock biomass estimates must be treated with extreme caution. This was further corroborated by the good match between the catch-only method CMSY for NA, but strong discrepancies between CMSY and fitted models for SA. The latter can be attributed to the apparent contradiction between the observation process (i.e. CPUE) and process equation, which is informed by the catch and resilience (r) information.

Appendix 5

Additional results using the Visual BASIC Bayesian Surplus Production Software (BSP1 and BSP2), and the equivalent in JAGS (BSP2-JAGS)

This appendix presents results of the BSP1, BSP2 and BSP2-JAGS runs that were discussed at the assessment meeting, but not included in the main text. This includes the detailed results of BSP1 and BSP2 continuity runs, as well as some sensitivity analyses done with BSP2-JAGS.

The continuity runs using the BSP1 VisualBASIC model were set up using the same catch data and indices as all the other BSP models (Section 3.1). We ran three models for the North Atlantic (**Table Appendix 1a**) and three models for the South Atlantic (**Table Appendix 1b**) using data through 2015. For the North and the South the first run (na1, sa1) was the C1 catch starting in 1950 and 1971 respectively. Both second runs (na2, sa2) used the C2 catch series both starting in 1971. The final run (na3, sa3) applied a generalized production model and the alternative catch series both starting in 1971. Runs na2 and sa1 are continuity runs for comparison to the 2012 assessment methods. All BSP1 models were able to converge adequately, with percent maximum weight less than 0.5% and similar values of the log(weights) and log(likelihood*priors). However, without process error they were not able to fit the zigzag pattern in the CPUE series in the North Atlantic (**Figure Appendix 1**), or the increasing trend in the South Atlantic (**Figure Appendix 2**). All BSP1 results had high K values and were fairly optimistic (**Table Appendix 2, Table Appendix 3, Figure Appendix 3, Figure Appendix 4, Figure Appendix 5**).

Although the BSP2 VisualBASIC model with process error (BSP2) was able to estimate the mode of the posterior distribution, the SIR algorithm did not converge on the posterior distribution. For the North Atlantic, the authors were able to estimate the mode of the posterior distribution, and the fit at the mode (**Figure Appendix 6**) was similar to the fits from the BSP2-JAGS models with the same data (**Figure Appendix 7**).

Additional sensitivity analyses of the BSP1, BSP2 and BSP2-JAGS models were presented using slightly different priors and weighting methods, with the same catch and CPUE data through 2015. These models were presented at the beginning of the meeting, and they have different priors than the runs used for the assessment. The models were used in part to explore the differences between BSP VisualBASIC and BSP2-JAGS implementations (Babcock and Cortés (in press)). They were based on the runs conducted during the 2012, except where noted (**Table Appendix 4**). While the starting year was 1971 for the North Atlantic in the 2012 assessment, these runs used the first year of the catch series, which was 1950. The indices used in the north Atlantic were US-Log, JPLL-N, POR-LL-N, ESP-LL-N, and CH-TA-LLN. In a sensitivity run, the US-Obs series was also included. Catches were either the catches from the data preparatory meeting (C1), or the alternative catch scenario based on ratios (C2). In the north, the C1 catches were used for 1950 to 1970 in the C1 catch scenario. In one run, catches from 1950 to 1996 were predicted from effort using an estimated constant of proportionality. For the south Atlantic, the indices were UR-LL-Log, JPLL-S, BR-L, UR-LL-Obs, ESP-LL-S, and CH-TA-LLS.

For both the North and the South, a lognormal informative prior was used for r, in which the mean of r was set to the mean of the newly calculated values of r from several different methods life history methods. The log-standard deviation of r was the same as the 2012 assessment (log-sd=0.12). The means were 0.046 for the north and 0.073 for the south (corresponding to log-means of -3.09 in the north and -2.62 in the south). In one sensitivity analysis the log-sd of r was doubled. The other priors were the same as in 2012. The starting biomass relative to K was lognormal with a mean of one and log-standard deviation of 0.2, bounded between 0.2 and 1.1. K was uniform on log-K, bounded between 0.01 and 5,000,000. In the BSP1 and BSP2 runs, q was estimated using the MLE shortcut. For the BSP2-JAGS runs, for each series was estimated with a uniform prior between 1.0E-10 and 10. In most model runs, the error standard deviation was assumed to be the same for all points and was estimated with a uniform prior between 0.01 and 10. In the "catch weighting" runs, the error standard deviation in each data point was estimated from the proportion of catch in each year in each series. In the BSP2 runs, it is not possible to estimate the error standard deviation, so error standard deviation was set equal to a value slightly larger than the mean MLE sigma (0.4 in the north, and 0.45 in the south). Process error was zero in all the BSP1 runs, and fixed at either log-sd=0.05 or log-sd=0.005 in BSP2 and BSP2-JAGS. We also conducted post-model pre-data runs to evaluate the impact of the priors on the posterior distribution. These runs included only a single CPUE data point so that the results are driven entirely by the priors and the catch time series.

In the north Atlantic, the BSP1 alternative models were all able to converge adequately, with percent maximum weight less than 0.5% and similar values of the log(weights) and log(likelihood*priors). For the BSP2 runs, none of the importance functions produced good convergence; the final percent maximum weight was 1.97% for run n5, above the target of 0.5%. The BSP1 and BSP2 models generally produced fits that were quite optimistic, with biomass above B_{MSY} and F below F_{MSY} (**Table Appendix 5**, **Figure Appendix 5**, **Figure Appendix 8, Figure Appendix 9**). The BS2-JAGS alternative models for the north Atlantic also suffered from convergence problems, but generally had Gelman Rubin diagnostics less than 1.05 (**Table Appendix 6**). Like the BSP runs, the BSP2-JAGS runs returned values of r that were very similar to the priors. However, the BSP2-JAGS runs produced lower estimate of K, and were generally more pessimistic (**Table Appendix 6, Figure Appendix 10, Figure Appendix 11**). Process error improved the model fits.

For the south Atlantic, the BSP1 alternative models converged adequately, but the BSP2 model did not. The percent maximum weight was13.5% for run s2, above the target of 0.5%. The BSP2-JAGS runs all converged adequately. All models produced posterior distributions that were similar to the priors for r. However, the BSP2-JAGS models estimated higher values of K, so that they were more optimistic than the BSP2-JAGS models (**Table Appendix 7, Table Appendix 8, Figure Appendix 12, Figure Appendix 13**). The BSP2-JAGS runs estimated an increasing trend during the years with CPUE data (**Figure Appendix 14**).

Finally, **Figure Appendix 15** shows the Kobe plot for the main assessment model results described in section 3.1 for the South Atlantic.

Table Appendix 1. Inputs for the BSP1 and BSP2 continuity runs.

(a) North BSP1

Run	*Weighting*	*Catch*	*Catch start date*	*B0/K prior*	*r prior*	*Name*	*Shape*
na1	equal	C1	1950	lnorm(1)	lnorm(log(0.0254), 0.434)	N 1950	n=2
na2	equal	alt	1971	lnorm (.85)	lnorm(log(0.0254), 0.434)	N continuity	n=2
na3	equal	alt	1971	lnorm(.85)	lnorm(log(0.0254), 0.434)	N 1971 gen	n=5

b) South BSP1

Run	*Weighting*	*Catch*	*Catch start date*	*B0/K prior*	*r prior*	*Name*	*Shape*
sa1	equal	C1	1971	lnorm	lnorm(log(0.052), 0.275)	S continuity	n=2
sa2	equal	alt	1971	lnorm	lnorm(log(0.052), 0.275)	S alt cat	n=2
sa3	equal	alt	1971	lnorm	lnorm(log(0.052), 0.275)	S alt cat gen	n=5

(c) North BSP2

Run	*Area*	*Weighting*	*Catch*	*Process error*	*Catch start date*	*B0/K prior*	*r prior*	*Name*	*Shape*
na4	North	input CV	C1	0.05	1950	lnorm(1)	lnorm(log(0.0254), 0.434)	N 1950	n=2
na5	North	input CV	alt	0.05	1971	lnorm (.85)	lnorm(log(0.0254), 0.434)	N continuity	n=2
na6	North	input CV	alt	0.05	1950	lnorm(.85)	lnorm(log(0.0254), 0.434)	N 1971 gen	n=5

(d) South BSP2

Run	*Area*	*Weighting*	*Catch*	*Process error*	*Catch start date*	*B0/K prior*	*r prior*	*Name*	*Shape*
sa4	South	input CV	C1	0.05	1971	lnorm	lnorm(log(0.052), 0.275)	S continuity	n=2
sa5	South	input CV	alt	0.05	1971	lnorm	lnorm(log(0.052), 0.275)	S alt cat	n=2
sa6	South	input CV	alt	0.05	1971	lnorm	lnorm(log(0.052), 0.275)	S alt cat gen	n=5

Table Appendix 2. Expected values (CVs) of estimated parameters for the BSP1 continuity model runs for North Atlantic mako sharks.

Variable	*mako17Na1*	*mako17Na2*	*mako17Na3*
K (1000)	1755.63(0.70)	1967.08(0.6)	1670.76(0.76)
r	0.03(0.46)	0.03(0.5)	0.03(0.48)
MSY (1000)	10.98(0.88)	11.93(0.8)	22.95(0.97)
Bcur (1000)	1620.98(0.74)	1713.97(0.7)	1595.70(0.79)
Binit (1000)	1603.58(0.71)	1663.14(0.7)	1451.19(0.78)
Bcur/Binit	0.99(0.12)	1.01(0.1)	1.09(0.14)
Ccur/MSY	0.55(0.83)	0.61(0.8)	0.39(0.85)
Bcur/Bmsy	1.77(0.09)	1.67(0.1)	1.38(0.09)
Fcur/Fmsy	0.34(0.99)	0.40(0.9)	0.31(1.03)

Table Appendix 3. Expected values (CVs) of estimated parameters for the BSP1 model continuity runs for South Atlantic mako sharks.

Variable	*mako17Sa1*	*mako17Sa2*	*mako17Sa3*
K (1000)	2547.55(0.50)	2473.56(0.52)	1842.71(0.72)
r	0.06(0.21)	0.06(0.21)	0.04(0.18)
MSY (1000)	35.02(0.54)	34.24(0.56)	37.99(0.72)
Bcur (1000)	2317.55(0.51)	2243.62(0.53)	1792.91(0.73)
Binit (1000)	1360.17(0.55)	1318.90(0.57)	711.75(0.77)
Bcur/Binit	1.75(0.19)	1.75(0.19)	2.60(0.19)
Ccur/MSY	0.11(0.79)	0.11(0.78)	0.13(0.91)
Bcur/Bmsy	1.81(0.05)	1.80(0.05)	1.44(0.03)
Fcur/Fmsy	0.06(0.85)	0.06(0.86)	0.09(0.97)

Table Appendix 4. Inputs for the BSP and BSP2-JAGS sensitivity runs using alternative priors.

(a) North Atlantic

Run	*Weighting*	*Catch*	*Indices*	*Est Cat*	*Proc. error*	*Software*	*Cat start date*	*B0/K prior*	*r prior*	*Name*
n1	equal, estimated	C1	base	no	0	BSP	1950	lnorm (mean 1, CV 0.2)	lnorm, mean 0.046	N equal wt
n2	equal, estimated	C1	base	effort	0	BSP	1997	uniform (0.2, 1.1)	lnorm,mean 0.046	N effort fit
n3	catch wt	C1	base	no	0	BSP	1950	lnorm	lnorm,mean 0.046	N catch wt
n4	equal, estimated	C1	base	no	0	BSP	1950	lnorm	lnorm,mean 0.046, double sd	N double r sd
n1pmpd	NA	C1	NA	no	0	BSP	1950	lnorm	lnorm,mean 0.046	N pmpd
n5	equal, estimated	C1	base	no	0.05	BSP2	1950	lnorm	lnorm,mean 0.046	N process error
n6	by series	C1	base	no	0	BSP	1950	lnorm	lnorm,mean 0.046	N series wt
n7	equal, estimated	C2	base	no	0	BSP	1950	lnorm	lnorm,mean 0.046	N alt catch
n8	equal, estimated	C1	base+US obs	no	0	BSP	1950	lnorm	lnorm,mean 0.046	N alt index
jn1	equal, estimated	C1	base	no	0.005	JAGS	1950	lnorm	lnorm,mean 0.046	N equal wt
jn2	equal, estimated	C1	base	effort	0.005	JAGS	1997	uniform	lnorm,mean 0.046	N effort fit
jn3	catch wt	C1	base	no	0.005	JAGS	1950	lnorm	lnorm,mean 0.046	N catch wt
jn4	equal, estimated	C1	base	no	0.005	JAGS	1950	lnorm	lnorm,mean 0.046, double sd	N double r sd
n1pmpd	NA	C1	NA	no	0.005	JAGS	1950	lnorm	lnorm,mean 0.046	N pmpd
jn5	equal, estimated	C1	base	no	0.05	JAGS	1950	lnorm	lnorm,mean 0.046	N process error
jn6	by series	C1	base	no	0.005	JAGS	1950	lnorm	lnorm,mean 0.046	N series wt
jn7	equal, estimated	C2	base	no	0.005	JAGS	1950	lnorm	lnorm,mean 0.046	N alt catch
jn8	equal, estimated	C1	base+US obs	no	0.005	JAGS	1950	lnorm	lnorm,mean 0.046	N alt index
jn1s1	estimated	C1	1	no	0.005	JAGS	1950	lnorm	lnorm,mean 0.046	N index 1
jn1s2	estimated	C1	2	no	0.005	JAGS	1950	lnorm	lnorm,mean 0.046	N index 2
jn1s3	estimated	C1	3	no	0.005	JAGS	1950	lnorm	lnorm,mean 0.046	N index 3
jn1s4	estimated	C1	4	no	0.005	JAGS	1950	lnorm	lnorm,mean 0.046	N index 4
jn1s5	estimated	C1	5	no	0.005	JAGS	1950	lnorm	lnorm,mean 0.046	N index 5

(b) South Atlantic

Run	*Weighting*	*Catch*	*Indices*	*Est cat*	*Proc. error*	*Software*	*Catch start date*	*B0/K prior*	*r prior*	*Name*
s1	equal, estimated	C1	base	no	0	BSP	1971	lnorm	lnorm, mean 0.073	S equal wt
s2	equal, fixed	C1	base	no	0.05	BSP2	1971	lnorm	lnorm, mean 0.073	S process error
s1pmpd	NA	C1	NA	no	0	BSP	1971	lnorm	lnorm, mean 0.073	S pmpd
js1	equal, estimated	C1	base	no	0.005	JAGS	1971	lnorm	lnorm, mean 0.073	S equal wt
js2	equal, estimated	C1	base	no	0.05	JAGS	1971	lnorm	lnorm, mean 0.073	S process error
js1pmpd	NA	C1	NA	no	0.005	JAGS	1971	lnorm	lnorm, mean 0.073	S pmpd

Table Appendix 5. Expected values (CVs) of estimate parameters for the BSP1 and BSP2 model alternative runs for North Atlantic mako sharks.

Variable	*mako17N1*	*mako17N2*	*mako17N3*	*mako17N4*	*mako17N5*	*mako17N6*	*mako17N7*	*mako17N8*	*mako17N1PMPD*
	equal wt	*effort fit*	*catch wt*	*double r sd*	*process error*	*series wt*	*C2 catch*	*alt index*	
K (1000)	1592.96(0.78)	446.71(1.0)	1395.38(0.9)	1594.17(0.78)	1160.38(0.8)	1088.96(1.0)	1810.40(0.70)	1756.96(0.70)	1245.22(1.0)
r	0.05(0.12)	0.05(0.1)	0.05(0.1)	0.05(0.24)	0.05(0.1)	0.05(0.1)	0.05(0.12)	0.05(0.12)	0.05(0.1)
MSY (1000)	18.20(0.80)	5.20(1.0)	16.04(0.9)	18.16(0.84)	13.54(0.8)	12.54(1.0)	20.68(0.71)	20.11(0.71)	14.32(1.0)
Bcur (1000)	1515.92(0.82)	302.00(1.6)	1316.91(1.0)	1514.94(0.82)	1020.82(0.8)	1013.84(1.1)	1715.90(0.73)	1678.88(0.73)	1165.04(1.1)
Binit (1000)	1455.62(0.80)	294.65(1.5)	1260.14(0.9)	1456.44(0.80)	1058.20(0.8)	1004.30(1.0)	1655.66(0.71)	1596.00(0.71)	1122.33(1.0)
Bcur/Binit	1.02(0.14)	1.04(0.4)	0.97(0.2)	1.02(0.14)	0.91(0.2)	0.95(0.2)	1.02(0.14)	1.04(0.14)	0.90(0.3)
Ccur/MSY	0.34(0.82)	0.78(0.3)	0.50(0.9)	0.35(0.82)	0.53(0.7)	0.53(0.7)	0.36(0.78)	0.28(0.78)	0.70(1.0)
Bcur/Bmsy	1.82(0.08)	1.17(0.3)	1.73(0.2)	1.82(0.08)	1.64(0.2)	1.72(0.1)	1.82(0.08)	1.85(0.06)	1.59(0.3)
Fcur/Fmsy	0.20(0.96)	0.79(0.5)	0.37(1.4)	0.21(0.97)	0.37(0.8)	0.34(0.8)	0.21(0.94)	0.16(0.90)	1.27(4.3)

Table Appendix 6. BSP2-JAGS alternative model expected values and CVs for north Atlantic mako sharks.

Parameter	*1N equal wt*	*2N effort fit*	*3N catch wt*	*4N double r sd*	*5N pmpd*	*6N process error*	*7N series wt*	*8N C2 catch*	*9N alt index*
Rhat	1.01	1.17	1.02	1.04	1.15	1	1.01	1.02	1.02
n.eff	280	15	87	110	24	2100	180	520	110
K(1000)	251.57(0.29)	256.72(0.17)	342.33(0.08)	252.16(0.29)	493.29(1.87)	159.99(0.26)	227.14(0.24)	304.17(0.3)	265.69(0.27)
r	0.05(0.12)	0.05(0.13)	0.05(0.06)	0.05(0.12)	0.05(0.12)	0.05(0.12)	0.05(0.12)	0.05(0.12)	0.05(0.12)
B0/Bmsy	1.75(0.16)	1.82(0.13)	0.41(0.03)	1.79(0.14)	1.82(0.13)	1.81(0.13)	1.81(0.13)	1.77(0.14)	1.77(0.14)
Bcur.Bmsy	1.36(0.12)	0.88(0.24)	1.3(0.04)	1.37(0.12)	0.73(1.12)	1.09(0.21)	1.32(0.11)	1.35(0.13)	1.42(0.1)
HRcur.HRmsy	0.88(0.34)	1.22(0.25)	0.57(0.08)	0.88(0.34)	2441.6(1.23)	1.75(0.32)	0.97(0.29)	0.99(0.37)	0.78(0.32)

Table Appendix 7. Expected values (CVs) of model outputs from BSP1 and BSP2 alternative model runs for the South Atlantic.

Variable	*mako17S1*	*mako17s2*	*mako17S1PMPD*
	equal wt	*process error*	*pmpd*
K (1000)	2416.85(0.53)	1489.99(0.51)	1079.86(1.1)
r	0.07(0.11)	0.07(0.09)	0.07(0.1)
MSY (1000)	42.86(0.54)	26.21(0.47)	19.70(1.2)
Bcur (1000)	2288.62(0.54)	1594.18(0.52)	1039.75(1.2)
Binit (1000)	1238.15(0.58)	922.35(0.60)	976.59(1.2)
Bcur/Binit	1.90(0.20)	1.82(0.13)	0.93(0.3)
Ccur/MSY	0.09(0.82)	0.13(0.47)	0.60(1.2)
Bcur/Bmsy	1.88(0.03)	2.13(0.08)	1.66(0.3)
Fcur/Fmsy	0.05(0.88)	0.06(0.47)	1.05(4.6)

Table Appendix 8. Expected values (CVs) or model outputs from BSP2-JAGS alternative model runs for the South Atlantic.

Parameter	*10S equal wt*	*11S process error*	*12S pmpd*
Rhat	1	1	1.21
n.eff	1400	3600	13
K(1000)	236.69(0.44)	161.93(0.43)	352.39(2.28)
r	0.07(0.11)	0.07(0.11)	0.07(0.12)
B1.K	1.07(0.22)	1.1(0.2)	1.83(0.12)
Bcur.Bmsy	1.58(0.09)	2.04(0.15)	0.7(1.2)
HRcur.HRmsy	0.47(0.47)	0.55(0.43)	4363.62(1.19)

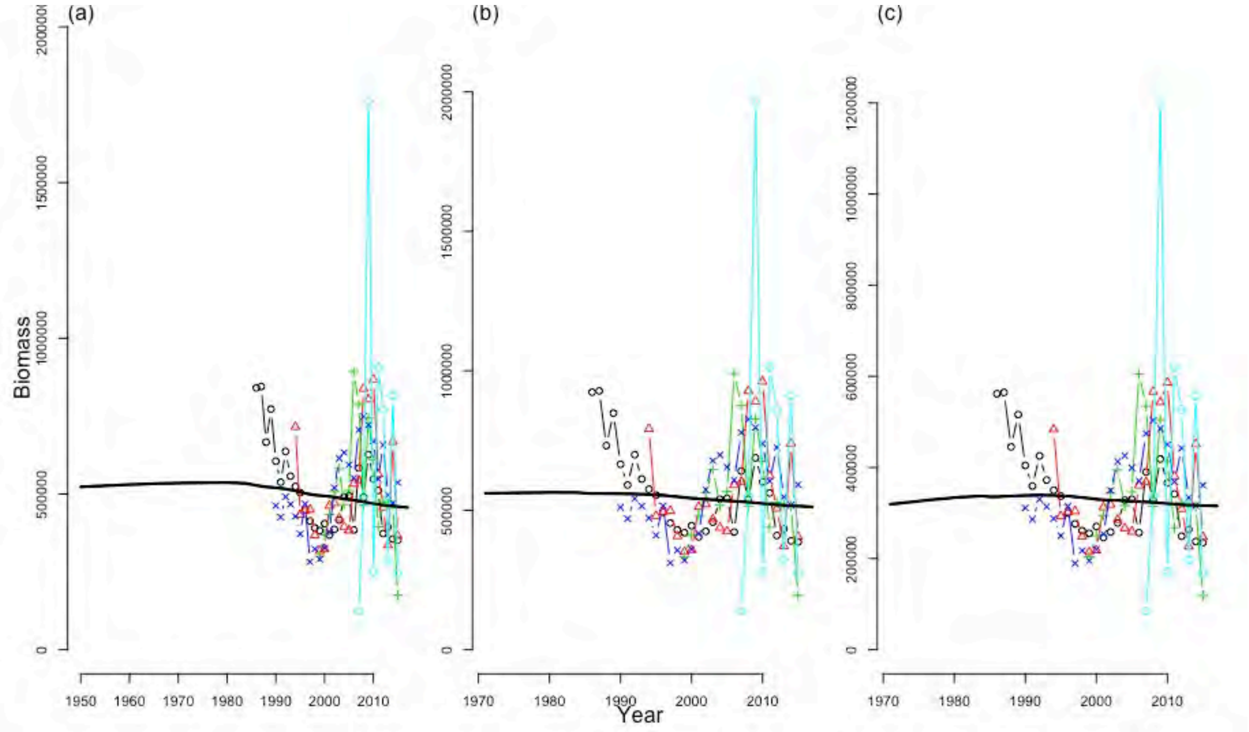

Figure Appendix 1. BSP1 model fits for the North Atlantic, for the runs described in **Table Appendix 1a**.

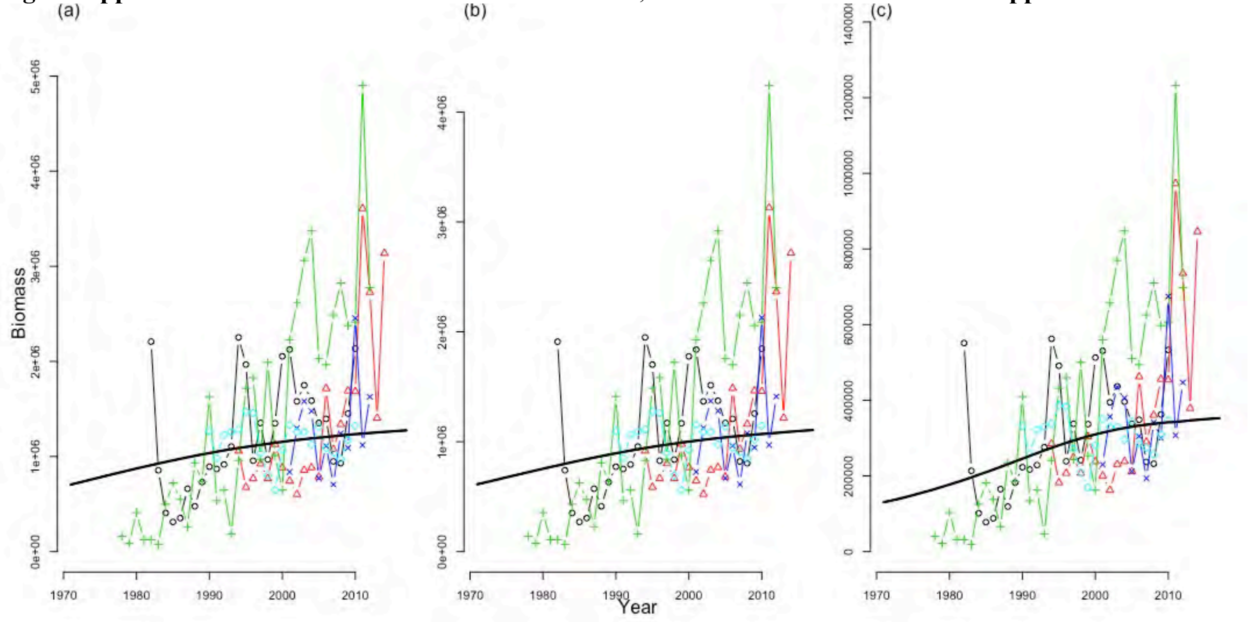

Figure Appendix 2. BSP1 continuity model fits for the South Atlantic for the runs described in **Table Appendix 1b**.

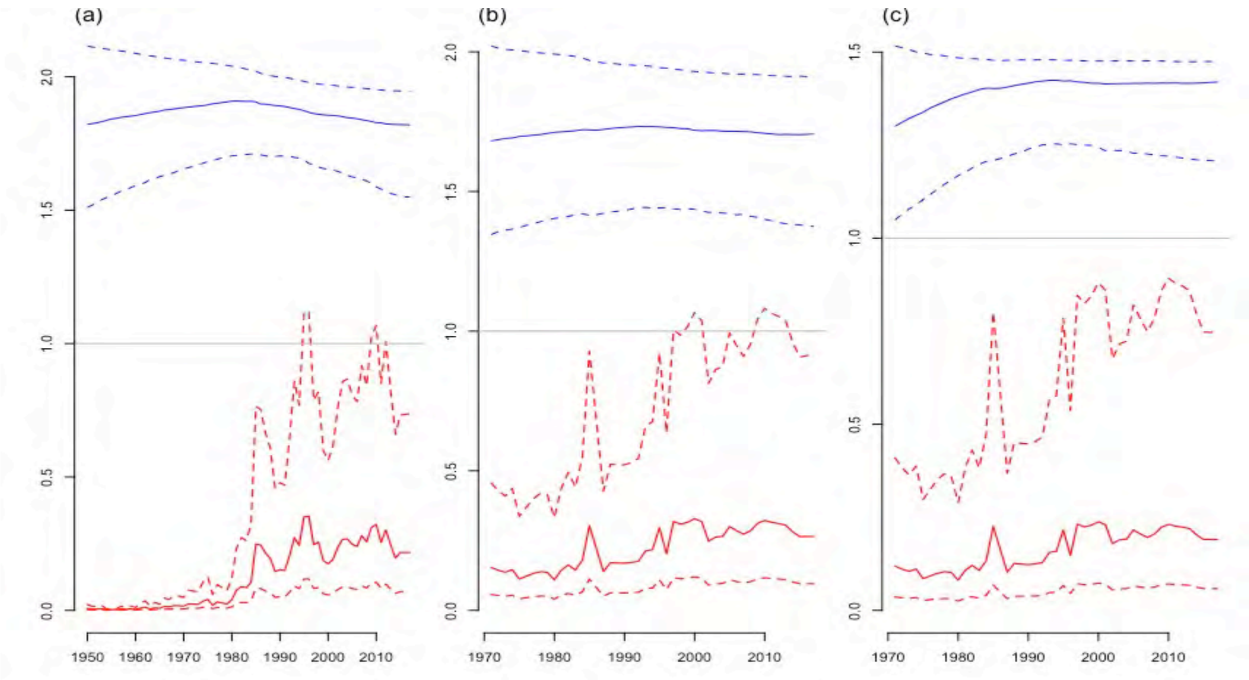

Figure Appendix 3. B/B$_{MSY}$ (blue) and H/H$_{MSY}$ (red) with 80% credible intervals for north Atlantic mako BSP1 continuity runs (a) C1 catch, (b) C2 catch, and (c) generalized model with C1 catch.

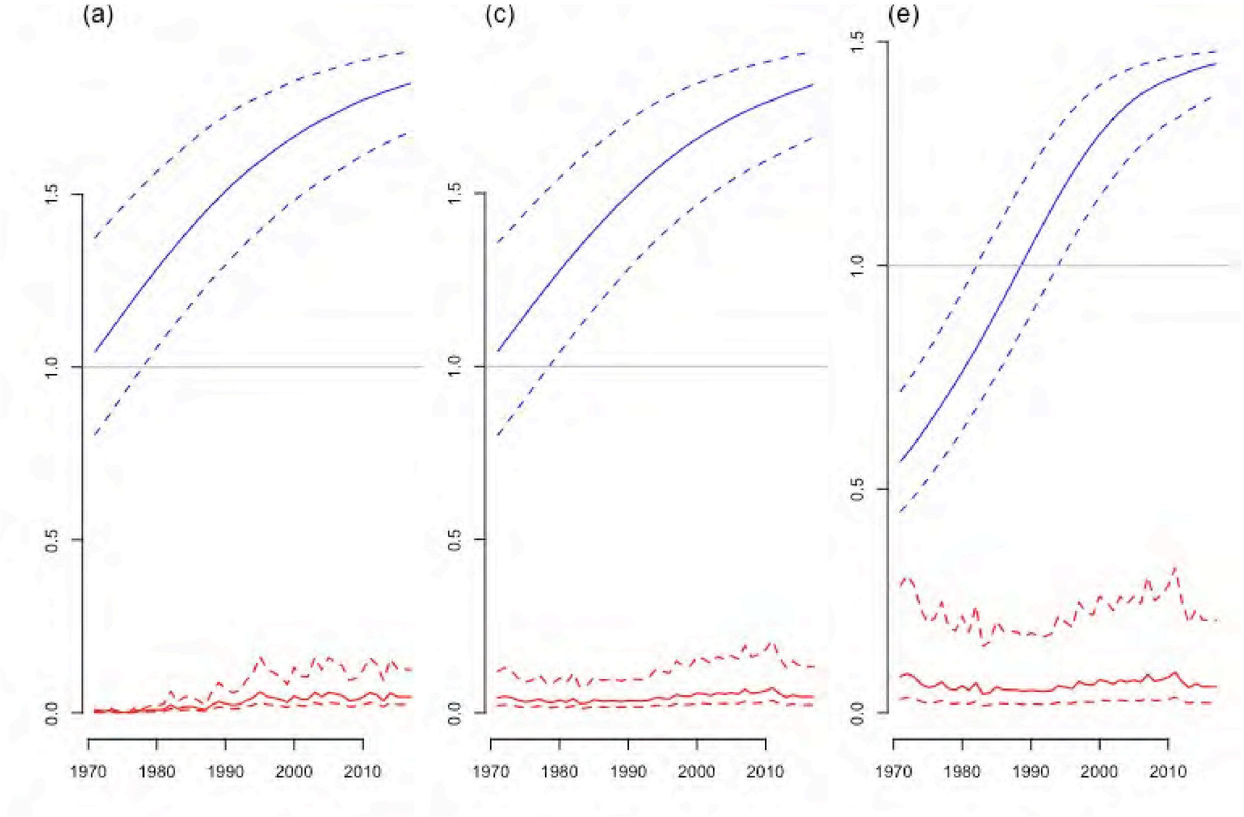

Figure Appendix 4. B/B$_{MSY}$ (blue) and F/F$_{MSY}$ (red) with 80% credible intervals for south Atlantic mako BSP1 continuity runs (a) C1 catch , (b) C2 catch, and (c) generalized model with C1 catch.

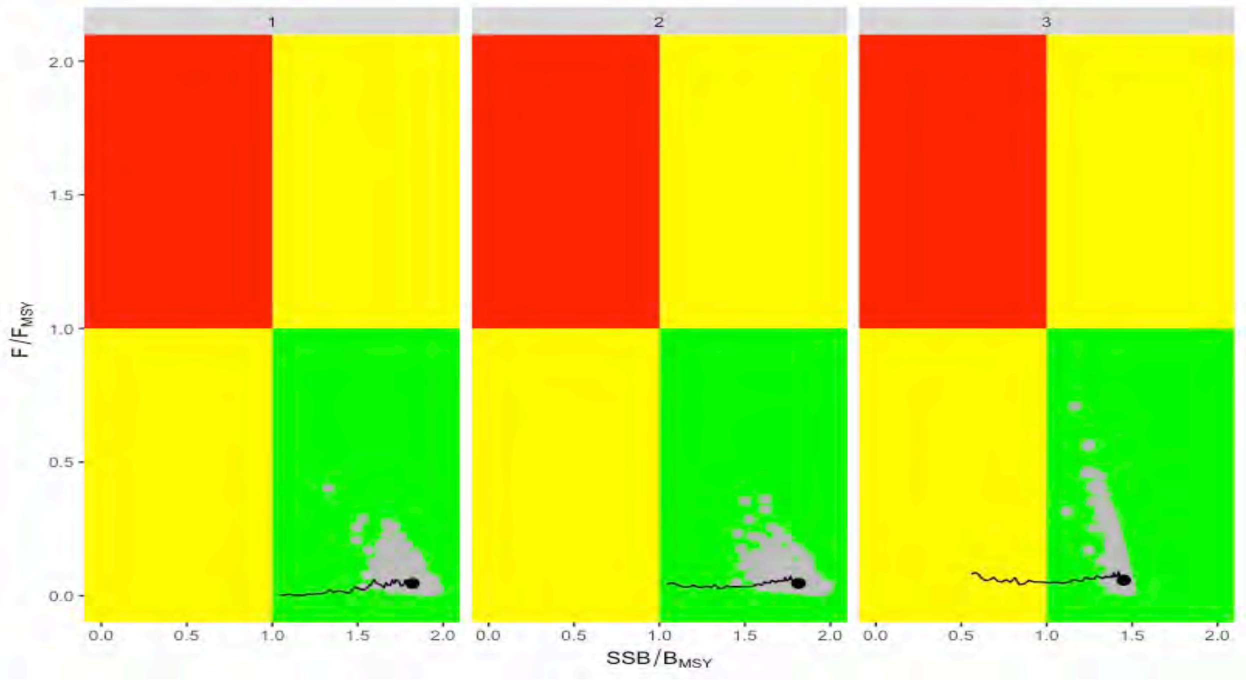

Figure Appendix 5. Kobe plots for south Atlantic mako BSP1 runs (a) C1 catch, (b) C2 catch, (c) generalized model.

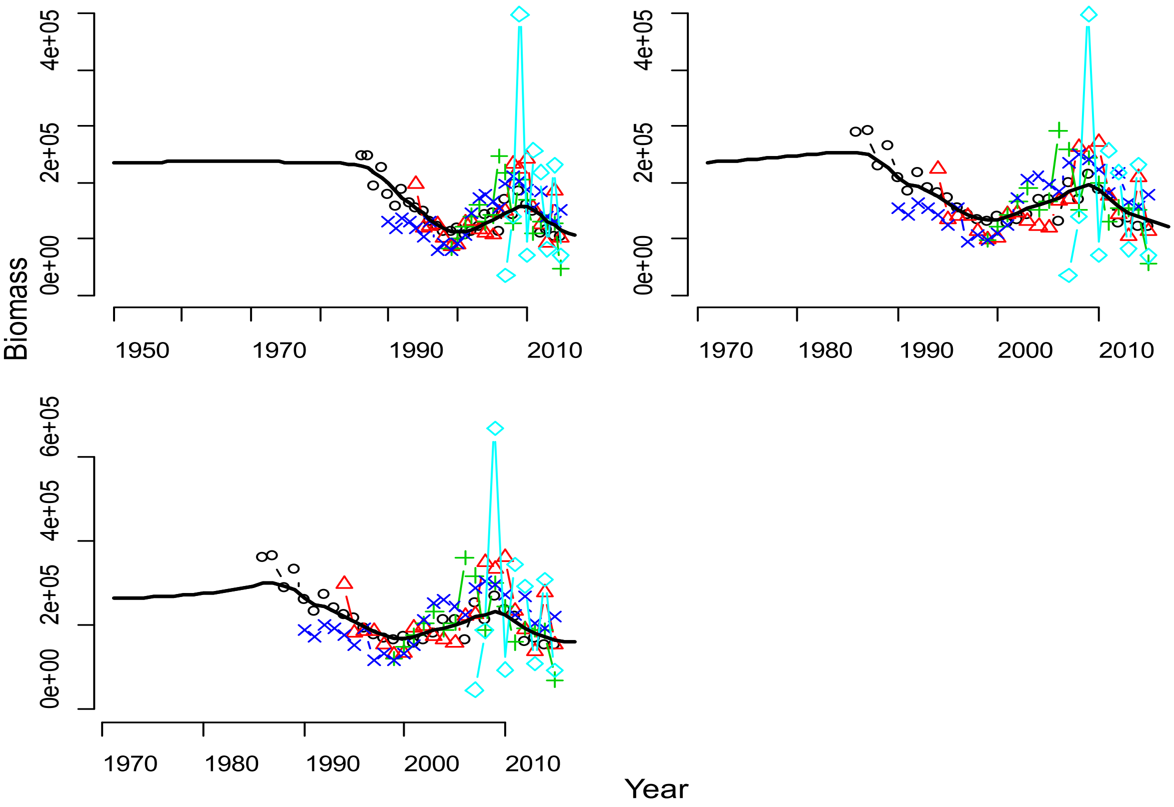

Figure Appendix 6. Mode of the posterior biomass trend for the BSP2 runs in the North Atlantic, with CPUE fits, for (a) C1 catch Schaefer, (b) C2 catch Schaefer, (c) C2 catch generalized production model.

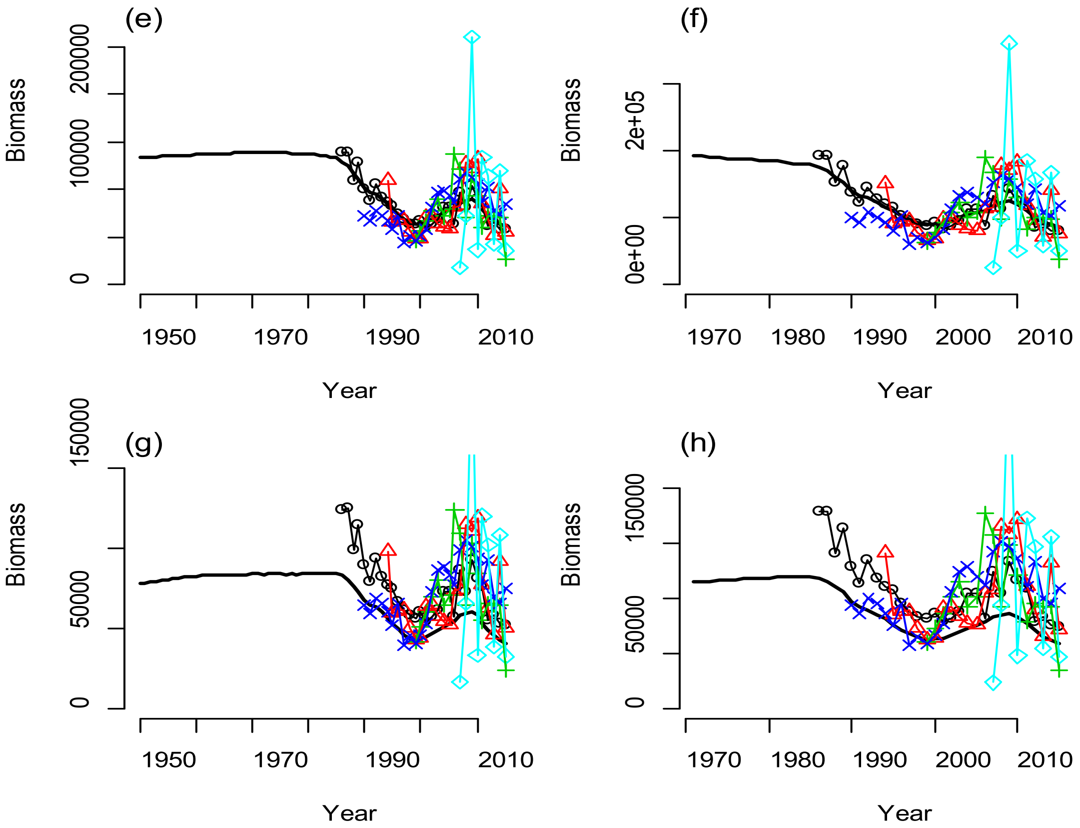

Figure Appendix 7. Median biomass trajectory from the BSP2-JAGS runs described in section 3.1 for the North Atlantic, for (a) the C1 catch Schaefer model, (b) C2 catch Schaefer model, (c) C1 catch generalized production model, and (d) C2 catch generalized production model.

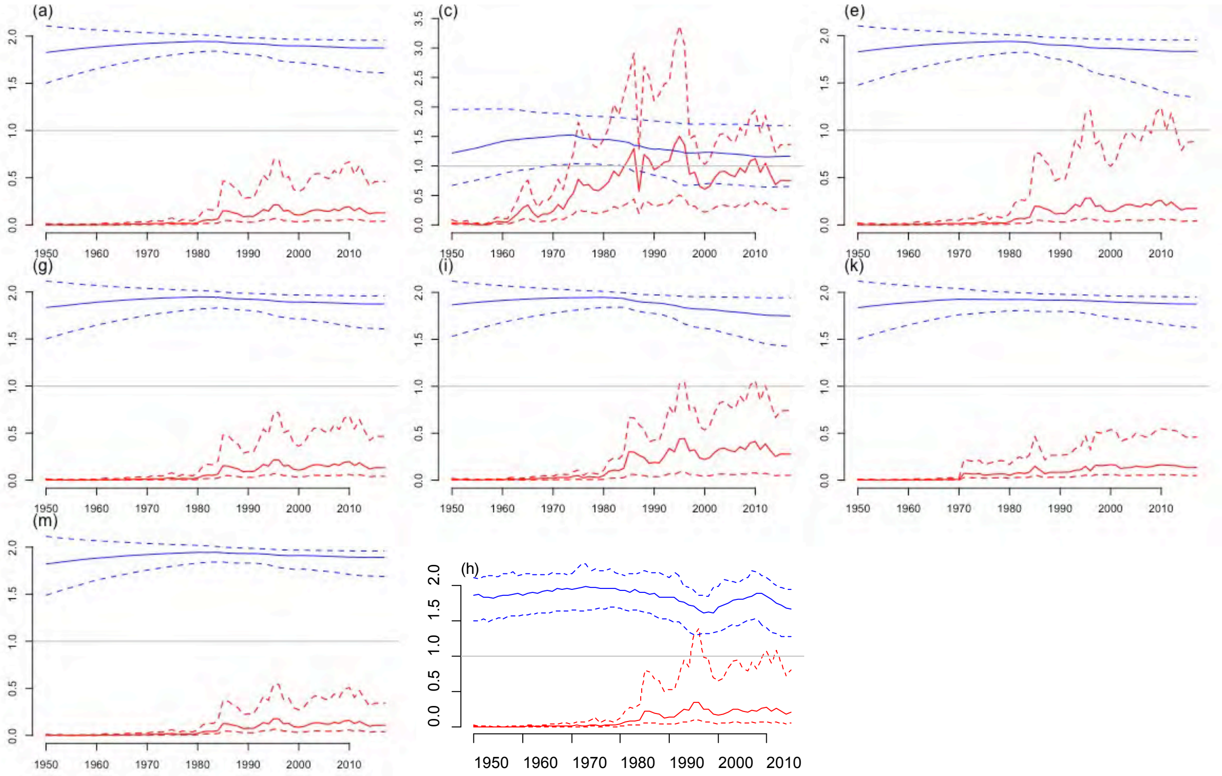

Figure Appendix 8. History of B/B$_{MSY}$ (blue) and H/H$_{MSY}$ (red) with 80% credible intervals for north Atlantic mako BSP1 and BSP2 alternative runs (a) equal weighting, (b) fitted to effort, (c) catch weighting, (d) double r standard deviation, (e) series weighting, (f) catch C2, (g) alternative index, and (h) BSP2 with process error.

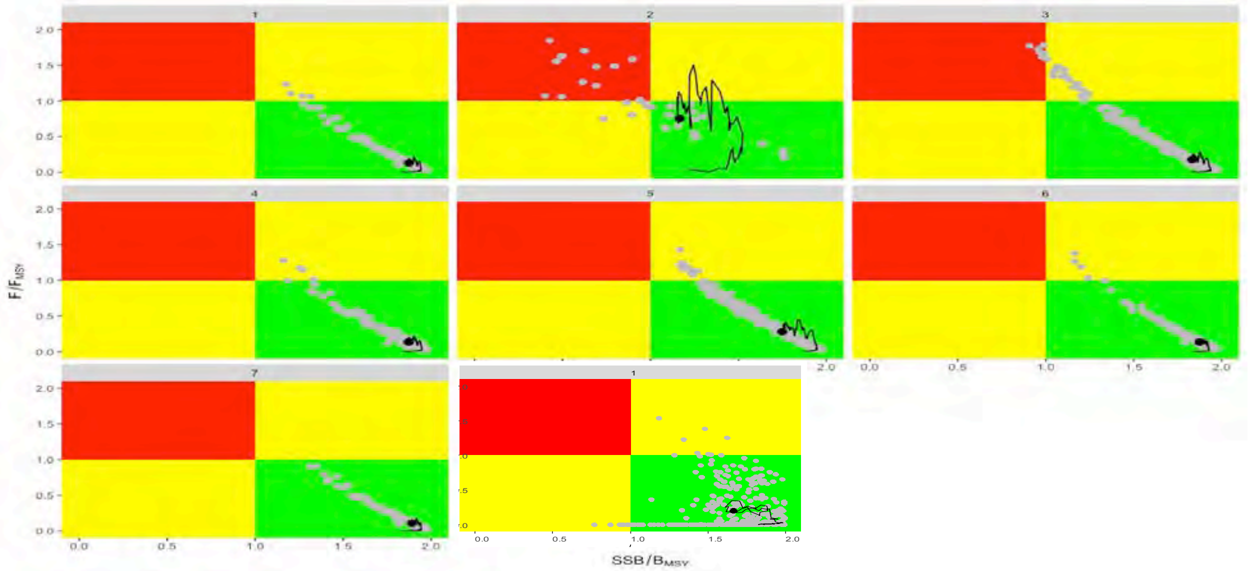

Figure Appendix 9. Kobe plots for north Atlantic mako BSP1 and BSP2 alternative runs (1) equal weighting, (2) fitted to effort, (3) catch weighting, (4) double r standard deviation, (5) series weighting, (6) C2 catch, (7) alternative index, and BSP 2. Current year is 2015.

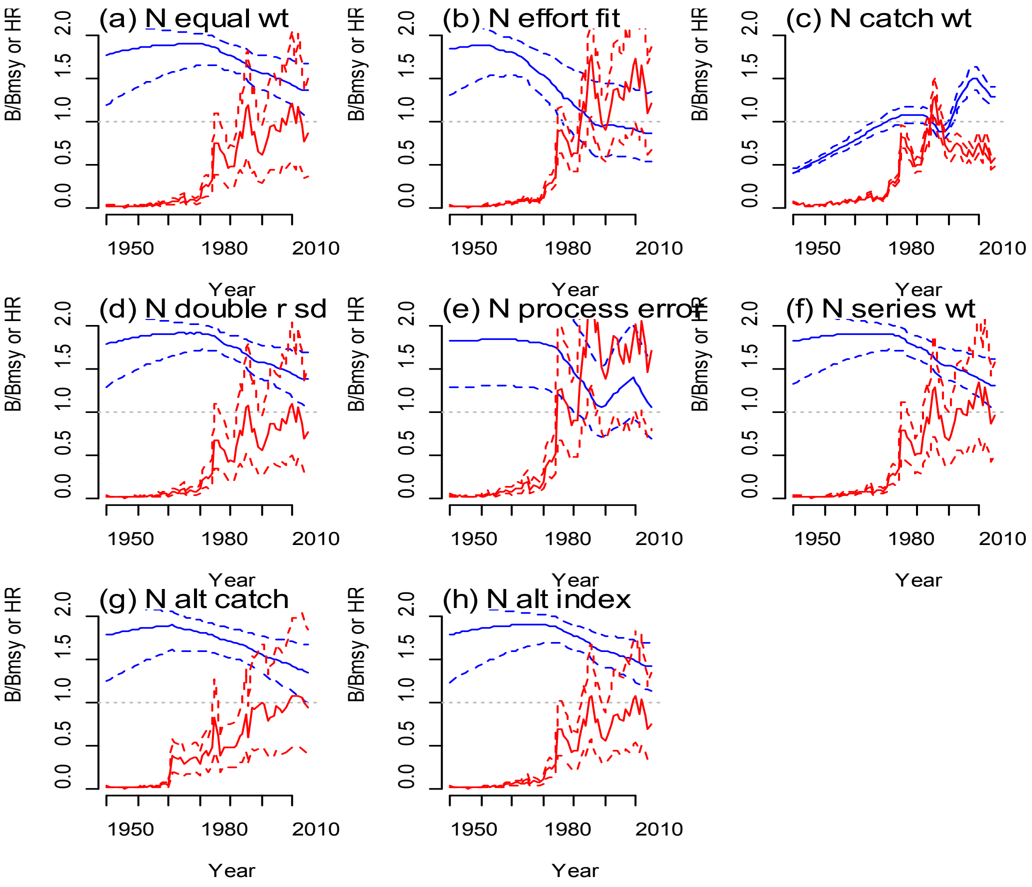

Figure Appendix 10. Biomass and harvest rate trends from BSP2-JAGS alternative models for North Atlantic mako sharks.

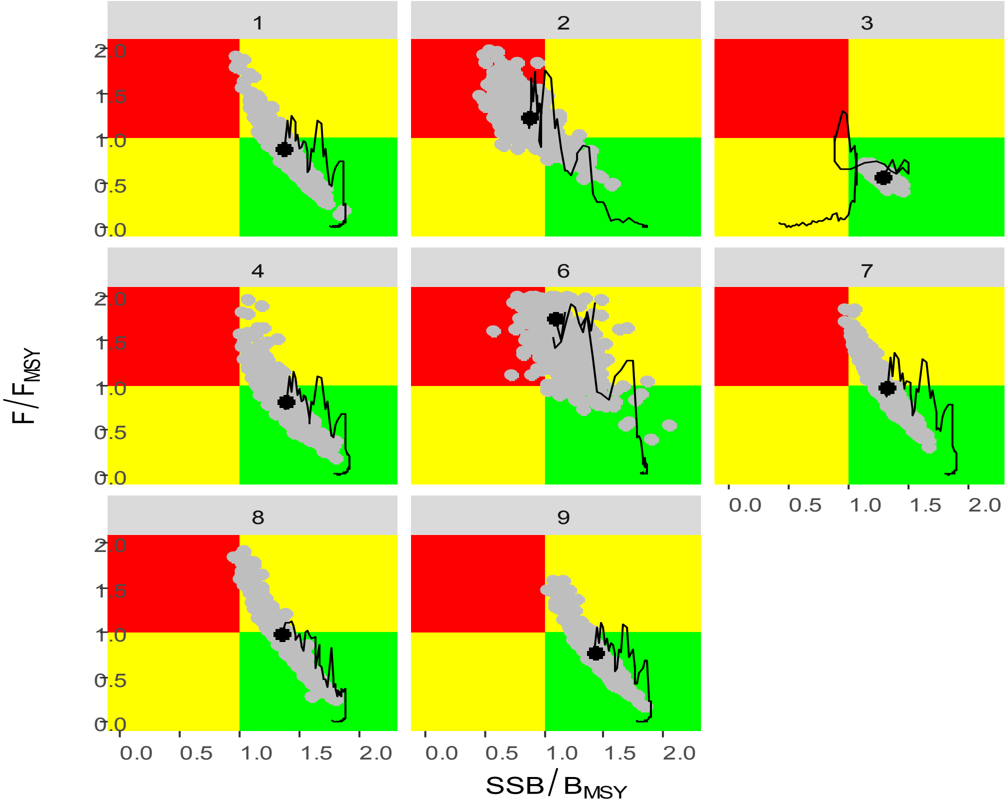

Figure Appendix 11. Kobe plots from BSP2-JAGS alternative models for North Atlantic mako sharks. Current year is 2015 (solid black dot).

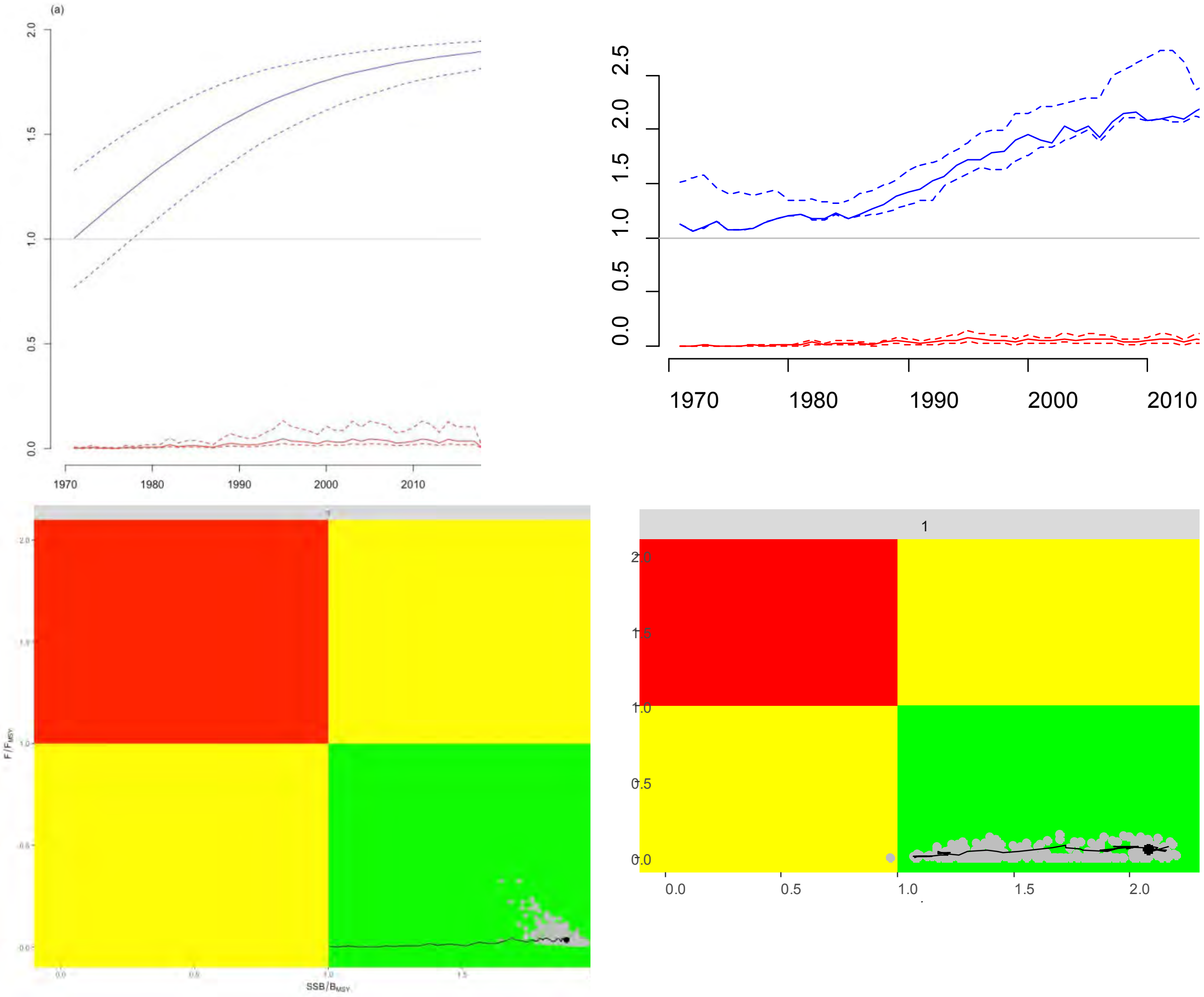

Figure Appendix 12. Biomass and harvest rate trends (top) and Kobe plots (bottom) for South Atlantic mako sharks obtained with the BSP1 (left) and BSP2 (right) results.

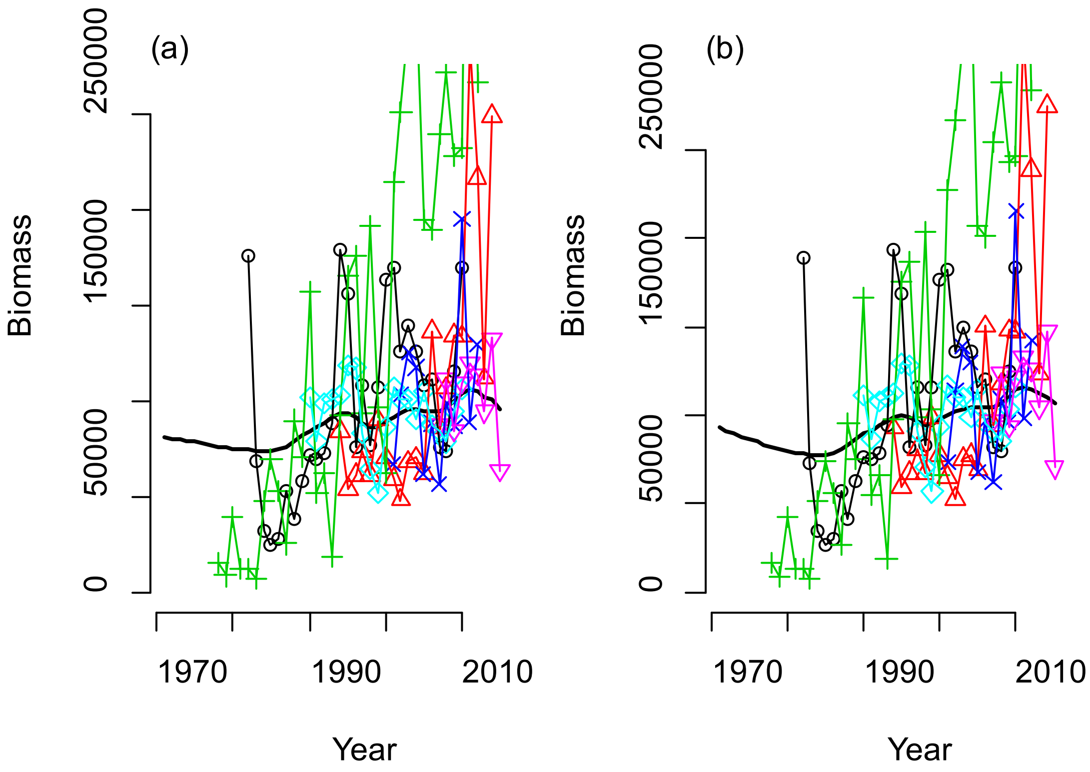

Figure Appendix 13. Median biomass trajectory from the BSP2-JAGS runs for the South Atlantic.

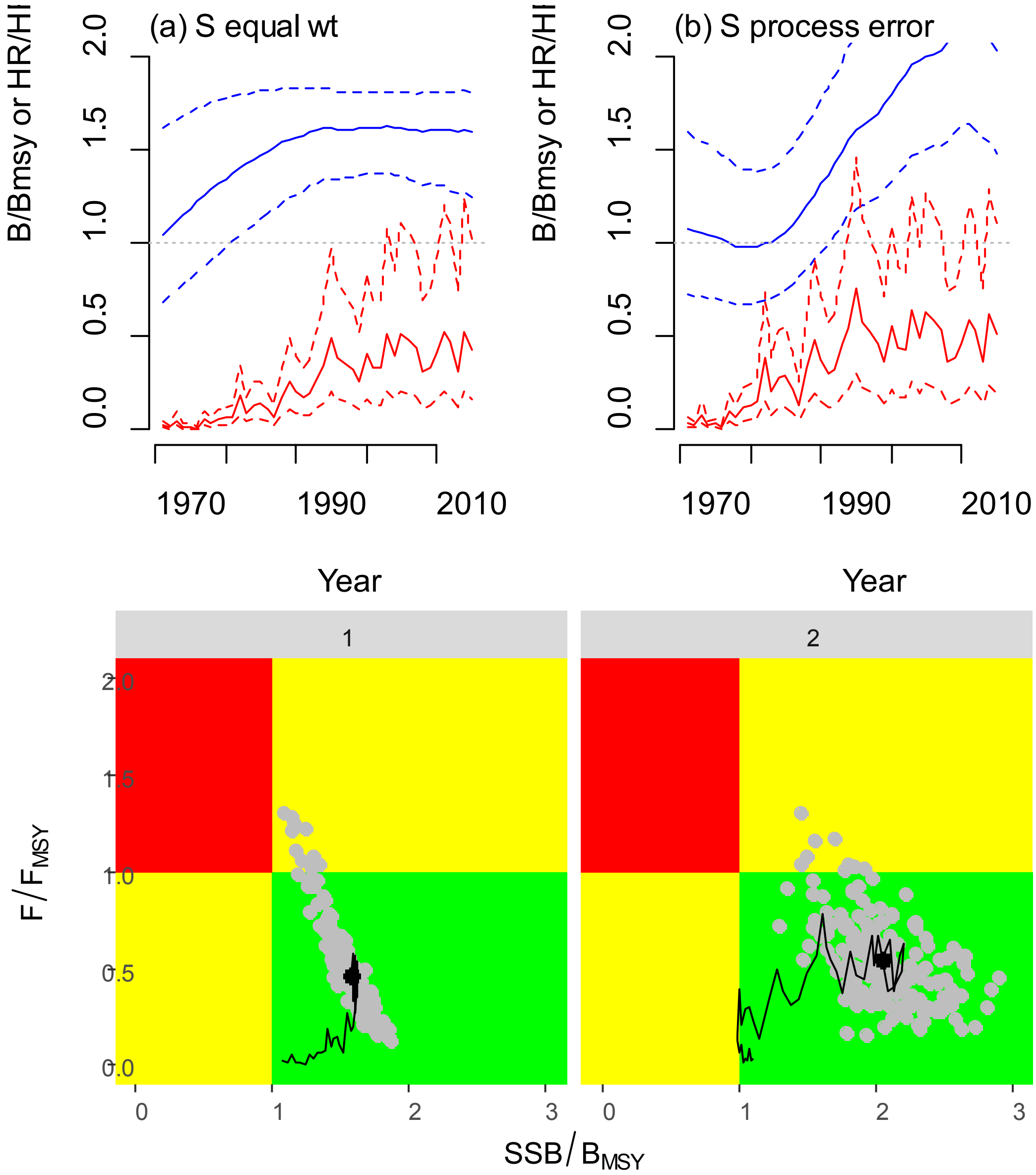

Figure Appendix 14. South Atlantic BSP2-JAGS results without process error (left) and with process error (right), using the priors described in **Table Appendix 1**.

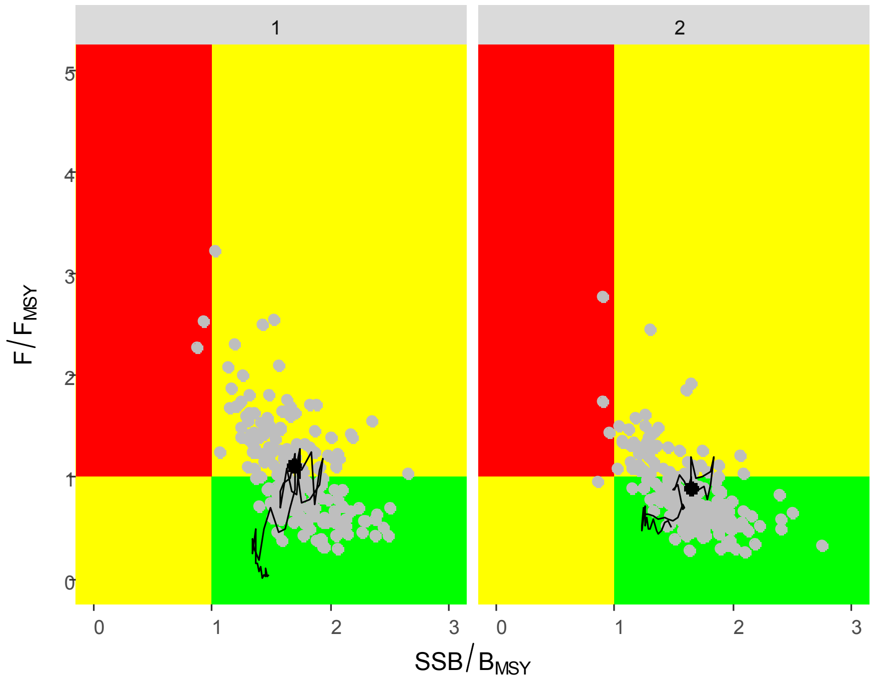

Figure Appendix 15. South Atlantic BSP2-JAGS results from the process error Schaefer models described in section 3.1, using catch C1 (left) or catch C2 (right).

alternatives and, when regulation is necessary, to select regulatory approaches that maximize net benefits (including potential economic, environmental, public health and safety effects, and other advantages; distributive impacts; and equity). Executive Order 13563 (Improving Regulation and Regulatory Review) emphasizes the importance of quantifying both costs and benefits, reducing costs, harmonizing rules, and promoting flexibility. Executive Order 12866 (Regulatory Planning and Review) defines a ''significant regulatory action'' requiring review by OMB, unless OMB waives such review, as ''any regulatory action that is likely to result in a rule that may: (1) Have an annual effect on the economy of $100 million or more or adversely affect in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety, or State, local, or tribal governments or communities; (2) Create a serious inconsistency or otherwise interfere with an action taken or planned by another agency; (3) Materially alter the budgetary impact of entitlements, grants, user fees, or loan programs or the rights and obligations of recipients thereof; or (4) Raise novel legal or policy issues arising out of legal mandates, the President's priorities, or the principles set forth in this Executive Order.''

The economic, interagency, budgetary, legal, and policy implications of this regulatory action have been examined, and it has been determined not to be a significant regulatory action under Executive Order 12866. VA's impact analysis can be found as a supporting document at *http://www.regulations.gov,* usually within 48 hours after the rulemaking document is published. Additionally, a copy of the rulemaking and its impact analysis are available on VA's website at *http://www.va.gov/orpm/,* by following the link for ''VA Regulations Published From FY 2004 Through Fiscal Year to Date.'' This rule is not an Executive Order 13771 regulatory action because this rule is not significant under Executive Order 12866.

Unfunded Mandates

The Unfunded Mandates Reform Act of 1995 requires, at 2 U.S.C. 1532, that agencies prepare an assessment of anticipated costs and benefits before issuing any rule that may result in the expenditure by state, local, and tribal governments, in the aggregate, or by the private sector, of $100 million or more (adjusted annually for inflation) in any one year. This final rule will have no such effect on state, local, and tribal governments, or on the private sector.

Paperwork Reduction Act

This final rule contains no provisions constituting a collection of information under the Paperwork Reduction Act of 1995 (44 U.S.C. 3501–3521).

Regulatory Flexibility Act

The Regulatory Flexibility Act, 5 U.S.C. 601 *et seq.* (RFA), imposes certain requirements on Federal agency rules that are subject to the notice and comment requirements of the Administrative Procedure Act (APA), 5 U.S.C. 553(b). This final rule is exempt from the notice and comment requirements of the APA because the 2015 Act directed the Department to issue the annual adjustments without regard to section 553 of the APA. Therefore, the requirements of the RFA applicable to notice and comment rulemaking do not apply to this rule. Accordingly, the Department is not required either to certify that the final rule would not have a significant economic impact on a substantial number of small entities or to conduct a regulatory flexibility analysis.

Catalog of Federal Domestic Assistance

The Catalog of Federal Domestic Assistance number and title for the program affected by this document is 64.114, Veterans Housing Guaranteed and Insured Loans.

List of Subjects

38 CFR Part 36

Condominiums, Housing, Individuals with disabilities, Loan programs—housing and community development, Loan programs—Veterans, Manufactured homes, Mortgage insurance, Reporting and recordkeeping requirements, Veterans.

38 CFR Part 42

Administrative practice and procedure, Claims, Fraud, Penalties.

Signing Authority

The Secretary of Veterans Affairs, or designee, approved this document and authorized the undersigned to sign and submit the document to the Office of the Federal Register for publication electronically as an official document of the Department of Veterans Affairs. Gina S. Farrisee, Deputy Chief of Staff, Department of Veterans Affairs, approved this document on February 23, 2018, for publication.

Dated: February 23, 2018.

Jeffrey Martin,

Impact Analyst, Office of Regulation Policy & Management, Office of the Secretary, Department of Veterans Affairs.

For the reasons stated in the preamble, the Department of Veterans Affairs amends 38 CFR parts 36 and 42 as set forth below:

PART 36—LOAN GUARANTY

■ 1. The authority citation for part 36 continues to read as follows:

Authority: 38 U.S.C. 501 and 3720.

§ 36.4340 [Amended]

■ 2. In § 36.4340, amend paragraphs (k)(1)(i) introductory text and (k)(3) by removing ''$21,563'' and adding, in its place, ''$22,363.''

PART 42—STANDARDS IMPLEMENTING THE PROGRAM FRAUD CIVIL REMEDIES ACT

■ 3. The authority citation for part 42 continues to read as follows:

Authority: Pub. L. 99–509, secs. 6101–6104, 100 Stat. 1874, codified at 31 U.S.C. 3801–3812.

§ 42.3 [Amended]

■ 4. In § 42.3, amend paragraphs (a)(1)(iv) and (b)(1)(ii) by removing ''$10,781'' and adding, in its place, ''$11,181.''

[FR Doc. 2018–04241 Filed 3–1–18; 8:45 am]

BILLING CODE 8320–01–P

DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

50 CFR Part 635

[Docket No. 180104009–8201–01]

RIN 0648–BH49

Emergency Measures To Address Overfishing of Atlantic Shortfin Mako Shark

AGENCY: National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA), Commerce.

ACTION: Interim final rule, emergency action; request for comments.

SUMMARY: NMFS is taking emergency action through this interim final rule, in response to a new stock assessment for North Atlantic shortfin mako sharks to implement measures required by International Commission for the Conservation of Atlantic Tunas (ICCAT)

Recommendation 17–08. Based on the results of the stock assessment, on December 13, 2017, NMFS determined the North Atlantic shortfin mako shark stock to be overfished, with overfishing occurring. The emergency management measures will reduce shortfin mako shark landings in commercial and recreational shark fisheries, with retention allowed only in certain limited circumstances. The emergency management measures are expected to meet the United States' obligations in relation to ending overfishing, but are not expected to result in significant economic impacts.

DATES: Effective March 2, 2018 through August 29, 2018. Comments must be received on May 7, 2018. A public hearing will be held at the Highly Migratory Species (HMS) Advisory Panel meeting on March 7, 2018, from 11 a.m.–12:15 p.m., EST. For specific location and webinar information, please see the **SUPPLEMENTARY INFORMATION** section of this document and the HMS AP meeting website at: *https://www.fisheries.noaa.gov/event/march-2018-hms-advisory-panel-meeting.*

ADDRESSES: Copies of the Environmental Assessment and other supporting documents for this emergency action are available from the HMS Management Division website at *https://www.fisheries.noaa.gov/topic/atlantic-highly-migratory-species.*

Written comments, identified by NOAA–NMFS–2018–0010, may be submitted to the HMS Management Division by either of the following methods:

- *Electronic Submissions:* Submit all electronic public comments via the Federal e-Rulemaking portal. Go to *www.regulations.gov/#!docketDetail;D=NOAA-NMFS-2018-0010,* click the ''Comment Now!'' icon, complete the required fields, and enter or attach your comments.
- *Mail:* Submit written comments to NMFS, Highly Migratory Species Management Division, 1315 East-West Highway, Silver Spring, MD 20910. Mark the outside of the envelope ''Comments on Atlantic Shortfin Mako Emergency Rule.''

Instructions: Comments sent by any other method, to any other address or individual, or received after the end of the comment period, may not be considered by NMFS. All comments received are a part of the public record and generally will be posted for public viewing on *www.regulations.gov* without change. All personal identifying information (*e.g.,* name, address, etc.), confidential business information, or otherwise sensitive information submitted voluntarily by the sender will be publicly accessible. NMFS will accept anonymous comments (enter ''N/A'' in the required fields if you wish to remain anonymous).

FOR FURTHER INFORMATION CONTACT: Tobey Curtis at 978–281–9273 or Guy DuBeck or Lauren Latchford at 301–427–8503.

SUPPLEMENTARY INFORMATION:

Background

The North Atlantic shortfin mako shark (*Isurus oxyrinchus*) is a highly migratory species that ranges across the entire North Atlantic Ocean and is caught by fishermen from numerous countries. These sharks are a small but valued component of U.S. recreational and commercial shark fisheries, which are managed under the 2006 Consolidated Atlantic HMS Fishery Management Plan and its amendments. In recent years, U.S. catch represents only approximately 11 percent of the species' total catch in the North Atlantic by all reporting countries. International measures are, therefore, critical to the species' effective conservation and management.

In August 2017, ICCAT's Standing Committee on Research and Statistics (SCRS) conducted a new benchmark stock assessment on the North Atlantic shortfin mako stock. At its November 2017 annual meeting, ICCAT accepted this stock assessment and determined the stock to be overfished, with overfishing occurring. On December 13, 2017, based on this assessment, NMFS issued a status determination finding the stock to be overfished and experiencing overfishing using domestic criteria. The assessment specifically indicated that biomass (B_{2015}) is substantially less than the biomass at maximum sustainable yield (B_{MSY}) for eight of the nine models used for the assessment (B_{2015}/B_{MSY} = 0.57–0.85). In the ninth model, spawning stock fecundity (SSF) was less than SSF_{MSY} (SSF_{2015}/SSF_{MSY} = 0.95). Additionally, the assessment indicated that fishing mortality (F_{2015}) was greater than F_{MSY} (1.93–4.38), with a combined 90-percent probability from all models that the population is overfished, with overfishing occurring.

The 2017 assessment estimated that total North Atlantic shortfin mako catches across all ICCAT parties are currently between 3,600 and 4,750 mt per year, and that total catches would have to be at 1,000 mt or below (72–79 percent reductions) to prevent further population declines and that catches of 500 t or less currently are expected to stop overfishing and begin to rebuild the stock. The projections indicate that a total allowable catch of 0 mt would produce a greater than 50 percent probability of rebuilding the stock by the year 2040, which is approximately equal to one mean generation time. Research indicates that post-release survival rates of Atlantic shortfin mako sharks are high (70 percent); however, the assessment could not determine if requiring live releases alone would reduce landings sufficiently to end overfishing and rebuild the stock.

Based on this information, ICCAT adopted new management measures for Atlantic shortfin mako (Recommendation 17–08), which the United States must implement as necessary and appropriate under the Atlantic Tunas Convention Act. These measures largely focus on maximizing live releases of Atlantic shortfin mako sharks, allowing retention only in certain limited circumstances, increasing minimum size limits, and improving data collection in ICCAT fisheries. In November 2018, ICCAT will review the catches from the first six months of 2018 and decide whether these measures should be modified. In 2019, the SCRS will evaluate the effectiveness of these measures in ending overfishing and beginning to rebuild the stock. SCRS will also provide rebuilding information that reflects rebuilding timeframes of at least two mean generation times. Also in 2019, ICCAT will establish a rebuilding plan that will have a high probability of avoiding overfishing and rebuilding the stock to B_{MSY} within a timeframe that takes into account the biology of the stock.

Emergency Management Measures

NMFS is implementing emergency measures in HMS recreational and commercial fisheries consistent with Recommendation 17–08 to address overfishing and to provide meaningful information reflective of the new measures for the six-month reporting requirement in the Recommendation. Management measures in the emergency rule are as follows:

- Commercial fishermen on vessels deploying pelagic longline gear, which are required to have a functional electronic monitoring system on board under current regulations, must release all live shortfin mako sharks with a minimum of harm, while giving due consideration to the safety of crew members. Commercial fishermen using pelagic longline gear can only retain a shortfin mako shark if it is dead at haulback.

- Commercial fishermen using gear other than pelagic longline commercial gear (*e.g.,* bottom longline, gillnet, handgear, etc.) must release all shortfin mako sharks, whether they are dead or alive.
- Recreational fishermen (fishermen with HMS Angling or Charter/Headboat permits, and fishermen with Atlantic Tunas General category and Swordfish General Commercial permits when participating in a registered HMS tournament) must release any shortfin mako sharks smaller than the minimum size of 83 inches (210 cm) fork length (FL). This minimum size is an increase from the current minimum size of 54 inches FL. This measure is more conservative than what was specifically recommended in Recommendation 17–08, which suggested separate minimum size limits for males (180 cm FL) and females (210 cm FL). NMFS is implementing a single minimum size limit of 83 inches (210 cm) FL due to recent analyses conducted by NMFS (but were not available during the ICCAT meeting) that indicate the lower minimum size limit for males would not sufficiently reduce total shortfin mako shark landings to levels that the stock assessment estimates are required to end overfishing (refer to the EA; see ADDRESSES). Furthermore, confirming the sex of a large and potentially active shortfin mako shark prior to its landing can be challenging for fishermen and may have safety implications. Therefore, a single minimum size limit for the species is simpler to implement and enforce, and is more consistent with the objectives of this action.

NMFS is soliciting public comment on this interim final rule and will take into consideration any comments received and any testimony at the public hearing, as it evaluates whether any modifications to the emergency measures are needed. These emergency measures will be effective until August 29, 2018, with a possible extension of up to an additional 186 days. These measures will be replaced by long-term measures, which will be considered through notice and comment rulemaking for an upcoming fishery management plan amendment, accompanied by an Environmental Impact Statement (EIS). The Notice of Intent to Prepare an Environmental Impact Statement for that fishery management plan amendment will publish in the same issue of the **Federal Register** as this interim final rule.

These emergency measures are expected to reduce shortfin mako landings in the HMS commercial fisheries and the ex-vessel revenues from those landings by approximately 75 percent. Thus, the commercial fisheries could cumulatively experience revenue losses of approximately $281,000 per year, 97 percent of which would be lost by the pelagic longline fishery. Lost revenues would have greater social and economic impacts on fishing communities with higher shortfin mako shark landings, including Wanchese, NC, Fairhaven/New Bedford, MA, and Barnegat Light, NJ. Shortfin mako sharks are a minor source of economic revenue to the overall HMS commercial fishery, but may be an important source of seasonal revenue to some individual fishermen. The socioeconomic impacts associated with these reductions in revenue are not expected be significant overall, however, as shortfin mako sharks comprise less than 1 percent of total ex-vessel revenues in the pelagic longline fishery on average, and an even smaller fraction of total fisheries revenues in the potentially-affected fishing communities. Therefore, socioeconomic impacts on the commercial fishery are expected to be slightly negative.

These emergency measures would also reduce recreational landings of shortfin mako sharks by approximately 83 percent. However, as catch-and-release practices would still be permitted, a significant reduction in recreational fishing or charter/headboat activity is not expected. However, the reduced opportunities to catch and land a shortfin mako shark of legal size may slightly reduce demand and revenues for charters and tournaments that target this species. Approximately five percent of charter vessels and seven percent of headboat vessels in the U.S. Atlantic target pelagic sharks, including shortfin mako, with the majority of these businesses located off the northeast United States. According to NMFS Northeast Fisheries Science Center tournament data, the larger minimum size limit may not significantly limit the ability of tournaments to land shortfin mako sharks, because most of the largest shortfin mako sharks landed at tournaments in recent years have been above the 83 inches FL minimum size limit. However, it is likely that fewer vessels will be able to catch a shortfin mako shark of legal size, within or outside of tournaments. Therefore, the socioeconomic impacts associated with recreational shark fishing effort (fuel, bait, fishing supply expenditures, tournament participation, etc.) are expected to be slightly negative.

Public Hearing

Comments on this interim final rule may be submitted via *http://www.regulations.gov* or mail, and comments may also be submitted at the public hearing. NMFS solicits comments on this interim final rule by May 7, 2018. During the comment period, NMFS will hold one public hearing for this interim final rule.

TABLE 1—DATE, TIME, AND LOCATION OF THE UPCOMING PUBLIC HEARING

Venue	Date/time	Meeting locations	Location contact information
Public Hearing	March 7, 2018, 11 a.m.–12:15 p.m.	Silver Spring, MD	HMS AP Meeting, Sheraton Silver Spring, 8777 Georgia Avenue, Silver Spring, MD 20910.

Classification

This emergency interim final rule is promulgated pursuant to section 305(c) of the Magnuson-Stevens Act, and NMFS has determined that it is consistent with that Act and other applicable laws. NMFS policy guidelines for the use of emergency rules (August 21, 1997; 62 FR 44421) specify the following three criteria that define what an emergency situation is: (1) The emergency results from recent, unforeseen events or recently discovered circumstances; (2) the emergency presents serious conservation or management problems in the fishery; and (3) if the emergency action is being implemented without prior public comment, the emergency can be addressed through emergency regulations for which the immediate benefits outweigh the value of advance notice, public comment, and deliberative consideration of the impacts on participants to the same extent as would be expected under the normal rulemaking process.

This action meets the NMFS guidelines and criteria for emergency rulemaking. The action is needed to address recently discovered circumstances including the 2017 ICCAT stock assessment and Recommendation 17–08 for North Atlantic shortfin mako shark in November and NMFS's determination that the stock is overfished and overfishing is occurring in December (Criteria 1). The stock assessment conclusions differ significantly and unexpectedly from the most recent previous assessments, which had indicated that the stock was not overfished or experiencing overfishing. The new assessment indicates that dramatic immediate reductions in fishing mortality are needed to end overfishing of this stock, and this action is needed to address this serious conservation problem (Criteria 2). Finally, the immediate benefits to the shortfin mako shark resource and our need to meet obligations under the Magnuson-Stevens Act and Atlantic Tunas Convention Act outweigh the value of the advance notice and public comments provided under the normal rulemaking process (Criteria 3). Without an emergency rule to implement these measures, the reported U.S. catches at the end of the ICCAT six-month reporting period (ending at the end of June 2018) would reflect catches under the existing management practices and thus not reflect whether the new measures were effective to address overfishing. Any resulting action based on such information could disadvantage U.S. fishermen in the long-term.

Pursuant to 5 U.S.C. 553(b)(B) and 5 U.S.C. 553(d)(3), the Assistant Administrator for Fisheries finds good cause to waive the otherwise applicable requirements for both notice-and-comment rulemaking and a 30-day delay in effectiveness for this interim final, emergency rule implementing North Atlantic shortfin mako shark management measures. The recent unforeseen circumstances described above, and need for expedient action, make it impracticable to provide prior notice-and-comment opportunity and a 30-day delay. The new stock assessment for Atlantic shortfin mako sharks was completed in August 2017 and accepted in November by ICCAT and December 2017 by NMFS, revealing that the North Atlantic shortfin mako shark stock is overfished, with overfishing occurring. ICCAT developed Recommendation 17–08 at its annual meeting in November 2017, which the United States must implement as necessary and appropriate under the Atlantic Tunas Convention Act. It would be potentially harmful to the long-term sustainability of the resource to implement these measures through notice-and-comment rulemaking because immediate reductions in fishing mortality are needed to address overfishing and begin to rebuild the stock and data will be re-evaluated as soon as November 2018 to determine whether additional measures are needed. Unless the new measures are in place, they cannot be properly evaluated for effectiveness in the fall and ICCAT will not be able to determine whether additional measures are immediately needed. Additionally, affected fishing vessel owners should not require time to adjust to these regulations, as the regulations do not constitute substantive operational changes, such as changes to equipment that might require time for purchasing and installation, or changes to practices that might require special training. Here, the rule only affects the landing of a particular species, and thus vessel owners should be able to understand and implement the changes immediately. Furthermore, the agency requested voluntary implementation of these measures earlier this year, so fishermen have already been notified of these management changes.

For the reasons outlined, NMFS finds it impracticable and contrary to the public interest to provide prior opportunity to comment on the Atlantic shortfin mako shark emergency measures. As noted above, NMFS is soliciting public comment on this interim final rule and will take into consideration any comments received and any testimony at the public hearing, as it evaluates whether any modifications to the emergency measures are needed. In addition, there will be multiple opportunities for public participation and notice-and-comment rulemaking as NMFS develops a long-term fishery management amendment to rebuild North Atlantic shortfin mako sharks.

This action is being taken pursuant to the emergency provision of the Magnuson-Stevens Act and is exempt from OMB review.

This rule is exempt from the otherwise applicable requirement of the Regulatory Flexibility Act to prepare a regulatory flexibility analysis because the rule is issued without opportunity for prior public comment.

List of Subjects in 50 CFR Part 635

Fisheries, Fishing, Fishing vessels, Foreign relations, Imports, Penalties, Reporting and recordkeeping requirements, Treaties.

Dated: February 27, 2018.

Samuel D. Rauch, III,

Deputy Assistant Administrator for Regulatory Programs, National Marine Fisheries Service.

For the reasons set out in the preamble, 50 CFR part 635 is amended as follows:

PART 635—ATLANTIC HIGHLY MIGRATORY SPECIES

■ 1. The authority citation for part 635 continues to read as follows:

Authority: 16 U.S.C. 971 *et seq.;* 16 U.S.C. 1801 *et seq.*

* * * * *

■ 2. In § 635.20 suspend paragraph (e)(2) and add paragraphs (e)(6) and (7) to read as follows:

§ 635.20 Size limits.

* * * * *

(e) * * *

(6) All sharks, except as otherwise specified in this subsection below, landed under the recreational retention limits specified at § 635.22(c)(2) must be at least 54 inches (137 cm) FL.

(7) All North Atlantic shortfin mako sharks landed under the recreational retention limits specified at § 635.22(c)(2) must be at least 83 inches (210 cm) fork length.

* * * * *

■ 3. In § 635.21, add paragraphs (a)(4) and (c)(1)(iv) to read as follows:

§ 635.21 Gear operation and deployment restrictions.

(a) * * *

(4) Any person issued a commercial shark permit must release all shortfin mako sharks, alive or dead, caught on any gear other than pelagic longline gear.

* * * * *

(c) * * *

(1) * * *

(iv) Has pelagic longline gear on board, persons aboard that vessel are required to release unharmed, to the extent practicable, any shortfin mako shark that is alive at the time of haulback. Any shortfin mako shark that is dead at the time of haulback may be retained provided the electronic monitoring system is installed and functioning in accordance with § 635.9.

* * * * *

■ 4. In § 635.24, suspend paragraphs (a)(4)(i) and (iii), and add paragraphs (a)(4)(v) and (vi) to read as follows:

§ 635.24 Commercial retention limits for sharks, swordfish, and BAYS tunas.

* * * * *

(a) * * *

(4) * * *

(v) A person who owns or operates a vessel that has been issued a directed shark LAP may retain, possess, or land pelagic sharks if the pelagic shark fishery is open per §§ 635.27 and 635.28. Shortfin mako sharks may only be retained by persons using pelagic longline gear, and only if each shark is dead at the time of haulback per § 635.21(c)(1).

(vi) Consistent with paragraph (a)(4)(ii) of this section, a person who owns or operates a vessel that has been issued an incidental shark LAP may retain, possess, land, or sell no more than 16 SCS and pelagic sharks, combined, per vessel per trip, if the respective fishery is open per §§ 635.27 and 635.28. Of those 16 SCS and pelagic sharks per vessel per trip, no more than 8 shall be blacknose sharks. Shortfin mako sharks may only be retained by persons using pelagic longline gear, and only if each shark is dead at the time of haulback per § 635.21(c)(1).

* * * * *

■ 5. In § 635.71, add paragraphs (d)(27) through (29) to read as follows:

§ 635.71 Prohibitions.

* * * * *

(d) * * *

(27) Land a shortfin mako shark that was caught with gear other than pelagic longline as specified at § 635.21(a).

(28) Retain, land, or possess a shortfin mako shark that was caught with pelagic longline gear and was alive at haulback as specified at § 635.21(c)(1).

(29) As specified at § 635.21(c)(1), retain, land, or possess a shortfin mako shark that was caught with pelagic longline gear when the electronic monitoring system was not installed and functioning in accordance with the requirements at § 635.9.

* * * * *

[FR Doc. 2018–04262 Filed 3–1–18; 8:45 am]

BILLING CODE 3510–22–P

Issues and Options for

Amendment 11 to the 2006 Consolidated Atlantic Highly Migratory Species Fishery Management Plan

March 2018

Highly Migratory Species Management Division
Office of Sustainable Fisheries
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, Maryland 20910

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1 Introduction

The National Marine Fisheries Service (NMFS) intends to amend the 2006 Consolidated Atlantic Highly Migratory Species (HMS) Fishery Management Plan (FMP) (Consolidated HMS FMP) to address overfishing of the North Atlantic shortfin mako shark. This document examines potential management options to address overfishing of and begin rebuilding the North Atlantic shortfin mako stock and also requests additional information and input from consulting parties and the public prior to development of a formal Draft Environmental Impact Statement (DEIS) and proposed rule. The Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) requires NMFS to "consult with and consider the comments and views of affected Councils, commissions and advisory groups appointed under Acts implementing relevant international fishery agreements pertaining to highly migratory species, and the [HMS] advisory panel in preparing and implementing any fishery management plan or amendment." Therefore, we are starting our scoping stage and requesting comments and views on this Issues and Options document for Amendment 11 to the 2006 Consolidated Atlantic HMS FMP by May 7, 2018. An electronic version of this document is available on the HMS Management Division website at: https://www.fisheries.noaa.gov/topic/atlantic-highly-migratory-species.

In August 2017, the International Commission for the Conservation of Atlantic Tunas (ICCAT) Standing Committee on Research and Statistics (SCRS) conducted a new benchmark stock assessment on the North Atlantic shortfin mako shark stock. In November 2017 at its annual meeting, ICCAT accepted this stock assessment and its results, which indicated that the stock was overfished with overfishing occurring. On December 13, 2017, based on the results of this assessment, NMFS also determined the stock to be overfished with overfishing occurring. Based on the stock assessment, ICCAT adopted new management measures for shortfin mako (Recommendation 17-08), which the United States must implement as necessary and appropriate under the Atlantic Tunas Convention Act (ATCA). NMFS initially implemented these measures through an interim final rule using emergency Magnuson-Stevens Act authority to temporarily and immediately implement commercial and recreational measures. In 2018, ICCAT will review the catches from the first six months of 2018 and decide whether the measures contained in Recommendation 17-08 should be modified. Without implementing the interim final rule, the reported U.S. catch data for the first half of 2018 would reflect catches under the existing management practices, and thus not reflect the true potential of the new measures at addressing overfishing. Any resulting action by ICCAT based on such incomplete information could disadvantage U.S. fishermen. For more details on the stock assessment and recommendation, please refer to the ICCAT website at http://www.iccat.int/.

NMFS is developing Amendment 11 to the 2006 Consolidated Atlantic HMS FMP (Amendment 11) in response to the ICCAT Recommendation and the stock status determination. NMFS anticipates that the proposed rule and DEIS will be available in mid-2018 and the Final Amendment 11 and its related documents will be available in Spring 2019. NMFS requests receipt of any comments on this scoping document by May 7, 2018.

Any written comments on this document should be submitted to Guý DuBeck, HMS Management Division, F/SF1, Office of Sustainable Fisheries, 1315 East West Highway, Silver Spring, MD 20910 or via the Federal e-Rulemaking Portal (*www.regulations.gov/#!docketDetail;D=NOAA-NMFS*-2018-0011) by May 7, 2018. For further information, contact Guý DuBeck or Karyl Brewster-Geisz at (301) 427-8503.

This document includes a summary of the anticipated purpose and need (Chapter 1) of the FMP amendment and tables summarizing the potential environmental, social, and economic impacts of conservation and management options that NMFS is considering at this time (Chapter 2). The options outlined in Chapter 2 may be modified, removed, or supplemented based on any comments received, additional analyses, and other factors, as appropriate.

NMFS specifically solicits opinions and advice on the potential range of options and whether there are additional options that should be addressed and considered in the rulemaking process. Additionally, NMFS solicits opinions and advice on the impacts described for each option.

1.1 Management History

Atlantic HMS fisheries are managed under the dual authority of the Magnuson-Stevens Act and ATCA. HMS fisheries require management at the international, national, and state levels because of the highly migratory nature of the species. NMFS manages HMS fisheries in federal waters (domestic) and the high seas (international), while individual states establish regulations for some HMS in their own waters. However, there are exceptions to this generalization. For example, as a condition of their permit, federally-permitted HMS fishermen are required to follow federal regulations in all waters, including state waters, unless the state has more restrictive regulations, in which case the state laws prevail. Additionally, in 2005, the Atlantic States Marine Fisheries Commission (ASMFC) agreed to develop an interstate coastal shark FMP. This interstate FMP coordinates management measures among all states along the Atlantic coast (Florida to Maine). NMFS participated in the development of this interstate shark FMP, which went into effect in 2010.

On the international level, NMFS participates in the stock assessments conducted by the SCRS and in the annual ICCAT meetings. NMFS implements conservation and management measures adopted through ICCAT and through other relevant international agreements, consistent with specific domestic implementing legislation. ICCAT has assessed the Atlantic blue and the shortfin mako shark stocks, participated with the International Council for the Exploration of the Sea (ICES) on a joint porbeagle assessment, and has conducted several ecosystem risk assessments for various shark species, among other things. Stock assessments and management recommendations or resolutions are listed on ICCAT's website at http://www.iccat.int. As described below, in recent years ICCAT has adopted several shark-specific recommendations, to address sharks caught in association with ICCAT fisheries.

NMFS manages sharks domestically through the 2006 Consolidated HMS FMP and its amendments, along with other Atlantic HMS. For more information on the complete HMS management history as it relates to sharks, please refer to the 2006 Consolidated HMS FMP and Amendments 2, 3, 5a, 5b, 6, 9, and 10, which address shark conservation and management. Relevant proposed rules, final rules, and other official notices, along with supporting documents including the original FMPs, can be found on the HMS Management Division's webpage at https://www.fisheries.noaa.gov/topic/atlantic-highly-migratory-species. Documents can also be requested by calling the HMS Management Division at (301) 427-8503.

1.2 Shortfin Mako Shark Stock Assessment

ICCAT's SCRS has assessed blue, shortfin mako, and porbeagle sharks. All SCRS final stock assessment reports can be found at www.iccat.int/en/assess.htm. The shortfin mako ICCAT SCRS report from 2017 can be found at http://iccat.int/Documents/Meetings/Docs/2017_SCRS_REP_ENG.pdf

The 2017 stock assessment included significant updates to inputs and model structures compared to the 2012 shortfin mako shark assessment. In addition to including a new model structure, the new assessment also used improved and longer catch time series (1950-2015), sex-specific biological parameters, updated length composition data, and new tagging data. One of the primary changes in data for the new stock assessment was a new estimate of the fishing mortality rate largely derived from satellite tagging research (Byrne et al. 2017). For this research, 40 shortfin mako sharks were tagged and then tracked in the North Atlantic between 2013 and 2016 for periods of 81-754 days. Of these tagged sharks, 12 (30 percent) were captured by fishing vessels (Figure 1). These direct observations of mortality resulted in fishing mortality rate estimates of 0.19-0.53, which are significantly higher than the estimates of 0.015-0.024 used in previous assessments (SCRS 2012).

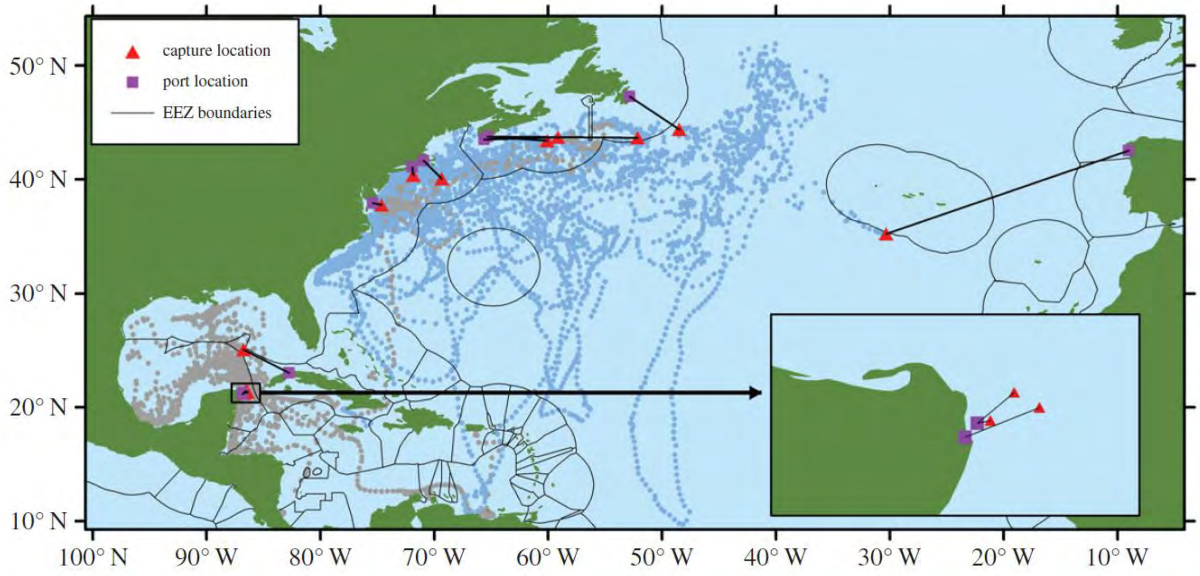

Figure 1. Tracks (dots) and capture locations (triangles) of 40 satellite tagged shortfin mako sharks from Byrne et al. (2017).

In November 2017 at its annual meeting, ICCAT accepted this stock assessment and its results, which determined that the stock was overfished with overfishing occurring applying

ICCAT criteria. On December 13, 2017, based on the results of this assessment, NMFS determined the stock to be overfished with overfishing occurring. The assessment specifically indicated that B_{2015} is substantially less than B_{MSY} for eight of the nine models (B_{2015}/B_{MSY} = 0.57-0.85). In the ninth model, spawning stock fecundity (SSF) was less than SSF_{MSY} (SSF_{2015}/SSF_{MSY} = 0.95). Additionally, the assessment indicated that F_{2015} was greater than F_{MSY} (1.93-4.38), with a combined 90-percent probability from all models that the population is overfished with overfishing occurring (Figure 2).

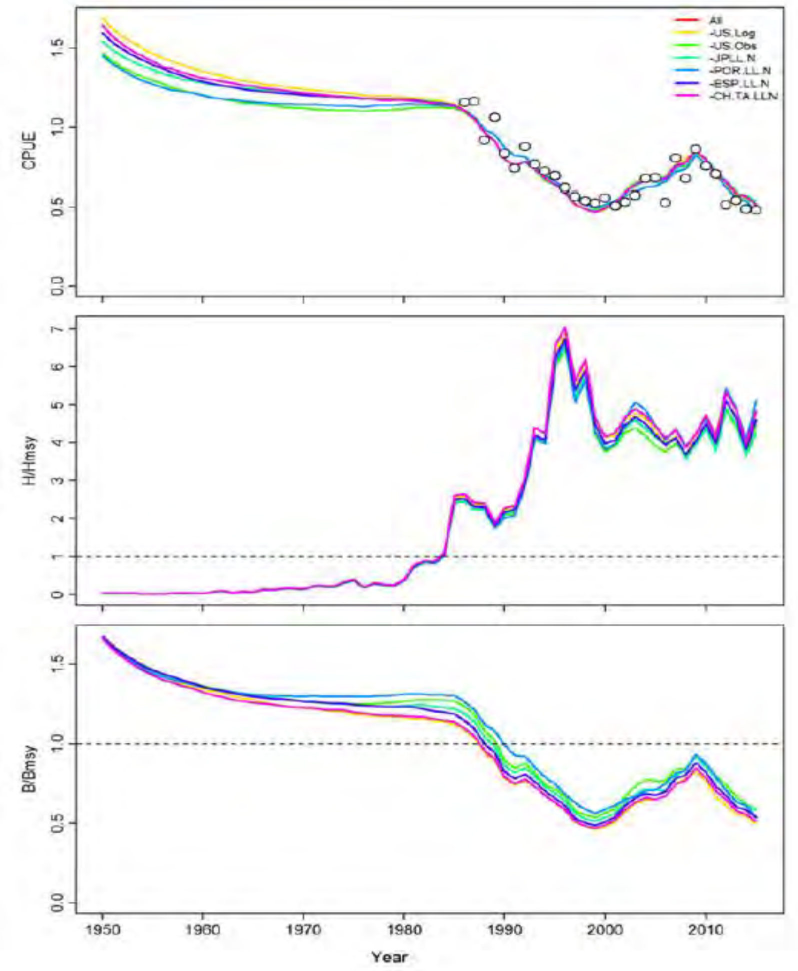

Figure 2. Trends in North Atlantic shortfin mako shark CPUE, F/F_{MSY}, and B/B_{MSY} using the C1 catch scenario used in the 2017 stock assessment. Circles denote US pelagic longline CPUE.

The 2017 assessment estimated that total North Atlantic shortfin mako shark catches across all nations are currently between 3,600 and 4,750 mt per year and that total catches would have to be reduced below 1,000 mt (72-79 percent reductions) to prevent further population declines. The projections indicate that a total allowable catch of 0 mt would produce a greater than 50-percent probability of rebuilding the stock by the year 2040, which is approximately equal to one mean generation time. Research indicates that post-release survival rates of shortfin mako sharks are high (70 percent); however, the assessment could not determine if requiring live releases alone would reduce landings sufficiently to end overfishing and rebuild the stock.

1.3 Biological Information

The shortfin mako shark is an oceanic species found in warm to warm-temperate waters throughout all oceans. Mark-recapture information from the NMFS Apex Predator Program is shown in Figure 3. Northwest Atlantic tagging data for immature sharks presented at the 2017 ICCAT shortfin mako stock assessment meeting indicated distinct core use areas in the Mid-Atlantic Bight and off the western edge of the Yucatan Channel (Mexico). Vaudo et al. (2017) also noted spatial segregation between 12 sharks tagged in the Gulf of Mexico/Caribbean and 14 sharks tagged in the northwest Atlantic. Sharks tagged off the Yucatan Peninsula traveled considerably less distance by several orders of magnitude, than sharks tagged in the Mid-Atlantic Bight. Seasonal distribution was observed in the latter, with several individuals observed making round-trips between the Sargasso Sea and northern habitats between the Mid-Atlantic Bight and the Grand Banks. Many of the sharks tagged off Mexico remained along the eastern edge of Campeche Bank, Mexico for several consecutive months (i.e., no seasonal patterns were observed in the data). Similar results are presented in Byrne et al. (2017), which analyzed data collected on 46 sharks over a three-year time span to evaluate fishery interactions and mortality. Vaudo et al. (2017) hypothesized that behavioral differences were linked to resource utilization; the unique oceanography off the Yucatan Peninsula may have created an environment that concentrated prey resources, whereas in the northwest Atlantic shortfin mako sharks may have moved in response to large-scale climactic and oceanographic forces that affected prey distribution. Shortfin mako sharks feed on fast-moving fishes such as swordfish, tuna, and other sharks (Castro 1983) as well as clupeids, needlefishes, crustaceans, and cephalopods (Maia et al. 2007a). MacNeil et al. (2005) found evidence of a diet switch from cephalopod to bluefish in the spring.

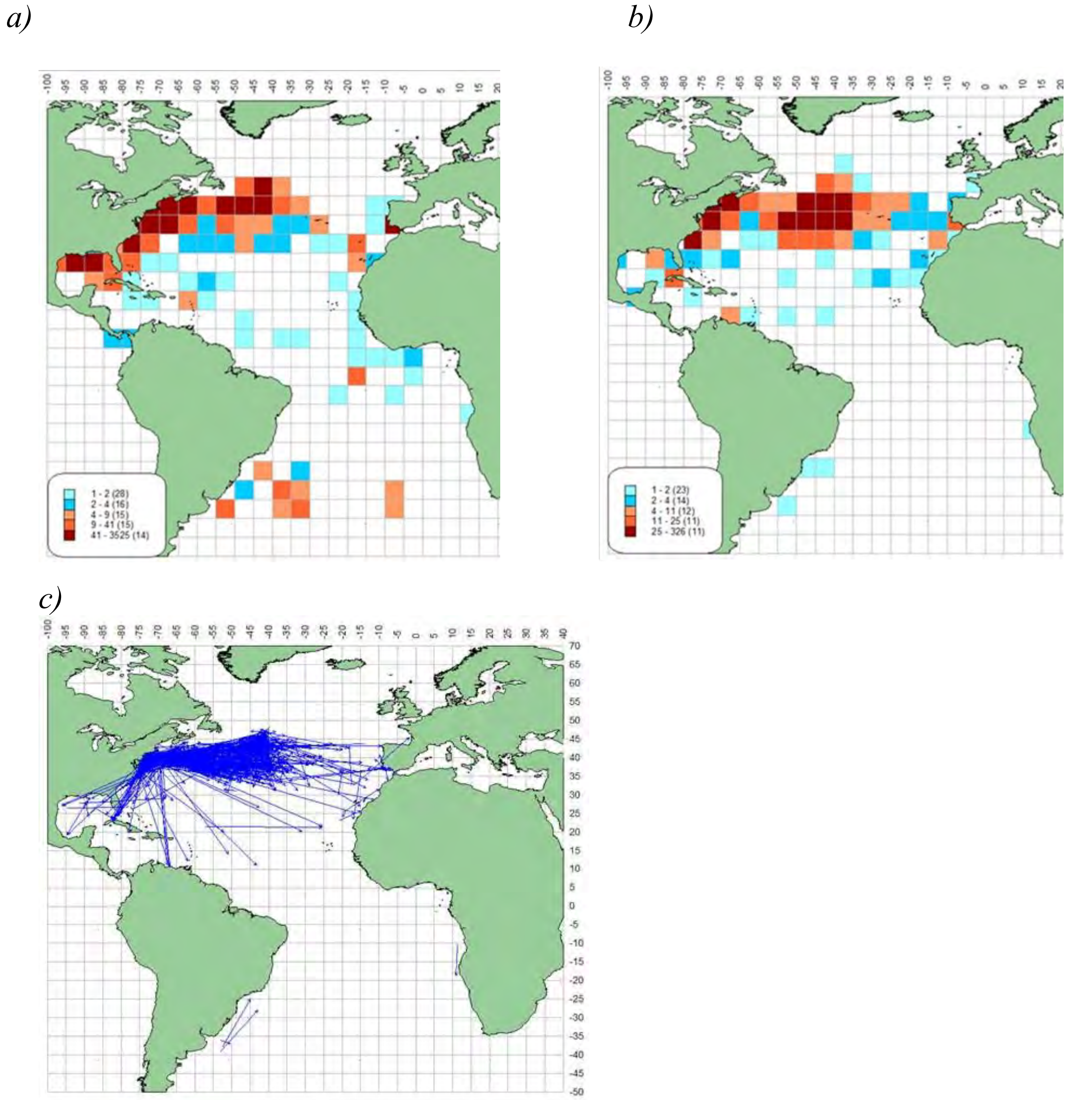

Figure 3. NMFS Apex Predator Program tag and release distributions for shortfin mako in the Atlantic Ocean (a = Density of releases, b = Density of recoveries, c = Straight displacement between release and recovery locations). Source: SCRS 2012.

Considerable variation exists in the descriptions of reproductive life history for shortfin mako sharks. For example, reported age and length at maturity varies by region (ICCAT 2006-2016), and it has been noted that males have double the growth rate of females in the North Atlantic. Cailliet and Mollet (1997) estimated that a female mako shark matures at four to six years, has a two-year reproductive cycle, and a gestation period of approximately 12 months. According to Pratt and Casey (1983), females mature at about 7 years of age; however, Campana et al. (2002) used radiocarbon assays and found that the estimate may have been incorrect. Bishop et al. (2006) considered Campana et al. (2002) when estimating median age at maturity in New Zealand waters to be 19 to 21 years for females and 7 to 9 years for males. In Maia et al.

(2007b), length at maturity for males was estimated at 180 cm FL, which is similar to the size of Natanson et al. (2006); size at female maturity was not estimated because female sharks from 210-290 cm FL were not sampled, although this appears to be the interval where maturation occurs. Cailliet et al. (1983) estimated the von Bertalanffy parameters (n = 44) for the shortfin mako shark as: L = 3210 mm, K = .072, and t_0 = -3.75.

Litter size ranges from 4 to 25, and size at birth is approximately 70 cm TL (Mollet et al. 2000). Gestation period was estimated at 15-18 months and the reproductive cycle at 3 years. Semba et al. (2011) estimated gestation period being between 9 and 13 months, with fecundity increasing as the female grows. North Atlantic shortfin mako shark populations have higher productivity than South Atlantic shortfin mako shark populations (SCRS 2017).

Based on cohort analysis of shortfin mako sharks in the eastern North Atlantic, average growth was determined as 61.1 cm/year for the first year and 40.6 cm/year for the second year (Maia et al*.,* 2007b). There was a marked seasonality in growth, with average monthly rates of 5.0 cm/month in summer and 2.1 cm/month in winter. Lack of sex differences in cohort analysis for the first years of life was in accordance with previous studies that reported male and female mako sharks grew at the same rate until they reached about 200 cm FL (Casey and Kohler, 1992; Campana et al. 2005). Bishop et al. (2006) described rapid initial growth rates to approx. 39 cm fork length in the first year. Thereafter, males and females grew at similar, but slower rates until about age 7 years, after which the relative growth of males declined. Life span estimates are varied; published maximum ages for females are 11.5 years (Pratt and Casey 1983), 25 years (Cailiet and Mollet 1997), and 29 years (Bishop et al. 2006), and 28 years for males (Bishop et al. 2006).

Heist et al. (1996) found considerable intraspecific genetic variation and significant partitioning of haplotypes between the North Atlantic and other regions; however, there was no evidence of multiple subspecies, nor of any past genetic isolation among shortfin mako shark populations. Very weak evidence of population structure throughout the Atlantic and Pacific Oceans was found in microsatellite analysis by Schrey and Hiest (2003). The authors indicated that integrating the results from microsatellite- and mitochondrial-based studies may provide evidence for gender-biased dispersal for the shortfin mako. The significant genetic structure detected in mtDNA data indicated that female shortfin mako sharks may exhibit philopatry for parturition sites, and thus reproductive stocks of mako sharks may exist in the presence of considerable male-mediated gene flow. Pregnant shortfin mako sharks have only been captured between 20° and 30° N or S lat. (Gilmore 1993); however, there is no information about the area where mating occurs.

1.3.1 Shortfin Mako Essential Fish Habitat

Section 303(a)(7) of the Magnuson-Stevens Act requires FMPs to describe and identify essential fish habitat (EFH), minimize to the extent practicable adverse effects on such habitat caused by fishing, and identify other actions to encourage the conservation and enhancement of such habitat. The Magnuson-Stevens Act defines EFH as “those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity” (16 U.S.C. § 1802 (10)).

Implementing regulations for EFH provisions are at 50 C.F.R. 600, Subpart J. Shortfin mako EFH was identified following the methods described in Amendment 10 to the 2006 Consolidated HMS FMP (NMFS 2017). Size breaks used to distinguish different life stages of pelagic sharks, including shortfin mako, are shown in Table 1.

Table 1. Size class information for Atlantic HMS pelagic sharks used in EFH analyses. Source: NMFS 2017.

Pelagic Sharks	**Young-of-the-year FL (cm) ≤**	**Juveniles FL (cm) =**	**Adults** F 50% mat or max range at 1st maturty **FL (cm) ≥**	Young-of-the- year size range **FL (cm) =**	Embryo size range or maximum embryo size in term females **FL (cm) =**	Length at 1st maturity or range at 50% maturity **FL (cm) =**	**References**
Bigeye Thresher *Alopias superciliosus*			216			209-216	Stillwell & Casey (1976), Moreno & Moron (1992)
Blue *Prionace glauca*	76	77-184	185	30-76	46.61	185	Stevens (1975), Silva (1996), Skomal & Natanson (2003), Pratt (1979)
Common Thresher *Alopias vulpinus*	111	112-212	213		94	213	Moreno *et al.* (1989), Gervelis (2005)
Longfin Mako *Isurus paucus*			225			225	Guitart-Manday (1966)
Oceanic Whitetip *Carcharhinus longimanus*	68	69-179	180	42-68	55	180	Leesa *et al.* (1999), Seki *et al.* (1998), ICCAT (2014)^
Porbeagle *Lamna nasus*	105	106-196	197	57-105	66	197	Jensen *et al.* (2002), Natanson *et al.* (2002)
Shortfin Mako *Isurus oxyrinchus*	128	129-274	275	64-128	70	275	Duffy & Francis (2001), Natanson et al. (2006), ICCAT (2014)^

^ICCAT manual, with notations on life history parameters.
https://www.iccat.int/Documents/SCRS/Manual/Appendices/Appendix%204%20III_SHK.pdf

A map depicting the boundaries of shortfin mako shark EFH is shown in Figure 4. At this time, available information is insufficient for the identification of EFH by life stage, therefore all life stages are combined in the EFH designation. EFH in the Atlantic Ocean includes pelagic habitats seaward of the continental shelf break between the seaward extent of the U.S. EEZ boundary and Georges Bank (off Massachusetts) to Cape Cod (seaward of the 200 m bathymetric line); coastal and offshore habitats between Cape Cod and Cape Lookout, North Carolina; and localized habitats off South Carolina and Georgia. EFH in the Gulf of Mexico is seaward of the 200 m isobaths in the Gulf of Mexico, although in some areas (e.g., northern Gulf of Mexico by the Mississippi delta) EFH extends closer to shore. EFH in the Gulf of Mexico is located along the edge of the continental shelf off Fort Meyers to Key West (southern West Florida Shelf), and also extends from the northern central Gulf of Mexico around Desoto Canyon and the Mississippi Delta to pelagic habitats of the western Gulf of Mexico that are roughly in line with the Texas/Louisiana border. For more information, please refer to Final Amendment 10 at [http://www.nmfs.noaa.gov/sfa/hms/documents/fmp/am10/index.html.](http://www.nmfs.noaa.gov/sfa/hms/documents/fmp/am10/index.html)

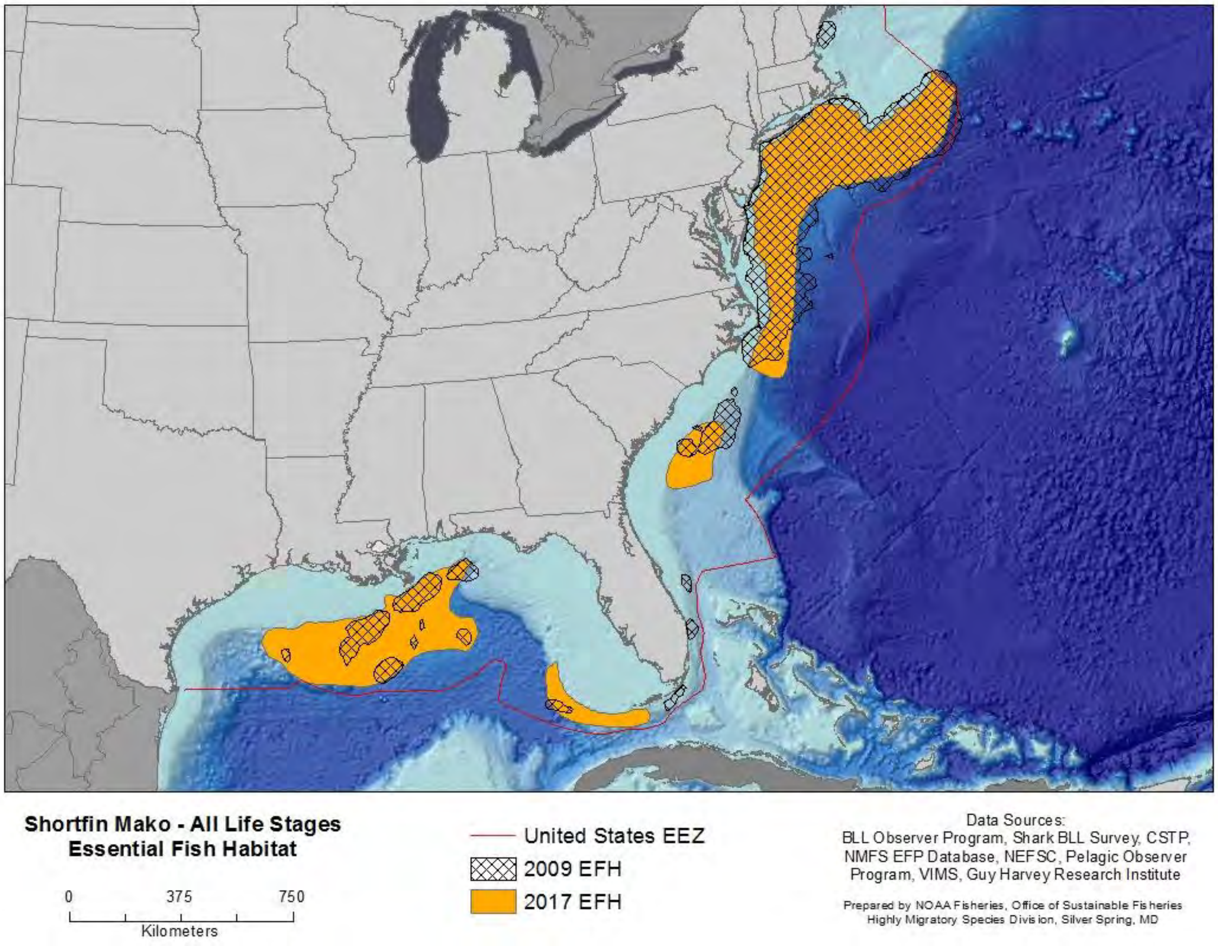

Figure 4. EFH of shortfin mako sharks (all life stages combined). Note: Neonate/YOY (≤ 128 cm FL), Juvenile (129 to 274 cm FL), and Adult (≥ 275 cm FL)

1.4 ICCAT Recommendation 17-08

In November 2017, as a result of the most recent stock assessment, ICCAT adopted Recommendation 17-08 requiring new commercial and recreational management measures for shortfin mako sharks, which the United States must implement under the Atlantic Tunas Convention Act. The recommendation requires the release of all shortfin mako sharks in a manner that causes the least harm, while giving due consideration to the safety of crew members. Under the commercial measures, fishermen using pelagic longline gear must release all live shortfin mako sharks and can retain a shortfin mako shark only if it is dead at haulback and either an observer or functioning electronic monitoring system are on board. Under the recreational measures, fishermen that hold an HMS Angling or HMS Charter/Headboat permit, and fishermen that hold Atlantic Tunas General category and/or Swordfish General Commercial permits when participating in a registered HMS tournament, and who choose to land a shortfin mako shark can only land – at a minimum – males at least 71 inches (180 cm) FL and females at least 83 inches (210 cm) FL. For more details on the recommendation, please refer to the ICCAT website at http://www.iccat.int/.

1.5 Purpose, Need, and Objectives

The purpose of Amendment 11 is to develop and implement management measures that would address overfishing and will take steps towards rebuilding the North Atlantic shortfin mako shark stock. This action is consistent with ICCAT Recommendation 17-08, and U.S. responsibilities under ATCA and the Magnuson-Stevens Act.

The need of Amendment 11 is to implement management measures consistent with the requirements of ATCA, the Magnuson-Stevens Act, and other statutes. On December 13, 2017, NMFS determined that North Atlantic shortfin mako sharks are overfished with overfishing occurring. NMFS, as required by Magnuson-Stevens Act on behalf of the Secretary, must take action to end overfishing immediately and to implement conservation and management measures to rebuild overfished stocks within two years of making this determination. To address overfishing and to ensure that timely data is provided to ICCAT under a provision in Recommendation 17-08, an interim final rule was published to implement management measures for North Atlantic shortfin mako sharks based on the measures in the ICCAT Recommendation, and using NMFS' authority to issue emergency regulations under the Magnuson-Stevens Act. Under this authority, temporary regulations may remain in effect for no more than 180 days, but may be extended for an additional 186 days as described in section 305(c) of the Magnuson-Stevens Act. Since the emergency rule may only be effective for up to 366 days, NMFS is developing an amendment to the 2006 Consolidated Atlantic HMS Fishery Management Plan that will consider and evaluate the measures in ICCAT Recommendation 17-08 and additional management options to address overfishing and to establish a foundation for rebuilding the North Atlantic shortfin mako shark stock. This amendment is expected to be implemented prior to the expiration of the emergency rule. This Issues and Options paper is part of the scoping process for that FMP amendment and associated rulemaking.

The goal of this issues and options document is to examine potential management options to address overfishing of and take steps toward rebuilding the Atlantic shortfin mako stock, and to request additional information and input from consulting parties and the public, prior to development of a DEIS and proposed rule.

Objectives: To achieve the purpose and address the need for acting, NMFS would implement management measures to address overfishing and take steps toward rebuilding the stock. More specifically, NMFS has identified the following objectives with regard to this proposed action:

- Address overfishing of shortfin mako sharks;
- Develop and implement management measures consistent with the ICCAT Recommendation 17-08; and
- Take steps towards rebuilding the shortfin mako shark stock.

2 Range of Potential Options

In this chapter, NMFS examines an initial range of options to meet the objectives of the rule and NEPA requirements and invites comment these options and on whether additional options should be examined. This chapter is organized by the following sections: commercial, recreational, recreational monitoring, and rebuilding program.

2.1 Commercial Options

NMFS is considering a variety of commercial options, some of which are from ICCAT Recommendation 17-08 and the interim final rule, and some that end overfishing and/or rebuilding, but are not specifically included in the ICCAT Recommendation. These options include no action, requiring live release, creating new shark management quotas, allowing additional shortfin mako shark landings by non-pelagic longline gear, and prohibiting commercial retention of shortfin mako sharks.

Option 1 – No Action. Keep current regulations for shortfin mako sharks.

Under Option 1, NMFS would not implement any new management measures in commercial HMS fisheries. Directed and Incidental shark limited access permit (LAP) holders would continue to be allowed to land and sell shortfin mako sharks to an authorized dealer, subject to current limits, including the pelagic shark commercial quota. In recent years, about 180,000 lb dw of shortfin mako sharks have been landed and the commercial revenues from shortfin mako sharks have averaged approximately $375,000 per year, which equates to approximately 1 percent of overall HMS ex-vessel revenues (Table 2).

Table 2. Average shortfin mako shark ex-vessel prices, and overall percentage of total shark ex-vessel revenue, 2013-2016. Sources: HMS eDealer database, 2017 SAFE Report.

Year	**Shortfin Mako**	**Annual landings (lb dw)**	**AVG Ex-Vessel Price**	**Ex-Vessel Annual Revenue**	**Percentage of Overall Shark Ex-Vessel Revenue**	**Percentage of Overall HMS Ex-Vessel Revenue**
2013	Meat	199,177	$1.92	$382,420	20.3%	1.0%
	Fins	6,573	$6.05	$39,766		
	Total			$422,186		
2014	Meat	218,295	$1.97	$430,041	19.4%	1.0%
	Fins	5,894	$2.34	$13,792		
	Total			$443,833		
2015	Meat	141,720	$1.92	$272,102	9.4%	0.8%
	Fins	4,393	$2.93	$12,872		
	Total			$284,975		
2016	Meat	160,829	$2.07	$332,916	13.8%	0.9%
	Fins	4,342	$3.58	$15,546		
	Total			$348,462		

Pros

- Would have no negative economic impacts in the short-term on U.S. commercial fishermen since no fishing restrictions would be implemented.
- HMS commercial fishermen would continue to be able to harvest shortfin mako sharks under the current regulations.

Cons

- Overfishing of shortfin mako sharks would continue and further reduce the stock size, complicating rebuilding efforts. If stock health continues to decline, future stock assessments may advise no fishing mortality immediately, which could result in reduced access to the resource for U.S. fishermen and restrictions in fisheries that interact with the species.
- This option would not implement ICCAT Recommendation 17-08, which requires contracting parties to reduce mortality of shortfin mako sharks and includes several measures that largely focus on maximizing live releases of shortfin mako sharks. Failing to implement ICCAT Recommendation 17-08 and address overfishing of shortfin mako sharks would be inconsistent with ATCA and may result in ICCAT penalties or restrictions specific to the United States.
- Would be inconsistent with the Magnuson-Stevens Act requirement to end overfishing and to implement a rebuilding plan within two years of determining a species is overfished and experiencing overfishing.

Option 2 – Require live release of shortfin mako sharks in the commercial pelagic longline fishery

Under Option 2, fishermen using pelagic longline gear would be required to release all live shortfin mako sharks with a minimum of harm, while giving due consideration to the safety of crew members. This option would be consistent with ICCAT Recommendation 17-08. This option would reduce the number of landings by pelagic longline vessels on average by 74 percent based on observer data from 2013-2016 (Table 3). However, this option would not reduce the number of shortfin mako shark interactions by commercial pelagic longline gear. On average, pelagic longline vessels interact annually with 2,902 shortfin mako sharks (Table 4). This option would require those fishermen to release all shortfin mako sharks that are brought to the vessel alive. There could be greater socioeconomic impacts on fishing communities with higher reliance on shortfin mako shark landings, including Wanchese, NC; Fairhaven/New Bedford, MA; and Barnegat Light, NJ (Table 5). However, shortfin mako sharks are a minor source of economic revenue to the overall HMS commercial fisheries, but may be a significant source of seasonal revenue to individual fishermen. Shortfin mako shark ex-vessel revenue accounts for over 15 percent of the total shark ex-vessel revenue, but only 1 percent of overall HMS ex-vessel revenue (Table 2).

Table 3. Disposition of shortfin mako shark interactions with pelagic longline gear, 2013-2016. Source: Atlantic Pelagic Observer Program

Year	Number of Shortfin Mako Discarded Alive	Number of Shortfin Mako Discarded Dead	Number of Shortfin Mako Kept (Alive at Vessel)	Number of Shortfin Mako Kept (Dead at Vessel)	Total	Percent of Shortfin Mako Alive at Vessel	Percent of Shortfin Mako Discarded Alive
2013	204	52	132	81	469	71.6%	60.7%
2014	105	31	137	31	344	70.3%	43.4%
2015	128	27	212	59	444	76.6%	37.6%
2016	87	30	480	211	808	70.2%	15.3%
AVG	131	35	240	96	502	74.0%	35.3%

Table 4. Shortfin mako shark interactions in the pelagic longline fishery, 2012-2016. Source: Fisheries Logbook System (pelagic longline)

Year	Total Number of Vessels	Total Number of Trips	Number of Vessels Reporting Shortfin Mako Sharks	Number of Trips with Shortfin Mako Shark Interactions	Number of Shortfin Mako Sharks Kept	Number of Shortfin Mako Sharks Discarded Dead	Number of Shortfin Mako Sharks Discarded Live	Total Shortfin Mako Shark Interactions
2012	112	1,592	108	659	2,226	58	367	2,651
2013	115	1,558	103	663	2,941	24	407	3,372
2014	110	1,422	90	508	3,117	17	388	3,522
2015	104	1,185	81	434	2,007	16	483	2,506
2016	85	1,025	70	402	2,062	49	347	2,458
AVG	107	1,356	90	533	2,471	33	398	2,902

Table 5. Top 10 ports reporting shortfin mako shark landings, 2013-2017. Note: All commercial landings are in lb dw. Source: HMS eDealer database

Port	State	Total Commercial Landings of Shortfin Mako Shark	Percentage of Total Shortfin Mako Shark Landings
Wanchese	NC	336,793	37.2%
Fairhaven	MA	98,843	10.9%
Barnegat Light	NJ	56,992	6.3%
Ocean City Harbor	MD	41,407	4.6%
New Bedford	MA	34,282	3.8%
Fort Pierce	FL	34,260	3.8%
Newfoundland and Labrador	CN	33,762	3.7%
Beaufort	NC	32,468	3.6%
Islip	NY	27,090	3.0%
Wadmalaw Isalnd	SC	20,979	2.3%

Pros

- Would have ecological benefits since it is expected to result in live release and reducing shortfin mako shark fishing mortality.
- Would assist with the rebuilding of the stock since the U.S. would be implementing part of the ICCAT Recommendation under this option.
- Would be consistent with the Magnuson-Stevens Act requirement to end overfishing and to implement a rebuilding plan within two years of determining a species is overfished and experiencing overfishing.

Cons

- Would have some negative socioeconomic impacts on fishermen since they would have to release all live shortfin mako sharks, reducing efficiency, landings, and potential economic benefits, although shortfin mako sharks are not significant source of revenue.

Option 3 – Allow retention of a shortfin mako shark by persons with a Directed or Incidental shark LAP only if the shark is dead at haulback, caught incidentally with pelagic longline gear during fishing for other species, and there is a functional electronic monitoring system on board the vessel

Option 3 would allow retention of a shortfin mako shark only if it is dead at haulback by a vessel with a Directed or Incidental shark LAP, if it is caught incidentally during fishing for other species using pelagic longline gear, and a functional electronic monitoring system onboard the vessel. In the commercial fishery, the vast majority of shortfin mako sharks are rarely targeted. Rather, these sharks are caught incidentally on pelagic longline sets that are targeting tunas and swordfish. Under the current HMS regulations, all HMS permitted pelagic longline vessels are already required to have an electronic monitoring system on board the vessel (79 FR 71510; December 2, 2014) and either a Directed or Incidental shark LAP. Commercial vessels with other gear types, such as bottom longline or gillnet vessels, could not land dead shortfin mako sharks under this option.

Based on HMS logbook data, 85 percent of shortfin mako sharks caught are kept and landed by fishermen across all gear types, while 14 percent are discarded alive and 1 percent are discarded dead (Table 4). Based on Pelagic Observer Program data, over 70 percent of the shortfin mako sharks are alive upon capture on pelagic longline vessels (Table 6). Therefore, this option would require those individuals to release the majority of the shortfin mako sharks caught and only a small portion of shortfin mako sharks would be retained (those that are dead at haulback and of legal size). Survival rates are expected to be high for released sharks.

Table 6. Summary of all available observed shortfin mako shark interactions by data source, 2012-2016.

Year	Data Source	Number of Vessels Observed with Shortfin Mako	Number of Shortfin Mako Kept	Number of Shortfin Mako Discarded Dead	Number of Shortfin Mako Discarded Alive	Total
2012	NEFSC Northeast Fisheries Observer Program	3	0	3	0	3
	Atlantic Pelagic Observer Program (PLL)	66	167	56	153	376
	SEFSC Bottom Longline Observer Program Targeting Sharks	1	0	0	1	1
	SEFSC Gillnet Observer Program Targeting Sharks	0	0	0	0	0
2013	NEFSC Northeast Fisheries Observer Program	2	0	2	0	2
	Atlantic Pelagic Observer Program (PLL)	75	213	52	204	469
	SEFSC Bottom Longline Observer Program Targeting Sharks	0	0	0	0	0
	SEFSC Gillnet Observer Program Targeting Sharks	0	0	0	0	0
2014	NEFSC Northeast Fisheries Observer Program	9	9	4	1	14
	Atlantic Pelagic Observer Program (PLL)	56	206	31	105	342
	SEFSC Bottom Longline Observer Program Targeting Sharks	0	0	0	0	0
	SEFSC Gillnet Observer Program Targeting Sharks	0	0	0	0	0
2015	NEFSC Northeast Fisheries Observer Program	8	3	5	0	8
	Atlantic Pelagic Observer Program (PLL)	54	271	26	131	428
	SEFSC Bottom Longline Observer Program Targeting Sharks	0	0	0	0	0
	SEFSC Gillnet Observer Program Targeting Sharks	0	0	0	0	0
2016	NEFSC Northeast Fisheries Observer Program	4	5	0	1	6
	Atlantic Pelagic Observer Program (PLL)	50	691	27	143	861
	SEFSC Bottom Longline Observer Program Targeting Sharks	2	2	1	0	3
	SEFSC Gillnet Observer Program Targeting Sharks	0	0	0	0	0

Currently, commercial pelagic longline vessels are required to report shortfin mako shark catches in logbooks. Landings information is reported by an authorized HMS dealer while observers record information on catches. Since an operating electronic monitoring system is already required on board the vessel, the footage would assist with improving monitoring of shortfin mako sharks.

Pros

- Improved health of the stock as there would be an increase on live releases of shortfin mako sharks that would otherwise have been retained and landed.
- No increases in fishing effort in the commercial pelagic longline fishery expected.
- Provides another potential check of data between all other sources: observers, logbooks, or dealers.
- Does not create additional reporting or permit requirements for pelagic longline vessels.
- Contribute to ending overfishing and rebuilding consistent with MSA requirements and contribute to ICCAT recommendation requirements consistent with ICCAT obligations and ATCA.

Cons

- Reduced opportunities to land shortfin mako sharks for vessels who do not meet the criteria and may want to retain shortfin mako (e.g., bottom longline, gillnet, handgear, etc.).
- Reduced opportunities and revenue losses by the pelagic longline fishery as a result of the landing reduction for the commercial fishery. Even though shortfin mako sharks are a minor source of economic revenue to the overall HMS commercial fisheries, this species could be a significant source of seasonal revenue to individual fishermen.
- Could have negative socioeconomic impacts on fishing communities with higher reliance on shortfin mako shark landings.

Option 4 – Prohibit the landing of all shortfin sharks caught on non-pelagic longline gear (e.g., bottom longline, gillnet, handgear, etc.)

Under Option 4, NMFS would prohibit the landing of all shortfin mako sharks caught by commercial fishermen using non-pelagic longline gear (e.g., bottom longline, gillnet, handgear, etc.). Commercial fishermen using non-pelagic longline gear would be required to release all shortfin mako sharks with a minimum of harm, while giving due consideration to the safety of crew members. Based on HMS logbook data, an annual average of ten commercial vessels that used non-pelagic longline gear interacted with shortfin mako sharks (Table 7). Those vessels only interacted with, on average, 18 shortfin mako sharks per year of these 14 shortfin mako sharks were kept. This represents less than 1 percent of the total shortfin mako shark interactions in the HMS logbook data.

Table 7. Shortfin mako shark interactions in non-pelagic longline fisheries, 2012-2016. Source: Fisheries Logbook System.

Year	Total Number of Vessels	Total Number of Trips	Number of Vessels Reporting Shortfin Mako Sharks	Number of Trips with Shortfin Mako Shark Interactions	Number of Shortfin Mako Sharks Kept	Number of Shortfin Mako Sharks Discarded Dead	Number of Shortfin Mako Sharks Discarded Live	Total Shortfin Mako Shark Interactions
2012	123	1,136	14	23	17	0	6	23
2013	92	844	8	19	15	0	6	21
2014	88	751	12	19	13	0	8	21
2015	89	640	7	8	7	0	7	8
2016	87	538	10	15	18	0	1	19
AVG	96	782	10	17	14	0	6	18

Pros

- Improved health of the stock as there would be an increase on live releases of shortfin mako sharks that would otherwise have been retained and landed.
- No increase in protected resources interactions or fishing effort in the commercial pelagic longline fishery expected.
- Would only affect a small number of fishermen since pelagic longline gear is the primary commercial gear used to land pelagic shark species, including shortfin mako sharks.
- Would have few socioeconomic impacts for individual fishermen, given so few shortfin mako sharks are caught on non-pelagic longline gears.

Cons

- Would cause fishermen who interact with shortfin mako sharks with non-pelagic longline gear to release the sharks regardless on their status (live or dead).
- Reduced opportunities and revenue losses by the pelagic longline fishery as a result of the landings reduction for the commercial fishery.
- Would have negative socioeconomic impacts on individual fishermen with higher reliance on shortfin mako shark landings.

Option 5 – Remove shortfin mako sharks from pelagic shark quota; use recent landings to both establish a shortfin mako shark quota and adjust the pelagic shark quota

Under Option 5, NMFS would remove shortfin mako sharks from the pelagic shark quota and would establish a species-specific quota for shortfin mako sharks and a new pelagic shark species quota for common thresher and oceanic whitetip sharks based on recent landings. The quotas for blue and porbeagle sharks would not change under this option and would be 273 mt dw and 1.7 mt dw, respectively. Regulations regarding overharvest and underharvest of pelagic shark quota, and retention limits for pelagic sharks would remain the same.

Shortfin mako sharks are caught as bycatch in the pelagic longline fishery, and there is no directed fishery in the United States for this species. Removing shortfin mako sharks from the quota group of pelagic sharks, which includes common thresher, oceanic whitetip, and shortfin mako sharks, would allow them to be managed separately and would give NMFS the ability to track this separate quota more efficiently. To be consistent with the current ICCAT Recommendation, NMFS would need to require live release of shortfin mako sharks in the pelagic longline fishery, so only shortfin mako sharks that are dead at haulback could be retained (as described in Commercial Options 2 and 3 above) and counted towards a shortfin mako shark quota. Currently, the annual quota for common thresher, oceanic whitetip, and shortfin mako is 488 mt dw. On average, only 24 percent (116.3 mt dw) of the pelagic shark quota is filled every year of which approximately 71 percent (82.1 mt dw) is comprised of shortfin mako sharks (Table 8). While establishing a quota could allow NMFS to track shortfin mako and pelagic shark landings more efficiently, establishing a shortfin mako shark quota goes beyond the current ICCAT Recommendation. Additionally, if a large number of dead shortfin mako sharks are caught and appropriately landed under the ICCAT Recommendation, any quota established could be exceeded which would cause the fishery to close and require fishermen to release dead shortfin mako sharks, contributing to regulatory discards and waste, which would not be consistent with the recommendation.

Table 8. Commercial Landings of Shortfin Mako, Oceanic Whitetip, and Thresher Sharks, 2013-2017.
Source: 2013-2016 data from 2017 HMS SAFE Report; 2017 data from HMS eDealer database (preliminary).

Year	Shortfin Mako Shark (lb dw)	Shortfin Mako shark (mt dw)	Oceanic Whitetip Shark (lb dw)	Oceanic Whitetip Shark (mt dw)	Thresher Shark (lb dw)	Thresher shark (mt dw)
2013	199,177	90.3	62	< 0.1	48,768	22.1
2014	218,295	99.0	22	< 0.1	116,012	52.6
2015	141,720	64.2	0	0	72,463	32.9
2016	160,829	73.0	0	0	78,219	35.5
2017	185,403	84.1	0	0	61,284	27.8
Average	181,085	82.1	17	< 0.1	75,349	34.2

Pros

- Establishing a separate shortfin mako shark quota could allow fishermen to track monthly updates of how many shortfin mako sharks have been caught, via the shark landings updates released on the HMS Management Division listserv and website.
- Establishing a quota would cap commercial landings of shortfin mako sharks in the U.S. which would assist with a potential rebuilding plan in the future.

Cons

- A species-specific landings quota would require authorized fishermen to discard all shortfin mako sharks once the quota is reached, potentially leading to an increase in regulatory discards, which would not contribute to the health of the stock.
- A reduced pelagic shark species quota may also lead to increased regulatory discards of common thresher and oceanic whitetip sharks if the quota is reached.
- Given there are no current stock assessments for oceanic whitetip or common thresher sharks, it would be difficult to determine the ecological impacts of setting a reduced quota for these two species when you remove shortfin mako sharks from the pelagic shark species management group.
- ICCAT has not established country-specific TACs for shortfin mako sharks. Because the United States does not have a TAC for shortfin mako sharks, it is difficult to determine at what level to set a species-specific quota to best benefit the stock, while also accounting for high catches from other countries.
- The data are not yet available from the ICCAT SCRS on areas of high shortfin mako shark interactions, there is no information fishermen can use to avoid interacting with shortfin mako sharks once the quota is met.
- A reduced pelagic shark species quota and species-specific shortfin mako shark quota could potentially result in revenue losses to fishermen and businesses that rely on this resource if the quotas are met before the season ends.
- A shortfin mako shark quota and a reduced pelagic shark species quota could disadvantage vessels that primarily fish later in the year, depending on when in the year the quotas are met.

Option 6 – Allow retention of shortfin mako sharks greater than 83 inches FL by persons with a Directed or Incidental shark LAP caught on non-pelagic longline gear (e.g., bottom longline, gillnet, handgear, etc.)

Option 6 would establish a commercial minimum size of 83 inches FL (210 cm FL) for non-pelagic longline gears to retain a shortfin mako shark. The majority of commercial shortfin mako shark interactions occur in the pelagic longline fishery (> 97 percent of catch), but observer reports from the NEFSC Northeast Fisheries Observer Program and SEFSC Bottom Longline Observer Program Targeting Sharks have observed small numbers of shortfin mako shark interactions (Table 6). Currently, there are no commercial minimum size restrictions for sharks because any such restriction would require the head remain attached for the size to be valid. Because sharks need to be dressed quickly to preserve the quality of the meat, fishermen are allowed to dress the shark by removing the head and the viscera as long as the fins remain naturally attached to the carcass. Under this option, fishermen would be required to leave the head of the shortfin mako shark attached to the carcass unless an appropriate alternative minimum size specific to shortfin mako sharks can be determined.

Pros

- Could have beneficial socioeconomic impact on non-pelagic longline gears since fishermen with this gear would have to discard all shortfin mako sharks under other options (i.e., Commercial Option 4 and 5).
- Could have beneficial ecological impacts to the stock since non-pelagic longline gear fishermen would only be able to retain shortfin mako sharks greater than 83 inches FL (210 cm FL).
- Would be consistent with ICCAT Recommendation 17-08.

Cons

- Vessels with non-pelagic longline gear on board are not required to have electronic monitoring or have a low to no observer coverage rate.
- Would allow additional landings of shortfin mako sharks (dead or alive), which could have ecological impacts to the stock.
- Would require the head remain attached to the shark carcass, which could reduce the quality of the meat and reduce the ex-vessel price. Additionally, keeping the head on a large shark could also complicate the packing/storage process and reduce efficiencies on the vessel.

Option 7 – Allow landing of shortfin mako sharks that are dead at haulback by persons with a Directed or Incidental shark LAP caught on non-pelagic longline gear (e.g., bottom longline, gillnet, handgear, etc.) only if an observer is on board

Option 7 would allow fishermen to retain shortfin mako sharks caught on gears other than pelagic longline (e.g., bottom longline, gillnet, handgear, etc.), provided that an observer is on board that can verify that the shark was dead at haulback. This option is similar to Commercial Option 3 except that the observer would be acting in a capacity similar to the electronic monitoring system and confirming whether the shark was dead before it was brought onboard the vessel. On average, only about one percent of the total shortfin mako shark landings occurred on non-pelagic longline gear (Table 9). Currently, observer coverage on bottom longline shark research fishery is 100 percent and bottom longline observer overage outside the shark research fishery is 5 – 10 percent. Observer coverage in the shark gillnet fishery is 4 – 11 percent.

Table 9. Shortfin mako shark commercial landings by gear type, 2013-2016. Source: HMS eDealer database, which includes some uncertainty in gear type reporting.

Gear Type	Total Landed Weight (lb dw)	Percent of Total
Longline (Pelagic and Bottom)	700,263	97.26%
Gillnets	7,914	1.10%
Hook and Line	7,180	1.00%
Hand Line	2,758	0.38%
Other/Unknown	1,906	0.26%

Pros

- Would allow other gears types to catch and land a small amount (less than one percent of total landings) of shortfin mako sharks when compared to pelagic longline.
- Could provide beneficial socioeconomic per-trip revenue for some fishermen.
- Would be consistent with ICCAT Recommendation 17-08.

Cons

- Would not lead to a large amount of landings due to the low landings reported and observations on non-pelagic longline gear. Imposing additional regulations may not justify the minimal impact.
- Observers would be required to determine the disposition of the shark and whether the fishermen can retain it. This could hinder normal observer data collection activities and exacerbate tensions on the vessel.
- Shortfin mako sharks that are caught when no observer is onboard the vessel, which is likely given the rarity of catching a shortfin mako shark on these gears and the current percent of observer coverage for these gear types, would still need to be discarded, live or dead.

Option 8 – Prohibit the commercial landing of all shortfin mako sharks, live or dead

Option 8 would place shortfin mako sharks on the prohibited species list to prohibit any catch or retention of shortfin mako sharks in commercial HMS fisheries, although some small level of bycatch would be expected to occur. HMS permit holders would be prohibited from landing shortfin mako sharks commercially. On average, 181,085 lb dw of shortfin mako sharks are landed annually, which accounts for on average 71 percent of the total pelagic shark landings (Table 10).

Table 10. Commercial Landings of Shortfin Mako Sharks and Percentage of the Pelagic Shark Landings, 2013-2017. Source: HMS eDealer database.

Year	Commercial Landings (lb dw)	Percentage of Pelagic Shark Landings
2013	199,177	77%
2014	218,295	61%
2015	141,720	66%
2016	160,829	67%
2017	185,403	75%
Average	181,085	71%

Pros

- Could result ecological benefits and assist with the potential rebuilding of the stock since the total landings of shortfin mako sharks would be reduced from their current levels to zero.
- Interactions with shortfin mako sharks would still occur in commercial fisheries, but all individuals would be release or discarded. The only remaining sources of mortality would be from post-release mortality and those individuals that are dead at haulback.
- Would result a large numbers of live releases of shortfin mako sharks would be released that would otherwise have been retained and landed.
- Would comply with the obligations under MSA since we would prohibit landings and assist with ending overfishing of the stock.

Cons

- Would eliminate all commercial ex-vessel revenues derived from shortfin mako sharks (approximately $375,000 per year).
- Lost revenues would have greater socioeconomic impacts on fishing communities with higher reliance on shortfin mako shark landings, including Wanchese, NC, Fairhaven/New Bedford, MA, and Barnegat Light, NJ.

2.2 Recreational Options

NMFS is also considering a variety of recreational options, some of which are from ICCAT Recommendation 17-08 and interim final rule, and some that otherwise promote ending overfishing and/or rebuilding, but are not specifically included in the ICCAT Recommendation. These range from no action, creating a catch and release fishery for shortfin mako sharks, increasing the minimum size to 83 inches FL or greater, restricting landings to tournaments or tagging program, revising the circle hook requirement, and establishing a variable inseason minimum size restriction.

Option 1 – No Action. Keep current regulations for shortfin mako sharks

Under Option 1, NMFS would maintain the current recreational regulations that pertain to shortfin mako sharks established in the 2006 Consolidated HMS FMP and amendments. Recreational fishermen would continue to be limited to one authorized shark species, which includes shortfin mako sharks, greater than 54 inches FL per vessel per trip along with one Atlantic sharpnose and bonnethead shark per person and an unlimited number of smoothhound sharks per trip. In addition, keeping the current regulations the same would allow overfishing of shortfin mako sharks to continue and further reduce the stock size.

Pros

- HMS recreational fishermen would continue to be able to harvest shortfin mako sharks under the current recreational vessel and size limit.
- No short-term negative economic effects on the fishery.

Cons

- Overfishing of shortfin mako sharks would continue and further reduce the stock size, complicating rebuilding efforts. If stock health continues to decline, future stock assessments may advise no fishing mortality immediately, which could result in reduced access to the resource for U.S. fishermen and restrictions in fisheries that interact with the species.
- This option would not implement ICCAT Recommendation 17-08, which requires contracting parties to reduce mortality of shortfin mako sharks and includes several measures that largely focus on maximizing live releases of shortfin mako sharks. Failing to implement ICCAT Recommendation 17-08 and address overfishing of shortfin mako sharks would be inconsistent with ATCA and may result in ICCAT penalties or restrictions specific to the United States.
- Would be inconsistent with the Magnuson-Stevens Act requirement to end overfishing and to implement a rebuilding plan within two years of determining a species is overfished and experiencing overfishing.

Option 2 – Prohibit landing of shortfin mako sharks in in the HMS recreational fishery (catch and release only)

Under Option 2, recreational HMS anglers (fishermen who hold HMS Angling or Charter/Headboat permits, or Atlantic Tunas General category and Swordfish General Commercial permits when participating in a registered HMS tournament) would only be authorized to catch and release shortfin mako sharks. This is similar to recreational measures for the catch and release of white sharks.

Pros

- Could reduce mortalities of shortfin mako sharks in the recreational fishery.
- Could help to rebuild the overfished stock.
- Would not prevent U.S. fishermen from recreational fishing for shortfin mako sharks.

Cons

- May have some negative socioeconomic impacts to HMS tournaments that have traditionally landed sharks, due to the decreased opportunity to land shortfin mako sharks. However, HMS tournaments could still target shortfin mako sharks under this option.
- Could have some negative socioeconomic impacts on charter/headboat operators whose passengers want to land shortfin mako sharks.

Option 3 – Increase the minimum size limit for the retention of shortfin mako sharks from 54 inches FL to 71 inches FL (180 cm FL) for male and 83 inches FL (210 cm FL) for female shortfin mako sharks

Option 3 would implement management measures for the HMS recreational fishery consistent with ICCAT Recommendation 17-08. Recreational HMS permit holders would only be allowed to retain male shortfin mako sharks that measure at least 71 inches FL (180 cm FL) and female shortfin mako sharks that measure at least 83 inches FL (210 cm FL), reducing the amount of recreational landings. According to length composition information from the Large Pelagics Survey (LPS), this option would reduce the recreational landings of male shortfin mako sharks by up to 44 percent and female shortfin mako sharks by up to 78 percent assuming 100 percent retention of legal-sized sharks (Table 11). Shortfin mako sharks below those minimum sizes would likely still be caught and released by recreational fishermen, but only 56 percent of males and 22 percent of females that are caught are expected to be large enough to retain under this option.

Table 11. Size composition of sampled male and female mako sharks in the recreational fishery, 2010-2016 (N=581). Source: Large Pelagics Survey.

Fork Length Category	Percent of Total Males	Percent of Total Females
<54 in (137 cm)	0	1
54-71 in (137-180 cm)	44	38
71-83 in (180-210 cm)	45	39
>83 in (210 cm)	11	22

Pros

- Could result in beneficial ecological impacts since a large numbers of live releases of shortfin mako sharks would occur in the U.S. that would otherwise have been retained and landed.

Cons

- Would potentially result in negative socioeconomic impacts to recreational fishermen and tournament operators due to decreased opportunity to land shortfin mako sharks.
- Confirming the sex of a large and potentially active shortfin mako shark prior to its landing can be challenging for fishermen and may have safety implications.

Option 4 – Increase the minimum size of all shortfin mako sharks from 54 inches FL to 83 inches (210 cm) FL

Under Option 4, recreational fishermen (those who hold HMS Angling or Charter/Headboat permits, and Atlantic Tunas General category and Swordfish General Commercial permits when participating in a registered HMS tournament) could only land shortfin mako sharks, male or female, that are at least 83 inches FL (210 cm FL). According to length composition information from the Large Pelagics Survey, this recreational minimum size limit could reduce landings by approximately 83 percent in the HMS recreational fishery (Table 12).

Table 12. Proportions and cumulative weights of shortfin mako sharks in various length categories in the recreational fishery, 2012-2016. Source: Large Pelagics Survey.

Fork Length Category	Count	Percent of Total (Count)	Weight in Category (kg)	Percent of Total (Weight)
<54 inches FL (137 cm FL)	89	1%	1,691	0%
54-71 inches FL (137-180 cm FL)	5,490	45%	256,655	29%
71-83 inches FL (180-210 cm FL)	4,676	38%	361,937	41%
>83 inches FL (210 cm FL)	1,911	16%	265,497	30%
Total	12,166		885,779	

Pros

- Could result in beneficial ecological impacts to the stock since a large numbers of live releases of shortfin mako sharks would occur in the U.S. that would otherwise have been retained and landed.
- Would comply with obligations under MSA and ACTA to implement ICCAT recommendations.

Cons

- Would potentially result in negative socioeconomic impacts to recreational fishermen and tournament operators due to the decreased opportunity to land shortfin mako sharks.

Option 5 – Increase the minimum size of all shortfin mako sharks to 83 inches FL and allow retention in registered HMS tournaments only

Under Option 5, shortfin mako sharks could not be retained outside of registered HMS tournaments. Within registered HMS tournaments, the minimum size for shortfin mako sharks would be increased to 83 inches FL (201 cm FL). HMS tournaments are an important aspect of the HMS recreational fishery. On average, there are 250 HMS tournaments each year with 73 tournaments indicating pelagic sharks as a prize category, which would include shortfin mako sharks (Table 13). Overall, tournaments indicating pelagic sharks as a prize category were the highest in 2014 and 2015 with 84 tournaments in both years. However, 2016 showed a decrease in the number of these tournaments. Based on LPS data, tournaments account for approximately half of the shortfin mako interactions over the last five years; 63 percent of the sharks caught were retained (Table 14). Non-tournament shark interactions result in 53.6 percent being kept. This measure would require the release of all shortfin mako sharks outside tournaments, which could reduce shortfin mako shark mortality over 44 percent. Prohibiting the retention of shortfin mako sharks outside of tournaments and an increase in the minimum size would reduce recreational shortfin mako shark landings in the United States.

Table 13. HMS tournaments targeting shortfin mako and pelagic shark species, 2012-2016.

Year	Total Number of HMS Tournaments	Number of HMS Tournaments with Shortfin Mako Shark in the title or otherwise mentioned by name	Number of HMS Tournaments that Indicated Pelagic Sharks as Target Species (Sharks in General)	HMS Tournaments with Pelagic Sharks as Category by Area	
				Area	Number of Tournaments
2012	218	11	53 (71)	Gulf of Mexico (Caribbean)	25 (2)
				South Atlantic (Keys to SC)	9
				Mid-Atlantic (NC to NY)	16
				North Atlantic (CT to ME)	3
2013	212	13	74 (80)	Gulf of Mexico (Caribbean)	34 (1)
				South Atlantic (Keys to SC)	8
				Mid-Atlantic (NC to NY)	27
				North Atlantic (CT to ME)	5
2014	274	8	84 (85)	Gulf of Mexico	24
				South Atlantic (Keys to SC)	7
				Mid-Atlantic (NC to NY)	39
				North Atlantic (CT to ME)	14
2015	279	8	84 (92)	Gulf of Mexico	27
				South Atlantic (Keys to SC)	12
				Mid-Atlantic (NC to NY)	33
				North Atlantic (CT to ME)	12
2016	267	10	72 (77)	Gulf of Mexico	20
				South Atlantic (Keys to SC)	3
				Mid-Atlantic (NC to NY)	41
				North Atlantic (CT to ME)	8
Average	250	10	73 (81)		

Table 14. Shortfin mako shark observations (numbers and percent) in the Large Pelagic Survey by Tournament and Non-Tournament trips, and their disposition for each trip type, 2010-2015.

Year	Trip Type	Number of Shortfin Mako Interactions (Percentage of Overall)	Number of Shortfin Mako Kept (Percentage of Overall)	Number of Shortfin Mako Released (Percentage of Overall)
2010	Tournament	123 (45.4%)	80 (65.0%)	43 (35.0%)
	Non-Tournament	146 (53.6%)	72 (49.7%)	73 (50.3%)
2011	Tournament	130 (48.7%)	90 (69.2%)	40 (30.8%)
	Non-Tournament	136 (50.9%)	79 (58.1%)	56 (41.2%)
2012	Tournament	149 (56.2%)	100 (67.1%)	49 (32.9%)
	Non-Tournament	116 (43.8%)	51 (44.0%)	65 (56.0%)
2013	Tournament	151 (54.3%)	103 (68.2%)	48 (31.8%)
	Non-Tournament	127 (45.7%)	75 (59.8%)	51 (40.2%)
2014	Tournament	134 (47.4%)	86 (64.2%)	48 (35.8%)
	Non-Tournament	149 (52.6%)	89 (59.7%)	60 (40.3%)
2015	Tournament	161 (53.1%)	78 (48.5%)	83 (51.5%)
	Non-Tournament	142 (46.9%)	74 (50.7%)	70 (49.3%)
Total	Tournament	848 (50.9%)	537 (63.3%)	311 (36.7%)
	Non-Tournament	817 (49.1%)	438 (53.6%)	375 (46.4%)

Pros

- Would have positive ecological impact to the stock since it would limit shortfin mako shark harvest to mature individuals and in tournaments only.
- Could have positive impact on HMS tournament participation since shortfin mako sharks can only be retained in tournaments.
- Would comply with obligations under MSA and ACTA to implement ICCAT recommendations.

Cons

- Negative economic impacts on charter/headboat operators whose passengers have been landing shortfin mako sharks outside of tournaments.
- Negative socioeconomic impacts on non-tournament HMS recreational fishermen since shortfin mako shark retention would be prohibited.

Option 6 – Establish a tagging or lottery program to land shortfin mako sharks greater than 83 inches FL recreationally

Under Option 6, NMFS would establish a tagging or lottery program to allow for the recreational landing of shortfin mako sharks. For this option, registered HMS tournaments would be excluded from this tagging or lottery program and participants would still be allowed to retain shortfin mako sharks greater than 83 inches FL. A possible way to implement this program would be to distribute non-transferable tags to interested HMS recreational permit holders based on a random lottery. HMS recreational permit holders would indicate that they wanted to be included in the lottery when applying for their HMS permit. NMFS would hold random lottery drawings throughout the year, where permit numbers of interested constituents would be selected. This would allow NMFS to potentially set a target catch limit for shortfin mako sharks with the number of tags offered. After tags were distributed, HMS recreational permit holders who received a tag would be able to land a shortfin mako shark greater than 83 inches FL (210 cm FL). Tags would be valid for one year from the date of issuance, with a current HMS permit. NMFS could implement a limit for the number of tags each HMS recreational permit holders would receive a fishing year. The tag would be required to be affixed to the shark at time of landing, and would be required to be reported online within 48 hours of landing. Unused tags, after the date of expiration, would need to be mailed back to NMFS. Failure to comply could jeopardize the ability for constituents to participate in the future.

Pros

- Could result in minor ecological benefits since the number of shortfin mako sharks landed would be limited to the selected recreational HMS permit holders.
- Could result in equal geographic distribution to all recreational participants to the extent that permits are equally distributed.
- Positive socioeconomic benefits if registered HMS tournaments are excluded from this potential tagging or lottery program and participants are still allowed to retain shortfin mako sharks at the new size limit.

- Increase in data availability and confidence in shortfin mako sharks landing estimates.

Cons

- Could cause negative socioeconomic impacts for HMS recreational or charter/headboat permit holders who were not selected to receive a tag in a given fishing year.
- More registered HMS tournaments might occur to get around this program and there is no current reporting requirements for tournaments.
- Administrative burden on HMS recreational permit holders and to the agency to procure and distribute tags, track landings, and ensure tag returns.

Option 7 – Require use of circle hooks for recreational shark fishing in all areas (remove the current management line established for dusky sharks near Chatham, MA)

Option 7 would expand the requirement to use non-offset, non-stainless steel circle hook by all HMS permit holders with a shark endorsement when fishing for sharks recreationally, except when fishing with flies or artificial lures, to all waters managed within HMS management division. As of January 1, 2018, this regulation has been in place for all federally managed waters south of 41° 43’ N latitude (near Chatham, Massachusetts), but this option would remove the boundary line, requiring fishermen in all areas to use circle hooks. The use of circle hooks may improve the survival rate of sharks that are released by decreasing deep hooking and attendant mortality associated with J-hooks.

Pros

- Would have ecological benefits to the stocks for all sharks including shortfin mako sharks since circle hooks would allow sharks to be more easily released in better condition, reducing dead discards and post-release mortality.
- Would simplify recreational management measures across entire region.

Cons

- Could cause some confusion with constituents since this would change the regulation just implemented at the start of 2018.
- Would cause minor socioeconomic impacts on recreational shark fishermen above the current Chatham, MA line since they would need to buy circle hooks.

Option 8 – Establish a minimum size limit for the retention of shortfin mako sharks that is greater than 83 inches FL

Raising the recreational minimum size for shortfin mako sharks from 54 to 83 inches FL (210 cm FL) would result in significant reductions in recreational landings, but there is some disagreement in the scientific literature about the median size at maturity for female shortfin mako sharks. ICCAT adopted 83 inches FL (210 cm FL) as the minimum size for female shortfin mako sharks based on the results of Maia et al. (2007b) which estimated length at maturity for females to be between 83 to 114 inches FL (210 to 290 cm FL). Other papers have identified the median size at maturity for female mako sharks to be in the upper reaches of this range with Stevens (1983) and Kohler et al. (2002) estimating it to be as high at 102 or 108 inches FL. Thus, Option 8 considers establishing a minimum size limit that is greater than the ICCAT Recommendation of 83 inches FL (**Table 15**).

Table 15. Estimated number of shortfin mako sharks harvested from 2012-2016 under the existing 54 inches FL minimum size limit compared to the number that would have been harvested under four options of minimum length limits. Source: Large Pelagic Survey.

Minimum Size	2012	2013	2014	2015	2016	Average	Average (mt ww)
54 inches FL	2,735	2,762	2,650	2,126	1,893	2,433	177.2
83 inches FL	408	542	309	325	327	382	53.1
90 inches FL	46	181	172	103	235	147	25.1
102 inches FL	0	0	0	0	117	23	5.4
108 inches FL	0	0	0	0	30	6	1.7

Increasing the minimum size limit for mako sharks from 54 to 83 inches FL would reduce recreational harvest by 84 percent, or 124 mt whole weight (ww), based on average landings from 2012 to 2016 (Table 16). Raising the minimum size to 90 inches FL would reduce the average annual landings by 94 percent and a further 25 mt ww, while further raising the minimum size limit to 102 inches FL would reduce average landings by 99 percent. Any minimum size greater than 102 inches FL would result in estimates of zero harvest of shortfin mako sharks in most years. A breakdown of observed shortfin mako shark landings in the LPS by sex also shows that the sex to size ratio of shortfin mako shark landings below 83 inches FL is approximately 45 percent male and 55 percent female. Above 83 inches FL this ratio shifts to 26 percent male and 74 percent female with 100 percent of observed harvest being female at 102 inches FL or greater.

Table 16. Observed sex to size ratio of shortfin mako sharks harvested from 2012-2016 by size range. Source: Large Pelagic Survey.

Size Range	Percent of Male Shortfin Mako Sharks	Percent of Female Shortfin Mako Sharks
54 to 83 inches FL	45.4%	54.6%
83 to 90 inches FL	26.4%	73.6%
Greater than 102 inches FL	0.0%	100.0%

Increasing the minimum size beyond 83 inches FL may also have a slight negative socioeconomic effect on HMS tournaments. According to NMFS Northeast Fisheries Science Center tournament data, the 83 inches FL (210 cm FL) minimum size implemented by the emergency rule may not greatly impact tournament landings of shortfin mako sharks, where most of the largest sharks landed were above the 83 inches FL (210 cm FL) minimum size (Table 17). However, the larger minimum size limits being considered (102 inches and 108 inches FL) would exceed the sizes of many tournament winning sharks since 2012.

Table 17. Mean weights and lengths of the five largest shortfin mako sharks landed at Northeast shark tournaments, 2012-2016. Source: NEFSC Apex Predator Program

Year	Mean weight of 5 largest sharks (lb ww)	Fork Length (inches)	Fork Length (cm)	Largest male (lb ww)	Fork Length (inches)	Fork Length (cm)
2012	349	95	241.3	368	96	243.8
2013	329.2	93	236.2	311	91	231.1
2014	319.1	92	233.7	294.4	90	228.6
2015	415.8	100	254	349	95	241.3
2016	443.8	102	259.1	507	107	271.8

Pros

- Could result in beneficial ecological impacts.
- Increasing the minimum size limit beyond the ICCAT Recommendation could further reduce recreational harvest and could allow for some minor increased benefit in beginning to rebuild the North Atlantic shortfin mako shark stock.
- Could result in the release of more immature female sharks, which could increase the available breeding stock.

Cons

- Would potentially result in negative socioeconomic impacts to recreational fishermen and tournament operators due to the decreased opportunity to land shortfin mako sharks.
- Would largely turn the shortfin mako shark recreational fishery into a catch-and-release fishery since majority of the sharks (94-99 percent) would be below the considered minimum size limits.

Option 9 – Establish a variable inseason minimum size limit for shortfin mako sharks

Option 9 would establish criteria for making adjustments to the recreational minimum size limit for shortfin mako sharks on an inseason basis in response to landings estimates from LPS. Under this option, the minimum size for shortfin mako sharks would initially be set at 83 inches FL (210 cm FL). NMFS would monitor monthly landings estimates generated by LPS which covers Maine to Virginia from June through October each year. If shortfin mako shark landings estimates for the year exceed a set threshold, based on a rebuilding program, action could be taken to increase the minimum size within a fishing season. This would reduce landings while still allowing for harvest by HMS tournaments and recreational anglers. The minimum size limits under consideration would be within the range analyzed in Recreational option 8, and the size limit selected would be determined based on how much landings exceeded the rebuilding program. Option 9 is similar to current regulations at 50 CFR 635.20 (d)(5) where minimum size limits for blue marlin, white marlin, and roundscale spearfish may be increased within a fishing season as total landings approach the 250 marlin annual landings limit. The purpose of this measure for shortfin mako sharks would give recreational fishermen extra incentive to practice catch-and-release of shortfin mako sharks, and ensure rebuilding targets are not exceeded.

However, without mandatory reporting of shortfin mako landings, such an action would likely not be taken any earlier than August as the first LPS harvest estimates are not available until late July. Analysis of shortfin mako shark catch in the LPS from 2012 to 2016 show that on average the majority (54 percent) of harvest occurs in the month of June with 23 percent of harvest occurring in July, and the remaining 23 percent being spread out from August to October (Table 18). As such, the first LPS monthly estimate for June should provide an accurate impression of the scale of harvest for the year.

Table 18. Mean shortfin mako catch, harvest, and release estimates by month from, 2012-2016. Source: Large Pelagic Survey.

Month	Monthly Catch (Number of sharks)	Percent of Total Catch	Monthly Harvest (Number of sharks)	Percent of Total Harvest	Monthly Releases (Number of sharks)	Percent of Total Releases
June	2,779	43.1%	1,306	53.7%	1,473	36.7%
July	2,165	33.6%	570	23.4%	1,596	39.7%
August	870	13.5%	302	12.4%	568	14.1%
September	428	6.6%	195	8.0%	233	5.8%
October	207	3.2%	60	2.5%	147	3.7%

Pros

- Would increase flexibility in the management of the recreational mako shark fishery.
- Would have fewer negative socioeconomic benefits than establishing a minimum size limit greater than 83 in FL.

Cons

- Could have minimal limited efficiency for management as the majority of shortfin mako shark harvest occurs within the first couple months of the recreational fishing season.
- Could cause confusion with HMS tournaments and permit holders if the minimum size for shortfin mako sharks changes inseason multiple times.
- Could cause socioeconomic impacts to Northeast HMS tournaments and permit holders if the minimum size limit increases to greater than 83 inches FL when the water warms in their fishing area and they are starting to target shortfin mako sharks.
- Increasing the minimum size limit at a size greater than 83 inches FL would impact HMS tournaments if participants cannot land this species.

- Could have negative economic impacts to late season tournaments if they have to reprint tournament brochures and regulations due to an inseason adjustment in the shortfin mako minimum size limit.

2.3 Monitoring Options

ICCAT Recommendation 17-08 suggests improving data collection for shortfin mako sharks. In the HMS commercial fisheries, data collection occurs through the electronic monitoring coverage on each pelagic longline vessel, logbook reporting, observers, and dealer reports of landings. However, NMFS could improve reporting by establishing mandatory reporting through the vessel monitoring system (VMS). In the HMS recreational fishery, data collection occurs through LPS or another recreational reporting database like Marine Recreational Information Program (MRIP) and state catch cards. Since the data collection in the recreational fishery is not as real-time, NMFS is considering some options to help improve the recreational estimates for shortfin mako sharks.

Option 1 – No action. Do not require reporting of shortfin mako sharks outside of current reporting systems.

Under Option 1, no additional reporting requirements would be placed on shortfin mako shark landings in HMS fisheries. HMS commercial fishermen would continue to report through vessel logbooks along with dealer reporting. HMS recreational anglers fishing from Maine to Virginia would continue to be required to report shortfin mako landings and released if intercepted by the LPS, and data would continue to be collected on shortfin mako shark catches by the Access Point Angler Intercept Survey (APAIS), which is part of MRIP. HMS Angling and HMS Charter/ Headboat permit holders would not be required to report their landings of shortfin mako sharks on non-tournament trips, and tournament operators would not be required to report landings associated with shark tournaments unless selected.

Pros

- Would not increase reporting burden on HMS permit holders and HMS tournaments.

Cons

- Logbook reporting could be delayed up to 30 days.
- Reports of shortfin mako sharks in the LPS and APAIS would become less frequent if the minimum size limit is increased and cause less precise estimates of recreational landings, which could increase uncertainty in stock assessments.

Option 2 – Establish mandatory reporting of shortfin mako catches (landings and discards) on VMS

Option 2 would require vessels with an Directed or Incidental shark LAP to report daily the number of shortfin mako sharks retained and discarded dead as well as fishing effort (number of sets and number of hooks). This option is intended to support the inseason monitoring of shortfin mako shark catches. Currently, commercial vessels are required to report shortfin mako shark catch in the HMS logbook. In addition, landings information is reported by dealers and observers record information on catches. However, more timely information on shortfin mako catches, as can be obtained through VMS reporting, could improve real-time inseason monitoring. There is a time lag between the time logbooks are submitted or the field information is reported by the observer during a fishing trip, the time the data are entered into a database, and the time the data are finalized (after a process of quality control) and available for use.

Reporting to NMFS would be similar to bluefin tuna caught on pelagic longline gear as required by regulations at 50 C.F.R. § 635.69(e)(4)(i). For example, each set, as instructed by NMFS, the date and area of the set, the number of hooks and the length of all shortfin mako sharks retained (actual), and the length of all shortfin mako sharks discarded dead or alive (approximate), would need to be reported within 12 hours of completing each pelagic longline haulback via the VMS unit.

Under current HMS regulations, pelagic longline vessels and purse seine vessels are required to have NMFS-approved enhanced mobile transmitting unit (E-MTU) VMS installed, as are vessels with a Directed shark LAP and bottom longline or gillnet gear on board as described at §635.69(a). A requirement to report shortfin mako shark catches on VMS would be an additional reporting requirement for those vessels on their existing systems, while for other commercial vessels the requirement would mean installing VMS to report shortfin mako catches. Eligible commercial vessel owners could receive reimbursement for the cost of purchasing a VMS, contingent on the availability of funds.

<u>Pros</u>

- Supports timely inseason monitoring of catch, which would support implementation of certain other management options (e.g., a shortfin mako shark quota).
- Provides another source of data to verify data from other sources: electronic monitoring, observers, logbooks, or dealers.

<u>Cons</u>

- Creates an additional reporting requirement for vessels with Directed or Incidental shark LAPs.
- Creates a requirement for Directed or Incidental shark LAP vessels who fish commercially with handgear to install VMS.
- May not be necessary given existing reporting requirements (i.e., logbooks, eDealer, electronic monitoring), depending on what other management options VMS reporting would support.

Option 3 – Implement mandatory reporting of shortfin mako shark landings and discards in registered HMS tournaments (ATR)

Existing regulations at 50 CFR 635.5(d) authorize NMFS to select tournaments for reporting. Currently, only billfish and swordfish tournaments are selected for reporting. Under Option 3, NMFS would begin selecting shark tournaments for mandatory reporting of shortfin mako shark landings and discards in registered HMS tournaments; between 2012-2016 an average of 73 tournaments targeted sharks (Table 13). An Atlantic HMS tournament is any fishing competition involving Atlantic HMS in which participants must register or otherwise enter or in which a prize or award is offered for catching or landing such fish. Atlantic HMS tournaments are conducted from ports along the U.S. Atlantic coast, Gulf of Mexico, and U.S. Caribbean. Atlantic HMS tournaments vary in size. They may range from relatively small "members-only" club events with as few as ten participating boats (40 – 60 anglers) to larger, statewide tournaments with 250 or more participating vessels (1,000 – 1,500 anglers).

Under current HMS regulations, participants may target one or more HMS in a tournament. Most tournaments register to catch multiple HMS. Often, there is a primary species targeted in the tournament, and other species are caught for entry in separate categories. Figure 5 gives a breakdown of the number of tournaments in each state that registered for billfish, sharks, swordfish, or tuna species in 2016. Total numbers of tournaments divided by state for HMS species in 2016 were 182 billfish (top left), 76 shark (top right), 71 swordfish (bottom left), and 184 tuna (bottom right) in Figure 5.

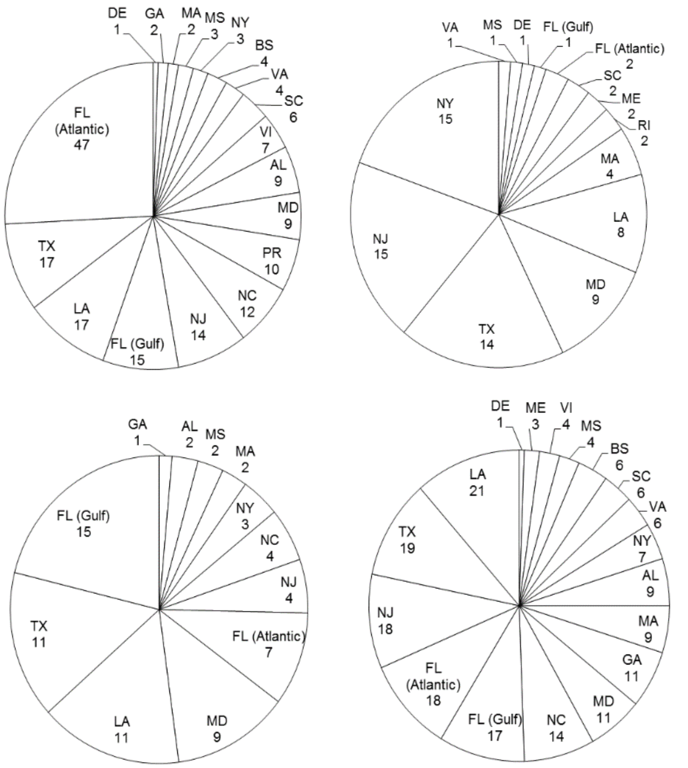

Figure 5. Number of Tournaments in each State that Registered for Billfish (Top Left), Shark (Top Right), Swordfish (Bottom Left), or Tuna (Bottom Right) Species in 2016.

Table 13 gives the breakdown of total number of HMS tournaments, the number of HMS tournaments with shortfin mako sharks in the title or otherwise mentioned by name, the number of HMS tournaments targeting 'Pelagic Sharks/All Shark' tournaments, and the number of HMS tournaments with pelagic sharks Category by Area. From 2012-2016, there were 250 HMS tournaments per year of which 10 specifically mentioned targeting shortfin mako sharks, and 73 reported targeting pelagic sharks which includes shortfin mako sharks.

Within this option, operators of tournaments targeting sharks (Table 13) could be selected by NMFS for reporting, in which case a record of tournament catch and effort would be submitted to NMFS within seven days of the conclusion of the tournament. In 2016, 76 shark tournaments (Table 13) occurred with greatest landing recorded for June, July, and August. Regional landings were greatest for Northeast Atlantic (88 percent), followed by Southeast Atlantic (67 percent), and Gulf of Mexico (70 percent) (Figure 6).

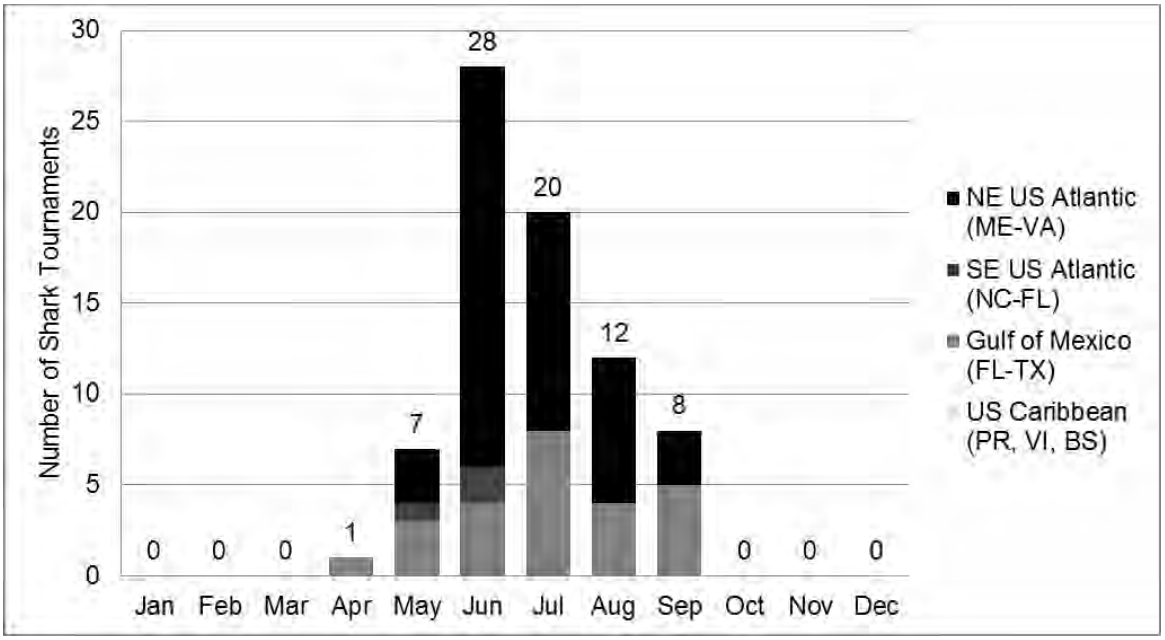

Figure 6. Regional distribution of tournaments that select sharks for 2016 time frame.

Table 19 provides the total numbers of HMS tournaments in 2016 that registered to award points or prizes for the catch or landing of each HMS. Marlin, sailfish, and yellowfin tuna continue to be the most sought after species.

Table 19. Number of Atlantic HMS Tournaments per Species in 2016.

Species		2016
Billfishes	Blue marlin	157
	White marlin	143
	Longbill spearfish	55
	Roundscale spearfish	45
	Sailfish	254
Swordfish		71
Tunas	Bluefin tuna	98
	Bigeye tuna	78
	Albacore tuna	41
	Yellowfin tuna	171
	Skipjack tuna	41
Sharks	Smoothhound	0
	Small coastal sharks	12
	Large Coastal Sharks	27
	Pelagic sharks	76

In Table 20, NMFS shows the number of billfish and swordfish tournaments (all of which are selected for reporting) and the additional number of tournaments that would be selected if shark tournaments are selected for reporting, an increase of 20 percent, based on data from 2016.

Table 20. Analysis of 2016 data showing number of tournaments reporting and the additional number of tournaments that would be required to report if tuna and or sharks are selected for reporting. Source: Atlantic Tournament Registration and Reporting.

	Total Numbers	**Percentages**
Registered HMS Tournaments	268	-
Billfish and Swordfish Tournaments	189	70%
Tournaments Targeting Sharks	76	28%
Shark Tournaments that Overlap With Billfish and Swordfish Tournaments	38	20%
New Tournaments to Report	38	20%

Pros

- Provides a census of shark tournaments through which accurate records of landing may be obtained.
- The additional information will help improve data that the United States reports to ICCAT.

Cons

- There would be additional burden on tournament operator(s) to collect information on and report shortfin mako shark landings.
- Participants of the tournament would have the added of tracking all interactions of shortfin mako sharks.

Option 4 – Implement mandatory reporting of all recreationally landed and discarded shortfin mako sharks (e.g., app, website, Vessel Trip Reports)

Under Option 4, NMFS would implement mandatory reporting of all recreational interactions (landed and discarded) of shortfin mako sharks. Under the larger minimum size limit implemented in the emergency rule or being considered in this action, the number of shortfin mako shark landings would decrease significantly. This would also reduce the number of observations of shortfin mako sharks in LPS and other MRIP surveys, resulting in recreational landings estimates that are much more variable and uncertain with significantly higher percent standard errors (PSE). This increased variability in the data would reduce NMFS' ability to effectively monitor the recreational harvest of the stock using traditional intercept surveys alone.

Currently, HMS Angling and Charter/Headboat permit holders are required to report each individual landing of bluefin tuna, billfish, and swordfish within 24 hours to facilitate quota monitoring. Atlantic Tunas General and Harpoon permit holders are also required to make these reports for bluefin tuna. Shark landings have been excluded from this mandatory reporting requirement with the exception of the Maryland and North Carolina Catch Card programs. NMFS has maintained a shortfin mako shark reporting app as an educational tool to encourage the practice of catch-and-release. Additionally, the potential burden associated with mandatory landings reports for shortfin mako sharks would be significantly reduced under the increased minimum size limits being considered in this rulemaking (Table 21). As such, NMFS is considering expanding mandatory landings reports to include shortfin mako sharks.

Table 21. Estimated reporting burden for shortfin mako shark landings reports under minimum size limits ranging from 54 to 108 inches FL based on average landings from 2012-2016 and a burden estimate of 5 minutes per report. Source: Large Pelagic Survey

Minimum Size Limit	Estimated Number of Responses	Estimated Burden Hours
54 inches FL	2,433	203
72 inches FL	1,317	110
83 inches FL	382	32
90 inches FL	147	13
102 inches FL	23	2
108 inches FL	6	1

HMS permit holders would have a variety of options for reporting shortfin mako shark landings including a phone-in system, internet website, and/or a smartphone app. However, shortfin mako sharks landed in Maryland are already required to be reported through the state reporting stations where anglers submit a state landings report (catch card) and obtain a fish tag. The state reports these landings to NMFS on a bi-weekly (during the bluefin tuna season, June-October) basis, and submits final, complete, annual summary reports at the end of the year. The State of North Carolina has a similar HMS Catch Card program that allows for voluntary reporting of shark landings, but currently does not require them. If mandatory reporting is adopted, anglers in North Carolina could be required to report their shortfin mako shark landings through either the NMFS reporting options, or the State of North Carolina HMS Catch Card reporting program.

Pros

- Would increase data collection on the harvest of the species to support management, and meet reporting requirements for ICCAT.
- Mandatory reporting of shortfin mako landings would provide an alternative source of shortfin mako harvest data from the LPS and MRIP where PSE estimates could become less precise due to less frequent observations in the LPS and MRIP if the minimum size limit is increased to 83 inches FL or greater.

Cons

- Would result in additional reporting burden for HMS anglers.
- Would entail costs for initial setup and monitoring along with some enforcement concerns as recreational landings do not have matching dealer reports to verify compliance with the reporting requirement.
- Would require recreational fishermen to be able to accurately identify shortfin mako sharks from other shark species that would not be required to be reported.

2.4 Rebuilding Program

Since the North Atlantic shortfin mako sharks have been declared to be overfished and subject to overfishing, NMFS must take action to address overfishing in the fishery and to implement conservation and management measures to rebuild overfished stocks within 2 years of making this determination domestically. The United States accounts for about 11 percent of the recent total shortfin mako shark mortality. Thus, NMFS is considering options to address shortfin mako shark overfishing and potentially implement a rebuilding plan domestically or work with ICCAT to implement a rebuilding program.

Option 1 – No action. Do not establish a rebuilding plan for shortfin mako sharks.

Under Option 1, NMFS would not establish a rebuilding plan for shortfin mako sharks and the stock would continue to be overfished with overfishing occurring. However, NMFS could still implement management measure in the HMS recreational and commercial fisheries, consistent with the ICCAT Recommendation.

Pros

- Short-term management measures developed for shortfin mako sharks would assist in avoiding overfishing of the species within Federal waters of the United States.
- No additional management measures beyond the ICCAT Recommendation.

Cons

- Under this option, there is a higher probability that Atlantic shortfin mako sharks would continue to experiencing overfishing.
- If overfishing continues, future ICCAT recommendations could require more severe reductions and cause socioeconomic impacts to HMS permit holders.
- The United States would not meet its obligation under ATCA.

Option 2 – Establish a domestic rebuilding plan for shortfin mako sharks unilaterally (i.e., without ICCAT)

Under Option 2, NMFS would establish a domestic rebuilding plan independent of ICCAT. This option would allow the United States to develop a rebuilding plan domestically to avoid overfishing of shortfin mako sharks in U.S. Federal waters. This option would not feature international cooperation, thus allowing the stock to continue to be overfished, with overfishing occurring.

Pros

- Rebuilding plan would just focus on the overfishing of shortfin mako sharks domestically.
- No additional management measures beyond the ICCAT Recommendation.

Cons

- Would not address the overfishing and overfished status of North Atlantic shortfin mako shark stock at the international level where approximately 90 percent of mortality is occurring.
- The United States would not meet its obligation under ATCA.

Option 3 – Establish the foundation for developing an international rebuilding program for shortfin mako sharks

Under Option 3, NMFS would take action at the international level through ICCAT, the relevant regional fishery management organization, to address overfishing of and rebuild shortfin mako sharks. This rebuilding program would encompass the objectives set forth by ICCAT based on new scientific advice from the SCRS. ICCAT is planning to establish a rebuilding program for shortfin mako sharks in 2019. Under this option, NMFS would continue to implement new management measures for North Atlantic shortfin mako based on the recommendations from ICCAT. Any international management recommendations adopted by the United States to help protect shortfin mako sharks would be implemented domestically. This option would allow the United States and other international partners to work together to develop an international rebuilding program with a high probability of avoiding overfishing of shortfin mako sharks and rebuilding the stock to within a timeframe that takes into account the biology of the stock.

Pros

- Would work with ICCAT to establish an international rebuilding plan that would consider the impacts to HMS fishermen.
- Would address overfishing at the international level where approximately 90 percent of the mortality occurs and would have ecological benefits for the stock.

Cons

- Could cause socioeconomic impacts to HMS permit holders if the new scientific advice from the SCRS lead to more restrictive management measures.
- If the United States does not implement a rebuilding program, this could cause negative ecological impacts to the North Atlantic shortfin mako stock. International cooperation is needed by all parties to rebuild the stock, which is overfished and experiencing overfishing.

2.5 References

Bishop, S.D.H.; M.P. Francis; C. Duffy and J.C. Montgomery. 2006. Age, growth, maturity, longevity and natural mortality of the shortfin mako shark (*Isurus oxyrinchus*) in New Zealand waters. Marine and Freshwater Research. 57:143-154.

Byrne, M.E., E. Cortes, J.J. Vaudo, G.C.M. Harvey, M. Sampson, B.M. Wetherbee, and M. Shivji. 2017. Satellite telemetry reveals higher fishing mortality rates than previously estimated, suggesting overfishing of an apex marine predator. Proceedings of the Royal Society B 284: 20170658.

Cailliet, G.M., L.K. Martin, J.T. Harvey, D. Kusher, and B.A. Welden. 1983. Preliminary studies on the age and growth of blue, *Prionace glauca*, common thresher, *Alopias vulpinus*, and shortfin mako, *Isurus oxyrhinchus*, sharks from California waters. NOAA Technical Report NMFS 8. U.S. Dept. Comm., Washington DC: 179-188.

Cailliet, G.F. and H.F. Mollet. 1997. Preliminary demographic analysis of the shortfin mako, *Isurus oxyrinchus*. Abstract. 77th Annual Meeting of the American Society of Ichthyologists and Herpetologists.

Campana, S.E., L.J. Natanson, and S. Mykelvoll. 2002. Bomb dating and age determination of large pelagic sharks. Canadian Journal of Fisheries and Aquatic Sciences 59: 450-455.

Campana, S.E., L. Marks, W. Joyce. 2005. The biology and fishery of shortfin mako sharks (*Isurus oxyrhinchus*) in Atlantic Canadian waters. Fisheries Research 73:341-352. doi:10.1016/j.fishres.2005.01.009

Casey, J.G., and N.E. Kohler. 1992. Tagging studies on the shortfin mako shark (*Isurus oxyrinchus*) in the western North Atlantic. Aust. J. Mar. Freshwater Res. 43: 45-60.

Castro, J.I. 1983. The Sharks of North American Waters. Texas A&M University Press, College Station. 180 pp.

Conrath, C.L. and J.A. Musick. 2002. Reproductive biology of the smooth dogfish, Mustelus canis, in the northwest Atlantic Ocean. Environmental Biology of Fishes 64: 367-377.

Gilmore, R.G. 1993. Reproductive biology of Lamnoid sharks. Environ. Biol. Fishes 38:95-114.

Guitart Manday, D. 1975. Las pesquerias pelagico- oceanicas de corto radio de accion en la region noroccidental de Cuba. Academia de Ciencias de Cuba, Instituto de Oceanologia. Serie Oceanologia 31. 26pp.

Heist, E.J., J.A. Musick and J.E. Graves. 1996. Genetic population structure of the shortfin mako (*Isurus oxyrinchus*) inferred from restriction fragment length polymorphism analysis of mitochondrial DNA. Can. J. Fish. Aquat. Sci. 53: 583-588.

ICCAT. 2006-2016. ICCAT Manual. International Commission for the Conservation of Atlantic Tuna. In: ICCAT Publications [on-line]. Updated 2016. [Cited 01/27/]. http://www.iccat.int/en/ICCATManual.asp, ISBN (Electronic Edition): 978-92-990055-0-7

Jensen C., T. Thorpe, M. Moser, J.J. Francesconi, G.A. Hopkins, D. Beresoff, D. 2002. Shark Nursery Areas in North Carolina State Waters. Pgs 61-73 *in* Shark nursery grounds of the Gulf of Mexico and the east coast waters of the United States: an overview. McCandless C.T., H.L. Pratt, Jr., and, N.E Kohler, (eds). An internal report to NOAA's Highly Migratory Species. NOAA Fisheries Narragansett Lab, 28 Tarzwell Drive, Narragansett, Rhode Island 02882, USA.

Jones LM, Driggers WB, Hannan KM, Hoffmayer ER, Jones CM. 2014. Identification, life history and distribution of *Mustelus canis, M. norrisi,* and *M. sinusmexicanus* in the northern Gulf of Mexico. SEDAR Data Workshop, SEDAR 39-DW-22. http://sedarweb.org/docs/wpapers/S39_DW_22_jonesetal_final.pdf

Kohler, N.E., P.A. Turner, J.J. Hoey, L.J. Natanson, and R. Briggs. 2002. Tag and recapture data for three pelagic shark species: Blue shark (*Prionace glauca*), shortfin mako (*Isurus oxyrinchus*), and porbeagle (*Lamna nasus*) in the North Atlantic Ocean. Col. Vol. Sci. Pap. ICCAT 54(4): 1231-1260.

Kohler NE, Turner PA, Pezzullo M, McCandless CT. 2014. Mark/Recapture Data for the Smooth Dogfish, Mustelus canis, in the Western North Atlantic from the NMFS Cooperative Shark Tagging Program. 2014 SEDAR Data Workshop Document, SEDAR39-DW-20.

Lessa, R., F. Santana, R. Menni, and Z. Almeida. 1999. Population structure and reproductive biology of the smalltail shark (*Carcharhinus porosus*) off Maranhao (Brazil). Marine and Freshwater Research 50: 383-388.

Maia, A.; N. Queiroz; J.P. Correia; H. Cabral. 2007a. Food habits of the shortfin mako, Isurus oxyrinchus, off the southwest coast of Potugal. Environ. Biol. Fish. 77:157-167.

Maia, A.; N. Queiroz; H.N. Cabral; A.M. Santos; and J.P. Correia. 2007b. Reproductive biology and population dynamics of the shortfin mako, *Isurus oxyrinchus* Rafinesque, 1810, off the southwest Portuguese coast, eastern North Atlantic. Journal of Applied Ichthyology 23:246-251.

MacNeil, M.A., G.B. Skomal, and A.T. Fisk. 2005. Stable isotopes from multiple tissues reveal diet switching in sharks. Marine Ecology Progress Series 302: 199-206.

Mollet H.F., G. Cliff, H.L. Pratt Jr, J.D. Stevens. 2000. Reproductive biology of the female shortfin mako, *Isurus oxyrinchus* Rafinesque, 1810, with comments on the embryonic development of lamnoids. Fishery Bulletin 98(2):299-318.

Moreno, J.A., Parajua, J.I., and Moron, J. 1989. Biologia reproductiva y fenologia de Alopias vulpinus (Bonnaterre, 1788) (Squaliformes: Alopiidae) en el Atlantico nor-oriental y Mediterraneo occidental. Scientia Marina (Barcelona) 53(1):37-46.

Moreno, J.A., and J. Morón. 1992. Reproductive biology of the bigeye thresher shark, *Alopias superciliosus* (Lowe 1839). Aust. J. Mar. Freshwater Res. 43: 77-86.

Natanson, L.J., N.E. Kohler, D. Ardizzone, G.M. Cailliet, S.P. Wintner, and H.F. Mollet. 2006. Validated age and growth estimates for the shortfin mako, *Isurus oxyrinchus*, in the North Atlantic Ocean. Environmental Biology of Fishes 77(3-4): 367-383.

NMFS. 2017. Final Amendment 10 to the 2006 Consolidated Atlantic Highly Migratory Species Fishery Management Plan: Essential Fish Habitat (and Environmental Assessment). Atlantic Highly Migratory Species Management Division, National Marine Fisheries Service, Bethesda, MD.

Pratt, Jr., H.L. 1979. Reproduction in the blue shark, Prionace glauca. Fishery Bulletin 77(2):445-470.

Pratt, H.L. and J.G. Casey. 1983. Age and growth of the shortfin mako, Isurus oxyrinchus, using four methods. Canadian Journal of Fisheries and Aquatic Sciences 40(11): 1944-1957.

Schrey, A.W., Heist, E.J., 2003. Microsatellite analysis of population structure in the shortfin mako (Isurus oxyrinchus). Can. J. Fish. Aquat. Sci. 60, 670–675.

SCRS. 2012. 2012 Shortfin Mako Stock Assessment and Ecological Risk Assessment Meeting. June 11-18, 2017. Olhao, Portugal. https://www.iccat.int/Documents/Meetings/Docs/2012_SHK_ASS_ENG.pdf

SCRS. 2017. Report of the 2017 ICCAT Shortfin Mako Assessment Meeting. June 12-16, 2017. Madrid, Spain. https://www.iccat.int/Documents/Meetings/Docs/2017_SMA_ASS_REP_ENG.pdf

SEDAR. 2015. SEDAR 39 Stock Assessment Report: HMS Atlantic Smooth Dogfish Shark. Southeast Data Assessment & Review, Charleston SC. http://sedarweb.org/docs/sar/S39_Atl_smooth_dog_SAR.pdf

Seki, T., Taniuchi, T., Nakano, H., and Shimizu, M. 1998. Age, growth and reproduction of the oceanic whitetip shark from the Pacific Ocean. Fisheries Science 64(1):14-20

Semba, Y., I. Aoki, and K. Yokawa. (2011). Size at maturity and reproductive traits of shortfin mako, Isurus oxyrinchus, in the western and central North Pacific. Mar. Fresh. Res., 62 (1): 20-29.

Silva, A.A., Silva, H.M. and Erzini, K. 1996. Some results on the biology of the blue shark, Prionace glauca, in the North Atlantic based on data form a research cruise of the R/V Arquipelago in Azorean waters: a summary paper, 9 pp. Universidade dos Azores, Horta, Azores, Portugal.

Skomal, G.B. and L.J. Natanson. 2003. Age and growth of the blue shark (Prionace glauca) in the North Atlantic Ocean. Fish. Bull. 101:627-639.

Springer, S. and R.A. Waller. 1969. *Hexanchus vitulus*, a new sixgill shark from the Bahamas. Bull. Mar. Sci. 19: 159-174.

Stevens, J.D. 1983. Observations on reproduction in the shortfin mako Isurus oxyrinchus. Copeia, No. 1; pp 126-130.

Stevens, J.D. and K.J. Mcloughlin. 1991. Distribution, size, and sex composition, reproductive biology and diet of sharks from northern Australia. Austr. J. Mar. Freshwater Res., 42: 151-99.

Stillwell, C.E. and J.G. Casey. 1976. Observations on the bigeye thresher shark, *Alopias superciliosus*, in the western North Atlantic. Fish. Bull. 74:221-225.

Vaudo J.J., M.E. Byrne, B.M. Wetherbee, G.M. Harvey, M.S. Shivji. 2017. Long-term satellite tracking reveals region-specific movements of a large pelagic predator, the shortfin mako shark, in the western North Atlantic Ocean. J Appl Ecol 54(6) 1765-1775 doi: 10.1111/1365-2664.12852

Atlantic States Marine Fisheries Commission

Coastal Sharks Technical Committee Call Summary

Wednesday March 28, 2018

Attendees: Lisa Hollensead (NC), Brent Winner (FL), Wilson Laney (USFWS), Chris Scott (NY), Angel Willey (MD), Carolyn Belcher (GA), Eric Schneider (RI), Karyl Brewster-Geisz (NOAA HMS), Greg Hinks (NJ), Greg Skomal (MA), Julie Neer (SAFMC), Scott Newlin (DE), Matt Gates (CT)
Staff: Kirby Rootes-Murdy

1) **Welcome/Review draft agenda** *(K. Rootes-Murdy*)

   The group nominated Bryan Frazier to become TC Chair and Angel Willey to become TC Vice Chair.

2) **Presentation on Atlantic shortfin mako shark stock assessment and emergency rule (***K. Brewster-Geisz*)

   Karyl Brewster-Geiz presented to the TC a summary of the Atlantic shortfin mako stock assessment and the recently implemented emergency management measures in response to the assessment. At the November 2017 ICCAT Meeting, the recent stock assessment on Atlantic shortfin mako was presented, with a finding that the resource is overfished and overfishing is occurring. The assessment was completed in Summer 2017, and included a new modelling approach (stock synthesis), longer time series of catch data (1950-2015), sex-specific biological parameters, updated length composition information, and new satellite tagging data. The new reference points were in the following ranges: B_{2015}/B_{MSY} = 0.57-0.85 and F_{2015}/F_{MSY} = 1.93-4.38. To address the new stock assessment status, it was determined at the ICCAT Meeting that reductions of approximately 72-79% from current landings levels are needed to prevent further declines in the population and a reduction to 0 metric tons landings are needed to rebuild the resource by 2040. To address the needed reductions in landings, NOAA implemented earlier in March the following measures: an increase in the minimum size limit (fork length) for the recreational fishery from 54” to 83” and a prohibition of landings in the commercial fishery for all gear types with the exception of the pelagic longline fleet. For the pelagic longline vessels that have an HMS permit, electronic monitoring devices are required in order to retain sharks that are dead at haul back; any live sharks must be released. These emergency measures have been implemented on an interim basis through August 2018 and may be extended for up to 6 months at that time. At the next ICCAT Meeting in November 2018 an evaluation of reduction in landings will be evaluated for 2018 and different measures may be recommended to be implemented for member countries; the US would be bound to implement new recommended measures into place for HMS permit holders. At the same time, NOAA HMS has begun a scoping process for Amendment 11 that puts forth a range of alternatives to address reducing Atlantic shortfin mako fishing mortality in US federal waters.

The TC discussed the emergency measures and how such measures could be implemented in state waters; states can individually move forward with implementing the measures if they chose, but to be compelled to would likely require an Addendum to the FMP. The Board could also take emergency action to compel the states to implement the emergency rule measures; if this approach were to be taken, there are a number of procedural steps including holding at least 4 public hearings that would be required. Next the group discussed how many landings come from state waters relative to landings from federal waters; many were of the opinion that Atlantic shortfin mako commercial landings from state waters constitute a small percentage of overall landings, and that similarly most recreational catch and harvest occurs in federal waters due to the species preference for open ocean habitat/pelagic habits.

The TC was tasked by the Board Chair to review the stock assessment and consider the potential conservation benefit of implementing the emergency measures in state waters. Taking into consideration the likely very low landings levels, the TC indicated that implementing the emergency measures in state waters would likely not have significant impact as most landings are coming from federal waters. Additionally, the timing of the emergency measures- (that they will be up for potential renewal in less than 6 months and may change between now and end of year), would present challenges if the states need to change measures more than once before the end of the year. There were concerns raised by TC members that in not adopting the emergency rule measures in state waters, inconsistency in regulations may create some enforcement challenges for state permitted recreational anglers & for-hire vessels. Many indicated that it would better to provide comments in the scoping process for Amendment 11 and recommend that states individually implement the emergency measures if possible to have more consistency in measures between state and federal waters.

3) **Presentation on sandbar shark stock assessment** (*K. Brewster-Geisz)*

Next Karyl presented a summary of the sandbar shark stock assessment results. A new modeling approach was used (stock synthesis 3) that included replication of the previous assessment (SEDAR 21) that matched the biomass trend over the last 2 decades; the stock status is overfished but overfishing isn't occurring; and that based on the biomass projection the Total Allocation Catch could be increased by approximately 12%. While the Assessment passed peer-review it has not yet been officially adopted yet by NOAA HMS for management use.

The TC was tasked by the Board Chair to review the recent stock assessment and provide recommendation on potential management actions. The Sandbar Shark fishery is research take only; given that there is not a commercial fishery and NOAA HMS has not taken steps to adjust the management program for Sandbar sharks at this time, the TC had no formal recommendations to the Board other than to maintain status quo measures.

4) **Update on Oceanic Whitetip Sharks ESA Status** *(K. Brewster-Geisz)*

Next, the TC was presented information on the new Endangered Species Act (ESA) status (Threatened) for Oceanic Whitetip Sharks. This status change was due to a status review that was initiated by Defenders of Wildlife to list the global species as threatened or endangered under the ESA. The status review took into account life history parameters which include being long lived (up to 20 years), late maturity (6-7 years for both sexes in the Atlantic DPS), lengthy gestation (9-12 months) and low fecundity (5-6 pups with pupping every other year). Additionally the status review found that within the global commercial fishery that fishing mortality is likely too high and that there are inadequate regulations in other parts of the world; this combined with the market demand for shark fins has increased illegal, unreported, and unregulated (IUU) fishing and trafficking. While NOAA has changed the status to threatened under the ESA, there are additional analyses that will need to take place, namely section 7 consultations for relevant fisheries that may interact with the species. These consultations can take time. Such consultation is already underway for NOAA HMS fisheries.

The TC was tasked by the Board Chair to review the status change and provide the Board with any recommendation on potential management responses. The TC noted that the species is generally not found in state waters due to its preferred habitat of Open Ocean in water depths of greater than 184 meters. One TC member noted that most of the ASMFC state are north of the known range (Oceanic whitetip sharks are found worldwide in warm tropical and subtropical waters between 20° North and 20° South latitude, but can be found up to about 30° North and South latitude during seasonal movements to higher latitudes in the summer months[1]). Given there was no proposed management changes at this time by NOAA HMS, the TC had no formal recommendations to the Board other than to maintain status quo measures but to consider moving the species to the prohibited species list once consultations are completed.

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[1] 'Oceanic Whitetip Sharks. http://www.nmfs.noaa.gov/pr/species/fish/oceanic-whitetip-shark.html#description

SEDAR
Southeast Data, Assessment, and Review

SEDAR 54
Stock Assessment Report

HMS Sandbar Shark

October 2017

SEDAR
4055 Faber Place Drive, Suite 201
North Charleston, SC 29405

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SEDAR

Southeast Data, Assessment, and Review

SEDAR 54

HMS Sandbar Sharks

SECTION I: Introduction

SEDAR
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1. SEDAR PROCESS DESCRIPTION

SouthEast Data, Assessment, and Review (**SEDAR**) is a cooperative Fishery Management Council process initiated in 2002 to improve the quality and reliability of fishery stock assessments in the South Atlantic, Gulf of Mexico, and US Caribbean. SEDAR seeks improvements in the scientific quality of stock assessments and the relevance of information available to address fishery management issues. SEDAR emphasizes constituent and stakeholder participation in assessment development, transparency in the assessment process, and a rigorous and independent scientific review of completed stock assessments.

SEDAR is managed by the Caribbean, Gulf of Mexico, and South Atlantic Regional Fishery Management Councils in coordination with NOAA Fisheries and the Atlantic and Gulf States Marine Fisheries Commissions. Oversight is provided by a Steering Committee composed of NOAA Fisheries representatives: Southeast Fisheries Science Center Director and the Southeast Regional Administrator; Regional Council representatives: Executive Directors and Chairs of the South Atlantic, Gulf of Mexico, and Caribbean Fishery Management Councils; and Interstate Commission representatives: Executive Directors of the Atlantic States and Gulf States Marine Fisheries Commissions.

SEDAR is organized around two workshops and a series of webinars. First is the Data Workshop, during which fisheries, monitoring, and life history data are reviewed and compiled. The second stage is the Assessment Process, which is conducted via a series of webinars, during which assessment models are developed and population parameters are estimated using the information provided from the Data Workshop. Third and final is the Review Workshop, during which independent experts review the input data, assessment methods, and assessment products. The completed assessment, including the reports of all 3 workshops and all supporting documentation, is then forwarded to the Council SSC for certification as ‘appropriate for management’ and development of specific management recommendations.

SEDAR workshops are public meetings organized by SEDAR staff and the lead Cooperator. Workshop participants are drawn from state and federal agencies, non-government organizations, Council members, Council advisors, and the fishing industry with a goal of including a broad range of disciplines and perspectives. All participants are expected to contribute to the process by preparing working papers, contributing, providing assessment analyses, and completing the workshop report.

SEDAR Review Workshop Panels consist of a chair, 3 reviewers appointed by the Center for Independent Experts (CIE), and three reviewers appointed from the SSC of the Council having jurisdiction over the stocks being assessed. The Review Workshop Chair is appointed by the Council from their SSC. Participating councils may appoint additional representatives of their SSC, Advisory, and other panels as observers.

2. MANAGEMENT OVERVIEW

A SUMMARY OF THE MANAGEMENT OF ATLANTIC LARGE COASTAL SHARKS

Presented to the 2017 Data Workshop of the Sandbar Stock Assessment

2.1 Fishery Management Plans and Amendments

Given the interrelated nature of the shark fisheries, the following section provides an overview of shark management primarily since 1993 through 2016 for sandbar sharks. The following summary, to the extent possible, focuses only on those management actions that likely affect sandbar sharks. The management measures implemented under fishery management plans and amendments are also summarized in Table 1.

The U.S. Atlantic shark fisheries developed rapidly in the late 1970s due to increased demand for their meat, fins, and cartilage worldwide. At the time, sharks were perceived to be underutilized as a fishery resource. The high commercial value of shark fins led to the controversial practice of “finning,” or removing the valuable fins from sharks and discarding the carcasses. Growing demand for shark products encouraged expansion of the commercial fishery throughout the late 1970s and the 1980s. Tuna and swordfish vessels began to retain a greater proportion of their shark incidental catch and some directed fishery effort expanded as well.

Preliminary Fishery Management Plan (PMP) for Atlantic Billfish and Sharks

In January 1978, NMFS (National Marine Fisheries Service) published the Preliminary Fishery Management Plan (PMP) for Atlantic Billfish and Sharks (43 FR 3818), which was supported by an Environmental Impact Statement (EIS) (42 FR 57716). This PMP was a Secretarial effort. The management measures contained in the plan were designed to:

1. Minimize conflict between domestic and foreign users of billfish and shark resources;
2. Encourage development of an international management regime; and
3. Maintain availability of billfishes and sharks to the expanding U.S. fisheries.

Primary shark management measures in the Atlantic Billfish and Shark PMP included:

- Mandatory data reporting requirements for foreign vessels;
- A hard cap on the catch of sharks by foreign vessels, which when achieved would prohibit further landings of sharks by foreign vessels;
- Permit requirements for foreign vessels to fish in the Fishery Conservation Zone (FCZ) of the United States;
- Radio checks by foreign vessels upon entering and leaving the FCZ;

- Boarding and inspection privileges for U.S. observers; and
- Prohibition on intentional discarding of fishing gears by foreign fishing vessels within the FCZ that may pose environmental or navigational hazards.

In the 1980s, the Regional Fishery Management Councils were responsible for the management of Atlantic highly migratory species (HMS), including sharks. Thus, in 1985 and 1988, the five Councils finalized joint FMPs for swordfish and billfish, respectively. As catches accelerated through the 1980s, shark stocks started to show signs of decline. Peak commercial landings of large coastal and pelagic sharks were reported in 1989. In 1989, the five Atlantic Fishery Management Councils asked the Secretary of Commerce (Secretary) to develop a Shark Fishery Management Plan (FMP). The Councils were concerned about the late maturity and low fecundity of sharks, the increase in fishing mortality, and the possibility of the resource being overfished. The Councils requested that the FMP cap commercial fishing effort, establish a recreational bag limit, prohibit finning, and begin a data collection system.

On November 28, 1990, the President of the United States signed into law the Fishery Conservation Amendments of 1990 (Pub. L. 101-627). This law amended the Magnuson Fishery Conservation and Management Act (later renamed the Magnuson-Stevens Fishery Conservation and Management Act or Magnuson-Stevens Act) and gave the Secretary the authority (effective January 1, 1992) to manage HMS in the exclusive economic zone (EEZ) of the Atlantic Ocean, Gulf of Mexico, and Caribbean Sea under authority of the Magnuson-Stevens Act (16 U.S.C. §1811). This law also transferred from the Fishery Management Councils to the Secretary, effective November 28, 1990, the management authority for HMS in the Atlantic Ocean, Gulf of Mexico, and Caribbean Sea (16 U.S.C. §1854(f)(3)). At this time, the Secretary delegated authority to manage Atlantic HMS to NMFS.

1993 Fishery Management Plan for Sharks of the Atlantic Ocean (1993 FMP)

In 1993, the Secretary of Commerce, through NMFS, implemented the FMP for Sharks of the Atlantic Ocean. The management measures in the 1993 FMP included:

- Establishing a fishery management unit (FMU) consisting of 39 frequently caught species of Atlantic sharks, separated into three groups for assessment and regulatory purposes (Large Coastal Sharks (LCS), Small Coastal Sharks (SCS), and pelagic sharks)[1];
- Establishing calendar year commercial quotas for the LCS and pelagic sharks and dividing the annual quota into two equal half-year quotas that applied to the following two fishing periods – January 1 through June 30 and July 1 through December 31;
- Establishing a recreational trip limit of four sharks per vessel for LCS or pelagic shark species groups;

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[1] At that time, sandbar sharks were managed within the large coastal shark complex.

- Requiring that all sharks not taken as part of a commercial or recreational fishery be released uninjured;
- Establishing a framework procedure for adjusting commercial quotas, recreational bag limits, species size limits, management unit, fishing year, species groups, estimates of maximum sustainable yield (MSY), and permitting and reporting requirements;
- Prohibiting finning by requiring that the ratio between wet fins/dressed carcass weight not exceed five percent;
- Prohibiting the sale by recreational fishermen of sharks or shark products caught in the Economic Exclusive Zone (EEZ);
- Requiring annual commercial permits for fishermen who harvest and sell shark products (meat products and fins);
- Establishing a permit eligibility requirement that the owner or operator (including charter vessel and headboat owners/operators who intend to sell their catch) must show proof that at least 50 percent of earned income has been derived from the sale of the fish or fish products or charter vessel and headboat operations or at least $20,000 from the sale of fish during one of three years preceding the permit request;
- Requiring trip reports by permitted fishermen and persons conducting shark tournaments and requiring fishermen to provide information to NMFS under the Trip Interview Program; and,
- Requiring NMFS observers on selected shark fishing vessels to document mortality of marine mammals and endangered species.

At that time, NMFS identified LCS as overfished and established the commercial quota at 2,436 metric tons (mt) dressed weight (dw) based on a 1992 stock assessment. Under the rebuilding plan established in the 1993 FMP, the LCS quota was expected to increase in 1994 and 1995 up to the MSY estimated in the 1992 stock assessment (3,800 mt dw).

In 1994, under the rebuilding plan implemented in the 1993 FMP, the LCS quota was increased to 2,570 mt dw. Additionally, a new stock assessment was completed in March 1994. This stock assessment focused on LCS, suggested that recovery to the levels of the 1970s could take as long as 30 years, and concluded that “increases in the [Total Allowable Catch (TAC)] for sharks [are] considered risk-prone with respect to promoting stock recovery.” A final rule that capped quotas for LCS at the 1994 levels was published on May 2, 1995 (60 FR 21468).

1999 Fishery Management Plan for Atlantic Tunas, Swordfish and Sharks (1999 FMP)

In June 1996, NMFS convened another stock assessment to examine the status of LCS stocks. The 1996 stock assessment found no clear evidence that LCS stocks were rebuilding and concluded that “[a]nalyses indicate that recovery is more likely to occur with reductions in effective fishing mortality rate of 50 [percent] or more.” In addition, in 1996, amendments to the Magnuson-Stevens Act modified the definition of overfishing and established new provisions to halt overfishing and rebuild overfished stocks, minimize bycatch and bycatch mortality to the extent practicable, and identify and protect essential fish habitat. Accordingly, in 1997, NMFS began the process of creating a rebuilding plan for overfished HMS, including LCS, consistent with the new provisions. In addition, in 1995 and 1997, new quotas were established for LCS and SCS (see Section 2.0 below). In June 1998, NMFS held another LCS stock assessment. The 1998 stock assessment found that LCS were overfished and would not rebuild under 1997 harvest levels. Based in part on the results of the 1998 stock assessment, in April 1999, NMFS published the final 1999 FMP, which included numerous measures to rebuild or prevent overfishing of Atlantic sharks in commercial and recreational fisheries. The 1999 FMP amended and replaced the 1993 FMP. Management measures related to sharks that changed in the 1999 FMP included:

- Reducing commercial LCS quotas;
- Establishing ridgeback (e.g., sandbar *Carcharhinus plumbeus*) and non-ridgeback (e.g., blacktip (*Carcharhinus limbatus*) categories of LCS;
- Implementing a commercial minimum size for ridgeback LCS;
- Reducing recreational retention limits for all sharks;
- Establishing a recreational minimum size for all sharks except Atlantic sharpnose;
- Established essential fish habitat (EFH) for 39 species of sharks;
- Implementing limited access in commercial fisheries;
- Establishing a shark public display quota;
- Establishing new procedures for counting dead discards and state landings of sharks after Federal fishing season closures against Federal quotas; and
- Establishing season-specific over- and underharvest adjustment procedures.

The implementing regulations were published on May 28, 1999 (64 FR 29090). However, in 1999, a court enjoined implementation of the 1999 regulations, as they related to the ongoing litigation on the 1997 quotas. As such, many of the regulations in the 1999 FMP had a delayed implementation or were never implemented. These changes are explained below under Section 2.0.

2003 Amendment 1 to the 1999 FMP for Atlantic Tunas, Swordfish, and Sharks (Amendment 1)

In 2002, additional LCS stock assessments were conducted. Based on these assessments, NMFS re-examined many of the shark management measures in the 1999 FMP for Atlantic Tunas, Swordfish, and Sharks. The changes in Amendment 1 affected all aspects of shark management. The final management measures (December 24, 2003, 68 FR 74746) selected in Amendment 1 included, among other things:

- Re- aggregating the large coastal shark complex;
- Using maximum sustainable yield as a basis for setting commercial quotas;

- Eliminating the commercial minimum size;
- Establishing regional commercial quotas and trimester commercial fishing seasons, adjusting the recreational bag and size limits, establishing gear restrictions to reduce bycatch or reduce bycatch mortality;
- Establishing a time/area closure off the coast of North Carolina to reduce fishing mortality of dusky sharks and juvenile sandbar sharks;
- Updating EFH identifications for five species of sharks, including sandbar shark; and,
- Changing the administration for issuing permits for display purposes.

2006 Consolidated HMS FMP

NMFS issued two separate FMPs in April 1999 for the Atlantic HMS fisheries. The 1999 Fishery Management Plan for Atlantic Tunas, Swordfish, and Sharks combined, amended, and replaced previous management plans for swordfish and sharks, and was the first FMP for tunas. Amendment 1 to the Billfish Management Plan updated and amended the 1988 Billfish FMP. The 2006 Consolidated HMS FMP consolidated the management of all Atlantic HMS into one comprehensive FMP, adjusted the regulatory framework measures, continued the process for updating HMS EFH, and combined and simplified the objectives of the previous FMPs.

In 2005, NMFS released the draft Consolidated HMS FMP. In July 2006, the final Consolidated HMS FMP was completed and the implementing regulations were published on October 2, 2006 (71 FR 58058). Measures that were specific to the shark fisheries included:

- Mandatory workshops and certifications for all vessel owners and operators that have pelagic longline (PLL) or bottom longline (BLL) gear on their vessels and that had been issued or were required to be issued any of the HMS limited access permits (LAPs) to participate in HMS longline and gillnet fisheries. These workshops provide information and ensure proficiency with using required equipment to handle release and disentangle sea turtles, smalltooth sawfish, and other non-target species;
- Mandatory Atlantic shark identification workshops for all federally permitted shark dealers to train shark dealers to properly identify shark carcasses;
- Differentiation between PLL and BLL gear based upon the species composition of the catch onboard or landed;
- The requirement that the 2nd dorsal fin and the anal fin remain on all sharks through landing; and,
- Prohibition on the sale or purchase of any HMS that was offloaded from an individual vessel in excess of the retention limits specified in §§ 635.23 and 635.24.

2008 Amendment 2 to the 2006 Consolidated HMS FMP

In 2005/2006, a new stock assessment was conducted on the LCS complex, sandbar, blacktip, porbeagle, and dusky sharks. Based on the results of these assessments, NMFS amended the 2006 Consolidated HMS FMP. On April 10, 2008, NMFS released the Final EIS for Amendment 2 to the Consolidated HMS FMP. The assessment for sandbar shark indicated that the species was overfished with overfishing occurring. NMFS implemented management measures consistent with the recent stock assessment for sandbar, among other things. The implementing regulations were published on June 24, 2008 (73 FR 35778; corrected version published July 15, 2008; 73 FR 40658). Management measures implemented in Amendment 2 included:

- Initiating a rebuilding plan for sandbar sharks consistent with the stock assessment;
- Prohibiting the retention of sandbar sharks in the recreational fisheries and in the commercial fisheries unless participants were part of the shark research fishery (see Table
- Implementing a commercial quota of 87.9 mt dw for sandbar sharks, which could be harvested only by a limited number of participants in the shark research fishery who had 100 percent observer coverage and specific gear and fishing restrictions.;
- Requiring that all Atlantic sharks be offloaded with fins naturally attached;
- Collecting shark life history information via the implementation of a shark research fishery; and,
- Implementing time/area closures recommended by the South Atlantic Fishery Management Council.

2010 Amendment 5a to the 2006 Consolidated HMS FMP (Amendment 5a)

In 2011, a new stock assessment was conducted on sandbar, blacknose, and dusky sharks. Based on the results of these assessments, NMFS amended the 2006 Consolidated HMS FMP. On October 7, 2011, NMFS published a notice announcing our intent to prepare a proposal for Amendment 5 to the 2006 Consolidated HMS FMP with an Environmental Impact Statement (EIS) in accordance with the requirements of the NEPA (76 FR 62331). NMFS made stock status determinations for sandbar, dusky, and blacknose sharks based on the results of the Southeast Data, Assessment, and Review (SEDAR) 21 process. Determinations in the October 2011 notice included that sandbar sharks were still overfished, but no longer experiencing overfishing.

After reviewing all of the comments received on the proposed rule, NMFS decided to analyze further those measures pertaining to dusky sharks in a separate, but related FMP amendment, EIS, and proposed rule. For clarity in referring to the two related rulemaking processes, the FMP amendment for non-dusky shark species included in draft Amendment 5--specifically, scalloped hammerhead, sandbar, blacknose, and Gulf of Mexico blacktip sharks--

was called "Amendment 5a," and the FMP amendment for dusky sharks was referred to as "Amendment 5b."

On July 3, 2013, NMFS published a final rule (78 FR 40318) to implement Amendment 5a, which included shark fishery management measures and established the scalloped hammerhead shark rebuilding program. While Amendment 5a did not change any sandbar-specific requirements, the requirements that changed could affect the bycatch of sandbar sharks. Specifically, the final rule established several new regional shark management groups and quotas for the commercial fishery and a new minimum size limit for recreational fishermen for hammerhead sharks. This final rule addressed annual regional quotas for the aggregated LCS, hammerhead sharks, and Gulf of Mexico blacktip, blacknose, and non-blacknose sharks. Amendment 5a implemented regional quota linkages between management groups whose species are often caught together in the same fisheries to prevent exceeding the newly established quotas through discarded bycatch. In addition, Amendment 5a established a new minimum size limit for the large hammerhead shark species (great, smooth, and scalloped) of 78 inches (6.5 feet) fork length (FL). The size limit for other shark species, including sandbar sharks, and the retention limits did not change.

2015 Amendment 6 to the 2006 Consolidated HMS FMP (Amendment 6)

On August 20, 2015, NMFS published a final rule (80 FR 50074) for Amendment 6 to the 2006 Consolidated Atlantic HMS FMP that, among other things, adjusted the commercial sandbar shark research fishery quota from 116.6 mt dw to 90.7 mt dw. The final action also included:

- Modifying retention limits for LCS;
- Creating a new management boundary for SCS in the Atlantic region;
- Creating subregional commercial quotas for LCS in the Gulf of Mexico region;
- Modifying quota linkages between blacknose and non-blacknose SCS in both the Atlantic and Gulf of Mexico regions;
- Modifying the TACs and commercial quotas for non-blacknose SCS in both the Atlantic and Gulf of Mexico regions,
- Modifying vessel upgrading restrictions.

As a result of these modifications to the commercial quotas and the creation of a management boundary in the Atlantic region, the non-blacknose SCS fisheries in the Gulf and Atlantic regions were re-opened. The proposed rule for this action published on January 20, 2015 (80 FR 2648) and the public comment period ended on April 3, 2015.

2016 Amendment 10 to the 2006 Consolidated HMS FMP (Amendment 10)

On October 14, 2016, NMFS published the availability of Draft Amendment 10 on essential fish habitat (EFH) and an associated Environmental Assessment (EA) (81 FR 62100). Draft Amendment 10 proposes to update and revise existing HMS EFH; proposes to modify existing HAPCs or designate new HAPCs for bluefin tuna, and sandbar, lemon, and sand tiger sharks, as necessary; and analyzes fishing and non-fishing impacts on EFH by considering environmental and management changes and new information since 2009. New information on the biology, distribution, habitat requirements, life history characteristics, migratory patterns, spawning, pupping, and nursery areas of Atlantic HMS is being considered when updating Atlantic HMS EFH designations (comment period ends on December 22, 2016). EFH and HAPC designations are intended to focus conservation efforts and bring heightened awareness to the importance of HMS habitat.

Table 1 FMP Amendments and regulations affecting sandbar sharks

Effective Date	FMP/Amendment	Description of Action
January 1978	Preliminary Fishery Management Plan (PMP) for Atlantic Billfish and Sharks	• Mandatory data reporting requirements for foreign vessels; and, • Established a hard cap on the catch of sharks by foreign vessels, which when achieved would prohibit further landings of sharks by foreign vessels
Most parts effective April 26, 1993, such as quotas, complexes, etc. Finning prohibition effective May 26, 1993. Need to have permit, report landings, and carry observers effective July 1, 1993.	FMP for Sharks of the Atlantic Ocean	• Established a fishery management unit (FMU) consisting of 39 frequently caught species of Atlantic sharks, separated into three groups for assessment and regulatory purposes (LCS, SCS, and pelagic sharks); • Established calendar year commercial quotas for the LCS (2,436 mt dw) and pelagic sharks (580 mt dw) and divided the annual quota into two equal half-year quotas that apply to the following two fishing periods – January 1 through June 30 and July 1 through December 31; • Establishing a recreational trip limit of 4 LCS & pelagic sharks/vessel ; • Prohibited finning by requiring that the ratio between wet fins/dressed carcass weight not exceed five percent; • Prohibited the sale by recreational fishermen of sharks or shark products caught in the Economic Exclusive Zone (EEZ); • Required annual commercial permits for fishermen who harvest and sell shark (meat products and fins); and, • Requiring trip reports by permitted fishermen and persons conducting shark tournaments and requiring fishermen to provide information to NMFS under the Trip Interview Program. Other management measures included: establishing a framework procedure for adjusting commercial quotas, recreational bag limits, species size limits, management unit, fishing year, species groups, estimates of maximum sustainable yield (MSY), and permitting and reporting requirements; establishing a permit eligibility requirement that the owner or operator (including charter vessel and headboat owners/operators who intend to sell their catch); and requiring NMFS observers on selected shark fishing vessels to document mortality of marine mammals and endangered species.
July 1, 1999 -Limited access permits issued immediately;	FMP for Atlantic Tunas, Swordfish and Sharks	• Implemented limited access in commercial fisheries; • Reduced commercial LCS to 1,285 mt dw ; • Reduced recreational retention limits for all sharks to 1 shark/vessel/trip except for Atlantic sharpnose (1 Atlantic sharpnose/person/trip); • Established a recreational minimum size for all sharks except Atlantic sharpnose (4.5 feet); • Established a shark public display quota (60 mt ww);

Effective Date	FMP/Amendment	Description of Action
application and appeals processed over the next year (measures in italics were delayed)		- Established new procedures for counting dead discards and state landings of sharks after Federal fishing season closures against Federal quotas; and established season-specific over- and underharvest adjustment procedures *(effective January 1, 2003)*; - Established ridgeback and non-ridgeback categories of LCS (annual quotas of 783 mt dw for non-ridgeback LCS & 931 mt dw for ridgeback LCS; *effective January 1, 2003; suspended after 2003 fishing year*); and, - Implemented a commercial minimum size for ridgeback LCS (*suspended*).
February 1, 2004, except LCS and SCS quotas, and recreational retention and size limits, which were delayed	Amendment 1 to the FMP for Atlantic Tunas, Swordfish and Sharks	- Aggregated the large coastal shark complex; - Eliminated the commercial minimum size; - Established gear restrictions to reduce bycatch or reduce bycatch mortality (allowed only handline and rod and reel in recreational shark fishery); - Used maximum sustainable yield as a basis for setting commercial quotas (LCS quota=1,017 mt dw) (*effective December 30, 2003*); - Adjusted the recreational bag and size limits (allowed 1 bonnethead/person/trip in addition to 1 Atlantic sharpnose/person/trip with no size limit for bonnethead or Atlantic sharpnose) (*effective December 30, 2003*); - Established regional commercial quotas and trimester commercial fishing seasons (*trimesters not implemented until January 1, 2005; 69 FR 6964*); and, - Established a time/area closure off the coast of North Carolina (*effective January 1, 2005*). Other management measures included: establishing a mechanism for changing the species on the prohibited species list; updating essential fish habitat identifications for five species of sharks; requiring the use of non-stainless steel corrodible hooks and the possession of line cutters, dipnets, and approved dehooking device on BLL vessels; requiring vessel monitoring systems (VMS) for fishermen operating near the time/area closures off North Carolina and on gillnet vessels operating during the right whale calving season and, changing the administration for issuing display permits.
November 1, 2006, except for workshops	Consolidated HMS FMP	- Differentiation between PLL and BLL gear based upon the species composition of the catch onboard or landed; - The requirement that the 2nd dorsal fin and the anal fin remain on all sharks through landing; - Mandatory workshops and certifications for all vessel owners and operators that have PLL or BLL gear on their vessels for fishermen with HMS LAPs (*effective January 1, 2007*); and - Mandatory Atlantic shark identification workshops for all Federally permitted shark dealers (*effective January 1, 2007*).
July 24, 2008	Amendment 2 to the 2006 Consolidated HMS FMP	- Initiating rebuilding plan for sandbar sharks consistent with stock assessments; - Established a shark research fishery which collects shark life history information; - Implemented a sandbar research annual quota of 87.9 mt dw; sandbar retention only allowed within shark research fishery (see Table X for research fishery requirements); - Prohibiting the retention of sandbar sharks for recreational fishermen and commercial fishermen outside the shark research fishery;

Effective Date	FMP/Amendment	Description of Action
		• Required that all Atlantic sharks be offloaded with fins naturally attached; and, • Implemented BLL time/area closures recommended by the South Atlantic Fishery Management Council. • Other management measures included: modifying reporting requirements (dealer reports must be received by NMFS within 10 days of the reporting period), and modifying timing of shark stock assessments.
July 3, 2013	Amendment 5a to the 2006 Consolidated HMS FMP	• Implemented regional quota linkages between management groups whose species are often caught together in the same fisheries to prevent exceeding the newly established quotas through discarded bycatch. • Established a new minimum size limit for the large hammerhead shark species (great, smooth, and scalloped) of 78 inches (6.5 feet) fork length (FL). • The size limit for other shark species, including sandbar sharks, and the retention limits remained the same.
August 18, 2015	Amendment 6 to the 2006 Consolidated HMS FMP	Amendment 6 adjusted the annual commercial sandbar shark research fishery quota to 90.7 mt dw. The final action also: • Modified retention limits for LCS; • Created a new management boundary for SCS in the Atlantic region; • Created sub-regional commercial quotas for LCS in the Gulf of Mexico region; • Modified quota linkages between blacknose and non-blacknose SCS in both the Atlantic and Gulf of Mexico regions; • Modified the TACs and commercial quotas for non-blacknose SCS in both the Atlantic and Gulf of Mexico regions, • Modified vessel upgrading restrictions.
October 14, 2016	Draft Amendment 10 to the 2006 Consolidated HMS FMP	• Proposes updates and revisions to existing HMS EFH; • Proposes to modify existing HAPCs or designate new HAPCs for bluefin tuna, and sandbar, lemon, and sand tiger sharks, as necessary; and • Analyzes fishing and non-fishing impacts on EFH by considering environmental and management changes and new information since 2009.

2.2 Emergency and Other Major Rules

Rules in Relation to 1993 FMP

A number of difficulties arose in the initial year of implementation of the 1993 FMP that resulted in a short season and low ex-vessel prices. First, the January to June semi-annual LCS quota was exceeded shortly after implementation of the FMP, and that portion of the commercial fishery was closed on May 10, 1993. The LCS fishery reopened on July 1, 1993, with an adjusted quota of 875 mt dw (see Table 3 below). Derby-style fishing, coupled with what some participants observed to be an unusual abundance or availability of sharks, led to an intense and short fishing season for LCS, with the fishery closing within one month. Although fin prices remained strong throughout the brief season, the oversupply of shark carcasses led to reports of record low prices. The closure was significantly earlier than expected, and a number of commercial fishermen and dealers indicated that they were adversely affected. The intense season also complicated the task of monitoring the LCS quota and closing the season with the required advance notice.

To address these problems, a commercial trip limit of 4,000 lb for permitted vessels for LCS was implemented on December 28, 1993 (58 FR 68556), and a control date for the Atlantic shark fishery was established on February 22, 1994 (59 FR 8457). A final rule to implement additional measures authorized by the 1993 FMP published on October 18, 1994 (59 FR 52453), which:

- Clarified operation of vessels with a Federal commercial permit;
- Established the fishing year;
- Consolidated the regulations for drift gillnets;
- Required dealers to obtain a permit to purchase sharks;
- Required dealer reports;
- Established recreational bag limits;
- Established quotas for commercial landings; and
- Provided for commercial fishery closures when quotas were reached.

A final rule that capped quotas for LCS (2,570 mt dw) at the 1994 levels was published on May 2, 1995 (60 FR 21468).

In response to a 1996 LCS stock assessment, in 1997, NMFS reduced the LCS commercial quota by 50 percent to 1,285 mt dw and the recreational retention limit to two LCS, SCS, and pelagic sharks combined per trip with an additional allowance of two Atlantic sharpnose sharks per person per trip (62 FR 16648, April 2, 1997). On May 2, 1997, the Southern Offshore Fishing Association (SOFA) and other commercial fishermen and dealers sued the Secretary of Commerce (Secretary) on the April 1997 regulations.

In May 1998, NMFS completed its consideration of the economic effects of the 1997 LCS quotas on fishermen and submitted the analysis to the court. NMFS concluded that the 1997 LCS quotas may have had a significant economic impact on a substantial number of small entities and that there were no other available alternatives that would both mitigate those economic impacts and ensure the viability of the LCS stocks. Based on these findings, the court allowed NMFS to maintain those quotas while the case was settled in combination with litigation mentioned below regarding the 1999 FMP.

Rules in Relation to the 1999 FMP

The implementing regulations for the 1999 FMP were published on May 28, 1999 (64 FR 29090). At the end of June 1999, NMFS was sued several times by several different entities regarding the commercial and recreational management measures in the 1999 FMP. Due to the overlap of one of those lawsuits with the 1997 litigation, on June 30, 1999, NMFS received a court order enjoining it from enforcing the 1999 regulations with respect to Atlantic shark commercial catch quotas and fish-counting methods (including the counting of dead discards and state commercial landings after Federal closures), which were different from the quotas and fish counting methods prescribed by the 1997 Atlantic shark regulations. Due to the injunction, NMFS was unable to implement measures that would have established limited access in commercial fisheries, ridgeback and non-ridgeback categories of LCS, with sandbar sharks being placed in the ridgeback category, a commercial minimum size of 4.5 ft for ridgeback LCS, including sandbar sharks, and a reduced commercial LCS annual quota of 1,285 mt dw.

On September 25, 2000, the United States District Court for the District of Columbia ruled against the plaintiffs regarding the commercial pelagic shark management measures, stating that the regulations were consistent with the Magnuson-Stevens Act and the Regulatory Flexibility Act. On September 20, 2001, the same court ruled against different plaintiffs regarding the recreational shark retention limits in the 1999 FMP, again stating that the regulations were consistent with the Magnuson-Stevens Act. This recreational shark retention limits established a recreational minimum size for all sharks of 4.5 ft for all sharks, including sandbar sharks, except Atlantic sharpnose.

On November 21, 2000, SOFA *et al*. and NMFS reached a settlement agreement for the May 1997 and June 1999 lawsuits. On December 7, 2000, the United States District Court for the Middle District of Florida entered an order approving the settlement agreement and lifting the injunction. The settlement agreement required, among other things, an independent (*i.e.*, non-NMFS) review of the 1998 LCS stock assessment. The settlement agreement did not address any regulations affecting recreational shark fisheries, which included establishing a recreational minimum size of 4.5 ft for all sharks, including sandbar sharks, except Atlantic sharpnose. The injunction was lifted, on January 1, 2001 (66 FR 55) and on March 6, 2001, NMFS published an emergency rule implementing the settlement agreement (66 FR 13441). This emergency rule expired on September 4, 2001, and established the LCS annual quota (including sandbar sharks) (1,285 mt dw) at 1997 levels.

In late 2001, the Agency received the results of the independent peer review of the 1998 LCS stock assessment. These peer reviews found that the 1998 LCS stock assessment was not the best available science for LCS. Taking into consideration the settlement agreement, the results of the peer reviews of the 1998 LCS stock assessment, current catch rates, and the best available scientific information (not including the 1998 stock assessment projections), NMFS implemented another emergency rule for the 2002 fishing year that suspended certain measures. Under the 1999 regulations pending completion of new LCS and SCS stock assessments and a peer review of the new LCS stock assessment (66 FR 67118, December 28, 2001; extended 67 FR 37354, May 29, 2002). Specifically, NMFS maintained the 1997 LCS commercial quota (1,285 mt dw), suspended the commercial ridgeback LCS minimum size, suspended counting dead discards and state landings after a Federal closure against the quota, and replaced season-specific quota accounting methods with subsequent-season quota accounting methods. That emergency rule expired on December 30, 2002.

On May 28, 2002 (67 FR 36858), NMFS announced the availability of a modeling document that explored the suggestions of the CIE and NRC peer reviews on LCS. Then NMFS held a 2002 LCS stock assessment workshop in June 2002. On October 17, 2002, NMFS announced the availability of the 2002 LCS stock assessment and the workshop meeting report (67 FR 64098). The results of this stock assessment indicated that the LCS complex was still overfished and overfishing was occurring. Additionally, the 2002 LCS stock assessment found that sandbar sharks were overfished, but that overfishing was not occurring.

Based on the results of the 2002 LCS stock assessment, NMFS implemented an emergency rule to ensure that the commercial management measures in place for the 2003 fishing year were based on the best available science (67 FR 78990, December 27, 2002; extended 68 FR 31987, May 29, 2003). Specifically, the emergency rule implemented the LCS ridgeback/non-ridgeback split established in the 1999 FMP (the ridgeback quota was set at 783 mt dw and the non-ridgeback quota was set at 931 mt dw), suspended the commercial ridgeback LCS minimum size, and allowed both the season-specific quota adjustments and the counting of all mortality measures to go into place. Additionally, NMFS announced its intent to conduct an EIS and amend the 1999 FMP (67 FR 69180, November 15, 2002).

The emergency rule was an interim measure to maintain the status of LCS pending the re-evaluation of management measures in the context of the rebuilding plan through the amendment to the 1999 FMP. The emergency rule for the 2003 fishing year implemented for the first and only time the classification system (ridgeback/non-ridgeback LCS) finalized in the 1999 FMP. Table 5 indicates which LCS were considered ridgeback and which non-ridgeback. NMFS also implemented for the first time a provision to count state landings after a Federal closure and to count dead discards against the quota. To calculate the commercial quotas for these groups, NMFS took the average landings for individual species from 1999 through 2001 and either increased them or decreased them by certain percentages, as suggested by scenarios presented in the stock assessment. Because the stock assessment scenarios suggested that an increase in catch for blacktip sharks would not cause overfishing and that maintaining the sandbar sharks would not increase overfishing (the two primary species in the LCS fishery), this method resulted in an increase in the overall quota for the length of the emergency rule. During the comment period on the emergency rule and scoping for this amendment, NMFS received comments regarding, among other things, the quota levels under the rule, concern over secondary species and discards, the ability of fishermen to target certain species, and impacts of the different season length for ridgeback and non-ridgeback LCS. NMFS responded to these comments when extending the emergency rule and further considered these comments when examining the alternatives presented in the Amendment to the 1999 FMP.

NMFS received the results of the peer review of the 2002 LCS stock assessment in December 2002. These reviews were generally positive.

Rules in Relation to 2003 Amendment 1

Based on the 2002 LCS stock assessment, NMFS re-examined many of the shark management measures in the 1999 FMP for Atlantic Tunas, Swordfish, and Sharks. The changes in Amendment 1 affected all aspects of shark management, including management of sandbar sharks which were part of the LCS complex. Shortly after the final rule for Amendment 1 was published, NMFS conducted a rulemaking that adjusted the percent quota of LCS for each region, changed the seasonal split for the North Atlantic based on historical landing patterns of LCS, and finalized a method of changing the split between regions and/or seasons as necessary to account for changes in the fishery over time, and established a method to adjust from semi-annual to trimester seasons (November 30, 2004, 69 FR 6954).

Rules to Reduce Bycatch and Bycatch Mortality in the Atlantic PLL Fishery

Pelagic longline is not a primary gear used to target LCS or SCS; however, sandbar and dusky sharks, in particular, are often caught on PLL gear, which targets swordfish and tuna. Therefore, regulations affecting the PLL fishery could also result in changes in dusky and/or sandbar catches. In the 1999 FMP, NMFS committed to implement a closed area to PLL gear that would effectively protect small swordfish. NMFS began to work towards this goal shortly after the publication of the 1999 FMP. After the publication of the 1999 FMP, NMFS was sued by several entities who felt, among other things, that the Agency had not done enough to reduce bycatch in HMS fisheries. As a result, NMFS expanded the goal of the rule to reduce all bycatch and bycatch mortality, to the extent practicable, in the HMS PLL fishery. The following objectives were developed to guide agency action for this goal:

- Maximize the reduction in finfish bycatch;
- Minimize the reduction in the target catch of swordfish and other species;
- Consider impacts on the incidental catch of other species to minimize or reduce incidental catch levels; and
- Optimize survival of bycatch and incidental catch species.

NMFS published the final rule implementing the first regulatory amendment to the 1999 FMP on August 1, 2000 (65 FR 47214), which closed three large areas (DeSoto Canyon, Florida East Coast, and Charleston Bump) and prohibited the use of live bait in the Gulf of Mexico. The DeSoto Canyon closure was effective on November 1, 2000. The other closures were effective March 1, 2001. Given that shark, such as sandbar sharks, are often caught on PLL gear, the reduction of three commercially important areas minimized the incidental catch and bycatch. mortality of non-target species such as sandbar sharks.

During the course of this rulemaking, the PLL fleet exceeded the Incidental Take Statement (ITS) for sea turtles established during the Endangered Species Act (ESA) Section 7 Consultation for the 1999 FMP. That, combined with new information on sea turtles and the uncertainty regarding what the closures would mean for sea turtles, resulted in NMFS implementing certain measures to avoid jeopardy by reducing sea turtle bycatch in the PLL fishery. On July 6, 2004 (69 FR 40734), NMFS required the use of circle hooks for its entire US pelagic longline fleet. Although the use of circle hooks was initially adopted to protect sea turtles, research showed that their use can benefit other bycatch species (i.e., blue marlin).

Shark Rules After 2006 Consolidated HMS FMP

On February 16, 2006, NMFS published a temporary rule (71 FR 8223) to prohibit, through March 31, 2006, any vessel from fishing with any gillnet gear in the Atlantic Ocean waters between 32°00’ N. Lat. (near Savannah, GA) and 27°51’ N. Lat. (near Sebastian Inlet, FL) and extending from the shore eastward out to 80°00’ W. long under the authority of the Atlantic Large Whale Take Reduction Plan (ALWTRP) (50 CFR 229.32 (g)) and ESA. NMFS took this action based on its determination that a right whale mortality was the result of an entanglement by gillnet gear within the Southeast U.S. Restricted Area in January of 2006.

In 2007, NMFS expanded the equipment required for the safe handling, release, and disentanglement of sea turtles caught in the Atlantic shark BLL fishery (72 FR 5633, February 7, 2007). As a result, the equipment required for BLL vessels is now consistent with the requirements for the PLL fishery (e.g., vessels must carry dehookers and line cutters). Furthermore, this action implemented several year-round BLL closures to protect EFH to maintain consistency with the Caribbean Fishery Management Council.

On September 16, 2011 (76 FR 57709), NMFS published a NOI that announced NMFS’ intent to prepare an EIS and FMP Amendment that would consider catch shares for the Atlantic shark fisheries. The NOI also established a control date for eligibility to participate in an Atlantic shark catch share program, announced the availability of a white paper describing design elements of catch share programs in general and issues specific to the Atlantic shark fisheries, and requested public comment on the implementation of catch shares in the Atlantic shark fisheries. NMFS received comments on a variety of modifications to the existing management structure for the Atlantic shark fisheries, including programs such as catch shares, limited access privilege programs (LAPPs), individual fishing quotas (IFQs), and/or sectors. In addition, fishermen requested sandbar sharks landings be included when determining the landings history of fishermen for allocation purposes and that for any individuals quota provided, the current sandbar research quota be equally distributed to all qualified shark fishermen and allowed to be landed.

On December 2, 2011 (76 FR 75492), NMFS published a final rule that changed VMS requirements in Atlantic HMS fisheries. All vessels with Atlantic HMS permits that are required to use VMS, including vessels with pelagic longline gear on board, vessels with bottom longline gear on board in the vicinity of the mid-Atlantic closed area (between 33º N and 36º 30’ N) from January 1 to July 31, and vessels with shark gillnet gear on board fishing between November 15 and April 15, must comply with the new requirements. The purpose of this final action was to facilitate enhanced communication with HMS vessels at sea, provide HMS fishery participants with an additional means of sending and receiving information at sea, ensure that HMS VMS units are consistent with the current VMS technology and type approval requirements that apply to newly installed units, and to provide NMFS enforcement with additional information describing gear onboard and target species, such as interactions with prohibited species such as sandbar and/or dusky sharks.

On October 14, 2016, NMFS published the availability of Draft Amendment 10 on essential fish habitat (EFH) and an associated Environmental Assessment (EA) (81 FR 62100). Draft Amendment 10 proposes to update and revise existing HMS EFH; proposes to modify existing HAPCs or designate new HAPCs for bluefin tuna, and sandbar, lemon, and sand tiger sharks, as necessary; and analyzes fishing and non-fishing impacts on EFH by considering environmental and management changes and new information since 2009

Table 2 Chronological list of most of the Federal Register publications relating to Atlantic large coastal sharks, when appropriate specific to sandbar sharks.

Federal Register Cite	Date	Rule or Notice
Pre 1993		
48 FR 3371	1/25/1983	Preliminary management plan with optimum yield and total allowable level of foreign fishing for sharks
56 FR 20410	5/3/1991	NOA of draft FMP; 8 hearings
57 FR 1250	1/13/1992	NOA of Secretarial FMP
57 FR 24222	6/8/1992	Proposed rule to implement FMP
57 FR 29859	7/7/1992	Correction to 57 FR 24222
1993		
58 FR 21931	4/26/1993	Final rule and interim final rule implementing FMP
58 FR 27336	5/7/1993	Correction to 58 FR 21931
58 FR 27482	5/10/1993	LCS commercial fishery closure announcement
58 FR 40075	7/27/1993	Adjusts 1993 second semi-annual quotas
58 FR 40076	7/27/1993	LCS commercial fishery closure announcement
58 FR 46153	9/1/1993	Notice of 13 public scoping meetings
58 FR 59008	11/5/1993	Extension of comment period for 58 FR 46153
58 FR 68556	12/28/1993	Interim final rule implementing trip limits
1994		
59 FR 3321	1/21/1994	Extension of comment period for 58 FR 68556
59 FR 8457	2/22/1994	Notice of control date for entry
59 FR 25350	5/16/1994	LCS commercial fishery closure announcement
59 FR 33450	6/29/1994	Adjusts second semi-annual 1994 quota
59 FR 38943	8/1/1994	LCS commercial fishery closure announcement
59 FR 44644	8/30/1994	Reopens LCS fishery with new closure date
59 FR 48847	9/23/1994	Notice of public scoping meetings
59 FR 51388	10/11/1994	Rescission of LCS closure
59 FR 52277	10/17/1994	Notice of additional scoping meetings
59 FR 52453	10/18/1994	Final rule implementing interim final rule in 1993 FMP
59 FR 55066	11/3/1994	LCS commercial fishery closure announcement
1995		
60 FR 2071	1/6/1995	Proposed rule to adjust quotas
60 FR 21468	5/2/1995	Final rule indefinitely establishes LCS quota at 1994 level
60 FR 27042	5/22/1995	LCS commercial fishery closure announcement
60 FR 30068	6/7/1995	Announcement of Shark Operations Team meeting
60 FR 37023	7/19/1995	Adjusts second semi-annual 1995 quota
60 FR 38785	7/28/1995	ANPR - Options for Permit Moratoria
60 FR 44824	8/29/1995	Extension of ANPR comment period
60 FR 49235	9/22/1995	LCS commercial fishery closure announcement
60 FR 61243	11/29/1995	Announces Limited Access Workshop
1996		
61 FR 21978	5/13/1996	LCS commercial fishery closure announcement
61 FR 37721	7/19/1996	Announcement of Shark Operations Team meeting.
61 FR 39099	7/26/1996	Adjusts second semi-annual 1996 quota
61 FR 43185	8/21/1996	LCS commercial fishery closure announcement
61 FR 67295	12/20/1996	Proposed rule to reduce Quotas/Bag Limits

Federal Register Cite	Date	Rule or Notice
61 FR 68202	12/27/1996	Proposed rule to establish limited entry (Draft Amendment 1 to 1993 FMP)
1997		
62 FR 724	1/6/1997	NOA of Draft Amendment 1 to 1993 FMP
62 FR 1705	1/13/1997	Notice of 11 public hearings for Amendment 1
62 FR 1872	1/14/1997	Extension of comment period and notice of public hearings for proposed rule on quotas
62 FR 4239	1/29/1997	Extension of comment period for proposed rule on quotas
62 FR 8679	2/26/1997	Extension of comment period for Amendment 1 to 1993 FMP
62 FR 16647	4/7/1997	Final rule reducing quotas/bag limits
62 FR 16656	4/7/1997	LCS commercial fishery closure announcement
62 FR 26475	5/14/1997	Announcement of Shark Operations Team meeting
62 FR 26428	5/14/1997	Adjusts second semi-annual 1997 LCS quota
62 FR 27586	5/20/1997	Notice of Intent to prepare an supplemental environmental impact statement
62 FR 27703	5/21/1997	Technical Amendment regarding bag limits
62 FR 38942	7/21/1997	LCS commercial fishery closure announcement
1998		
63 FR 14837	3/27/1998	LCS commercial fishery closure announcement
63 FR 19239	4/17/1998	NOA of draft consideration of economic effects of 1997 quotas
63 FR 27708	5/20/1998	NOA of final consideration of economic effects of 1997 quotas
63 FR 29355	5/29/1998	Adjusts second semi-annual 1998 LCS quota
63 FR 41736	8/5/1998	LCS commercial fishery closure announcement
63 FR 57093	10/26/1998	NOA of draft 1999 FMP
1999		
64 FR 3154	1/20/1999	Proposed rule for draft 1999 FMP
64 FR 14154	3/24/1999	LCS commercial fishery closure announcement
64 FR 29090	5/28/1999	Final rule for 1999 FMP
64 FR 30248	6/7/1999	Fishing season notification
64 FR 37700	7/13/1999	Technical amendment to 1999 FMP final rule
64 FR 37883	7/14/1999	Fishing season change notification
64 FR 47713	9/1/1999	LCS fishery reopening
64 FR 52772	9/30/1999	Notice of Availability of outline for National Plan of Action for sharks
64 FR 53949	10/5/1999	LCS closure postponement
64 FR 66114	11/24/1999	Fishing season notification
2000		
65 FR 16186	3/27/2000	Revised timeline for National Plan of Action for sharks
65 FR 35855	6/6/2000	Fishing season notification and 2nd semi-annual LCS quota adjustment
65 FR 47214	8/1/2000	Final rule closing Desoto Canyon, Florida East Coast, and Charleston Bump and requiring live bait for PLL gear in Gulf of Mexico
65 FR 47986	8/4/2000	Notice of Availability of National Plan of Action for sharks
65 FR 38440	6/21/2000	Implementation of prohibited species provisions and closure change
65 FR 60889	10/13/2000	Final rule closed NED and required dipnets and line clippers for PLL vessels
65 FR 75867	12/5/2000	Fishing season notification
2001		
66 FR 55	1/2/2001	Implementation of 1999 FMP pelagic shark quotas

Federal Register Cite	**Date**	**Rule or Notice**
66 FR 10484	2/15/2001	NOA of Final National Plan of Action for the Conservation and Management of Sharks
66 FR 13441	3/6/2001	Emergency rule to implement settlement agreement
66 FR 33918	6/26/2001	Fishing season notification and 2nd semi-annual LCS quota adjustment
66 FR 34401	6/28/2001	Proposed rule to implement national finning ban
66 FR 36711	7/13/2001	Emergency rule implementing 2001 BiOp requirements
66 FR 46401	9/5/2001	LCS fishing season extension
66 FR 48812	9/24/2001	Amendment to emergency rule (66 FR 13441) to incorporate change in requirement for handling and release guidelines
66 FR 67118	12/28/2001	Emergency rule to implement measures based on results of peer review and fishing season notification
2002		
67 FR 6194	2/11/2002	Final rule implementing national shark finning ban
67 FR 8211	2/22/2002	Correction to fishing season notification 66 FR 67118
67 FR 30879	5/8/2002	Notice of availability of SCS stock assessment
67 FR 36858	5/28/2002	Notice of availability of LCS sensitivity document and announcement of stock evaluation workshop in June
67 FR 37354	5/29/2002	Extension of emergency rule and fishing season announcement
67 FR 45393	7/9/2002	Final rule to implement measures under 2001 BiOp (gangion placement measure not implemented), including HMS shark gillnet measures
67 FR 64098	10/17/2002	Notice of availability of LCS stock assessment and final meeting report
67 FR 69180	11/15/2002	Notice of intent to conduct an environmental impact assessment and amend the 1999 FMP
67 FR 72629	12/6/2002	Proposed rule regarding EFPs
67 FR 78990	12/27/2002	Emergency rule to implement measures based on stock assessments and fishing season notification
2003		
68 FR 1024	1/8/2003	Announcement of 4 public hearings on emergency rule
68 FR 1430	1/10/2003	Extension of comment period for proposed rule on EFPs
68 FR 3853	1/27/2003	Announcement of 7 scoping meetings and notice of availability of Issues and Options paper
68 FR 31983	5/29/2003	Emergency rule extension and fishing season notification
68 FR 45196	8/1/2003	Proposed rule and NOA for draft Amendment 1 to 1999 FMP
68 FR 47904	8/12/2003	Public hearing announcement for draft Amendment 1 to 1999 FMP
68 FR 51560	8/27/2003	Announcement of HMS AP meeting on draft Amendment 1 to 1999 FMP
68 FR 54885	9/19/2003	Rescheduling of public hearings and extending comment period for draft Amendment 1 to 1999 FMP
68 FR 64621	11/14/2003	NOA of availability of Amendment 1
68 FR 66783	11/28/2003	NOI for SEIS
68 FR 74746	12/24/2003	Final Rule for Amendment 1
2004		
69 FR 6621	02/11/04	Proposed rule for PLL fishery
69 FR 10936	3/9/2004	SCS fishery closure
69 FR 19979	4/15/2004	VMS type approval notice
69 FR 26540	5/13/2004	N. Atlantic Quota Split Proposed Rule

Federal Register Cite	Date	Rule or Notice
69 FR 28106	5/18/2004	VMS effective date proposed rule
69 FR 30837	6/1/2004	Fishing season notice
69 FR 33321	6/15/2004	N. Atlantic Quota Split Final Rule
69 FR 40734	07/06/04	Final rule for PLL fishery
69 FR 44513	07/26/04	Notice of sea turtle release/protocol workshops
69 FR 47797	8/6/2004	Technical amendment correcting changes to BLL gear requirements
69 FR 49858	08/12/04	Advanced notice of proposed rulemaking; reducing sea turtle interactions with fishing gear
69 FR 51010	8/17/2004	VMS effective date final rule
69 FR 56024	9/17/2004	Regional quota split proposed rule
69 FR 6954	11/30/2004	Regional quota split final rule and season announcement
69 FR 71735	12/10/2004	Correction notice for 69 FR 6954
2005		
70 FR 11922	3/10/2005	2nd and 3rd season proposed rule
70 FR 21673	4/27/2005	2nd and 3rd season final rule
70 FR 24494	5/10/2005	North Carolina Petition for Rulemaking
70 FR 29285	5/20/2005	Notice of handling and release workshops for BLL fishermen
70 FR 48804	8/19/2005	Proposed rule Draft Consolidated HMS FMP
70 FR 48704	8/19/2005	NOA of Draft EIS for Draft Consolidated HMS FMP
70 FR 52380	9/2/2005	Correction to 70 FR 48704
70 FR 53146	9/7/2005	Cancellation of hearings due to Hurricane Katrina
70 FR 54537	9/15/2005	Notice of LCS data workshop
70 FR 55814	9/23/2005	Cancellation of Key West due to Hurricane Rita
70 FR 58190	10/5/2005	Correction to 70 FR 54537
70 FR 58177	10/5/2005	Extension of comment period for Draft Consolidated HMS FMP
70 FR 58366	10/6/2005	1st season proposed rule
70 FR 72080	12/1/2005	1st season final rule, fishing season notification
70 FR 73980	12/14/2005	Final Agency decision on petition for rulemaking to amend mid-Atlantic closed area
70 FR 76031	12/22/2005	Notice for Large Coastal Shark 2005/2006 Stock Assessment Workshop
70 FR 76441	12/27/2005	Rescheduling and addition of public hearings for Consolidated HMS FMP
2006		
71 FR 8223	2/16/2006	Temporary rule prohibiting gillnet gear in areas around the Southeast U.S. Restricted Area
71 FR 8557	2/17/2006	Proposed Rule for third and second trimester seasons
71 FR 12185	3/9/2006	Notice for Large Costal Shark Review Workshop
71 FR 15680	3/29/2006	Proposed rule for gear operation and deployment for BLL and gillnet fishery and complementary closure
71 FR 16243	3/31/2006	Final rule for second and third trimester seasons
71 FR 26351	5/4/2006	Scientific research permit for pelagic shark research
71 FR 30123	5/25/2006	Notice of availability of stock assessment of dusky sharks
71 FR 41774	7/24/2006	Notice of availability of final stock assessment for Large Costal Sharks
71 FR 58058	10/2/2006	Final Rule for the HMS Consolidated Fishery Management Plan
71 FR 58058	10/2/2006	1st season proposed rule
71 FR 62095	10/23/2006	Notice of shark dealer identification workshops and protected species safe handling and release workshops
71FR 64213	11/1/2006	Extension of comment period regarding the 2007 first trimester season proposed rule

Federal Register Cite	**Date**	**Rule or Notice**
71 FR 65086	11/7/2006	Notice of Intent to prepare Amendment 2 to the 2006 Consolidated HMS FMP and status determination for sandbar, blacktip, dusky, the LCS complex, and porbeagle sharks based on the latest stock assessments
71 FR 65087	11/7/2006	Notice of Intent to prepare Amendment 1 to the 2006 Consolidated HMS FMP for Essential Fish Habitat for Some Atlantic Highly Migratory Species
71 FR 66154	11/13/2006	Extension of comment period regarding the 2007 first trimester season proposed rule
71 FR 68561	11/27/2006	Notice of shark dealer identification workshops and protected species safe handling and release workshops
71 FR 75122	12/14/2006	Final Rule and Temporary Rule for the 2007 first trimester season and south Atlantic quota modification
71 FR 75714	12/18/2006	Notice of shark dealer identification workshops and protected species safe handling and release workshops
2007		
72 FR 123	1/3/2007	Notice of public hearings for scoping for Amendment 2 to the 2006 Consolidated HMS FMP
72 FR 5633	2/7/2007	Final rule for gear operation and deployment for BLL and gillnet fishery and complementary closures
72 FR 7417	2/15/2007	Revised list of equipment models for careful release of sea turtles in the PLL and BLL fisheries
72 FR 8695	2/27/2007	Notice of new VMS type approval for HMS fisheries and other programs
72 FR 10480	3/8/2007	Proposed rule for second and third trimester seasons
72 FR 11335	3/13/2007	Schedule of public protected resources dehooking workshops and Atlantic shark identification workshops
72 FR 20765	4/26/2007	Final rule for second and third trimester season
72 FR 32836	6/14/2007	Schedule of public protected resources dehooking workshops and Atlantic shark identification workshops
72 FR 34632	6/25/2007	Final rule prohibiting gillnet gear from November 15-April 15 between NC/SC border and 29°00’N.
72 FR 41392	7/27/2007	Proposed rule for Amendment 2 to the Consolidated Atlantic Highly Migratory Species Fishery Management Plan
72 FR 52552	9/14/2007	Schedules for Atlantic shark identification workshops and protected species safe handling, release, and identification workshops
72 FR 55729	10/1/2007	Proposed rule for 2008 first trimester quotas
72 FR 56330	10/3/2007	Amendment 2 to the Consolidated FMP – extension of comment period
72 FR 57104	10/5/2007	Final rule amending restriction in the Southeast U.S. Monitoring Area
72 FR 67580	11/29/2007	Final rule for 2008 first trimester quotas
2008		
73 FR 11621	3/4/2008	Notice of Atlantic shark identification workshops and protected species safe handling, release, and identification workshops
73 FR 19795	4/11/2008	Proposed rule for renewal of Atlantic tunas longline limited access permits; and, Atlantic shark dealer workshop attendance requirements
73 FR 25665	5/7/2008	Stock Status Determinations; Notice of Intent (NOI) to prepare an Environmental Impact Statement (EIS) for Amendment 3 to the 2006 Consolidated HMS FMP
73 FR 32309	6/6/2008	Notice of Atlantic shark identification workshops and protected species safe handling, release, and identification workshops

Federal Register Cite	**Date**	**Rule or Notice**
73 FR 35778	6/24/2008	Final rule for Amendment 2 to the 2006 Consolidated HMS FMP and fishing season notification
73 FR 35834	6/24/2008	Shark research fishery; Notice of intent; request for applications
73 FR 38144	7/3/2008	Final rule for renewal of Atlantic tunas longline limited access permits; and, Atlantic shark dealer workshop attendance requirements
73 FR 40658	7/15/2008	Final rule for Amendment 2 to the 2006 Consolidated HMS FMP and fishing season notification; correction/republication
73 FR 47851	8/15/2008	Effectiveness of collection-of-information requirements to implement fins-on check box on Southeast dealer form
73 FR 51448	9/3/2008	Notice of Atlantic shark identification workshops and protected species safe handling, release, and identification workshops
73 FR 53408	9/16/2008	Notice of public meeting, public hearing, and scoping meetings regarding the AP meeting and various other hearings/meetings
73 FR 53851	9/17/2008	Atlantic Shark Management Measures; Changing the time and location of a scoping meeting
73 FR 63668	10/27/2008	Proposed rule for 2009 shark fishing season
2009		
74 FR 8913	2/27/2009	Notice of Atlantic shark identification workshops and protected species safe handling, release, and identification workshops
74 FR 27506	6/10/2009	Notice of Atlantic shark identification workshops and protected species safe handling, release, and identification workshops
74 FR 30479	6/26/2009	Inseason action to close the commercial non–sandbar large coastal shark fisheries in the shark research fishery and Atlantic region
74 FR 46572	9/10/2009	Notice of Atlantic shark identification workshops and protected species safe handling, release, and identification workshops
74 FR 51241	10/6/2009	Inseason action to close the commercial sandbar shark research fishery
74 FR 55526	10/28/2009	Proposed rule for 2010 shark fishing season
74 FR 56177	10/30/2009	Notice of intent for 2010 shark research fishery; request for applications
2010		
75 FR 29991	5/28/2010	Notice of Schedules for Atlantic Shark Identification Workshops and Protected Species Safe Handling Release, and Identification Workshops
75 FR 52510	8/26/2010	Notice for Fisheries of the Gulf of Mexico and South Atlantic; Southeast Data, Assessment, and Review for Highly Migratory Species Fisheries; Sandbar, Dusky, and Blacknose Sharks
75 FR 53665	9/1/2010	Notice of Schedules for Atlantic Shark Identification Workshops and Protected Species Safe Handling Release, and Identification Workshops
75 FR 54598	9/8/2010	Notice of Schedules for Atlantic Shark Identification Workshops and Protected Species Safe Handling, Release, and Identifications Workshops; Correction
75 FR 57235	9/20/2010	Advance Notice of Proposed Rulemaking for Atlantic Shark Management Measures
75 FR 57240	9/20/2010	Proposed Rule for 2011 Commercial Fishing Season and Adaptive Management Measures for the Atlantic Shark Fishery
75 FR 57259	9/20/2010	Notice of Intent for Atlantic Shark Management Measures: 2011 Research Fishery
75 FR 62690	10/13/2010	Inseason Action to Close the Commercial Non-sandbar Large Coastal Shark Research Fishery
75 FR 70216	11/17/2010	Fisheries of the Gulf of Mexico and South Atlantic; Southeast Data, Assessment, and Review (SEDAR); Assessment Process Webinar for Highly Migratory Species (HMS) Fisheries Sandbar, Dusky, and Blacknose Sharks
75 FR 74693	12/1/2010	Notice of Schedules for Atlantic Shark Identification Workshops and

Federal Register Cite	**Date**	**Rule or Notice**
		Protected Species Safe Handling, Release, and Identification Workshop
75 FR 75416	12/3/2010	Inseason Action to Close the Commercial Non-Sandbar Large Coastal Shark Fishery in the Atlantic Region
2011		
76 FR 5340	1/31/2011	Notice of Schedules for Atlantic Shark Identification Workshops and Protected Species Safe Handling, Release and Identification Workshops, Correction
76 FR 13985	3/15/2011	Notice of Public Meeting for the Fisheries of the Gulf of Mexico and South Atlantic; Southeast Data, Assessment, and Review (SEDAR)
76 FR 34209	6/13/2011	Notice of Schedules for Atlantic Shark Identification Workshops and Protected Species Safe Handling, Release, and Identification Workshops
76 FR 36071	6/21/2011	Proposed rule for Atlantic Highly Migratory Species; Vessel Monitoring Systems
76 FR 37750	6/28/2011	Proposed Rule for Atlantic Highly Migratory Species; Electronic Dealer Reporting Requirement
76 FR 38107	6/29/2011	Correction on Proposed Rule for Atlantic Highly Migratory Species; Electronic Dealer Reporting Requirement
76 FR 38598	7/1/2011	Notice of Atlantic Highly Migratory Species; Vessel Monitoring Systems
76 FR 44501	7/26/2011	Inseason Action To Close the Commercial Non-Sandbar Large Coastal Shark Research Fishery
76 FR 57709	9/16/2011	Notice of Intent for Catch Shares in the Atlantic Shark Fisheries
76 FR 59661	9/27/2011	Notice of Schedules for Atlantic Shark Identification Workshops and Protected Species Safe Handling, Release, and Identification Workshop
76 FR 61092	10/3/2011	Notice of Availability of Stock Assessment Reports for Dusky, Sandbar, and Blacknose Sharks in the U.S. Atlantic and Gulf of Mexico
76 FR 62331	10/7/2011	Notice of Stock Status Determinations
76 FR 64074	10/17/2011	Notice of Schedules for Atlantic Shark Identification Workshops and Protected Species Safe Handling, Release, and Identification Workshops; Correction
10/24/2016	10/24/2011	Atlantic Highly Migratory Species; Advisory Panel for Atlantic Highly Migratory Species Southeast Data, Assessment, and Review Workshop
76 FR 65673	10/24/2011	Notice of Stock Status Determinations
76 FR 67149	10/31/2011	Notice of Intent for 2012 Research Fishery Participants
76 FR 67121	10/31/2011	Proposed Rule for 2012 Atlantic Shark Commercial Fishing Season
76 FR 72383	11/23/2011	Atlantic Highly Migratory Species; Atlantic Shark Management Measures; Notice of Workshops
76 FR 72678	11/25/2011	Notice of Intent to Issue Exempted Fishing, Scientific Research, Display, and Chartering Permits; Letters of Acknowledgements
2012		
77 FR 3393	1/24/2012	Final Rule to Establish the Quotas and Opening Dates for the 2012 Atlantic Shark Commercial Fishing Season
77 FR 8218	2/14/2012	NMFS Announces a Public Meeting for Selected Participants of the 2012 Shark Research Fishery
77 FR 31562	5/29/2012	NMFS Considers Adding Gulf of Mexico Sharks to Amendment 5 to the 2006 Consolidated HMS FMP
77 FR 35357	6/13/2012	NMFS Announces the Opening Date of the Commercial Atlantic Region Non-Sandbar Large Coastal Fishery
77 FR 39648	7/5/2012	Inseason Action to Close the Commercial Non-Sandbar Large Coastal Shark Fishery in the Gulf of Mexico Region
77 FR 61562	10/10/2012	Proposed Rule to Establish the Quotas and Opening Dates for the 2013 Atlantic Shark Commercial Fishing Season

Federal Register Cite	Date	Rule or Notice
77 FR 67631	10/13/2012	Notice of Intent for Applications to the 2013 Shark Research Fishery
77 FR 73608	12/11/2012	Public Hearings for Draft Amendment 5 to the 2006 Consolidated HMS FMP
77 FR 75896	12/26/2012	Final Rule Regarding the 2013 Atlantic Shark Commercial Fishing Season
2013		
78 FR 279	1/3/2013	Two Additional Public Hearings and a Change in Date of One Public Hearing for Draft Amendment 5 to the 2006 Consolidated HMS FMP
78 FR 14515	3/6/2013	Public Meeting for Selected Participants of the 2013 Shark Research Fishery
78 FR 24743	4/26/2013	Availability of the Final EIS for Amendment 5a to the 2006 Consolidated HMS FMP
78 FR 25685	5/2/2013	Proposed Rule to Implement Provisions of the Shark Conservation Act of 2010
78 FR 40318	7/3/2013	Final Rule for Amendment 5a to the 2006 Consolidated HMS FMP and Closure of the Gulf of Mexico Blacktip Shark Management Group
78 FR 52487	8/23/2013	Proposed Rule to Establish the Quotas and Opening Dates for the 2014 Atlantic Shark Commercial Fishing Season
78 FR 65974	11/4/2013	Nominations for the Atlantic HMS SEDAR Pool
78 FR 70018	11/22/2013	Notice of Intent for Applications to the 2014 Shark Research Fishery
78 FR 70500	11/26/2013	Final Rule Regarding the 2014 Atlantic Shark Commercial Fishing Season
2014		
79 FR 12155	3/4/2014	Public Meeting for Selected Participants of the 2014 Shark Research Fishery
79 FR 30064	5/27/2014	Notice of Intent to Prepare an EA for Amendment 6 to the 2006 Consolidated HMS FMP
79 FR 54252	9/11/2014	Proposed Rule to Establish the Quotas and Opening Dates for the 2015 Atlantic Shark Commercial Fishing Season
79 FR 64750	10/31/2014	Notice of Intent for Applications to the 2014 Shark Research Fishery
79 FR 71331	12/2/2014	Final Rule to Establish the Quotas and Opening Dates for the 2015 Atlantic Shark Commercial Fishing Season
79 FR 73555	12/11/2014	Nominations for the Atlantic HMS SEDAR Pool
2015		
80 FR 2648	1/20/2015	Proposed Rule for Amendment 6 to the 2006 Consolidated Atlantic HMS FMP
80 FR 2916	1/21/2015	Notice of Intent for Applications from the Gulf of Mexico Region to the 2015 Shark Research Fishery
80 FR 3221	1/22/2015	Public Meeting for Selected Participants of the 2015 Shark Research Fishery
80 FR 12394	3/9/2015	Notice to Reschedule the Manteo, NC Public Hearing for Draft Amendment 6 to the 2006 Consolidated HMS FMP
80 FR 50074	8/18/2015	Final Rule for Amendment 6 to the 2006 Consolidated Atlantic HMS FMP
80 FR 49974	8/18/2015	Proposed Rule to Establish the Quotas and Opening Dates for the 2016 Atlantic Shark Commercial Fishing Season
80 FR 68513	11/5/2015	Notice of Intent for Applications to the 2016 Shark Research Fishery
80 FR 74999	12/1/2015	Final Rule to Establish the Quotas and Opening Dates for the 2016 Altantic Shark Commercial Fishing Season
2016		
81 FR 1941	1/14/2016	Notice of Public Meeting for Selected Participants of the 2016 Shark Research Fishery
81 FR 59167	8/29/2016	Proposed Rule to Establish Quotas, Opening Dates, and Retention Limits for the 2017 Atlantic Shark Commercial Fishing Season

Table 3 **List of Large Coastal Shark Seasons, 1993-2016**

Note: SB=sandbar shark; NSB=non-sandbar LCS; GOM = Gulf of Mexico; ATL = Atlantic.

Year	Open dates	Quota (mt dw)
1993	Jan. 1 - May 15	1,218
	July 1 - July 31	875
1994	Jan. 1 - May 17	1,285
	July 1 - Aug 10 Sept. 1 - Nov. 4	1,318
1995	Jan. 1 - May 31	1,285
	July 1 - Sept. 30	968
1996	Jan. 1 - May 17	1,285
	July 1 - Aug. 31	1,168
1997	Jan. 1 - April 7	642
	July 1 - July 21	326
1998	Jan. 1 - Mar. 31	642
	July 1 - Aug. 4	600
1999	Jan. 1 - Mar. 31	642
	July 1 - July 28 Sept. 1 - Oct. 15	585
2000	Jan. 1 - Mar. 31	642
	July 1 - Aug. 15	542
2001	Jan. 1 - Mar. 24	642
	July 1 - Sept. 4	697
2002	Jan. 1 - April 15	735.5
	July 1 - Sept. 15	655.5
2003	Jan. 1 - April 15 (Ridgeback LCS) Jan. 1 - May 15 (Non-ridgeback LCS)	391.5 (Ridgeback LCS) 465.5 (Non-ridgeback LCS)
	July 1 - Sept. 15 (All LCS)	424 (Ridgeback LCS) 498 (Non-ridgeback LCS)
2004	GOM: Jan. 1 - Feb. 29 S. Atl: Jan 1 - Feb. 15 N. Atl: Jan 1 - April 15	190.3 244.7 18.1
	GOM: July 1 - Aug. 15 S. Atl: July 1 - Sept. 30 N. Atl: July 1 - July 15	287.4 369.5 39.6
2005	GOM: Jan 1 - Feb 28 S. Atl: Jan. 1 - Feb 15 N. Atl: Jan. 1 - April 30	156.3 133.3 6.3
	GOM: July 6 - July 23 S. Atl: July 6 - Aug 31 N. Atl: July 21 - Aug 31	147.8 182 65.2
	GOM: Sept. 1 - Oct. 31 S. Atl: Sept 1 - Nov. 15 N. Atl: Sept 1 - Sept. 15	167.7 187.5 4.9
2006	GOM: Jan 1 - April 15 S. Atl: Jan 1 - Mar. 15 N. Atl: Jan 1 - April 30	222.8 141.3 5.3
	GOM: July 6 – July 31 S. Atl: July 6 – Aug. 16 N. Atl: July 6 – Aug. 6	180 151.7 66.3

Year	Open dates	Quota (mt dw)
	GOM: Sept.1 – Nov. 7 S. Atl: Sept.1 – Oct. 3 N. Atl: Closed	225.6 50.3 Closed
2007	GOM: January 1 – January 15 S. Atl: Closed N. Atl: January 1 – April 30	62.3 Closed (-112.9) 7.9
	GOM: September 1 – September 22 S. Atl: July 15 – August 15 N. Atl: July 6 – July 31	83.1 163.1 69.0
	GOM: merged with 2nd season S. Atl: merged with 2nd season N. Atl: CLOSED	
2008	GOM: CLOSED to July 23 S. Atl: CLOSED to July 23 N. Atl: CLOSED to July 23	Closed (51) Closed (16.3) Closed (10.7)
	SB Research: July 24 - Dec. 31	87.9
2009	SB: Jan 23 – Oct 14	87.9
2010	SB: Jan 5 – Dec 31	87.9
2011	SB: Jan 1 – Dec 31	87.9
2012	SB: Jan 24 – Dec 31	87.9
2013	SB: Jan 1 – Dec 31	116.6
2014	SB: Jan 1 – Dec 31	116.6
2015	SB: Jan 1 – Dec 31	116.6 / 90.7
2016	SB: Jan 1 – Dec 31	90.7

Table 4 List of species that are LCS and LCS that later became a prohibited species

Common name	Species name	Notes
LCS		
Ridgeback Species		
Sandbar	*Carcharhinus plumbeus*	
Silky	*Carcharhinus falciformis*	
Tiger	*Galeocerdo cuvier*	
Non-Ridgeback Species		
Blacktip	*Carcharhinus limbatus*	
Spinner	*Carcharhinus brevipinna*	
Bull	*Carcharhinus leucas*	
Lemon	*Negaprion brevirostris*	
Nurse	*Ginglymostoma cirratum*	
Scalloped hammerhead	*Sphyrna lewini*	

Common name	Species name	Notes
Great hammerhead	*Sphyrna mokarran*	
Smooth hammerhead	*Sphyrna zygaena*	
Prohibited Species		
Sand tiger	*Odontaspis taurus*	Part of LCS complex until 1997
Bigeye sand tiger	*Odontaspis noronhai*	Part of LCS complex until 1997
Whale	*Rhincodon typus*	Part of LCS complex until 1997
Basking	*Cetorhinus maximus*	Part of LCS complex until 1997
White	*Carcharodon carcharias*	Part of LCS complex until 1997
Dusky	*Carcharhinus obscurus*	Part of LCS complex until 1999
Bignose	*Carcharhinus altimus*	Part of LCS complex until 1999
Galapagos	*Carcharhinus galapagensis*	Part of LCS complex until 1999
Night	*Carcharhinus signatus*	Part of LCS complex until 1999
Caribbean reef	*Carcharhinus perezi*	Part of LCS complex until 1999
Narrowtooth	*Carcharhinus brachyurus*	Part of LCS complex until 1999

Table 5 Summary of current large coastal shark regulations

Requirement for Sandbar Research Fishery	Retention Limits	Quotas	Other Requirements
Inside the Commercial Shark Research Fishery	Trip limit is specific to each vessel and owner(s) combination and is listed on the Shark Research Permit.	Quota from 2008-2012: 87.9 mt dw Quota from 2013-Aug. 17, 2015: 116.6 mt dw Quota as of Aug. 18, 2015 – 90.7 mt dw	- Need Shark Research Fishery Permit -100 percent observer coverage when participating in research fishery - Adjusted quotas (established through Dec. 31, 2016) may be further adjusted based on future overharvests, if any.
Outside the Commercial Shark Research Fishery	No retention outside of the Commercial Shark Research Fishery allowed.	NA	.
All Commercial Shark Fisheries	**Gears Allowed:** Gillnet; Bottom/Pelagic Longline; Rod and Reel; Handline; Bandit Gear		
	Authorized Species: Non-sandbar LCS (silky (not authorized for PLL), blacktip, spinner, bull, lemon, nurse, great hammerhead (not authorized for PLL), scalloped hammerhead (not authorized for PLL), smooth hammerhead (not authorized for PLL), and tiger sharks), pelagic sharks (porbeagle, common thresher, shortfin mako, oceanic whitetip (not authorized for PLL), and blue sharks), and SCS (bonnethead, finetooth, blacknose, and Atlantic sharpnose sharks)		
	Landings condition: All sharks (sandbar, non-sandbar LCS, SCS, and pelagic sharks) must have *fins naturally attached* through offloading; fins can be cut slightly for storage but must remain attached to the carcass via at least a small amount of uncut skin; shark carcasses must remain in whole or log form through offloading. Sharks can have the heads removed but the tails must remain naturally attached.		
	Permits Required: Commercial Directed or Incidental Shark Permit		
	Reporting Requirements: All commercial fishermen must submit commercial logbooks; all dealers must report weekly		
All Recreational Shark Fisheries	**Gears Allowed:** Rod and Reel; Handline		
	Authorized Species: Non-ridgeback LCS (blacktip, spinner, bull, lemon, nurse, great hammerhead, scalloped hammerhead, smooth hammerhead); tiger sharks; pelagic sharks (porbeagle, common thresher, shortfin mako, oceanic whitetip, and blue sharks); and SCS (bonnethead, finetooth, blacknose, and Atlantic sharpnose sharks)		
	Landing condition: Sharks must be landed with head, fins, and tail naturally attached		
	Retention limits: 1 shark > 54” FL vessel/trip, plus 1 Atlantic sharpnose and 1 bonnethead per person/trip (no minimum size, except for great hammerhead, smooth hammerhead, scalloped hammerhead which have a recreational minimum size of 78” FL)		
	Permits Required: HMS Angling; HMS Charter/Headboat; and, General Category Permit Holders (fishing in a shark tournament), General Commercial Swordfish Permit Holders (fishing in a shark tournament)		
	Reporting Requirements: Participate in MRIP and LPS if contacted		

Definitions of Acronyms in Table 1: Fork Length (FL); Highly Migratory Species (HMS); Large Coastal Sharks (LCS); Large Pelagic Survey (LPS); Marine Recreational Information Program (MRIP); Small Coastal Sharks (SCS).

Table 6. Summary of Shark Fishery Management Measures (2008-2016)

Management Measure	2008	2009	2010	2011	2012	2013	2014	2015	2016
Number of Vessels	11	7	7	10	5	6	5	7	6
Number of Trips per Month	2	2	2	3-Feb	1	1	1	1	1
Captain's Meeting Held	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Retention Limits	2,750 lbs dw (of which no more than 2,000 lbs dw can be sandbar sharks)	45 sandbar/trip inside research fishery	33 sandbar per trip 33 non-sandbar LCS per trip	33 sandbar per trip 33 non-sandbar LCS per trip	None. All sharks, except for prohibited species, brought to vessel dead must be landed.	None. All sharks, except for prohibited species, brought to vessel dead must be landed.	None. All sharks, except for prohibited species, brought to vessel dead must be landed.	None. All sharks, except for prohibited species, brought to vessel dead must be landed	None. All sharks, except for prohibited species, brought to vessel dead must be landed
Gear Restrictions				Hook restriction: ≤ 500 hooks per set	Set limit: one longline set per trip	Set limit: two non-concurrent longline sets per trip: 1st set ≤ 150 hooks; soak time no more than 2 hours; 2nd set ≤ 300 hooks; no soak time limit	Set limit: two non-concurrent longline sets per trip: 1st set ≤ 150 hooks; soak time no more than 2 hours; 2nd set ≤ 300 hooks; no soak time limit	Set limit: two non-concurrent longline sets per trip: 1st set ≤ 150 hooks; soak time no more than 2 hours; 2nd set ≤ 300 hooks; no soak time limit	Set limit: two non-concurrent longline sets per trip: 1st set ≤ 150 hooks; soak time no more than 2 hours; 2nd set ≤ 300 hooks; no soak time limit
					Hook restriction: ≤ 150 or fewer hooks on board	Hook restriction: ≤ 500 hooks on board	Hook restriction: ≤ 500 hooks on board	Hook restriction: ≤ 500 hooks on board	Hook restriction: ≤ 500 hooks on board

Gear Restrictions					*Amendment 1* Set limit: two non-concurrent longline sets per trip: 1st set ≤ 75 hooks; soak time no more than 2 hours; 2nd set ≤ 150 hooks; no soak time limit Hook restriction: ≤ 250 hooks on board *Amendment 2*					
					Set limit: two non-concurrent longline sets per trip: 1st set ≤ 150 hooks; soak time no more than 2 hours; 2nd set ≤ 300 hooks; no soak time limit Hook restriction: ≤ 500 hooks on board					

Individual Vessel Quota		None. All landings counted towards the overall sandbar and LCS research quotas Sandbar: 87.9 mt dw Non-sandbar LCS: 37.5 mt dw		None. All landings counted towards the overall sandbar and LCS research quotas Sandbar: 87.9 mt dw Non-sandbar LCS: 37.5 mt dw	Sandbar quota and LCS research quota split equally among selected vessels Sandbar: 14.06 mt dw Non-sandbar LCS: 6.0 mt dw	Sandbar quota and LCS research quota split equally among selected vessels Sandbar: 15.5 mt dw Non-sandbar LCS: 6.7 mt dw	Sandbar quota and LCS research quota split equally among selected vessels Sandbar: 18.6 mt dw Non-sandbar LCS: 8.0 mt dw	Sandbar quota and LCS research quota split equally among selected vessels Sandbar: 13.3 mt dw Non-sandbar LCS: 5.7 mt dw	Sandbar quota and LCS research quota split equally among selected vessels Sandbar: 14.5 mt dw Non-sandbar LCS: 8.0 mt dw
	None. All landings counted towards the overall sandbar and LCS research quotas Sandbar: 87.9 mt dw Non-sandbar LCS: 37.5 mt dw								

Mid-Atlantic Closed Area			Vessels could fish in the closed area	Vessels could fish in the closed area	Vessels could fish in the closed area	Vessels could not fish in the closed area	Vessels could fish in the closed area only when the observer program intends to place a satellite archival tag(s) on a dusky shark(s)	Vessels could fish in the closed area only when the observer program intends to place a satellite archival tag(s) on a dusky shark(s)	Vessels could fish in the closed area only when the observer program intends to place a satellite archival tag(s) on a dusky shark(s)

2.3 Control Date Notices

February 22, 1994 (59 FR 8457), September 16, 2011 (76 FR 57709)

Management Program Specifications

Table 7 General management information for the sandbar shark

Species	Sandbar shark (*Carcharhinus plumbeus*)
Management Unit	Atlantic Ocean, Gulf of Mexico, and Caribbean Sea
Management Unit Definition	All federal waters within U.S. EEZ of the western north Atlantic Ocean, including the Gulf of Mexico and the Caribbean Sea.
Management Entity	NMFS, Highly Migratory Species Management Division
Management Contacts **SERO / Council**	Karyl Brewster-Geisz N/A
Current stock exploitation status	Overfishing not occurring
Current stock biomass status	Overfished

Table 8 Specific management criteria for sandbar shark

Criteria	Value
Current Relative Biomass Level	SSF_{2009}/SSF_{MSY} = 0.51 – 0.72
Domestic Minimum Stock Size Threshold	301,821 – 1,190,419 (based on SSF_{MSY}
Years to Rebuild	66
Current Relative Fishing Mortality	F_{2009}/F_{MSY} = 0.29 - 2.62
Maximum Fishing Mortality Threshold	0.004 - 0.06
B_{MSY}	SSF_{MSY} = 349,330 - 1,377,800 (numbers of sharks)

Table 9 Stock Projection Information for Sandbar Sharks

	Value
First year under current rebuilding program	2008
End year under current rebuilding program	2070
First Year of Management based on this assessment	2020
Projection Criteria during interim years should be based on (e.g., exploitation or harvest)	F=0; Fixed Harvest =220 mt ww (current TAC) = 158.3 mt dw
Projection criteria values for interim years should be determined from (e.g., terminal year, avg of X years)	Average landings of previous 2 years (2014, 2015)

2.4 Quota Calculations

Sandbar Sharks

Table 10 Quota calculation details for sandbar sharks.

Current Quota Value	Commercial Quota = 90.7 mt dw (as of Aug. 18, 2015)
Next Scheduled Quota Change	-
Annual or averaged quota ?	Annual quota
If averaged, number of years to average	-
Does the quota include bycatch/discard ?	No, but the quota is a subset of overall TAC of 158.3 mt dw; the rest of the TAC is partitioned between dead discards and recreational harvest

How is the quota calculated - conditioned upon exploitation or average landings?

The quota was determined based on the TAC calculated during SEDAR 11 (158.3 mt dw). To determine the proportion of the 158.3 mt dw TAC for sandbar that would be available for the commercial fishery, NMFS accounted for mortality of sandbar sharks in all sectors of recreational and commercial fisheries. NMFS first determined the commercial TAC by subtracting the average number of recreational sandbar shark landings (27 mt dw) per year from the 158.3 mt dw TAC, resulting in a commercial TAC of 131.3 mt dw (Table 11). NMFS then determined the available commercial quota by subtracting discards in the HMS PLL fishery and non-HMS fisheries (*e.g*., the snapper-grouper and tilefish fisheries) as well as the set-aside for display and research quota. NMFS also accounted for landings recorded in the Coastal Fisheries Logbook by fishermen who did not have valid or current HMS shark permits. NMFS subtracted dead discards/landings from non-permit holders and recreational fishermen because it is assumed that mortality will continue regardless of directed fishery management measures. The total landings and discards from each of these data sources can be found in Table 11). Based on that TAC, the HMS Management Division subtracted average annual recreational harvest from 2003-2005 (27 mt dw) and discards from 2003-2005 (14.7 mt dw), resulting in a commercial quota of 116.6 mt dw (calculations in Table 11).

Table 11 **Calculation of sandbar quota (Source: Amendment 2 EIS; p. Appendix 1).**

	mt dw
Total sandbar shark TAC	158.3
Average Annual Recreational Landings	27
Resultant Commercial TAC (158.3 mt dw – 27 mt dw)	**131.3 (7,147.3* sandbar sharks)**
Average annual number of sandbars landed/discarded by non-HMS permit holders in Coastal Fisheries Logbook	6.1
Average annual number of sandbars discarded by incidental permit holders in Coastal Fisheries Logbook	2.3
Average annual number of dead discards on PLL gear in the HMS Logbook	4.3
Public display quota	1
Research quota	1
All gillnet discards	0.018
Extrapolated number of discards in snapper-grouper and tilefish BLL fishery based on BLL observer program	0
Total discards	*14.7*
Resultant sandbar shark quota (131.3 mt dw – 14.7 mt dw)	**116.6 (6,346.9* sandbar sharks)**

*assumes an average commercial sandbar shark weight of 40.5 lb dw (Cortés and Neer, 2005)

However, large overharvests during 2007 resulted in the HMS Management Division reducing the commercial quota to 87.9 mt dw during 2008-2012 to account for the overharvests. The quota was increased to 116.6 mt dw during 2013 –Aug. 17 of 2015. On August 18, 2015, the HMS Management Division reduced the commercial quota to 90.7 mt dw with the implementation of Amendment 6.

As described in Amendment 2, the retention limit for LCS was in part based on how many sandbar sharks would be discarded dead from the number of shark trips that were expected to interact with sandbar sharks. In Amendment 6, NMFS used a portion of the unharvested sandbar shark research fishery quota to account for sandbar shark discards that might occur with a higher LCS retention limit and adjusting the sandbar shark research fishery quota accordingly.

To calculate the adjustment to the sandbar shark research fishery quota necessary in order to increase the LCS retention limit, NMFS used the average number of directed shark trips (592 directed shark trips), the Atlantic region catch composition ratio of 1:8.8 for retention limit calculations, and the observed dead discard rate of sandbar sharks (31.5 percent) in the Atlantic region.

NMFS used the following steps to calculate the adjustment to the sandbar shark research fishery quota. First, NMFS divided the current retention limit of 55 LCS other than sandbar sharks per trip by the LCS catch composition ratio from the Atlantic region (8.8:1; 8.8 LCS other than sandbar sharks per 1 sandbar shark) to determine the potential number of sandbar shark discards per trip (Column A in Table 12). Under the current retention limit of 55 LCS other than sandbar sharks per trip, this resulted in 6.2 sandbar sharks being discarded per trip (55 LCS other than sandbar sharks per trip divided by 8.8 = 6.2 sandbar sharks per trip). Next, the sandbar shark discards per trip in Column A in Table 12 was multiplied by the average number of directed shark trips (592 trips) to determine the potential number of sandbar sharks discarded per year by shark fishermen targeting LCS (Column B in Table 12). This resulted in potential discards of 3,696 sandbar sharks being discarded live or dead per year (6.2 sandbar sharks per trip * 592 trips per year = 3,696 sandbar sharks per year). Third, to determine the number of sandbar sharks discarded dead (Column C), NMFS multiplied the number of sandbar sharks discarded per year in Column B by the observed dead discard rate of sandbar sharks (31.5 percent) in the Atlantic region from the commercial bottom longline observer program. This resulted in potential dead discards of sandbar sharks per year of 1,166 sharks (3,696 sandbar sharks discarded per year * 0.315 sandbar sharks observed dead = 1,166 sandbar sharks discarded dead per year). Fourth, to determine the total weight of the dead discards of sandbar sharks, NMFS used the average weight of 49.0 lb dw based on the 2010/2011 stock assessment, which is the most recent stock assessment for sandbar sharks. This resulted in 57,113 lb dw, or 25.9 mt dw of dead discards of sandbar sharks (Column D in Table 12; 1,166 dead sandbar sharks per year * 49.0 lb dw = 57,113 lb dw of dead sandbar sharks / 2,204.6 lb = 25.9 mt dw). Last, to compensate for the additional mortality of sandbar sharks in directed shark fishing trips, NMFS adjusted the sandbar shark research fishery quota by subtracting the additional mortality from the current baseline quota. This resulted in a sandbar research fishery quota of 199,943 lb dw, or 90.7 mt dw (257,056 lb dw baseline sandbar shark research quota – 57,113 lb dw additional mortality of sandbar sharks = 199,943 lb dw, or 90.7 mt dw new baseline sandbar shark research quota) (Column E in Table 12).

Table 12. Adjusted sandbar shark quota in the Atlantic shark research fishery based on the current commercial retention limit. **Note:** Dead discard rate is 31.5 percent; average weight of sandbar sharks = 49.0 lb dw; baseline sandbar shark research fishery quota is 116.6 mt dw (257,056 lb dw). (Source: Amendment 6 EIS; p. 14-16)

Current Retention Limit	**(A)** Sandbar Shark Discards per Retention Limit (Number of Sharks)	**(B)** Sandbar Shark Discards (Number of sharks)	**(C)** Sandbar Shark Dead Discards (Number of Sharks)	**(D)** Sandbar Shark Quota Adjustment	**(E)** Sandbar Shark Research Fishery Quota Under the Different Alternatives
55	6.2	3,696	1,166	25.9 mt dw (57,113 lb dw)	90.7 mt dw (199,943 lb dw)

Does the quota include bycatch/discard estimates? If so, what is the source of the bycatch/discard values? What are the bycatch/discard allowances?

The commercial quota does not include bycatch/discards estimates. Such estimates are removed before the commercial quota is calculated.

Are there additional details of which the analysts should be aware to properly determine quotas for this stock?

The quota is adjusted each year through a season rule. Overharvests are deducted from the following year. No overharvests have been experienced for sandbar sharks since implementation of Amendment 2 in 2008. Table 13 shows the history of shark quotas adjusted for under and overharvest. The commercial sandbar shark quota is not adjusted for underharvests as underharvests do not apply to stocks that have been determined to be overfished, have overfishing occurring, or an unknown stock status.

2.5 Management and Regulatory Timeline

The following tables provide a timeline of Federal management actions by fishery. It should be noted that federally permitted fishermen must follow federal regulations unless state regulations are more restrictive.

Table 13 Annual commercial sandbar shark regulatory summary (managed in the LCS complex until 2008 when separate quota and sandbar shark research fishery established under Amendment 2 except in 2003 where it was managed as a ridgeback).

		Fishing Year			**Possession Limit**
Year	*Base Quota (LCS complex)*	*N. Atlantic*	*S. Atlantic*	*Gulf*	*All regions*
1993	2,436 mt dw	One region; calendar year with two fishing periods			No trip limit
1994	2,346 mt dw	One region; calendar year with two fishing periods			4,000 lb dw LCS combined/trip
1995	2,570 mt dw	One region; calendar year with two fishing periods			4,000 lb dw LCS combined/trip
1996	2,570 mt dw	One region; calendar year with two fishing periods			4,000 lb dw LCS combined/trip
1997	1,285 mt dw	One region; calendar year with two fishing periods			4,000 lb dw LCS combined/trip
1998	1,285 mt dw	One region; calendar year with two fishing periods			4,000 lb dw LCS combined/trip
1999	1,285 mt dw	One region; calendar year with two fishing periods (but fishing season open and closed twice during 2nd season-see Table 3)			4,000 lb dw LCS combined/trip; 5 LCS for incidental permit holders*
2000	1,285 mt dw	One region; calendar year with two fishing periods			4,000 lb dw LCS combined/trip; 5 LCS for incidental permit holders
2001	1,285 mt dw	One region; calendar year with two fishing periods			4,000 lb dw LCS combined/trip; 5 LCS for incidental permit holders
2002	1,285 mt dw	One region; calendar year with two fishing periods			4,000 lb dw LCS combined/trip; 5 LCS for incidental permit holders
2003	783 mt dw	One region; calendar year with two fishing periods but ridgeback and non-ridgeback split-see Table 3)			4,000 lb dw LCS combined/trip; 5 LCS for incidental permit holders
2004	1,107 mt dw	Regions† with two fishing seasons	Regions† with two fishing seasons	Regions† with two fishing seasons	4,000 lb dw LCS combined/trip; 5 LCS for incidental permit holders
2005	1,107 mt dw	Trimesters/Regions†	Trimesters/Regions†	Trimesters/Regions†	4,000 lb dw LCS combined/trip; 5 LCS for incidental permit holders
2006	1,107 mt dw	Trimesters/Regions†	Trimesters/Regions†	Trimesters/Regions†	4,000 lb dw LCS combined/trip; 5 LCS for incidental permit holders
2007	1,107 mt dw	Trimesters/Regions†	Trimesters/Regions†	Trimesters/Regions†	4,000 lb dw LCS combined/trip; 5 LCS for incidental permit holders
2008**	87.9 mt dw	One region; calendar year			2,750 lb dw of LCS/trip of which no more than 2,000 lb dw could be sandbar inside research fishery; trip limit= 0 outside research fishery
2009**	87.9 mt dw	One region; calendar year			45 sandbar/trip inside research fishery; trip limit= 0 outside research fishery
2010**	87.9 mt dw	One region; calendar year			33 sandbar/trip inside research fishery; trip limit= 0 outside research fishery
2011**	87.9 mt dw	One region; calendar year			33 sandbar/trip inside research fishery; trip limit= 0 outside research fishery
2012**	87.9 mt dw	One region; calendar year			no trip limit inside research fishery; trip limit = 0 outside research fishery
2013**	116.6 mt dw	One region; calendar year			no trip limit inside research fishery; trip limit = 0

			outside research fishery
2014**	116.6 mt dw	One region; calendar year	no trip limit inside research fishery; trip limit = 0 outside research fishery
2015**	90.7 mt dw	One region; calendar year	no trip limit inside research fishery; trip limit = 0 outside research fishery
2016**	90.7 mt dw	One region; calendar year	no trip limit inside research fishery; trip limit = 0 outside research fishery

*Limited Access Permits (LAPs) were implemented for the shark and swordfish fisheries under 1999 FMP; †Regions = Gulf of Mexico, South Atlantic, and North Atlantic.

**Sandbar specific quota; Sharks required to be offloaded with all fins naturally attached under Amendment 2

Table 14 Annual recreational sandbar shark regulatory summary (managed in the LCS complex until 2008 recreational retention prohibited under Amendment 2).

Year	Fishing Year	Size Limit	Bag Limit
1993	Calendar Year	No size limit	4 LCS or pelagic sharks/vessel
1994	Calendar Year	No size limit	4 LCS or pelagic sharks/vessel
1995	Calendar Year	No size limit	4 LCS or pelagic sharks/vessel
1996	Calendar Year	No size limit	4 LCS or pelagic sharks/vessel
1997	Calendar Year	No size limit	2 LCS/SCS/pelagic sharks combined/vessel
1998	Calendar Year	No size limit	2 LCS/SCS/pelagic sharks combined/vessel
1999	Calendar Year	No size limit	2 LCS/SCS/pelagic sharks combined/vessel
2000	Calendar Year	Minimum size =4.5 ft	1 LCS/SCS/pelagic shark combined/vessel/trip
2001	Calendar Year	Minimum size =4.5 ft	1 LCS/SCS/pelagic shark combined/vessel/trip
2002	Calendar Year	Minimum size =4.5 ft	1 LCS/SCS/pelagic shark combined/vessel/trip
2003	Calendar Year	Minimum size =4.5 ft	1 LCS/SCS/pelagic shark combined/vessel/trip
2004	Calendar Year	Minimum size =4.5 ft	1 LCS/SCS/pelagic shark combined/vessel/trip
2005	Calendar Year	Minimum size =4.5 ft	1 LCS/SCS/pelagic shark combined/vessel/trip
2006	Calendar Year	Minimum size =4.5 ft	1 LCS/SCS/pelagic shark combined/vessel/trip
2007	Calendar Year	Minimum size =4.5 ft	1 LCS/SCS/pelagic shark combined/vessel/trip
2008*	Prohibited	N/A	1 LCS/SCS/pelagic shark combined/vessel/trip
2009*	Prohibited	N/A	1 LCS/SCS/pelagic shark combined/vessel/trip
2010*	Prohibited	N/A	1 LCS/SCS/pelagic shark combined/vessel/trip
2011*	Prohibited	N/A	1 LCS/SCS/pelagic shark combined/vessel/trip
2012*	Prohibited	N/A	1 LCS/SCS/pelagic shark combined/vessel/trip
2013*	Prohibited	N/A	1 LCS/SCS/pelagic shark combined/vessel/trip
2014*	Prohibited	N/A	1 LCS/SCS/pelagic shark combined/vessel/trip
2015*	Prohibited	N/A	1 LCS/SCS/pelagic shark combined/vessel/trip
2016*	Prohibited	N/A	1 LCS/SCS/pelagic shark combined/vessel/trip

*Retention prohibited in recreational fishery under Amendment 2.

Table 15: Sandbar Recreational Regulatory History
prepared by: Delisse Ortiz

Year	Quota (units)	ACL (units)	Days Open	Fishing Season	season start date (first day implemented)	season end date (last day effective)	reason for closure	Size limit (TL, natural, or maximum)	size limit start date	size limit end date	Retention Limit (# fish)	Retention Limit Start Date	Retention Limit End Date	Aggregate Retention Limit[1] (# fish)	Aggregate Retention Limit Start Date	Aggregate Retention Limit End Date
1993	NA	NA	365	Open	1-Jan	31-Dec	NA	None	NA	NA	4 LCS or pelagic sharks/vessel [A]	1-Jan	31-Dec	4 LCS or pelagic sharks/vessel [A]	1-Jan	31-Dec
1994	NA	NA	365	Open	1-Jan	31-Dec	NA	None	NA	NA	4 LCS or pelagic sharks/vessel [A]	1-Jan	31-Dec	4 LCS or pelagic sharks/vessel [A]	1-Jan	31-Dec
1995	NA	NA	365	Open	1-Jan	31-Dec	NA	None	NA	NA	4 LCS or pelagic sharks/vessel [A]	1-Jan	31-Dec	4 LCS or pelagic sharks/vessel [A]	1-Jan	31-Dec
1996	NA	NA	365	Open	1-Jan	31-Dec	NA	None	NA	NA	4 LCS or pelagic sharks/vessel [A]	1-Jan	31-Dec	4 LCS or pelagic sharks/vessel [A]	1-Jan	31-Dec
1997	NA	NA	365	Open	1-Jan	31-Dec	NA	None	NA	NA	2 LCS/SCS/pelagic sharks combined/vessel [B]	1-Jan	31-Dec	2 LCS/SCS/pelagic sharks combined/vessel [B]	1-Jan	31-Dec
1998	NA	NA	365	Open	1-Jan	31-Dec	NA	None	NA	NA	2 LCS/SCS/pelagic sharks combined/vessel [B]	1-Jan	31-Dec	2 LCS/SCS/pelagic sharks combined/vessel [B]	1-Jan	31-Dec
1999	NA	NA	365	Open	1-Jan	31-Dec	NA	None	NA	NA	2 LCS/SCS/pelagic sharks combined/vessel [B]	1-Jan	31-Dec	2 LCS/SCS/pelagic sharks combined/vessel [B]	1-Jan	31-Dec
2000	NA	NA	365	Open	1-Jan	31-Dec	NA	Minimum size =4.5 ft [C]	1-Jan	31-Dec	1 LCS/SCS/pelagic shark combined/vessel/trip [C]	1-Jan	31-Dec	1 LCS/SCS/pelagic shark combined/vessel/trip [C]	1-Jan	31-Dec
2001	NA	NA	365	Open	1-Jan	31-Dec	NA	Minimum size =4.5 ft [C]	1-Jan	31-Dec	1 LCS/SCS/pelagic shark combined/vessel/trip [C]	1-Jan	31-Dec	1 LCS/SCS/pelagic shark combined/vessel/trip [C]	1-Jan	31-Dec
2002	NA	NA	365	Open	1-Jan	31-Dec	NA	Minimum size =4.5 ft [C]	1-Jan	31-Dec	1 LCS/SCS/pelagic shark combined/vessel/trip [C]	1-Jan	31-Dec	1 LCS/SCS/pelagic shark combined/vessel/trip [C]	1-Jan	31-Dec
2003	NA	NA	365	Open	1-Jan	31-Dec	NA	Minimum size =4.5 ft [C,D]	1-Jan	31-Dec	1 LCS/SCS/pelagic shark combined/vessel/trip [C, D]	1-Jan	31-Dec	1 LCS/SCS/pelagic shark combined/vessel/trip [C, D]	1-Jan	31-Dec
2004	NA	NA	365	Open	1-Jan	31-Dec	NA	Minimum size =4.5 ft [C,D]	1-Jan	31-Dec	1 LCS/SCS/pelagic shark combined/vessel/trip [C, D]	1-Jan	31-Dec	1 LCS/SCS/pelagic shark combined/vessel/trip [C, D]	1-Jan	31-Dec
2005	NA	NA	365	Open	1-Jan	31-Dec	NA	Minimum size =4.5 ft [C,D]	1-Jan	31-Dec	1 LCS/SCS/pelagic shark combined/vessel/trip [C, D]	1-Jan	31-Dec	1 LCS/SCS/pelagic shark combined/vessel/trip [C, D]	1-Jan	31-Dec
2006	NA	NA	365	Open	1-Jan	31-Dec	NA	Minimum size =4.5 ft [C,D]	1-Jan	31-Dec	1 LCS/SCS/pelagic shark combined/vessel/trip [C, D]	1-Jan	31-Dec	1 LCS/SCS/pelagic shark combined/vessel/trip [C, D]	1-Jan	31-Dec
2007	NA	NA	365	Open	1-Jan	31-Dec	NA	Minimum size =4.5 ft [C,D]	1-Jan	31-Dec	1 LCS/SCS/pelagic shark combined/vessel/trip [C, D]	1-Jan	31-Dec	1 LCS/SCS/pelagic shark combined/vessel/trip [C, D]	1-Jan	31-Dec
2008[E]	NA	NA	NA	Closed	1-Jan	31-Dec	No retention alllowed [E]	NA	NA	NA	NA	NA	NA	NA	NA	NA
2009[E]	NA	NA	NA	Closed	1-Jan	31-Dec	No retention alllowed [E]	NA	NA	NA	NA	NA	NA	NA	NA	NA
2010[E]	NA	NA	NA	Closed	1-Jan	31-Dec	No retention alllowed [E]	NA	NA	NA	NA	NA	NA	NA	NA	NA
2011[E]	NA	NA	NA	Closed	1-Jan	31-Dec	No retention alllowed [E]	NA	NA	NA	NA	NA	NA	NA	NA	NA
2012[E]	NA	NA	NA	Closed	1-Jan	31-Dec	No retention alllowed [E]	NA	NA	NA	NA	NA	NA	NA	NA	NA
2013[E]	NA	NA	NA	Closed	1-Jan	31-Dec	No retention alllowed [E]	NA	NA	NA	NA	NA	NA	NA	NA	NA
2014[E]	NA	NA	NA	Closed	1-Jan	31-Dec	No retention alllowed [E]	NA	NA	NA	NA	NA	NA	NA	NA	NA
2015[E]	NA	NA	NA	Closed	1-Jan	31-Dec	No retention alllowed [E]	NA	NA	NA	NA	NA	NA	NA	NA	NA
2016[E]	NA	NA	NA	Closed	1-Jan	31-Dec	No retention alllowed [E]	NA	NA	NA	NA	NA	NA	NA	NA	NA

1 = The aggregate recreational bag limit includes several species(LCS: including sandbar, silky, tiger, blacktip, spinner, bull, lemon, nurse, scalloped hammerhead, great hammerhead, and smooth
A = Established a recreational trip limit of 4 LCS or pelagic sharks per vessel (1993 FMP for Sharks of the Atlantic Ocean; effective April 26, 1993);
B= Reduced recreational retention limit for all sharks to 2 LCS/SCS/pelagic sharks combined per trip (effective April 2, 1997)
C = Reduced recreational retention limits for all sharks to 1 shark per vessel per trip except for Atlantic sharpnose (1 Atlantic sharpnose/person/trip) and established a recreational minimum size for all sharks except Atlantic sharpnose (4.5 feet) (1999 FMP for Atlantic Tunas, Swordfish and Sharks; effective date July 1, 1999);
D= Adjusted the recreational bag and size limits (allowed 1 bonnethead/person/trip in addition to 1 Atlantic sharpnose/person/trip with no size limit for bonnethead or Atlantic sharpnose) (Amendment 1 to the FMP for Atlantic Tunas, Swordfish and Sharks ; effective December 30, 2003);
E = Retention of sandbar sharks prohibited in recreational fishery (Amendment 2, effective July 24, 2008).

Note:

Table 16. State Shark Regulations

State	Confirmed by State?	pre-1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Alabama	No	no shark regulations	First shark regulations implemented: state shark fishery closes with the federal shark fishery		By 1998: only short lines in state waters; time/area and size restrictions on the recreational use of gillnets						By Feb 2004: Recreational daily bag limit - 2 sharpnose/person/day; all other species - 1fish/person/day; Recreational minimum size all sharks (except sharpnose) - 54" FL		By May 2006: Recreational & Commercial non-sharpnose min size – 54” FL or 30” dressed; Prohibition: Atlantic angel, bigeye thresher, dusky, longfin make, sand tiger, basking, whale, white, and nurse sharks		By Oct 2008: no new regs	Recreational & commercial sharpnose bag limit dropped to 1 sharpnose per person per day; no shark fishing on weekends, Memorial Day, Independence Day, or Labor Day	Recreational & commercial: bag limit – 1 sharpnose/person/day and 1 bonnethead/person/day; no min size; all other sharks – 1/person/day; min size – 54” FL or 30” dressed; state waters close when federal season closes; no shark fishing on weekends, Memorial Day, Independence Day, or Labor Day; Prohibited species: dusky, sand tiger, bigeye sand tiger, basking, whale, and white sharks; Restrictions of chumming and shore-based angling if creating unsafe bathing conditions; Regardless of open or closed season, gillnet fishermen targeting other fish may retain sharks with a dressed weight not exceeding 10% of total catch	no new shark regulations	no new shark regulations	no new shark regulations	Great hammerhead, smooth hammerhead, scalloped hammerhead 1/person/day - 78” FL; all other sharks – 1/person/day; min size – 54” FL or 30” dressed; Commercial - no size limit and no possession limit on any non-prohibited species.	no new shark regulations	no new shark regulations
Connecticut	Yes	no shark regulations	no shark regulations	no shark regulations	no shark regulations	no shark regulations	no shark regulations	no shark regulations	no shark regulations	no shark regulations	no shark regulations	no shark regulations	no shark regulations	no shark regulations	no shark regulations	July: No possession or landing of large coastal shark species by any commercial fishing gear or for commercial purposes.	Feb: Commercial possession of prohibited Small Coastal Sharks: Atlantic sharpnose, finetooth, blacknose, bonnethead until a 2010 quota is set by NMFS; Sandbar shark take prohibited in the commercial and recreational fisheries per ASMFC FMP except under Scientific Collection Permit	– Prohibited species same as federal regulations; No commercial fishing for large coastal sharks; No commercial small coastal shark fishing until further notice	no new shark regulations	no new shark regulations	Great hammerhead, smooth h	Prohibited species same as federal regulations; Possession of sandbar shark (Carcharhinus plumbeus) prohibited except by permit for research and display purposes	Prohibited species same as federal regulations; Possession of sandbar sharks prohibited except by permit for research and display purposes. No commercial fishing for large coastal sharks; No commercial small coastal shark fishing until further notice
Delaware	Yes	no shark regulations	no shark regulations	no shark regulations	Commercial shark fishermen must hold a federal shark permit even when fishing in state waters, therefore, state regulations match federal regulations; sharks must be landed with meat and fins intact, but head can be removed; any shark not kept must be released in a manner that maximizes survival; taking of basking, white, whale, sand tiger, and bigeye sand tiger prohibited; seasonal gillnet restrictions. Recreational regulations: no more than two sharks per vessel except that 2 sharpnose can also be landed; prohibition on finning and filleting or taking of the 5 prohibited species	no new shark regulations	Creel limit on regulated sharks of 1 shark per vessel per day; creel limit for sharpnose is 2 sharks per day; minimum size on regulated sharks is 54 inches FL; fins must be naturally attached; 14 prohibited species added (Atlantic angel shark, bigeye sixgill shark, bigeye thresher, bignose shark, Caribbean reef shark, Caribbean sharpnose shark, dusky shark, Galapagos shark, longfin mako, narrowtooth shark, night shark, sevengill shark, sixgill shark, smalltail shark)	no new shark regulations	no new shark regulations	no new shark regulations	no new shark regulations	no new shark regulations	no new shark regulations	no new shark regulations	no new shark regulations	ASMFC Plan	ASMFC Plan	ASMFC Coastal Shark Plan	ASMFC Coastal Shark Plan	Sharks – ASMFC Coastal Shark Plan	Sharks – ASMFC Coastal Shark Plan; Great hammerhead, smooth hammerhead, scalloped hammerhead recreational minimum size of 78” FL	Sharks – ASMFC Coastal Shark Plan	ASMFC Coastal Shark Plan
Florida	Yes	1992: first shark-specific regulations: must hold federal shark permit; commercial and recreational possession limit of 1 shark per person per day or 2 sharks per vessel per day, whichever is less (virtually no commercial shark fishery in state waters); prohibition on landing fins withour corresponding carcass; released sharks should be released in a manner that maximizes survival; recreationally caught sharks cannot be transerred at sea; recreatioanlly cuagth sharks cannot be sold; prohibition on harvest, landing and sale of basking and whale sharks; state shark fishery closes with federal shark fishery; 1994: prior to landing, fins cannot be removed from a shark harvested in state waters; fishermen returning from federal waters with sharks or shark parts harvested in federal waters, cannot fish in state waters; 1995: ban on the use of entanglement nets larger than 500 square feet	No new shark regulations	No new shark regulations	By 1998: ban on longlines; 1998: Added sand tiger, bigeye sandtiger, and white sharks to prohibited species list; prohibition on filleting sharks at sea.	No new shark regulations	No new shark regulations	No new shark regulations	No new shark regulations	No new shark regulations	No new shark regulations	No new shark regulations	March: Same prohibited species as federal regulations, except Caribbean sharpnose is not included	No new shark regulations	No new shark regulations	No new shark regulations	Jan: Commercial/recreational min size – 54” except no min. size on blacknose, blacktip, bonnethead, smooth dogfish, finetooth, Atlantic sharpnose; Allowable gear – hook and line only; prohibition on the removal of shark heads and tails in state waters; prohibition on harvest of sandbar, silky, and Caribbean sharpnose sharks in state waters; March: prohibition on all harvest of lemon sharks in state waters.	– 54” except no min. size on blacknose, blacktip, bonnethead, smooth dogfish, finetooth, Atlantic sharpnose; Commercial/recreational possession limit – 1 shark/person/day, max. 2 sharks/vessel on any vessel with 2 or more persons on board; Allowable gear – hook and line only; State waters close to commercial harvest when adjacent federal waters close; Federal permit required for commercial harvest, so federal regulations apply in state waters unless state regulations are more restrictive; Finning, removing heads and tails, and filleting prohibited; Prohibited species same as federal regulations plus prohibition on harvest of lemon and sandbar sharks in state waters, direct and continuous transit through state waters to place of landing of lemon sharks and sandbar sharks legally caught in federal waters is allowed.	no new shark regulations	no new shark regulations	Great hammerhead, smooth h	no new shark regulations	It is unlawful to harvest any shark with the use of any multiple hook in conjunction with live or dead natural bait and unlawful to harvest shark by snagging (snatch hooking)
Georgia	Yes	1950s: ban on gillnets and longlines; All finfish spp. must be landed with head and fins intact	No new shark regulations	No new shark regulations	First shark regulation: prohibition on taking sand tiger sharks; Small Shark Composite (Atl. Sharpnose, bonnethead, spiny dogfish) 30"TL min. size;Creel: 2/person/day All other sharks 2/person/day or 2 /boat/day, whichever is less. 54"TL min. size, only one shark over 84" TL	No new shark regulations	Sharks may not be landed in Georgia if harvested using gillnets	No new shark regulations	No new shark regulations	No new shark regulations	No new shark regulations	No new shark regulations	No new shark regulations	No new shark regulations	No new shark regulations	Recreational: 1 shark from the Small Shark Composite (bonnethead, sharpnose, and spiny dogfish, min size 30” FL; All other sharks - 1 shark/person or boat, whichever is less, min size 54” FL, Prohibited Species: sand tiger sharks, sandbar, silky, bigeye sandtiger, whale, basking, white, dusky, bignose, Galapagos, night, reef, narrowtooth, Caribbean sharpnose, smalltail, Atlantic angel, longfin mako, bigeye thresher, sharpnose sevengill, bluntnose sixgill, and bigeye sixgill.	Commercial/Recreational: 1 shark from the Small Shark Composite (bonnethead, sharpnose, and spiny dogfish, min size 30” FL; All other sharks - 1 shark/person or boat, whichever is less, min size 54” FL, Prohibited Species: sand tiger sharks, sandbar, silky, bigeye sandtiger, whale, basking, white, dusky, bignose, Galapagos, night, reef, narrowtooth, Caribbean sharpnose, smalltail, Atlantic angel, longfin mako, bigeye thresher, sharpnose sevengill, bluntnose sixgill, and bigeye sixgill; All species must be landed head and fins intact; Sharks may not be landed in Georgia if harvested using gill nets	Commercial/Recreational: 2/person/boat for sharks from the Small Shark Composite (bonnethead, sharpnose, and spiny dogfish, min size 30” FL; All other sharks - 2 shark/person or boat, whichever is less, min size 48” FL; unlawful to have in possession more than one shark greater than eighty-four inches (84") total length; Prohibited Species: same as federal, plus silky sharks; All species must be landed head and fins intact; Sharks may not be landed in Georgia if harvested using gillnets	Commercial/Recreational: 1/person/boat for sharks from the Small Shark Composite (bonnethead, sharpnose, and spiny dogfish, min size 30” FL; All other sharks - 1 shark/person or boat, whichever is less, min size 54” FL Prohibited Species: same as federal, plus silky sharks; All species must be landed head and fins intact; Sharks may not be landed in Georgia if harvested using gillnets; ASMFC Coastal Shark Plan	no new shark regulations	Commercial/Recreational: 1/person for sharks from the Small Shark Composite (bonnethead, Atlantic sharpnose, and spiny dogfish), min size 30” FL. All other sharks - 1 shark/person or boat, whichever is less, min size 54” FL. Hammerheads (great, scalloped and smooth)- 1/person, minimum size – 78” FL. Prohibited Species: same as federal, plus silky sharks; All species must be landed head and fins intact; Sharks may not be landed in Georgia if harvested using gillnets; ASMFC Coastal Shark Plan; Great hammerhead, smooth hammerhead, scalloped hammerhead recreational minimum size of 78” FL	no new shark regulations	no new shark regulations
Louisiana	No			Ban on entanglement nets	No new shark regulations						By Feb 2004: Minimum size - 54" except sharpnose; Possession limit - 1 fish/vessel/trip; Trip limit 4,000 lbs dw LCS; Reference to federal regulations; State waters closed to rec/commercial April 1 through June 30		By May 2006: Recreational: min size – 54” FL, except Atlantic sharpnose and bonnethead; bag limit - 1 sharpnose/person/day; all other sharks – 1 fish/person/day; Commercial: 4,000 lb LCS trip limit, no min size; Com & Rec Harvest Prohibited: 4/1-6/30; Prohibition: same as federal regulations		By Oct 2008: Commercial: 33 per vessel per trip limit, no min size	No new shark regulations	Recreational: min size – 54” FL, except Atlantic sharpnose and bonnethead; bag limit - 1 sharpnose/person/trip, all other sharks – 1 fish/person/day; Commercial: 33 per vessel per trip limit; no min size; Com & rec harvest prohibited: 4/1- 6/30; Prohibited species: same as federal regulations; Fins must remain naturally attached to carcass though off-loading	Commercial shark fishing requires annual state shark permit. Owners/operators of vessels other than those taking sharks in compliance with state or federal commercial permits are restricted to no more than one shark from either the large coastal, small coastal, or pelagic group per vessel per trip within or without Louisiana waters.	no new shark regulations	no new shark regulations	Commercial: 33/vessel/day limit (36/vessel/day by mid-2013); no min size; Com & rec harvest prohibited: Apr 1 - Jun 30	Commercial: 36/vessel/day limit; no min size; Com & rec harvest prohibited: Apr 1 - Jun 30; Prohibited species: same as federal regulations; Fins must remain naturally attached to carcass though offloading.	; Commercial: 45/vessel/day limit; no min size; Com & rec prohibited: Apr 1 - Jun 30; Prohibited species: same as federal regulations; Fins must remain naturally attached to carcass though off-loading. Commercial shark fishing requires annual state shark permit. Owners/operators of vessels other than those taking sharks in compliance with state or federal commercial permits are restricted to no more than one shark from either the large coastal, small coastal, or pelagic group per vessel per trip within or without Louisiana waters, except Atlantic sharpnose and bonnethead which are allowed at one/person/day.
Maine	No	No shark regulations	No shark regulations	No shark regulations	By 1998: large state water closures to gillnets resulting in virtually no gillnet fishery; 1998: no shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	Maximum 5 % fin-to-carcass ratio	– Fins of coastal sharks can be removed at sea, but fin weight may not exceed 5% of the carcass weight	Prohibited species same as federal, plus silky and sandbar; commercial harvest of porbeagle sharks prohibited in state waters, porbeagle cannot be landed after federal quota closes; sharks must be landed with head, fins, and tail naturally attached to the carcass	Commercial harvest of sharks (except spiny dogfish) in state waters prohibited; finning prohibited; sharks harvested elsewhere but landed in Maine, or sharks landed recreationally, must be landed with head, fins, and tail naturally attached to the carcass; porbeagle cannot be landed commercially after federal quota closes dealers who purchase sharks must obtain a federal dealer permit. Recreational anglers must possess a federal HMS angling permits	no new shark regulations	Great hammerhead, smooth h	no new shark regulations	no new shark regulations
Maryland	No		4000 lb shark limit per person per day; fins must accompany carcass and not exceed 5% fin-to-carcass ratio, state shark fishery closes with federal shark fishery		Size limit of 58 inches FL or a carcass less than 31 inches; recreational bag limit of one shark per person per day; by 1998: maximum gillnet mesh size of 6 inches; no longlining in tidal waters.						By Feb 2004: minimum FL reduced to 54 inches, carcass length the same (31 inches); recreational catch limit of 1 shark per person per day; reference to federal regs 50 CFR 635.	ASMFC Coastal Shark Plan	By May 2006: no new shark regulations		By Oct 2008: no new shark regulations	ASMFC Plan	Sharks – ASMFC Coastal Shark Plan		ASMFC Coastal Shark Plan	Recreational catch required to be tagged; ASMFC Coastal Shark Plan	Recreational catch required to be tagged; ASMFC Coastal Shark Plan; all recreationally harvested sharks must have heads, tails, and fins attached naturally to the carcass through landing; all commercially harvested sharks other than smoothhounds must have tails and fins attached naturally to carcass through landing; smoothhound sharks harvested commercially may have dorsal, pectoral and caudal fins removed (caudal fins may not exceed 4% of total dressed weight of smoothhound shark carcasses on board; dorsal and pectoral fins may not exceed 8% of total dressed weight of smoothhound shark carcasses on board); Great hammerhead, smooth hammerhead, scalloped hammerhead recreational minimum size of 78” FL	no new shark regulations	no new shark regulations
Massachusetts	No	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations		By May 2006: Prohibition on harvest, catch, take, possession, transportation, selling or offer to sell any basking, dusky, sand tiger, or white sharks.		By Oct 2008: no new shark regulations	No new shark regulations	ASMFC Coastal Shark Plan except that the tails and fins of smooth dogfish must remain attached through landing	ASMFC Coastal Shark Plan (no shark species may be landed with tails or fins removed 322 CMR 6.37(3)(d))	ASMFC Coastal Shark Plan (no shark species may be landed with tails or fins removed 322 CMR 6.37(3)(d))	ASMFC Coastal Shark Plan (no shark species may be landed with tails or fins removed 322 CMR 6.37(3)(d))	ASMFC Coastal Shark Plan (no shark species may be landed with tails or fins removed 322 CMR 6.37(3)(d)); Great hammerhead, smooth hammerhead, scalloped hammerhead recreational minimum size of 78” FL	Sharks – ASMFC Coastal Shark Plan (no shark species may be landed with tails or fins removed 322 CMR 6.37(3)(d))	Commercial - During the period of May 15-July 15 an individual may not harvest the species listed in §A(6) and (7) of this regulation from State waters or transport the species listed in §A(6) and (7) of this regulation in State waters, unless the shark was harvested from federal waters provided:
Mississippi	No			prohibit taking and possession of sand tiger, bigeye sand tiger, whale, basking, and white sharks; Recreational: bag limit of 4 small coastal sharks (Atlantic sharpnose, Caribbean sharpnose, finetooth, blacknose, smalltail, bonnethead and Atlantic angel shark) per person per day; limit of 3 large coastal and pelagic sharks, in aggregate per vessel per day, same prohibited species as commercial fishers; minimum size of 25 inches total length for small coastal sharks and 37 inches total length for large coastal sharks							By Feb 2004: no new shark regulations		By May 2006: no new shark regulations		By Oct 2008: Recreational bag limit - LCS/Pelagics 1/person up to 3/vessel; SCS 4/person; Commercial & Prohibited Species - Reference to federal regulations		Recreational: min size - LCS/Pelagics 37” TL; SCS 25” TL; bag limit - LCS/Pelagics 1/person/day up to 3/vessel/day; SCS 4/person/day; Commercial and prohibited species – same as federal regulations; Prohibition on finning	no new shark regulations	no new shark regulations	no new shark regulations	no new shark regulations	no new shark regulations	It is unlawful for commercial fishermen to possess sandbar sharks. Prohibition on finning
New Hampshire	No	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No commercial take of porbeagle	Prohibited sharks listed; Federal Dealer permit required for all shark dealers; Porbeagle sharks can only be taken by recreational fishing; Head, fins and tail must remain attached to all shark species through landing	no new shark regulations	no take, landings, or possession of prohibited shark species; NH Wholesale Marine Species License and a Federal Dealer permit required for all dealers purchasing listed sharks; Porbeagle sharks can only be taken by recreational fishing; Head, fins and tail must remain attached to all shark species through landing	no new shark regulations	Great hammerhead, smooth h	no new shark regulations	no new shark regulations
New Jersey	No				No shark-specific regulations; by 1998: no longline fishing; restrictions on the use of gillnets						By Feb 2004: commercial/recreational possession limit of 2 sharks per vessel; prohibition on finning; dorsal fin to pre-caudal pit must be at least 23 inches in length; total length must be 48 inches in length		By May 2006: no sale during federal closures; Finning prohibited; Prohibited Species: basking, bigeye sand tiger, sand tiger, whale and white sharks		By Oct 2008: no new shark regulations	No new shark regulations	ASMFC Coastal Shark Plan	ASMFC Coastal Shark Plan	ASMFC Coastal Shark Plan	Sharks – ASMFC Coastal Shark Plan	Sharks – ASMFC Coastal Shark Plan; Great hammerhead, smooth hammerhead, scalloped hammerhead recreational minimum size of 78” FL	Sharks – ASMFC Coastal Shark Plan	Sharks ASMFC Coastal Shark Plan

New York	No				By 1998: prohibition on finning sharks; no other shark regulations						By Feb 2004: reference to federal regs 50 CFR part 635; prohibited sharks listed		By May 2006: no new shark regulations		By Oct 2008: no new shark regulations	No new shark regulations	ASMFC Coastal Shark Plan	ASMFC Coastal Shark Plan	ASMFC Coastal Shark Plan	Sharks – ASMFC Coastal Shark Plan	Sharks – ASMFC Coastal Shark Plan; Great hammerhead, smooth hammerhead, scalloped hammerhead recreational minimum size of 78" FL	Shark Plan. Separate requirement that No person shall possess, sell, offer for sale, trade, or distribute a shark fin; provided, however, that this prohibition shall not apply to any shark fin that was taken from a spiny dogfish (Squalus acanthias) or a smooth dogfish (Mustelus canis) lawfully caught by a licensed commercial fisherman; a shark fin may be possessed by any person if the shark was lawfully caught and the person has a recreational marine fishing registration or a license or permit from the department for bona	A SMFC Coastal Plan. Non-stainless, non-offset circle hooks must be used when taking sharks.
North Carolina	Yes	1990: prohibition on finning 1990 – 7500 lbs per trip, dogfish exempt; unlawful to land fins without carcass; fins no more than 10%; unlawful to land dried fins; required record keeping; Recreational - bag limit is 2 per day 1992 – Reduced fins to no more than 7%	No new shark regulations	No sharks, except Atlantic sharpnose and pelagic sharks, can be taken by commercial gear in state waters; fins must be landed with the carcass; maximum 5% fin-to-carcass ratio; fishers cannot posses or land dried shark fins	No new shark regulations	No new shark regulations	One shark per vessel per day with commercial gear (except Atlantic sharpnose and dogfish) while federal waters are open for species group; 84 inch maximum size limit except for tiger, thresher, bigeye thresher, shortfin mako and hammerhead species; must be landed with head, tail and fins intact; Recreational – bag limit is 1 per person per day with a minimum size of 54" (none on Atlantic sharpnose) and a maximum of 84" (except for tiger, thresher, bigeye thresher, shortfin mako and hammerhead species); Prohibited species – basking, white, sand tiger and whale sharks	No new shark regulations	No new shark regulations	April: Prohibited ridgebacks (sandbar, silky, and tiger sharks) from Large Coastal Group	No new shark regulations	No new shark regulations	Open seasons and species groups same as federal; 4000 lb trip limit for LCS; retain fins with carcass through point of landing; longline shall only be used to harvest LCS during open season, shall not exceed 500 yds or have more than 50 hooks (state waters reopened to commercial fishing); Recreational: LCS (54" FL min size) - no more than 1 shark/vessel/day or 1 shark/person/day, SCS (no min size) – no more than 1 finetooth or blacknose shark/vessel/day and no more than 1 Atlantic sharpnose and 1 bonnethead/person/day, pelagics (no min size) -1 shark/vessel/day; Same prohibited shark species as federal regulations	No new shark regulations	July: Adopted federal regulations of 33 Large Coastal sharks per trip and fins must be naturally attached to carcass	Fins must be naturally attached to shark carcass	Director may impose restrictions for size, seasons, areas, quantity, etc. via proclamation; Commercial: open seasons and species groups same as federal; 33 non-sandbar LCS retention limit; no retention of sandbar sharks; fins naturally attached to shark carcass, except for smooth dogfish; LL shall only be used to harvest LCS during open season, shall not exceed 500 yds or have more than 50 hooks; Recreational: LCS (54" FL min size) - no more than 1 shark/vessel/day or 1 shark/person/day, SCS (no min size) – no more than 1 finetooth or blacknose shark/vessel/day and no more than 1 Atlantic sharpnose and 1 bonnethead/person/day, pelagics (no min size) -1 shark/vessel/day; Same prohibited shark species as federal regulations	Director may impose restrictions for size, seasons, areas, quantity, etc. via proclamation; ASMFC Coastal Shark IFMP; additionally: LL in the shark fishery shall not exceed 500 yds or have more than 50 hooks	no new shark regulations	no new shark regulations	Great hammerhead, smooth h	no new shark regulations	no new shark regulations
Puerto Rico	Yes	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	Year-round closed season on nurse sharks Shark "finning" is prohibited. PR regulations indicate the need for compliance by local fishers with federal shark regulations.	no new shark regulations	no new shark regulations	no new shark regulations	no new shark regulations	no new shark regulations	Swordfish or billfish, tuna and shark are covered under the federal Atlantic HMS regulations (50 CFR, Part 635); Fishers who capture these species are required to comply with said regulation; billfish captured incidentally with long line must be released by cutting the line close to the fishhook, avoiding the removal of the fish from the water; in the case of tuna and swordfish, fishers shall obtain a permit according to the requirements of the federal government; Year-round closed season on nurse sharks	no new shark regulations	no new shark regulations	no new shark regulations	Swordfish or billfish, tuna, and shark are covered under the federal Atlantic HMS regulations (50 CFR, Part 635), which also apply in territorial waters; Fishers who capture these species are required to comply with said regulation; billfish captured incidentally with long line must be released by cutting the line close to the fishhook, avoiding the removal of the fish from the water; in the case of tuna and swordfish, fishers shall obtain a permit according to the requirements of the federal government; Year-round closed season on nurse sharks.	no new shark regulations	no new shark regulations
Rhode Island	No	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	No shark regulations	– ASMFC Coastal Shark Plan	ASMFC Coastal Shark Plan	ASMFC Coastal Shark Plan	Sharks - RIMFC Regulations part VII 7.24	Sharks – ASMFC Coastal Shark Plan. Great hammerhead, smooth hammerhead, scalloped hammerhead recreational minimum size of 78" FL	Sharks – ASMFC Coastal Shark Plan	ASMFC Coastal Shark Plan
South Carolina	No				By 1998: federal regs adopted by reference; use of gillnets prohibited in the shark fishery						By Feb 2004: retention limit of 2 Atlantic sharpnose per person per day and 1 bonnethead per person per day; no min size for recreationally caught bonnethead sharks; reference to federal commercial regulations and closures		By May 2006: non-Atlantic sharpnose/bonnethead sharks – 1 shark/boat/trip, min size – 54" FL		By Oct 2008: no new shark regulations	No new shark regulations	Defer to federal regulations; Gillnets may not be used in the shark fishery in state waters; State permit required for shark fishing in state waters	no new shark regulations	no new shark regulations	no new shark regulations	Great hammerhead, smooth hammerhead, scalloped hammerhead recreational minimum size of 78" FL	no new shark regulations	no new shark regulations
Texas	Yes	Sept. 1989: Bag limit set at five sharks per day for both rec and commercial anglers; Sept 1992: Bag limit increased to ten sharks per day. Trotlines were added as allowable gear for sharks.		1997: Commercial bag limit of 5 sharks; possession limit of 10 sharks; no min or max size. Recreational bag, possession, and lack of size restrictions same as commercial	1998: commercial fishing for sharks can only be done with rod and reel; no entanglement nets						Sept: Commercial/Recreational retention limit 1 fish/person/day; Commercial/Recreational possession limit is twice the daily bag limit (i.e., 1 fish/person/day); Commercial/Recreational minimum size 24 in TL		By May 2006: no new shark regulations		By Oct 2008: no new shark regulations	Sept: Min size 24" TL for Atlantic sharpnose, blacktip, and bonnethead sharks and 64" TL for all other lawful sharks. Prohibited species: same as federal regulations	- Commercial/recreational: bag limit - 1 shark/person/day; Commercial/recreational possession limit is twice the daily bag limit (i.e., 2 sharks/person/day); min size 24" TL for Atlantic sharpnose, blacktip, and bonnethead sharks and 64" TL for all other lawful sharks. Prohibited species: same as federal regulations	no new shark regulations	no new shark regulations	no new shark regulations	no new shark regulations	no new shark regulations	no new shark regulations
Virginia	No	1991: no longlines in state waters; recreational bag limit of 1 shark per person per day; established a commercial trip limit of___; 1993: mandatory reporting of all shark landings		7500 lb commercial trip limit; minimum size of 58 inches FL or 31 inches carcass length (but can keep up to 200 lbs dw of sharks per day less than 31 inches carcass length); prohibition on finning; recreational: possession limit of 1 shark per person per day	By 1998: no longlining in state waters	no new shark regulations	no new shark regulations	no new shark regulations	no new shark regulations	no new shark regulations	no new shark regulations		By May 2006: Recreational: bag limit – 1 LCS, SCS, or pelagic shark/vessel/day with a min size of 54" FL or 30" CL; 1 Atlantic sharpnose and bonnethead/person/day with no min size; Commercial: possession limit - 4000 lb dw/day, min size - 58" FL or 31" CL west of the COLREGS line and no min size limit east of the COLREGS line; Prohibitions: fillet at sea, finning, longlining, same prohibited shark species as federal regulations	no new shark regulations	no new shark regulations	ASMFC Plan	ASMFC Coastal Shark Plan	ASMFC Coastal Shark Plan	ASMFC Coastal Shark Plan	ASMFC Coastal Shark Plan	ASMFC Coastal Shark Plan - Great hammerhead, smooth hammerhead, scalloped hammerhead recreational minimum size of 78" FL	Sharks – ASMFC Coastal Shark Plan	ASMFC Coastal Shark Plan

3. ASSESSMENT HISTORY AND REVIEW

The sandbar shark was first assessed individually in 1998 and later in 2002, 2006, and 2011. Prior to that, it was part of the Large Coastal Shark complex, which was first assessed in 1991 and subsequently updated in 1994, 1996, and 1998. In the 1998 Shark Evaluation Workshop (NMFS 1998), a Bayesian surplus production modeling approach was used to assess sandbar sharks, concluding that the 1998 stock size was 58-70% of the stock size at MSY. The 2002 Stock Evaluation Workshop saw the use of multiple assessment methodologies, which resulted in contradictory conclusions on stock status, but the report (Cortés et al. 2002) noted that the status of the resource had improved compared to the conclusions from the 1998 assessment. It was noted, however, that when averaged over the range of models judged plausible, overfishing of the resource could be occurring but current biomass was near or somewhat above that producing MSY.

The first assessment of sandbar sharks under the SEDAR framework took place in 2006 (SEDAR 11, NMFS 2006). Although up to 5 models were initially presented, it was decided that an age-structured production model would be used as the base model given that catch and age-specific biological and selectivity information were available. The 2006 assessment concluded that the stock was overfished (SSF_{2004}/SSF_{MSY}=0.72-0.85; range of base and sensitivity model runs) with overfishing occurring (F_{2004}/F_{MSY}=1.73-18.3; range of base and sensitivity model runs). The main changes between the 2002 and 2006 assessments included differences in the CPUE series used, a maturity ogive shifted towards older ages in 2006, the use of age-specific values of M in 2006 vs. a fixed M at age in 2002, and differing assumptions relating to virgin conditions and historic exploitation.

SEDAR 21 (in 2011) assessed sandbar sharks with the state-space, age-structured production model (ASPM) as the primary assessment modeling approach. Probabilities obtained through likelihood profiling of the base run indicated that there was a 69 % probability that the stock in 2009 was overfished and an 86% probability that there was no overfishing in 2009. Of the 16 sensitivity runs explored, all estimated an overfished status (with the exception of a run that used fishery-independent indices only), and all runs estimated that the stock was not undergoing overfishing, except for two runs (hierarchical index with equal weights and high M run). Following the completion of the assessment, The Review Panel identified seven additional sensitivity runs to better understand how assessment outputs were related to key model assumptions. All runs still indicated that the stock was overfished (SSF_{2009}/SSF_{MSY} ranged from 0.51 to 0.72) and undergoing overfishing (F_{2009}/F_{MSY} ranged from 0.29 to 0.93), with the exception of a low productivity run which estimated overfishing. The main changes between the 2006 and 2011 assessments included: the 2011 assessment started in 1960 (vs. 1975 in the 2006 assessment), catches spanned 1960-2009 (vs. 1975-2004) and commercial catches were split into the Gulf of Mexico and Atlantic (vs. one single commercial series), there were 11 indices, 5 of them new to SEDAR 21 and all of which were reanalyzed (vs. 8 indices in SEDAR 11), there were 4 selectivities for catches, 3 of which were new (vs. 3), and 8 selectivities for indices (vs. 2), there were new biological parameters, including a new von Bertalanffy growth curve with a more rapid growth coefficient K=0.12 (vs. 0.09), lifespan was shorter at 27 years (vs. 40), there was a new maturity-at-age ogive that was shifted to younger ages, with a median maturity of 13 years (vs. 19), the Data Workshop Panel agreed on a longer reproductive cycle of 2.5 years as a compromise between 2 and 3 years (vs. 2 in SEDAR 11), and new estimates of natural mortality at age were produced, with lower values for the younger ages and higher values for the older ages. These changes affected the potential productivity/resiliency of the stock in different directions: the higher K, shorter lifespan, and maturity ogive shifted to the left can be associated with a more productive stock, but at the same time there were 13 fewer years during which females can produce offspring and at a slower rate of every 2.5 years.

References

Cortés, E., L. Brooks, and G. Scott. 2002. Stock assessment of large coastal sharks in the U.S. Atlantic and Gulf of Mexico. Sustainable Fisheries Division Contribution SFD-02/03-177. 222 pp.

NMFS (National Marine Fisheries Service). 1998. Report of the Shark Evaluation Workshop. NOAA/NMFFS Panama City Laboratory.

NMFS (National Marine Fisheries Service). 2006. Southeast Data, Assessment and Review (SEDAR) 11. Large Coastal Shark complex, blacktip and sandbar shark stock assessment report. NOAA/NMFS Highly Migratory Species Division, Silver Spring, MD.

NMFS (National Marine Fisheries Service). 2011. Southeast Data, Assessment and Review (SEDAR) 21. Large Coastal Shark complex, blacktip and sandbar shark stock assessment report. NOAA/NMFS Highly Migratory Species Division, Silver Spring, MD.

4. SEDAR ABBREVIATIONS

ABC	Allowable Biological Catch
ACCSP	Atlantic Coastal Cooperative Statistics Program
ADMB	AD Model Builder software program
ALS	Accumulated Landings System; SEFSC fisheries data collection program
AMRD	Alabama Marine Resources Division
ASMFC	Atlantic States Marine Fisheries Commission
B	stock biomass level
BAM	Beaufort Assessment Model

BMSY	value of B capable of producing MSY on a continuing basis
CFMC	Caribbean Fishery Management Council
CIE	Center for Independent Experts
CPUE	catch per unit of effort
EEZ	exclusive economic zone
F	fishing mortality (instantaneous)
FMSY	fishing mortality to produce MSY under equilibrium conditions
FOY	fishing mortality rate to produce Optimum Yield under equilibrium
FXX% SPR	fishing mortality rate that will result in retaining XX% of the maximum spawning production under equilibrium conditions
FMAX	fishing mortality that maximizes the average weight yield per fish recruited to the fishery
F0	a fishing mortality close to, but slightly less than, Fmax
FL FWCC	Florida Fish and Wildlife Conservation Commission
FWRI	(State of) Florida Fish and Wildlife Research Institute
GA DNR	Georgia Department of Natural Resources
GLM	general linear model
GMFMC	Gulf of Mexico Fishery Management Council
GSMFC	Gulf States Marine Fisheries Commission
GULF FIN	GSMFC Fisheries Information Network
HMS	Highly Migratory Species
LDWF	Louisiana Department of Wildlife and Fisheries
LGL	LGL Ecological Research Associates
M	natural mortality (instantaneous)
MARMAP	Marine Resources Monitoring, Assessment, and Prediction
MDMR	Mississippi Department of Marine Resources
MFMT	maximum fishing mortality threshold, a value of F above which overfishing is deemed to be occurring
MRFSS	Marine Recreational Fisheries Statistics Survey; combines a telephone survey of households to estimate number of trips with creel surveys to estimate catch and effort per trip

MRIP	Marine Recreational Information Program
MSST	minimum stock size threshold, a value of B below which the stock is deemed to be overfished
MSY	maximum sustainable yield
NC DMF	North Carolina Division of Marine Fisheries
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
OY	optimum yield
SAFMC	South Atlantic Fishery Management Council
SAS	Statistical Analysis Software, SAS Corporation
SC DNR	South Carolina Department of Natural Resources
SEAMAP	Southeast Area Monitoring and Assessment Program
SEDAR	Southeast Data, Assessment and Review
SEFIS	Southeast Fishery-Independent Survey
SEFSC	Fisheries Southeast Fisheries Science Center, National Marine Fisheries Service
SERO	Fisheries Southeast Regional Office, National Marine Fisheries Service
SPR	spawning potential ratio, stock biomass relative to an unfished state of the stock
SSB	Spawning Stock Biomass
SS	Stock Synthesis
SSC	Science and Statistics Committee
TIP	Trip Incident Program; biological data collection program of the SEFSC and Southeast States.
TPWD	Texas Parks and Wildlife Department
Z	total mortality, the sum of M and F

SEDAR

Southeast Data, Assessment, and Review

SEDAR 54

HMS Sandbar Shark

SECTION II: Assessment Process Report

October 2017

SEDAR
4055 Faber Place Drive, Suite 201
North Charleston, SC 29405

Table of Contents

1 INTRODUCTION

1.1 WORKSHOP TIME AND PLACE

The SEDAR 54 Assessment Process was held via a series of webinars between May 2017 and August 2017.

1.2 TERMS OF REFERNCE

1. Conduct a stock assessment of Sandbar Shark using Stock Synthesis (SS) with data through 2015 using the same data inputs used in the SEDAR 21 benchmark assessment model to the fullest extent appropriate. Document any differences between SS and the previous model.
2. Evaluate the input data listed below compared to the SEDAR 21 assessment model data and document any changes or deviations with respect to those data:
   - Updated life history information (age and growth and reproductive parameters)
   - The relative abundance indices vetted in SEDAR 21 and used in the baseline scenario
   - Updated commercial and recreational discard information
   - Updated length composition information
   - Any new data sources that may have become available since SEDAR 21 was conducted and that may be used with Stock Synthesis.

   Provide updated input data tables, as appropriate, including any catch (e.g., commercial, recreational, discards) in both weight and number.
3. Provide model parameter estimates and their variances, model uncertainties, diagnostics to determine model performance, including fit to data and convergence, and estimates of stock status and management benchmarks. Provide criteria used to identify the base model run and conduct model sensitivity analysis to address uncertainty in data inputs and model configuration, including model runs that represent plausible alternate states of nature previously identified and vetted in SEDAR 21, as well as other model uncertainties identified during the assessment.
4. Project future stock conditions regardless of the status of the stock. Develop new rebuilding schedules, only if there is new and unexpected information about the status of the stock. Stock projections shall be developed in accordance with the following:

   A) If the stock is overfished and no new rebuilding schedule is warranted, then utilize projections to evaluate current rebuilding plan (started in 2008, projected to end in 2070):

   - F resulting in 50% and 70% probability of rebuilding by 2070
   - Fixed level or removals (TAC) allowing rebuilding of stock by 2070 with 50% and 70% probability

   B) If the stock is overfished and a new rebuilding schedule is warranted, then utilize projections to determine:

   - Provide the estimated generation time for the stock.
   - Year in which F=0 results in a 70% probability of rebuilding (Year $F=0_{p70}$)
   - Target rebuilding year (Year $F=0_{p70}$ + 1 generation time) ($\text{Year}_{\text{rebuild}}$)

- F resulting in 50% and 70% probability of rebuilding by $\text{Year}_{\text{rebuild}}$
- Fixed level or removals (TAC) allowing rebuilding of stock with 50% and 70% probability

C) Otherwise, utilize a P* approach to determine:

- The F needed and corresponding removals associated with a 70% probability of overfishing not occurring (P* = 0.3)

D) If data or other issues preclude classic projections (i.e. A, B or C above), explore alternate projection models to provide management advice.

5. Develop a stock assessment report to address these TORs and fully document the input data, methods, and results.

1.3 LIST OF PARTICIPANTS

Workshop Panel

Joel Rice, Lead Analyst	NMFS Consultant
Peter Barile	DSF, Inc.
Carolyn Belcher	GADNR
John Carlson	NMFS Panama City
Enric Cortes	NMFS Panama City
Dean Courtney	NMFS Panama City
Trey Driggers	NMFS Pascagoula
Brian Frazier	SCDNR
Dean Grubbs	FSU
Dewey Heilright	Industry Rep
Russell Hudson	DSF, Inc.
Rob Latour	VIMS
Cami McCandless	NMFS Narragansett
Xinsheng Zhang	NMFS Panama City

Staff

Julie Neer	SEDAR
Karyl Brewster-Geisz	HMS

Webinar Attendees

Heather Bartlein	HMS
Tobey Curtis	NMFS SERO
Guy DuBeck	HMS
Steve Durkee	HMS
Luke Harris	
Clifford Hutt	NMFS
Juan Izabak	
Lauren Latchford	NMFS
Ian Miller	NMFS
Delisse Ortiz	HMS

Adam Pollack..NMFS Pascagoula
Gray Redding ....NMFS
Carrie Soltanoff...NMFS
Jackie Wilson ....HMS

1.4 LIST OF DATA WORKSHOP WORKING PAPERS & REFERNCE DOCUMENTS

Document #	Title	Authors	Date Submitted
Documents Prepared for the Assessment			
SEDAR54-WP-01	Updated life history parameters for sandbar sharks, *Carcharhinus plumbeus*	William B. Driggers III, Bryan S. Frazier, John K. Carlson, Bethany M. Deacy, Michael P. Enzenauer and Andrew N. Piercy	8 May 2017
SEDAR54-WP-02	Updated catch rates of sandbar sharks (*Carcharhinus plumbeus)* in the northwest Atlantic Ocean from the Shark Bottom Longline Observer Program, 1994-2015	John K. Carlson and Alyssa N. Mathers	3 May 2017
SEDAR54-WP-03	Standardized catch rates of sandbar sharks from the Large Pelagics Rod and Reel Survey 1986-2015	John Walter and Craig A. Brown	7 April 2017
SEDAR54-WP-04	Sandbar Shark Abundance Indices from NMFS Bottom Longline Surveys in the Northern Gulf of Mexico	Adam G. Pollack, David S. Hanisko and G. Walter Ingram, Jr.	19 May 2017
SEDAR54-WP-05	Standardized catch rates for sandbar sharks from the U.S. pelagic longline observer program using generalized linear mixed models	Enric Cortés and Xinsheng Zhang	15 May 2017
SEDAR54-WP-06	Example Implementation of a Hierarchical Cluster Analysis and Cross-correlations of Selected CPUE Indices for the SEDAR 54 Assessment	Dean Courtney	20 Sept 2017
SEDAR54-WP-07			

Final Stock Assessment Reports		
SEDAR54-SAR1	HMS Sandbar Shark	SEDAR 54 Panel

1.5 STATEMENT ADDRESSING EACH TERM OF REFERENCE

Terms of Reference.

1. *Conduct a stock assessment of Sandbar Shark using Stock Synthesis (SS) with data through 2015 using the same data inputs used in the SEDAR 21 benchmark assessment model to the fullest extent appropriate. Document any differences between SS and the previous model.*

This report documents the stock assessment of sandbar shark using the modeling framework Stock Synthesis. Descriptions of the data used in the current assessment and the differences in that data from SEDAR 21 are provided in Section 2. A replication analysis that reproduced SEDAR 21 results with Stock Synthesis is provided in Sections 3.1.1 and 3.1.2. A continuity analysis that updated the catch data, the indices of abundance, and certain biological parameters is provided in Section 3.1.3. The base case assessment model methods, results and sensitivity analyses are described in Section 3.2. The base case data sources are summarized in Section 3.2.2. The software and general assessment approach are summarized in Sections 3.2.3 and 3.2.4. Base case model results are provided in Section 3.2.5. Retrospective and Markov Chain Monte Carlo (MCMC) analyses conducted for the base case model are provided in Section 3.2.6. Sensitivity runs representing alternative state of nature scenarios are provided in Section 3.2.7. An investigation of model structure uncertainty using profile likelihoods for the base case and selected alternate states of nature is provided in Section 3.2.8. Reference points for the base case and selected alternative states of nature are provided in Section 3.2.9. Projections for the base case and selected alternative states of nature are provided in Section 3.2.10. Assessment research recommendations are provided in Section 3.3.

2. Evaluate the input data listed below compared to the SEDAR 21 assessment model data and document any changes or deviations with respect to those data:

- *Updated life history information (age and growth and reproductive parameters)*
- *The relative abundance indices vetted in SEDAR 21 and used in the baseline scenario*
- *Updated commercial and recreational discard information*
- *Updated length composition information*
- *Any new data sources that may have become available since SEDAR 21 was conducted and that may be used with SS*

Provide updated input data tables, as appropriate, including any catch (e.g., commercial, recreational, discards) in both weight and number.

Changes to the biology and fishery inputs used for SEDAR 21 were evaluated in recognition of updated information that had become available since the last assessment. These changes are documented in Section 2. The main changes included:

a) The von Bertalanffy growth curves were updated based on the work by Hale and Baremore (2013) combined with new samples of smaller animals that became available (J. Carlson, unpublished data). Maximum age was also updated from 27 to 31 years based on the new growth curve and a bomb radiocarbon dating and mark-recapture study by Andrews et al. (2011).
b) New estimates of natural mortality were produced for this analysis with the same indirect estimators used in SEDAR 21 using updated life history estimates.
c) The estimate of steepness was updated to 0.3 from 0.29 based on a recalculation of the parameter based on the updated life history inputs
d) Updated indices of relative abundance. The previous analyses have for the most part been extended until 2015 (from 2009), with exceptions noted in section 2.
e) Commercial and recreational catches and discards have been re-computed or re-estimated using the same methods as previously used.
f) Length composition for 3 fisheries and 11 CPUE series were integrated into the assessment.

3. Provide model parameter estimates and their variances, model uncertainties, diagnostics to determine model performance, including fit to data and convergence, and estimates of stock status and management benchmarks. Provide criteria used to identify the base model run and conduct model sensitivity analysis to address uncertainty in data inputs and model configuration, including model runs that represent plausible alternate states of nature previously identified and vetted in SEDAR 21, as well as other model uncertainties identified during the assessment.

All modeling methods are described in Section 3; the results of the replication analysis and continuity analysis are presented in Section 3.1. The base case model configuration and results are described in section 3.2. Measures of overall model fit are provided in Section 3.2.5 along with estimates of model parameters, and associated measures of uncertainty Information on the evaluation of uncertainty, including sensitivity runs, is described in Sections 3.2.6, 3.2.7, and 3.2.8; information on benchmarks and reference points is in section 3.2.9.

4. Project future stock conditions regardless of the status of the stock. Develop new rebuilding schedules, only if there is new and unexpected information about the status of the stock. Stock projections shall be developed in accordance with the following:

A) If the stock is overfished and no new rebuilding schedule is warranted, then utilize projections to evaluate current rebuilding plan (started in 2008, projected to end in 2070):

- *F resulting in 50% and 70% probability of rebuilding by 2070*
- *Fixed level or removals (TAC) allowing rebuilding of stock by 2070 with 50% and 70% probability*

B) If the stock is overfished and a new rebuilding schedule is warranted, then utilize projections to determine:

- *Provide the estimated generation time for the stock.*
- *Year in which F=0 results in a 70% probability of rebuilding (Year F=0p70)*
- *Target rebuilding year (Year F=0p70 + 1 generation time) (Year rebuild)*
- *F resulting in 50% and 70% probability of rebuilding by Year rebuild*
- *Fixed level or removals (TAC) allowing rebuilding of stock with 50% and 70% probability*

C) Otherwise, utilize a P approach to determine:*

- *The F needed and corresponding removals associated with a 70% probability of overfishing not occurring (P* = 0.3)*

D) If data or other issues preclude classic projections (i.e. A, B or C above), explore alternative projection models to provide management advice.

Details and results of the projections are explained in section 3.2.10. The base case model results fell within item A of this TOR. Stochastic projections were carried out at levels of TAC that were estimated to allow rebuilding of the stock by 2070 with 50% and 70% probability. Forecast probabilities were calculated via MCMC analysis with the forecast module internal to SS3. This method carries forward the uncertainty in the estimated model parameters, but did not forecast recruitment variability. Alternative configurations of the base case led to estimations of stock status where items B and C may apply. In these situations, projections using TACs estimated to meet the criteria specified in the TORs were carried out via MCMC analysis in the same fashion as for the base case projections.

5. Develop a stock assessment report to address these TORs and fully document the input data, methods, and results.

This is the present document.

2 DATA REVIEW AND UPDATE

2.1 REPLICATION AND COUNTINUITY DATA SETS

Prior to undertaking the analysis for SEDAR 54 a reproduction of the previous base case assessment (SEDAR 21), termed a replication analysis, was completed. Following the replication analysis, a series of continuity analyses were conducted that sequentially incorporated new catch inputs and extended the catches through the updated time frame from 1960-2015 (as opposed to 1960-2009), and incorporated updated estimates of life history parameters. These changes are documented in section 3.1. In general, all data inputs (catches, CPUE series, life history inputs, selectivities) used for the replication analysis were the same as those used in SEDAR 21. For the continuity analyses, the inputs were updated in a stepwise manner.

2.2 NEW DATA SOURCES CONSIDERED (FOR NEW ANALYSES)

2.2.1 Life History

The life history inputs used in the assessment are presented in Tables 2.1 and 2.2. These include age and growth, as well as several parameters associated with reproduction, including sex ratio, reproductive frequency, fecundity by length, maturity at age, and month of pupping, and age-specific natural mortality. Stock synthesis uses most life history characteristics as constants (inputs) and others are estimated parameters, which can be assigned priors and initial values, or estimated via initial conditions and associated minimum and maximum values. Differences between the input data for SEDAR 21 and SEDAR 54 included updated natural mortality, growth curve, and maximum age information (Tables 2.1 and 2.2). The main changes included:

a) The von Bertalanffy growth curves were updated based on the work by Hale and Baremore (2013) combined with new samples of smaller animals that became available (J. Carlson, unpublished data). Maximum age was also updated from 27 to 31 years based on the new growth curve and a bomb radiocarbon dating and mark-recapture study by Andrews et al. (2011).
b) New estimates of natural mortality were produced for this analysis with the same indirect estimators used in SEDAR 21 using updated life history estimates.
c) The estimate of steepness was updated to 0.3 from 0.29 based on a recalculation of the parameter based on the updated life history inputs
d) Updated indices of relative abundance. The previous analyses have for the most part been extended until 2015 (from 2009), with exceptions noted in section 2.
e) Commercial and recreational catches and discards have been re-computed or re-estimated using the same methods as previously used.
f) Length composition for 3 fisheries and 11 CPUE series were integrated into the assessment.

2.2.2 Catch Data

No changes were introduced to the methods to develop the catch series used in SEDAR 21, though the input data was updated. This section (2.2.2) references the SEDAR 21 Data Workshop (DW) and Assessment Workshop (AW) Reports and working paper SEDAR21-DW-09, which describe in detail the methods used to estimate the catch series for SEDAR 54. The catch trends from SEDAR 21 (in numbers) and SEDAR 54 (in numbers) differ slightly in their overlapping years (Figure 2.1). The same four fisheries (F1, F2, F3, and F4) that were used in SEDAR 21 have been maintained in this analysis, and are described below. Landings for commercial fisheries, which are typically reported in dressed weight, are converted to whole weight with a conversion factor of 1.39 (whole weight =1.39*dressed weight), which is consistent with previous analyses.

F1 and F2 Commercial landings

Commercial landings data used in the assessment are presented in Table 2.3 and Figure 2.2. A full description of the landings and how they were calculated is given in the SEDAR 21 DW Report and SEDAR21-DW-09. Briefly, the commercial catch series was split into a Gulf of Mexico (F1 GOM) and an Atlantic (F2 ATL) component to reflect capture of animals of different sizes in the two areas and assign separate selectivity patterns to each area. Computation of these two separate catch series proceeded as follows. First, for 1991-2015, commercial landings were split into GOM and ATL using the percentage by region and year from the general canvass data (1991-2012) or from the HMS eDealer database (2013-2015). Secondly, prior to 1991 there were only regional landings data for 1987-1990, but the annual percentages oscillated widely from one area to another so for 1960-1990, total commercial landings were apportioned into GOM and ATL using the average percent composition by region for the first five years with more reliable data (1991-1995). Unreported commercial catches in 1986-1991 were split into the two regions using the percent composition reported on page 3 of SEDAR21-DW-09. These values represent landings only for the commercial fisheries.

F3 Recreational and Mexican catches

The recreational catch data used in the assessment are presented in Table 2.3 and Figure 2.2. A full description of the catches and how they were computed is given in the SEDAR 21 DW Report and SEDAR21-DW-09. Briefly, annual catch estimates are the sum of estimates reported in the MRFSS/MRIP (fish landed [A] and discarded dead [B1]), Headboat survey (fish landed) and Texas Parks and Wildlife Department survey (fish landed). The only changes with respect to SEDAR 21 were that catches were extended to 2015 (from 2009 in SEDAR 21); for 2004-2015, MRIP estimates, which have replaced MRFSS, were used; and catches were also expressed in weight. For the Mexican catches, sandbar sharks caught in the states of Tamaulipas and Veracruz in Mexico that were assumed to have come from the USA were as reported in the previous assessment until 2000 and came from online fisheries statistics from Conapesca for 2001-2008 (see the SEDAR 21 DW Report and SEDAR21-DW-09 for the methods pertaining to the derivation of these catches). The only changes with respect to SEDAR 21 were that catches were extended to 2015 using Conapesca fisheries statistics available online for 2009-2013 (catches for 2014 and 2015 were assumed equal to the mean of those in 2011-2013). Landings are provided in weight in the Mexican fishery statistics. Values represent landings and dead discards for the recreational fishery and reported landings for the Mexican fishery.

F4 Menhaden Fishery Discards

This was the only series of commercial discards incorporated into the assessment (Table 2.3 and Figure 2.2) and has a very small magnitude (less than 800 fish in any year). A full description of the derivation of these estimates is given in the SEDAR 21 DW Report and SEDAR21-DW-09. The only changes with respect to SEDAR 21 were that catches were extended to 2015 using updated effort data (number of vessels) in the purse seine menhaden fishery in the Gulf of Mexico.

2.2.3 Indices of Abundance

The indices and their temporal coverages are listed in Table 2.4 and shown in Figure 2.3, and the values and the estimated coefficients of variation (CVs) are in Tables 2.5 and 2.6. Aside from having been updated to 2015, the majority of the indices of abundance are unchanged in their methodology or data sources from SEDAR 21. There were four exceptions. The first exception is that S9, the COASTSPAN SE LL index, now replaces the old GA and SC COASTSPAN indices and adds the FL COASTSPAN index. The GA and SC COASTSPAN indices were removed and the years 1988 and 1999 eliminated because they were uncertain. The second exception is that S11, the SEAMAP SE LL index, is combined with the GA red drum index starting in 2007. The third change is that the index from the SEFSC Shark Bottom Longline Observer Program was split in 2007 to reflect a change in reporting requirements (see below for details). Finally, the Panama City Gillnet index was dropped from the analysis based on the advice from the author of that paper due to the very low occurrence of sandbar sharks in that index (approximately 2-3 per year). The following is an overview of the available indices of abundance; each description is preceded by the name of the index, the corresponding paper from SEDAR 21 that details the methods, and the name of the survey in SEDAR 54.

Large Pelagic Survey (SEDAR21-DW-44) S1 LPS

The original paper presented an update to two abundance indices for sandbar (*Carcharhinus plumbeus*) and dusky sharks (*Carcharhinus obscurus*) sharks off the coast of the United States from Virginia through Massachusetts that were developed using data obtained during interviews of rod and reel anglers in 1986-2009. The analysis was updated using data through 2015. Subsets of the data were analyzed to assess effects of factors such as month, area fished, boat type (private or charter), interview type (dockside or phone) and fishing method on catch per unit effort. Standardized catch rates were estimated through generalized linear models by applying delta-Poisson error distribution assumptions. A stepwise approach was used to quantify the relative importance of the main factors explaining the variance in catch rates. The same models used in the indices constructed in 2004 and 2009 were used in this paper for the binomial and Poisson.

SEFSC Shark Bottom Longline Observer Program (SEDAR21-DW-02) S2 And S3

Catch rate series were developed from the data collected by on-board observers in the shark bottom longline fishery for the period 1994-2015 for sandbar sharks. All series were subjected to a Generalized Linear Model (GLM) standardization technique that treats the proportion of sets with positive catches (i.e., where at least one shark was caught) assuming a binomial error distribution with a logit link function, and the catch rates of sets with positive catches assuming a lognormal error distribution with a log link function separately. Historically, vessels in this fishery primarily targeted sandbar shark. With the introduction of the shark research fishery in 2008, vessels outside the research fishery were not permitted to target or land sandbar sharks. This change in management regulations likely influences the time series of abundance for sandbar shark such that vessels fishing in the research fishery should be modeled separately from those outside the research fishery. Therefore, two indices of abundance were created from this data series; 1994-2007 for all vessels and 2008-2015 for vessels in the research fishery. While observations of vessels outside the research fishery were made from 2008-2015, the low sample size in some years combined with the change in targeting practices precluded including those data. Year, depth and area were significant as a main effect in most models. The relative abundance index over both time periods showed a flat trend in abundance since 1994 for sandbar shark with some increase in later years.

VIMS Longline (SEDAR21-DW-18) S4 VA LL

The Virginia Institute of Marine Science (VIMS) has conducted a fishery-independent longline survey during summer months since 1974. Data for sandbar sharks captured in the survey between 1975 and 2015 were analyzed. Most of the sandbar sharks encountered by the survey were immature, with females composing almost all of the mature sandbar catch. Nominal and standardized catch rates were presented. CPUE decreased from the early 1980s to minima in 1992. CPUE then slightly increased and has oscillated since. The previous assessment (in 2004) included a Data Workshop including an Indices working group which recommended removal of all years where less than five standard stations were sampled, thus these years were removed and analyses were conducted on the new data sets. Removal of these years did not change explanatory factors in the models.

NMFS Southeast Bottom Longline (SEDAR21-DW-39) S5 NMFS LLSE

The Southeast Fisheries Science Center (SEFSC) Mississippi Laboratories has conducted standardized bottom longline surveys in the Gulf of Mexico, and off the east coast of the United States since 1995. The objective of this longline survey was to provide fisheries independent data for stock assessment for as many species as possible. This survey was used to develop abundance indices for sandbar sharks for in the GOM and Atlantic. To develop standardized indices of annual average CPUE for sandbar sharks for both the GOM and Atlantic, a delta-lognormal model, as described by Lo *et al.* (1992), was employed. For the SEDAR 54 assessment one index of abundance was developed that was based on all of the data.

NMFS COASTSPAN Longline (SEDAR21-DW-27) S6 CST NELL

This document detailed the young of the year (YOY), age 1+ juvenile and the total juvenile sandbar shark catch from the Northeast Fisheries Science Center (NEFSC), Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) survey conducted in Delaware Bay. Catch per unit effort (CPUE) in number of sharks per 50-hook set per hour was used to examine the relative abundance of juvenile sandbar sharks between the summer nursery seasons from 2001 to 2015. The CPUE was standardized using a two-step delta-lognormal approach originally proposed by Lo et al (1992) that models the proportion of positive catch with a binomial error distribution separately from the positive catch, which is modeled using a lognormal distribution. All three juvenile sandbar shark time series showed a fairly stable trend in relative abundance from 2001 to 2005 with only a brief decrease in abundance in 2002, which may be attributed to a large storm (associated with a hurricane offshore) that passed through the Bay that year. This stable trend was followed by a decreasing trend from 2005 to 2008, followed by an increase in relative abundance in 2009 and a subsequent decrease and then increase in the trend. Overall this trend shows high annual variability.

NMFS Northeast Longline (SEDAR21-DW-28) S7 NMFS NE

This document detailed sandbar and dusky shark catch from the Northeast Fisheries Science Center (NEFSC) coastal shark bottom longline survey, conducted by the Apex Predators Program, Narragansett Laboratory, Narragansett, RI from 1996-2015. Data from this survey were used to look at the trends in relative abundance of sandbar and dusky sharks in the waters off the east coast of the United States. Catch per unit effort (CPUE) by set in number of sharks/(hooks*soak time) were examined for each year of the bottom longline survey, 1996, 1998, 2001, 2004, 2007, 2009, 2012, and 2015. The CPUE was standardized using a two-step delta lognormal approach originally proposed by Lo *et al.* (1992) that models the proportion of positive catch with a binomial error distribution separately from the positive catch, which was modeled using a lognormal distribution. Sandbar sharks showed a declining trend from 1998 to 2004 followed by an increase in relative abundance through 2015. Sandbar sharks showed an increasing trend in relative abundance post 2004, particularly in 2007-2015.

Southeast Pelagic Longline Observer Program (SEDAR21-DW-08) S8 PLLOP

Updated indices of abundance were developed for sandbar sharks (*Carcharhinus plumbeus*) from the US pelagic longline observer program (1992-2015). Indices were calculated using a two-step delta-lognormal approach that treats the proportion of positive sets and the CPUE of positive catches separately. Standardized indices with 95% confidence intervals are reported. The trends from the observer index decreased from 1992 to 2003, after which it showed an upward trend. Fishing regulations such as time-area closures or bait restrictions were taken into account in the index standardization.

SC COASTSPAN / SCDNR Red drum Longline (SEDAR21-DW-30) S9 COASTSPAN SE LL and *S10 SCDNR Red Drum*

This document detailed shark catches from the South Carolina Department of Natural Resources (SCDNR), Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) survey and the SCDNR adult red drum survey, both conducted in South Carolina's estuarine and nearshore waters from 1998-2009. Catch per unit effort (CPUE) in number of sharks per hook hour were used to examine sandbar shark relative abundance for all SCDNR time series. The SCDNR red drum time series had to be analyzed in two separate time segments (1998-2006 and 2007-2009) due to a change in gear and sampling design. The CPUE for all time series was standardized using a two-step delta-lognormal approach originally proposed by Lo *et al.* (1992) that models the proportion of positive catch with a binomial error distribution separately from the positive catch, which is modeled using a lognormal distribution. Sandbar sharks from the SCDNR COASTSPAN survey showed a fairly stable trend in relative abundance from 1998 to 2003, followed by a slight increasing trend during the mid-2000s. Sandbar sharks from the 1998-2006 SCDNR red drum survey showed a drop in abundance from 1999 to 2000 followed by a more stable trend in the 2000s. Sandbar sharks from the 2007-2009 SCDNR red drum survey also showed a relatively stable trend during the three year time frame this survey has been in existence.

SEAMAP LL ATL survey (SC/GA combined, with recent red drum series for SC)
S11_SEAMAP_LL_SE

For the SEAMAP LL ATL survey only fish 80 cm FL and greater were included in the time series. The CPUE = sandbar catch (80 cm FL +) per 100 hook hours standardized using a delta-lognormal model with stepwise forward incorporation of the following factors: year (2007-2015), month (May-September), area (Winyah Bay, Charlestown Harbor, St Helena Sound, Port Royal Sound, southern Georgia, northern Florida), salinity (<25, 25-29, 30-34, 35+ ppt), temperature (<20, 20-25, 25+ degC), depth (<10 m, 10+ m), and set (sequential set number in a given day of sampling). Analyses were conducted using SAS. Final models were ppos= year + area + month + salinity and log pos cpue = year + area. A declining trend is seen until 2012 and then the trend is positive for the remainder of the time series.

2.3 TABLES

Table 2.1 Age specific life history inputs to the model: natural mortality at age (M), and proportion mature at age. All these quantities are treated as constants in the SEDAR 54 assessment.

Age	Natural mortality (M)	Proportion mature
0	0.1604	0.00
1	0.1604	0.00
2	0.1604	0.00
3	0.1604	0.00
4	0.1604	0.00
5	0.1604	0.00
6	0.1578	0.01
7	0.1168	0.02
8	0.1168	0.03
9	0.1168	0.06
10	0.1168	0.12
11	0.1168	0.21
12	0.1168	0.33
13	0.1168	0.49
14	0.1168	0.65
15	0.1168	0.78
16	0.1168	0.88
17	0.1168	0.93
18	0.1168	0.96
19	0.1168	0.98
20	0.1168	0.99
21	0.1168	0.99
22	0.1168	1.00
23	0.1168	1.00
24	0.1168	1.00
25	0.1168	1.00
26	0.1168	1.00
27	0.1168	1.00
28	0.1168	1.00
29	0.1168	1.00
30	0.1168	1.00
31	0.1168	1.00

Table 2.2 Life history inputs to the model. All these quantities are treated as constants in the SEDAR 54 assessment.

Quantity	VALUE
Sex ratio:	1:1
Reproductive frequency:	2.5 yr
Pupping month:	June
Length vs litter size relation:	pups = 0.0324*FL + 4.2447
L_{inf}	183.3 cm FL (F), 175.5cm (M)
k	0.124(F), 0.143(M)
t_0	-3.098(F), -2.388(M)
Weight vs Fork length relation:	$W=0.000010885L^{3.0124}$
SR function	Beverton Holt
SR steepness	0.3

Table 2.3 Catch statistics for use in the SEDAR 54 assessment SS3 model. Catch for F1, F2 and F3 is in metric tons (mt) and catch for F4 is in 1000s of animals. See Table 2.4 for definition of F1, F2, F3, and F4.

Year	F1 Commercial GOM (MT)	F2 Commercial South Atlantic (MT)	F3 Recreational and Mexican (MT)	F4 Menhaden Discards (1000's)
1960	0.8	0.3	0.0	0.5
1961	1.5	0.7	0.0	0.5
1962	2.3	1.0	0.0	0.5
1963	3.1	1.3	0.0	0.5
1964	3.9	1.7	0.1	0.5
1965	4.6	2.0	0.1	0.5
1966	5.4	2.3	0.1	0.5
1967	6.2	2.6	0.1	0.5
1968	7.0	3.0	0.1	0.5
1969	7.7	3.3	0.1	0.5
1970	8.5	3.6	0.1	0.5
1971	9.3	4.0	0.1	0.5
1972	10.1	4.3	0.1	0.5
1973	10.8	4.6	0.1	0.5
1974	11.6	5.0	0.2	0.5
1975	12.4	5.3	0.2	0.5
1976	17.6	7.5	0.8	0.5
1977	24.9	10.7	3.4	0.5
1978	35.4	15.1	15.3	0.5
1979	50.2	21.5	68.7	0.5
1980	71.2	30.5	308.1	0.5
1981	101.1	43.2	1380.6	0.7
1982	101.1	43.2	1078.8	0.7
1983	109.2	46.7	1861.8	0.7
1984	149.1	63.8	1203.4	0.7
1985	138.5	59.3	972.1	0.6
1986	411.3	150.5	1281.2	0.6
1987	1177.4	431.8	719.6	0.7
1988	1701.6	1009.8	1090.8	0.6
1989	2280.2	1215.1	769.5	0.7
1990	1902.5	760.7	1052.7	0.7
1991	1933.7	169.3	843.0	0.5
1992	1511.5	676.6	880.0	0.4
1993	983.2	582.5	806.1	0.5
1994	2021.8	936.1	747.5	0.5
1995	1103.4	795.7	866.9	0.5
1996	619.5	644.5	1051.0	0.4
1997	413.7	395.8	790.7	0.5
1998	485.1	456.9	716.4	0.4

1999	370.3	720.8	703.5	0.5
2000	436.0	533.7	282.3	0.4
2001	606.4	509.5	327.3	0.4
2002	738.6	771.2	202.9	0.4
2003	606.7	552.9	176.5	0.4
2004	448.2	501.4	172.2	0.4
2005	398.2	543.8	167.4	0.4
2006	571.6	518.0	175.0	0.4
2007	169.8	303.5	182.0	0.4
2008	20.7	46.1	130.1	0.4
2009	84.4	40.0	116.2	0.4
2010	56.0	26.5	127.9	0.4
2011	70.8	33.5	79.5	0.4
2012	35.0	16.6	101.2	0.3
2013	26.4	26.9	99.6	0.3
2014	24.0	51.9	90.1	0.3
2015	33.6	71.0	91.6	0.3

Table 2.4. Names and time frame of the fishery and CPUE series used in the SEDAR 54 assessment.

Number	Type	Name	Short Name	Time Period
1	Fishery	Commercial Gulf of Mexico Longline	F1_COM_GOM	1960-2015
2	Fishery	Commercial South Atlantic Longline	F2_COM_SA	1960-2015
3	Fishery	Recreational and Mexican catches	F3_RecMEX	1960-2015
4	Fishery	Menhaden Discards	F4_MEN_DSC	1960-2015
5	CPUE	Large Pelagic Survey	S1_LPS	1986-2015
6	CPUE	Bottom Longline Observer Program 1	S2_BLLOP_1	1994-2007
7	CPUE	Bottom Longline Observer Program 2	S3_BLLOP_2	2008-2015
8	CPUE	Virginia Longline Survey	S4_VA_LL	1975, 1977, 1980,1981, 1990-1993, 1995-2015
9	CPUE	NMFS Southeast Bottom Longline	S5_NMFS_LLSE	1995-1997, 1999-2015
10	CPUE	Coastspan NE LL Survey	S6_CST_NE_LL	2001-2015
11	CPUE	NMFS Longline Northeast Survey	S7_NMFS_NE	1996, 1998, 2001, 2004,2007, 2009, 2012, 2015
12	CPUE	Pelagic longline observer program	S8_PLLOP	1992-2015
13	CPUE	Coastspan SE LL Survey	S9_COASTSPAN_SE_LL	2000-2015
14	CPUE	South Carolina DNR red drum observer program	S10_SCDNR_RedDr	1998-2006
15	CPUE	SEAMAP Longline SE Survey	S11_SEAMAP_LL_SE	2007-2015

Table 2.5 Indices of abundance used in the SEDAR 54 assessment.

YEAR	S1 LPS	S2 BLLOP 1	S3 BLLOP 2	S4 VA_LL	S5 NMFS LLSE	S6 CST NELL	S7 NMFS NE	S8 PLLOP	S9 COASTSPAN SE LL	S10 SCDNR RedDr	S11 SEAMAP LL SE
1960											
1961											
1962											
1963											
1964											
1965											
1966											
1967											
1968											
1969											
1970											
1971											
1972											
1973											
1974											
1975				2.362							
1976											
1977				1.629							
1978											
1979											
1980				2.106							
1981				2.406							
1982											
1983											
1984											
1985											
1986	1.183										
1987	0.363										
1988	1.184										
1989	1.352										
1990	0.471			0.299							

1991	0.762			0.408							
1992	0.584			0.149				0.593			
1993	0.261			0.755				0.483			
1994	0.175	223.74						0.192			
1995	0.138	188.64		0.606	0.215			0.304			
1996	0.164	178.42		0.626	0.110		0.0005	0.071			
1997	0.198	284.33		0.619	0.199			0.281			
1998	0.051	298.58		0.935			0.0032	0.113		0.140	
1999	0.081	168.69		0.854	0.090			0.300		0.595	
2000	0.085	103.26		0.767	0.137			0.112	0.308	0.058	
2001	0.370	360.60		0.883	0.205	3.529	0.0016	0.085	0.683	0.350	
2002	0.145	189.97		0.422	0.151	1.232		0.007	1.269	0.231	
2003	0.066	308.88		0.425	0.170	3.414		0.006	2.027	0.154	
2004	0.030	223.06		0.519	0.131	3.312	0.0015	0.110	5.876	0.338	
2005	0.156	226.42		0.298	0.049	3.524		0.032	4.275	0.155	
2006	0.046	299.50		0.795	0.083	1.815		0.161	5.078	0.279	
2007	0.104	388.02		0.251	0.214	1.864	0.0075	0.094	4.656		1.681
2008	0.135		536	0.834	0.162	0.581		0.109	4.894		1.205
2009	0.201		1371	1.188	0.409	4.620	0.0121	0.138	2.512		0.862
2010	0.106		1158	1.110	0.478	2.084		0.075	2.522		0.740
2011	0.086		729	0.624	0.371	3.351		0.097	2.864		0.346
2012	0.070		1381	1.146	0.636	0.862	0.0165	0.081	2.542		0.289
2013	0.275		910	0.959	0.443	2.400		0.128	3.015		0.301
2014	0.461		936	0.749	0.480	5.697		0.079	3.604		0.417
2015	0.232		1584	0.469	0.704	3.485	0.0270	0.126	1.177		0.589

Table 2.6 Estimated CVs for the indices of abundance used in the SEDAR 54 assessment.

YEAR	S1 LPS	S2 BLLOP 1	S3 BLLOP 2	S4 VA_LL	S5 NMFS LLSE	S6 CST NELL	S7 NMFS NE	S8 PLLOP	S9 COASTSPAN SE LL	S10 SCDNR RedDr	S11 SEAMAP LL SE
1960	-	-	-	-	-	-	-	-	-	-	-
1961	-	-	-	-	-	-	-	-	-	-	-
1962	-	-	-	-	-	-	-	-	-	-	-
1963	-	-	-	-	-	-	-	-	-	-	-
1964	-	-	-	-	-	-	-	-	-	-	-
1965	-	-	-	-	-	-	-	-	-	-	-
1966	-	-	-	-	-	-	-	-	-	-	-
1967	-	-	-	-	-	-	-	-	-	-	-
1968	-	-	-	-	-	-	-	-	-	-	-
1969	-	-	-	-	-	-	-	-	-	-	-
1970	-	-	-	-	-	-	-	-	-	-	-
1971	-	-	-	-	-	-	-	-	-	-	-
1972	-	-	-	-	-	-	-	-	-	-	-
1973	-	-	-	-	-	-	-	-	-	-	-
1974	-	-	-	-	-	-	-	-	-	-	-
1975	-	-	-	0.382	-	-	-	-	-	-	-
1976	-	-	-	-	-	-	-	-	-	-	-
1977	-	-	-	0.586	-	-	-	-	-	-	-
1978	-	-	-	-	-	-	-	-	-	-	-
1979	-	-	-	-	-	-	-	-	-	-	-
1980	-	-	-	0.239	-	-	-	-	-	-	-
1981	-	-	-	0.230	-	-	-	-	-	-	-
1982	-	-	-	-	-	-	-	-	-	-	-
1983	-	-	-	-	-	-	-	-	-	-	-
1984	-	-	-	-	-	-	-	-	-	-	-
1985	-	-	-	-	-	-	-	-	-	-	-
1986	0.155	-	-	-	-	-	-	-	-	-	-
1987	0.218	-	-	-	-	-	-	-	-	-	-
1988	0.199	-	-	-	-	-	-	-	-	-	-
1989	0.133	-	-	-	-	-	-	-	-	-	-

1990	0.184	-	-	0.404	-	-	-	-	-	-	-
1991	0.180	-	-	0.449	-	-	-	-	-	-	-
1992	0.193	-	-	0.570	-	-	-	0.403	-	-	-
1993	0.564	-	-	0.414	-	-	-	0.287	-	-	-
1994	0.485	0.31	-	1	-	-	-	0.379	-	-	-
1995	0.579	0.33	-	0.302	0.248	-	-	0.362	-	-	-
1996	0.591	0.31	-	0.328	0.379	-	0.3531	0.978	-	-	-
1997	0.483	0.33	-	0.311	0.237	-	1.0000	0.435	-	-	-
1998	1.001	0.35	-	0.305	-	-	0.2759	0.783	0.6990429	0.464	-
1999	0.841	0.49	-	0.404	0.362	-	1.0000	0.498	0.6398977	0.353	-
2000	0.870	0.52	-	0.302	0.261	-	1.0000	0.535	0.627	0.549	-
2001	0.650	0.39	-	0.299	0.207	0.229	0.2720	0.595	0.586	0.468	-
2002	0.778	0.33	-	0.411	0.179	0.414	1.0000	2.480	0.561	0.402	-
2003	0.592	0.29	-	0.416	0.209	0.249	1.0000	2.488	0.345	0.365	-
2004	0.666	0.33	-	0.357	0.220	0.272	0.3262	0.442	0.207	0.293	-
2005	0.467	0.35	-	0.410	0.516	0.256	1.0000	0.642	0.218	0.423	-
2006	0.788	0.33	-	0.276	0.331	0.309	1.0000	0.552	0.175	0.261	-
2007	0.443	0.37	-	0.452	0.303	0.288	0.3341	0.489	0.200	1.000	0.233
2008	0.447	-	0.21	0.290	0.275	0.493	1.0000	0.360	0.202	1.000	0.147
2009	0.388	-	0.14	0.355	0.160	0.188	0.1865	0.385	0.247	1.000	0.219
2010	0.401	-	0.13	0.308	0.167	0.331	1.0000	0.493	0.191	1.000	0.214
2011	0.509	-	0.13	0.516	0.141	0.304	1.0000	0.439	0.182	1.000	0.304
2012	0.690	-	0.18	0.256	0.139	0.415	0.2258	0.394	0.172	1.000	0.285
2013	0.343	-	0.17	0.312	0.167	0.305	1.0000	0.35	0.269	1.000	0.270
2014	0.340	-	0.17	0.262	0.185	0.193	1.0000	0.488	0.197	1.000	0.226
2015	0.360	-	0.14	0.319	0.133	0.250	0.1809	0.401	0.226	1.000	0.222

2.4 FIGURES

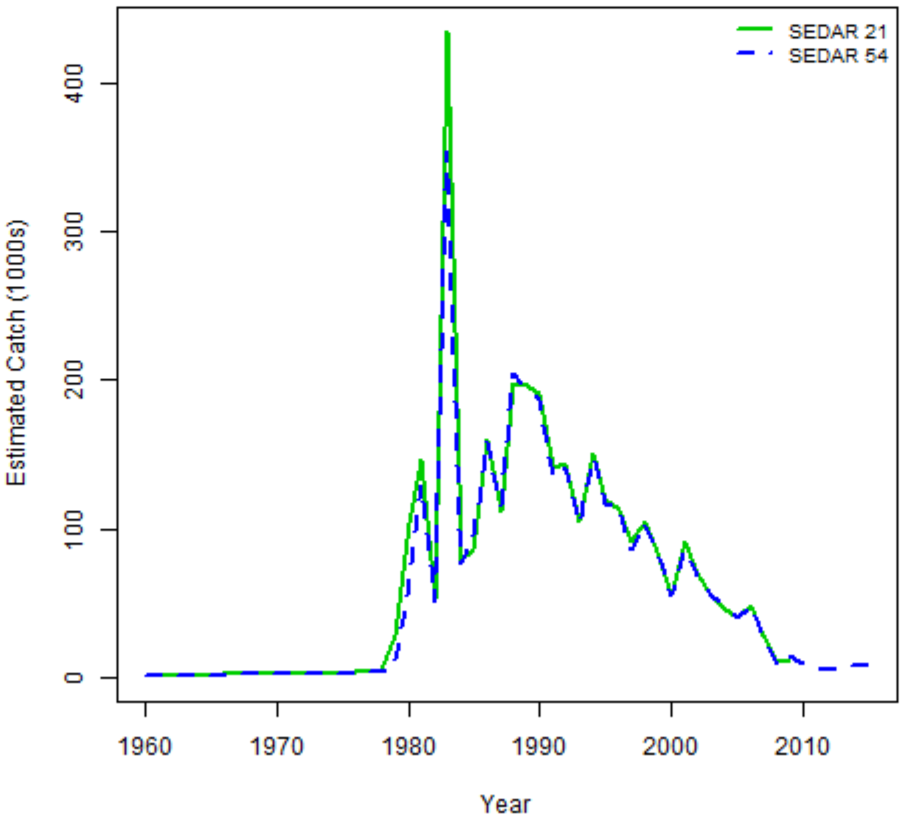


Figure 2.1 Catches of sandbar sharks (numbers) used in the SEDAR 21 (green line) and SEDAR 54 (blue line) assessments.

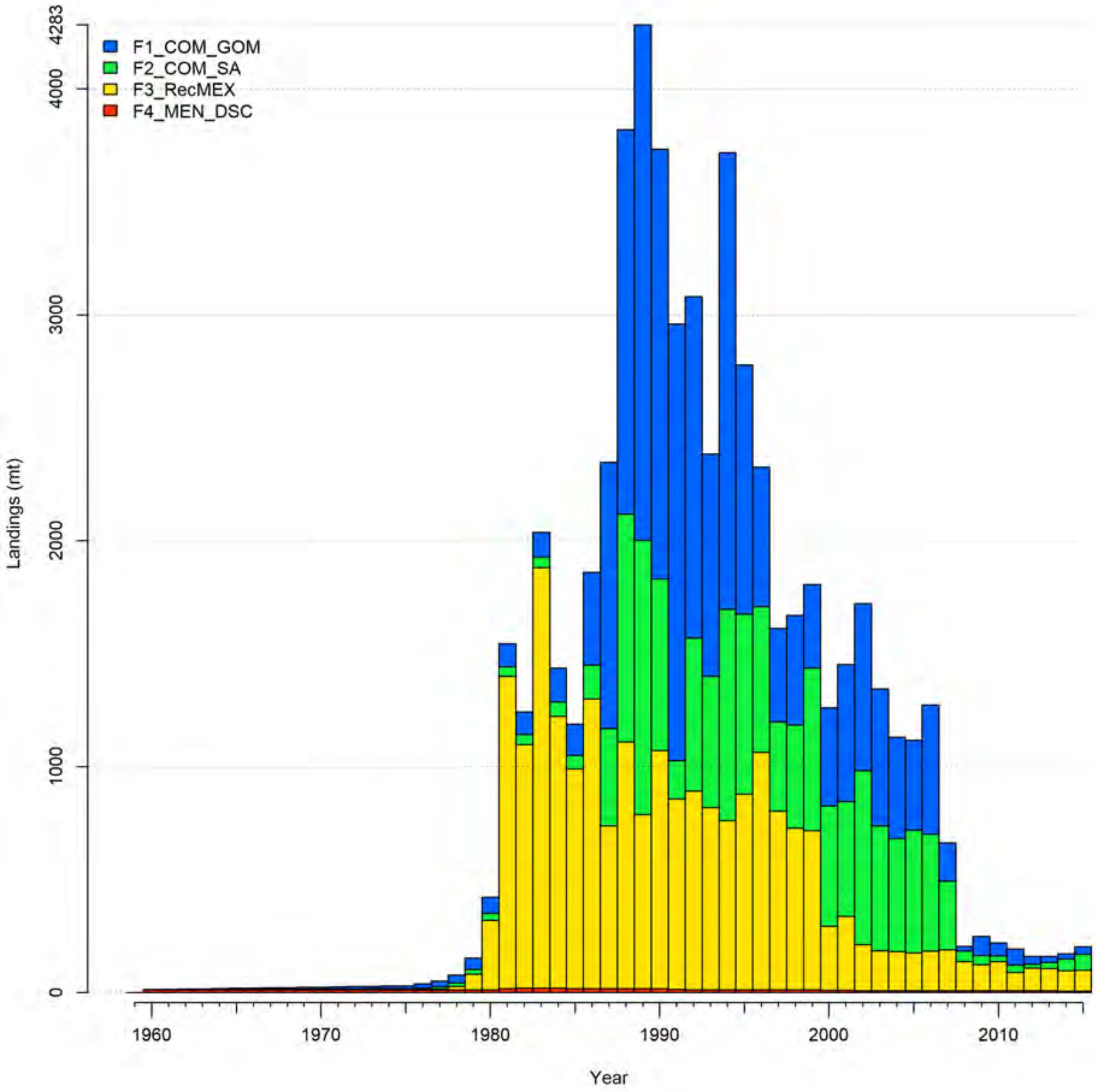


Figure 2.2. Catch of sandbar shark by fleet in metric tons (mt) used in the SEDAR 54 analysis.

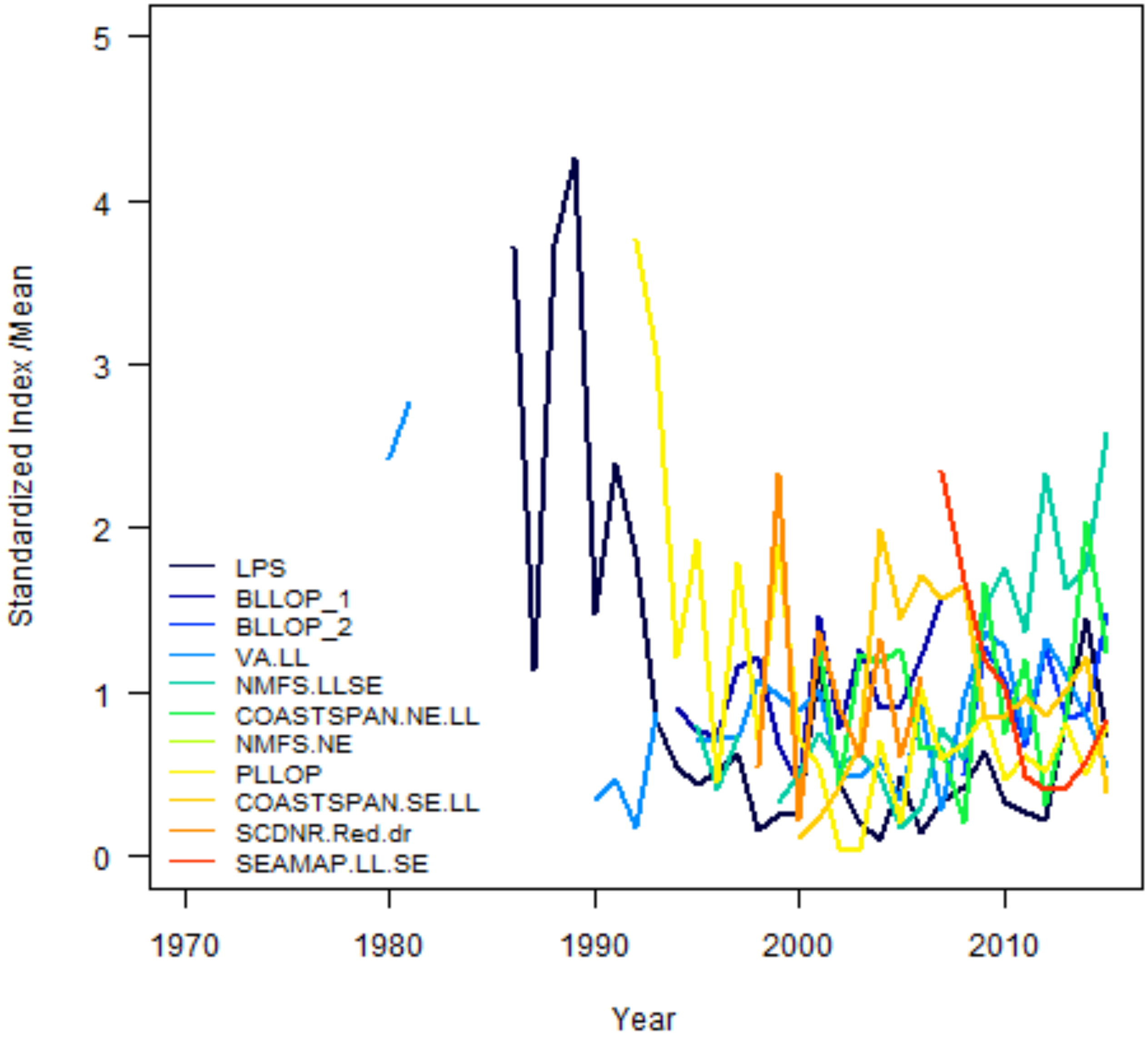


Figure 2.3 Indices of relative abundance used for the SEDAR 54 assessment.

3 STOCK ASSESMENT MODEL AND RESULTS

The analytical approach used for this assessment was a length-based age-structured statistical model (Stock Synthesis; Methot and Wetzel 2013; Wetzel and Punt 2011a, 2011b). The stock assessment methods and results were formatted following those in recent SEDAR assessments implemented with Stock Synthesis (e.g., SEDAR 39 Atlantic smooth dogfish).

3.1 REPLICATION ANALYSIS

The analysis conducted for SEDAR 21 used a state-space age structured production model (SSASPM, Porch 2003, ICCAT 2005). The initial model for SEDAR 54 (this analysis) parameterized SS3 to recreate as closely as possible the assessment results from SEDAR 21 prior to undertaking an updated assessment using SS3. SS3 can be used to create an age structured production model (ASPM) by fixing (not estimating) the selectivity at length or age and eliminating the model’s functionality to fit deviations in the stock recruitment relationship.

3.1.1. Replication Analysis Model Configuration

As with the previous assessment this analysis assumes one unified stock (Figure 3.1.1, Atlantic and Gulf of Mexico), and covers the temporal framework from 1960 to 2009, with the stock status in 1960 assumed to be close to virgin stock size. The data included in this analysis consisted of catch (Table 3.1.1) and indices of abundance (Table 3.1.2; Figure 3.1.1).

Parameterization of the model included parameters for fecundity, proportion mature and natural mortality at age (M) (Table 3.1.3 and 3.1.4). The growth curve, length-weight relationship, and other biological parameters were kept the same, with the exception that the growth parameters were entered as sex-specific parameters (Table 3.1.4) and the relationship between pup production and maternal age was expressed as a function of length, as recommended in working paper (SEDAR21-DW-26 2011). These differences are shown in bold face in Table 3.1.4.

Selectivities for the fishery and index of abundance data in the previous analysis were a mix of logistic and double logistic models (Table 3.1.5). This analysis used the same logistic selectivities but reparametrized the double logistic models as double normal as this is the preferred alternative in SS3 (Table 3.1.5). The differences in the selectivity functional form of the previous analysis (SEDAR 21) and this analysis are presented in Table 3.1.5 and Figures 3.1.2 and 3.1.3.

3.1.2 Replication Analysis Results

The list of derived parameters in the SS model is presented in Table 3.1.6 along with values from the base case run from SEDAR 21. Note that there exist differences in relevant metrics as this analysis is conducted in biomass and the SEDAR 21 analysis was conducted in numbers; similar outputs have been shaded in grey. The replication analysis model was able to capture the general trend for indices in all surveys, and overall biomass trends and stock status conclusions are the same (Figure 3.1.4., Table 3.1.6). The results in Table 3.1.6 and Figures 3.1.4 and 3.1.5 show the management quantities, total biomass trends and ratio of the estimated biomass trends (SEDAR21/SEDAR 54). This analysis includes the majority of the assumptions in the previous analysis, to the extent that the modeling frameworks allowed. The SEDAR 21 analysis down weighted the historical catch and the 1983 recreational catch; the replication analysis did not, and instead fit the catch exactly.

As noted above, the replication analysis was conducted in biomass as opposed to the SEDAR 21 analysis which was conducted in numbers, and as such not all of the management quantities are comparable. The replication analysis estimated that F_{2009}/F_{MSY} was 0.51, indicating that the stock was not experiencing overfishing, while the SEDAR 21 assessment resulted in a similar estimate of 0.62, also indicating that the stock was not experiencing overfishing. The SSF_{2009}/SSF_{MSY} from this study was 0.70, whereas the SEDAR 21 analysis reported SSF_{2009}/SSF_{MSY} of 0.66. As in the previous SEDAR 21 assessment, spawning output in the stock-recruitment relationship was modelled as spawning stock fecundity (SSF), and calculated here as the sum of female numbers at age (in 1,000s) multiplied by annual female pup production at age (male and female pups, assuming a 1:1 ratio of male to female pups) at the beginning of each calendar year. For the purposes of this assessment, SSF and Spawning Stock Biomass (SSB) are referred to interchangeably in some figures and tables. They both show that the stock was overfished. Figures 3.1.6 and 3.1.7 show a relatively good fit (compared to SEDAR 21) of the model to all of the indices.

3.1.1 Continuity analysis

Stepwise progression of updating the model to the current case proceeded by updating the catch data, the indices of abundance and certain biological parameters. These continuity runs precede the finer scale model fitting that leads to the base case analysis, and are presented here in aggregate. Details of the continuity runs presented are listed in Table 3.1.7 and shown in Figure 3.1.8. Briefly, the first run was to update the catch to the new estimated catch series, then to extend the catch series up to 2015 (Update Catch Run, Continuity Run #1, respectively); these two runs estimate the same total biomass for the years 1960-2009. The next continuity run (Continuity Run #2) was to update the longevity from 27 to 31 years, and Continuity Run #3 included updates to the life history data according to the values in Table 2.2). The stepwise continuity analysis showed similar trends across the individual runs. The final step to updating the model included the addition of length composition and the new indices of abundance (Figure 2.3). The base case model fit to all the data is presented in the next section (3.2); changes to the CPUE series with respect to SEDAR 21 are shown in Figure 3.1.9 through Figure 3.1.11.

3.2 BASE CASE MODEL AND SENSITIVITY ANALYSES METHODS AND RESULTS

3.2.1 Overview

The assessment model was implemented in Stock Synthesis version 3.24f (SS3 Methot 2013). A newer version of the model is available (version 3.3) but due to time constraints and the overall similarity of the model versions for the features implemented in this assessment, the SS3 model was not updated to version 3.3. SS3 (v. 3.24f) was implemented here as a length-based age-structured stock assessment model (Methot and Wetzel 2013; e.g., Wetzel and Punt 2011a, 2011b). SS3 utilizes an integrated modeling approach (Maunder and Punt 2013) to take advantage of the many data sources available for the stock of sandbar shark (*Carcharhinus plumbeus*). An advantage of the integrated modeling approach is that the development of statistical methods that combine several sources of information into a single analysis allows for consistency in assumptions and permits the uncertainty associated with each data source to be propagated to final model outputs (Maunder and Punt 2013).

3.2.2 Data Sources

The catches, indices of abundance, length compositions, and biological inputs used in the SEDAR 54 stock synthesis assessment are described next.

Catches

For the purposes of this assessment the fisheries catching sandbar sharks in the Atlantic and Gulf of Mexico were separated into four fleets, F1-F4 (Table 3.2.1) as in SEDAR 21. A full description of the derivation of these estimates is given in the SEDAR 21 DW Report and SEDAR21-DW-09. Total catch (landed catch, bycatch and dead discards) by year and fishery are explained in section 2.2.2 and shown in Table 2.3 and Figure 2.2; it is assumed that prior to the start of the catch time series the stock was experiencing minimal, if any bycatch and hence was at or near virgin biomass. Further information on the catch estimates can be found in section 2.

Relative Abundance Indices

These data are described in section 2.2.3, shown in Figures 3.1.9 -3.1.11, and their spatial extent is shown in Figures 2.3 and 3.2.1. The indices of abundance were used in the model as shown in Table 3.2.1. The CVs for these indices were re-scaled according to the Francis (2011) approach, which fits a smooth line to the CPUE series, then estimates the CV that would be necessary to fit the data points at least as well as an independently fit smooth line, and then rescales the input CVs so that the mean of the input CVs is equal to the estimated CV.

Timeframe, Biological Inputs and Assumptions

The model was iterated from 1960-2015 using an annual time-step. The life history inputs used in the assessment are presented in Tables 2.1 and 2.2. These include age and growth, as well as several parameters associated with reproduction, including sex ratio, reproductive frequency, fecundity, maturity at age, and month of pupping, and natural mortality. Stock synthesis uses these life history characteristics as constants (inputs), which are reported for the base case in the Appendix 1 Control File. The maturity and mortality schedules for the base case of this assessment are reported in Table 2.1. Changes from the previous assessment (SEDAR 21) include steepness set to 0.3 (0.29 previously), new natural mortality schedules, and growth parameters. As in the previous SEDAR 21 assessment, spawning output in the stock-recruitment relationship was modelled as spawning stock fecundity (SSF), and calculated here as the sum of female numbers at age (in 1,000s) multiplied by annual female pup production at age (male and female pups, assuming a 1:1 ratio of male to female pups) at the beginning of each calendar year.

Size Composition Data

Length-frequency information from animals caught in scientific observer programs, recreational fishery surveys, and various fishery-independent surveys was available for this analysis (Figure 3.2.2). Length-composition data collected by observers were available for the commercial fisheries (F1 and F2), length data for F3 (recreational and Mexican fisheries) were available from the MRFSS/MRIP, Headboat, and Texas Parks and Wildlife Department surveys and no length data was available for F4 (bycatch in the menhaden fishery). Most of the CPUE series, with the exception of the BLLOP, PLLOP, and LPS series, were based on fishery independent surveys and some length data was available for all of the surveys. In general, the length data exhibits high interannual variability, and is limited for all of the survey CPUE series. An annual effective sample size equal to the number of sets was assumed for each group of length composition. The annual sample size was then weighted by the Francis (2011) likelihood weighting method. The number of samples, number of sets, and weights given to each of the length composition data series is in Table 3.2.2.

3.2.3 Software

The analysis was undertaken with Stock synthesis SS V3.234F, 64 bit version (Methot 2000, 2009, executable available from http://nft.nefsc.noaa.gov/SS3.html), running on Microsoft Windows 10. Typical function minimization of the full model (without running additional MCMC analysis) on a 3.0 GHz personal computer required about 10 minutes. Additional simplifications and aggregations could probably reduce the minimization time further, without significant loss to the stock status inferences.

3.2.4 General Assessment Approach

This was a standard assessment and as such used the ‘base case’ model configuration from the previous assessment, which included all CPUE series. Note that the overall suite of indices of abundance changed from the previous assessment, though the Assessment Panel agreed to use all submitted indices of abundance for the base case model run. Sensitivities to the base case model were carried out by dropping one of two groups of CPUE series and their associated length composition data from the analysis. The grouping of the CPUE series was chosen in part by using a hierarchical cluster analysis to identify separate groupings of similar indices of abundance (SEDAR54_TEMP1). Hierarchical cluster analysis identified two groupings of time-series. The first group was characterized by time-series which were highly correlated with each other and which had some highly negative correlations with time-series not included in the group. The second group was characterized by time-series which were less highly correlated with each other or were slightly negatively correlated with each other. Because CPUEs with conflicting information were identified, it may be reasonable to assume that the indices reflect alternative hypotheses about states of nature and to run scenarios for single or sets of indices identified that represent a common hypothesis as alternative sates of nature. Cross-correlations identified strong autocorrelation in some CPUE indices over 2 to 3 years, which could indicate a year-class effect. Cross-correlations also identified strong cross correlation of lagged values of some CPUE indices (at lags between 2 to 10 years) with the current values of other CPUE indices, which could indicate that some CPUE indices represent younger age-classes than others. However, the specific lagged relationships with high correlation were not consistent among the series. Further information can be found in section 3.2.7 and SEDAR54_TEMP1.

Model Assumptions

The most important model assumptions are described in the following sections. Standard population dynamics and statistical terms are described verbally, while equations can be found in Methot (2000, 2010). Attachment 1 contains all the template specification files for the base case model, with the exception of the data file which is voluminous and provided separately. The template file includes additional information on secondary elements of model formulation which may be omitted in the description below.

Growth

The standard assumptions made concerning age and growth in the Stock Synthesis model are (i) the lengths-at-age are assumed to be normally distributed for each age-class; (ii) the mean lengths-at-age are assumed to follow a von Bertalanffy growth curve. For any specific model, it is necessary to assume the number of significant age-classes in the exploited population, with the last age-class being defined as a “plus group”, i.e. all fish of the designated age and older. For the results presented here, 31 yearly age-classes have been assumed, as age 31 approximates the age at the theoretical maximum length of an average fish.

Population and Fishery Dynamics

The model partitions the population into 31 yearly age-classes in one region (Figure 3.2.1). The last age-class comprises a “plus group” in which mortality and other characteristics are assumed to be constant. The population is “monitored” in the model at yearly time steps, extending through a time window of 1960-2015. The main population dynamics processes are as follows: In this model “recruitment” is the appearance of age-class 0 fish (i.e. fish averaging approximately 45 cm fork length (FL) in the population). The results presented in this report were derived using one recruitment episode per year, which is assumed to occur at the start of each year. Annual recruitment deviates from the recruitment relationship were estimated, but constrained to reflect the limited scope for compensation given the estimates of fecundity. Deviations from the stock recruitment relationship (SRR) were estimated in two parts; first, the early recruitment deviates for the 10 years prior to the model period that contains the bulk of the length composition information (1970-1980) and second, the main recruitment deviates that covered the model period (1981 - 2015).

Initial Population State

In the previous model it was assumed that the sandbar shark population was at an unfished state of equilibrium at the start of the model (1960). The same assumption is made for SEDAR 54 based on the historical nature of the longline fishery in the Gulf of Mexico and western Atlantic. The population age structure and overall size in the first year is determined as a function of the estimate of the first year recruitment (R1) and the initial equilibrium catch (set to 0.1 mt from the F4 Menhaden Fishery).

Selectivity Curves

Selectivity is fishery and index specific and was assumed to be time-invariant. A double normal functional form was assumed for the fishery selectivity curves F1 and F3, and logistic with asymptotic selectivity used for F2 and F4. Initially the model was fit with a double normal selectivity for F2; however, this was changed to include an asymptotic selectivity function to avoid situations where a cryptic biomass of large fish is estimated in the model. Selectivities for the CPUE series were all double normal with the exception of S9, which was fit with a cubic spline (Table 3.2.1). An offset on the peak and scale was estimated for sex-specific differences in selectivity where data was available by sex. The selectivity function was fixed at 100% for fishery F4 (menhaden discards) under the assumption that all fish encountered were caught (as done in SEDAR 21). The selectivity was fixed (not estimated) for the CPUE series S2 and S3 as these CPUE series share the length compositions with the fisheries F1 and F2, so as to not use the same data in the estimation phase more than once.

Parameter Estimation and Uncertainty

Model parameters were estimated by maximizing the log-likelihoods of the data plus the log of the probability density functions of the priors, and the normalized sum of the recruitment deviates estimated in the model. For the catch and the CPUE series we assumed lognormal likelihood functions while a multinomial distribution was assumed for the size data. The maximization was performed by an efficient optimization using exact numerical derivatives with respect to the model parameters (Fournier et al. 2012). Estimation was conducted in a series of phases, the first of which used arbitrary starting values for most parameters. The Hessian matrix computed at the mode of the posterior distribution was used to obtain estimates of the covariance matrix. This was used in combination with the Delta method to compute approximate confidence intervals for parameters of interest. For the base case model and two alternative states of nature (see section 3.2.7) Markov Chain Monte Carlo (MCMC) estimates were calculated for all parameters. MCMC analysis was conducted with one chain, 500,000 iterations thinned every 1000 with a 100 iteration burn in. This MCMC analysis was also used for projections to carry the uncertainty in the parameter estimates forward to the projection period.

Benchmark and Reference Point Methods

Benchmarks included estimates of absolute population levels and fishing mortality for the terminal year, 2015 (F_{2015}, SSF_{2015}, B_{2015}). These values are reported against reference points relative to MSY levels, and depletion estimates (relative to virgin levels). In addition, trajectories for F_{YEAR}/F_{MSY} and SSF_{YEAR}/SSF_{MSY} were plotted and phase plots provided. Stock status, including MSST (Minimum Stock Size Threshold) were also included in the benchmark reporting. Because $M<0.5$, MSST is computed as $(1-M)*SSF_{MSY}$ (Restrepo et al. 1998). The value of M used (0.126) was the arithmetic mean of the age-specific values of M used for the baseline run (Table 2.1).

Other Model Considerations

With the exception of re-weighting the length composition annual sample size by the Francis (2011) likelihood weighting method and estimating the minimum average CV associated with the indices of abundance no data was changed or weighted in this assessment.

Projections

Projections were carried out using the forecast module internal to SS3 via MCMC analysis and as such used the uncertainty associated with the parameter estimates calculated internally to SS3. Recruitment variability was not included in the projections, but given the reproductive biology of this species variability in recruitment is expected to be low. Based on the observation that the influence of the high and low productivity scenarios had minimal effect on stock status in comparison to the CPUE groupings (see section 3.2.7) projections were only carried out for the base case productivity assumptions. Projections were carried out using the forecast module internal to Stock Synthesis using the MLE estimates over a grid of TAC and also via MCMC analysis to incorporate the uncertainty associated with the parameter estimates calculated internally to Stock Synthesis. The forecast routine internal to Stock Synthesis calculates fishing intensity levels that would satisfy fishery management. Much like other integrated stock assessment platforms (e.g. MULTIFAN-CL), stock synthesis is basically a simulation of a stock's age-structured population dynamics. Methot and Wetzel (2013) note that "this enables SS to utilize a selected fishing mortality approach (e.g. harvest policy) to extend into a forecast of the future age-structured stock abundance and yield that would occur while fishing according to that harvest policy (Maunder et al., 2006)". The forecast routine is implemented in Stock Synthesis after the variance estimate phase so that the aspects of parameter uncertainty calculated using the inverse Hessian method in the maximum likelihood estimation are propagated into the variance of the derived quantities (i.e. forecasts of stock abundance under a chosen TAC). The forecast routine is implemented much same way during the MCMC analysis phase so that the equilibrium and forecast results become part of the output for each selected set of parameters. For further technical details see Methot and Wetzel (2013). Projections were carried out using the MLE estimates over a range of values to determine the levels of TAC that would result in the SSF/SSFMSY=1 by the rebuilding year with a given probability (see the TOR) given the stock status (see the next section). The corresponding TAC value associated was then forecast using MCMC. MCMC analysis was not carried out over a range of values because of the prohibitive time constraint of running the MCMC analysis (>2 days).

3.2.5 Base Case Model Results

Model Fits to Abundance Indices

The model appeared to have trouble reconciling the conflicting trends and oscillations of some of the indices of abundance (Figure 3.2.3). As a result, some of the indices were poorly fit, particularly the model did not fit well the increasing trend at the end of the S5_NMFS_LLSE (2010-2015) or the increase in the last three data points of S7 NMFS LLNE, which were from 2009, 2012, and 2015. Other series that had decreasing and then increasing trends (S11 SEAMAP LL SE, S1 LPS) were well fit in the middle period but not the later years. The model fit the later years of the S9 COASTSPAN SE index well with the exception of 2015. The model fit the S3 BLLOP 2 and S4 VA LL time series adequately given the decrease in the beginning and the later increase in the time series. The longest running series (S1 LPS and S4 VA LL) show a decrease from the early and mid- 1980s through the remainder of the time series, which were fit well. Several of the indices (S3 BLLOP 2, S9 Coastspan SE LL SE, S6 NMFS Coastspan age-1+, and S10 SCDNR historic red drum) showed no clear trend and three indices (S5 NMFS LL SE, S7 NMFS NE LL, and S11 SEAMAP LLSE) showed a generally increasing trend. The model interpreted those trends by predicting a stabilization and slight increase of abundance in the most recent years. It is worth noting also that the increasing trend in relative abundance of several of the indices in recent years conflicted with other trends in the indices of abundance. The catch data indicates relatively stable catch in the recent years (approximate average of 190 mt over 2008-2015) which corresponds with management controls and a rebuilding stock. In general, the poor fit to some of the indices is caused in part by high interannual variability that does not seem to be compatible with the life history of the species, suggesting that the statistical standardization of the indices done externally to the model may not have included all factors that help explain relative abundance.

Parameter Estimates and Associated Measures of Uncertainty

A list of estimated model parameters is presented in Table 3.2.3 (main parameters) and Table 3.2.4 (estimated recruitment deviations). The table includes predicted parameter values with their associated standard deviation (Parm_StDevs based on the asymptotic standard errors from the Hessian at the converged solution), initial parameter values, minimum and maximum allowed values, and prior density functions assigned to parameters where applicable. Parameters designated as constant were estimated as such; parameters that were held fixed (not estimated) are not included in this table.

Annual Abundance at Age

Predicted annual stock abundance at age is presented in Figure 3.2.4. The first seven age classes made up the majority of the population (>50%) in any given year and mean age by year varied very little.

Annual Estimates of Total Biomass, Spawning Output and Recruitment

Annual estimates of total biomass, spawning output and recruits are presented in Table 3.2.5 and Figure 3.2.5. All trajectories show little depletion from 1960 to the early 1980s, corresponding to very low catches, effort and estimated F in the historic period, and a marked decline until 2007, followed by stabilization until 2010 and an increase until the end of the model. Decreasing biomass and abundance over the period between 1983-2009 correspond to increased catches over that period compared with the 1960s and 1970s, and possibly declining trends in the early years of some indices, whereas the stabilization in the last few years of data likely corresponds to reduced catches and increasing CPUE rates for some of the CPUE series in those years.

Model Fits to Length Compositions

The fits to the aggregated length composition data are shown in Figure 3.2.6. In general the length data are characterized by low sample sizes and high inter-annual variability. This figure shows that most fleets fully select for immature animals (length at 50% maturity is 153 cm FL for females, 142 cm FL for males), and that F3 is almost exclusively on animals less than 100 cm, which corresponds to approximately 3.5 years old. The fit to the F1 length composition is quite good, the data associated with this fishery are among the most uniform in the model and are uni-modal. In comparison, the fits to the F2 length composition are poorer, the distribution is wider and the largest ages in the sample are not well fit. With respect to the length composition for the survey data (S1-S11), the majority of the samples had broad distributions with one or more large spikes that made fitting the entire length composition difficult. The fits to the length composition in general capture the appropriate size classes and reflect the observed sex ratio in the length composition data.

Fishing Mortality

Estimated total and fleet-specific instantaneous fishing mortality rates are presented in Table 3.2.6 and Figure 3.2.7. Fishing mortality was very low in 1960-1981 in accordance with very low catches and effort during that period. In the late 1970s fishing mortality increased with the advent of the Recreational and Mexican fishery (F3). Starting in the mid-1980s overall fishing mortality began to increase sharply, with large fluctuations due in part to the changes in the F3 rate and the start of the commercial fisheries. The contribution of the menhaden fishery fleet to total F was insignificant. During 1981 to 2007 the total annual fishing mortality rate was above F_{MSY}, but has been below F_{MSY} from 2008 to the present, with the exception of 2010 (Table 3.2.6 and Figure 3.2.8).

Stock-recruitment Parameters

The predicted virgin recruitment (R0; number of age 0 pups) was 533,000 animals (Table 3.2.5) and the number of estimated pups declined from the mid-1980s through 2009, after which estimated recruitment slowly increased (Figure 3.2.9). The corresponding estimated stock recruitment relationship and annual deviations are also shown in Figure 3.2.9.

3.2.6 Retrospective and MCMC Analyses Conducted for the Base Case

A retrospective analysis was carried out for the base case model by sequentially dropping a year of data from the model, for up to five years, and refitting the model. Results of the retrospective analysis are presented in Figure 3.2.10. Two model output quantities were examined in the analysis: 1) spawning stock depletion (relative to virgin stock size), and 2) estimated virgin biomass on the natural log scale. The depletion trajectories for all retrospective runs are very similar, overlapping the base run, which indicates that the estimated stock status is robust to removing the last year of data for up to five years. The retrospective analysis had a negligible effect on the estimate of R0 on the log scale, which is the global scaling parameter, indicating that the estimates of absolute population scale obtained for the base case model are robust to the sequential deletion of the last 5 years of data.

Stock status uncertainty was evaluated with MCMC analysis for the base case model. Figure 3.2.11 shows the estimated values from SS3 (the maximum likelihood estimate (MLE)) along with the 50th quantile and distribution of the MCMC analysis. The MLE estimates of SSF_{2015}/SSF_{MSY} and F_{2015}/F_{MSY} were 0.599 and 0.750, respectively, while the 50th quantiles of the MCMC analysis differ slightly at 0.634 and 0.7, respectively, for the same quantities, indicating a slight negative bias in SSF_{2015}/SSF_{MSY} and a slight positive bias in F_{2015}/F_{MSY} relative to the median MCMC output. The negative bias in SSF_{2015}/SSF_{MSY} appears to result from a skewed distribution of the MCMC output for that management quantity. The reasons for the positive bias in F_{2015}/F_{MSY} are not obvious.

3.2.7 Model Sensitivity Runs Representing Alternative State of Nature Scenarios

Model uncertainty was evaluated in this assessment with a set of sensitivity runs representing plausible alternative states of nature to the base case model, as recommended in part by the SEDAR 21 CIE reviewers (Table 3.2.7). Three groupings of the CPUE series (base plus two others) and three groupings of productivity assumptions (as recommended by the SEDAR 21 CIE reviewers) were used in a fully interacted grid providing nine individual model runs. The groupings of the CPUE series were determined mostly through a hierarchical cluster analysis (SEDAR54_TEMP1 and Appendix 2) and to a lesser extent by expert opinion. The first group of CPUEs that the hierarchical cluster analysis identified (named “POS_1” CPUE group) was: S3_BLLOP_2, S4_VA_LL, S5_NMFS_LLSE, S7_NMFS_NE, and the CPUE series S2_BLLOP1 was added to this group because the Assessment Panel felt that it helped extend the available time series to the period where the majority of the fishing effort occurred (see Appendix 2). The second sensitivity grouping of CPUE series (named “NEG” CPUE group because they were negatively correlated with the first group) included all the indices that were not included in the first group, which were S1_LPS, S6_CST_NE_LL, S8_PLLOP, S9_COASTSPAN_SE_LL, S10_SCDNR_RedDr, and S11_SEAMAP_LL_SE. In addition to the three CPUE groupings (BASE, POS_1 and NEG) three levels of overall productivity were assumed based on variability reported in the literature for this species. These levels of productivity were: low, medium, and high, with medium being the base case parameterization. Further details are in Table 3.2.7. The effect of changing the productivity from the base case parameterization to the high and low values on the estimates of overall depletion and virgin stock size was fairly minimal (Figure 3.2.12). The result of changing the CPUE series by far outweighed the changes to the productivity assumptions (Figure 3.2.12). Estimates of stock depletion were lower (more depleted) for the NEG grouping of the CPUE series than the base case grouping and higher (less depleted) for the POS_1 grouping than the base case. The uncertainty with respect to initial stock size and overall depletion was highest with the POS CPUE grouping and lowest with the NEG CPUE grouping (Figure 3.2.12).

Reference points for the base case and each sensitivity run representing an alternative state of nature are provided in Table 3.2.8 and Figure 3.2.13. MCMC reference point uncertainty for the base case and sensitivity runs representing two alternative states of nature scenarios evaluated for CPUE (POS_1, NEG) with the base case productivity scenario as defined in the main text are provided in Table 3.2.9 and Figure 3.2.14.

3.2.8 Profile Likelihoods

An investigation of model structure uncertainty was undertaken via the use of profile likelihood on the global scaling parameter (R0) (Lee et al 2014). The negative log likelihood of a specific parameter or data component should, in theory decline to an obvious minimum. In situations where this does not happen, at least from one side, there may be insufficient information within the data to estimate other parameters. Virgin recruitment (R0) is an ideal scaling parameter because it is proportional to the unfished biomass. Profiles were run with the natural log of virgin recruitment, ln(R0), parameter fixed at various values above and below the model estimated value; the corresponding likelihood profile quantified how much loss of fit was contributed by each data source.

Profile likelihoods for the base case and sensitivity runs representing two alternative states of nature scenarios evaluated for CPUE (POS_1, NEG) with the base case productivity scenario as defined in the main text are provided in Figures 3.2.15 – 3.2.23. Two data components were profiled for each alternative model run, the length composition data and CPUE likelihood data. Component-specific likelihoods for the base case are provided in Figures 3.2.15, 3.2.16 and

3.2.17 for the CPUE length composition, the fishery length composition, and the CPUE, respectively. Component-specific likelihoods for the POS_1 CPUE scenario with the base case productivity are provided in Figures 3.2.18, 3.2.19, and 3.2.20. Component-specific likelihoods for the NEG CPUE scenario with the base case productivity are provided in Figures 3.2.21, 3.2.22, and 3.2.23.

Examples of evidence for informative data components are a “U” or “V” shape in the likelihood profile such as is apparent in the profile likelihoods for S4 and S9 CPUE length composition (Figure 3.2.15). Examples of evidence for non-informative data are a flat or highly variable likelihood profile, such as is apparent in the profile likelihoods for S10 and S11 CPUE length composition (Figure 3.2.15).

In general the likelihood profiles showed that the individual data components were not equally informative about the scale of the population. The length composition likelihood profiles for the base case CPUE indices (Figure 3.2.15) showed that the information from S3, S4 and S9 was being overwhelmed by the data from the other surveys. The length composition likelihood profiles for the base case fisheries data (Figure 3.3.16) were internally consistent but did not have a local minimum and supported larger values of ln (R_0) than length likelihood profiles for the base case CPUE indices. The CPUE likelihood pertaining to the base case (Figure 3.2.18) was fairly informative overall but included series that were in conflict with other series in the grouping (i.e. S8 and S11 show a contrasting profile to S6 and S9). These results indicate that R_0 in the base case configuration is mostly informed by S3, and to an extent by S4, for which the length and CPUE components are in agreement, and that the overall likelihood profile of the base case is informative about the scale.

The likelihood profiles based on the POS_1 CPUE grouping (Figures 3.2.18 – 3.2.20) show that the information in the length composition data from S3 and S4 is less influential than the length composition data in S2 and S5 combined with the length composition data in the fishery, because the total likelihood reflects length composition data in S2 and in the fishery more closely than the other CPUE’s profiles. The profile likelihoods for the CPUE data from the model with the POS_1 CPUE grouping are in better agreement with the overall likelihood, but the relatively flat right hand side of the likelihoods indicates that there is not much information about the scale of the population in the CPUE data. The likelihood profiles based on the negatively correlated CPUE groupings (Figures 3.2.21 and 3.2.23) showed that S8 was influential in the length composition as well as in the CPUE data.

3.2.9 Reference Points

Reference points for the proposed base configuration and alternative scenarios are presented in Table 3.2.8. The base case model estimated an overfished stock but that overfishing was no longer occurring (Table 3.2.8; Figures 3.2.13 and 3.2.8). The base model estimated that the stock had been overfished since 1997 (SSF = 660, Table 3.2.5; SSF_{MSY} = 662 Table 3.2.8) but that overfishing no longer occurred as of 2008, with the exception of 2010 where F_{2010}/F_{MSY}=1.015 (Table 3.2.6 and Figures 3.28).

Probabilities obtained through MCMC analysis of the base case indicated that there was a 99 % probability that the stock in 2015 was overfished ($P(SSB_{2015}<SSB_{MSY})=0.99$) and a 97% probability that there was no overfishing in 2015 ($P(F_{2015}<F_{MSY})=0.97$) (Figure 3.2.11).

All sensitivity runs using the base case CPUE selections indicated that the stock was overfished but that over fishing was not occurring; all sensitivity runs from the POS_1 group estimated that the stock was not overfished and that overfishing was not occurring; and all sensitivity runs from the NEG CPUE grouping indicated that the stock was overfished and that overfishing was occurring (Table 3.2.8 and Figure 3.2.13). Similar results were obtained from MCMC analysis for the base case model configuration and for the two alternative states of nature scenarios evaluated for CPUE (POS_1, NEG) with the base case productivity scenario, except that the wide ranges of uncertainty among scenarios overlapped for the MCMC analyses (Table 3.2.9 and Figure 3.2.14).

3.2.10 Projection Results

Projections were carried out using the forecast module internal to SS3 via the maximum likelihood estimates (MLE) and also via MCMC analysis. The MLE projections use uncertainty associated with the MLE parameter estimates calculated internally to SS3 using the inverse Hessian method in the maximum likelihood estimation, which is then propagated into the variance of derived quantities, such as the fishing mortality intensity that would produce MSY, and forecasts of stock abundance and future yield for a given TAC. Recruitment variability (deviations from the spawner recruit relationship) was estimated in the main time period of the model but not included in the projections. Given the reproductive biology of this species variability in recruitment is expected to be low. Based on the observation that the influence of the high and low productivity scenarios had minimal effect on stock status in comparison to the CPUE groupings (Table 3.2.8, Figure 3.2.13) projections were only carried out for the base case productivity assumptions. This resulted in three projection scenarios: 1) the base case model configuration, 2) the alternative state of nature scenario evaluated for the POS_1 CPUE grouping with the base case productivity scenario (as defined in Table 3.2.8), and 3) the alternative state of nature scenario evaluated for the NEG CPUE grouping with the base case productivity scenario (as defined in Table 3.2.7). All projections were carried out using TAC on whole weight. To be consistent with previous analyses conversion of the whole weight TAC to dressed weight used 1.39 as the conversion factor (i.e. whole weight = 1.39*dressed weight).

Under the base case, the stock was estimated to be overfished, but not experiencing overfishing ($F_{2015}/F_{MSY} <1$). Therefore, as per the TORs, because there is no new or unexpected information about the status of the stock, no new rebuilding schedule was warranted, and projections were implemented consistent with the current rebuilding plan (started in 2005, projected to end in 2070) at a fixed level of removals (TAC on whole weight) allowing rebuilding of the stock by 2070 with 50% and 70% probability. Constant TAC strategies that would allow stock rebuilding by 2070 with a 50% and 70% probability, respectively, were 208 and 148 mt (whole weight) based on projections using the MLE (Figure 3.2.24 and 3.2.25). Projections based on the MCMC analysis associated with a 50% probability of rebuilding in the year 2070 resulted in estimates of the 50th quantile of the $SSF_{2070}/SSF_{MSY}=1.04$, indicating that the MCMC analysis was slightly more optimistic than the MLE based projections, which projected the $SSB_{2070}/SSB_{MSY}=1$ under the same catch. Projections based on the TAC associated with a 70% probability of rebuilding in the year 2070 were 148 MT (Figure 3.2.25); the corresponding projections based on MCMC indicated that this TAC would have a 50^{th} quantile of $SSF_{YR\_Rebuild}/SSF_{MSY} = 1.18$ (Table 3.2.10).

Under the scenario using the NEG CPUE grouping the stock was estimated to be overfished and experiencing overfishing. Therefore, as per the TORs, because this is a new status for the stock, a new rebuilding schedule had to be calculated. The stock was projected at F = 0 to determine the year when the stock can be declared recovered with a 70% probability (SSF/SSFMSY > 1, Year $F=0_{70\%}$), which was 2093. Because that year is greater than 10 years in the future, then management action should be implemented to rebuild the stock within the estimated rebuilding time + 1 generation time (Restrepo et al. 1998). The estimate of generation time, defined as the mean age of parents of offspring produced by a cohort over its lifetime (µ1; Caswell 2001), is approximately 18 years. Therefore the target rebuilding year would be 2111, and the model was projected with a fixed TAC strategy that would attain rebuilding by the designated year with 50% and 70% probability. These TACs were 71 mt and 53 mt (whole weight), respectively. It was assumed that any modification to a TAC will impact each fishery by the same proportion. The MCMC analysis (Figures 3.2.26 and 3.2.27) resulted in estimates of $SSF/SSF_{MSY} = 1.07$ and 1.16 for the 50% and 70% TAC levels, respectively. The estimates of SSF/SSF_{MSY} from the MCMC analysis are larger than the estimates from the MLE-based projections; this is due to the MCMC analysis incorporating the uncertainty in the parameter estimates into the projections.

Under the POS_1 CPUE grouping the stock was estimated to be neither overfished nor experiencing overfishing. Consequently, under the POS_1 CPUE grouping, a projection model (TOR 4D), analogous to a P* approach associated with a 70% probability of overfishing not occurring (P* = 0.3), was implemented that projected with constant TAC so that the probability of overfishing was less than or equal to 30% in the current rebuilding year, 2070. The estimated TAC that would result in no more than a 30% chance of overfishing by 2070 was 677 mt (whole weight) based on the MLE estimates. MCMC analysis with this level of TAC led to estimates of stock status in 2070 at SSF/SSFMSY = 1.4 with a 70% probability (Figure 3.2.28).

The inclusion of parameter uncertainty in the projections via the MCMC analysis indicated, across all CPUE groupings and TAC levels, that the $SSF_{YR\_Rebuild} / SSF_{MSY} > 1$. This is also evident in the comparison of the stock status for 2015 (Figure 3.2.11). This is because the distribution of the MCMC results, when taking into account all of the parameter uncertainty, for $SSF_{YR\_Rebuild} / SSF_{MSY}$ has a slightly non-normal distribution that is wider on the higher values than the MLE estimate. This indicates that when taking into account parameter uncertainty higher TAC values may reasonably be expected to reach SSF / SSF_{MSY} = 1 in the rebuilding year.

3.3 ASSESSMENT RESEARCH RECOMMENDATIONS

We list below research recommendations that are more feasible and would allow substantial improvement of future stock assessment of this stock:

- Determine what is missing in terms of experimental design or/and data analysis to arrive at incontrovertible (to the extent that it may be scientifically possible) conclusions on the reproductive periodicity of the stock
- Continue work on reconstruction of historical catches, especially catches outside of the US EEZ
- Investigate the length composition of the F3 Recreational and Mexican fisheries more in depth as this fishery is estimated to have a large impact on the stock mainly due to selecting age-0 fish.
- Research to estimate the degree of connectivity between the portions of the stock within the US and outside of the US EEZ.
- Study the distribution and movements of the stock relative to sampling coverage. It is possible that none of the indices alone track stock-wide abundance trends.

3.4 DISCUSSION

Although most shark species can likely be considered data poor when compared to most teleost stocks, information for sandbar sharks is relatively abundant mainly because—together with blacktip sharks—they have been the main target of commercial fisheries in the eastern U.S. seaboard since their inception. As a result, relatively good records of commercial landings exist, and biological and fishery information is available mainly from the directed bottom longline shark fishery observer program. Unlike other large coastal shark species, sandbar sharks are somewhat easy to identify, mostly by their high first dorsal fin in combination with the interdorsal ridge and placement of the pectoral fin compared with the origin of the dorsal fin.

Although these physical features should help distinguishing this species anecdotal evidence indicates that sandbar sharks are often confused with other species (i.e. dusky sharks).

Multiple indices that theoretically track relative abundance, many of them fishery independent, are also available. However, the majority of those fishery-independent indices started after 1995, and thus did not cover the main period of exploitation of this stock in the western North Atlantic Ocean. An issue of concern regarding the indices of relative abundance, is that many show interannual variability that does not seem to be compatible with the life history of the species, suggesting that the standardization procedure did not include all factors to help track relative abundance or that the spatial scope of sampling is too limited to allow for precise inference about stock-wide trends. The poor fit to some of the indices is thus likely the result of the model attempting to reconcile different signals provided by different indices and fitting a more central tendency (“compromise fit”).

The uncertainty associated with biological parameters (reproduction and natural mortality) affected the estimation of stock status to some extent but was less influential than the groupings of CPUE series. Recent work has led to similar estimates with respect to age, growth, reproduction and the associated life history characteristics. As such the range of variation investigated was not as wide as in the past but reflected nevertheless the best available estimates. Changes to the biology and life history inputs were minor with respect the last assessment. Changes were that: the maximum age is now 31 (from 27); steepness is now 0.30 (from 0.29); the theoretical maximum length has changed a few centimeters; and the natural mortality at age has been updated to new values. These changes may affect the potential productivity/resiliency of the stock in different ways but the overall characteristics of shark with low fecundity, long gestation period, and late age at maturity have remained.

In general, the results of the assessment were robust to structural assumptions regarding the productivity of the stock. The sensitivity runs that used alternative groupings of the CPUE indices showed a more productive and less impacted stock that was not overfished nor undergoing overfishing based on the POS_1 CPUE grouping. The sensitivity runs that included the NEG CPUE grouping showed a less productive, more impacted stock that was overfished and experiencing overfishing.

The uncertainty associated with the sensitivity runs that included the POS_1 CPUE groupings was much greater than the uncertainty associated with the Base or NEG CPUE groupings (Figure 3.2.12). The POS_1 CPUE groupings included most, but not all, of the CPUE series that were increasing in the final years, (note S11 SEAMAP SE), and does not include the CPUEs which index some of the smallest animals in the stock (the northeast and southeast Coastspan indices), and as such may not be representative of the entire stock. Alternatively, as the model tracks spawning stock fecundity (SSF), the other indices (e.g. NE BLL, SE BLL) that track the older portion of the population may be more indicative of the stock trend. In comparison the NEG CPUE grouping does not contain the indices from the main commercial fisheries (bottom longline), the longest running CPUE index (VA longline), or the index with the most complete geographic coverage (NMFS longline SE) and as such may be non-representative with respect to the exploited biomass.

There is no CPUE trend available for fishery F3, the recreational and Mexican fisheries, that has contributed to the majority of the estimated fishing mortality throughout the model and is the predominant source of fishing mortality since 2008; consequently the model is missing information on the abundance of the stock that has been exploited by the largest fishery in the last seven years of the model.

Despite the differences in life history inputs noted above, changes in some of the indices of abundance, and use of length compositions, estimated stock status in the base run did not change substantially between the 2011 (SEDAR 21) and the current assessment. This is in part because the species biology constrains the model to the plausible population dynamics for the species. In conjunction with the parameterization of the species biology the two assessments (SEDAR 21 and 54) share quite similar catch and CPUE trends, both of which are influential to the model fit. The current base run results confirm that the combination of life-history parameters and the vulnerability of sandbar sharks to the various gears long before they are mature suggest a population that cannot support a large level of exploitation and help explain the degree of depletion estimated by the model. However, the strict limitation on catches in recent years has ended overfishing.

Stock status under the base case model configuration estimated that the stock in 2015 was overfished and overfishing was not occurring ($SSF_{2015}/SSF_{MSY} = 0.6$, $F_{2015}/F_{MSY} = 0.75$, Table 3.2.8). This result was robust to the MCMC analysis, with a 97% probability of the stock being in that quadrant of the Kobe plot (Table 3.2.9). The results from the MCMC analysis based on the other CPUE groupings estimated the stock was either overfished and experiencing overfishing (NEG CPUE group; 99.8% probability) or that the stock was neither overfished nor experiencing overfishing (POS_1 CPUE group; 99% probability). Based on the MCMC analysis, the distribution of estimates for SSF_{2015}/SSF_{MSY} and F_{2015}/F_{MSY} is smallest for the base case (Figure 3.2.14). The uncertainty associated with the POS_1 sensitivity analysis shows that SSF_{2015}/SSF_{MSY} ranges from less than 1 (overfished) to greater than 2.5 (near virgin conditions). The results of the MCMC analysis with the POS_1 CPUE grouping show low levels (<0.6) of F_{2015}/F_{MSY}. In contrast, the MCMC analysis based on NEG CPUE grouping shows high variability in the F_{2015}/F_{MSY} estimates (from <1 to >3) and low variability in SSF_{2015}/SSF_{MSY} estimates (Figure 3.2.14).

The retrospective analysis found no systematic pattern of over- or under-estimation of abundance, relative abundance, or fishing mortality for the base case, which is as close as possible to the previous benchmark assessment base case configuration. The base model configuration, parameter values and input data are based on the best available information, and stock status results based on the base case run should thus be considered the most credible.

Projections at alternative fixed harvest levels were used to provide an approach for evaluating total allowable catch (TAC) along the main axis of structural uncertainty investigated, the groupings of CPUE series. Among the multiple projection scenarios evaluated, were fixed levels of TAC that resulted in a 50% and 70% chance of rebuilding by the rebuilding year for the base case configuration and the NEG CPUE grouping, and TAC values obtained analogously to a P* approach used here to determine the removals associated with a 70% probability of overfishing not occurring (P* = 0.3) for the POS_1 CPUE grouping. As a pragmatic approach we used the MLE projections to determine the TAC levels associated with the probabilities (50% and/or 70%) of rebuilding by the rebuilding year. The MCMC analysis was then based on these determined TACs; MCMC analysis was not run over a large number of TACs due to the length of time (> 2days) required for each MCMC run.

The MLE projections indicated that at the 70% probability level the TACs required for stock rebuilding by 2070 would be 148 mt, 53 mt, and 677 mt for Base, NEG, and POS_1 CPUE groupings, respectively. The MCMC analysis indicated, across all CPUE groupings and TAC levels, that the $SSF_{YR\_Rebuild}$ / SSF_{MSY} >1; the median values from the 70% probability TAC levels were 1.18, 1.6 and 1.4 for the for Base, NEG and POS_1 CPUE groupings, respectively, based on 500 bootstrap replicates sampled from 500,000 runs. This indicates that when taking into account MCMC uncertainty, higher TAC values may reasonably be expected to reach SSF / SSFMSY = 1 in the rebuilding year. This is expected given that the TAC providing a 70% chance of $SSF_{YR\_Rebuild}$ / SSF_{MSY} >1 is calculated such that 30th quantile would be approximately 1 (i.e. 70% of the runs >1). Figure 3.2.11 indicates that the shape of the MCMC distribution for SSF_{2015} / SSF_{MSY} is not symmetric. Because the estimated SSF / SSF_{MSY} distribution from the MCMC analysis is slightly skewed to values greater than 1 the MCMC estimated $SSF_{YR\_Rebuild}$ / SSF_{MSY} are larger than 1, and as a result both the 50% and 70% projection results differ from those obtained with the MLE and asymptotic variance obtained from the Hessian. These results are useful because they help to characterize uncertainty in the assessment. For example, in the future it may be important to determine why the discrepancy exists. However, this is beyond the scope of the current assessment. Comparison of the MLE estimates and the 50th quantile of the MCMC results (Table 3.2.11) shows agreement for the majority of the parameters, indicating that the MLE estimates are appropriate. However some estimates from the MCMC analysis show deviation from the MLE estimates (note the selectivity parameters for S10, SCDNR) indicating some discrepancies in the two modes of parameter estimation.

This is the second HMS shark assessment conducted within the SEDAR process to utilize the Stock Synthesis modeling framework (the first was SEDAR 39 Atlantic Smooth Dogfish). Previous HMS shark assessments conducted within the SEDAR process used a State Space Age Structured Production Model (SSASPM). It is important when transitioning between modeling platforms to identify the potential impacts of differences in modeling approaches on assessment outcomes. Consequently, an attempt was made in this assessment to implement many of the features previously implemented in HMS shark assessments conducted with SSASPM in order to identify and evaluate the potential impacts of differences in modeling approaches on assessment outcomes. However, two differences were identified between this assessment and previous assessments for HMS sharks conducted with SSASPM:

1. This assessment included length data from age-0 sharks. Previous assessments for HMS sharks conducted with SSASPM excluded age-0 sharks from the assessment.

2. This assessment estimated selectivity internally to the model. Previous assessments for HMS sharks conducted with SSASPM estimated selectivity externally of the stock assessment model.

The reason why the population is still recovering and the projected TAC is lower than the projected TAC from SEDAR 21 (the previous assessment) is likely due in part to these differences. The current assessment has different, slightly higher mortality levels on ages 0-6, which account for approximately 60% of the unfished population, and make up a bulk of the catches. Furthermore, the previous assessment did not include 0 age fish, and the fishing mortality in the recent years (2007-2015) is from the fishery that catches ages 0s. These factors result in an overall estimate of MSY that is lower.

The use of Stock Synthesis as a modeling platform is due to the recommendations of the CIE Reviewers from SEDAR 21, which did not specifically recommend Stock Synthesis but did recommend the following:

- Estimating the fishery and index selectivities within the assessment model.
- Development of a two sex model for more direct estimation of the spawning stock
- Fitting the model to either length or age data. In addition to being necessary in order to estimate selectivities, these data can be informative about changes in age-specific abundance.
- Exploration of models that do not require an assumption that the population is at virgin levels at some point in time.

By modeling the stock with Stock Synthesis the first 3 recommendations were fulfilled, while the last recommendation was initially addressed but ultimately the model was started at a time when the stock was assumed to be close to virgin levels. This was due to the relative confidence in the stock being at approximately unfished levels in 1960, and the uncertainty associated with estimating initial depletion. One last consideration is that for a highly migratory species that ranges from the western north Atlantic to the Gulf of Mexico, Caribbean and Brazil this assessment has included data from only a portion of that range. Although this may be appropriate given that tagging results indicated a high amount of movement between the eastern US coast and the Gulf of Mexico there is little to no information concerning the degree of connectedness throughout the species southern range.

4 REFERENCES

Andrews, A. H., Natanson, L.J., Kerr, L.A., Burgess, G.H., and G.M. Cailliet. 2011. Bomb radiocarbon and tag-recapture dating of sandbar shark (*Carcharhinus plumbeus*). Fish. Bull. 109(4), 454-465.

Baremore, I., and Hale, L. 2012. Reproduction of the Sandbar Shark in the Western North Atlantic Ocean and Gulf of Mexico. Marine and Coastal Fisheries 4(1), 560-572.

Cadrin, S.X., Vaughn, D.S. 1997.. Retrospective analysis of virtual population estimates for Atlantic menhaden stock assessment. Fish. Bull. 95(3), 445-455.

Fournier D A, Skaug HJ, Ancheta J, Ianelli J, Magnusson A, Maunder MN, Nielsen A, Sibert J. 2012. AD Model Builder: using automatic differentiation for statistical inference of highly parameterized complex nonlinear models. Optim. Methods Softw. 27:233-249.

Francis RICC. 2011. Data weighting in statistical fisheries stock assessment models. Canadian Journal of Fisheries and Aquatic Sciences, 2011, 68(6): 1124-1138

Francis RICC .2014. Replacing the multinomial in stock assessment models: A first step. Fisheries Research, 151, (2014), 70-84.

Hale, L., and Baremore, I. 2013. Age and growth of the sandbar shark from the Northern Gulf of Mexico and the Western North Atlantic Ocean. Gulf of Mexico Science 1-2, 28-39.

ICCAT (International Commission for the Conservation of Atlantic Tunas). 2005. Report of the 2004 Inter-sessional meeting of the ICCAT Subcommittee on by-catches: shark stock assessment. Col. Vol. Sci. Pap. ICCAT 58:799-890.

Lee, H.-H., Piner, K.R., Methot R.D., Maunder, M.N. 2014. Use of likelihood profiling over a global scaling parameter to structure the population dynamics model: An example using blue marlin in the Pacific Ocean. Fish. Res.

Maunder, M. N. and A. E. Punt. 2013. A review of integrated analysis in fisheries stock assessment. Fisheries Research 142:61–74.

Maunder, M.N., Harley, S.J., Hampton, J., 2006. Including parameter uncertainty in forward projections of computationally intensive statistical population dynamic models. ICES J. Mar. Sci. 63, 969–979.

Methot, R. D. 2000. Technical description of the stock synthesis assessment program. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-43: 46.

Methot, R. 2010. User manual for Stock Synthesis: model version 3.10b. Feb 26, 2010. NOAA Fisheries Service, Seattle, WA.

Methot R. D., Wetzel C. R. 2013. Stock synthesis: a biological and statistical framework for fish stock assessment and fishery management, Fisheries Research, vol. 142 (pg. 86-99)

Porch, C.E. 2003a. A preliminary assessment of Atlantic white marlin (Tetrapturus albidus) using a state-space implementation of an age-structured model. SCRS/02/68 23pp.

Restrepo, V. R., G. G. Thompson, P. M. Mace, W. L. Gabriel, L. L. Low, A. D. MacCall, R. D. Methot, J. E. Powers, B. L. Taylor, P.R. Wade, and J. F. Witzig. 1998. Technical guidance on the use of precautionary approaches to implementing National Standard 1 of the Magnuson-Stevens Fishery Conservation and Management Act. NOAA Technical Memo. NMFS-F/SPO-31, 54p. National Technical information Center, 5825 Port Royal Road, Springfield, VA 22161.

SEDAR 21, 2011. SEDAR 21 Stock Assessment Report, HMS Sandbar Shark. SEDAR 4055 Faber Place Drive, Suite 201, North Charleston, SC 29405. (http://sedarweb.org/sedar-21-final-stock-assessment-report-hms-sandbar-shark, accessed January 2017).

SEDAR21-DW-09. Updated catches of sandbar, dusky and blacknose sharks. E. Cortés and I.E. Baremore SEDAR 21 Data Workshop Report (http://sedarweb.org)

SEDAR 39, 2015. SEDAR 39 Stock Assessment Report, HMS Atlantic Smooth dogfish Shark. SEDAR 4055 Faber Place Drive, Suite 201, North Charleston, SC 29405. (http://sedarweb.org/).

SEDAR 54_TEMP1, 2017. Example Implementation of a Hierarchical Cluster Analysis and Cross-correlations of Selected CPUE Indices for the SEDAR 54 Assessment.

Wetzel, C. R., and A. E. Punt. 2011a. Model performance for the determination of appropriate harvest levels in the case of data-poor stocks. Fisheries Research 110:342–355.

Wetzel, C. R., and A. E. Punt. 2011b. Performance of a fisheries catch-at-age model (Stock Synthesis) in data-limited situations. Marine and Freshwater Research 62: 927–936.

5 TABLES

5.1 TABLES FROM SECTION 3.1

Table 3.1.1. Catches of sandbar shark by fleet in numbers used in the replication analysis. Catches are separated into four fisheries: commercial landings + unreported commercial catches in the GOM, commercial landings + unreported commercial catches in the ATL, recreational + Mexican catches, and menhaden fishery bycatch.

Year	Com+Un (GOM)	Com + Un (SA)	REC+MEX	Menhaden disc
1960	59	25	65	504
1961	119	51	129	504
1962	178	76	194	504
1963	237	102	259	504
1964	297	127	323	504
1965	356	152	388	504
1966	415	178	453	504
1967	475	203	517	504
1968	534	228	582	504
1969	593	254	647	504
1970	653	279	711	504
1971	712	305	776	504
1972	771	330	841	504
1973	831	355	905	504
1974	890	381	970	504
1975	949	406	1035	504
1976	969	414	1036	504
1977	1033	442	1079	504
1978	1236	529	2310	504
1979	1807	773	25366	504
1980	3018	1291	97983	504
1981	4650	1990	138933	696
1982	4650	1990	45401	713
1983	5024	2149	426979	705
1984	6861	2936	68135	705
1985	6373	2727	75593	635
1986	18908	6918	134151	626
1987	54132	19851	37438	653
1988	78241	46440	72789	635
1989	104839	55874	34532	670
1990	87469	34971	68479	653
1991	88900	7781	44428	505
1992	69488	31105	43450	444
1993	45201	26777	32922	452
1994	86311	39963	23411	486
1995	49038	35360	35206	445
1996	32126	33419	46817	444
1997	21190	20275	49315	452
1998	32264	30391	41846	435
1999	18087	35212	27329	479

2000	16781	20544	17794	409
2001	26185	21998	42127	383
2002	27572	28788	13062	374
2003	23663	21567	9252	365
2004	18472	20667	7395	374
2005	14109	19265	6126	374
2006	22096	20022	5059	374
2007	6068	10845	10638	374
2008	668	1485	7324	374
2009	2705	1281	7026	374

Table 3.1.2. Standardized indices of relative abundance used in the replication analysis. All indices are scaled (divided by their respective mean). For details on the indices of abundance and the definition of the acronyms please see the Section 2 and Table 2.4.

YEAR	LPS	BLLOP	VA-LL	NMFS LLSE	NMFS Coast age 1+	NMFS-NE	PLLOP	GA-Coastspan	SC-Coastspan	SCDNR-Red dr	PCGN
1975	-	-	1.826	-	-	-	-	-	-	-	-
1976	-	-	-	-	-	-	-	-	-	-	-
1977	-	-	1.636	-	-	-	-	-	-	-	-
1978	-	-	-	-	-	-	-	-	-	-	-
1979	-	-	-	-	-	-	-	-	-	-	-
1980	-	-	2.293	-	-	-	-	-	-	-	-
1981	-	-	2.397	-	-	-	-	-	-	-	-
1982	-	-	-	-	-	-	-	-	-	-	-
1983	-	-	-	-	-	-	-	-	-	-	-
1984	-	-	-	-	-	-	-	-	-	-	-
1985	-	-	-	-	-	-	-	-	-	-	-
1986	3.480	-	-	-	-	-	-	-	-	-	-
1987	1.024	-	-	-	-	-	-	-	-	-	-
1988	3.193	-	-	-	-	-	-	-	-	-	-
1989	3.780	-	-	-	-	-	-	-	-	-	-
1990	1.243	-	0.396	-	-	-	-	-	-	-	-
1991	2.078	-	0.558	-	-	-	-	-	-	-	-
1992	1.624	-	0.232	-	-	-	3.326	-	-	-	-
1993	0.828	-	0.749	-	-	-	2.633	-	-	-	-
1994	0.509	0.617	-	-	-	-	1.863	-	-	-	-
1995	0.440	0.658	0.885	1.855	-	-	1.500	-	-	-	-
1996	0.541	0.568	0.882	0.972	-	0.138	1.223	-	-	-	0.965
1997	0.623	0.912	0.818	1.466	-	-1	1.239	-	-	-	0.551
1998	0.170	1.003	1.335	-	-	0.835	0.876	-	0.702	0.548	1.394
1999	0.245	0.741	1.054	0.462	-	-	1.117	-	0.613	2.329	-
2000	0.294	0.438	1.000	1.084	-	-	0.408	0.156	0.105	0.226	-
2001	1.220	1.262	1.103	1.019	1.343	0.412	0.481	-	0.055	1.369	0.842
2002	0.418	0.524	0.596	0.798	0.465	-	0.033	-	0.222	0.903	0.812
2003	0.192	0.746	0.508	0.979	1.267	-	0.029	0.856	0.310	0.604	0.659
2004	0.111	0.582	0.682	0.767	1.261	0.319	0.554	0.963	1.748	1.322	1.611

2005	0.473	0.763	0.435	0.349	1.308	-	0.196	0.299	1.064	0.606	1.243
2006	0.150	1.073	1.079	0.446	0.677	-	0.880	1.105	1.778	1.094	-
2007	0.333	1.421	0.311	0.970	0.707	1.408	0.554	1.785	2.024	-	0.425
2008	0.395	1.064	0.958	0.839	0.219	-	0.538	1.554	2.007	-	2.022
2009	0.636	3.627	1.268	1.995	1.754	2.888	0.550	1.283	1.373	-	0.474

Table 3.1.3. Life history inputs used in the SEDAR 21 analysis and the SEDAR 54 replication analysis. All these quantities are treated as constants in the model, note that this table differs from Table 2.1 in the number of ages assumed and age specific values.

	Proportion	Natural Mortality
Age	mature female	M
1	0.00035	0.15431
2	0.00068	0.15431
3	0.00131	0.15431
4	0.00253	0.15431
5	0.00487	0.15431
6	0.00935	0.15431
7	0.01788	0.15431
8	0.03393	0.15323
9	0.06346	0.14812
10	0.11562	0.13116
11	0.20141	0.13116
12	0.32730	0.13116
13	0.48418	0.13116
14	0.64424	0.13116
15	0.77746	0.13099
16	0.87079	0.12942
17	0.92858	0.12806
18	0.96166	0.12688
19	0.97975	0.12586
20	0.98940	0.12497
21	0.99448	0.12419
22	0.99713	0.12351
23	0.99851	0.12291
24	0.99923	0.12239
25	0.99960	0.12193
26	0.99979	0.12153
27	0.99989	0.12117

Table 3.1.4. Summary of biological inputs used in SEDAR 21 and the SEDAR 54 replication analysis. Changes or updates are in bold font.

Quantity	SEDAR 21	SEDAR 54 Replication
Sex ratio:	1:1	1:1
Reproductive frequency:	2.5 yr	2.5 yr
Pupping month:	June	June
Age or Length vs litter size relation:	pups = 0.2591*age + 3.9897	**pups = 0.0324*FL + 4.2447**
L_{inf}	181.15 cm FL	**181.15 cm FL (F), 172.97cm (M)**
k	0.12	**0.12(F), 0.15(M)**
t_0	-2.33	**-3.09(F), -2.33(M)**
Weight vs fork length relation:	$W=0.000010885L^{3.0124}$	$W=0.000010885L^{3.0124}$
SR function	Beverton Holt	Beverton Holt
SR steepness	0.29	0.29

Table 3.1.5. Summary of selectivity inputs used in SEDAR 21 and the SEDAR 54 replication analysis.

Series	Selectivity	a_{50}	b	c_{50}	d	max(sel)
CATCH SERIES						
Commercial + unreported GOM	Logistic	6	2			
Commercial + unreported ATL	Logistic	8	1			
Recreational + Mexican	Double logistic	0.02	0.2	0.5	2.5	0.45
Menhaden discards	Logistic	-120	0.2			
CPUE SERIES						
BLLOP	Logistic	6	1			
VIMS	Logistic	0.02	0.24	8	2	0.96
LPS	Double logistic	5	2	12.5	2.5	0.71
PLLOP	Double logistic	8.53	0.59	23.97	2.01	1.00
NELL	Logistic	7.67	2.04			
NMFS Coastspan age-1+	Logistic	0.02	0.5			
GA Coastspan	Logistic	0.02	0.5			
SC Coastspan	Logistic	0.02	0.5			
SC Historic Red Drum	Logistic	2.5	0.4			
PC Gillnet	Double logistic	0.02	0.2	5	1.2	0.96
NMFS SE BLL	Logistic	6	1			

Changes for SEDAR 54 Replication Analysis

	Selectivity	PEAK	TOP	ASC-WIDTH	DSC-WIDTH	INIT	FINAL
Recreational + Mexican (Catch)	Double normal	-2	-4	-2	3	-9	-9
VIMS (Index)	Double normal	-1	-3	-2	4.2	-9	-9
LPS (Index)	Double normal	8	-3	3.4	3.4	-9	-9
PC Gillnet (index)	Double normal	-1	-3	-2	3	-9	-9

Table 3.1.6. Comparisons of the SEDAR 21 assessment base case and the SEDAR 54 replication analysis, greyed rows are directly comparable.

	Base (SEDAR 21)			Replication Analysis		
	Est	CV		Est	CV	Notes
SSF_{2009}/SSF_{MSY}	**0.66**	0.83	SSF_{2009}/SSF_{MSY}			
SSB_{2009}/SSB_{MSY}			SSB_{2009}/SSB_{MSY}	**0.70**		
F_{2009}/F_{MSY}	**0.62**	0.57	F_{2009}/F_{MSY}	**0.51**		
N_{2009}/N_{MSY}	0.74	---	N_{2009}/N_{MSY}			
B_{2009}/B_{MSY}			B_{2009}/B_{MSY}	0.70		
MSY (numbers)	160,643	---	MSY(biomass)	510		in MT
SPR_{MSY}	0.78	0.06	SPR_{MSY}	0.79		
F_{MSY}	0.021	---	F_{MSY}	0.03		
SSF_{MSY}	477,590	---	SSF_{MSY}			
SSB_{MSY}			SSB_{MSY}	699		
N_{MSY}	1,928,165	---	N_{MSY}			
B_{MSY}			B_{MSY}	38931		
F_{2009}	0.01	0.57	F_{2009}	0.02		
SSF_{2009}	312890	0.60	SSF_{2009}			
SSB_{2009}			SSB_{2009}	491		
N_{2009}	1,539,102	---	N_{2009}	1,776,785		
SSF_{2009}/SSF_0	0.28	0.41	SSF_{2009}/SSF_0			
SSB_{2009}/SSB_0			SSB_{2009}/SSB_0	0.32		
B_{2009}/B_0	0.34	0.33	B_{2009}/B_0	0.32		
R_0	563,490	0.20	R_0	600,821		
steepness	0.29	---	steepness	0.29		

Table 3.1.7 List of continuity runs.

Run Name	Description
SEDAR 21	Estimated Biomass from SEDAR 21
Replication	Estimated total biomass based on the SEDAR 21 inputs used in SS3.
Update Catch	Replication analysis using the catches re-estimated for SEDAR 54, 1960-2009
Cont_1	Updated Catch run plus catch from 2010-2015.
Cont_2	Updated the longevity from 27 to 31.
Cont_3	Updated life history and biological parameters to values in table 2.1 and 2.2

5.2 TABLES FROM SECTION 3.2

Table 3.2.1 Fishery and CPUE number, name, and selectivity functional form for the base case model configuration.

Number	Type	Name	Short Name	Selectivity Function
1	Fishery	Commercial Gulf of Mexico Longline	F1_COM_GOM	Double Normal
2	Fishery	Commercial South Atlantic Longline	F2_COM_SA	Logistic
3	Fishery	Recreational and Mexican catches	F3_RecMEX	Double Normal
4	Fishery	Menhaden Discards	F4_MEN_DSC	Logistic
5	CPUE	Large Pelagic Survey	S1_LPS	Double Normal
6	CPUE	Bottom Longline Observer Program 1	S2_BLLOP_1	Double Normal
7	CPUE	Bottom Longline Observer Program 2	S3_BLLOP_2	Double Normal
8	CPUE	Virginia Longline Survey	S4_VA_LL	Double Normal
9	CPUE	NMFS Longline Southeast Survey	S5_NMFS_LLSE	Double Normal
10	CPUE	Coastspan NE LL Survey	S6_CST_NE_LL	Double Normal
11	CPUE	NMFS Longline Northeast Survey	S7_NMFS_NE	Double Normal
12	CPUE	Pelagic longline observer program	S8_PLLOP	Double Normal
13	CPUE	Coastspan SE LL Survey	S9_COASTSPAN_SE_LL	Cubic Spline
14	CPUE	South Carolina DNR red drum observer program	S10_SCDNR_RedDr	Double Normal
15	CPUE	SEAMAP Longline SE Survey	S11_SEAMAP_LL_SE	Double Normal

Table 3.2.2. Details on the number of length measurement records, initial sample size used in Stock Synthesis, the sample size multiplier, and the resulting effective sample size input in the Stock Synthesis base case model configuration.

Number	Name	Number of records	Sex specific records	Initial sample size	Sample size multiplier	Effective sample size used in model
1	F1_COM_GOM	14634	Yes	1450	0.29	424
2	F2_COM_SA	31385	Yes	3263	0.03	96
3	F3_RecMEX	604	No	156	0.91	142
4	F4_MEN_DSC	NA	NA	NA	NA	NA
5	S1_LPS	236	No	114	1.14	130
6	S2_BLLOP_1	24862	Yes	3563	0.07	255
7	S3_BLLOP_2	21157	Yes	42	9.85	414
8	S4_VA_LL	6488	Yes	872	0.13	115
9	S5_NMFS_LLSE	1045	Yes	550	0.29	161
10	S6_CST_NE_LL	1084	Yes	384	1.58	607
11	S7_NMFS_NE	5122	Yes	333	0.14	48
12	S8_PLLOP	256	Yes	76	1.07	81
13	S9_COASTSPAN_SE_LL	1539	Yes	592	2.09	1238
14	S10_SCDNR_RedDr	516	Yes	203	0.16	33
15	S11_SEAMAP_LL_SE	842	Yes	515	0.43	219

Table 3.2.3. List of parameters estimated in SS3 for sandbar shark (base run). The list includes (columns from left to right) the parameter labels, the predicted parameter value, the minimum, maximum and initial value for the parameter, the parameter standard deviation, the prior type if applicable, the prior value (if applicable) and the prior standard deviation if applicable. Parameters that were held fixed (not estimated) are not included in this table.

Label	Value	Min	Max	Init	Parm_StDev	PR_type	Prior	Pr_SD
SR_LN(R0)	6.28	3	10	6.27	0.06	No_prior	NA	NA
SizeSel_1P_1_F1_COM_GOM	149.43	35	259	150.90	1.52	No_prior	NA	NA
SizeSel_1P_3_F1_COM_GOM	5.45	-15	15	5.96	0.20	No_prior	NA	NA
SizeSel_1P_4_F1_COM_GOM	5.61	-15	15	5.51	0.20	No_prior	NA	NA
SzSel_1Male_Ascend_F1_COM_GOM	0.74	-15	15	-0.05	0.20	No_prior	NA	NA
SzSel_1Male_Scale_F1_COM_GOM	0.67	-15	15	1.34	0.09	No_prior	NA	NA
SizeSel_2P_1_F2_COM_SA	93.63	1	200	94.68	6.22	No_prior	NA	NA
SizeSel_2P_2_F2_COM_SA	29.72	1	100	31.03	10.10	No_prior	NA	NA
SizeSel_3P_1_F3_RecMEX	55.06	35	259	55.03	0.64	Normal	55	1
SizeSel_3P_2_F3_RecMEX	-10.00	-15	15	-10.00	1.00	Normal	-10	1
SizeSel_5P_1_S1_LPS	155.53	35	259	155.50	11.11	No_prior	NA	NA
SizeSel_5P_3_S1_LPS	7.30	-15	15	7.31	0.50	No_prior	NA	NA
SizeSel_5P_4_S1_LPS	14.63	-15	15	14.62	9.96	No_prior	NA	NA
SizeSel_8P_1_S4_VA_LL	45.02	35	258	41.27	0.14	No_prior	NA	NA
SizeSel_8P_3_S4_VA_LL	-9.36	-15	15	-8.52	41.56	No_prior	NA	NA
SizeSel_9P_1_S5_NMFS_LLSE	161.85	35	259	156.52	6.25	No_prior	NA	NA
SizeSel_9P_3_S5_NMFS_LLSE	7.15	-15	15	6.91	0.31	No_prior	NA	NA
SizeSel_9P_4_S5_NMFS_LLSE	5.61	-15	15	5.88	0.83	No_prior	NA	NA
SzSel_9Male_Peak_S5_NMFS_LLSE	-6.15	-20	200	3.00	7.99	No_prior	NA	NA
SzSel_9Male_Ascend_S5_NMFS_LLSE	-0.66	-15	15	-0.14	0.52	No_prior	NA	NA
SzSel_9Male_Descend_S5_NMFS_LLSE	-0.80	-15	15	-0.60	1.24	No_prior	NA	NA
SzSel_9Male_Scale_S5_NMFS_LLSE	0.74	-15	15	0.67	0.18	No_prior	NA	NA
SizeSel_10P_1_S6_CST_NE_LL	57.03	35	258	70.82	0.68	No_prior	NA	NA
SizeSel_10P_3_S6_CST_NE_LL	-8.04	-15	15	6.07	69.31	No_prior	NA	NA
SizeSel_10P_4_S6_CST_NE_LL	7.58	-15	15	6.92	0.10	No_prior	NA	NA

Table 3.2.3 Continued.

Label	Value	Min	Max	Init	Parm_StDev	PR type	Prior	Pr_SD
SzSel_10Male_Peak_S6_CST_NE_LL	5.36	-20	200	4.21	1.44	No_prior	NA	NA
SzSel_10Male_Ascend_S6_CST_NE_LL	10.92	-15	15	-0.12	69.31	No_prior	NA	NA
SzSel_10Male_Descend_S6_CST_NE_LL	-0.79	-15	15	-0.60	0.16	No_prior	NA	NA
SzSel_10Male_Scale_S6_CST_NE_LL	1.08	-15	15	1.00	0.12	No_prior	NA	NA
SizeSel_11P_1_S7_NMFS_NE	132.67	35	259	129.64	10.92	No_prior	NA	NA
SizeSel_11P_3_S7_NMFS_NE	8.03	-15	15	7.90	0.54	No_prior	NA	NA
SizeSel_11P_4_S7_NMFS_NE	6.32	-15	15	6.66	0.86	No_prior	NA	NA
SzSel_11Fem_Scale_S7_NMFS_NE	2.32	-15	15	2.22	0.75	No_prior	NA	NA
SizeSel_12P_1_S8_PLLOP	147.30	35	259	146.63	5.60	No_prior	NA	NA
SizeSel_12P_3_S8_PLLOP	6.52	-15	15	6.70	0.63	No_prior	NA	NA
SzSel_12Male_Ascend_S8_PLLOP	-0.43	-15	15	-0.14	0.72	No_prior	NA	NA
SzSel_12Male_Descend_S8_PLLOP	-1.19	-15	15	-0.60	1.14	No_prior	NA	NA
SzSel_12Male_Scale_S8_PLLOP	1.45	-15	15	1.07	0.68	No_prior	NA	NA
SizeSpline_Val_1_S9_COASTSPAN_SE_LL_13	3.36	-5	5	1.24	0.36	No_prior	NA	NA
SizeSpline_Val_2_S9_COASTSPAN_SE_LL_13	2.54	-5	5.00	1.00	0.36	No_prior	NA	NA
SizeSpline_Val_3_S9_COASTSPAN_SE_LL_13	2.00	-5	5.00	-0.69	0.35	No_prior	NA	NA
SizeSpline_Val_4_S9_COASTSPAN_SE_LL_13	-1.05	-5	5.00	2.06	0.21	No_prior	NA	NA
SizeSel_14P_1_S10_SCDNR_RedDr	92.85	35	259.00	86.71	4.97	No_prior	NA	NA
SzSel_14Male_Ascend_S10_SCDNR_RedDr	1.58	-15	15.00	1.07	1.07	No_prior	NA	NA
SzSel_14Male_Descend_S10_SCDNR_RedDr	-0.31	-15	15.00	1.08	1.82	No_prior	NA	NA
SzSel_14Male_Scale_S10_SCDNR_RedDr	0.59	-15	15.00	0.79	0.31	Sym_Beta	4	50
SizeSel_15P_1_S11_SEAMAP_LL_SE	93.57	35	258.00	95.74	2.85	No_prior	NA	NA
SizeSel_15P_4_S11_SEAMAP_LL_SE	7.97	-15	15.00	8.09	0.26	No_prior	NA	NA
SzSel_15Male_Ascend_S11_SEAMAP_LL_SE	-0.37	-15	15.00	-0.12	0.42	No_prior	NA	NA
SzSel_15Male_Descend_S11_SEAMAP_LL_SE	-0.28	-15	15.00	-0.60	0.32	No_prior	NA	NA
SzSel_15Male_Scale_S11_SEAMAP_LL_SE	1.17	-15	15.00	1.16	0.21	No_prior	NA	NA

Table 3.2.4 Estimated recruitment deviations in the base case model configuration.

Label	Value	Parm_StDev	Prior	Pr_SD
Early_RecrDev_1970	-0.00862	0.179221	NA	NA
Early_RecrDev_1971	-0.01046	0.179053	NA	NA
Early_RecrDev_1972	-0.01074	0.178952	NA	NA
Early_RecrDev_1973	-0.00977	0.178864	NA	NA
Early_RecrDev_1974	-0.01185	0.178611	NA	NA
Early_RecrDev_1975	-0.00557	0.17884	NA	NA
Early_RecrDev_1976	0.00228	0.179649	NA	NA
Early_RecrDev_1977	0.011069	0.180348	NA	NA
Early_RecrDev_1978	0.03191	0.181665	NA	NA
Early_RecrDev_1979	0.042635	0.181954	NA	NA
Main_RecrDev_1980	0.034115	0.180875	NA	NA
Main_RecrDev_1981	0.035592	0.181527	NA	NA
Main_RecrDev_1982	0.042194	0.182736	NA	NA
Main_RecrDev_1983	0.055566	0.181956	NA	NA
Main_RecrDev_1984	0.033023	0.181476	NA	NA
Main_RecrDev_1985	-0.00221	0.178008	NA	NA
Main_RecrDev_1986	-0.01434	0.176295	NA	NA
Main_RecrDev_1987	-0.0342	0.175035	NA	NA
Main_RecrDev_1988	-0.05862	0.172592	NA	NA
Main_RecrDev_1989	-0.09764	0.169649	NA	NA
Main_RecrDev_1990	-0.12103	0.167203	NA	NA
Main_RecrDev_1991	-0.11763	0.166917	NA	NA
Main_RecrDev_1992	-0.11533	0.165902	NA	NA
Main_RecrDev_1993	-0.11451	0.167249	NA	NA
Main_RecrDev_1994	-0.09349	0.168192	NA	NA
Main_RecrDev_1995	-0.06212	0.168795	NA	NA
Main_RecrDev_1996	0.00675	0.172536	NA	NA
Main_RecrDev_1997	0.060591	0.174442	NA	NA
Main_RecrDev_1998	0.068298	0.17333	NA	NA
Main_RecrDev_1999	0.062987	0.1753	NA	NA
Main_RecrDev_2000	0.037741	0.172224	NA	NA
Main_RecrDev_2001	0.060012	0.165824	NA	NA
Main_RecrDev_2002	-0.00839	0.170931	NA	NA
Main_RecrDev_2003	0.094234	0.164966	NA	NA
Main_RecrDev_2004	0.137962	0.171418	NA	NA
Main_RecrDev_2005	0.512331	0.164567	NA	NA
Main_RecrDev_2006	0.300625	0.173098	NA	NA
Main_RecrDev_2007	0.108021	0.164314	NA	NA
Main_RecrDev_2008	0.025818	0.159392	NA	NA
Main_RecrDev_2009	-0.27804	0.1592	NA	NA
Main_RecrDev_2010	0.024232	0.157528	NA	NA

Table 3.2.4 Continued

Main_RecrDev_2011	-0.10821	0.162006	NA	NA
Main_RecrDev_2012	0.041292	0.156103	NA	NA
Main_RecrDev_2013	0.074059	0.157449	NA	NA
Main_RecrDev_2014	0.002395	0.153092	NA	NA
Main_RecrDev_2015	-0.17569	0.15647	NA	NA

Table 3.2.5. Estimated total biomass (in whole weight, mt), spawning stock fecundity (1000s) and recruits (1000s) in the base case model configuration

Year	Total biomass	Spawning stock fecundity	Recruits
1960	97218	1505	533
1961	97204	1505	533
1962	97190	1505	533
1963	97175	1505	533
1964	97159	1504	533
1965	97142	1504	533
1966	97125	1504	533
1967	97106	1503	533
1968	97088	1503	533
1969	97068	1503	533
1970	97038	1502	528
1971	96998	1502	527
1972	96947	1501	527
1973	96889	1501	527
1974	96822	1501	526
1975	96756	1500	529
1976	96701	1500	533
1977	96660	1499	538
1978	96646	1498	549
1979	96647	1497	555
1980	96574	1495	549
1981	96115	1492	550
1982	93890	1485	552
1983	91871	1478	558
1984	88483	1467	543
1985	85760	1455	521
1986	83357	1441	512
1987	80111	1416	497
1988	76562	1365	474
1989	71441	1284	439
1990	66026	1182	407
1991	61190	1093	388
1992	57259	1012	369
1993	53332	931	349
1994	50248	866	339
1995	45885	773	322
1996	42623	708	323
1997	39831	660	324
1998	37893	626	313
1999	35987	591	298

Table 3.2.5. Continued

2000	34015	557	277
2001	32834	527	271
2002	31531	494	241
2003	30143	456	250
2004	29277	426	246
2005	28950	401	340
2006	28728	378	262
2007	28325	355	205
2008	28436	345	184
2009	28797	344	136
2010	29025	345	184
2011	29133	350	163
2012	29251	358	193
2013	29417	370	205
2014	29579	383	196
2015	29665	397	169

Table 3.2.6. Estimated fishing mortality by fleet, with total fishing mortality and F/F_{MSY}.

Year	F1_COM_GOM	F2_COM_SA	F3_RecMEX	F4_MEN_DSC	F_Total	F/F_{MSY}
1960	0	0	0	0.0001	0	0.002
1961	0.0001	0	0	0.0001	0	0.003
1962	0.0001	0	0	0.0001	0	0.003
1963	0.0001	0	0	0.0001	0	0.004
1964	0.0002	0	0	0.0001	0	0.004
1965	0.0002	0	0	0.0001	0	0.005
1966	0.0002	0	0	0.0001	0	0.005
1967	0.0002	0	0	0.0001	0	0.006
1968	0.0003	0	0	0.0001	0	0.006
1969	0.0003	0	0	0.0001	0	0.007
1970	0.0003	0	0	0.0001	0.001	0.007
1971	0.0004	0	0	0.0001	0.001	0.008
1972	0.0004	0	0	0.0001	0.001	0.008
1973	0.0004	0.0001	0	0.0001	0.001	0.009
1974	0.0005	0.0001	0	0.0001	0.001	0.009
1975	0.0005	0.0001	0	0.0001	0.001	0.01
1976	0.0007	0.0001	0.0001	0.0001	0.001	0.014
1977	0.001	0.0001	0.0006	0.0001	0.002	0.025
1978	0.0014	0.0002	0.0026	0.0001	0.004	0.059
1979	0.002	0.0002	0.0114	0.0001	0.014	0.192
1980	0.0028	0.0003	0.0514	0.0001	0.055	0.763
1981	0.004	0.0005	0.2432	0.0002	0.248	3.459
1982	0.0041	0.0005	0.2043	0.0002	0.209	2.917
1983	0.0045	0.0006	0.3807	0.0002	0.386	5.385
1984	0.0064	0.0008	0.2639	0.0002	0.271	3.786
1985	0.0061	0.0008	0.2185	0.0002	0.226	3.148
1986	0.019	0.002	0.2966	0.0002	0.318	4.435
1987	0.0578	0.0059	0.1701	0.0002	0.234	3.267
1988	0.0901	0.0147	0.2643	0.0002	0.369	5.154
1989	0.1322	0.0191	0.1956	0.0003	0.347	4.844
1990	0.1207	0.0129	0.2846	0.0003	0.418	5.839
1991	0.1325	0.0031	0.244	0.0002	0.38	5.301
1992	0.1112	0.0132	0.2707	0.0002	0.395	5.516
1993	0.0771	0.0122	0.264	0.0002	0.353	4.932
1994	0.171	0.0211	0.2588	0.0003	0.451	6.295
1995	0.1014	0.0195	0.3203	0.0003	0.441	6.16
1996	0.0609	0.017	0.4199	0.0003	0.498	6.949
1997	0.043	0.0111	0.3328	0.0003	0.387	5.402
1998	0.0532	0.0135	0.3068	0.0003	0.374	5.215
1999	0.0431	0.0225	0.3078	0.0004	0.374	5.215
2000	0.0538	0.0175	0.123	0.0003	0.195	2.716

Table 3.2.6. Continued.

Year	F1_COM_GOM	F2_COM_SA	F3_RecMEX	F4_MEN_DSC	F_Total	F/FMSY
2001	0.0787	0.0175	0.1386	0.0003	0.235	3.279
2002	0.101	0.0277	0.0863	0.0003	0.215	3.004
2003	0.0864	0.0207	0.0745	0.0003	0.182	2.54
2004	0.065	0.0193	0.0722	0.0003	0.157	2.189
2005	0.058	0.0213	0.0646	0.0003	0.144	2.012
2006	0.0835	0.0206	0.0657	0.0003	0.17	2.372
2007	0.0245	0.012	0.0714	0.0003	0.108	1.509
2008	0.0029	0.0018	0.0549	0.0003	0.06	0.834
2009	0.0112	0.0015	0.0548	0.0003	0.068	0.946
2010	0.0071	0.001	0.0644	0.0003	0.073	1.015
2011	0.0087	0.0013	0.042	0.0003	0.052	0.73
2012	0.0042	0.0006	0.0535	0.0003	0.059	0.818
2013	0.0032	0.001	0.0513	0.0003	0.056	0.778
2014	0.0029	0.0019	0.0454	0.0002	0.05	0.704
2015	0.0041	0.0026	0.0468	0.0002	0.054	0.75

Table 3.2.7. Alternative states of nature scenarios evaluated for CPUE and productivity as defined in the main text. Bold text indicates base case.

GROUP	Scenario
	CPUE
CPUE scenario 1	**All CPUE SERIES**
CPUE scenario 2	"POS_1" CPUE group (S2_BLLOP1, S3_BLLOP_2, S4_VA_LL, S5_NMFS_LLSE, S7_NMFS_NE) 1.1.1.1.
CPUE scenario 3	"NEG" CPUE group (S1_LPS, S6_CST_NE_LL, S8_PLLOP, S9_COASTSPAN_SE_LL, S10_SCDNR_RedDr, S11_SEAMAP_LL_SE)
	Productivity
Productivity scenario 1	3 year reproductive cycle, pup survival reduced to 0.80, and natural mortality (M) for ages 1-max increased by 10%.
Productivity scenario 2	**2.5 year reproductive cycle, and** **pup survival as described in Section 2.**
Productivity scenario 3	2 year reproductive cycle, pup survival increased to 0.90, M for ages 1-max decreased by 10%, and constant fecundity of 9.65 pups.

Table 3.2.8. Reference points for base case model configuration and for alternative state of nature scenarios evaluated for CPUE and productivity as defined in the main text and Table 3.2.7 above. Stock status in 2015 relative to MSY based reference points is in the grey shaded rows. Bold text indicates base case model configuration.

CPUE Group Productivity	BASE Low	**BASE** **Medium**	BASE High	POS_1 Low	POS_1 Medium	POS_1 High	NEG Low	NEG Medium	NEG High
Catch2015/MSY	0.45	**0.47**	0.52	0.29	0.3	0.33	0.53	0.55	0.6
MSY	437	**417**	380	668	648	588	373	356	327
B_0	91,517	**97,218**	111,766	140,037	151,134	173,539	78,004	83,028	96,403
B_{MSY}	40,150	**42,778**	49,480	61,429	66,495	76,821	34,211	36,520	42,655
SSF_0	1,082	**1,505**	2,497	1,656	2,340	3,878	922	1,286	2,154
SSF_{MSY}	475	**662**	1,106	726	1,030	1,717	405	566	953
SSF_{2015}/SSF_{MSY}	0.61	**0.6**	0.58	1.28	1.28	1.26	0.26	0.26	0.28
F_{MSY}	0.07	**0.07**	0.07	0.07	0.07	0.07	0.07	0.07	0.07
F_{2015}/F_{MSY}	0.71	**0.75**	0.85	0.24	0.24	0.27	1.92	2	2.06
SSF_{2015}	288	**397**	640	928	1317	2156	106	148	264
F_{2015}	0.05	**0.05**	0.06	0.02	0.02	0.02	0.14	0.14	0.15
Total Biomass 2015	28,261	**29,665**	32,698	84,853	91,593	102,886	10,497	11,181	13,693
MSST	415	**578**	966	634	900	1,500	354	495	833

Table 3.2.9. Estimated stock status based on MCMC analysis for the base case model configuration (Base) and two alternative states of nature scenarios evaluated for CPUE (POS_1, NEG) with the base case productivity scenario as defined in the main text and Table 3.2.8 above, and for all of the above combined (overall). Values shown are the probabilities of being in that particular quadrant of the phase (Kobe) plot: red (overfished and overfishing); orange (not overfished but overfishing); yellow (overfished but no overfishing); green (not overfished and no overfishing).

	Quadrant			
	1	2	3	4
Base	**1.8%**	**0.0%**	**97.3%**	**0.8%**
CPUE scenario				
POS_1	**0.0%**	**0.0%**	**1.0%**	**99.0%**
NEG	**99.8%**	**0.0%**	**0.2%**	**0.0%**
Overall	**33.9%**	**0.0%**	**32.9%**	**33.3%**

Table 3.2.10. Projections based on CPUE groupings and TAC levels (in whole weight) from MLE projections and MCMC analysis. For the base case (Base), projections were implemented with constant TAC allowing rebuilding of stock by 2070 with 50% and 70% probability (TOR 4A). Under the NEG CPUE grouping, projections were implemented with constant TAC allowing rebuilding of stock by 2111 with 50% and 70% probability (TOR 4B). Under the POS_1 CPUE grouping, a projection model (TOR 4D), analogous to a P* approach associated with a 70% probability of overfishing not occurring (P* = 0.3), was implemented that projected with constant TAC so that the probability of overfishing was less than or equal to 30% in the current rebuilding year, 2070.

CPUE Group	Probability of Rebuilding by Year Rebuild	Year Rebuild	TAC Based on MLE Projections	50th Quantile (of SSF$_{YR\_rebuild}$/SSF$_{MSY}$) based on MCMC Projections
Base	70%	2070	148	1.18
Base	50%	2070	208	1.04
NEG	70%	2111	53	1.16
NEG	50%	2111	71	1.07
POS_1	70%	2070	677	1.4

Table 3.2.11. Comparison of MLE estimates and the 50th quantile of the MCMC estimates.

Parameter	MLE Estimate	MCMC 50th Quantile
SR_LN(R0)	6.279	6.309
SizeSel_1P_1_F1_COM_GOM	149.427	149.537
SizeSel_1P_3_F1_COM_GOM	5.451	5.463
SizeSel_1P_4_F1_COM_GOM	5.608	5.614
SzSel_1Male_Ascend_F1_COM_GOM	0.744	0.730
SzSel_1Male_Scale_F1_COM_GOM	0.673	0.679
SizeSel_2P_1_F2_COM_SA	93.632	94.907
SizeSel_2P_2_F2_COM_SA	29.720	34.870
SizeSel_3P_1_F3_RecMEX	55.059	54.968
SizeSel_3P_2_F3_RecMEX	-9.999	-9.971
SizeSel_5P_1_S1_LPS	155.527	157.816
SizeSel_5P_3_S1_LPS	7.303	7.386
SizeSel_5P_4_S1_LPS	14.632	12.320
SizeSel_8P_1_S4_VA_LL	45.023	43.868
SizeSel_8P_3_S4_VA_LL	-9.361	-2.699
SizeSel_9P_1_S5_NMFS_LLSE	161.846	162.655
SizeSel_9P_3_S5_NMFS_LLSE	7.150	7.235
SizeSel_9P_4_S5_NMFS_LLSE	5.609	5.596
SzSel_9Male_Peak_S5_NMFS_LLSE	-6.152	-6.570
SzSel_9Male_Ascend_S5_NMFS_LLSE	-0.657	-0.704
SzSel_9Male_Descend_S5_NMFS_LLSE	-0.804	-0.914
SzSel_9Male_Scale_S5_NMFS_LLSE	0.735	0.766
SizeSel_10P_1_S6_CST_NE_LL	57.026	56.783
SizeSel_10P_3_S6_CST_NE_LL	-8.038	-5.558
SizeSel_10P_4_S6_CST_NE_LL	7.576	7.594
SzSel_10Male_Peak_S6_CST_NE_LL	5.360	5.797
SzSel_10Male_Ascend_S6_CST_NE_LL	10.920	8.643
SzSel_10Male_Descend_S6_CST_NE_LL	-0.793	-0.841
SzSel_10Male_Scale_S6_CST_NE_LL	1.076	1.101
SizeSel_11P_1_S7_NMFS_NE	132.668	131.879
SizeSel_11P_3_S7_NMFS_NE	8.034	8.107
SizeSel_11P_4_S7_NMFS_NE	6.324	6.627
SzSel_11Fem_Scale_S7_NMFS_NE	2.319	2.601
SizeSel_12P_1_S8_PLLOP	147.300	149.481
SizeSel_12P_3_S8_PLLOP	6.524	6.899
SzSel_12Male_Ascend_S8_PLLOP	-0.428	-0.423
SzSel_12Male_Descend_S8_PLLOP	-1.194	-1.439
SzSel_12Male_Scale_S8_PLLOP	1.446	1.739
SizeSpline_Val_1_S9_COASTSPAN_SE_LL_13	3.356	3.384
SizeSpline_Val_2_S9_COASTSPAN_SE_LL_13	2.543	2.564
SizeSpline_Val_3_S9_COASTSPAN_SE_LL_13	2.001	2.044
SizeSpline_Val_4_S9_COASTSPAN_SE_LL_13	-1.045	-1.032

SizeSel_14P_1_S10_SCDNR_RedDr	92.854	93.974
SzSel_14Male_Ascend_S10_SCDNR_RedDr	1.578	7.492
SzSel_14Male_Descend_S10_SCDNR_RedDr	-0.311	-0.022
SzSel_14Male_Scale_S10_SCDNR_RedDr	0.592	0.523
SizeSel_15P_1_S11_SEAMAP_LL_SE	93.568	93.157
SizeSel_15P_4_S11_SEAMAP_LL_SE	7.974	8.045
SzSel_15Male_Ascend_S11_SEAMAP_LL_SE	-0.369	-0.437
SzSel_15Male_Descend_S11_SEAMAP_LL_SE	-0.280	-0.308
SzSel_15Male_Scale_S11_SEAMAP_LL_SE	1.170	1.217

6 FIGURES

6.1 FIGURES FROM SECTION 3.1 Replication Analysis

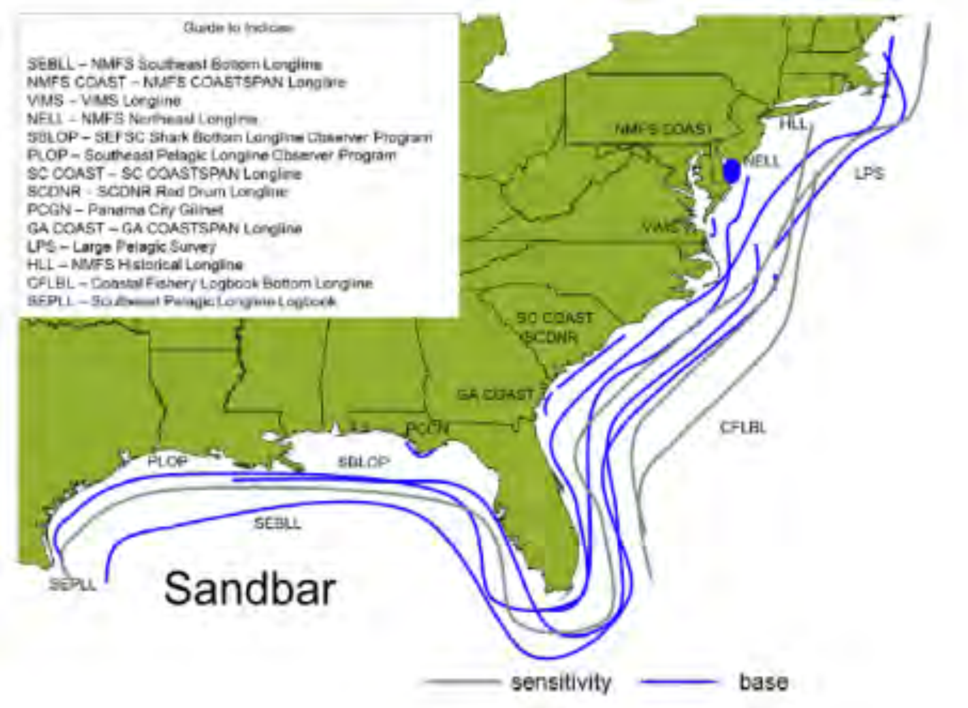


Figure 3.1.1. Approximate linear coverage of specific abundance indices for sandbar sharks *(Carcharhinus plumbeus*) along the coast of the Gulf of Mexico and Atlantic Ocean. Blue lines indicate the indices of abundance used in the SEDAR 21 base case assessment, as well as in the SEDAR 54 replication analysis. Grey lines indicate indices of abundance used in the SEDAR 21 sensitivity analysis.

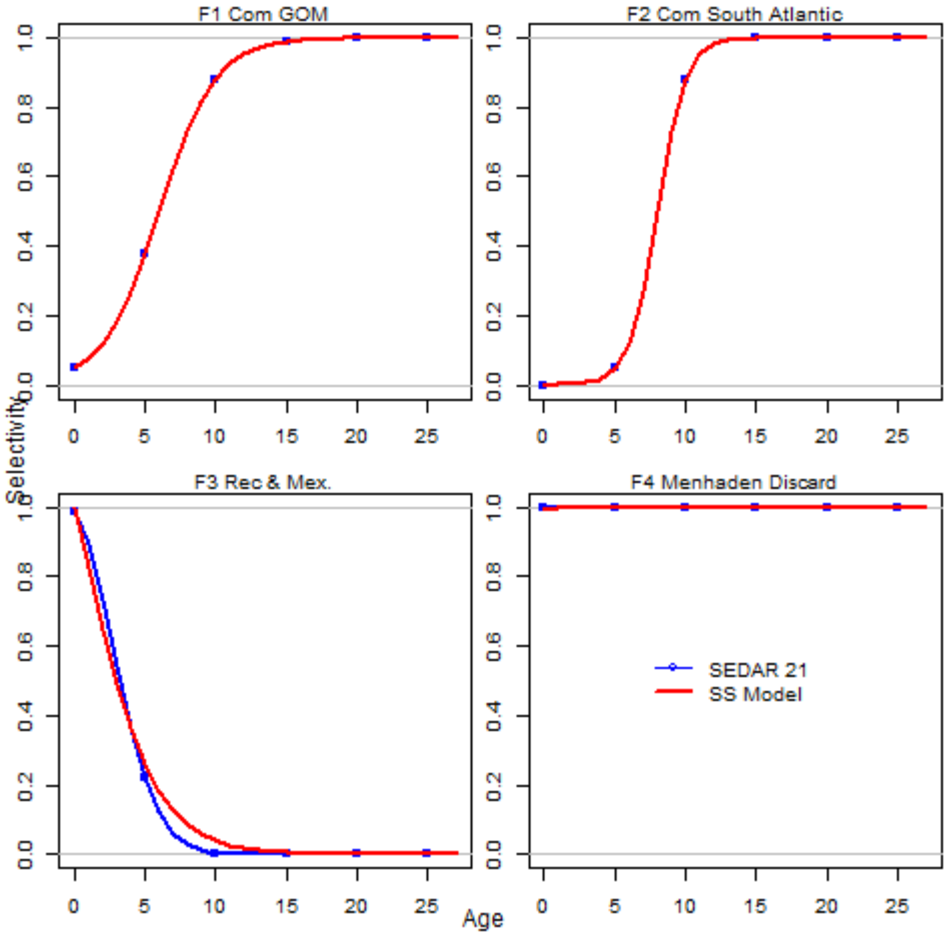


Figure 3.1.2. Selectivity of the catches showing the selectivity forms from SEDAR 21 (blue lines) and the forms used in the SEDAR 54 replication analysis (red lines).

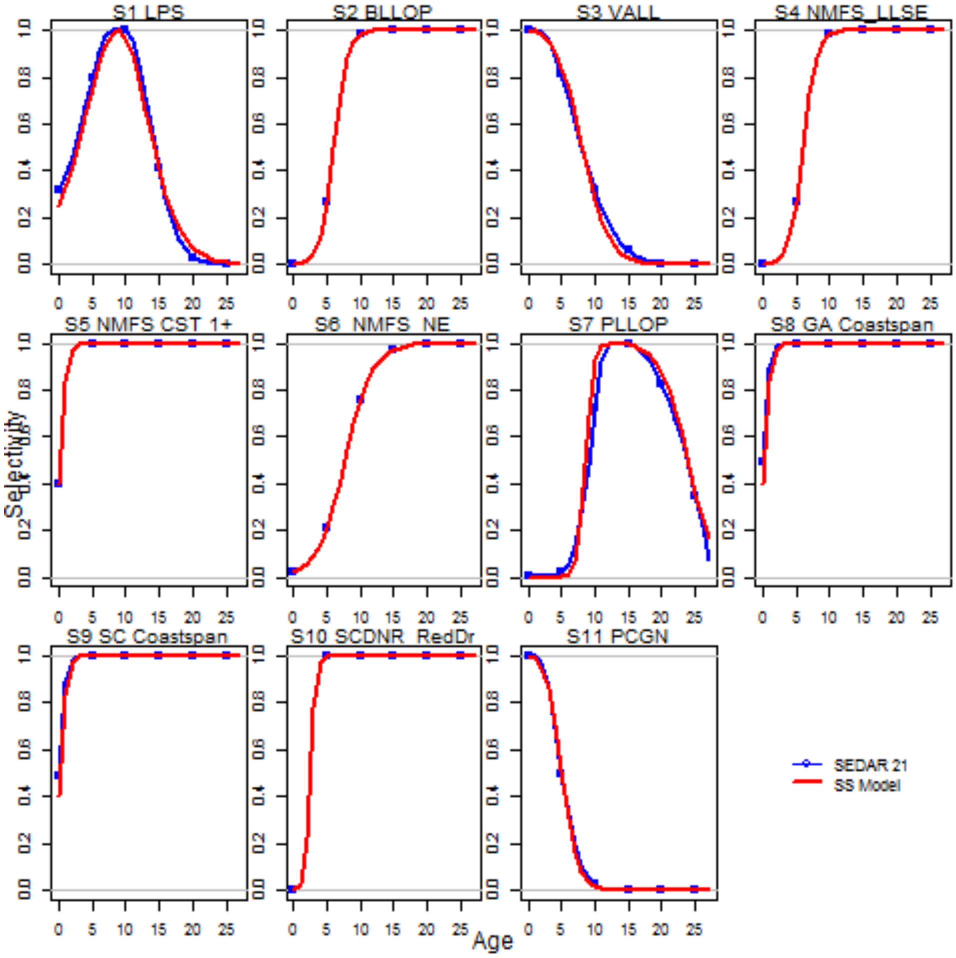


Figure 3.1.3. Selectivity of the indices of abundance showing the SEDAR 21 selectivity forms (blue lines) and the forms used in the SEDAR 54 replication analysis(red lines).

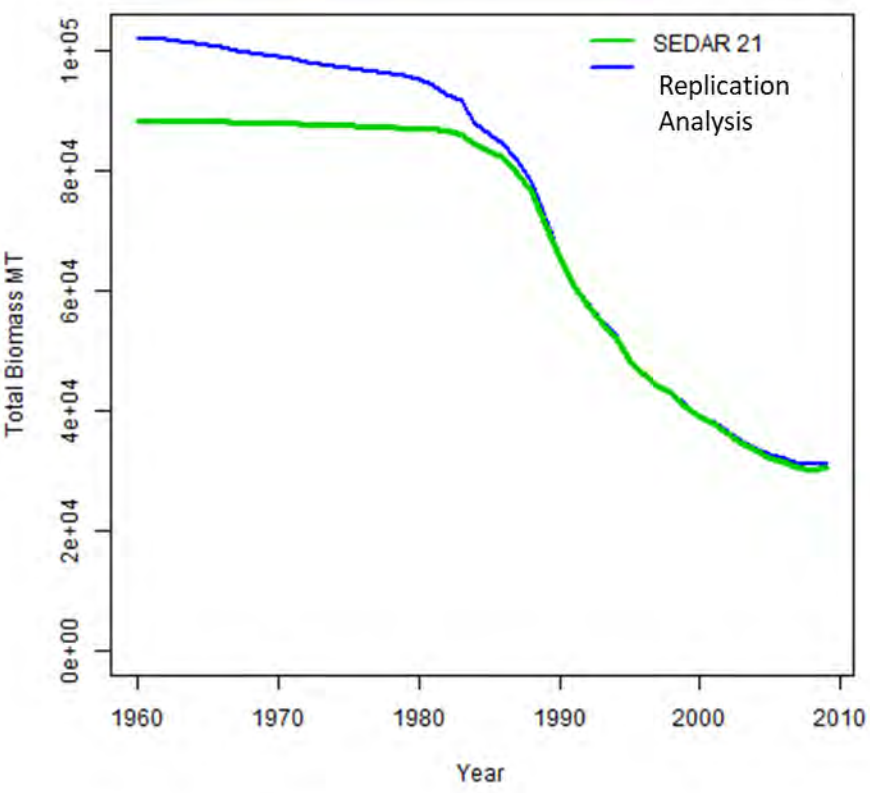


Figure 3.1.4. Comparison of biomass trends from the SEDAR 21 analysis and the SEDAR 54 replication analysis.

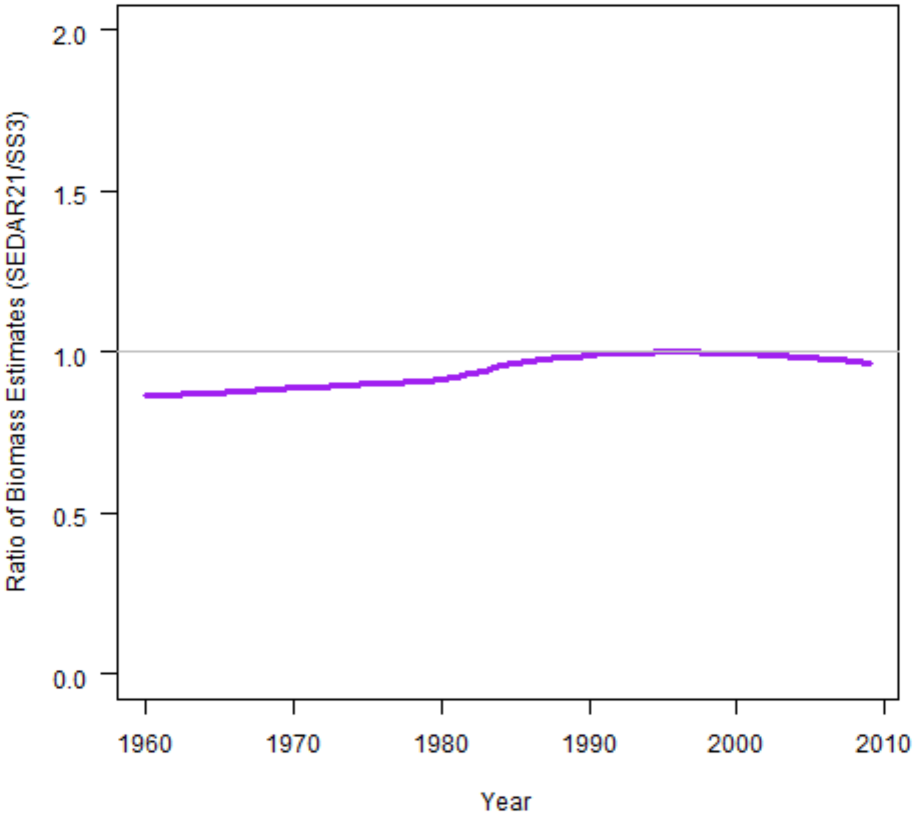


Figure 3.1.5. Ratio of total biomass estimates (SEDAR 21/ SEDAR 54 replication analysis) over the model time frame, the equivalence line is shown in grey.

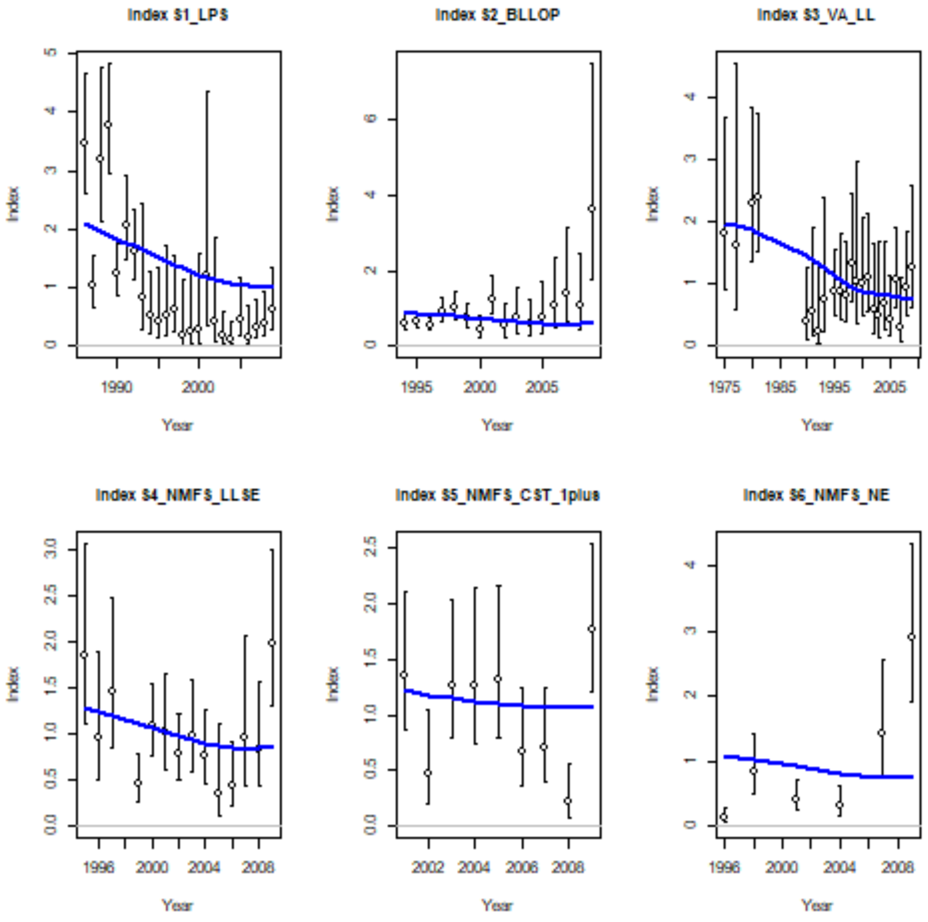
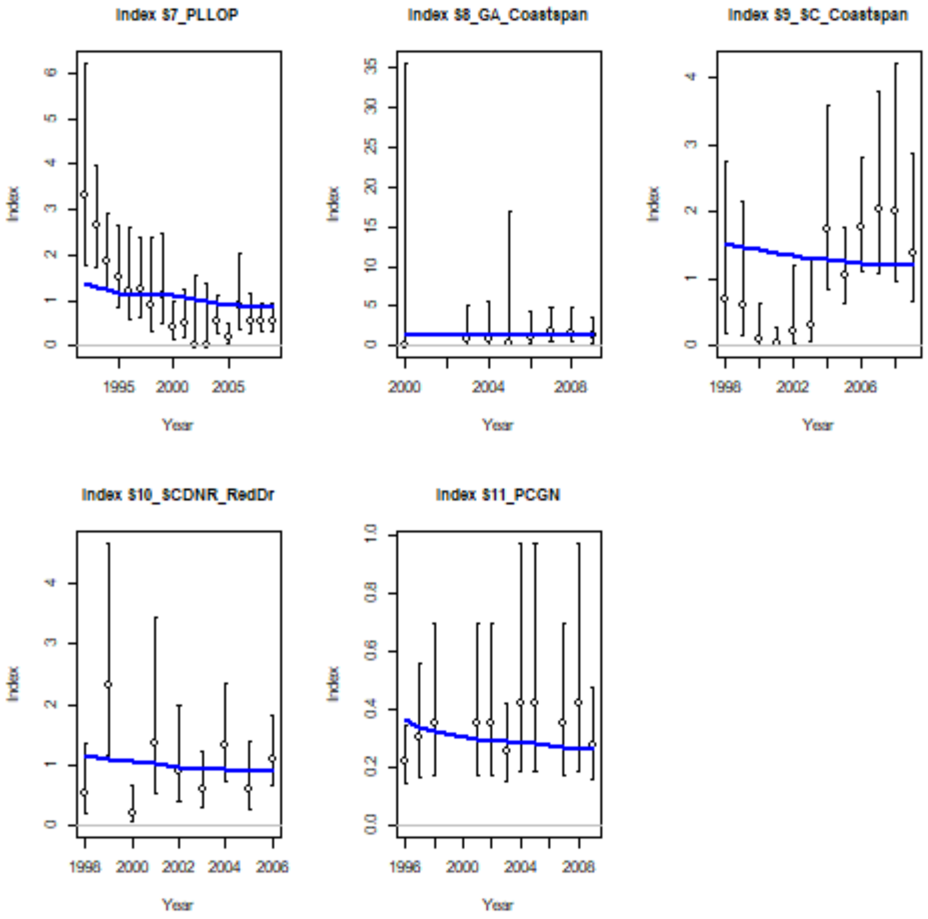


Figure 3.1.6. Model fits (blue line) to the CPUE series from the replication analysis (black circles are observed data) with associated CVs (black vertical lines). Fits for indices S1-S6 are shown.



Index S7_PLLOP

Index S8_GA_Coastspan

Index S9_SC_Coastspan

Index S10_SCDNR_RedDr

Index S11_PCGN

Figure 3.1.7 Model fits (blue line) to the CPUE series from the replication analysis (black circles are observed data) with associated CVs (black vertical lines). Fits for indices S7-S11 are shown.

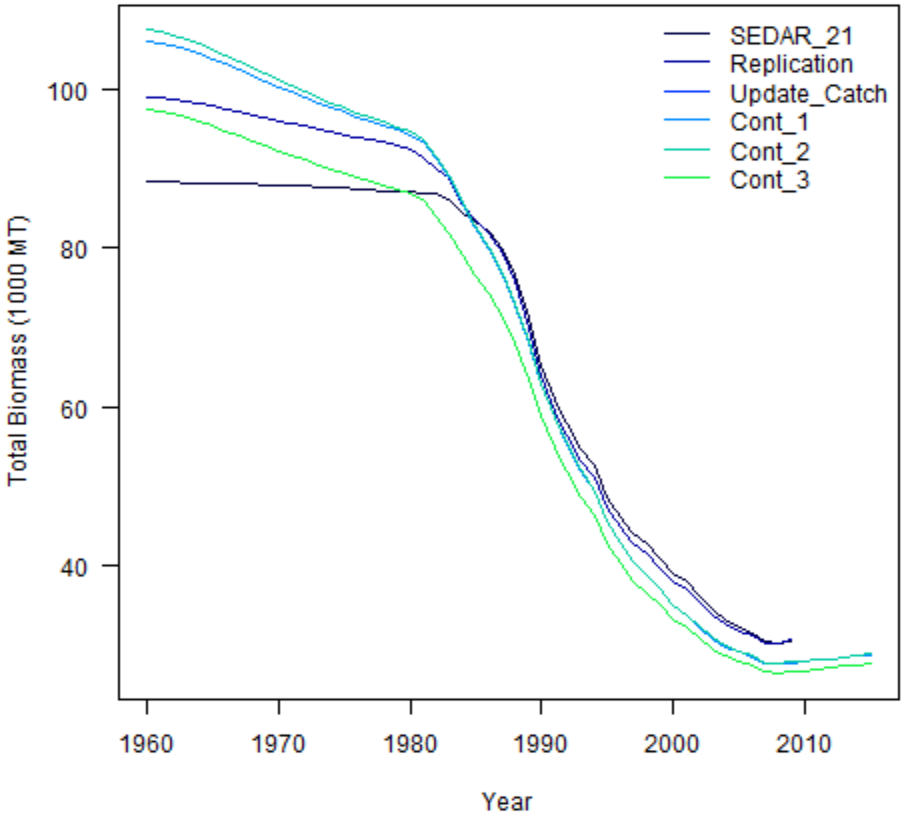


Figure 3.1.8 Estimated total biomass from the SEDAR 21 report, the replication analysis and the four continuity runs (Update_catch, Cont_1, Cont_2, and Cont_3) for the SEDAR 54 assessment. Note that continuity run #1 (Cont_1) overlays the Update_Catch run.

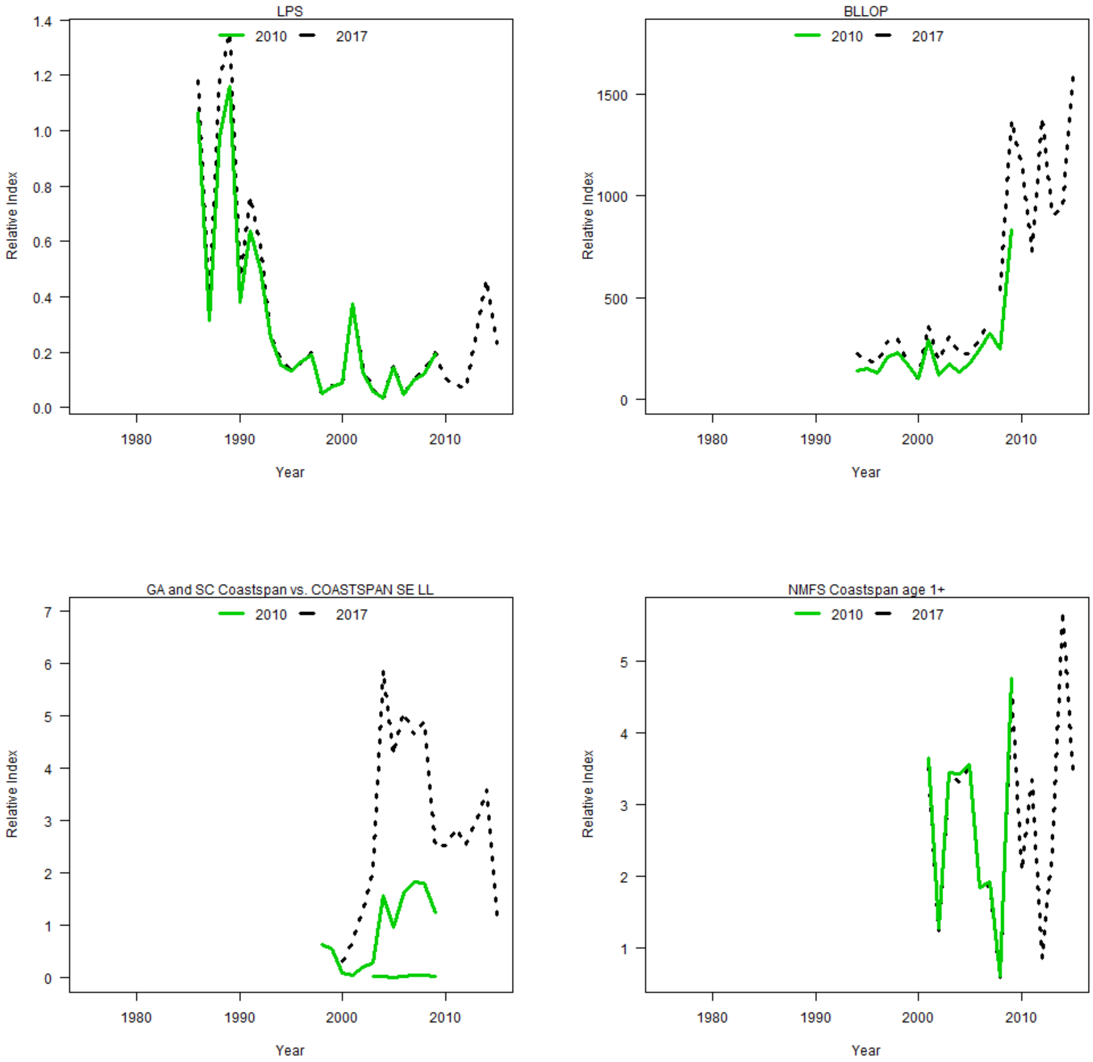


Figure 3.1.9 Comparison of CPUE series used in the SEDAR 21 and the series used in SEDAR 54 assessment; the black dotted line indicates the updated CPUE series used in SEDAR 54 for the base case. The top left panel is S1 LPS, the top right is the S2 and S3 BLLOP series, the bottom left is S9 Coastspan SE LL (compared to the GA and SC coastspan indices used in SEDAR 21), and the bottom right panel shows the S6 NMFS Coastspan 1+ survey.

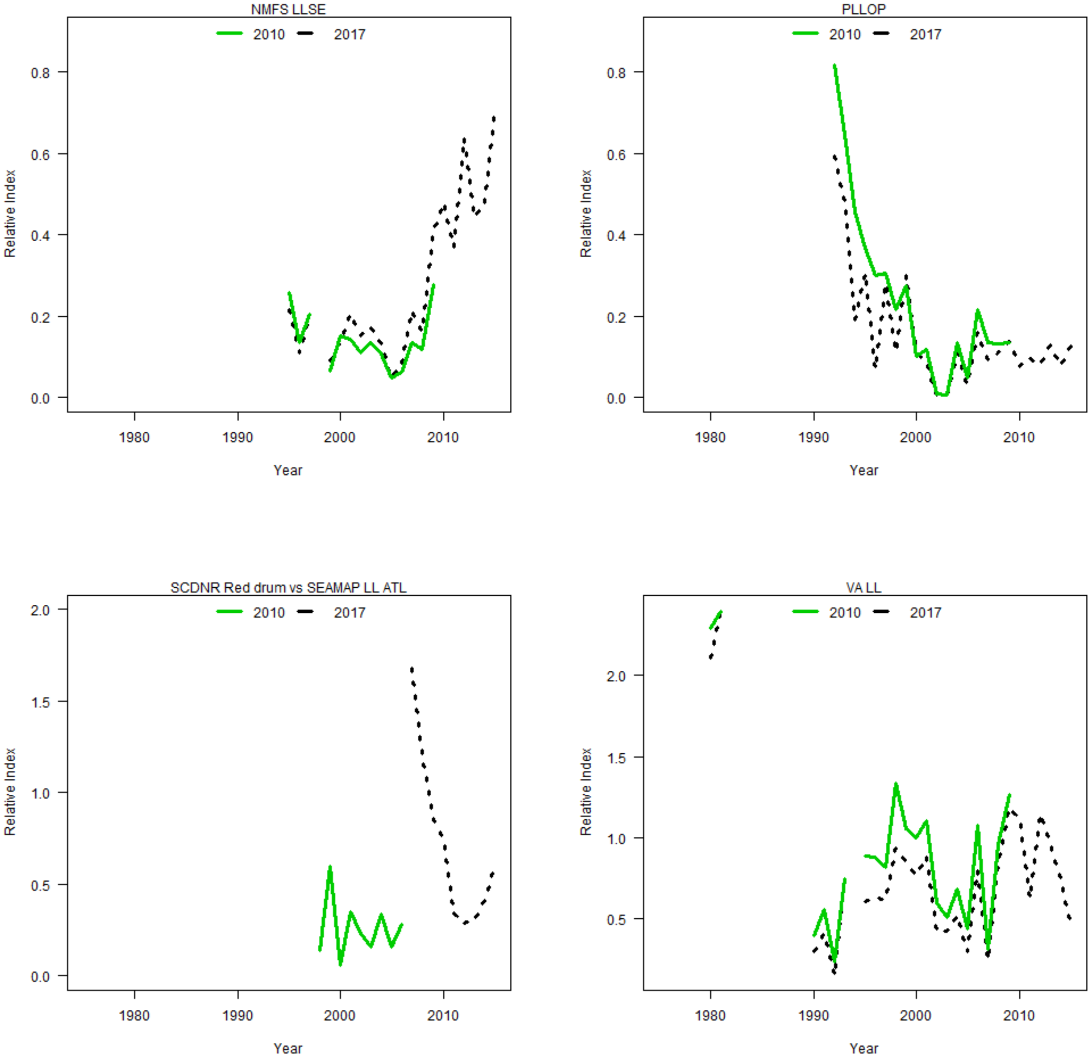


Figure 3.1.10. Comparison of CPUE series used in the SEDAR 21 and the series used in SEDAR 54 assessment; the black dotted line indicates the updated CPUE series used in SEDAR 54 for the base case. The top left panel is S5 NMFS LLSE, the top right is S8 PLLOP, the bottom left is S10 SCDNR Red drum (note that this index has not changed from SEDAR 21) and S11 SEAMAP LL SE, and the bottom right panel shows the S4 Virginia LL survey.

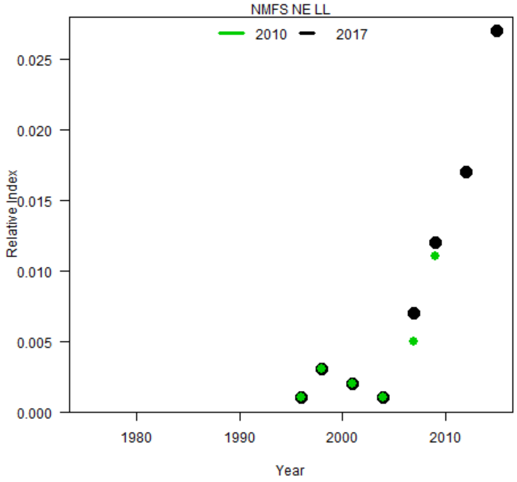


Figure 3.1.11 Comparison of CPUE series used in the SEDAR 21 and the series used in SEDAR 54 assessment; the black dotted line indicates the updated CPUE series used in SEDAR 54 for the base case. This figure shows S7 NMFS NE LL.

6.2 FIGURES FROM SECTION 3.2 BASE CASE

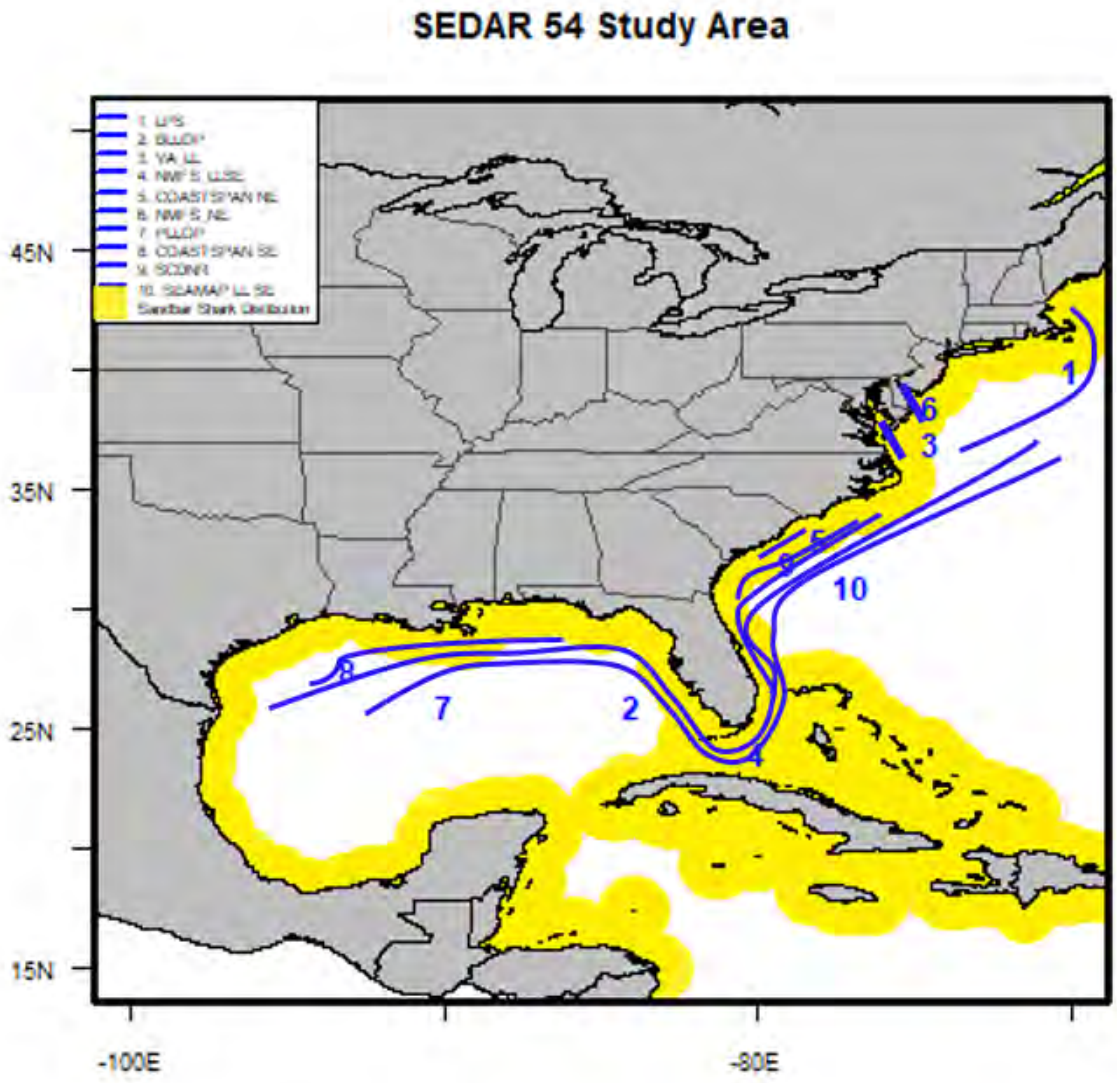


Figure 3.2.1 Spatial extent of the CPUE data used in the base case model configuration in this assessment (SEDAR 54). The blue lines represent individual CPUE series and the yellow area indicates the distribution of the sandbar shark in the western North Atlantic and Gulf of Mexico.

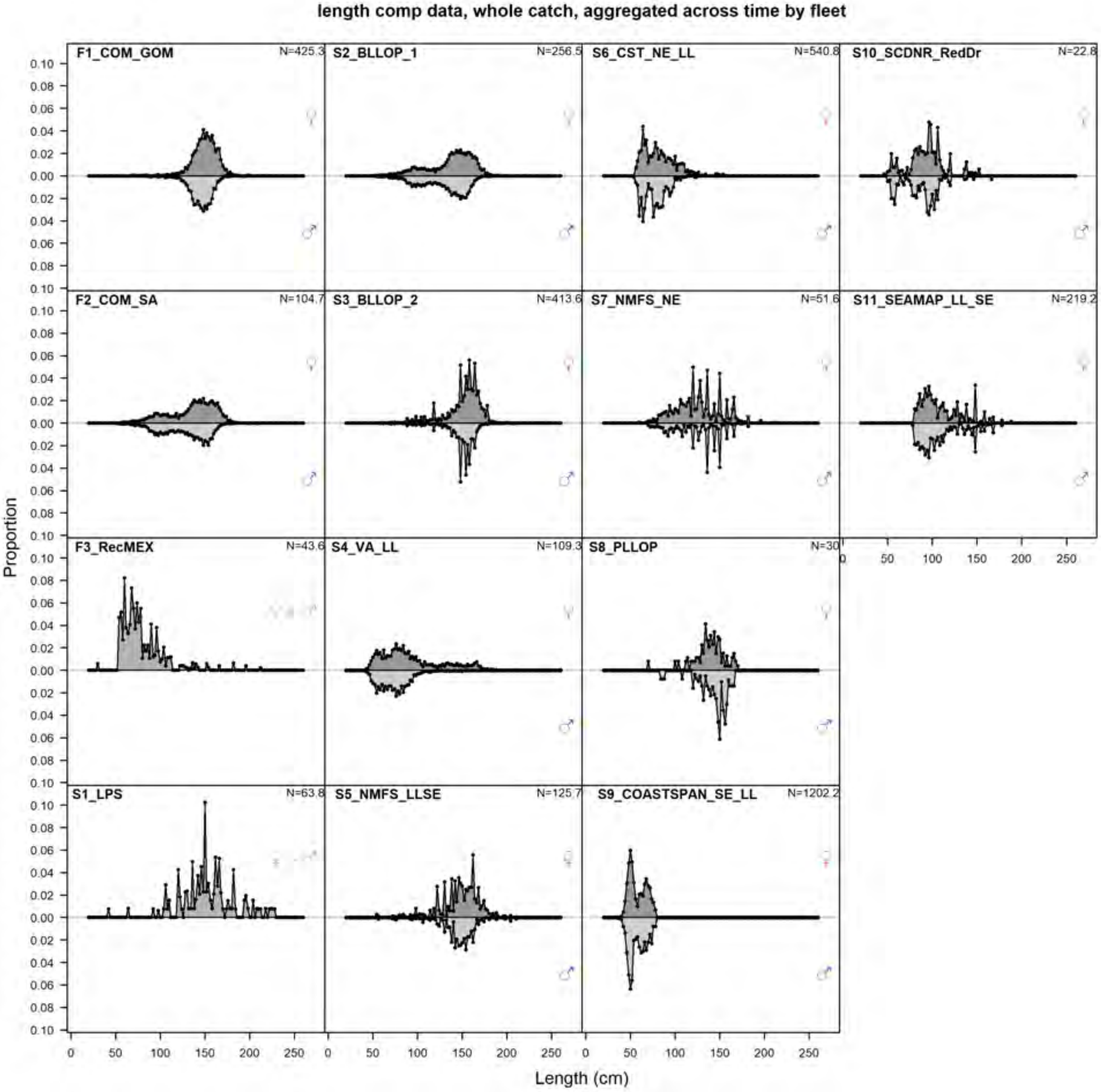


Figure 3.2.2. Available length frequency data by fishery and survey, aggregated across years, used in the base case model configuration

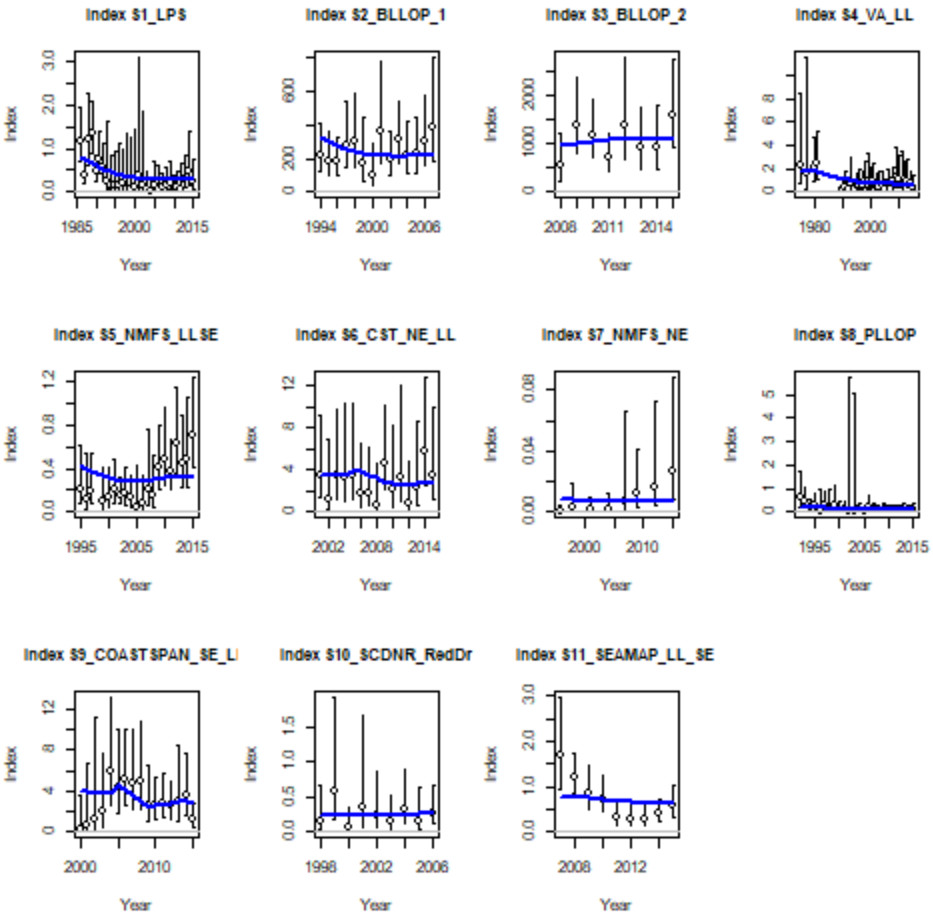


Figure 3.2.3 Fits to indices of abundance for the base case model configuration.

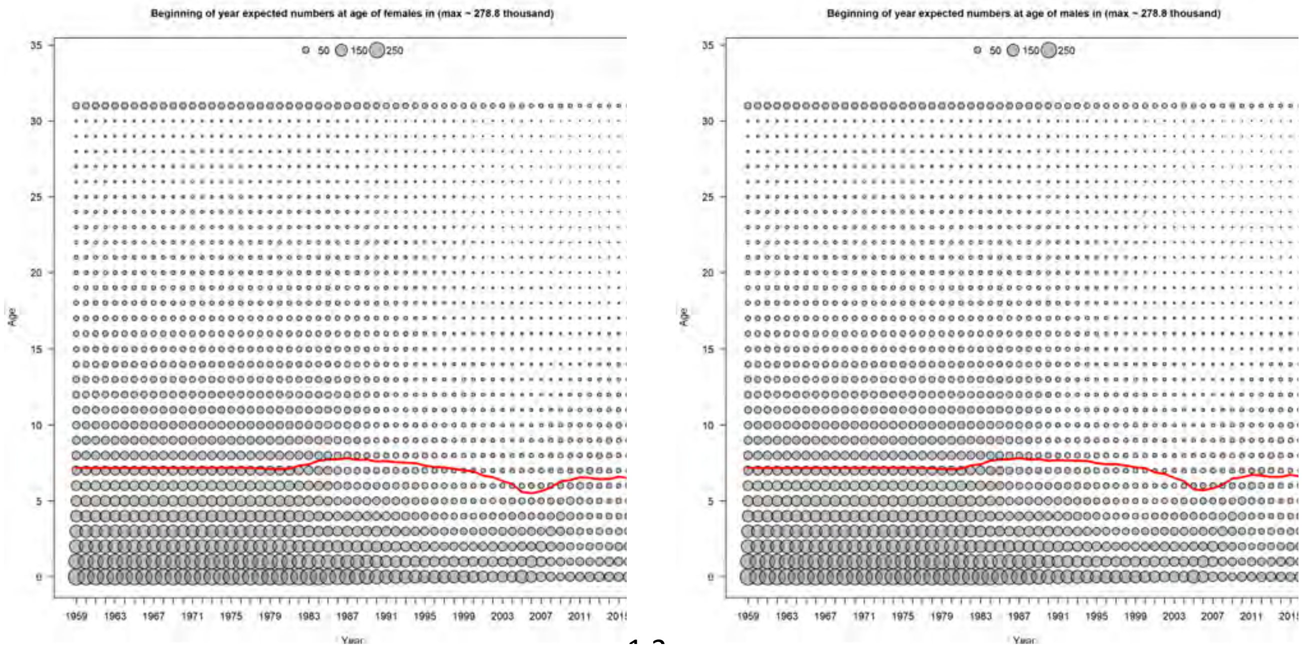


Figure 3.24 Estimated numbers at age of female (left panel) and male (right panel) by year for the base case model configuration.

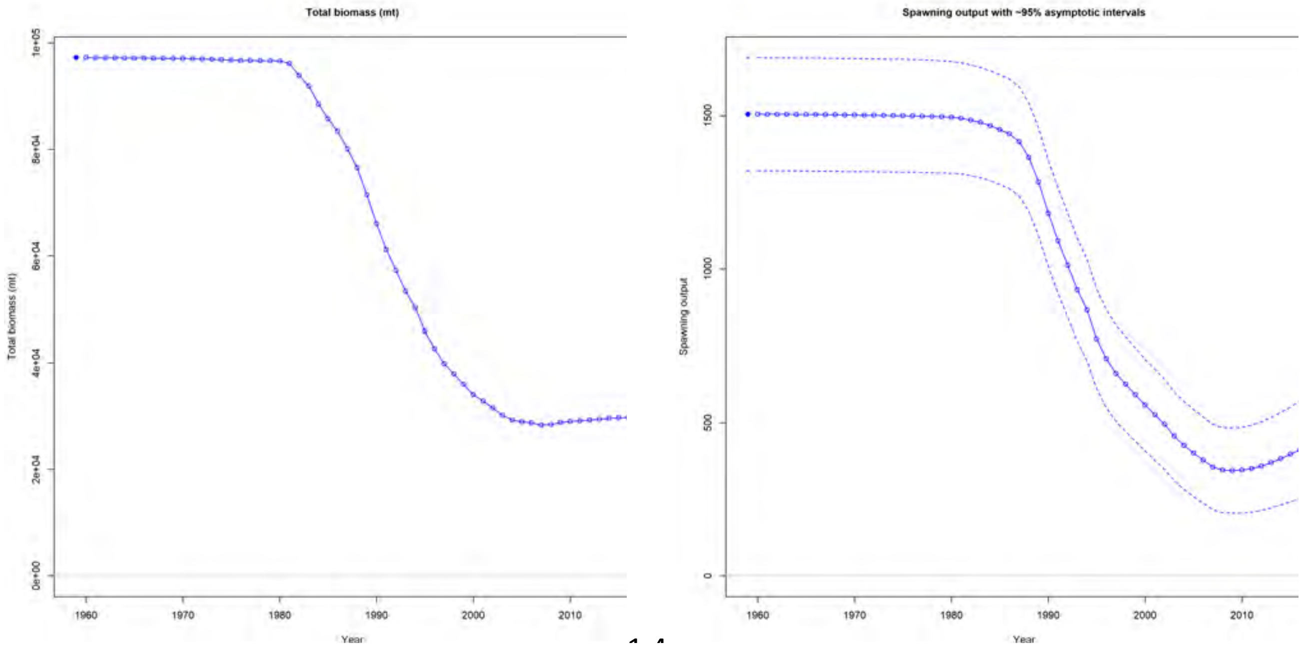


Figure 3.2.5. Estimated total biomass (left panel) and spawning output (SSF, right panel) by year for the base case model configuration.

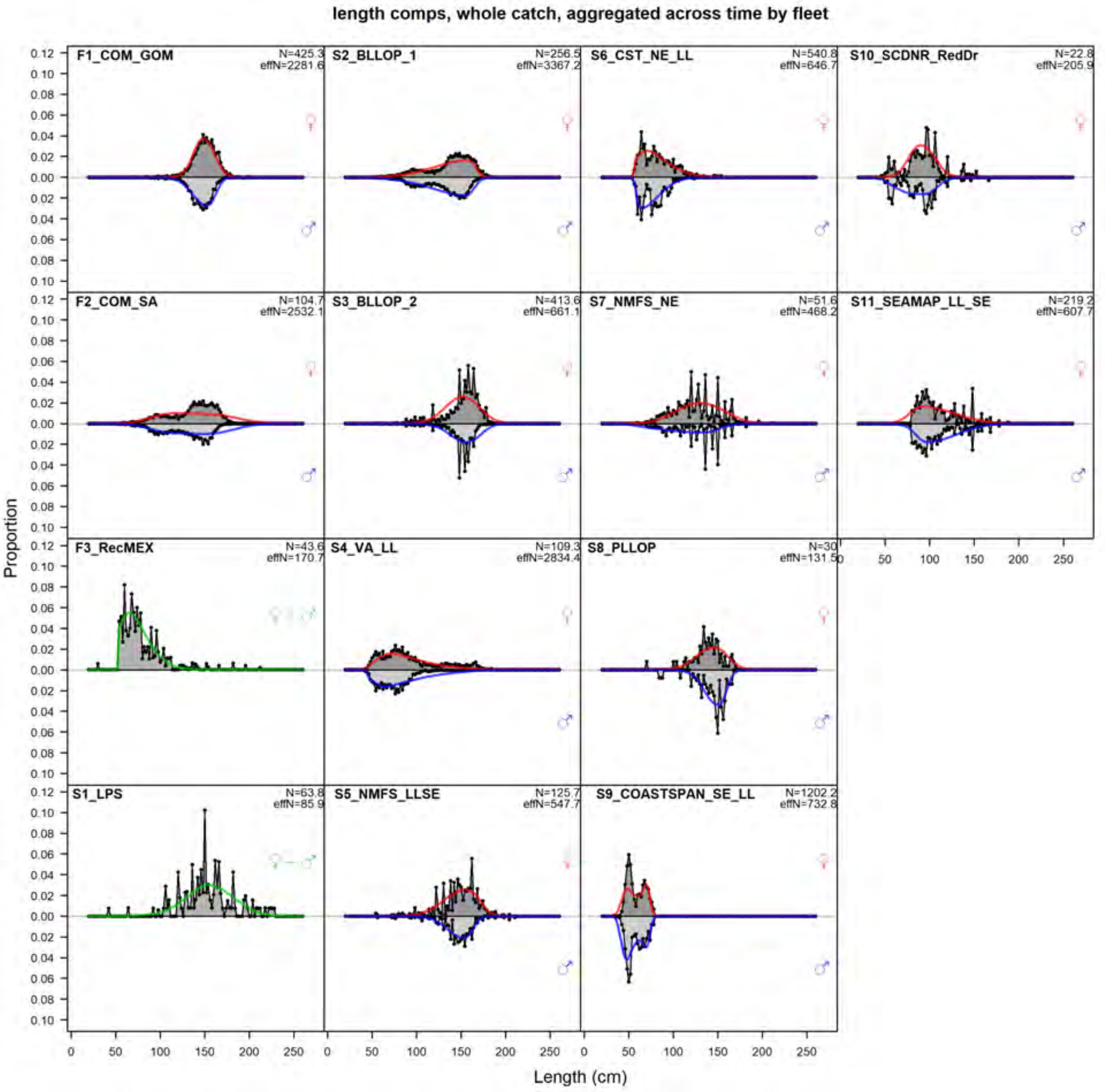


Figure 3.2.6. **.** Fits of the estimated length compositions to the length composition by fleet for the base case model configuration. Where possible the sex specific selectivity was estimated. For sex specific length compositions (all except F3 and S1) the top half of each panel shows the female length composition and estimated fit, while the bottom shows the male length compositions and corresponding fits.

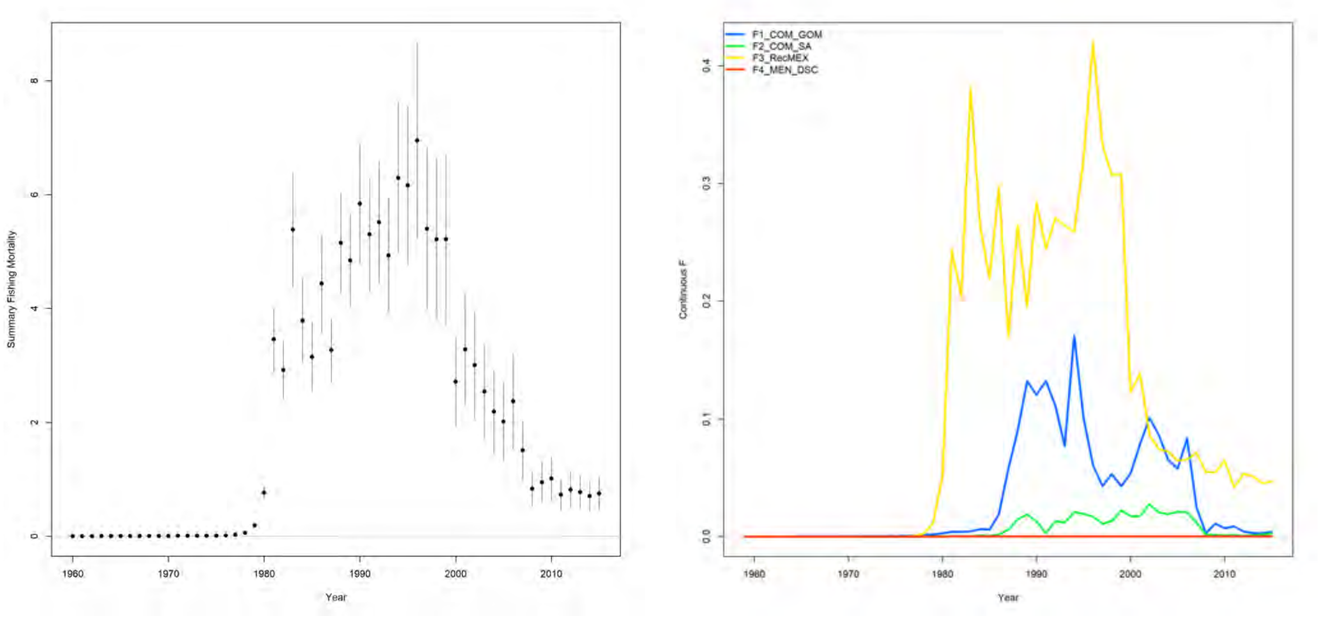


Figure 3.2.7. Estimated F/F_{MSY} (left panel) and fleet specific (right panel) fishing mortality by year for the base case model configuration.

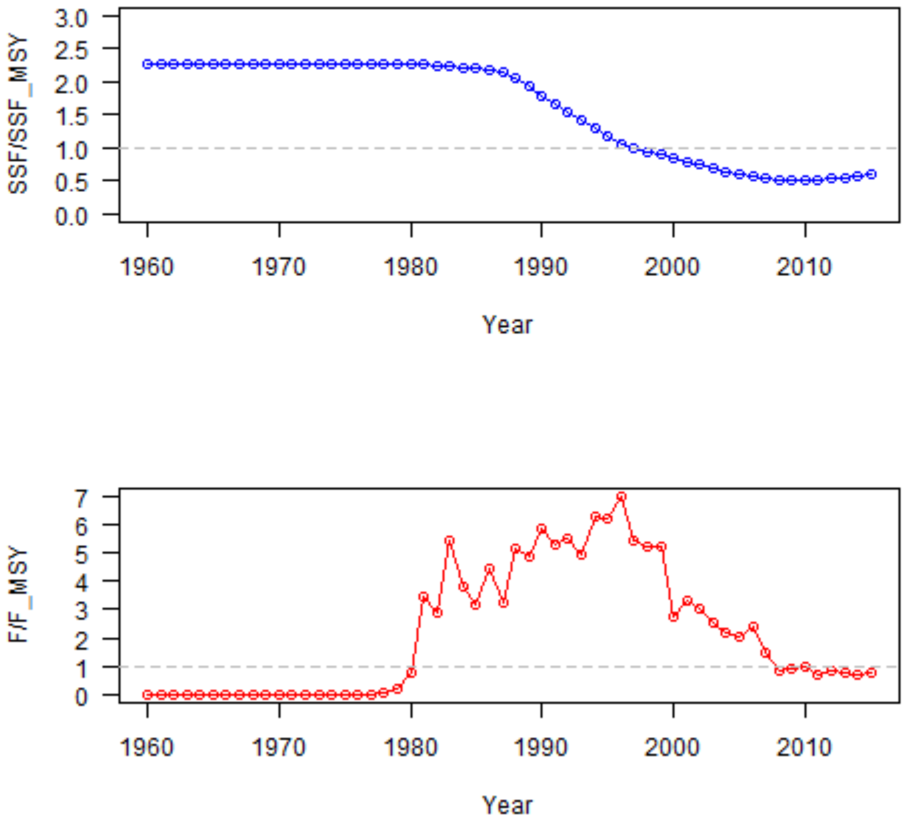


Figure 3.2.8. Time series of stock status parameters F/F_{MSY} and SSF/SSF_{MSY} for the base case configuration of the assessment model.

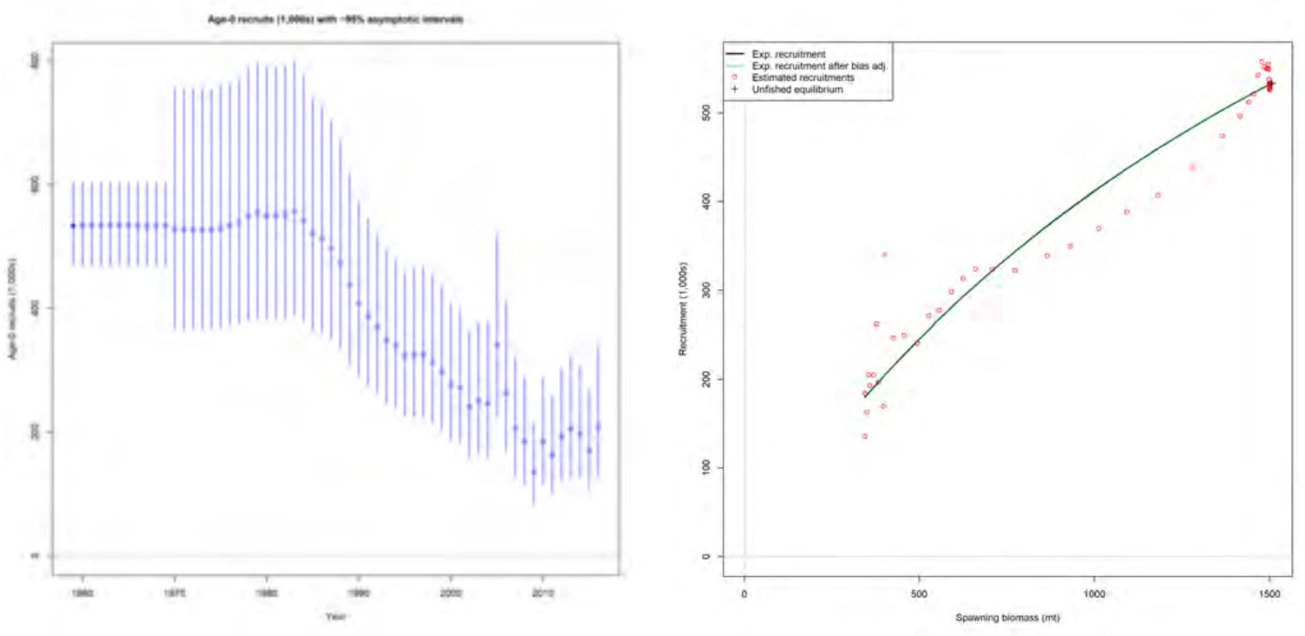


Figure 3.2.9. Estimated annual recruits (left panel) and estimated stock recruitment relationship (right panel) with annual recruitment deviates (red circles in right panel) by year for the base case model configuration.

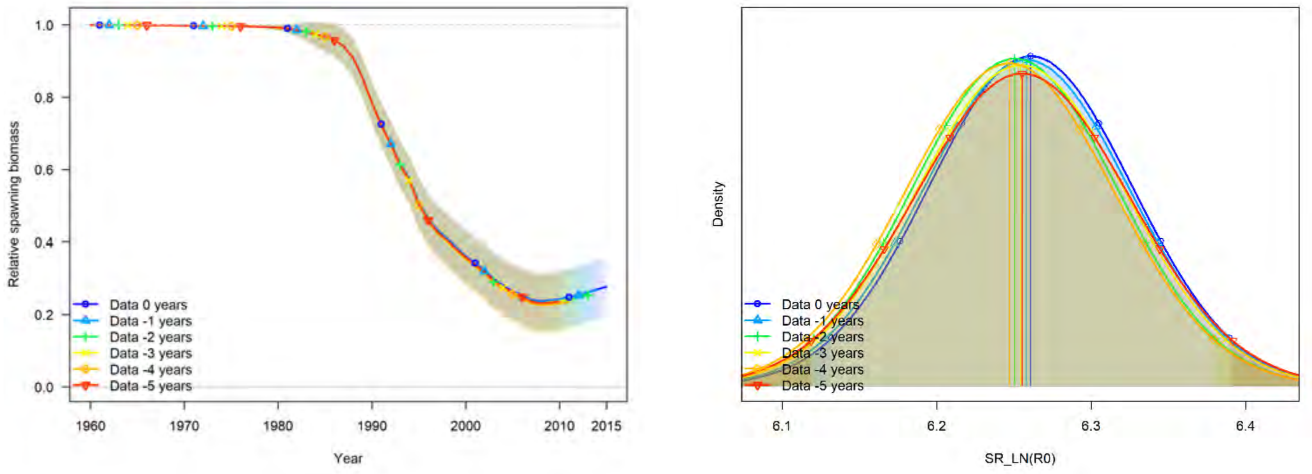
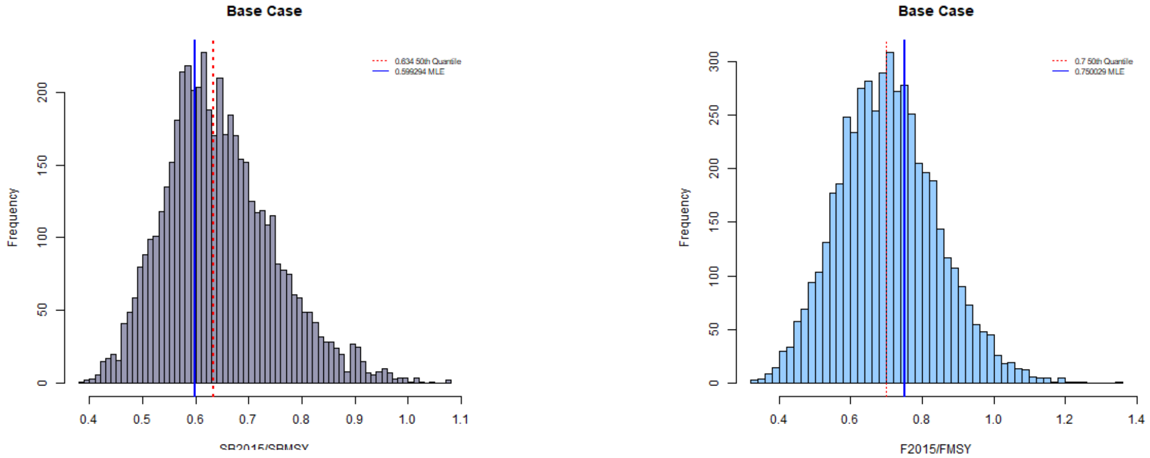


Figure 3.2.10. Estimated spawning output relative to virgin (SSF/SSF$_0$, left panel) by year along with 95% asymptotic uncertainty (shaded areas) and the maximum likelihood estimate (MLE, vertical lines) and asymptotic uncertainty (bell shaped curves) of the natural log of virgin recruitment size (right panel) for each of the retrospective model runs conducted for the base case model configuration.



SSF_{2015}/SSF_{MSY} F_{2015}/ F_{MSY}

Figure 3.2.11. Estimated spawning output in 2015 relative to MSY (SSF_{2015}/SSF_{MSY}, left panel) and estimated total fishing mortality in 2015 relative to MSY (F_{2015}/F_{MSY}, right panel) for the base case model configuration, comparing the maximum likelihood estimate (MLE blue line in both panels) obtained from Stock Synthesis and the 50th quantile (stippled red line in both panels) obtained from MCMC analysis (histograms in both panels).

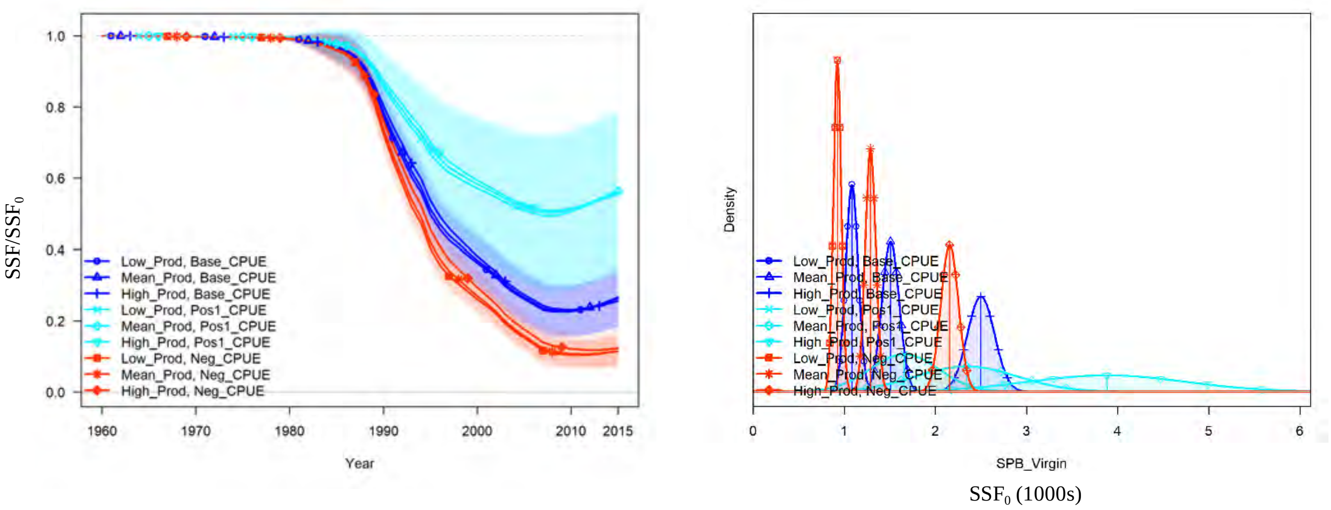


Figure 3.2.12. Estimated spawning output depletion (SFF/SSF$_0$, left panel) by year and asymptotic uncertainty (bell shaped curves) of estimated virgin spawning output (SSF$_0$, right panel) obtained for each of the nine alternative states of nature scenarios evaluated for CPUE and productivity as defined in Table 3.2.9 and in the main text. The base case is shown in dark blue with a triangle and denoted “Mean_Prod, BASE_CPUE”.

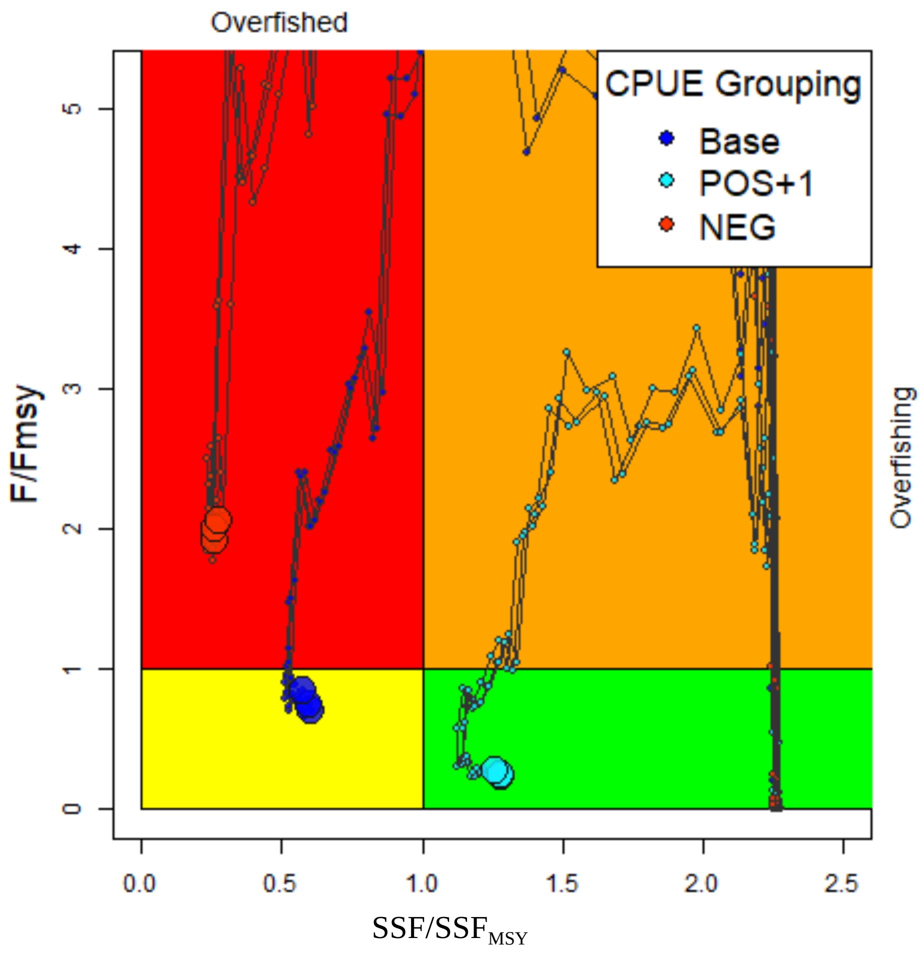


Figure 3.2.13. Time series of stock status based on estimated spawning output each year relative to MSY (SSF/SSF$_{MSY}$, x-axis) and estimated total fishing mortality each year relative to MSY (F/F$_{MSY}$, y-axis) obtained for each of the nine alternative states of nature scenarios evaluated for CPUE and productivity as defined in Table 3.2.9 and in the main text, and colored by CPUE grouping. The large circles indicate current (for 2015) conditions.

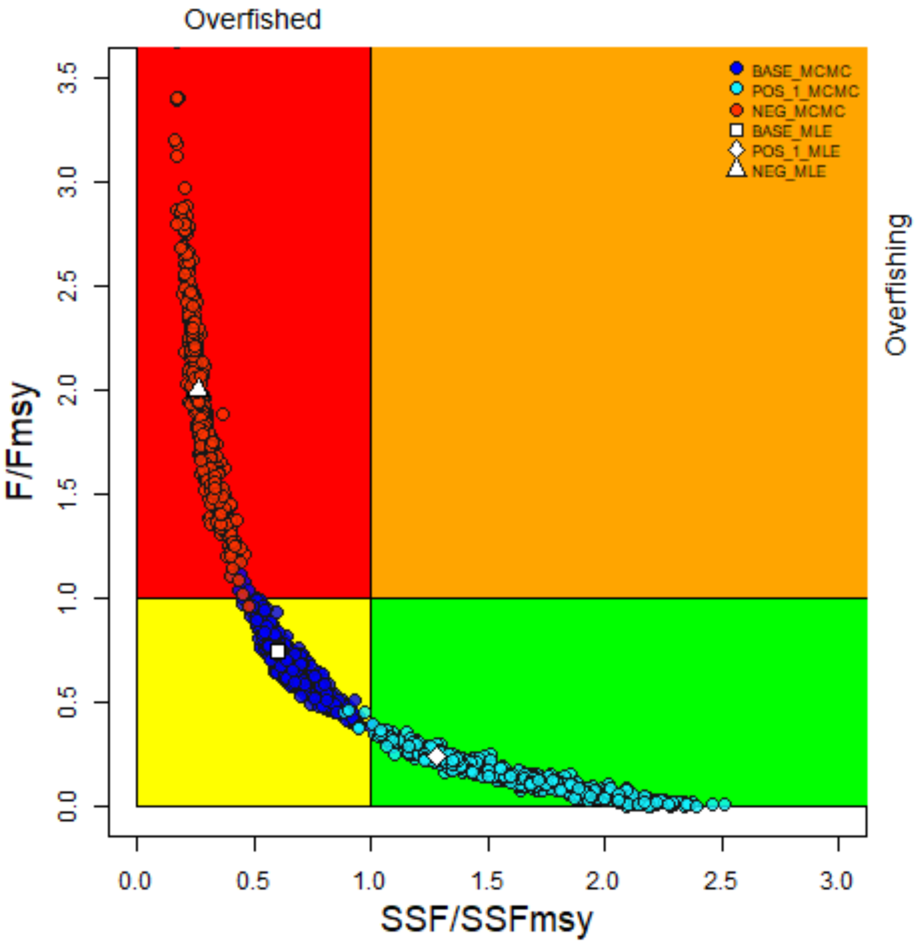


Figure 3.2.14 Estimated stock status based on MCMC analysis for the base case model configuration (Base, dark blue circles) and for two alternative states of nature scenarios evaluated for CPUE (POS_1, NEG) with the base case productivity scenario as defined in the main text and Table 3.2.9. The white square, triangle and diamond are MLE estimates.

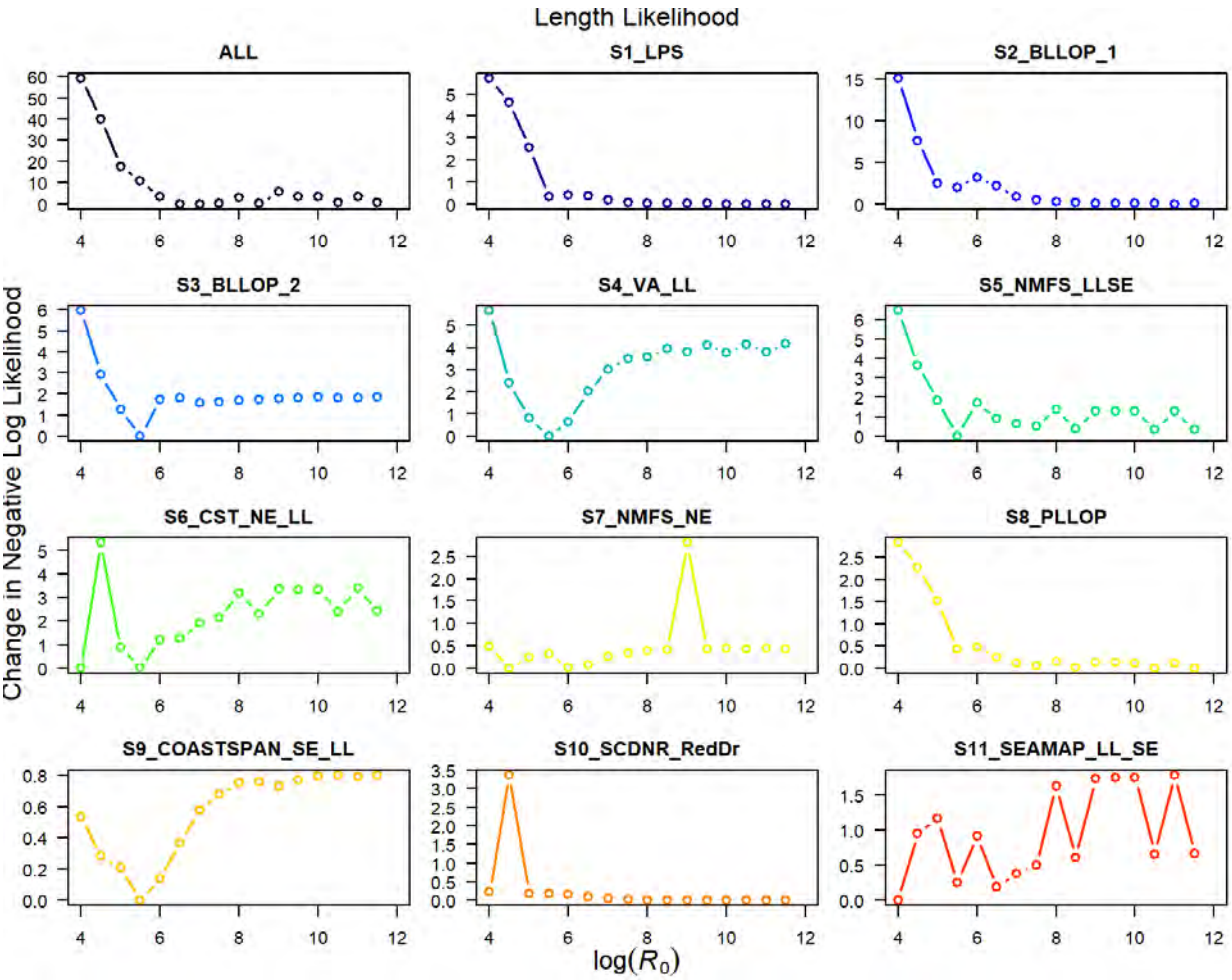


Figure 3.2.15. Profile likelihoods for the length composition associated with the CPUE data from the base case configuration as defined in Table 3.2.3 and the main text.

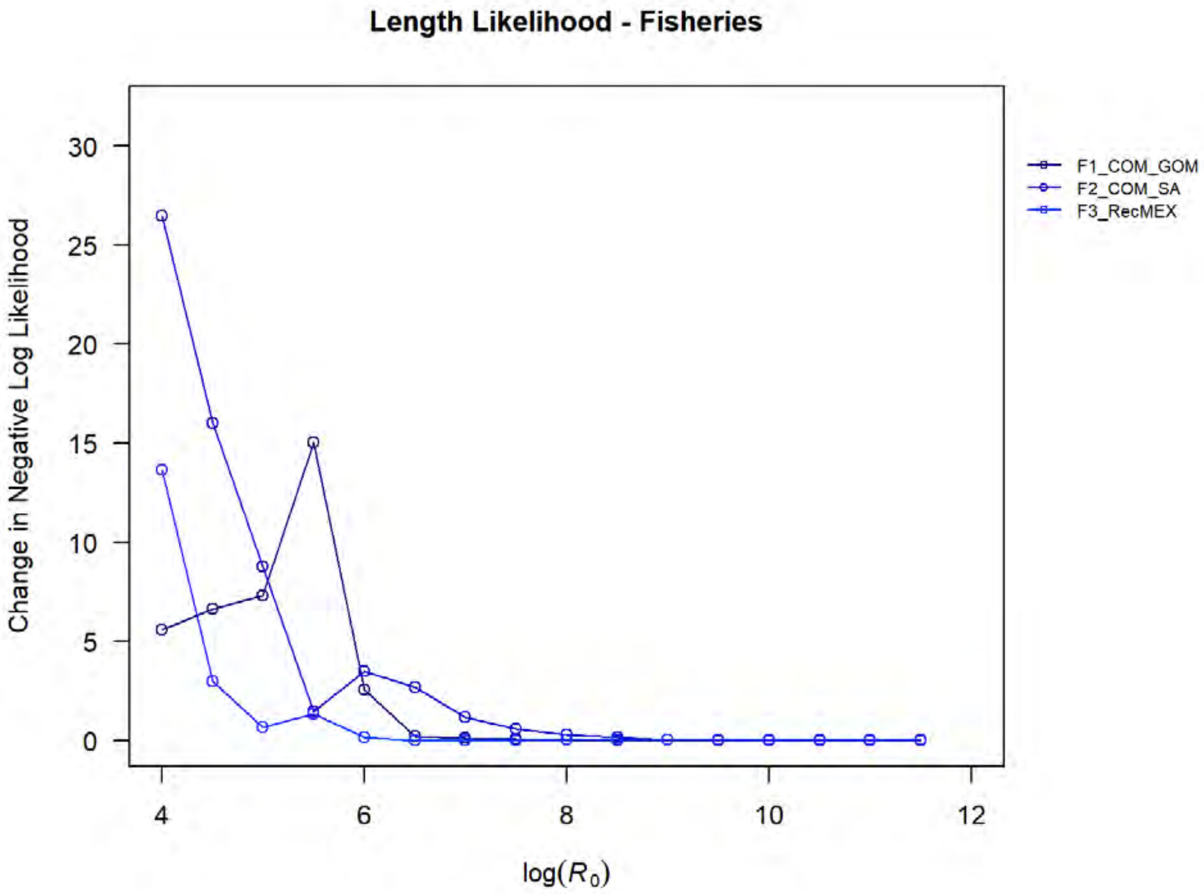


Figure 3.2.16. Profile likelihoods for the length composition data from fisheries F1-F3 for the base case configuration as defined in Table 3.2.3 and the main text.

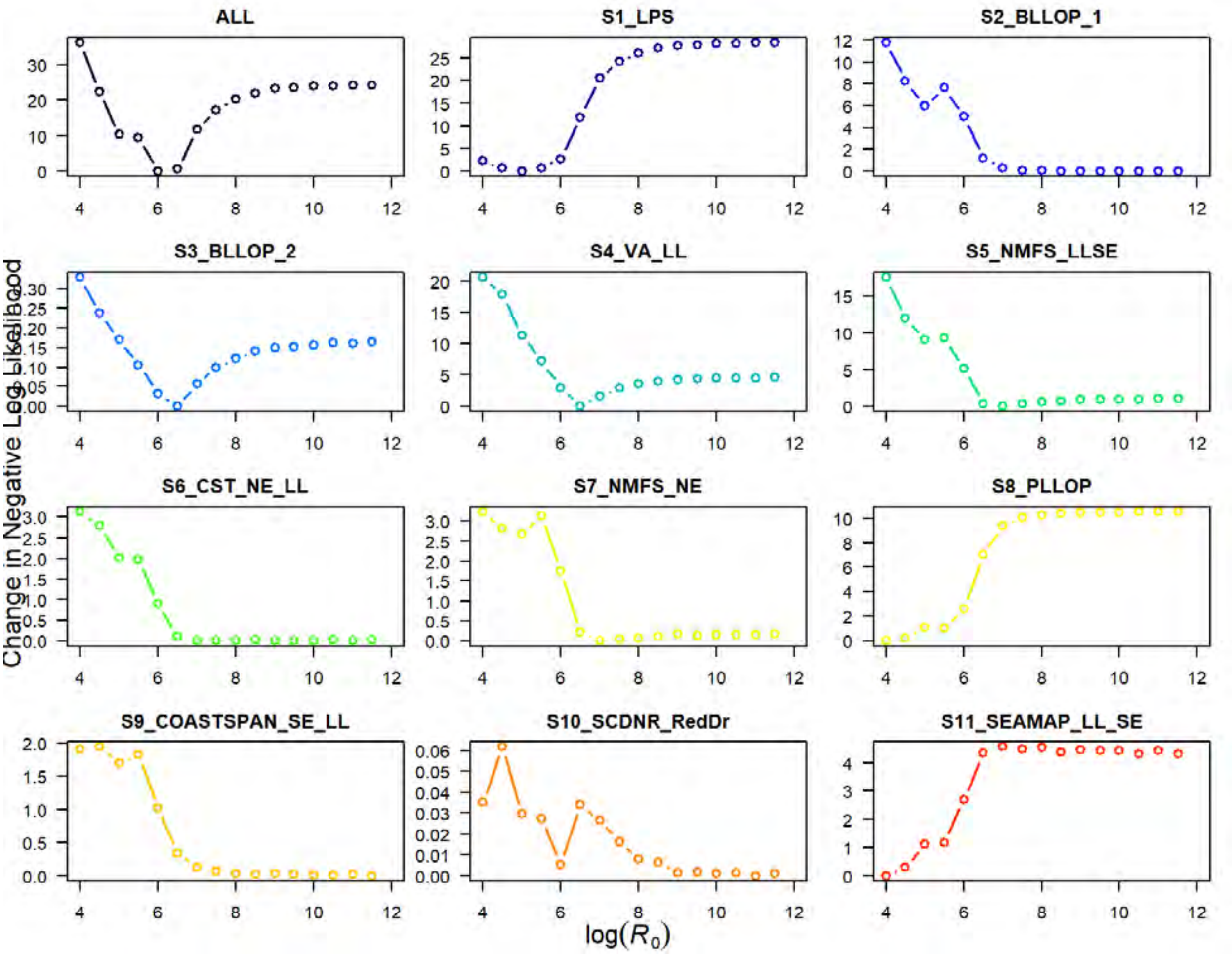


Figure 3.2.17. Profile likelihoods for the CPUE data from the base case configuration defined in table 3.2.1 and the main text above.

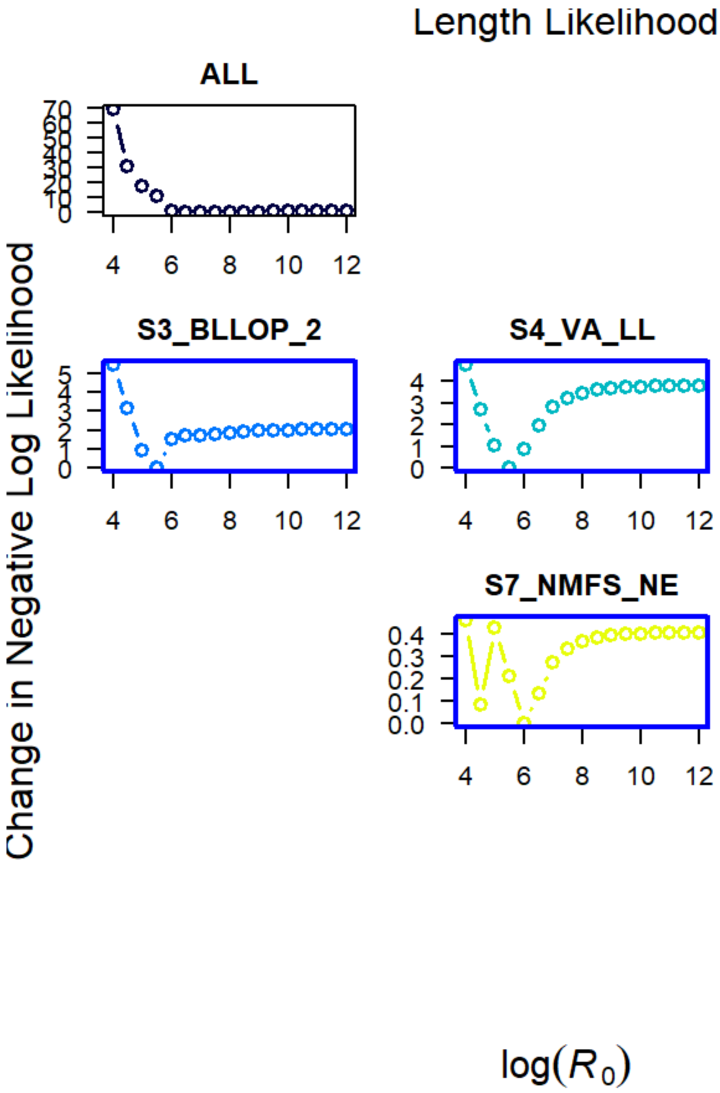


Figure 3.2.18 Profile likelihood values from the POS_1 CPUE grouping on the length composition likelihood associated with the CPUE series.

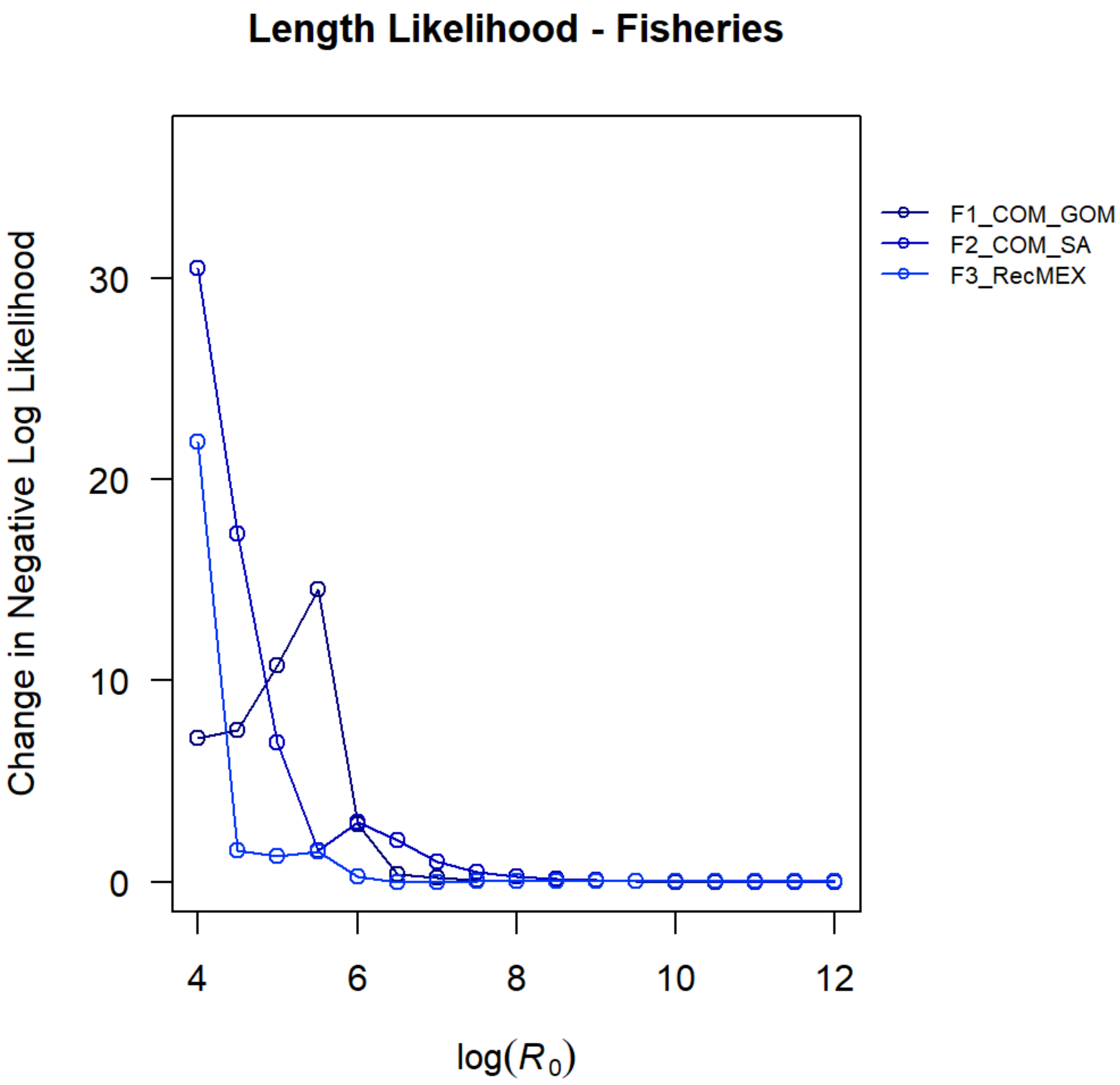


Figure 3.2.19 Profile likelihood values from the POS_1 CPUE grouping on the length composition likelihood from fisheries F1-F3.

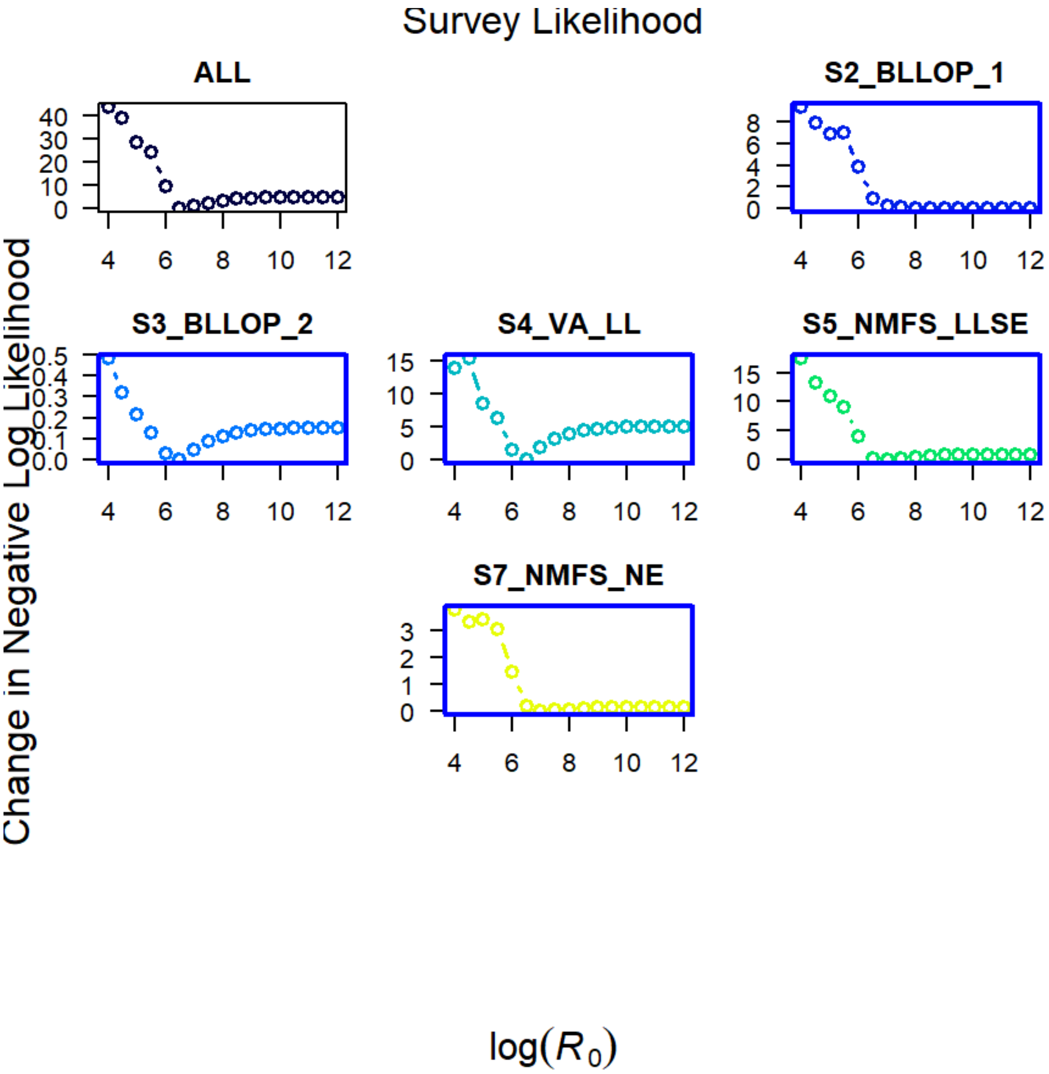


Figure 3.2.20. Profile likelihoods for the CPUE data from the model run with the POS_1 CPUE grouping.

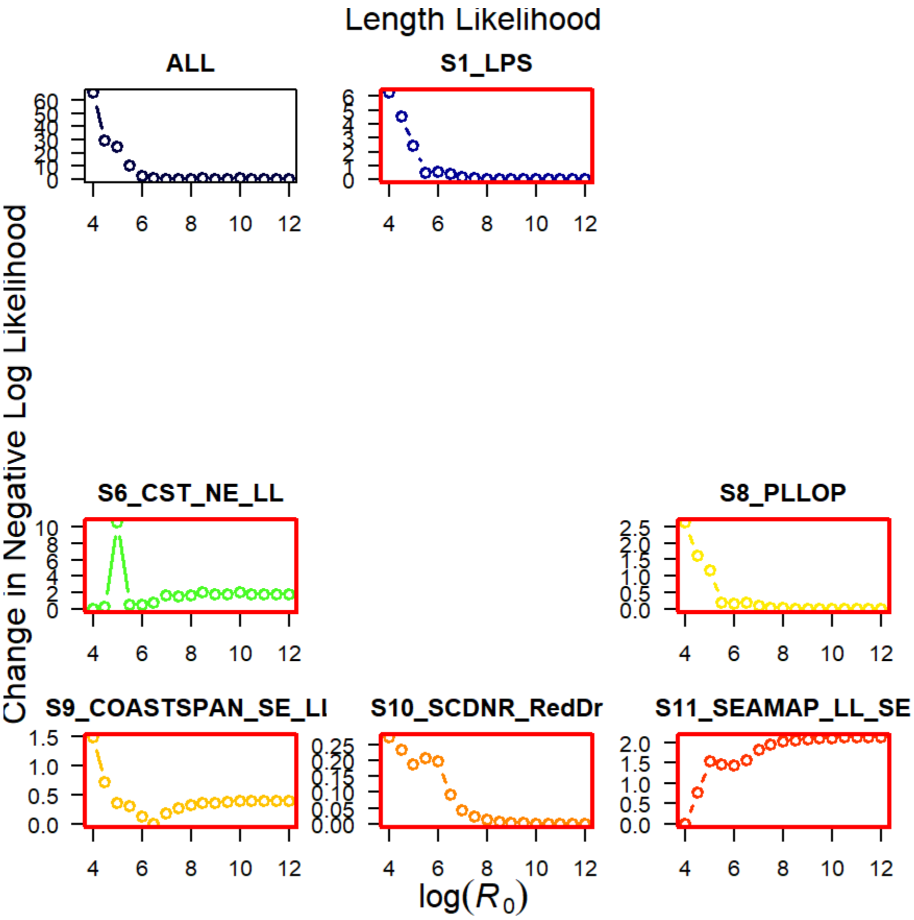


Figure 3.2.21 . Profile likelihoods for the length composition data from the model run with the NEG CPUE grouping for the length compositions associated with the CPUE series.

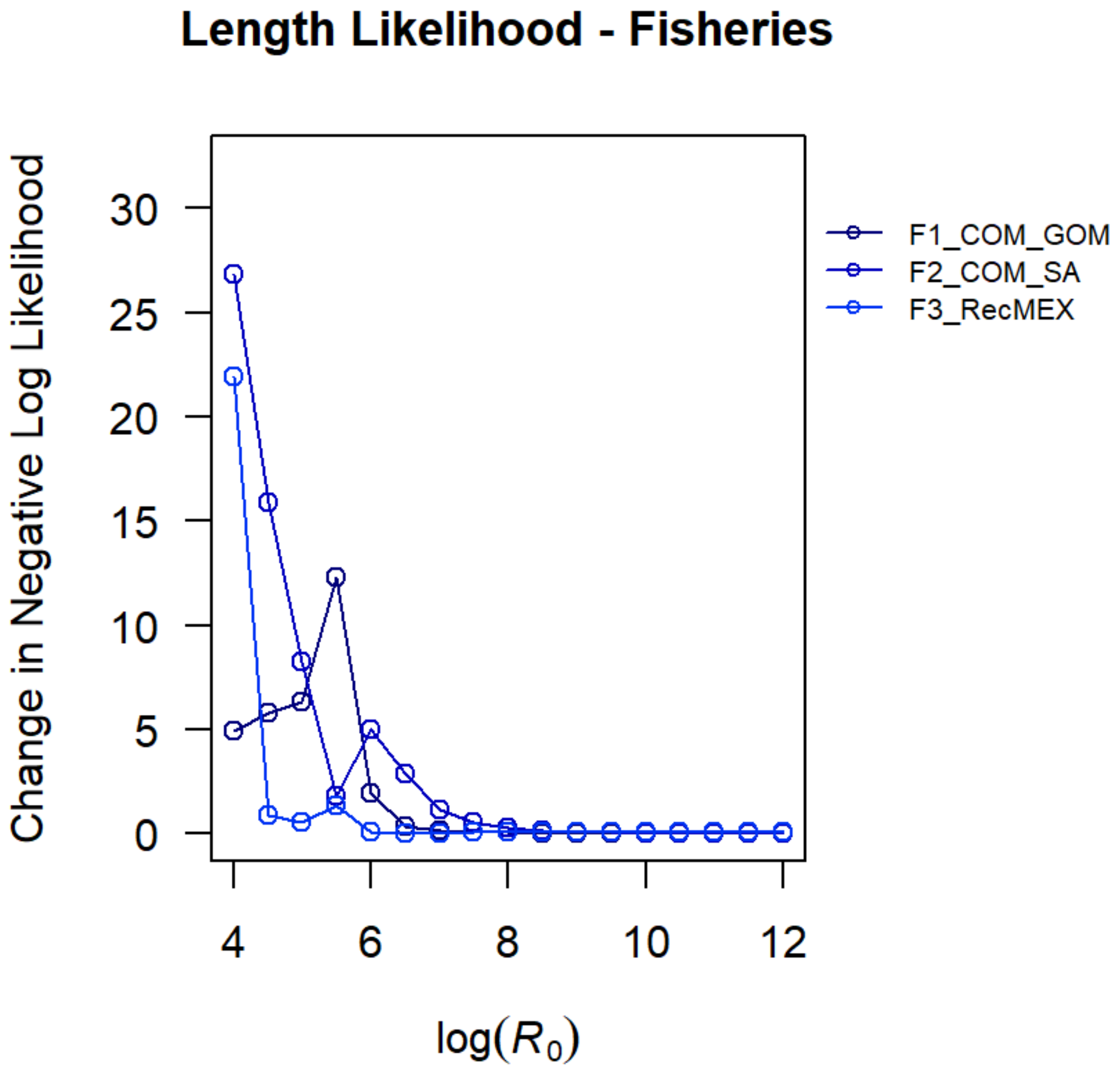


Figure 3.2.22 . Profile likelihoods for the length composition data from the model run with the NEG CPUE grouping for the length compositions associated with fisheries F1-F3.

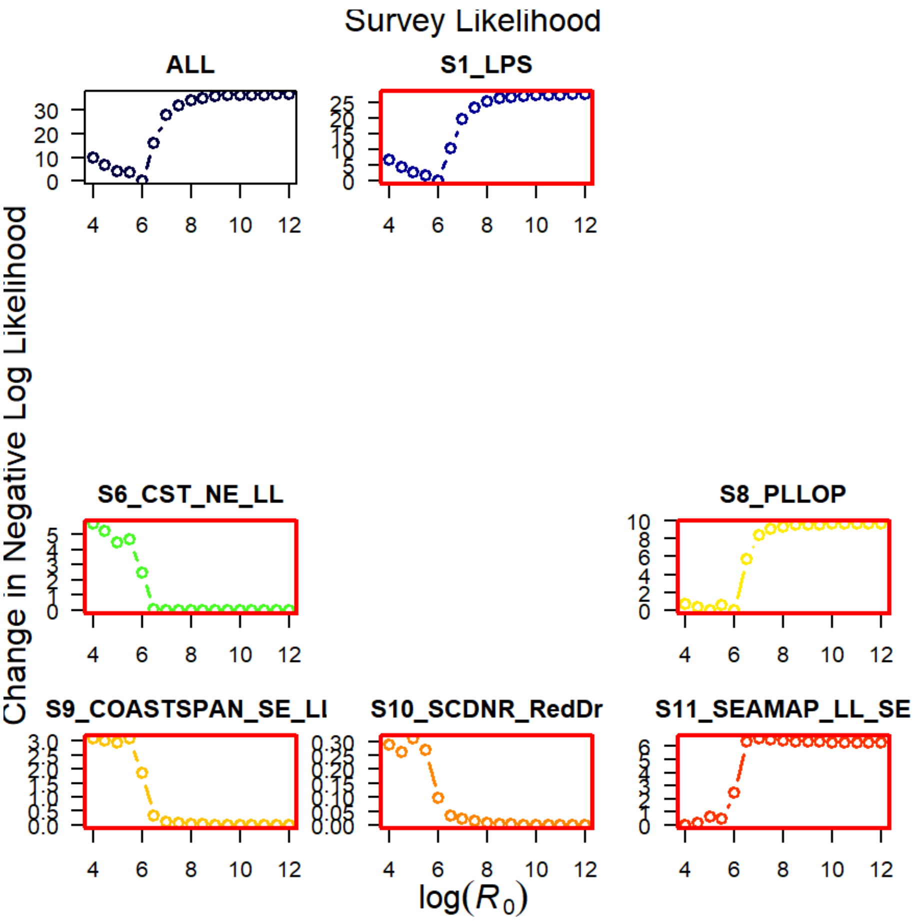


Figure 3.2.23. Profile likelihoods for the CPUE data from the model run with the NEG CPUE grouping.

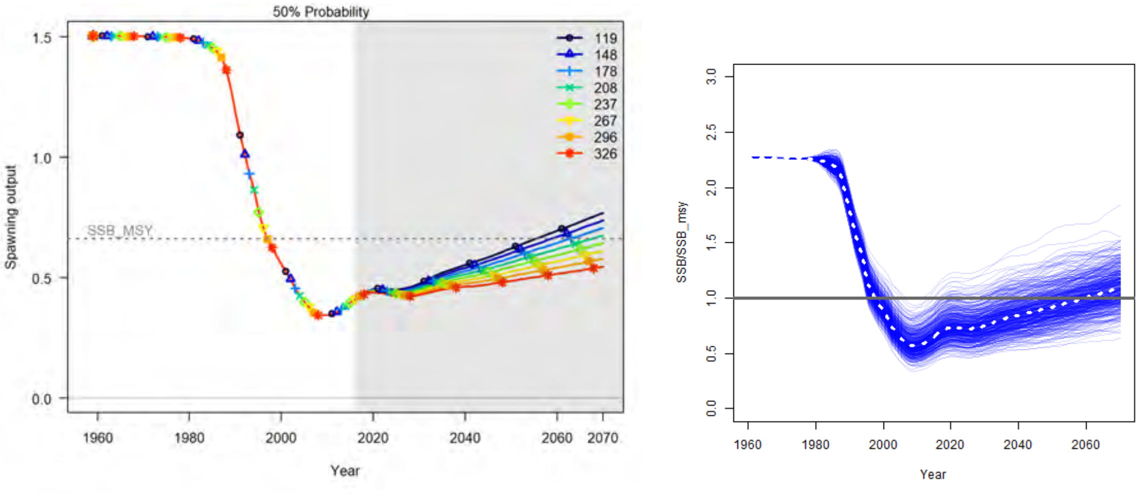


Figure 3.2.24. For the base case, projections were implemented with constant TAC allowing rebuilding of stock by 2070 with 50% and 70% probability (TOR 4A). Base case projections of spawning output (SSF in millions, left panel) under different levels of constant TAC (mt whole weight) indicate that a constant TAC of 208 mt would allow stock rebuilding by 2070 with a 50% probability. For comparison, the base case MCMC projections at a constant TAC of 208 mt are provided for SSF/SSF_{MSY} (right panel). The blue lines indicate individual MCMC runs and the stippled line in the right panel represents the 50th quantile of the runs.

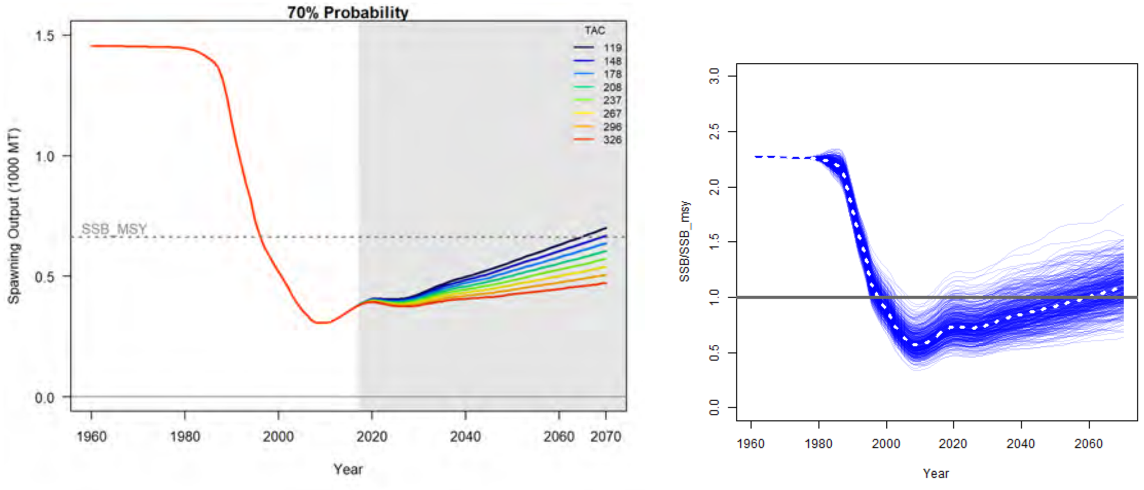


Figure 3.2.25. Base case projections of spawning output (SSF in millions, left panel) under different levels of constant TAC (mt whole weight) indicate that a constant TAC of 148 mt would allow stock rebuilding by 2070 with a 70% probability. For comparison, the base case MCMC projections at a constant TAC of 148 mt are provided for SSF/SSF_{MSY} (right panel). The blue lines indicate individual MCMC runs and the stippled line in right panel represents the 50^{th} quantile of the runs.

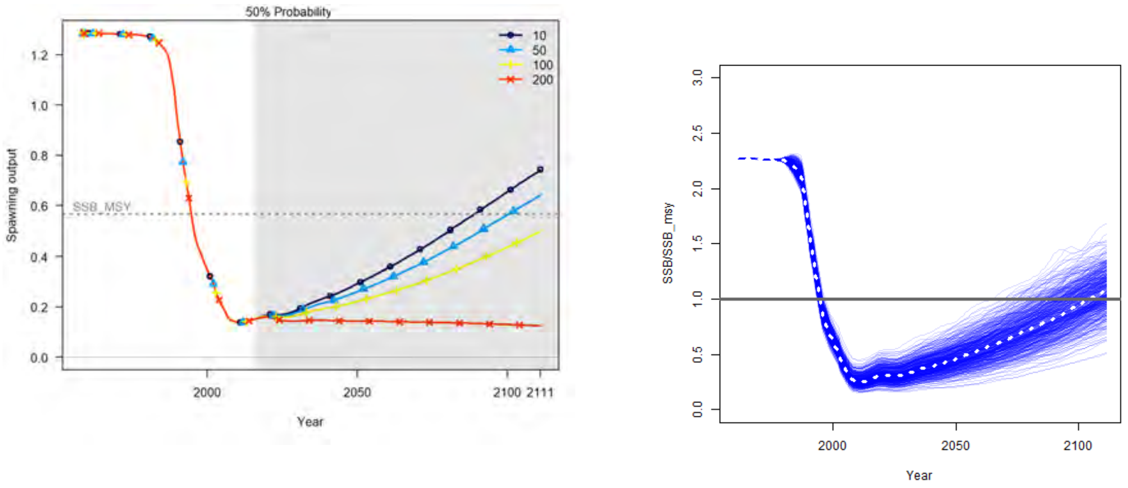


Figure 3.2.26. Under the NEG CPUE grouping, projections were implemented with constant TAC allowing rebuilding of stock by 2111 with 50% and 70% probability (TOR 4B). Projected estimates of spawning output (SSF in millions, left panel) under different levels of constant TAC (mt whole weight) indicate that a constant TAC of 71 mt would allow stock rebuilding by 2111 with a 50% probability. For comparison, the NEG CPUE grouping MCMC projections at a constant TAC of 71 mt are provided for SSF/SSF_{MSY} (right panel). The blue lines indicate individual MCMC runs and the stippled line in the right panel represents the 50th quantile of the runs.

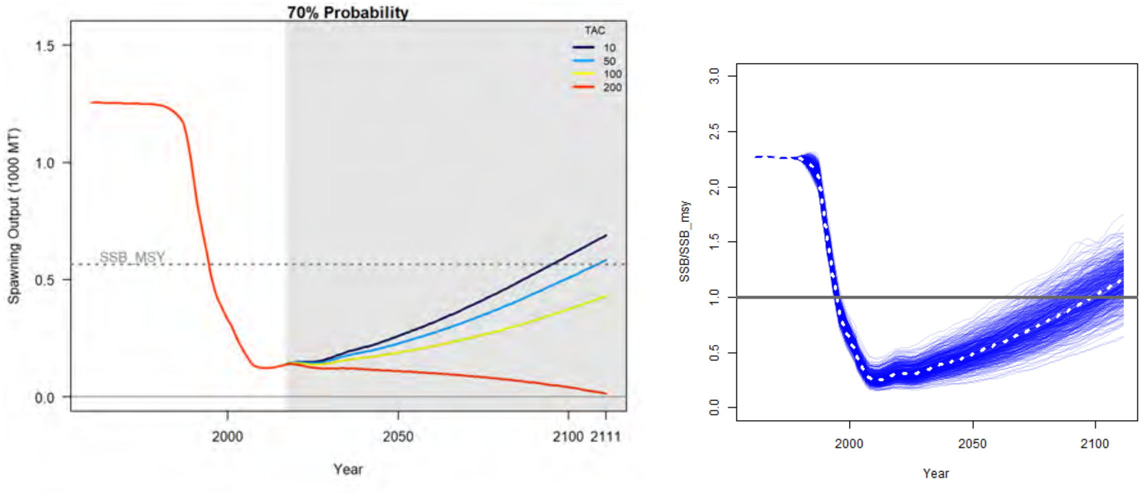


Figure 3.2.27. Projected estimates of the spawning stock biomass based on the NEG CPUE grouping (left panel) under a level of TAC projected until 2111 and estimated SSF/SSF_{MSY} based on MCMC based projections at a TAC of 53 mt which corresponds to the 70% probability of rebuilding by the estimated rebuilding year of 2111 (right panel). The blue lines indicate individual MCMC runs and the stippled line in the right panel represents the 50th quantile of the runs.

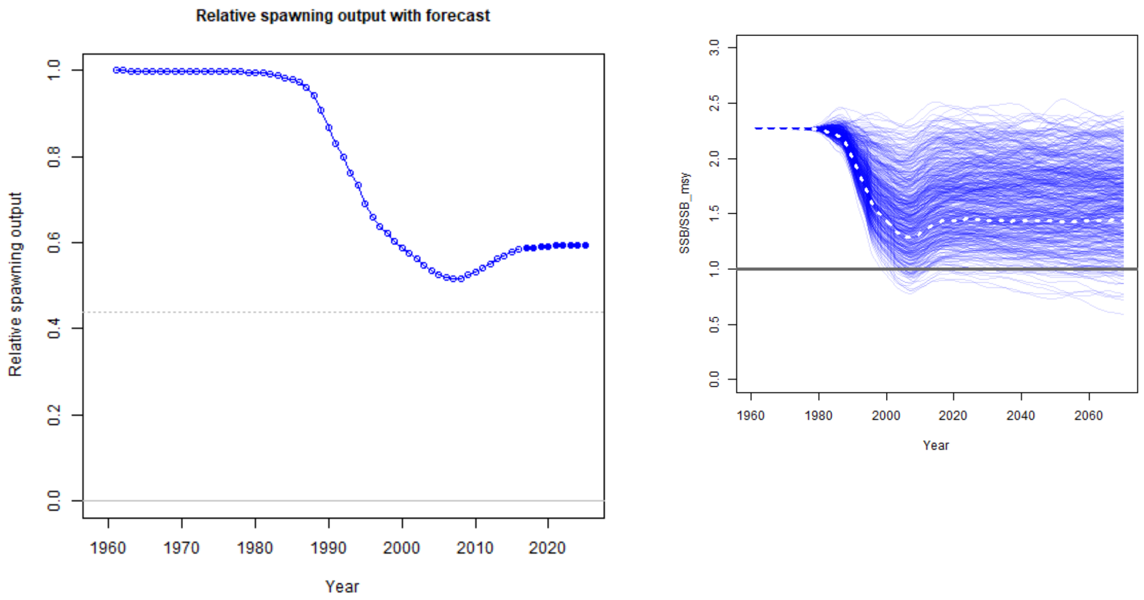


Figure 3.2.28. Under the POS_1 CPUE grouping, a projection model (TOR 4D), analogous to a P* approach associated with a 70% probability of overfishing not occurring (P* = 0.3), was implemented that projected with constant TAC so that the probability of overfishing was less than or equal to 30% in the current rebuilding year, 2070. Projected estimates of the spawning stock biomass based on the POS_1 CPUE grouping (left hand panel) under a TAC of 677 mt projected until 2070 and estimated SSF/SSF_{MSY} (right hand panel) based on MCMC based projections at the same TAC.

7 Appendix 1. MODEL FILES

```
# STARTER FILE
sandbar.dat
sandbar.ctl
0 # 0=use init values in control file; 1=use ss2.par
1 # run display detail (0,1,2)
1 # detailed age-structured reports in REPORT.SSO (0,1)
0 # write detailed checkup.sso file (0,1)
0 # write parm values to ParmTrace.sso (0=no,1=good,active; 2=good,all;
3=every_iter,all_parms; 4=every,active)
0 # write to cumreport.sso (0=no,1=like&timeseries; 2=add survey fits)
0 # Include prior_like for non-estimated parameters (0,1)
1 # Use Soft Boundaries to aid convergence (0,1) (recommended)
0 # Number of bootstrap datafiles to produce
100 # Turn off estimation for parameters entering after this phase
10 # MCMC burn interval
2 # MCMC thin interval
0  # jitter initial parm value by this fraction
-1 # min yr for sdreport outputs (-1 for styr)
```

```
-2 # max yr for sdreport outputs (-1 for endyr; -2 for endyr+Nforecastyrs)
0 # N individual STD years
# vector of year values
# 1973 1976

1e-004 # final convergence criteria (e.g. 1.0e-04)
0 # retrospective year relative to end year (e.g. -4)
0 # min age for calc of summary biomass
1 # Depletion basis:  denom is: 0=skip; 1=rel X*B0; 2=rel X*Bmsy; 3=rel X*B_styr
1 # Fraction (X) for Depletion denominator (e.g. 0.4)
2 # SPR_report_basis:  0=skip; 1=(1-SPR)/(1-SPR_tgt); 2=(1-SPR)/(1-SPR_MSY); 3=(1-SPR)/(1-SPR_Btarget); 4=rawSPR
3 # F_report_units: 0=skip; 1=exploitation(Bio); 2=exploitation(Num); 3=sum(Frates)
2 # F_report_basis: 0=raw; 1=F/Fspr; 2=F/Fmsy ; 3=F/Fbtgt
999 # check value for end of file
```

FORECAST FILE #V3.24f

```
# for all year entries except rebuilder; enter either: actual year, -999 for styr, 0 for endyr, neg number for rel. endyr
1 # Benchmarks: 0=skip; 1=calc F_spr,F_btgt,F_msy
2 # MSY: 1= set to F(SPR); 2=calc F(MSY); 3=set to F(Btgt); 4=set to F(endyr)
0.4 # SPR target (e.g. 0.40)
0.4 # Biomass target (e.g. 0.40)
#_Bmark_years: beg_bio, end_bio, beg_selex, end_selex, beg_relF, end_relF (enter actual year, or values of 0 or -integer to be rel. endyr)
 0 0 0 0 0 0
#  2015 2015 2015 2015 2015 2015 # after processing
1 #Bmark_relF_Basis: 1 = use year range; 2 = set relF same as forecast below
#
2 # Forecast: 0=none; 1=F(SPR); 2=F(MSY) 3=F(Btgt); 4=Ave F (uses first-last relF yrs); 5=input annual F scalar
1 # N forecast years
1 # F scalar (only used for Do_Forecast==5)
#_Fcast_years:  beg_selex, end_selex, beg_relF, end_relF  (enter actual year, or values of 0 or -integer to be rel. endyr)
 0 0 0 0
#  2015 2015 2015 2015 # after processing
1 # Control rule method (1=catch=f(SSB) west coast; 2=F=f(SSB) )
0.4 # Control rule Biomass level for constant F (as frac of Bzero, e.g. 0.40); (Must be > the no F level below)
0.1 # Control rule Biomass level for no F (as frac of Bzero, e.g. 0.10)
0.75 # Control rule target as fraction of Flimit (e.g. 0.75)
3 #_N forecast loops (1=OFL only; 2=ABC; 3=get F from forecast ABC catch with allocations applied)
3 #_First forecast loop with stochastic recruitment
0 #_Forecast loop control #3 (reserved for future bells&whistles)
```

```
0 #_Forecast loop control #4 (reserved for future bells&whistles)
0 #_Forecast loop control #5 (reserved for future bells&whistles)
2010  #FirstYear for caps and allocations (should be after years with fixed inputs)
0 # stddev of log(realized catch/target catch) in forecast (set value>0.0 to cause active impl_error)
0 # Do West Coast gfish rebuilder output (0/1)
1999 # Rebuilder:  first year catch could have been set to zero (Ydecl)(-1 to set to 1999)
2016 # Rebuilder:  year for current age structure (Yinit) (-1 to set to endyear+1)
1 # fleet relative F:  1=use first-last alloc year; 2=read seas(row) x fleet(col) below
# Note that fleet allocation is used directly as average F if Do_Forecast=4
2 # basis for fcast catch tuning and for fcast catch caps and allocation  (2=deadbio; 3=retainbio; 5=deadnum; 6=retainnum)
# Conditional input if relative F choice = 2
# Fleet relative F:  rows are seasons, columns are fleets
#_Fleet:  F1_COM_GOM F2_COM_SA F3_RecMEX F4_MEN_DSC
#  0.0760874 0.0485518 0.871055 0.00430538
# max totalcatch by fleet (-1 to have no max) must enter value for each fleet
 -1 -1 -1 -1
# max totalcatch by area (-1 to have no max); must enter value for each fleet
 -1
# fleet assignment to allocation group (enter group ID# for each fleet, 0 for not included in an alloc group)
 -1 -1 -1 0
#_Conditional on >1 allocation group
# allocation fraction for each of: 0 allocation groups
# no allocation groups
0 # Number of forecast catch levels to input (else calc catch from forecast F)
2 # basis for input Fcast catch:  2=dead catch; 3=retained catch; 99=input Hrate(F) (units are from fleetunits; note new codes in SSV3.20)
# Input fixed catch values
#Year Seas Fleet Catch(or_F)

#
999 # verify end of input
```

CONTROL FILE

```
#V3.24f
#_data_and_control_files: sandbar.dat // sandbar.ctl
1  #_N_Growth_Patterns
1 #_N_Morphs_Within_GrowthPattern
#_Cond 1 #_Morph_between/within_stdev_ratio (no read if N_morphs=1)
#_Cond  1 #vector_Morphdist_(-1_in_first_val_gives_normal_approx)
#
#_Cond 0  #  N recruitment designs goes here if N_GP*nseas*area>1
#_Cond 0  #  placeholder for recruitment interaction request
#_Cond 1 1 1  # example recruitment design element for GP=1, seas=1, area=1
```

```
#
#_Cond 0 # N_movement_definitions goes here if N_areas > 1
#_Cond 1.0 # first age that moves (real age at begin of season, not integer) also cond on
do_migration>0
#_Cond 1 1 1 2 4 10 # example move definition for seas=1, morph=1, source=1 dest=2, age1=4,
age2=10
#
0 #_Nblock_Patterns
#_Cond 0 #_blocks_per_pattern
# begin and end years of blocks
#
0.5 #_fracfemale
3 #_natM_type:_0=1Parm;
1=N_breakpoints;_2=Lorenzen;_3=agespecific;_4=agespec_withseasinterpolate
 #_Age_natmort_by gender x growthpattern
 0.160419 0.160419 0.160419 0.160419 0.160419 0.160419 0.157755 0.116805 0.116805
0.116805 0.116805 0.116805 0.116805 0.116805 0.116805 0.116805 0.116805 0.116805
0.116805 0.116805 0.116805 0.116805 0.116805 0.116805 0.116805 0.116805 0.116805
0.116805 0.116805 0.116805 0.116805 0.116805
 0.160419 0.160419 0.160419 0.160419 0.160419 0.160419 0.157755 0.116805 0.116805
0.116805 0.116805 0.116805 0.116805 0.116805 0.116805 0.116805 0.116805 0.116805
0.116805 0.116805 0.116805 0.116805 0.116805 0.116805 0.116805 0.116805 0.116805
0.116805 0.116805 0.116805 0.116805 0.116805
1 # GrowthModel: 1=vonBert with L1&L2; 2=Richards with L1&L2; 3=age_speciific_K; 4=not
implemented
0 #_Growth_Age_for_L1
999 #_Growth_Age_for_L2 (999 to use as Linf)
0 #_SD_add_to_LAA (set to 0.1 for SS2 V1.x compatibility)
0 #_CV_Growth_Pattern:  0 CV=f(LAA); 1 CV=F(A); 2 SD=F(LAA); 3 SD=F(A); 4
logSD=F(A)
3 #_maturity_option:  1=length logistic; 2=age logistic; 3=read age-maturity matrix by
growth_pattern; 4=read age-fecundity; 5=read fec and wt from wtatage.ss
#_Age_Maturity by growth pattern
 0.000182241 0.000352538 0.000681863 0.00131842 0.00254773 0.00491762 0.00947104
0.0181637 0.0345562 0.064767 0.118157 0.20587 0.334033 0.492501 0.652489 0.784147
0.875447 0.931502 0.963385 0.980735 0.989949 0.99478 0.997295 0.9986 0.999276 0.999626
0.999806 0.9999 0.999948 0.999973 0.999986 0.999993
13 #_First_Mature_Age
4 #_fecundity option:(1)eggs=Wt*(a+b*Wt);(2)eggs=a*L^b;(3)eggs=a*Wt^b; (4)eggs=a+b*L;
(5)eggs=a+b*W
0 #_hermaphroditism option:  0=none; 1=age-specific fxn
2 #_parameter_offset_approach (1=none, 2= M, G, CV_G as offset from female-GP1, 3=like
SS2 V1.x)
1 #_env/block/dev_adjust_method (1=standard; 2=logistic transform keeps in base parm bounds;
3=standard w/ no bound check)
#
```

```
#_growth_parms
#_LO HI INIT PRIOR PR_type SD PHASE env-var use_dev dev_minyr dev_maxyr dev_stddev
Block Block_Fxn
 10 120 58.4 58.4 -1 10 -4 0 0 0 0 0.5 0 0 # L_at_Amin_Fem_GP_1
 40 410 183.322 183 -1 10 -2 0 0 0 0 0.5 0 0 # L_at_Amax_Fem_GP_1
 0.1 0.25 0.124 0.12 -1 0.8 -4 0 0 0 0 0.5 0 0 # VonBert_K_Fem_GP_1
 0.05 0.3 0.22 0.123153 -1 99 -3 0 0 0 0 0 0 0 # CV_young_Fem_GP_1
 0.05 0.3 0.1197 0.1 -1 99 -3 0 0 0 0 0 0 0 # CV_old_Fem_GP_1
 -3 3 -0.14393 0 -1 0.8 -3 0 0 0 0 0.5 0 0 # L_at_Amin_Mal_GP_1
 -3 3 -0.0434285 0 -1 0.8 -2 0 0 0 0 0.5 0 0 # L_at_Amax_Mal_GP_1
 -3 3 0.142563 0 -1 0.8 -3 0 0 0 0 0.5 0 0 # VonBert_K_Mal_GP_1
 -3 3 0 0 -1 99 -3 0 0 0 0 0 0 0 # CV_young_Mal_GP_1
 -3 3 0 0.56 -1 99 -3 0 0 0 0 0 0 0 # CV_old_Mal_GP_1
 -3 3 1.08858e-005 1.08858e-005 -1 0.8 -3 0 0 0 0 0.5 0 0 # Wtlen_1_Fem
 -3 3.5 3.0124 3.0124 -1 0.8 -3 0 0 0 0 0.5 0 0 # Wtlen_2_Fem
 -3 300 154.9 55 -1 0.8 -3 0 0 0 0 0.5 0 0 # Mat50%_Fem
 -3 3 -0.138 -0.138 -1 0.8 -3 0 0 0 0 0.5 0 0 # Mat_slope_Fem
 -3 36 1.69908 0 -1 0.8 -3 0 0 0 0 0.5 0 0 # Eggs_intercept_Fem
 -3 30 0.01296 0 -1 0.8 -3 0 0 0 0 0.5 0 0 # Eggs_slope_len_Fem
 -3 3 1.08858e-005 1.08858e-005 -1 0.8 -3 0 0 0 0 0.5 0 0 # Wtlen_1_Mal
 -3 3.5 3.0124 3.0124 -1 0.8 -3 0 0 0 0 0.5 0 0 # Wtlen_2_Mal
 0 0 0 0 -1 0 -4 0 0 0 0 0 0 0 # RecrDist_GP_1
 0 0 0 0 -1 0 -4 0 0 0 0 0 0 0 # RecrDist_Area_1
 0 0 0 0 -1 0 -4 0 0 0 0 0 0 0 # RecrDist_Seas_1
 0 0 0 0 -1 0 -4 0 0 0 0 0 0 0 # CohortGrowDev
#
#_Cond 0  #custom_MG-env_setup (0/1)
#_Cond -2 2 0 0 -1 99 -2 #_placeholder when no MG-environ parameters
#
#_Cond 0  #custom_MG-block_setup (0/1)
#_Cond -2 2 0 0 -1 99 -2 #_placeholder when no MG-block parameters
#_Cond No MG parm trends
#
#_seasonal_effects_on_biology_parms
 0 0 0 0 0 0 0 0 0 0 #_femwtlen1,femwtlen2,mat1,mat2,fec1,fec2,Malewtlen1,malewtlen2,L1,K
#_Cond -2 2 0 0 -1 99 -2 #_placeholder when no seasonal MG parameters
#
#_Cond -4 #_MGparm_Dev_Phase
#
#_Spawner-Recruitment
3 #_SR_function: 2=Ricker; 3=std_B-H; 4=SCAA; 5=Hockey; 6=B-H_flattop;
7=survival_3Parm
#_LO HI INIT PRIOR PR_type SD PHASE
 3 10 6.27892 7 -1 1 1 # SR_LN(R0)
 0.2 0.7 0.3 0.29 -1 0.2 -3 # SR_BH_steep
 0 2 0.18 0.6 -1 0.8 -3 # SR_sigmaR
```

```
 -5 5 0 0 -1 1 -3 # SR_envlink
 -2 2 0 0 -1 0 -1 # SR_R1_offset
 0 0 0 -1 -1 99 -99 # SR_autocorr
0 #_SR_env_link
1 #_SR_env_target_0=none;1=devs;_2=R0;_3=steepness
2 #do_recdev:  0=none; 1=devvector; 2=simple deviations
1980 # first year of main recr_devs; early devs can preceed this era
2015 # last year of main recr_devs; forecast devs start in following year
3 #_recdev phase
1 # (0/1) to read 13 advanced options
 -10 #_recdev_early_start (0=none; neg value makes relative to recdev_start)
 1 #_recdev_early_phase
 0 #_forecast_recruitment phase (incl. late recr) (0 value resets to maxphase+1)
 1 #_lambda for Fcast_recr_like occurring before endyr+1
 1980.4 #_last_early_yr_nobias_adj_in_MPD
 2015 #_first_yr_fullbias_adj_in_MPD
 2015.9 #_last_yr_fullbias_adj_in_MPD
 2016 #_first_recent_yr_nobias_adj_in_MPD
 0.2543 #_max_bias_adj_in_MPD (-1 to override ramp and set biasadj=1.0 for all estimated recdevs)
 0 #_period of cycles in recruitment (N parms read below)
 -15 #min rec_dev
 15 #max rec_dev
 0 #_read_recdevs
#_end of advanced SR options
#
#_placeholder for full parameter lines for recruitment cycles
# read specified recr devs
#_Yr Input_value
#
#
#Fishing Mortality info
0.0005 # F ballpark for tuning early phases
-2009 # F ballpark year (neg value to disable)
3 # F_Method:  1=Pope; 2=instan. F; 3=hybrid (hybrid is recommended)
5 # max F or harvest rate, depends on F_Method
# no additional F input needed for Fmethod 1
# if Fmethod=2; read overall start F value; overall phase; N detailed inputs to read
# if Fmethod=3; read N iterations for tuning for Fmethod 3
4  # N iterations for tuning F in hybrid method (recommend 3 to 7)
#
#_initial_F_parms
#_LO HI INIT PRIOR PR_type SD PHASE
 0.1 5 0 -1 0 99 -1 # InitF_1F1_COM_GOM
 0.1 5 0 -1 0 99 -1 # InitF_2F2_COM_SA
 0.1 5 0 -1 0 99 -1 # InitF_3F3_RecMEX
```

```
 1e-007 5 1e-007 -1 0 99 -1 # InitF_4F4_MEN_DSC
#
#_Q_setup
 # Q_type options:  <0=mirror, 0=float_nobiasadj, 1=float_biasadj, 2=parm_nobiasadj,
3=parm_w_random_dev, 4=parm_w_randwalk, 5=mean_unbiased_float_assign_to_parm
#_for_env-var:_enter_index_of_the_env-var_to_be_linked
#_Den-dep  env-var  extra_se  Q_type
 0 0 0 0 # 1 F1_COM_GOM
 0 0 0 0 # 2 F2_COM_SA
 0 0 0 0 # 3 F3_RecMEX
 0 0 0 0 # 4 F4_MEN_DSC
 0 0 0 0 # 5 S1_LPS
 0 0 0 0 # 6 S2_BLLOP_1
 0 0 0 0 # 7 S3_BLLOP_2
 0 0 0 0 # 8 S4_VA_LL
 0 0 0 0 # 9 S5_NMFS_LLSE
 0 0 0 0 # 10 S6_CST_NE_LL
 0 0 0 0 # 11 S7_NMFS_NE
 0 0 0 0 # 12 S8_PLLOP
 0 0 0 0 # 13 S9_COASTSPAN_SE_LL
 0 0 0 0 # 14 S10_SCDNR_RedDr
 0 0 0 0 # 15 S11_SEAMAP_LL_SE
#
#_Cond 0 #_If q has random component, then 0=read one parm for each fleet with random q;
1=read a parm for each year of index
#_Q_parms(if_any)
#
#_size_selex_types
#discard_options:_0=none;_1=define_retention;_2=retention&mortality;_3=all_discarded_dead
#_Pattern Discard Male Special
 24 0 3 0 # 1 F1_COM_GOM
 1 0 0 0 # 2 F2_COM_SA
 24 0 0 0 # 3 F3_RecMEX
 1 0 0 0 # 4 F4_MEN_DSC
 24 0 0 0 # 5 S1_LPS
 24 0 4 0 # 6 S2_BLLOP_1
 24 0 3 0 # 7 S3_BLLOP_2
 24 0 0 0 # 8 S4_VA_LL
 24 0 3 0 # 9 S5_NMFS_LLSE
 24 0 3 0 # 10 S6_CST_NE_LL
 24 0 4 0 # 11 S7_NMFS_NE
 24 0 3 0 # 12 S8_PLLOP
 27 0 0 5 # 13 S9_COASTSPAN_SE_LL
 24 0 3 0 # 14 S10_SCDNR_RedDr
 24 0 3 0 # 15 S11_SEAMAP_LL_SE
#
```

```
#_age_selex_types
#_Pattern ___ Male Special
 0 0 0 0 # 1 F1_COM_GOM
 0 0 0 0 # 2 F2_COM_SA
 0 0 0 0 # 3 F3_RecMEX
 0 0 0 0 # 4 F4_MEN_DSC
 0 0 0 0 # 5 S1_LPS
 0 0 0 0 # 6 S2_BLLOP_1
 0 0 0 0 # 7 S3_BLLOP_2
 0 0 0 0 # 8 S4_VA_LL
 0 0 0 0 # 9 S5_NMFS_LLSE
 0 0 0 0 # 10 S6_CST_NE_LL
 0 0 0 0 # 11 S7_NMFS_NE
 0 0 0 0 # 12 S8_PLLOP
 0 0 0 0 # 13 S9_COASTSPAN_SE_LL
 0 0 0 0 # 14 S10_SCDNR_RedDr
 0 0 0 0 # 15 S11_SEAMAP_LL_SE
#_LO HI INIT PRIOR PR_type SD PHASE env-var use_dev dev_minyr dev_maxyr dev_stddev Block Block_Fxn
 35 259 149.427 50 -1 0 3 0 0 0 0 0.5 0 0 # SizeSel_1P_1_F1_COM_GOM
 -15 15 -10 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_1P_2_F1_COM_GOM
 -15 15 5.45132 0 -1 0 3 0 0 0 0 0.5 0 0 # SizeSel_1P_3_F1_COM_GOM
 -15 15 5.60819 0 -1 0 3 0 0 0 0 0.5 0 0 # SizeSel_1P_4_F1_COM_GOM
 -999 -999 -999 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_1P_5_F1_COM_GOM
 -999 -999 -999 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_1P_6_F1_COM_GOM
 -20 200 4 0 -1 50 -4 0 0 0 0 0 0 0 # SzSel_1Male_Peak_F1_COM_GOM
 -15 15 0.743742 4 -1 50 4 0 0 0 0 0 0 0 # SzSel_1Male_Ascend_F1_COM_GOM
 -15 15 -0.6 4 -1 50 -4 0 0 0 0 0 0 0 # SzSel_1Male_Descend_F1_COM_GOM
 -15 15 0 4 -1 50 -4 0 0 0 0 0 0 0 # SzSel_1Male_Final_F1_COM_GOM
 -15 15 0.672785 4 -1 50 5 0 0 0 0 0 0 0 # SzSel_1Male_Scale_F1_COM_GOM
 1 200 93.6324 120 -1 0.01 2 0 0 0 0 0 0 0 # SizeSel_2P_1_F2_COM_SA
 1 100 29.7201 25 -1 0.1 3 0 0 0 0 0 0 0 # SizeSel_2P_2_F2_COM_SA
 35 259 55.0586 55 0 1 2 0 0 0 0 0.5 0 0 # SizeSel_3P_1_F3_RecMEX
 -15 15 -9.99944 -10 0 1 3 0 0 0 0 0.5 0 0 # SizeSel_3P_2_F3_RecMEX
 -15 15 0 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_3P_3_F3_RecMEX
 -15 15 7.24959 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_3P_4_F3_RecMEX
 -15 15 -15 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_3P_5_F3_RecMEX
 -999 -999 -999 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_3P_6_F3_RecMEX
 1 200 45.6654 45 -1 99 -2 0 0 0 0 0.5 0 0 # SizeSel_4P_1_F4_MEN_DSC
 1 239 1 50 -1 99 -3 0 0 0 0 0 0 0 # SizeSel_4P_2_F4_MEN_DSC
 35 259 155.527 50 -1 0 3 0 0 0 0 0.5 0 0 # SizeSel_5P_1_S1_LPS
 -15 15 -10 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_5P_2_S1_LPS
 -15 15 7.30304 0 -1 0 3 0 0 0 0 0.5 0 0 # SizeSel_5P_3_S1_LPS
 -15 15 14.6321 0 -1 0 3 0 0 0 0 0.5 0 0 # SizeSel_5P_4_S1_LPS
 -999 -999 -999 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_5P_5_S1_LPS
 -999 -999 -999 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_5P_6_S1_LPS
```

```
35 259 155.527 50 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_6P_1_S2_BLLOP_1
-15 15 -10 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_6P_2_S2_BLLOP_1
-15 15 7.8872 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_6P_3_S2_BLLOP_1
-15 15 5 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_6P_4_S2_BLLOP_1
-999 -999 -999 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_6P_5_S2_BLLOP_1
-999 -999 -999 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_6P_6_S2_BLLOP_1
-20 200 4 0 -1 50 -4 0 0 0 0 0 0 0 # SzSel_6Fem_Peak_S2_BLLOP_1
-15 15 -0.14 4 -1 50 -4 0 0 0 0 0 0 0 # SzSel_6Fem_Ascend_S2_BLLOP_1
-15 15 -0.6 4 -1 50 -4 0 0 0 0 0 0 0 # SzSel_6Fem_Descend_S2_BLLOP_1
-15 15 0 4 -1 50 -4 0 0 0 0 0 0 0 # SzSel_6Fem_Final_S2_BLLOP_1
-15 15 1.02466 4 -1 50 -5 0 0 0 0 0 0 0 # SzSel_6Fem_Scale_S2_BLLOP_1
35 258 158.2 50 -1 0 -2 0 0 0 0 0.5 0 0 # SizeSel_7P_1_S3_BLLOP_2
-15 15 -10 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_7P_2_S3_BLLOP_2
-15 15 6.747 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_7P_3_S3_BLLOP_2
-15 15 6.66187 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_7P_4_S3_BLLOP_2
-999 -999 -999 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_7P_5_S3_BLLOP_2
-999 -999 -999 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_7P_6_S3_BLLOP_2
-20 200 4.21499 0 -1 50 -4 0 0 0 0 0 0 0 # SzSel_7Male_Peak_S3_BLLOP_2
-15 15 -0.117 4 -1 50 -4 0 0 0 0 0 0 0 # SzSel_7Male_Ascend_S3_BLLOP_2
-15 15 -0.599 4 -1 50 -4 0 0 0 0 0 0 0 # SzSel_7Male_Descend_S3_BLLOP_2
-15 15 0 4 -1 50 -4 0 0 0 0 0 0 0 # SzSel_7Male_Final_S3_BLLOP_2
-15 15 0.704246 4 -1 50 -5 0 0 0 0 0 0 0 # SzSel_7Male_Scale_S3_BLLOP_2
35 258 45.0234 50 -1 0 3 0 0 0 0 0.5 0 0 # SizeSel_8P_1_S4_VA_LL
-15 15 -10 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_8P_2_S4_VA_LL
-15 15 -9.36124 0 -1 0 3 0 0 0 0 0.5 0 0 # SizeSel_8P_3_S4_VA_LL
-15 15 8.69984 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_8P_4_S4_VA_LL
-999 -999 -999 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_8P_5_S4_VA_LL
-999 -999 -999 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_8P_6_S4_VA_LL
35 259 161.846 50 -1 0 2 0 0 0 0 0.5 0 0 # SizeSel_9P_1_S5_NMFS_LLSE
-15 15 -10 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_9P_2_S5_NMFS_LLSE
-15 15 7.14991 0 -1 0 3 0 0 0 0 0.5 0 0 # SizeSel_9P_3_S5_NMFS_LLSE
-15 15 5.60914 0 -1 0 3 0 0 0 0 0.5 0 0 # SizeSel_9P_4_S5_NMFS_LLSE
-999 -999 -999 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_9P_5_S5_NMFS_LLSE
-999 -999 -999 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_9P_6_S5_NMFS_LLSE
-20 200 -6.1517 0 -1 50 4 0 0 0 0 0 0 0 # SzSel_9Male_Peak_S5_NMFS_LLSE
-15 15 -0.656603 4 -1 50 4 0 0 0 0 0 0 0 # SzSel_9Male_Ascend_S5_NMFS_LLSE
-15 15 -0.804174 4 -1 50 4 0 0 0 0 0 0 0 # SzSel_9Male_Descend_S5_NMFS_LLSE
-15 15 0 4 -1 50 -4 0 0 0 0 0 0 0 # SzSel_9Male_Final_S5_NMFS_LLSE
-15 15 0.735386 4 -1 50 5 0 0 0 0 0 0 0 # SzSel_9Male_Scale_S5_NMFS_LLSE
35 258 57.0259 50 -1 0 2 0 0 0 0 0.5 0 0 # SizeSel_10P_1_S6_CST_NE_LL
-15 15 -10 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_10P_2_S6_CST_NE_LL
-15 15 -8.03807 0 -1 0 3 0 0 0 0 0.5 0 0 # SizeSel_10P_3_S6_CST_NE_LL
-15 15 7.57575 0 -1 0 3 0 0 0 0 0.5 0 0 # SizeSel_10P_4_S6_CST_NE_LL
-999 -999 -999 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_10P_5_S6_CST_NE_LL
-999 -999 -999 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_10P_6_S6_CST_NE_LL
-20 200 5.35953 0 -1 50 4 0 0 0 0 0 0 0 # SzSel_10Male_Peak_S6_CST_NE_LL
```

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-15 15 10.9201 4 -1 50 4 0 0 0 0 0 0 0 # SzSel_10Male_Ascend_S6_CST_NE_LL
-15 15 -0.792801 4 -1 50 4 0 0 0 0 0 0 0 # SzSel_10Male_Descend_S6_CST_NE_LL
-15 15 0 4 -1 50 -4 0 0 0 0 0 0 0 # SzSel_10Male_Final_S6_CST_NE_LL
-15 15 1.0764 4 -1 50 5 0 0 0 0 0 0 0 # SzSel_10Male_Scale_S6_CST_NE_LL
35 259 132.668 145 -1 0 2 0 0 0 0 0.5 0 0 # SizeSel_11P_1_S7_NMFS_NE
-15 15 -10 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_11P_2_S7_NMFS_NE
-15 15 8.03405 0 -1 0 3 0 0 0 0 0.5 0 0 # SizeSel_11P_3_S7_NMFS_NE
-15 15 6.32447 0 -1 0 3 0 0 0 0 0.5 0 0 # SizeSel_11P_4_S7_NMFS_NE
-999 -999 -999 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_11P_5_S7_NMFS_NE
-999 -999 -999 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_11P_6_S7_NMFS_NE
-20 200 0 0 -1 50 -4 0 0 0 0 0 0 0 # SzSel_11Fem_Peak_S7_NMFS_NE
-15 15 -1 4 -1 50 -4 0 0 0 0 0 0 0 # SzSel_11Fem_Ascend_S7_NMFS_NE
-15 15 1 4 -1 50 -4 0 0 0 0 0 0 0 # SzSel_11Fem_Descend_S7_NMFS_NE
-15 15 0 4 -1 50 -4 0 0 0 0 0 0 0 # SzSel_11Fem_Final_S7_NMFS_NE
-15 15 2.31853 5 -1 50 5 0 0 0 0 0 0 0 # SzSel_11Fem_Scale_S7_NMFS_NE
35 259 147.3 50 -1 0 2 0 0 0 0 0.5 0 0 # SizeSel_12P_1_S8_PLLOP
-15 15 -10 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_12P_2_S8_PLLOP
-15 15 6.52378 0 -1 0 3 0 0 0 0 0.5 0 0 # SizeSel_12P_3_S8_PLLOP
-15 15 6.0314 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_12P_4_S8_PLLOP
-999 -999 -999 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_12P_5_S8_PLLOP
-999 -999 -999 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_12P_6_S8_PLLOP
-20 200 4 0 -1 50 -4 0 0 0 0 0 0 0 # SzSel_12Male_Peak_S8_PLLOP
-15 15 -0.427904 4 -1 50 4 0 0 0 0 0 0 0 # SzSel_12Male_Ascend_S8_PLLOP
-15 15 -1.19422 4 -1 50 4 0 0 0 0 0 0 0 # SzSel_12Male_Descend_S8_PLLOP
-15 15 0 4 -1 50 -4 0 0 0 0 0 0 0 # SzSel_12Male_Final_S8_PLLOP
-15 15 1.44595 4 -1 50 5 0 0 0 0 0 0 0 # SzSel_12Male_Scale_S8_PLLOP
0 2 0 0 -1 0 -9 0 0 0 0 0 0 0 # SizeSpline_Code_S9_COASTSPAN_SE_LL_13
-0.001 10 0.004 0 -1 0.1 -3 0 0 0 0 0 0 0 # SizeSpline_GradLo_S9_COASTSPAN_SE_LL_13
-10 0.01 -0.003 0 -1 0.1 -3 0 0 0 0 0 0 0 # SizeSpline_GradHi_S9_COASTSPAN_SE_LL_13
1 150 45 0 -1 0 -99 0 0 0 0 0 0 0 # SizeSpline_Knot_1_S9_COASTSPAN_SE_LL_13
1 150 55 0 -1 0 -99 0 0 0 0 0 0 0 # SizeSpline_Knot_2_S9_COASTSPAN_SE_LL_13
1 150 65 0 -1 0 -99 0 0 0 0 0 0 0 # SizeSpline_Knot_3_S9_COASTSPAN_SE_LL_13
1 150 80 0 -1 0 -99 0 0 0 0 0 0 0 # SizeSpline_Knot_4_S9_COASTSPAN_SE_LL_13
1 150 85 0 -1 0 -99 0 0 0 0 0 0 0 # SizeSpline_Knot_5_S9_COASTSPAN_SE_LL_13
-5 5 3.35616 0 -1 0 2 0 0 0 0 0 0 0 # SizeSpline_Val_1_S9_COASTSPAN_SE_LL_13
-5 5 2.54332 0 -1 0 2 0 0 0 0 0 0 0 # SizeSpline_Val_2_S9_COASTSPAN_SE_LL_13
-5 5 2.00077 0 -1 0 2 0 0 0 0 0 0 0 # SizeSpline_Val_3_S9_COASTSPAN_SE_LL_13
-5 5 -1.04538 0 -1 0 2 0 0 0 0 0 0 0 # SizeSpline_Val_4_S9_COASTSPAN_SE_LL_13
-5 5 -4.40136 0 -1 0 -3 0 0 0 0 0 0 0 # SizeSpline_Val_5_S9_COASTSPAN_SE_LL_13
35 259 92.8542 50 -1 0 3 0 0 0 0 0.5 0 0 # SizeSel_14P_1_S10_SCDNR_RedDr
-15 15 -10 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_14P_2_S10_SCDNR_RedDr
-15 15 6 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_14P_3_S10_SCDNR_RedDr
-15 15 6 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_14P_4_S10_SCDNR_RedDr
-999 -999 -999 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_14P_5_S10_SCDNR_RedDr
-999 -999 -999 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_14P_6_S10_SCDNR_RedDr
-20 200 4 0 -1 50 -4 0 0 0 0 0 0 0 # SzSel_14Male_Peak_S10_SCDNR_RedDr
```

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 -15 15 1.57832 4 -1 50 4 0 0 0 0 0 0 0 # SzSel_14Male_Ascend_S10_SCDNR_RedDr
 -15 15 -0.310553 4 -1 50 4 0 0 0 0 0 0 0 # SzSel_14Male_Descend_S10_SCDNR_RedDr
 -15 15 0 4 -1 50 -4 0 0 0 0 0 0 0 # SzSel_14Male_Final_S10_SCDNR_RedDr
 -15 15 0.592267 4 1 50 5 0 0 0 0 0 0 0 # SzSel_14Male_Scale_S10_SCDNR_RedDr
 35 258 93.5684 50 -1 0 2 0 0 0 0 0.5 0 0 # SizeSel_15P_1_S11_SEAMAP_LL_SE
 -15 15 -10 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_15P_2_S11_SEAMAP_LL_SE
 -15 15 6.07161 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_15P_3_S11_SEAMAP_LL_SE
 -15 15 7.97427 0 -1 0 3 0 0 0 0 0.5 0 0 # SizeSel_15P_4_S11_SEAMAP_LL_SE
 -999 -999 -999 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_15P_5_S11_SEAMAP_LL_SE
 -999 -999 -999 0 -1 0 -3 0 0 0 0 0.5 0 0 # SizeSel_15P_6_S11_SEAMAP_LL_SE
 -20 200 4.21499 0 -1 50 -4 0 0 0 0 0 0 0 # SzSel_15Male_Peak_S11_SEAMAP_LL_SE
 -15 15 -0.36932 4 -1 50 4 0 0 0 0 0 0 0 # SzSel_15Male_Ascend_S11_SEAMAP_LL_SE
 -15 15 -0.279912 4 -1 50 4 0 0 0 0 0 0 0 # SzSel_15Male_Descend_S11_SEAMAP_LL_SE
 -15 15 0 4 -1 50 -4 0 0 0 0 0 0 0 # SzSel_15Male_Final_S11_SEAMAP_LL_SE
 -15 15 1.17049 4 -1 50 5 0 0 0 0 0 0 0 # SzSel_15Male_Scale_S11_SEAMAP_LL_SE
#_Cond 0 #_custom_sel-env_setup (0/1)
#_Cond -2 2 0 0 -1 99 -2 #_placeholder when no enviro fxns
#_Cond 0 #_custom_sel-blk_setup (0/1)
#_Cond -2 2 0 0 -1 99 -2 #_placeholder when no block usage
#_Cond No selex parm trends
#_Cond -4 # placeholder for selparm_Dev_Phase
#_Cond 0 #_env/block/dev_adjust_method (1=standard; 2=logistic trans to keep in base parm
bounds; 3=standard w/ no bound check)
#
# Tag loss and Tag reporting parameters go next
0  # TG_custom:  0=no read; 1=read if tags exist
#_Cond -6 6 1 1 2 0.01 -4 0 0 0 0 0 0 0  #_placeholder if no parameters
#
1 #_Variance_adjustments_to_input_values
#_fleet: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 #_add_to_survey_CV
  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 #_add_to_discard_stddev
  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 #_add_to_bodywt_CV
  0.2921 0.0294 0.9092 1 1.1398 0.0716 9.8483 0.1317 0.2936 1.5812 0.1447 1.0707 2.0907
0.1649 0.4257 #_mult_by_lencomp_N
  1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 #_mult_by_agecomp_N
  1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 #_mult_by_size-at-age_N
#
1 #_maxlambdaphase
1 #_sd_offset
#
31 # number of changes to make to default Lambdas (default value is 1.0)
# Like_comp codes:  1=surv; 2=disc; 3=mnwt; 4=length; 5=age; 6=SizeFreq; 7=sizeage;
8=catch;
# 9=init_equ_catch; 10=recrdev; 11=parm_prior; 12=parm_dev; 13=CrashPen; 14=Morphcomp;
15=Tag-comp; 16=Tag-negbin
```

```
#like_comp fleet/survey  phase  value  sizefreq_method
 1 1 1 0 1
 1 2 1 0 1
 1 3 1 0 1
 1 4 1 0 1
 1 5 1 1 1
 1 6 1 1 1
 1 7 1 1 1
 1 8 1 1 1
 1 9 1 1 1
 1 10 1 1 1
 1 11 1 1 1
 1 12 1 1 1
 1 13 1 1 1
 1 14 1 1 1
 1 15 1 1 1
 4 1 1 1 0
 4 2 1 1 0
 4 3 1 1 0
 4 4 1 0 0
 4 5 1 1 0
 4 6 1 0 0
 4 7 1 0 0
 4 8 1 1 0
 4 9 1 1 0
 4 10 1 1 0
 4 11 1 1 0
 4 12 1 1 0
 4 13 1 1 0
 4 14 1 1 0
 4 15 1 1 0
 9 1 1 0 0
#
# lambdas (for info only; columns are phases)
#  0 #_CPUE/survey:_1
#  0 #_CPUE/survey:_2
#  0 #_CPUE/survey:_3
#  0 #_CPUE/survey:_4
#  1 #_CPUE/survey:_5
#  1 #_CPUE/survey:_6
#  1 #_CPUE/survey:_7
#  1 #_CPUE/survey:_8
#  1 #_CPUE/survey:_9
#  1 #_CPUE/survey:_10
#  1 #_CPUE/survey:_11
#  1 #_CPUE/survey:_12
```

```
#  1 #_CPUE/survey:_13
#  1 #_CPUE/survey:_14
#  1 #_CPUE/survey:_15
#  1 #_lencomp:_1
#  1 #_lencomp:_2
#  1 #_lencomp:_3
#  0 #_lencomp:_4
#  1 #_lencomp:_5
#  0 #_lencomp:_6
#  0 #_lencomp:_7
#  1 #_lencomp:_8
#  1 #_lencomp:_9
#  1 #_lencomp:_10
#  1 #_lencomp:_11
#  1 #_lencomp:_12
#  1 #_lencomp:_13
#  1 #_lencomp:_14
#  1 #_lencomp:_15
#  0 #_init_equ_catch
#  1 #_recruitments
#  1 #_parameter-priors
#  1 #_parameter-dev-vectors
#  1 #_crashPenLambda
0 # (0/1) read specs for more stddev reporting
 # 0 1 -1 5 1 5 1 -1 5 # placeholder for selex type, len/age, year, N selex bins, Growth pattern, N growth ages, NatAge_area(-1 for all), NatAge_yr, N Natages
 # placeholder for vector of selex bins to be reported
 # placeholder for vector of growth ages to be reported
 # placeholder for vector of NatAges ages to be reported
999
```

8 Appendix 2. Excerpt from SEDAR_TEMP1

Example Implementation of a Hierarchical Cluster Analysis and Cross-correlations of Selected CPUE Indices for the SEDAR 54 Assessment

Summary

An example implementation of a hierarchical cluster analysis and cross-correlations of selected CPUE indices for the SEDAR 54 assessment was conducted to identify conflicting information among CPUE indices. Hierarchical cluster analysis identified two groupings of time-series. The first group was characterized by time-series which were highly correlated with each other and which had some highly negative correlations with some time-series not included in the group. The second group was characterized by time-series which were less highly correlated with each other or were slightly negatively correlated with each other. Because CPUEs with conflicting information were identified, it may be reasonable to assume that the indices reflect alternative hypotheses about states of nature and to run scenarios for single or sets of indices identified that represent a common hypothesis as alternative sates of nature. Cross-correlations identified strong autocorrelation in some CPUE indices over 2 to 3 years, which could indicate a year-class effect. Cross-correlations also identified strong cross correlation of lagged values of some CPUE indices (at lags between 2 to 10 years) with the current values of other CPUE indices, which could indicate that some CPUE indices represent younger age-classes than others. However, the specific lagged relationships with high correlation were not consistent among the series.

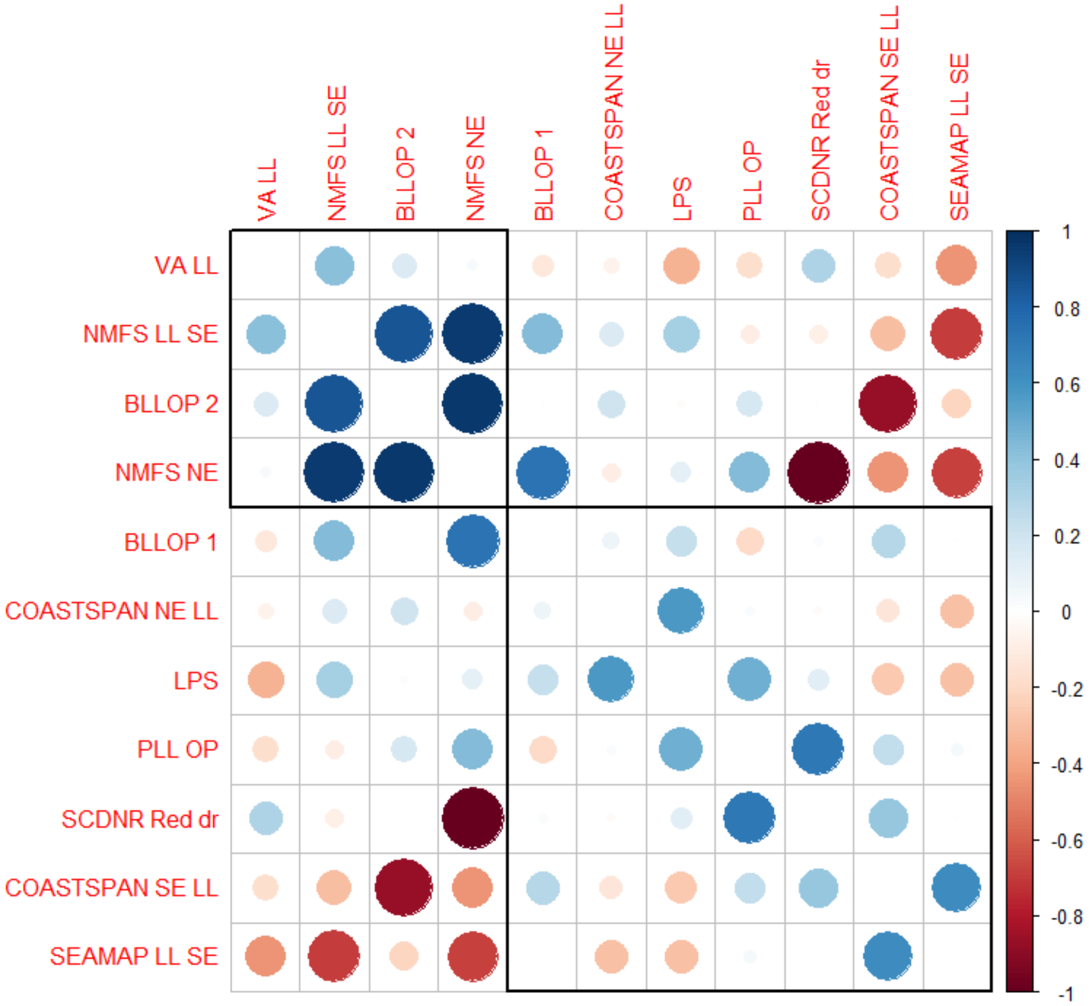

Figure A2.1. Correlation matrix for CPUE indices obtained for the SEDAR 54 assessment for the combined Gulf of Mexico and South Atlantic (GOMSA) region. Blue indicates positive and red negative correlations. The order of the indices and the rectangular boxes are chosen based on a hierarchical cluster analysis using a set of dissimilarities.

Endangered Species Act Status Review Report: Oceanic Whitetip Shark (*Carcharhinus longimanus*)

Photo credit: Andy Mann

2017
National Marine Fisheries Service
National Oceanic and Atmospheric Administration

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Executive Summary

This report was produced in response to a petition received from Defenders of Wildlife on September 21, 2015, to list the oceanic whitetip shark (*Carcharinus longimanus*) as endangered or threatened under the Endangered Species Act (ESA). On January 12, 2016, the National Marine Fisheries Service (NMFS) announced in the *Federal Register* that the petition has sufficient merit for consideration and that a status review was warranted (81 FR 1376). This report is summarizes the best available data and information on the species and presents an evaluation of its status and extinction risk.

The oceanic whitetip shark is a circumglobal species of shark, found in tropical and subtropical seas worldwide. The oceanic whitetip shark is a truly pelagic species, generally remaining offshore in the open ocean, on the outer continental shelf, or around oceanic islands in water depths greater than 184 m, and occurring from the surface to at least 152 m depth. This species has a strong preference for the surface mixed layer in warm waters above 20°C and is therefore a surface-dwelling species. Oceanic whitetip sharks are highly mobile and can travel great distances in the open ocean environment, with excursion estimates of several thousand kilometers. The oceanic whitetip shark is a long-lived, slow-growing, and late maturing species that has low-moderate productivity.

While the oceanic whitetip shark is wide-ranging, its distribution and abundance throughout its range are not well known. Historical fisheries data and observations suggest that the species was once one of the most common and ubiquitous shark species in tropical waters around the world. More recently, however, numerous lines of evidence from all three ocean basins suggest that the oceanic whitetip shark has experienced significant historical declines of varying magnitudes over the past several decades, with evidence that these declines are likely ongoing.

The most significant threat to the oceanic whitetip shark is overutilization of the species for commercial purposes. Because of the species' tropical distribution and tendency to remain in surface waters, the oceanic whitetip shark experiences high encounter and mortality rates in commercial fisheries (e.g., pelagic longline, purse seine, and gillnet fisheries) throughout its range. The species' high-value fins also create an economic incentive for retention and finning of the species for the international shark fin trade. Although there is considerable uncertainty regarding the species' current abundance throughout its range, the best available information indicates that the species has experienced population declines of potentially significant magnitude due to fisheries-related mortality throughout a large majority of its range (e.g., Eastern Pacific, Western and Central Pacific, Atlantic and Indian Oceans).

Recent evidence suggests that most populations are still experiencing various levels of decline due to continued fishing pressure and associated mortality. Efforts to address overutilization of the species through regulatory measures appear largely inadequate, with evidence of illegal retention and trafficking of oceanic whitetip fins despite prohibitions for the species in all Regional Fisheries Management Organizations (RFMOs) and its listing under the Convention on International Trade of Endangered Species of Fauna and Flora (CITES) Appendix II. As such, we conclude that overutilization will continue to be a threat to the oceanic whitetip shark through the foreseeable future (~30 years), placing the species at a moderate risk of extinction throughout its range.

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1. INTRODUCTION

Scope and Intent of the Present Document

On September 21, 2015, the National Marine Fisheries Service (NMFS) received a petition to list the oceanic whitetip shark, as either threatened or endangered under the U.S. Endangered Species Act (ESA). This document is a status review of the oceanic whitetip shark (*Carcharhinus longimanus*). Under the ESA, if a petition is found to present substantial scientific or commercial information that the petitioned action may be warranted, a status review shall be promptly commenced (16 U.S.C. 1533(b)(3)(A)). NMFS determined the petition presented substantial information for consideration and that a status review was warranted for the species (see following link for the Federal Register notice for oceanic whitetip: https://federalregister.gov/a/2016-00384). The ESA stipulates that listing determinations should be based on the best scientific and commercial information available. NMFS appointed a biologist in the Office of Protected Resources Endangered Species Conservation Division to undertake the scientific review of the biology, population status and trends, threats, and future outlook for the species. Using this scientific review, NMFS convened a team of biologists and shark experts to conduct an extinction risk analysis for the oceanic whitetip shark and make conclusions regarding the biological status of the species.

Therefore, this document reports the scientific review as well as the team's conclusions regarding the extinction risk of the oceanic whitetip shark. The conclusions in this status review are subject to revision should important new information arise in the future. Where available, we provide literature citations to review articles that provide even more extensive citations for each topic. Data and information were reviewed through October 2017.

2. LIFE HISTORY AND ECOLOGY

2.1 Taxonomy and Distinctive Characteristics

The oceanic whitetip shark is a large open ocean apex predatory shark found in tropical and subtropical waters around the globe. This species belongs to the family Carcharhinidae and is classified as a requiem shark (Order Carcharhiniformes). The oceanic whitetip belongs to the genus *Carcharhinus*, which includes other pelagic species of sharks, such as the silky shark (*C. falciformis*) and dusky shark (*C. obscuras*), and is the only truly oceanic shark of its genus (Bonfil *et al.,* 2008). Naturalist René-Primevère Lesson first described the oceanic whitetip shark in 1831 and named the shark *C. maou*. Felipe Poey later described it in 1861 as *Squalus longimanus*. The name *Pterolamiops longimanus* has also been used, but the current accepted name is *Carcharhinus longimanus*.

Compagno (1984) provides the following description of the oceanic whitetip: it has a stocky build with a large rounded first dorsal fin and very long and wide paddle-like pectoral fins. The first dorsal fin is very wide with a rounded tip, originating just in front of the rear tips of the pectoral fins. The second dorsal fin originates over or slightly in front of the base of the anal fin. The species also exhibits a distinct color pattern of mottled white tips on its front dorsal, caudal, and pectoral fins, with black tips on its anal fin and on the ventral surfaces of its pelvic fins. The head has a short and bluntly rounded nose and small circular eyes. The upper jaw contains broad, triangular serrated teeth, while the teeth in the lower jaw are more pointed with serrations only near the tip. The color of the body varies depending upon geographic location, but is generally grayish bronze to brown, while the underside is whitish with a yellow tinge on some individuals (Compagno 1984). Oceanic whitetip sharks typically swim slowly at or near the surface; however, they are capable of making sudden dashes for short distances when disturbed (Compagno 1984).

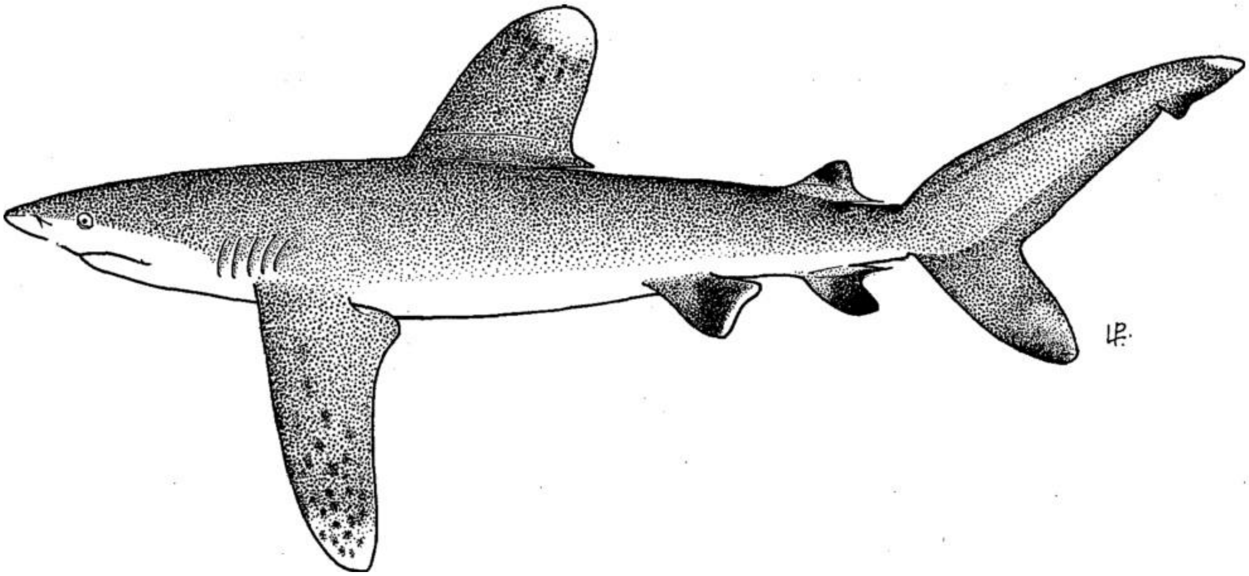

Figure 1 Oceanic whitetip. Source: Compagno 1984.

2.2 Distribution and Habitat Use

The oceanic whitetip shark is globally distributed in epipelagic tropical and subtropical waters between 30º North and 35º South latitudes (Baum *et al.,* 2006). In the Western Atlantic, oceanic whitetips occur from Maine to Argentina, including the Caribbean and Gulf of Mexico. In the Central and Eastern Atlantic, the species occurs from Madeira, Portugal south to the Gulf of Guinea, and possibly in the Mediterranean Sea. In the western Indian Ocean, the species occurs in waters of South Africa, Madagascar, Mozambique, Mauritius, Seychelles, India, and within the Red Sea. Oceanic whitetips also occur throughout the Western and Central Pacific, including China, Taiwan, the Philippines, New Caledonia, Australia (southern Australian coast), Hawaiian Islands south to Samoa Islands, Tahiti and Tuamotu Archipelago and west to Galapagos Islands. Finally, in the eastern Pacific, the species occurs from southern California to Peru, including the Gulf of California and Clipperton Island (Compagno 1984).

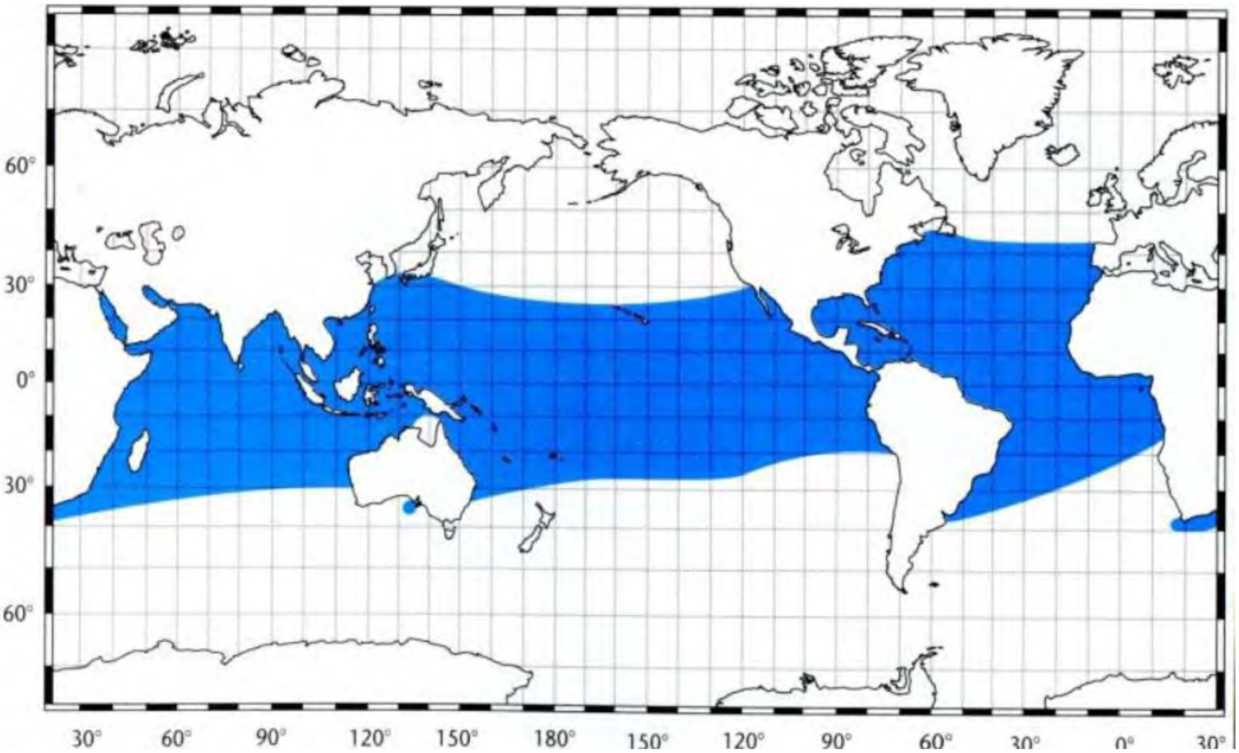

Figure 2 Geographic distribution of oceanic whitetip shark. Source: Last and Stevens 2009.

The oceanic whitetip shark was historically characterized as one of the most abundant oceanic sharks (Backus *et al.,* 1956; Compagno 1984); it is usually found offshore in the open ocean, on the outer continental shelf, or around oceanic islands in deep water greater than 184 m, and occurs from the surface to at least 152 m depth. This species has a clear preference for open ocean waters between 10˚N and 10˚S, but can be found in decreasing numbers out to latitudes of 30˚N and 35˚S, with abundance decreasing with greater proximity to continental shelves (Backus *et al.,* 1956; Strasburg 1958; Compagno 1984; Bonfil *et al.,* 2008). Although the oceanic whitetip occurs in waters between 15ºC and 28ºC, this species exhibits a strong preference for the surface mixed layer in warm waters above 20°C (Bonfil *et al*., 2008). It is, however, capable of tolerating colder waters down to 7.75°C for short durations, as shown by brief, deep dives into the mesopelagic zone below the thermocline (>200 m) (Howey-Jordan *et al.,* 2013; Howey *et al.,* 2016). This indicates that the oceanic whitetip shark may commonly explore extreme environments (e.g., deep depths, low temperatures) as a potential foraging strategy. However, exposures to these cold temperatures are not sustained (Musyl *et al.,* 2011; Tolotti *et al.,* 2015a) and there is some evidence to suggest the species tends to withdraw from waters below 15ºC (e.g., the Gulf of Mexico in winter; Compagno (1984)). The thermal preferences of oceanic whitetip sharks in conjunction with their reported range within 30° N and S suggest possible thermal barriers to inter-ocean basin movements around the southern tips of Africa and South America (Bonfil *et al.,* 2008; Musyl *et al.,* 2011; Howey-Jordan *et al.,* 2013; Gaither *et al.,* 2015).

Information regarding movement patterns or possible migration paths for oceanic whitetips is limited. In the Pacific, Musyl *et al.,* (2011) used pop-up satellite tags (PSATs) to describe the behavior of several shark species, including the oceanic whitetip, which showed a complex movement pattern generally restricted to tropical waters of the central Pacific north of the North

Equatorial Countercurrent (NEC) near the original tagging location (Musyl *et al*. 2011; see Figure 3 below). Results showed that oceanic whitetips remained in the near-surface mixed layer within 2°C of the sea surface temperature (SST; >25°C) over 95% of the time. Maximum time at liberty was 243 days, but the largest linear movement was 2,314 nmi (4,285 km) in 95 days (Musyl *et al*., 2011).

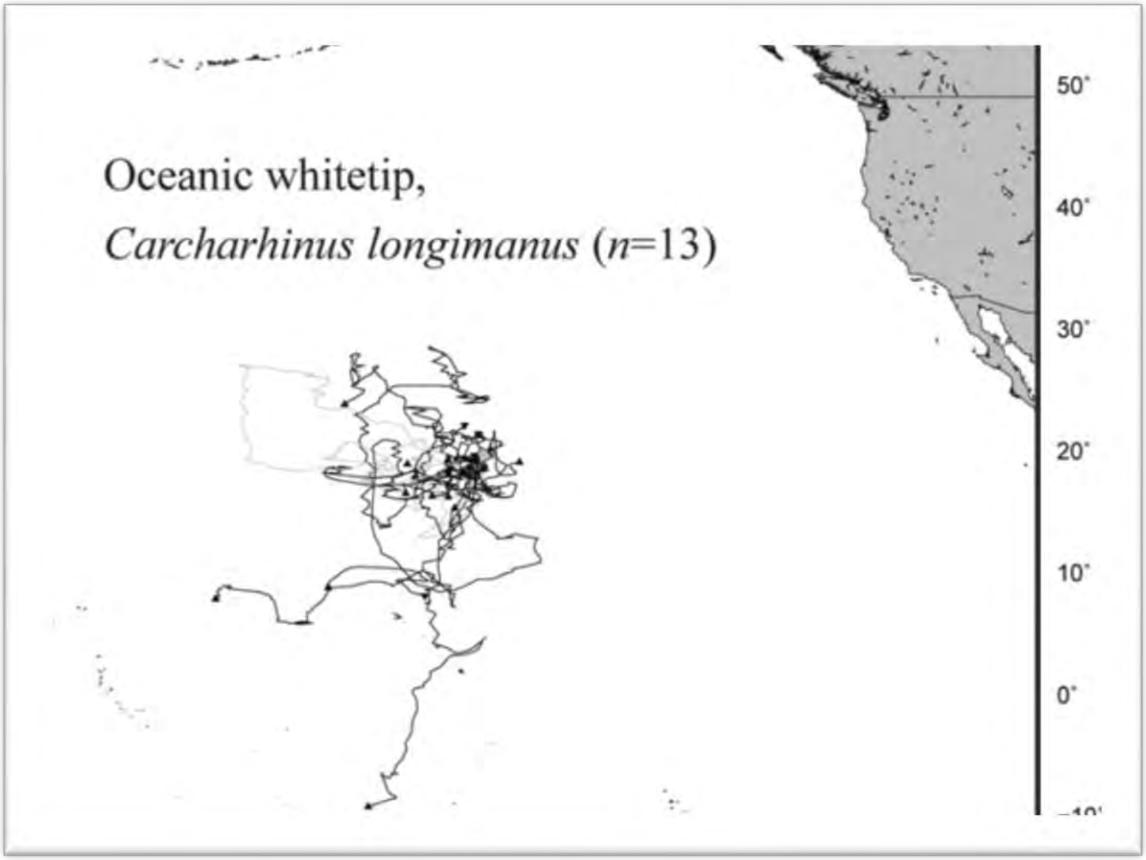

Figure 3 Most probable tracks for oceanic whitetip sharks tagged with PSATs and released in the central Pacific Ocean were estimated from the raw geolocations using the Kalman filter-sea surface temperature state-space model (see Appendix 1 in Musyl et al. 2011).

In the Atlantic Ocean, participants in the NMFS Cooperative Shark Tagging Program (CSTP) tagged 645 oceanic whitetips between 1962 and 2015, but only 8 were recaptured. Maximum time at liberty was 3.3 years, maximum distance traveled was 1,225 nmi (2,270 km), and maximum estimated speed was 17 nmi/day (32 km/day; Kohler *et al.,* (1998); NMFS unpublished data). These data show movements by juveniles from a variety of locations, including from the northeastern Gulf of Mexico to the East Coast of Florida, from the Mid-Atlantic Bight to southern Cuba, from the Lesser Antilles west into the central Caribbean Sea, from east to west along the equatorial Atlantic, and from off southern Brazil in a northeasterly direction (Kohler *et al.,* (1998); Bonfil *et al.,* (2008); see Figure 4 below). An immature female was also tagged in the waters between Cuba and Haiti and was recaptured the next day within 6 nmi (11 km) of the tagging location (NMFS unpublished data; see Figure 4 below). Additionally, an adult of unknown sex was tagged and recaptured three years apart in the vicinity of Cat Island, Bahamas (NMFS unpublished data; see Figure 4 below).

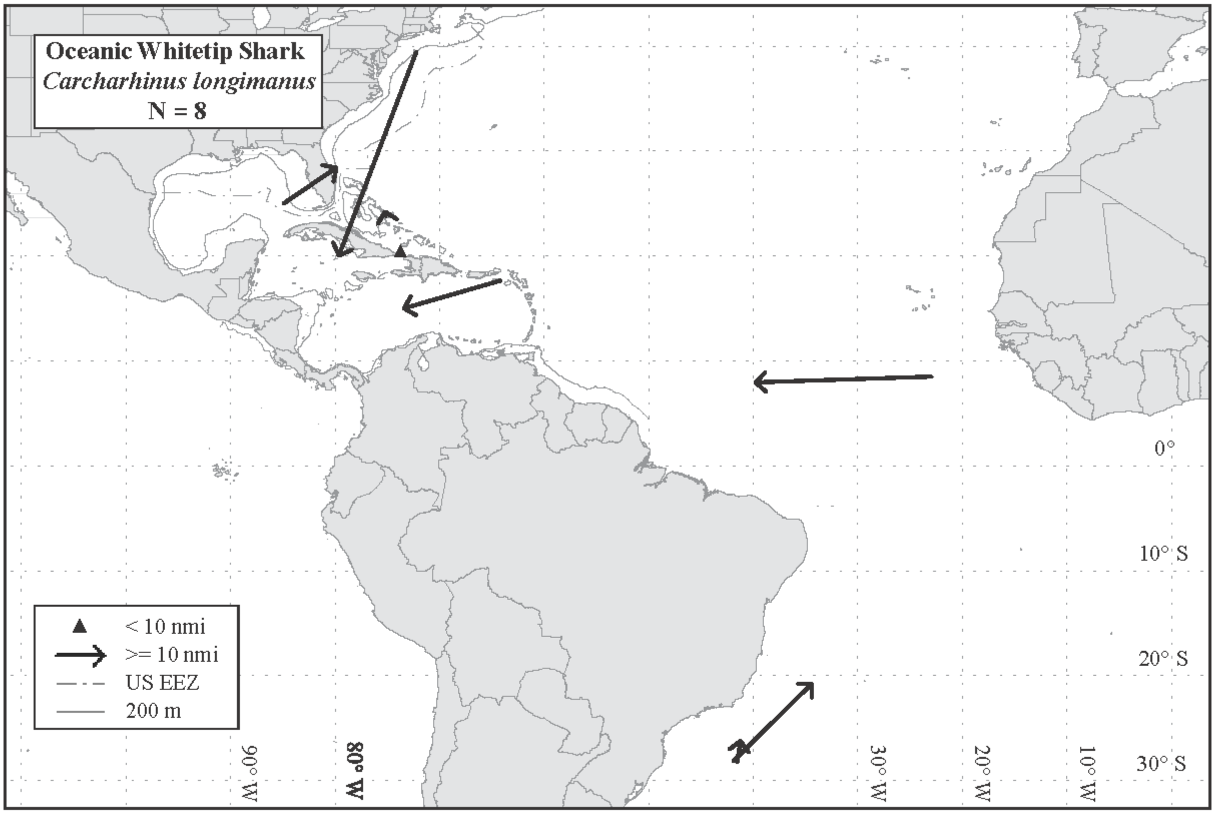

Figure 4 Recapture distribution for the oceanic whitetip shark, *C. longimanus*, from the NMFS Co-operative Shark Tagging Program during 1962-93 and NMFS unpublished data.

In the Gulf of Mexico, a satellite tagged oceanic whitetip shark moved a straight-line distance of 238 km from southeast Louisiana to the edge of the continental shelf about 300 km north of the Yucatan Peninsula. During the track, the shark rarely dove below 150 m staying above the thermocline, and only one dive to 256 m was recorded. The most frequently occupied depth during the entire track was 25.5-50 m (49.8% total time) and temperature was 24.05-26 °C (44.7% total time) (Carlson and Gulak 2012). More recently, a study from Cat Island, Bahamas tagged and tracked 11 mature oceanic whitetip sharks (10 females, 1 male). Individuals tagged at Cat Island stayed within 500 km of the tagging site for ~30 days before scattering across 16,422 km^2 of the western North Atlantic (Howey-Jordan *et al*. 2013). Times at liberty ranged from 30-245 days, after which the largest movement by an individual from the tagging site ranged from 290–1,940 km. Individuals moved to several different destinations thereafter (e.g., the northern Lesser Antilles, the northern Bahamas, and north of the Windward Passage (the strait between Cuba and Haiti)), with many returning to the Bahamas after ~150 days. Howey-Jordan *et al.* (2013) found generally high residency times of oceanic whitetips in the Bahamas Exclusive Economic Zone (mean = 68.2% of time). Similar to the tagging study in the Pacific by Musyl *et al.,* (2011), oceanic whitetip sharks in the Bahamas spent 99.7% of their time in waters shallower than 200 m and did not show differences mean depths between day and night, with average day and night temperatures of 26.26±0.003°C and 26.23±0.003°C, respectively. According to Howey-Jordan et al. (2013):

> "There was a positive correlation between daily sea surface temperature (SST) and mean depth occupied (i.e., as individuals experienced warmer SST, likely resulting from seasonal sea surface warming or migration to areas with warmer SST, mean daily depth increased, suggesting possible behavioral thermoregulation. All individuals made short duration (mean=13.06 minutes) dives into the mesopelagic zone (down to 1,082 m and 7.75˚C), which occurred significantly more often at night."

These tracking data also suggest that oceanic whitetip sharks exhibit site fidelity to Cat Island, Bahamas, although the reasons for this are still unclear. NMFS CSTP data (discussed earlier) from an adult oceanic whitetip, tagged and recaptured three years later in this area, provides supporting evidence of site fidelity to the waters around Cat Island. This information is important given the characterization of this species as highly migratory (Howey-Jordan *et al.,* 2013).

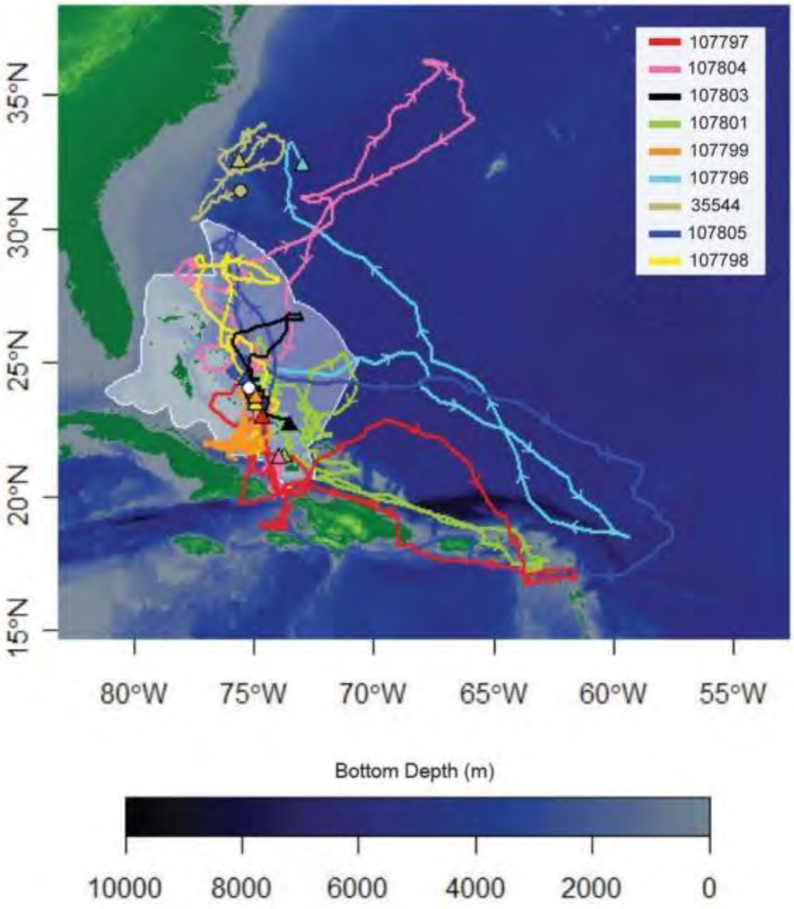

Figure 5 Map with bottom depth (m) showing filtered tracks for nine oceanic whitetip sharks equipped with Standard Rate tags. Colored lines represent tracks from individuals (listed by tag ID); triangle indicate pop-up location. Arrows on colored lines show direction of movement. Source: Howey-Jordan et al. 2013.

In the equatorial and southwestern Atlantic, Tolotti *et al*. 2015(a) obtained fisheries independent data from eight oceanic whitetip sharks tagged with PSATs in the area overlapping the operations of the Brazilian longline fleet. Tag deployment periods (i.e., the number of days the tag was deployed before it stopped recording data) varied from 60 to 178 days between 2010 and 2012. Similar to the study from Cat Island, Bahamas, this study showed that oceanic whitetip sharks exhibit some degree of site fidelity. Tagging and pop-up sites were relatively close to each other, although individuals tended to travel long distances before returning to the tagging area. In fact, 5 of the 8 tagged sharks concluded their tracks relatively close to their starting points, even after traveling several thousand kilometers (See Figure 6 below). Overall, the horizontal movements were more prominent in terms of latitude, whereas longitudinal movements were more restricted. Tolotti *et al*. (2015a) demonstrated that the sharks exhibited a strong preference for the warm and shallow waters of the mixed layer, and spent more than 70% of the time above the thermocline and 95% above 120 m. Additionally, for approximately 96% of the monitoring period, tagged individuals remained at temperatures between 24 and 30°C (Tolotti *et al.,* 2015a).

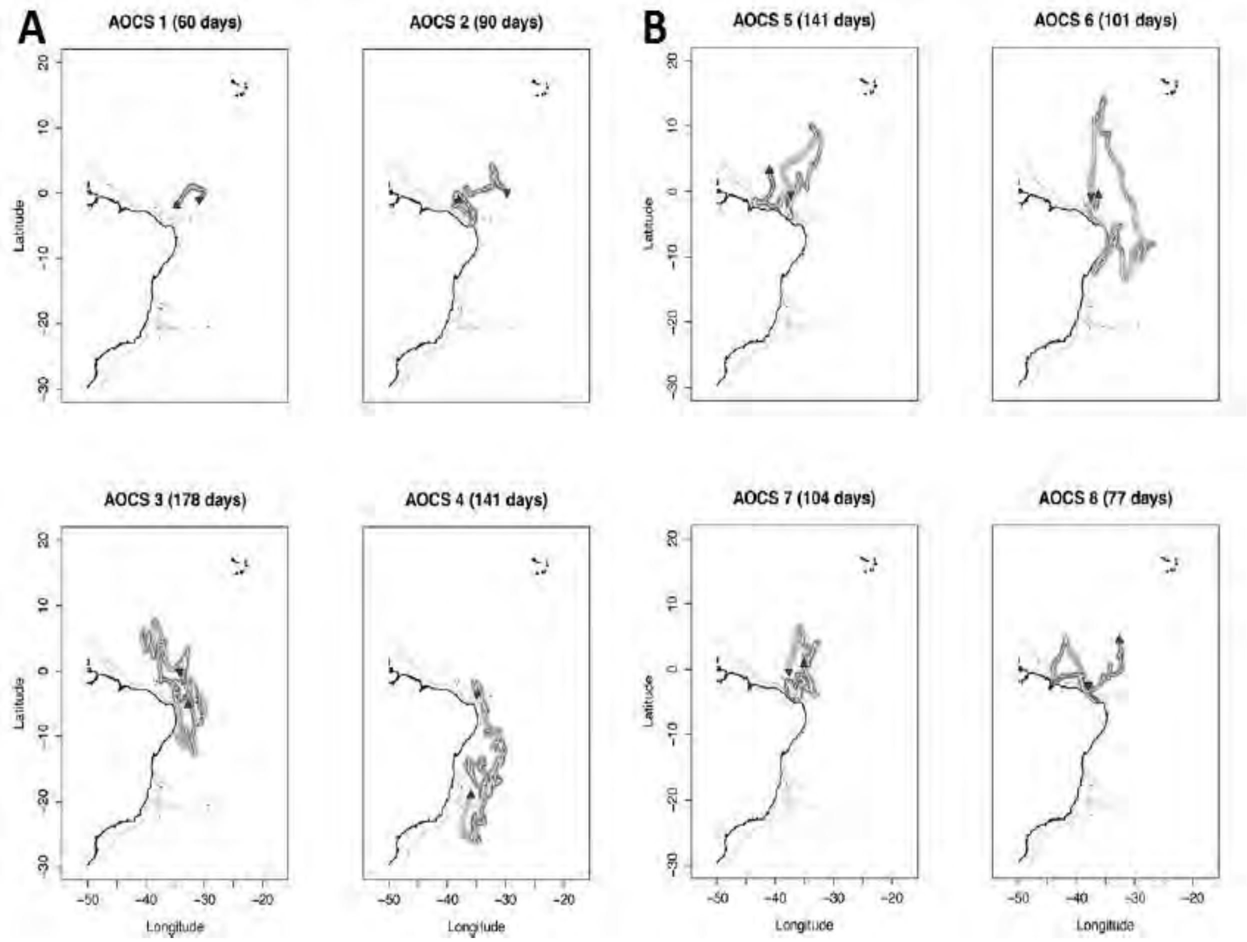

Figure 6 Post-processed tracks of oceanic whitetip sharks tagged in the western Atlantic Ocean. The downward triangles represent the tagging position and the upward triangles the end of the track. The grey-shaded area represents the error around estimated positions. (A) Oceanic whitetip sharks tagged in 2010 and 2011. (B) Oceanic whitetip sharks tagged in March 2012. Source: Tolotti *et al.,* (2015a).

Tagging data from the Indian Ocean is limited. Observations from the Spanish longline fishery targeting swordfish from 1993-2011 indicate that the distribution of oceanic whitetip in the Indian Ocean likely falls mainly within the warm water regions to North of 25ºS (Zones 1 and 2; see Figure 7 below) and with less probability in some of the nearby areas located slightly farther South, which are influenced by the seasonal expansion of warm water masses (García-Cortés *et al.,* 2012). It should be noted that in this case, the distribution of oceanic whitetip sharks is shown in total catches rather than CPUE; therefore, the results and patterns shown in the figure are highly influenced by the effort of the fleet.

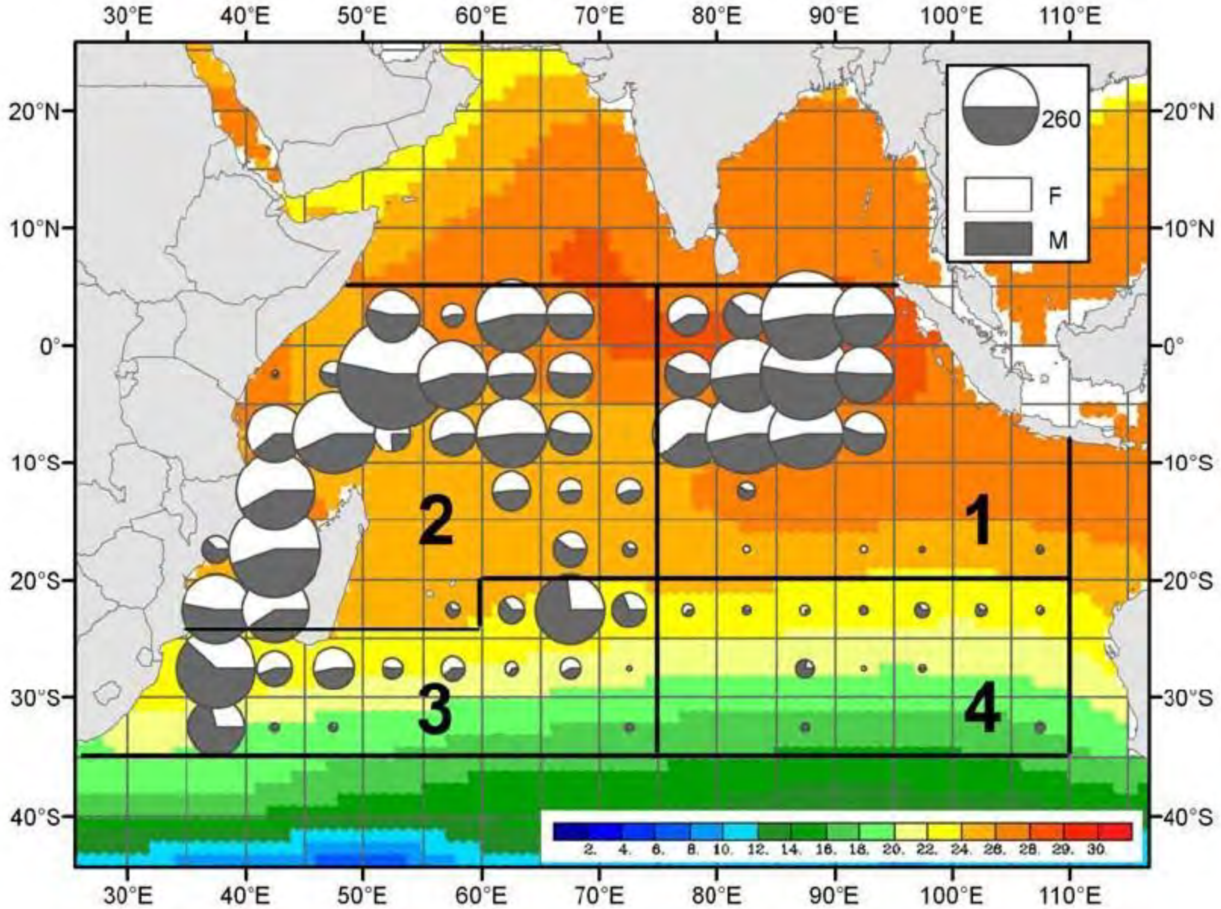

Figure 7 Observations of *C. longimanus* by 5ºx5º areas and sex in the Spanish longline fleet. The size of the circles is proportional to the number of observations available for both sexes combined. Sea temperature at 50m depth (yearly average) according to a color scale. Source: Garcia-Cortes *et al.* 2012.

Filmalter *et al.,* (2012) used pop-up archival tags (PATs) as well as mini-PATs to examine the vertical and horizontal behavior of oceanic whitetip sharks in the western Indian Ocean from 2009 to 2012. Similar to studies from the Atlantic and Pacific oceans, the two oceanic whitetip sharks tagged spent the majority of their time between 50 and 100 m depths. Long distance movements were also observed, with one tag that remained attached for 100 days. Filmalter *et al*. (2012) noted that this particular individual showed extensive horizontal movement; the shark traveled a distance of approximately 6,500 km during the study period, moving from the Mozambique Channel up the African east coast of Somalia and then traveling back down towards the Seychelles. The second tagged individual was monitored for only 19 days, during which time Filmalter *et al*. (2012) estimated the shark traveled 1,100 km in the southern Mozambique Channel. Both results demonstrate the ability of these sharks to travel large distances in the pelagic environment (Filmalter *et al.,* (2012); see Figure 8 below).

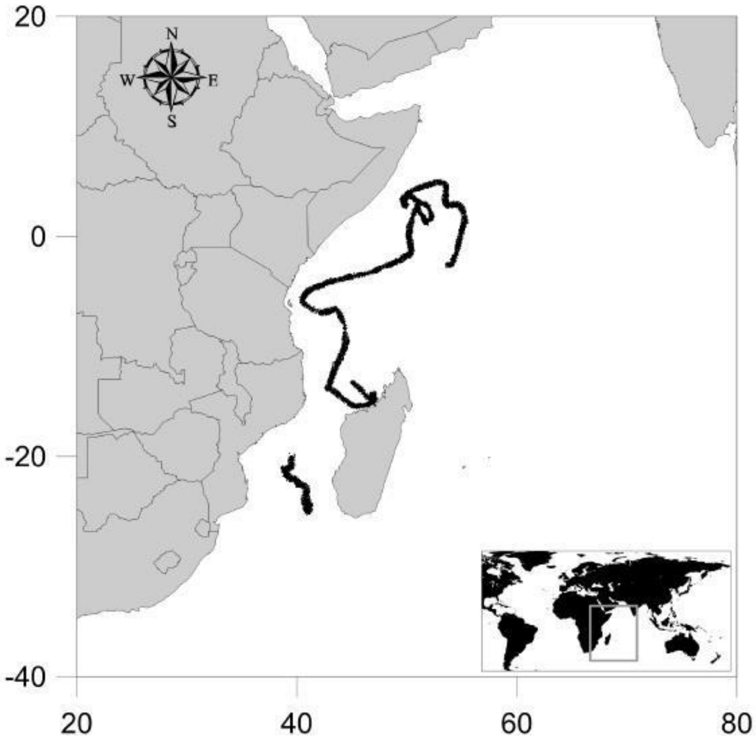

Figure 8 Horizontal movements of oceanic whitetip sharks (n = 2) tagged with PAT and mini-PATs in the western Indian Ocean. Source: Filmalter *et al.* 2012.

Finally, the Spanish fleet opportunistically tagged and released hundreds of sharks in the Indian Ocean, including oceanic whitetip (n= 56) from 1985-2004 (Mejuto *et al*. 2005). Results from this study (see Figure 9 below) indicate that the oceanic whitetip shark exhibits a trans-equatorial migration in the Indian Ocean (Mejuto *et al.,* 2005).

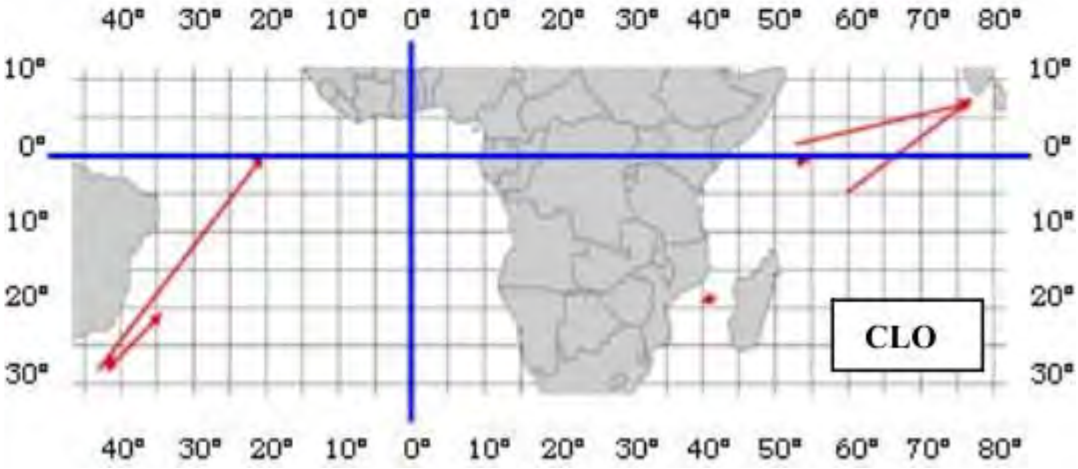

Figure 9 Rectilinear movements estimated on the basis of the tagging-recapture of Carcharhinus longimanus in the Atlantic and Indian Oceans. Source: Mejuto *et al.* 2005.

2.3 Feeding and Diet

Oceanic whitetip sharks are top-level predators in pelagic ecosystems and feed primarily on teleosts and cephalopods (Bonfil *et al.,* 2008), although studies have also reported that they consume sea birds, marine mammals, other sharks and rays, molluscs, crustaceans, and even garbage (Compagno 1984; Cortés 1999). Backus *et al.,* (1956) recorded various fish species in the stomachs of oceanic whitetip sharks, including blackfin tuna, barracuda, and white marlin. Historically, oceanic whitetip sharks were described as pests to pelagic longline fisheries for tuna, as the sharks would persistently follow boats and cause significant damage to the catches (Compagno 1984). The oceanic whitetip has also been observed scavenging off dead marine mammal carcasses off South Africa (Bass *et al.,* 1973; Compagno 1984). Based on the species' diet, the oceanic whitetip has a high trophic level, with a score of 4.2 out of a maximum 5.0 (Cortés 1999). The available evidence suggests that oceanic whitetip sharks are opportunistic feeders. For example, large pelagic teleosts (e.g. billfish, tunas, and dolphinfish) are abundant in the Bahamas, and anecdotal reports suggest that oceanic whitetips feed heavily on recreationally caught teleosts in the region (Madigan *et al.,* 2015). In a recent study of an oceanic whitetip shark aggregation at Cat Island, Bahamas, Madigan *et al*. (2015) used SIA-based Bayesian mixing model to estimate short-term (near Cat Island) diets, which showed more large pelagic teleosts (72%) than in long-term diets (47%), thus showing a spatial and temporal difference in feeding habits of oceanic whitetip sharks. The study concluded that the availability of large teleost prey and supplemental feeding from recreational sport fishermen may be potential mechanisms underpinning site-fidelity and aggregation of oceanic whitetips at Cat Island (Madigan *et al.,* 2015). This further supports the notion that oceanic whitetip sharks are opportunistic predators.

2.4 Growth and Reproduction

Despite its worldwide distribution and common occurrence in most high-seas fishery catches in tropical seas, the oceanic whitetip shark's biology and ecology remain understudied. To date, studies on the life history parameters of the oceanic whitetip shark are limited, with only a few publications available: two from the North Pacific (Joung *et al*. 2016 and Seki *et al*. 1998), one from the Western and Central Pacific in Papua New Guinea (D'Alberto *et al.,* 2017), one from the Indian Ocean (Varghese *et al.,* 2016) and two from the Southwest Atlantic Ocean (Lessa *et al.,* 1999; Rodrigues *et al.,* 2015). The results of these papers are summarized below.

The theoretical maximum age for the oceanic whitetip shark ranges from ~25-36 years (D'Alberto *et al*., 2017; Rice and Harley 2012). However, observed maximum ages based on vertebral ring counts are much lower, and range from 12 to 18 years in the North Pacific and Western and Central Pacific, respectively (Joung *et al*., 2016; D'Alberto *et al*., 2017), and from 13 to 19 in the South Atlantic (Seki *et al.,* 1998; Lessa *et al.,* 1999; Rodrigues *et al.,* 2015). However, these maximum observed ages may be underestimates of the species' actual maximum longevity, because vertebral band counts are not necessarily a full-proof methodology for estimating maximum age (D'Alberto *et al*., 2017). In fact, several other shark species have documented longevities that double what the vertebral band pair counts estimated (D'Alberto *et al.,* 2017). For purposes of this document, we consider the oceanic whitetip to live at least 20 years, and thus is a long-lived species.

In terms of size, the maximum length effectively measured for oceanic whitetip was 350 cm total length in the 1940s (TL; Bigelow and Schroder 1948 cited in Lessa *et al*. 1999), with "gigantic individuals" perhaps reaching 395 cm TL (Compagno 1984), though Compagno's length was never confirmed (Lessa *et al.,* 1999). Given the rarity of specimens larger than 270 cm TL, Lessa *et al.* (1999) noted that the length composition of the species may have been altered since the

1940s due to fishing pressure. D'Alberto *et al.* (2017) reiterated this possibility, given the lack of specimens large specimens >200 cm TL in their study. Lessa *et al.,* (1999) recorded a maximum size of 250 cm TL in the Southwest Atlantic, and estimated a theoretical maximum size of 325 cm TL (Lessa *et al.,* 1999); however, the most common sizes are below 300 cm TL (Compagno 1984).

The oceanic whitetip shark seems to have variable growth rates throughout its range. Earlier studies suggested that the oceanic whitetip shark is slow growing, but more recent studies have shown faster growth rates similar to blue and silky sharks (Clarke *et al.,* 2015b). In the Southwest Atlantic, male and female growth rates are similar; observed and back-calculated length-at age von Bertalanffy parameters from Lessa *et al.* (1999) are as follows:

Observed asymptotic length (L_∞) = 284.9 cm; growth coefficient (K) = 0.099 yr^{-1}, and T_0 = -3.391 yr^{-1}

Back-calculated asymptotic length (L_∞) = 325.4 cm; growth coefficient (K) = 0.075 yr^{-1}, and T_0 = -3.342 yr^{-1}

Growth rates are 25.2 cm yr^{-1} in the first free-living year; 13.6 cm yr^{-1} from ages 1 to 4; 9.7 cm yr^{-1} for adolescents of age 5; and 9.10 cm yr^{-1} for mature individuals (Lessa *et al.,* 1999). In a more recent study from the western North Pacific (Joung *et al.,* 2016), growth rates were also found to be similar between sexes. The von Bertalanffy growth parameters combining both sexes were as follows:

Asymptotic length (L_∞) = 309.4 cm TL; growth coefficient (K) = 0.0852 yr^{-1}

According to Branstetter (1990), growth coefficients (K) falling in the range of 0.05-0.10/yr is a slow-growing species; 0.1-0.2 is a moderate-growing species; and 0.2-0.5 is a fast-growing species. Under these parameters, the oceanic whitetip shark is considered a slow-growing species. Figure 10 below shows the various growth curves for the oceanic whitetip shark.

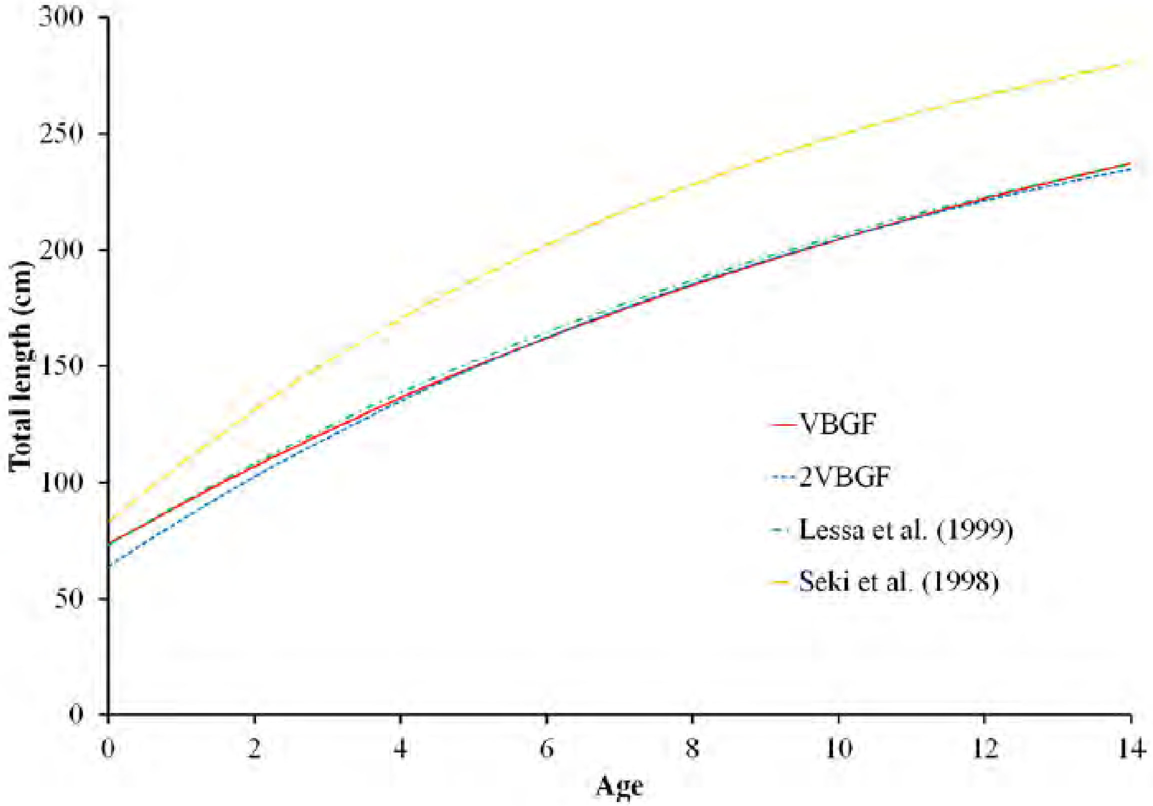

Figure 10 Comparison of the growth curves of the oceanic whitetip shark in different regions, from Seki *et al.* (1998), Lessa *et al.* (1999) and Joung *et al*. (2016). VBGF = von Bertalanffy growth function. 2VBGF was only used in Joung *et al.* (2016) and VBGF was used in the other studies. Source: Joung *et al.* 2016.

A length-weight equation is given by Romanov and Romanova (2009) from the Indian Ocean (Figure 11) for total weight (TW): TW=(.386e-4)*FL^((2.75586)) (n = 587; both sexes).

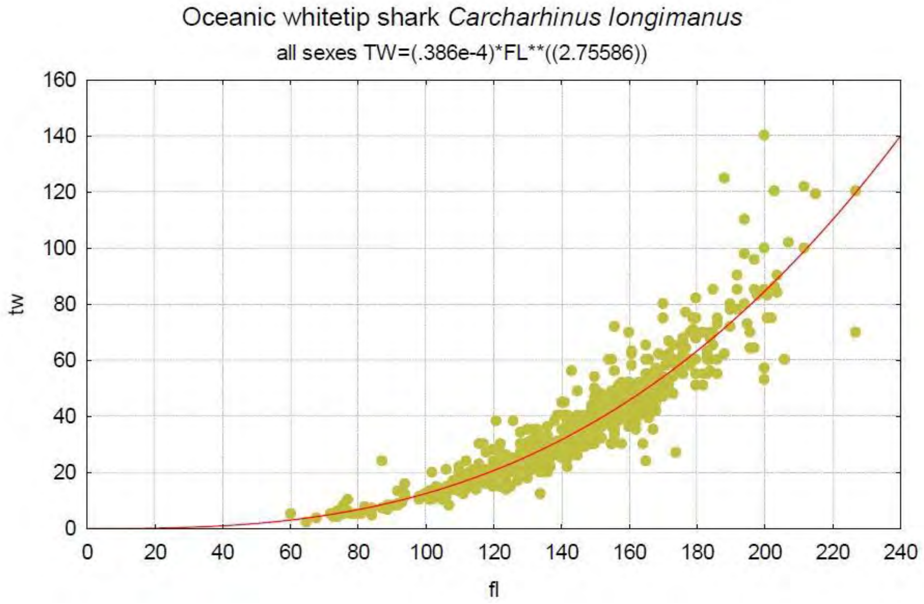

Figure 11 Length-weight scatterplot and relationship for oceanic whitetip shark (all sexes, n=587). Source: Romanov and Romanova 2009.

Age of maturity varies depending on geographic location. For example, in the Southwest Atlantic, age and size of maturity in oceanic whitetips was estimated to be 6-7 years and 180-190 cm TL, respectively, for both sexes (Lessa *et al.,* 1999). In the North Pacific, females become mature at about 168-196 cm TL, and males at 175-189 cm TL, which corresponds to an age of 4 and 5 years, respectively (Seki *et al.,* 1998). However, more recently Joung *et al*. (2016) determined a later age of maturity in the North Pacific of approximately 8.5-8.8 years for females and 6.8-8.9 years for males. In the Indian Ocean, both males and females mature at around 185-200 cm TL (IOTC 2014), although Varghese *et al.,* (2016) estimates the lengths of maturity to include slightly larger sizes (189-287 cm for males and 188-311 cm for females).

Like other carcharhinid species, the oceanic whitetip shark is viviparous (i.e., the species gives birth to live young) with placental embryonic development. The reproductive cycle is thought to be biennial, giving birth on alternate years, after a lengthy 10-12 month gestation period (Backus *et al*., 1956; Seki *et al.,* 1998; Bonfil *et al.,* 2008; Tambourgi *et al.,* 2013). The number of pups in a litter ranges from 1 to 14, with an average of 6, and there is a likely positive correlation between female size and number of pups per litter, with larger sharks producing more offspring in all three ocean basins (Bass *et al.,* 1973; Compagno 1984; Seki *et al.,* 1998; Bonfil *et al.,* 2008; IOTC 2015a; Varghese *et al.,* 2016). Size at birth also varies slightly but is generally similar across geographic locations, ranging from 55 to 75 cm TL in the North Pacific, around 65-75 cm TL in the northwestern Atlantic, and 60-65 cm TL off South Africa. Several studies suggest that oceanic whitetip sharks give birth from late spring to summer (Backus *et al.,* 1956; Bass *et al.,* 1973; Compagno 1984; Bonfil *et al.,* 2008). In contrast, Seki *et al*. (1998) found no apparent parturition period in the North Pacific, as embryo occurrence was observed in almost every month in which data was acquired, which is indicative of an extended parturition duration throughout the year. The locations of the nursery grounds are not well known but they are thought to be in oceanic areas.

Records of pregnant females and newborns from the tropical Pacific are concentrated between 20ºN and the equator, from 170ºE to 140ºW (see original citations in CITES 2013). In the Atlantic, young oceanic whitetip sharks have been observed well offshore along the southeastern coast of the United States, suggesting the possible presence of a nursery area in pelagic waters over the continental shelf (Compagno 1984; Bonfil *et al.,* 2008). In the equatorial and southwestern Atlantic, the prevalence of immature sharks, both female and male, in fisheries catch data suggests that this area may serve as potential nursery habitat for the oceanic whitetip shark (Coelho *et al.,* 2009; Tambourgi *et al.,* 2013; Tolotti *et al.,* 2013; Frédou *et al.,* 2015). Juveniles seem to be concentrated in equatorial latitudes, while specimens in other maturational stages are more widespread (Tambourgi *et al.,* 2013). Pregnant females have been found often close to shore, particularly around the Caribbean Islands, and one pregnant female was found washed ashore near Auckland, New Zealand. This may be indicative of females coming close to shore to give birth (Clarke *et al*. 2015b). Sexual segregation has been documented in oceanic whitetip sharks and may be related to the seasonal congregation of females in favored pupping grounds. For example, in the Gulf of Mexico, captures of oceanic whitetips were predominantly female (13 females and 3 males were caught in August 1954; Backus 1956). In contrast, Coelho *et al.* (2009) observed a sex ratio (male:female) of 1.2:1 in the southwestern equatorial region of the Atlantic, and individuals in this region seemed to be spatially segregated by size, with the large majority of individuals (80.7% of males and 89.4% of females) being immature. Similarly, Tambourgi *et al*., 2013) observed a nearly 1:1 ratio in the southwestern equatorial Atlantic. Although many pelagic shark species exhibit spatial/temporal separation between sizes, and are often segregated sexually once they reach reproductive maturity, it is unclear whether this has been demonstrated in the oceanic whitetip shark. Table 1 below provides a summary of life history characteristics reported in published literature.

Table 1 Life history parameters of *C. longimanus* from published literature (obs. = observed; m = male; f = female; PCL = Pre-caudal length; TL = Total Length).

Parameter	**Estimate**	**Reference**
Growth rate (von Bertalanffy k)	0.075-0.099 year^{-1} (SW Atlantic; both sexes) 0.103 year^{-1} (N. Pacific; both sexes) 0.0852 year^{-1} (western N. Pacific; both sexes	Lessa *et al.,* (1999) Seki *et al.,* (1998) Joung *et al.* (2016)
Max length	325 cm TL (SW Atlantic) 245 cm PCL (342 cm TL; N. Pacific) 246 TL (f; obs; N. Pacific) 268 TL (m, obs; N. Pacific) 272 cm TL (Atlantic) 252 cm TL (f; obs; SW Atlantic) 253 cm TL (m; obs; SW Atlantic)	Lessa *et al.,* (1999) Seki *et al.,* (1998) Joung *et al.* (2016) Cortés (2002); (2008b) Coelho *et al.,* (2009)

Parameter	**Estimate**	**Reference**
	227 cm TL (f; obs; SW Atlantic) 242 cm TL (m; obs; SW Atlantic)	Tambourgi *et al.,* (2013)
	252 cm TL (f; obs S. Atlantic) 242 cm TL (m; obs; S. Atlantic)	Rodrigues *et al.,* (2015)
Age at maturity (years)	6-7 (SW Atlantic; both sexes)	Lessa *et al.,* (1999)
	4–5 (N. Pacific; both sexes)	Seki *et al.,* (1998)
	8.5-8.8 years (N. Pacific; females) 6.8 – 8.9 years (N. Pacific; males)	Joung *et al.* (2016)
Length at maturity (cm TL)	180-190 (SW Atlantic; both sexes)	Lessa *et al.,* (1999)
	170 (SW Atlantic; f) 170-190 (SW Atlantic; m)	Tambourgi *et al.,* (2013)
	168-196 (N. Pacific; f) 175-189 (N. Pacific; m)	Seki *et al.,* (1998)
	190 cm TL (N. Pacific; f) 172 cm TL (N. Pacific; m)	Joung *et al.,* (2016)
	190-240 (Indian Ocean; both sexes)	IOTC (2015a)
	185 cm TL (Arabian Sea; f) 202 cm TL (Arabian Sea; m)	Varghese *et al.*, (2016)
Longevity (years)	19 (obs; SW Atlantic)	Rodrigues *et al.,* (2015)
	17 (theoretical; SW Atlantic)	Lessa *et al.,* (1999)
	11-12 (obs; N. Pacific)	Seki *et al.,* (1998); Joung *et al.* 2016
	36 (theoretical; WCPO but based on theoretical max length from N. Pacific from Seki *et al.* 1998)	Rice and Harley 2012
	24.9 (theoretical; WCPO; f) 24.6 (theoretical; WCPO; m) 18 (obs; WCPO; f) 17 (obs; WCPO; m)	D'Alberto *et al.*, (2017)

Parameter	**Estimate**	**Reference**
Gestation period	9 months (Pacific)	Bonfil *et al.,* (2008)
	12 months (Pacific)	Chen 2006 in Liu and Tsai (2011)
	10-12 months (SW Atlantic)	Coelho *et al.,* (2009)
Reproductive[1] periodicity	Every year (Pacific)	Chen 2006 in Liu and Tsai (2011)
	Every other year (SW Atlantic)	Tambourgi *et al.,* (2013)
	Resting period of 12 months (Pacific)	Backus *et al.,* (1956); Seki *et al.,* (1998)
Size at birth	63-77 cm TL (N. Pacific)	Seki *et al.,* (1998)
	64 cm TL (N. Pacific)	Joung *et al.,* (2016)
	50-65 cm TL (Indian Ocean)	White (2007)
	64.2-65.0 TL (Arabian Sea)	Varghese *et al*., (2016)
Litter size (# of pups)	5-6 (SW Atlantic)	Lessa *et al.,* (1999)
	1-14 (average = 6; N. Pacific)	Seki *et al.,* (1998);
	10-11 (N. Pacific)	Joung *et al.,* (2016)
	12 (Indian Ocean)	IOTC (2015a)
	3-9 (Indian Ocean; Arabian Sea)	Varghese *et al.* (2016)
Generation Time	7 years	Cortés (2002)
	11.1 years	Smith *et al.,* (2008)
Productivity (r, intrinsic rate of population increase, yr^{-1})	r= 0.067 (0.028-0.112)	Cortés (2008b)
	r= 0.094 (0.06-0.137)	Cortés *et al.,* (2010)[2]
	r= 0.111 (0.038-0.197)	Cortés (2002)
	r= 0.121 (0.104-0.137)	Cortés *et al.,* (2012)
	r= 0.15 (0.12-0.18)	Murua *et al.,* (2012)

It is not unusual for elasmobranchs to display variation in their life history characteristics across ocean basins or even regions. In fact, many other shark species show similar regional differences like those seen in the oceanic whitetip, including bonnethead sharks (*Sphyrna tib*uro), blacknose sharks (*Carcharhinus acronotus*), and blacktip reef sharks (*Charcharhinus melanopterus*), (Lombardi-Carlson *et al.,* 2003; Driggers *et al.,* 2004; Chin *et al.,* 2013) to name a few. Although regional differences can be indicative of variable population dynamics and resilience to fishing

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[1] Most data suggest a resting period of one year (Clarke et al. 2015b)

[2] This value was deemed the most reasonable in a review conducted by the Pacific Shark Life History Expert Panel Workshop (Clarke et al. 2015b).

pressure (D'Alberto *et al.,* 2017), variation in life history parameters across ocean basins can also result from temporal and methodological differences across studies (Goldman and Cailliet 2004).

2.5 Population Structure and Genetics

To date, only two studies (one published journal article and one Master's thesis) have been conducted on the genetics and population structure of the oceanic whitetip shark, which provide some preliminary evidence of genetic differentiation between various populations of the species. The first study (Camargo *et al.,* 2016) compared the mitochondrial control region in 215 individuals from the Indian Ocean and eastern and western Atlantic Ocean (Figure 12 below). They identified a total of 12 haplotypes. A total of 129 individuals shared one haplotype, which was the most common haplotype in all locations. Two additional haplotypes were found in all regions, and another two haplotypes were found in eastern and western Atlantic Ocean populations. The remaining seven haplotypes were each found in only one or two sharks. While results showed significant genetic differentiation (based on haplotype frequencies) between the eastern and western Atlantic Ocean ($\Phi_{ST} = 0.1039$, $P < 0.001$; Camargo *et al.,* (2016)), pairwise comparisons among populations within the regions revealed a complex pattern. Though some eastern Atlantic populations were significantly differentiated from western Atlantic populations ($F_{ST} = 0.09 – 0.27$, $P < 0.01$), others were not ($F_{ST} = 0.02 – 0.03$, $P > 0.01$), even after excluding populations with sample sizes of less than 10 individuals (Camargo *et al.,* 2016). Additionally, the sample size from the Indian Ocean ($N = 9$) may be inadequate to detect statistically significant genetic structure between this and other regions (Camargo *et al.,* 2016). Furthermore, since this study only used mitochondrial markers, male mediated gene flow is not reflected.

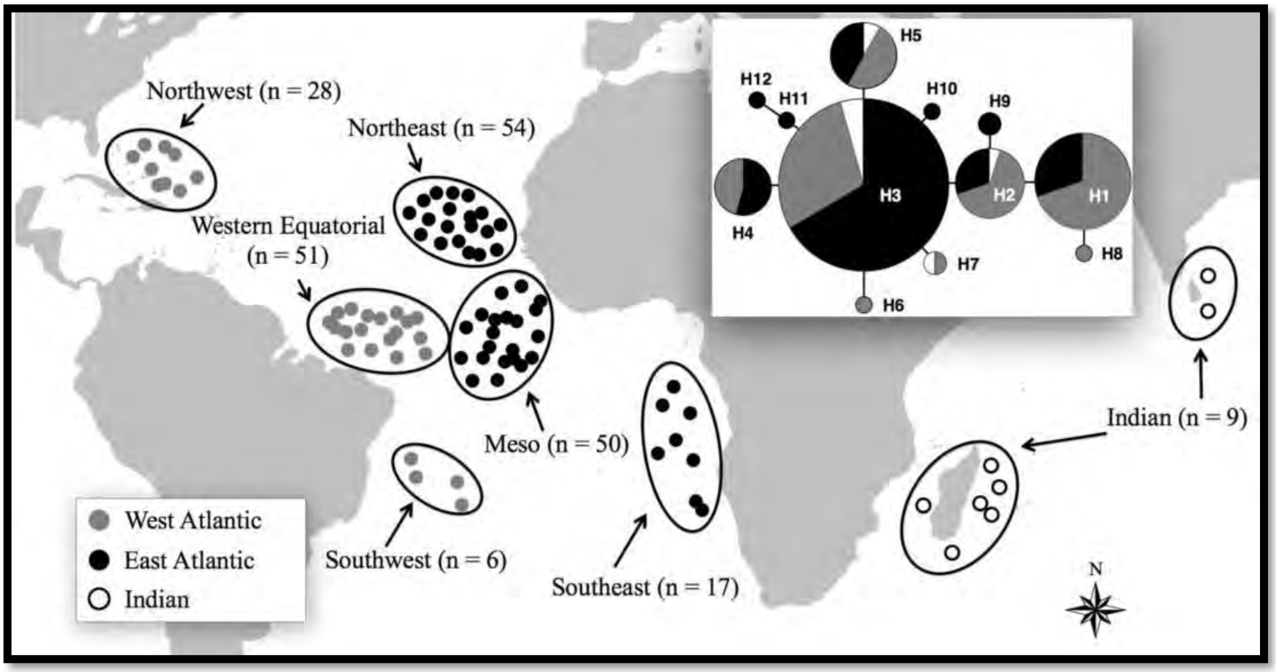

Figure 12 Geographic distribution of samples of *C. longimanus* with the network haplotypes analyzed and compiled from the sequences of the mitochondrial DNA control region. Source: Camargo *et al.* 2016.

In the second study, Ruck (2016) compared the mitochondrial control region, a protein-coding mitochondrial region, and nine nuclear microsatellite loci in 171 individuals sampled from the western Atlantic, Indian, and Pacific Oceans. Using three population-level pairwise metrics (PhiST, FST, and Jost's D), Ruck (2016) detected no fine-scale matrilineal structure within ocean basins. However, after comparing and analyzing the genetic samples of the two studies together (i.e., Camargo *et al.* 2016 and Ruck 2016), results showed significant maternal population structure within the western Atlantic with evidence of three matrilineal lineages (C. Ruck, personal communication, 2016). Specifically, the Northwest Atlantic samples show significant differentiation from the samples obtained from the rest of the western Atlantic (i.e., the Western Central Atlantic and Brazilian samples; Φ_{ST} Range: 0.058 – 0.078, F_{ST} Range: 0.063 – 0.078 ($P \leq 0.02$)) (Ruck, unpublished data). However, while this information is informative, the data showing population structure within the Atlantic relies solely on mitochondrial DNA and does not reflect male mediated gene flow.

On a global scale, Ruck (2016) found that the most common mitochondrial haplotypes were shared by individuals in the Atlantic, Indian, and Pacific Oceans, with no clear phylogeographic partitioning of haplotypes. Mitochondrial and nuclear analyses indicated weak but significant differentiation between western Atlantic and Indo-Pacific Ocean populations ($\Phi_{ST} = 0.076$, $P = 0.0002$; $F_{ST} = 0.017$, $P < 0.05$ after correction for False Discovery Rate). Although significant inter-basin population structure was evident (see Figure 13 below), Ruck (2016) also noted an association with deep phylogeographic mixing of mitochondrial haplotypes and evidence of contemporary migration between the western Atlantic and Indo-Pacific Oceans.

Figure 13 DISTRUCT plots summarizing STRUCTURE results of all genotyped samples: K = 2. The DISTRUCT plots clearly indicated strong sorting of two clusters: the Western Atlantic and the Indo-Pacific. Source: Ruck 2016.

Philopatry is another factor that could influence population structure within ocean basins. For example, Camargo *et al*., (2016) notes that the trans-Atlantic structure observed in their study may have developed in oceanic whitetips because females remain within or return to give birth on one side of the basin or the other (Camargo *et al.,* 2016). This is supported by recent tagging studies described previously, that suggest although oceanic whitetip sharks are highly migratory in terms of extensive travel distances, they seem to exhibit a high degree of philopatry to certain sites and may not mix with other regional populations (Howey-Jordan *et al.,* 2013; Tolotti *et al.,* 2015a). The shortest physical distance between the western and eastern Atlantic is between Brazil and Guinea-Bissau, requiring an oceanic crossing of approximately ~2,400 km (Camargo *et al.* 2016). Although the oceanic whitetip shark is likely physically capable of making this migration distance, this does not seem to be a typical behavioral characteristic of oceanic whitetip females, evidenced by genetic differentiation in those regions (western and eastern Atlantic) by female lineages (Camargo *et al*. 2016). However, as noted previously, this study relied on mitochondrial DNA (mtDNA) and does not reflect male mediated gene flow. Additionally, although the current telemetry tracking studies indicate patterns of site philopatry (Musyl *et al.,* 2011; Howey-Jordan *et al.,* 2013; Tolotti *et al.,* 2015a), sample sizes in the tracking studies are very small and may not necessarily be representative of the behavior of the species as a whole (Ruck 2016). For example, as shown previously in the NMFS CSTP tagging data, an immature female showed a large East to West Atlantic equatorial movement (refer back to Figure 4 above).

Both studies discussed above differ in genetic markers and sampling locations, but neither provides strong evidence for genetic discontinuity. Camargo *et al.* (2016) compared mitochondrial DNA sequences of samples collected in eight locations, including the southeast Atlantic and the southwest Indian Oceans (i.e., on either side of the southern tip of Africa). They concluded an absence of genetic structure between the East Atlantic and Indian Ocean subpopulations. Though the Indian Ocean sample size was small (n = 9), it included four haplotypes, all of which were also found in Atlantic Ocean subpopulations. Camargo *et al.* (2016) explained that this genetic connectivity (i.e., the existence of only one genetic stock around the African continent) may be facilitated by the warm Agulhas current, which passes under the Cape of Good Hope of South Africa and may transport oceanic whitetips from the Indian Ocean to the eastern Atlantic. Ruck (2016) compared longer mitochondrial DNA sequences and 11 microsatellite DNA loci of samples collected in seven locations; however, there were no samples from the southeast Atlantic and the southwest Indian Oceans (i.e., the closest sampling locations were Brazil and Arabian Sea). Ruck (2016) found weak but statistically significant differentiation between West Atlantic and Indo-Pacific subpopulations but explained that her study shows genetic evidence for contemporary migration between the West Atlantic and Indo-Pacific as a result of semi-permeable thermal barriers (i.e., the warm Agulhas current). Thus, we compare one study which may lack resolution but demonstrates genetic connectivity between the southeast Atlantic and the southwest Indian Ocean subpopulations (i.e., across the Agulhas current; Camargo *et al.,* 2016) to another that finds weak genetic structure and low-level contemporary migration across great distances (i.e., the West Atlantic and the northern Indian Ocean; Ruck 2016). We conclude that neither study provides unequivocal evidence for genetic discontinuity or marked separation between Atlantic and Indo-Pacific subpopulations.

In both studies, genetic diversity appears to be low. Compared to eight other circumtropical elasmobranch species, including the basking shark (*Cetorhinus maximus*), smooth hammerhead (*Sphyrna zygaena*), great hammerhead (Sphyrna mokarran), tiger shark (*Galeocerdo cuvier*), blacktip reef shark (*Carcharhinus limbatus*), sandbar shark (*Carcharhinus plumbeus*), silky shark (*Carcharhinus falciformis*), and the whale shark (*Rhincodon typus*), the oceanic whitetip shark ranks the fourth lowest in global mtCR genetic diversity (0.33% ± 0.19%). The oceanic whitetip has diversity similar to the smooth hammerhead (0.32% ± 0.18%, (Testerman 2014) and greater than tiger and basking sharks (0.27% ± 0.16%; Bernard 2014 and 0.13% ± 0.09%; Hoelzel *et al.,* (2006), respectively). The mtCR genetic diversity of the oceanic whitetip is about half that of the closely related silky shark (0.61% ± 0.32%; (Clarke *et al.,* 2015a)) and about a third that of the whale shark (1.1% ± 0.6%; (Castro *et al.,* 2007). Ruck (2016) noted that the relatively low mtDNA genetic diversity (concatenated mtCR-ND4 nucleotide diversity π = 0.32% ± 0.17%) compared to other circumtropical elasmobranch species raises potential concern for the future genetic health of this species. Camargo *et al.,* (2016) also observed low levels of genetic variability for the species, with both haplotype and nucleotide diversity significantly lower in the eastern Atlantic population than the western Atlantic population (34.2% and 36.9%, respectively). Low genetic variability rates, as exhibited by the oceanic whitetip shark, may represent a risk in terms of the species' ability to adapt, leading to a weaker ability to respond to environmental changes (Camargo *et al.,* 2016).

2.6 Demography

Oceanic whitetip sharks exhibit life history traits and population parameters that are generally moderate among other shark species, although there has been some disagreement in the literature regarding the species' productivity. In a 1998 study of Pacific sharks, productivity values and rebound rates were derived for 26 shark species, in which the oceanic whitetip shark ranked among the most productive species (6 out of 26) (Smith *et al.,* 1998). Cortés (2002) also found that the oceanic whitetip ranked among the more productive species of sharks, with an annual population growth rate (λ) of 1.117 year^{-1}. Similar results were found in Smith *et al.* (2008), in which the oceanic whitetip shark ranked the 2nd most productive species of 11 pelagic elasmobranchs evaluated. In contrast, a recent Ecological Risk Assessment (ERA) study, determined an intrinsic rate of population increase (i.e., the rate at which a population increases in size if there are no density-dependent forces regulating the population) (r) of 0.094, and identified the oceanic whitetip shark as the 5th most vulnerable species of 11 pelagic shark species (Cortés *et al.,* 2010). However, in an expansion of that ERA, Cortes calculated a higher intrinsic rate of increase (r) of 0.121 (Cortés *et al.,* 2012).

Smith *et al.,* (2008) estimated a natural mortality rate of 0.203 year^{-1}, assuming a maximum age of 22 years. Estimated generation times range from 7 to 11.1 years (Cortés 2008b; Smith *et al.,* 2008). Finally, the oceanic whitetip shark ranked among the highest in productivity when compared with other pelagic shark species (ranking 5 out of 26 overall) in terms of its egg production, rebound potential, potential for population increase, and for its stochastic growth rate (Chapple and Botsford 2013). However, overall, the growth rate (as indexed by the von Bertalanffy K parameter), natural mortality and the intrinsic rate of population increase are all consistent with low productivity while the ages of maturity and generation times indicate moderate productivity (or low to moderate) (FAO 2012). Thus, the biology of the oceanic whitetip shark indicates that it is likely to be a species with low resilience to fishing and minimal capacity for compensation (Rice and Harley 2012). Therefore, for the purpose of this status review, we consider the oceanic whitetip shark to have low-moderate productivity.

3. GLOBAL AND REGIONAL ABUNDANCE ESTIMATES AND TRENDS

Overall, global quantitative abundance estimates and trends are lacking for the oceanic whitetip. However, there are several studies on the abundance trends for a few regions and/or populations of oceanic whitetip sharks. There is also a recent stock assessment for the oceanic whitetip shark in the Western and Central Pacific (Rice and Harley 2012). Thus, the following section provides some insight into the abundance trends of the species. It should be noted that catch records of sharks, especially non-target shark species, are often inaccurate and incomplete. The oceanic whitetip shark is predominantly caught as bycatch and the reporting requirements for bycatch species have changed over time and differ by organization, and have therefore affected the reported catch.

3.1 Global Population Trends

Worldwide catches of oceanic whitetip shark are reported in the Food and Agricultural Administration (FAO) of the United Nations (UN) Global Capture Production dataset. According to the FAO, total catches of oceanic whitetip shark increased drastically in the late 1990s, peaking at 1,480 mt in 2000, and declining to 271 mt as of 2013 (Figure 14). Reported worldwide catches for oceanic whitetip shark for the last 10 years of available data (2003-2013) have ranged from 150 to 468 mt per year.

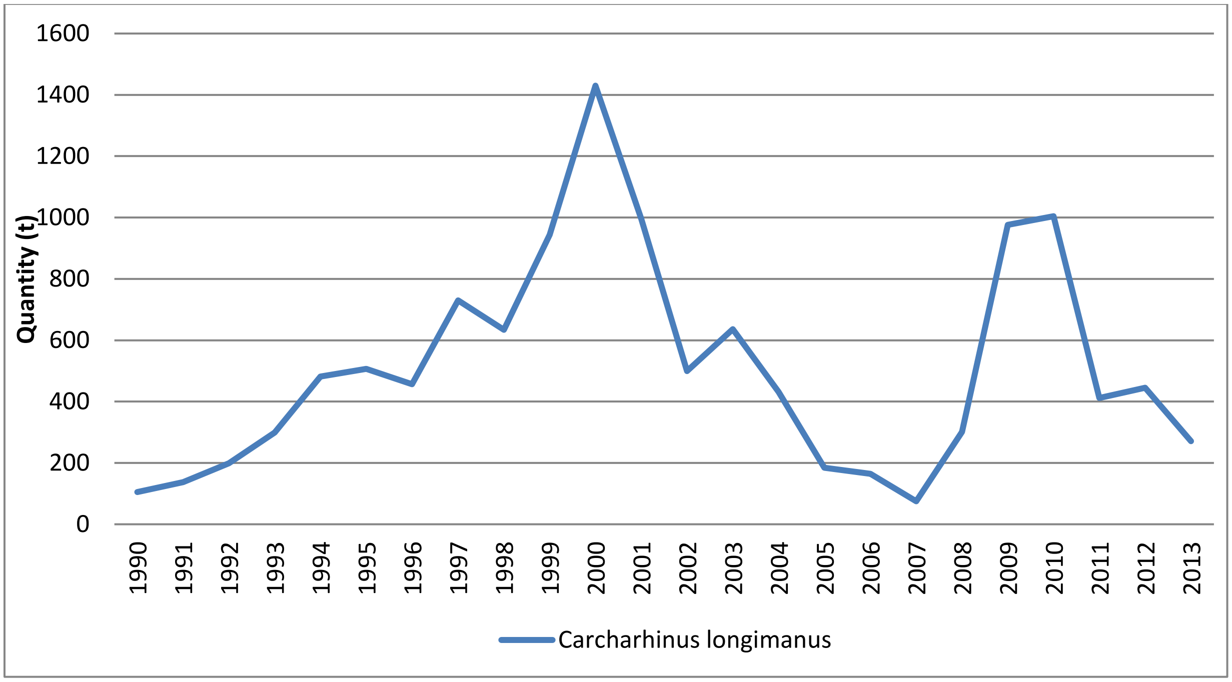

Figure 14 Global capture production for oceanic whitetip shark from 1990-2013; global capture production is production weight of the retained individuals before processing and thus may differ from landings weights. Source: FAO Global Capture Production; accessed January 28, 2016.

Although the FAO dataset supposedly represents the most comprehensive data available on world fisheries production, there are several caveats to interpreting these data and the data are likely not representative of oceanic whitetip catches through time. Because FAO data are generated from fisheries agencies reports of individual countries, the data suffer from the same limitations in reporting capabilities, including issues related to species identification and a lack of species-specific reporting altogether (Rose 1996). Further, some species may only be reported by a few nations despite the species having a very wide distribution and records in local fisheries. Additionally, many nations that report catch volumes to the FAO do not include catches that are discarded at sea (e.g., incidental catch or bycatch) (Rose 1996), with many countries not required to report discards at all. Although more countries and Regional Fishery Management Organizations (RFMOs) are working towards improving reporting of species-specific fish catches, catches of oceanic whitetip sharks have likely gone and continue to go unrecorded in many countries. Further, some catch records that do include oceanic whitetip sharks may not even differentiate between shark species in general. As described previously, these numbers are also likely under-reported as many catch records report dressed weights as opposed to live weights and/or do not account for discards (e.g., fins are kept but the carcass is discarded; IOTC 2015b). Additionally, in the case of no-retention rules (either RFMO or national laws) many annual catch records are now zero, either because species are discarded whole or because they simply aren't reported. Research suggests that annual global catch data compiled by the FAO are significantly underestimated for all sharks (Clarke *et al.,* 2006b). Thus, given these types of data, with current estimates highly uncertain, a quantitative global population trend for the oceanic whitetip shark would not be reliable at this time.

3.2 Regional Population Trends

The following section describes the available information regarding regional catch and abundance trends for the oceanic whitetip shark from the following regions: Eastern Pacific, Western and Central Pacific, North Atlantic, South Atlantic, and Indian Ocean. Some of the available information is derived from the relevant RFMOs, which are international organizations that have been formed by countries with fishing interests in a particular region of international waters or who are interested in fishing for a highly migratory species. Their purpose is to sustainably manage these shared fishery resources and they may advise cooperating countries on their fishing practices or even set catch and effort limits or other management measures. As oceanic whitetip sharks are global, highly migratory species that cross international boundaries, they are often caught as bycatch in the convention areas of those RFMOs for highly migratory fish stocks. Descriptions and information on these RFMOs and available catch data of oceanic whitetip sharks from vessels operating in these convention areas are provided below.

Eastern Pacific Ocean

There is a lack of quantitative abundance trends of oceanic whitetip shark in the Eastern Pacific Ocean. Historically, the oceanic whitetip shark was the third most abundant shark species after blue sharks (*Prionace glauca*) and silky sharks (*C. falciformis*). However, there is some evidence to suggest that the species has undergone significant population declines in this region. For example, in the eastern Pacific tropical tuna purse seine fisheries, unstandardized nominal catch data from the Inter-American Tropical Tuna Commission (IATTC) for the oceanic whitetip shark from purse seine sets on floating objects, unassociated sets and dolphin sets all show declining trends since 1994 (IATTC 2007). In particular, presence of oceanic whitetip sharks on sets with floating objects, which are responsible for 90% of the shark catches in Eastern Pacific purse seine fishery, has declined significantly (Hall and Román 2013). Figure 15 below shows the nominal catches per set of oceanic whitetip shark in floating object sets, and Figure 16 below shows a map describing the distribution of encounters with oceanic whitetip sharks. Both maps show four periods of time (1994-1997; 1998-2001; 2002-2005; and 2006-2009).

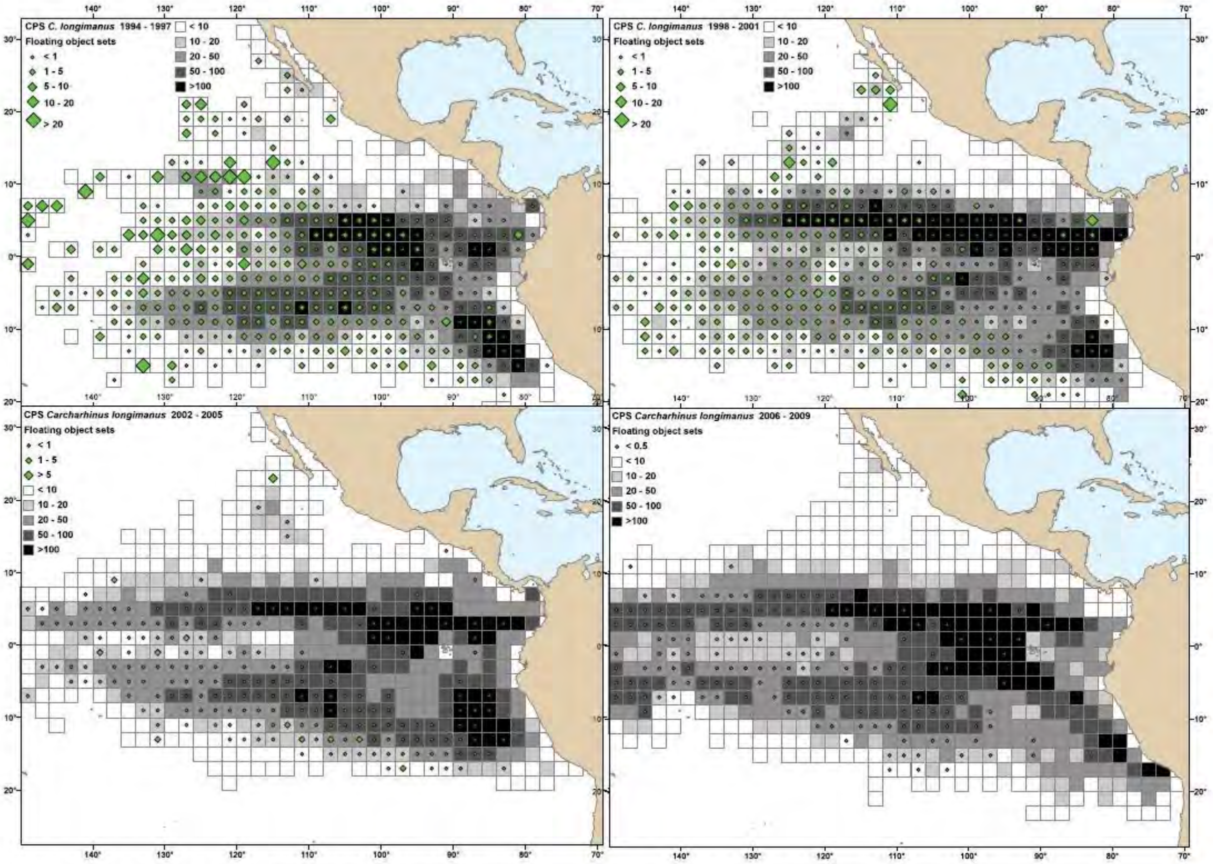

Figure 15 Numbers per set of oceanic whiteitp sharks in floating object sets in four periods (1994-1997; 1998-2001; 2002-2005; 2006-2009. The green diamonds represent numbers of oceanic whitetip shark caught; the gray shaded squares represents fishing effort (numbers of sets deployed). Source: Hall and Roman 2013.

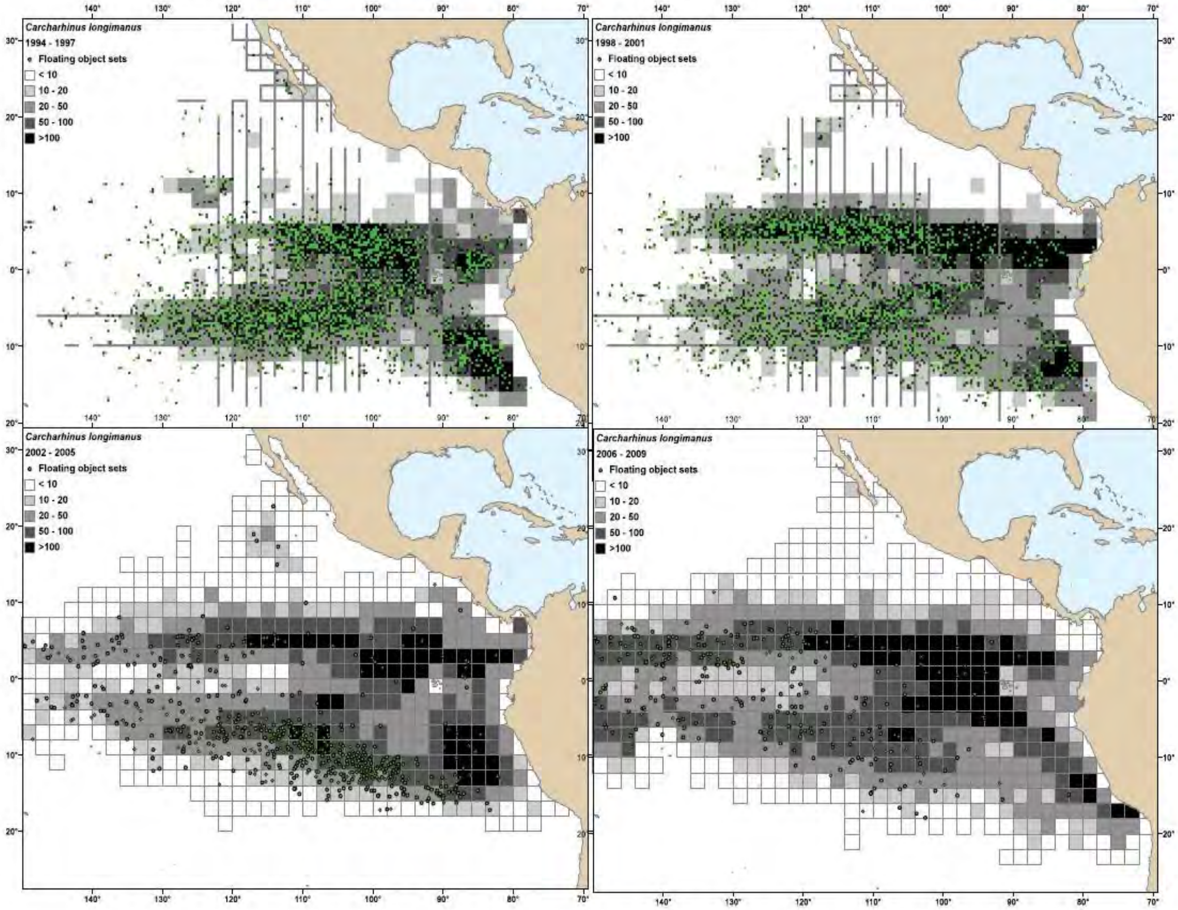

Figure 16 Encounters with oceanic whitetip sharks in floating object sets in four periods (1994-1997; 1998-2001; 2002-2005; 2006-2009). The green dots represent encounters with oceanic whitetip sharks in floating object sets (i.e., sets with oceanic whitetip sharks present); the gray shading represents fishing effort (number of sets deployed). Source: Hall and Roman 2013.

Figures 15 and 16 above provide a clear illustration of the decline in catches per set that accompanied a significant reduction in oceanic whitetip frequency (Hall and Roman 2013). Based on Figures 15 and 16 above, it is evident that the species has virtually been wiped out from the fishing grounds, in a seemingly north to south progression, with similar trends also observed in dolphin and school sets. These declines in nominal CPUE or the frequency of occurrence equates to an of 80–95% decline from population levels in the late 1990s (Hall and Román 2013).

Western and Central Pacific Ocean

The oceanic whitetip shark was historically considered one of the most abundant pelagic shark species throughout the Western and Central Pacific Ocean. For example, tuna longline survey data from the 1950s indicate oceanic whitetip sharks comprised 28% of the total shark catch of fisheries south of 10ºN (Strasburg 1958). Likewise, Japanese research longline records during 1967-1968 indicate that oceanic whitetip sharks were among the most common shark species taken by tuna vessels in tropical waters of the Western and Central Pacific, and comprised 22.5% and 23.5% of the total shark catch west and east of the International Date line, respectively (Taniuchi 1990). However, several recent lines of evidence indicate that the oceanic whitetip in has suffered significant population declines throughout the region, including declining trends in standardized CPUE, biomass and size indices.

In 2011, a "status snapshot" was developed for the oceanic whitetip shark to depict its status in the Western and Central Pacific Ocean (Clarke 2011; See Figure 17 below). This status snapshot summarizes the findings from several papers based on data from the Secretariat of the Pacific Community (SPC) (Clarke *et al.,* 2011a; Lawson 2011), Japan (from both commercial longlines and research training vessels (RTV) (Clarke *et al.,* 2011b), information from an ecological risk assessment (Kirby and Hobday 2007), and catch estimates based on shark fin trade records (Clarke 2009). The downward arrows in Figure 17 depict the various CPUE trends; all available abundance, size, and catch trend indices show declining trends.

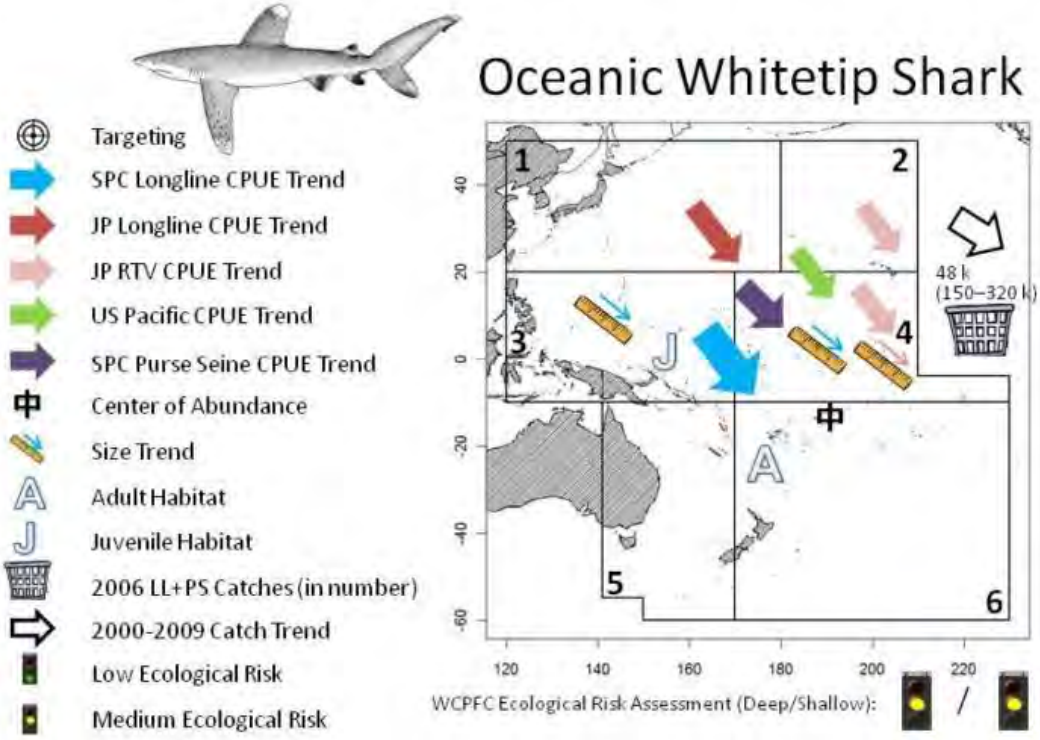

Figure 17 Status snapshot of oceanic whitetip shark in the Western and Central Pacific Fisheries Commission (WCPFC) Statistical Area. JP = Japanese; RTV – Research Training Vessels; SPC = Secretariat of the Pacific Community. Source: Clarke (2011).

In addition to the status snapshot, Rice and Harley (2012) conducted a stock assessment for the oceanic whitetip, in which standardized CPUE series were estimated in the Western and Central Pacific based on observer data from the SPC and collected from 1995-2009. Results show that the median estimate of oceanic whitetip biomass in the Western Central Pacific in 2010 was 7,295 tons (Rice and Harley 2012), which, when extrapolated, equaled a population of roughly 200,000 individuals (FAO 2012). Rice and Harley (2012) concluded that catch, CPUE, and size composition data for oceanic whitetip all show consistent declines from 1995-2009. Additionally, estimated spawning biomass, total biomass and recruitment also declined consistently throughout the time series. Specifically, current estimates of oceanic whitetip stock depletion indicate that the total biomass has been reduced to 6.6% of theoretical equilibrium virgin biomass (i.e., ~93% decline), with spawning biomass reduced by 86% since 1995 (Rice and Harley (2012); see Figures 18 and 19 below).

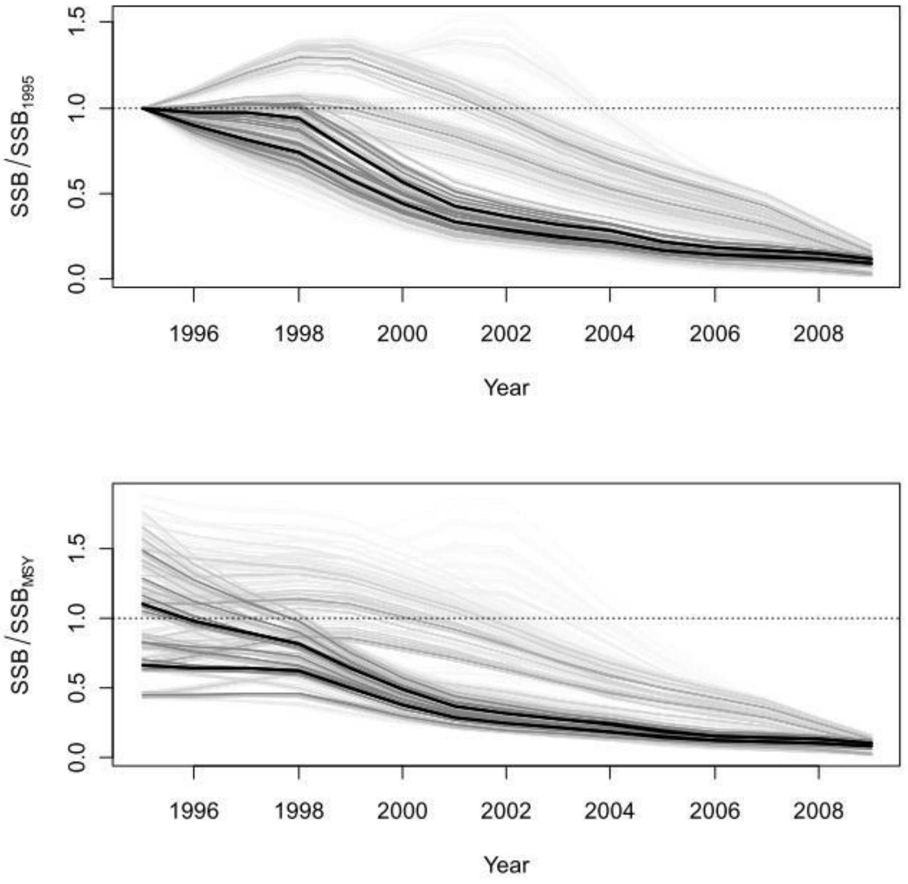

Figure 18 Changes in the spawning biomass relative to the first year of the model (1995 – top panel) and SBMSY (equilibrium spawning potential, referred to as spawning biomass at MSY; bottom panel). Each line represents one of 648 runs from the grid and the darker the line, the higher the assigned weight (plausibility) for that model run. Source: Rice and Harley 2012.

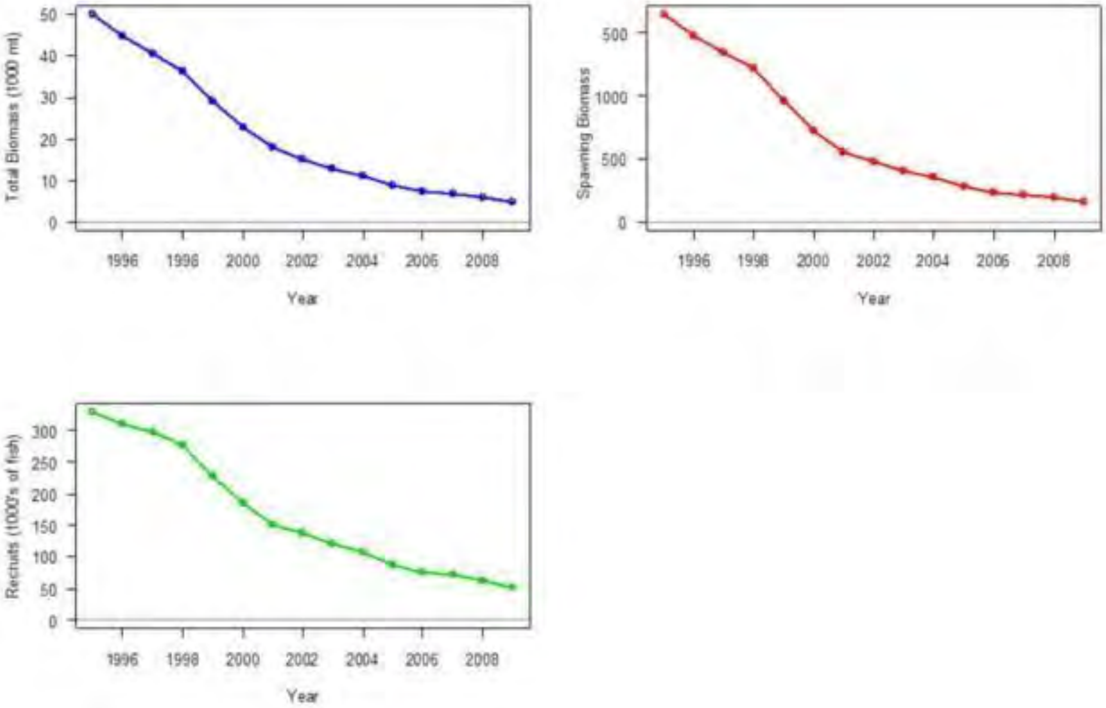

Figure 19 Estimated total biomass (top left in blue, 1000 metric tons), estimated spawning biomass (top right in red) and estimated annual recruitment (1000's of fish; bottom left in green) in the WCPO for the reference case. Source: Rice and Harley 2012.

More recently, Rice *et al.,* (2015) confirmed that population declines of oceanic whitetips have continued since the stock assessment report was completed in 2012. The proportion of positive oceanic whitetip catch in longline sets has also been steadily declining since the mid-1990s (see Figures 20 and 21 below).

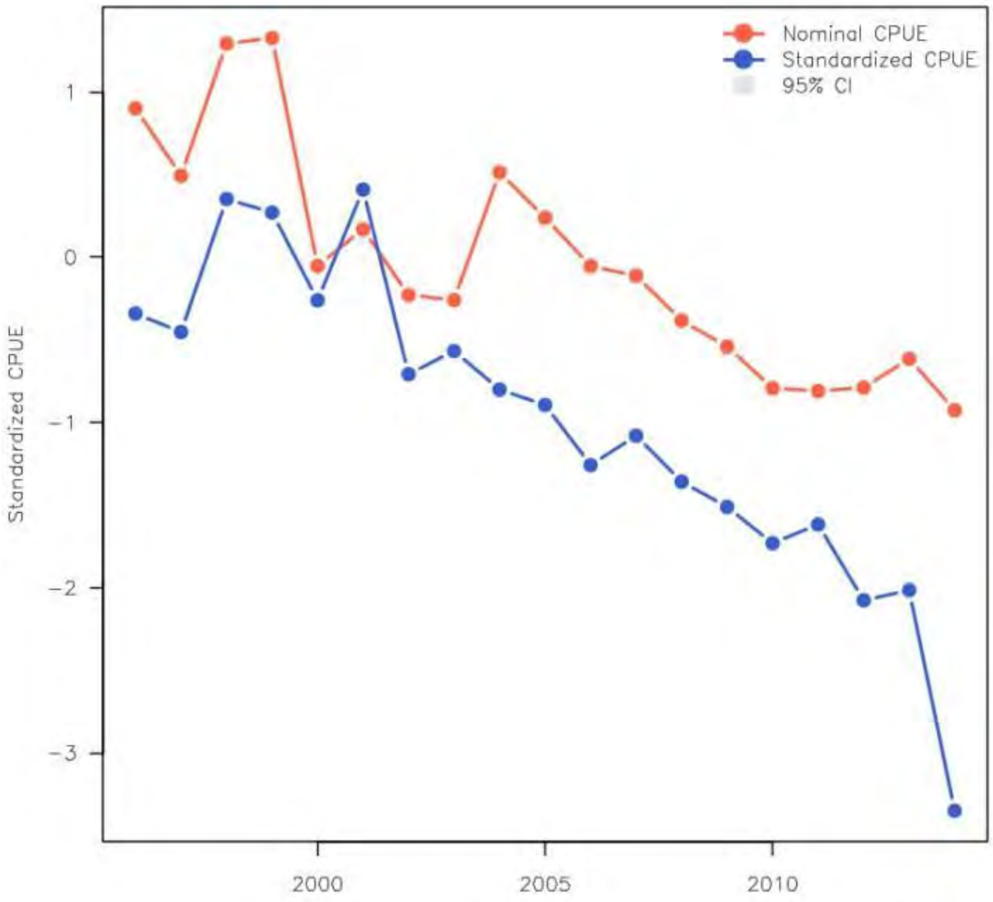

Figure 20 Nominal and Standardized CPUE trends of oceanic whitetip shark in the WCPFC. Source: Rice *et al.* 2015.

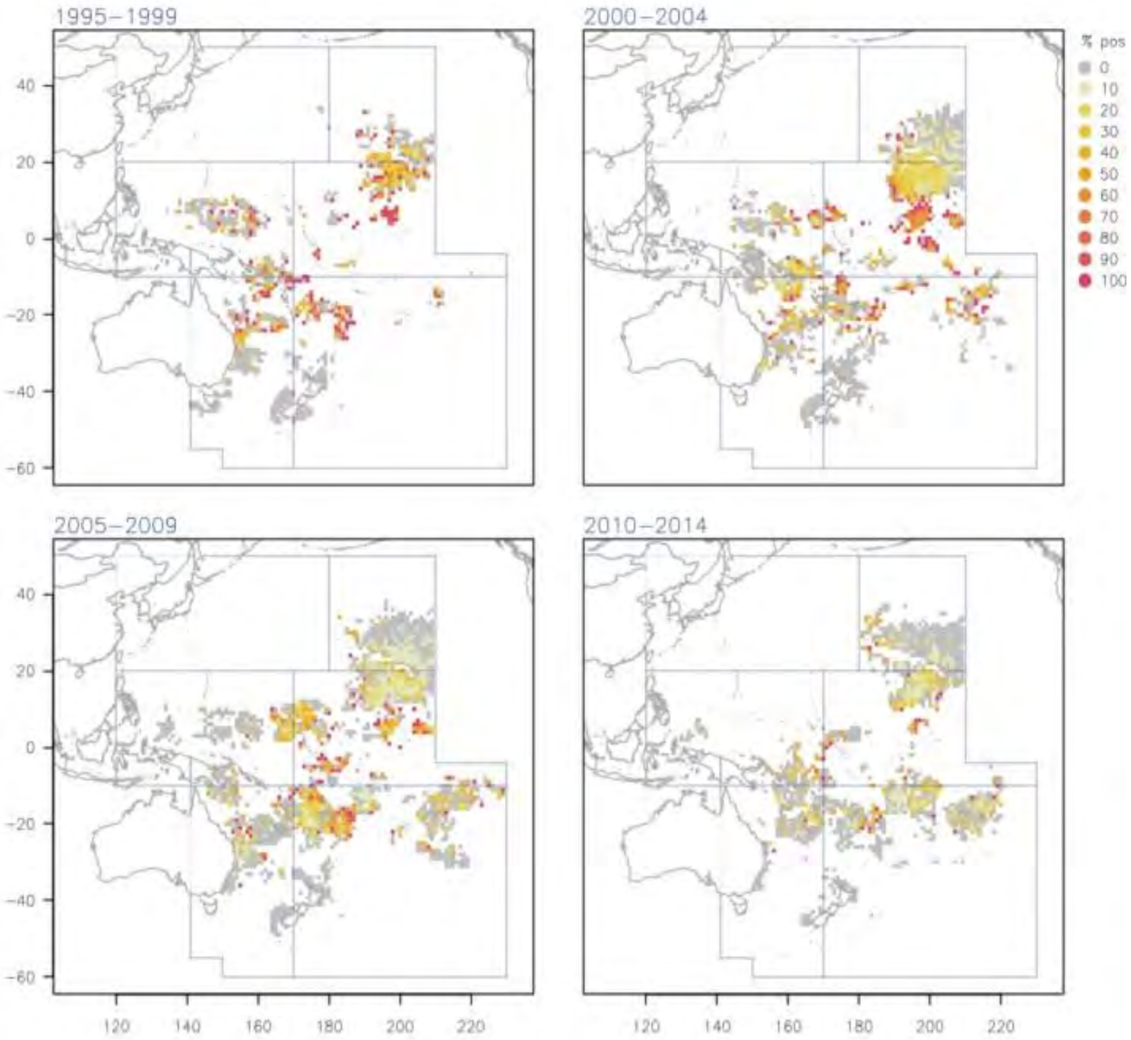

Figure 21 Spatial distribution of the proportion of longline sets for which one or more oceanic whitetip shark were caught for each five year period between 1995 and 2014. Source: Rice *et al.* 2015.

Overall, results from Rice *et al.* (2015) indicate that oceanic whitetip sharks in the Western and Central Pacific were more common prior to 2000, when the species frequently comprised >20% of the overall shark catch. However, the oceanic whitetip has not exceeded more than 20% of the total shark catch in their core tropical habitat area for over a decade, which is a significant contrast from the first ten years of the study. These results also confirm that oceanic whitetip shark abundance continues to decline throughout the tropical waters of the Western and Central Pacific Ocean (Rice *et al*., 2015). Although the trend may be exaggerated in the last year due to a lack of complete data for the last year of the dataset, the overall trend still shows a steady decline of oceanic whitetip shark abundance in the Western and Central Pacific Ocean. Additionally, while standardized CPUE data for the purse seine fishery are not available, the oceanic whitetip is one of only two species frequently caught in this fishery (the other being the silky shark) and nominal CPUE data from the purse seine fishery shows that the species has exhibited declines similar to those in the longline fishery (see Figure 22 below; Clarke *et al.,* (2012)).

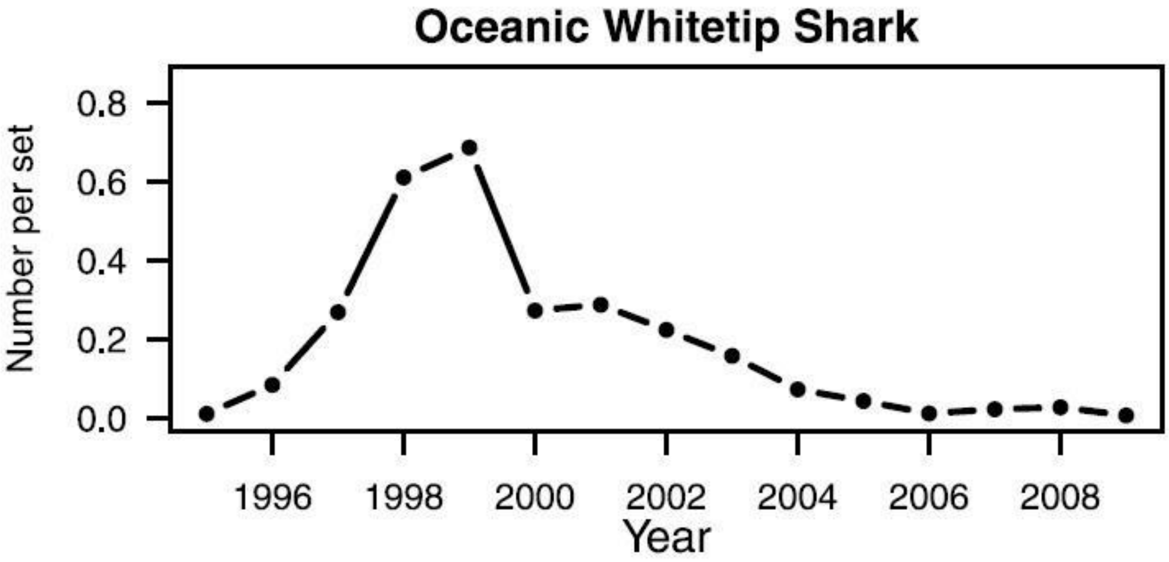

Figure 22 Nominal purse seine CPUE trend for oceanic whitetip in the western and central Pacific Ocean, 1996–2009. Source: Clarke *et al.,* (2012).

Separate analyses have also been conducted for the Hawaii-based pelagic longline fishery that found similar abundance declines (Walsh and Clarke 2011; Brodziak *et al.,* 2013). Based on observer data from the Pacific Islands Regional Observer Program (PIROP), mean annual nominal CPUE of oceanic whitetip decreased significantly from 0.428 sharks/1000 hooks in 1995 to 0.036 sharks/1000 hooks in 2010. This reflected a significant decrease in nominal CPUE on longline sets with positive catch from 1.690 sharks/1000 hooks to 0.773 sharks/1000 hooks, and a significant increase in longline sets with zero catches from 74.7% in 1995 to 95.3% in 2010. After accounting for various factors (e.g., sea surface temperature, fishery sector, and latitude), Walsh and Clarke (2011) concluded that oceanic whitetip CPUE declined by more than 90% in the Hawaii-based longline fishery since 1995.

Using the same data, Brodziak *et al*. (2013) found similar results by using several models in order to assess the species' CPUE from 1995 to 2010 in the Hawaii-based longline fisheries (both shallow and deep set). This study also found a decreasing trend in standardized CPUE from 1995 to 2010, which equates to a 90% decline in relative abundance due to increased sets with zero catches as well as decreased CPUE on sets with positive catch (Brodziak *et al.,* 2013; See Figure 23 below). The authors note that the similarity in the results from Hawaii in comparison to studies based on SPC observer data for the rest of the Western and Central Pacific suggest that declines of oceanic whitetip populations are not just local to Hawaii, but rather a Pacific-wide phenomenon. However, the authors emphasized that the closeness in alignment between the trends in Hawaii and the Western and Central Pacific Ocean may be partly due to the use of datasets that partially overlap for years prior to 2005. However, even after 2005, the trends show similar results suggesting that the patterns are fair representations of regional trends in oceanic whitetip abundance. Additionally, tuna purse seine fishery data documented a similar decrease in oceanic whitetip shark catches (79%) from 20°S to 20°N and 150°W to 130°E between 1999 and 2010 (Lawson 2011; Clarke *et al.,* 2012).

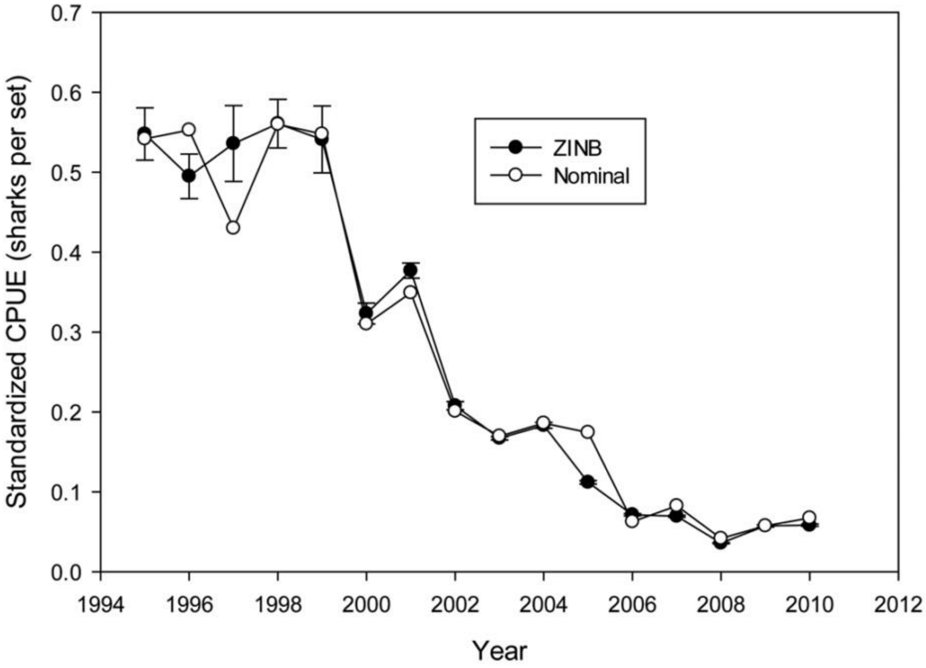

Figure 23 Comparisons of estimates of annual standardized CPUE (mean sharks per standardized longline set) for oceanic whitetip shark in the Hawaii-based pelagic longline fishery in 1995–2010 for the best-fitting model (ZINB) and the best-fitting model showing 95% confidence bars for the standard error of the mean CPUE and the nominal CPUE. Source: Brodziak *et al.* 2013.

The federally-mandated observer program accurately distinguishes the oceanic whitetip shark to species, and their occurrence in the data were examined in further detail by the ERA team, primarily to update the Brodziak *et al.,* (2013) publication with 4 additional years 2011-2014 (Figure 24 below). A standardized CPUE annual index was estimated using a generalized linear model (GLM) with a delta lognormal modeling approach in the statistical programming language R. This approach is fundamentally similar to the original study in which a zero-inflated negative binomial approach was used; both are well-suited methodologies to deal with relatively uncommon events. The delta lognormal is a 2-stage modeling approach, often termed a "hurdle" model (Cragg 1971; Maunder and Punt 2004), whereby the first model estimates the hurdle or probability of experiencing a non-zero catch. This probability is merged with the results of a second model, which estimates the magnitude of the non-zero catch. Two models are needed due to the different probability distributions associated with these two processes and the prevalence of zero catches. Using a binomial distribution for the proportion of zeros and a logarithmic Gaussian distribution for the positive catch component, the final GLM annual CPUE index is shown in Figure 39 below. The suite of variables used in the 2 modeling steps include haul quarter of the year, sea surface temperature, haul year, set type (i.e. shallow set or deep-set), hooks per float, region, vessel length, and interaction terms. The analysis presented here is not a formal stock assessment but is a preliminary exercise to glean relative abundance and trend information from a historically reliable data stream using a traditional approach, and to update the Brodziak *et al.* (2013) study with 4 additional years of information. Results show that the oceanic whitetip population in this area may have stabilized at a post-decline depressed state in recent years.

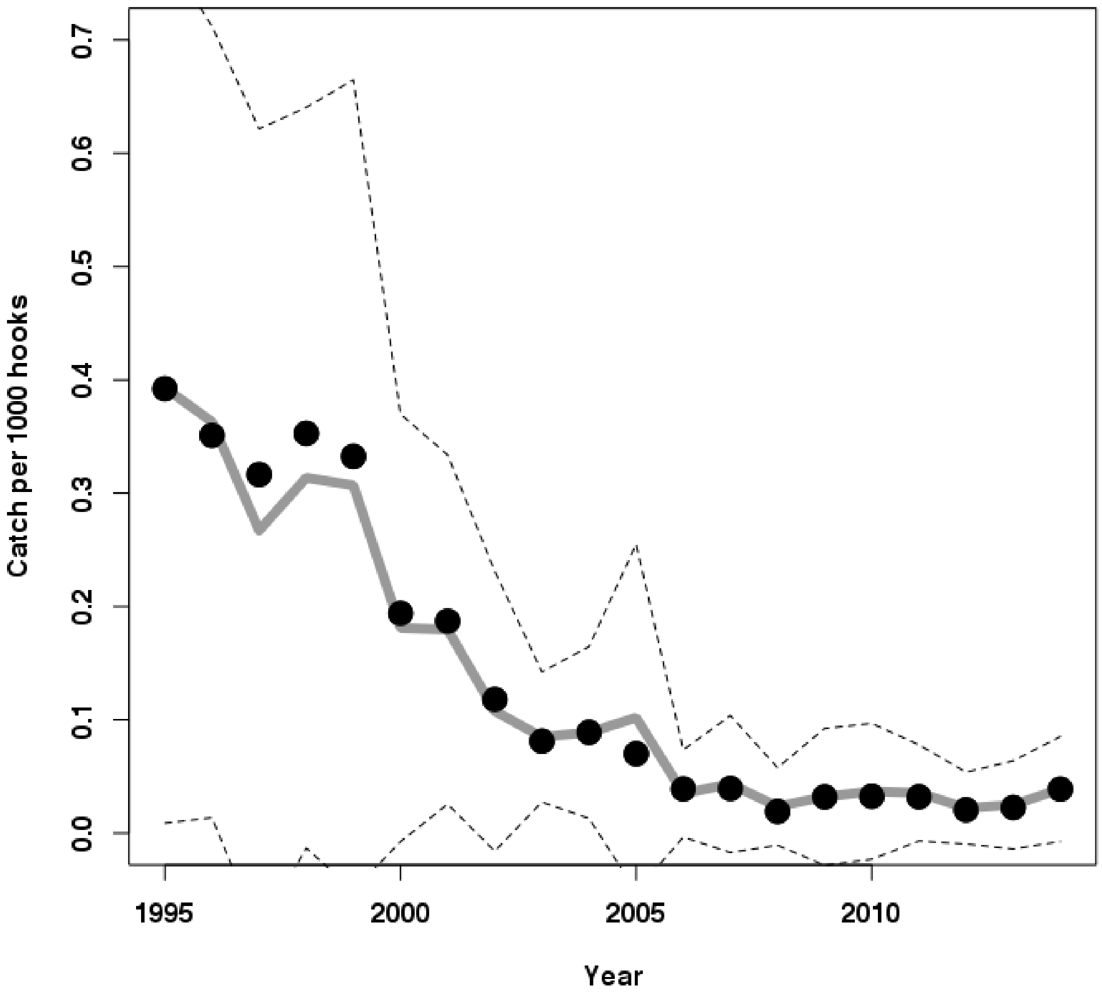

Figure 24 Comparisons of estimates of annual standardized CPUE (mean sharks per standardized longline set) for oceanic whitetip shark in the Hawaii-based pelagic longline fishery in 1995–2014. Source: NMFS PIROP Observer data; adapted from Brodziak *et al.* 2013.

Based on the foregoing information, the oceanic whitetip shark has experienced, and in most cases continues to experience, abundance declines across the Western and Central Pacific Ocean.

Atlantic Ocean

Northwest and Central Atlantic and Gulf of Mexico

Historically, the oceanic whitetip shark was described as widespread, abundant, and the most common pelagic shark in the warm parts of the North Atlantic (Mather and Day 1954; Backus *et al.,* 1956; Strasburg 1958). Historical accounts of the oceanic whitetip during exploratory research surveys in the western North Atlantic during the 1950s noted that several individuals often gathered at the surface around longlines, persistently investigated baited hooks, and occasionally attacked dead or dying tuna before they were hauled in (Backus *et al*., 1956). In fact, the sharks were so persistent, even attempts to drive them away via the use of underwater explosives were unsuccessful (Backus *et al.,* 1956). Recent information, however, suggests the species is now relatively rare in this region. Several studies have been conducted in this region to determine trends in abundance of various shark species, including the oceanic whitetip shark. In a study of observer data from the U.S. pelagic longline (PLL) fishery operating off the southeastern United States, Beerkircher *et al.,* (2002) showed highly variable annual mean CPUE estimates from 1992-2000, with nominal CPUE (numbers caught per 1,000 hooks) declining significantly between 1981-1983 (CPUE = 0.87; Berkeley and Campos (1988)) and 1992-2000 (CPUE = 0.48). In total, from 1992-2002, 407 oceanic whitetip sharks were caught as bycatch, and approximately 30% were discarded dead (Beerkircher *et al.,* 2004).

Baum *et al.,* (2003) analyzed logbook data for the U.S. pelagic longline fleets targeting swordfish and tunas in the Northwest Atlantic (see Figure 25 below), and reported a 70% decline in relative abundance for the oceanic whitetip shark from 1992 to 2000.

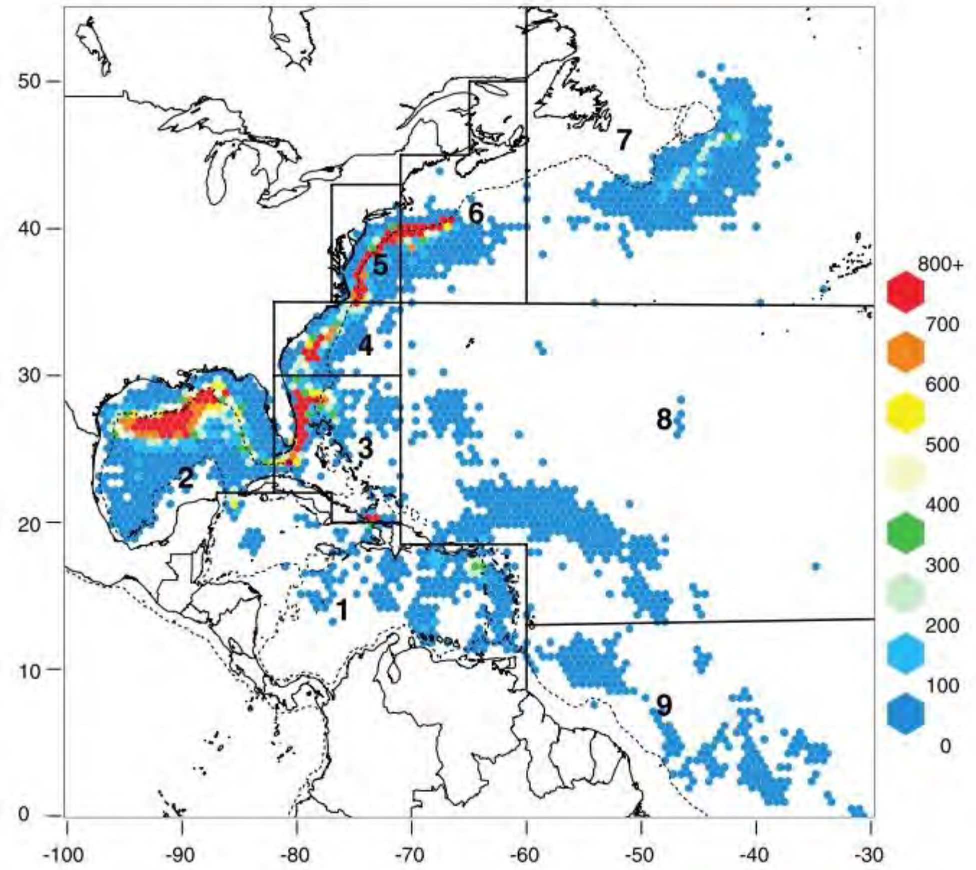

Figure 25 Map of the Northwest Atlantic showing the distribution of effort in the U.S. pelagic longline fishery between 1986 and 2000, categorized by number of sets (0 to 800), within the nine areas assessed: 1, Caribbean; 2, Gulf of Mexico; 3, Florida East Coast; 4, South Atlantic Bight; 5, Mid Atlantic Bight; 6, Northeast Coastal; 7, Northeast Distant; 8, Sargasso/North Central Atlantic; 9, Tuna North/Tuna South. Areas were modified from the U.S. National Marine Fisheries Service classification for longline fisheries. The 1000-m coastal isobath (dotted line) is given for reference. Source: Baum *et al.* 2003.

Similarly, Baum and Myers (2004) compared longline CPUE from research surveys from 1954-1957 to observed commercial longline sets from 1995-1999, and determined that the oceanic whitetip had declined by more than 150-fold, or 99.3% (95% CI: 98.3-99.8%) in the Gulf of Mexico during that time. However, the methods and results of Baum *et al*. (2003) and Baum and

Myers (2004) were challenged (see discussions in Burgess *et al.,* (2005b) and Burgess *et al.,* (2005a) on the basis of whether correct inferences were made regarding the magnitude of shark population declines in the Atlantic). More specifically, while the authors agreed that abundance of large pelagic sharks had declined, they presented arguments that the population declines were probably less severe than indicated. Of particular relevance to the oceanic whitetip, Burgess *et al.,* (2005b) noted that the change from steel to monofilament leaders between the 1950s and 1990s could have reduced the catchability of all large sharks, and the increase in the average depth of sets during the same period could have reduced the catchability of the surface-dwelling oceanic whitetip (FAO 2012). Driggers *et al.,* (2011) conducted a study on the effects of different leader materials on the CPUE of oceanic sharks and determined that with equivalent methods but using a wire leader, the catch rates of Baum and Myers (2004) for the recent period would have been 0.55 rather than 0.02 (as estimated by Baum and Myers (2004) using nylon leaders). Comparing the recent 0.55 value with the Baum *et al*. (2003) value of 4.62 for the 1950s results in an approximate decline of 88% (FAO 2012).

In a more recent re-analysis of the same U.S. pelagic longline logbook dataset using a similar methodology as Baum *et al*. (2003), Cortés *et al.,* (2007) reported a 57% decline from 1992-2005. The decline was predominantly driven by a 37% decline from 1992 to 1993 and a subsequent decline of 53% from 1997 to 2000, after which the time series remained stable (2000–2005). The number of positive observations progressively dropped after 1997. However, an analysis of the observer dataset from the same fishery showed a significantly lower decline than that of the logbook analysis, with a 9% decline in abundance from the same period of 1992-2005. It should be noted that although the authors attempted to include all areas in the analysis, in some cases, the dataset was restricted to certain areas due to insufficient or unbalanced observations by year in the remaining areas. Thus, only areas 1, 2, 3, 4, and 8 were included for oceanic whitetip sharks (refer back to Figure 25 above).

In 2010, Baum and Blanchard (2010) also analyzed observer data from 1992-2005 and reported a 50% decline (95% CI: 17–70%). However, the authors explained that although model estimates suggest significant declines in oceanic whitetip sharks between 1992 and 2005, there was a high degree of interannual variability in the individual year estimates (i.e., covariates that significantly influence catch rates of these species were not included in the models). Therefore, the catch rates were not fully standardized, limiting what can reasonably be inferred regarding the relative abundance of the species (Baum and Blanchard 2010). Finally, the Extinction Risk Analysis team conducted an updated analysis (1992-2015) using the same observer data analyzed by Cortés *et al.,* (2007) and Baum and Blanchard (2010). Similar to previous analyses, there was high variability in the initial years of the time series but overall the trend in abundance was relatively flat with about a 4% decline over the times series (Figure 26 below).

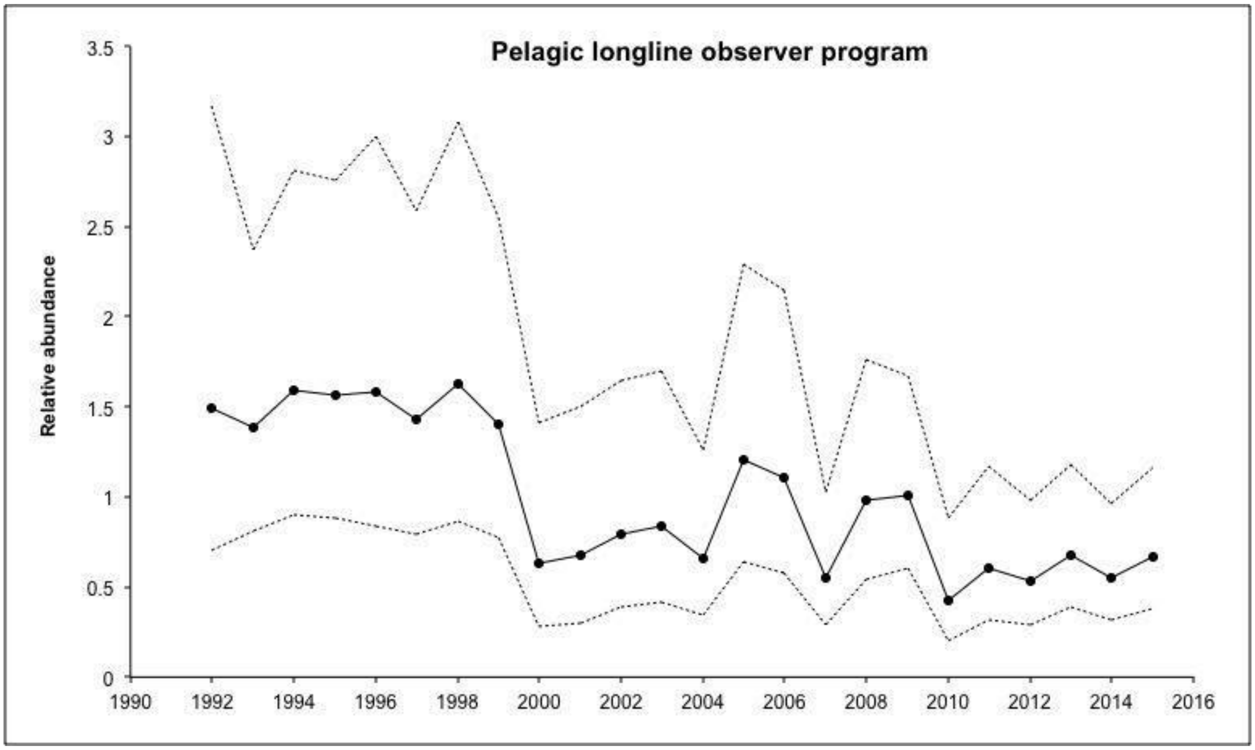

Figure 26 Estimated change in relative abundance (standardized catch per 1000 hooks) between 1992 and 2015 based on the Northwest Atlantic Pelagic Longline observer data for oceanic whitetip sharks. Relative abundance is expressed as the year's estimated mean index divided by the maximum estimated yearly mean index in each time series. Dotted lines represent upper and lower 95% confidence limits. Source: NMFS Observer Database).

Although observer data are generally regarded as more reliable than logbook data for non-target shark species (Walsh *et al.,* 2002), it should be noted that the sample size of oceanic whitetip in the observer data was substantially smaller than for other species, and thus the trends estimated should be regarded with caution. Although misreporting and species misidentification are likely to be much more prevalent in logbooks, and can obscure accurate abundance trends, species misidentification is not considered an issue for oceanic whitetip. It should also be noted that fishing pressure on the oceanic whitetip shark began decades prior to the time series covered in these studies, thus the percentage declines discussed here do not represent percentage declines from historical virgin biomass. Given all of the caveats and limitations of the studies discussed above, it appears that the oceanic whitetip shark population in the Northwest Atlantic and Gulf of Mexico suffered significant historical declines; however, relative abundance of oceanic whitetip shark may have stabilized in the Northwest Atlantic since 2000 and in the Gulf of Mexico/Caribbean since the late 1990s (Cortés *et al.,* 2007) coinciding with the first Federal Fishery Management Plan for Sharks and subsequent regulations that included trip limits and quotas.

Northeast Atlantic and Mediterranean

There is very little information regarding oceanic whitetip sharks in the Northeast Atlantic and Mediterranean. According to the International Council for the Exploration of the Sea (ICES), there is limited information with which to examine the stock structure of oceanic whitetip, and the ICES area would only be the northern extreme of its Northeast Atlantic distribution range. Oceanic whitetip sharks are found mostly in the southwestern parts of the ICES areas (e.g., Iberian Peninsula), though some may occasionally occur farther north (ICES 2014). Although oceanic whitetip sharks have been recorded from Portuguese waters, landings of the species are unconfirmed (Correia and Smith 2001). In the Mediterranean, Bigelow and Schroeder (1948) (cited in Backus *et al*., 1956) assumed the oceanic whitetip was historically common; however, they were not included in a comprehensive species checklist of cartilaginous fishes in the Mediterranean or overview of elasmobranchs of the Mediterranean Sea (Cavanagh and Gibson 2007; Bradai *et al.,* 2012). Additionally, of twelve species of shark identified in a study of incidental catch and estimated discards of pelagic sharks from the swordfish and tuna fisheries in the Mediterranean Sea, oceanic whitetip sharks were not identified as present (Megalofonu *et al.,* 2005). Thus, it appears that the occurrence of oceanic whitetip shark in the Northeast Atlantic and Mediterranean is likely rare, as these areas represent the northern extent of the species' range.

South Atlantic

There is very little information on the abundance trends of oceanic whitetip shark in the South Atlantic Ocean. Some countries in this region still do not collect shark data while others collect it but fail to report (Frédou *et al.,* 2015). Historically, the oceanic whitetip was considered one of the most abundant species of pelagic shark in this region. For example, it was the third most commonly caught shark species out of a total 33 shark species caught year-round in the prominent Brazilian Santos longline fishery, and one of 7 species that comprised >5% of total shark catches from 1971-1995 (Amorim 1998). In Itajai, southern Brazil, oceanic whitetip sharks were considered "abundant" and "frequent" in the surface longline and gillnet fleets, respectively, from 1994-1999 (Mazzoleni and Schwingel 1999). Abundant means the oceanic whitetip was observed in most of the landings (i.e., surface longline), whereas frequent means the species occurred in at least half of the landings recorded in one of the seasons of the year (i.e., surface gillnet). In northern Brazil, the oceanic whitetip was considered one of the most abundant shark species landed from 2000-2002, comprising 3% of the total catch weight (including tunas, billfishes and other sharks; Asano-Filho *et al.,* (2004)). In equatorial waters, the oceanic whitetip shark was historically reported as the second most abundant elasmobranch species, outnumbered only by the blue shark (*P. glauca*) in research surveys conducted within the EEZ of Brazil during the 1990s, and comprised 29% of the total elasmobranch catch (Lessa *et al.,* 1999). García-Cortés and Mejuto (2002) found that the oceanic whitetip comprised 17% of the total shark catch in the Spanish longline fishery targeting swordfish from 1990-2000. The research surveys conducted in the 1990s covered a limited area that ranged from 1˚N to 9˚S latitude and 40˚W to 30˚W longitude, which corresponds to the northeastern sector of the Brazilian EEZ (see Figure 27 below).

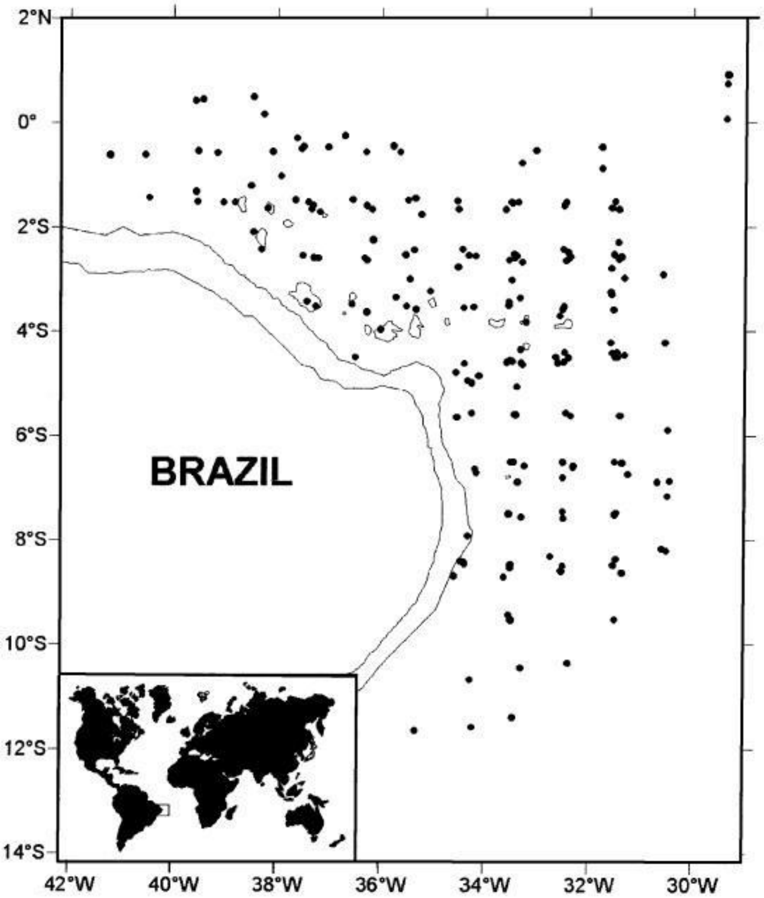

Figure 27 Location of the sampling area (small map) and station position (n = 197) performed for oceanic whitetip shark collected off northeastern Brazil (Source: Lessa *et al.* 1999).

From 1992-2002, oceanic whitetip CPUE in this area averaged 2.18 individuals/1000 hooks (Domingo *et al.,* 2007). More recently, however, average CPUE in this same area has seemingly declined to 0.1-0.3 individuals/1000 hooks (Figure 28 below). Additionally, none of the other areas within the region exhibit CPUE rates anywhere near the rates seen in the 1990s.

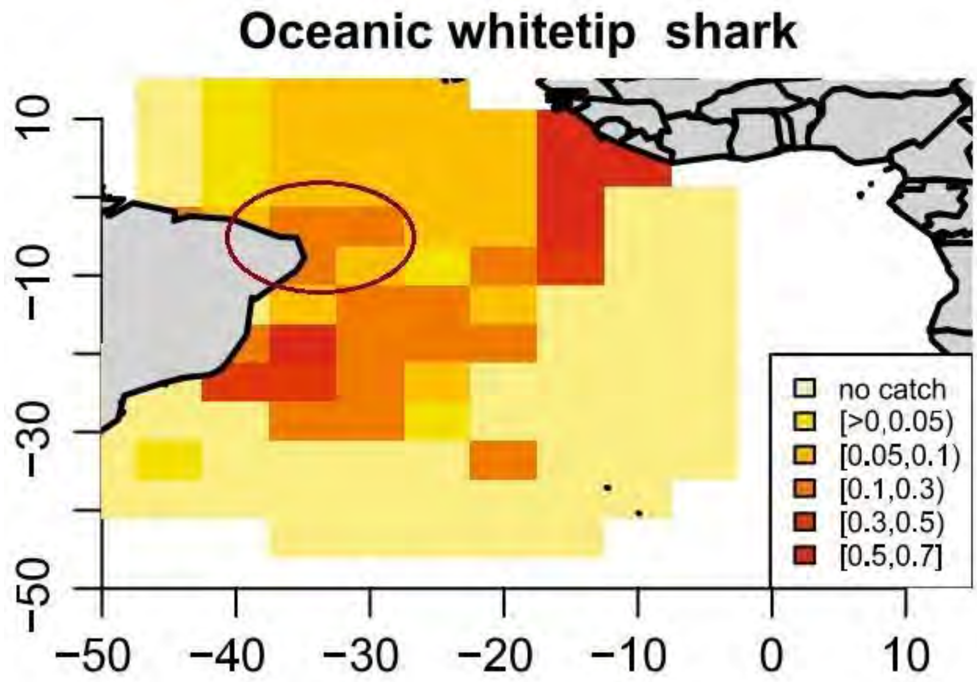

Figure 28 Longline catch per unit effort (CPUE individuals per 1,000 hooks) of the Brazilian chartered tuna longline fleet for the oceanic whitetip shark from 2004-2010 (Source: Frédou *et al.,* (2015).

Additionally, in earlier years the proportion of the oceanic whitetip shark in relation to the total catches of elasmobranches was very low at 2.7%; it showed a peak of 8.2% in 2008, and ranged from 0.8% to 3.4% in the remaining years. These values from 2004-2010 are much lower than the nearly 30% observed by Lessa *et al*. (1999) described previously. However, the results are not directly comparable due to the operational differences in the fishing gear and methods used by the experimental and the commercial operations. For example, the experimental vessels operated in much shallower layers of the water column, where encounters of oceanic whitetip shark is known to be much more frequent (Tolotti *et al.,* 2013).

More recently, Tolotti *et al*. (2013) analyzed catch and effort data from 14,835 longline sets conducted by foreign tuna longline vessels chartered by Brazil from 2004-2010 to assess the size, distribution and relative abundance of the oceanic whitetip shark in the southwestern and equatorial Atlantic Ocean. Standardized CPUE data showed a gradually increasing trend in oceanic whitetip shark abundance from 2004 to 2010. However, the authors noted that the CPUE standardization may have been compromised due to the low number of years in the data series as well as a lack of a homogeneous distribution of fishing effort and fishing strategy, both spatially and temporally. For example, although the Japanese fishing strategy (which typically catches fewer oceanic whitetip sharks due to deeper hook depth) accounted for the majority of hooks deployed in 2004 and 2005, the Spanish strategy (which has shown to catch more oceanic whitetip sharks due to the deployment of hooks at shallower depths) was consistently dominant from 2006 onwards. Further, in the last three years of the time series (i.e., 2008, 2009, and 2010) the Brazilian fleet consisted entirely of vessels fishing with the Spanish strategy, which may have influenced the gradual increase in CPUE over the time series. Overall, the authors concluded that the oceanic whitetip shark was encountered more frequently but in fewer numbers over time (Tolotti *et al*. 2013) and that CPUE of this species is particularly sensitive to changes in fishing strategy. However, definitive conclusions regarding abundance trends from this study could not be determined.

In northeastern Brazil, Santana *et al.,* (2004) conducted a demographic analysis for oceanic whitetip shark. In this analysis, the authors noted that natural mortality of oceanic whitetip shark is high, corresponding to a survival rate between birth and the first year of life of only 58.7%. From these rates, the authors analyzed various scenarios in order to observe the population's behavior based on different mortality rates. Thus, by using actual mortality rates, the authors concluded that the oceanic whitetip population of Northeast Brazil has declined approximately 7.2% per year, resulting in a rate of decline of about 50% of abundance over the course of a decade due to unsustainable fishing pressure. The authors noted that this rate of decline is within the standards known of exploited populations of oceanic whitetip shark in other parts of its range (Santana *et al*. 2004). More recently, the Government of Brazil, in its justification for listing the oceanic whitetip as Vulnerable on its List of Species of Brazilian Fauna Threatened with Extinction (MMA Ordinances No. 444/2014 and No. 445/2014) estimated that the oceanic whitetip population has potentially declined by up to 79% (ICMBio 2014)[3]. However, given the lack of historical fisheries data or a stock assessment, these estimates are uncertain.

Farther south in Uruguay, abundance of oceanic whitetip shark is seemingly low and patchy. In 6 years of observer data from the Uruguayan longline fleet (1998-2003), in which approximately 660,000 hooks were deployed between latitudes 26° and 37° S, catches of oceanic whitetip shark were described as "occasional" with CPUE rates of only 0.006 individuals/1,000 hooks (Domingo 2004). Domingo (2004) noted that it is unknown whether the low abundance of oceanic whitetip sharks in Uruguayan longline fisheries is because the species has always occurred in low numbers in this region of the South Atlantic, or because the population has been affected significantly by fishing effort. It should be noted that sampling in this study took place in waters with sea surface temperatures ranging between 16° and 23° C, which are largely below the preferred temperature of the species. In a more recent analysis of observer data, Domingo *et al.,* (2007) found similar results as the earlier study. For example, observer data from the Uruguayan longline fleet operating in this region reported low CPUE values for oceanic whitetip from 2003 to 2006, with the highest CPUE recorded not exceeding 0.491 individuals/1,000 hooks. In total, only 63 oceanic whitetips were caught on 2,279,169 hooks and 63% were juveniles. All catches occurred in sets with sea surface temperatures $\geq 22.5°$ C (Domingo *et al*., 2007). Again, this data does not indicate whether a decline in the population has occurred; but, it does seem to reflect the species' low abundance in this area (Domingo *et al.,* 2007).

Indian Ocean

The status and abundance of shark species in the Indian Ocean is poorly known despite a long history of research and more than 60 years of commercial exploitation by large-scale tuna fisheries (Romanov *et al.,* 2010). De Young (2006) characterized the status of shark populations off the coasts of Egypt, India, Iran, Oman, Saudi Arabia, Sudan, United Arab Emirates, and Yemen as currently unknown. Further, the status of shark populations off the coasts of the Maldives, Kenya, Mauritius, Seychelles, South Africa, and United Republic of Tanzania is presumed to be fully over-exploited. Despite evidence for high bycatch levels of pelagic sharks

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[3] http://www.icmbio.gov.br/portal/faunabrasileira/lista-de-especies/6526-especie-6526

in the Indian Ocean (Romanov 2002; Huang and Liu 2010), a lack of reliable data prohibits an assessment of historical changes in shark catch rate trends (Smale 2008). For oceanic whitetip sharks in particular, there is no quantitative stock assessment and only limited basic fishery indicators are available, making it difficult to determine abundance trends within this ocean basin. Therefore, the Indian Ocean Tuna Commission (IOTC) determined that the oceanic whitetip stock status in the Indian Ocean is currently uncertain (IOTC 2015a). However, historical research sampling data shows overall declines in both CPUE and mean weight of oceanic whitetip sharks (Romanov *et al.,* 2008); see Figure 29 below), and anecdotal reports suggest that oceanic whitetips have become rare throughout much of the Indian Ocean over the past 20 years (IOTC 2015a).

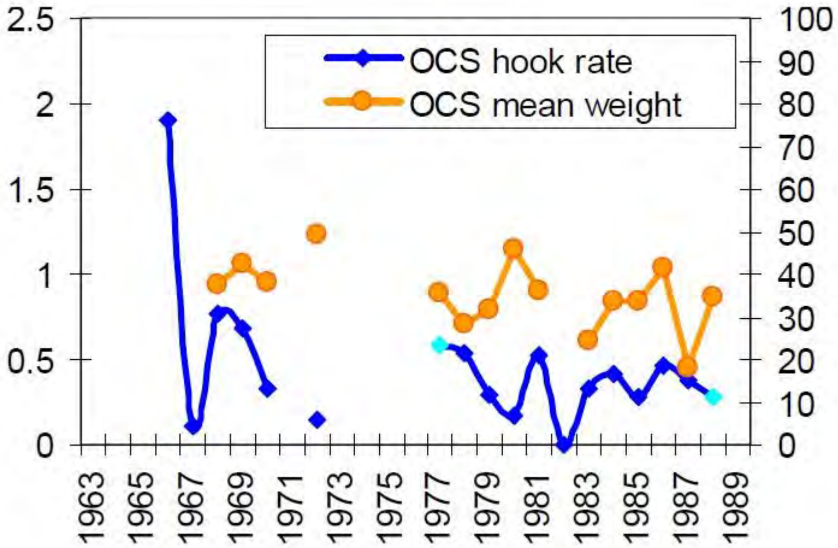

Figure 29 Historical nominal CPUE and mean weight of oceanic whitetip shark from 1963-1989 in the Indian Ocean. Left axis is CPUE; right axis is mean weight (Source: Romanov *et al.* 2008).

Additionally, some studies provide additional information on the decline of oceanic whitetip in the Indian Ocean. Data from an exploratory fishing survey for large pelagic species conducted off the eastern seaboard of the Maldives from 1987–88 indicated that oceanic whitetips represented 29% of the sharks caught by longline and 10% of the sharks caught by gillnet in all fishing zones (Anderson and Waheed 1990). In the center and north fishing zones, oceanic whitetip sharks contributed 19.9% of the total shark longline catch by numbers. During this survey, the average CPUE for all sharks was 48.7 sharks/1,000 hooks. Applying the percentage of oceanic whitetips in the catch to the total shark CPUE translates to an oceanic whitetip catch rate of approximately 1.41 individuals/100 hooks during the time period (FAO 2012). In comparison, Anderson *et al.,* (2011) conducted 4 missions to the island of Kulhudhuffushi (in the northern Haa Dhaalu atoll) from 2000-2004 to study the local shark fishery. The shark longline fishery in this region was conducted by small traditional dhonis that used an average of 141 hooks. Up until 2010, this was the most important shark fishing island in the country until the fishery closed because of a national ban on shark fishing. Anderson *et al*. (2011) estimated that the average CPUE of oceanic whitetip was 0.20 individuals per dhoni (or approximately 0.14 sharks/100 hooks), and estimated the species contributed only 3.5% of the shark landings. This is a stark contrast to the numbers reported from 1987-88, and represents a 90% decline in abundance between 1987–88 and 2000–04. This level of decline would be consistent with the decrease in the proportion of oceanic whitetip in the catch (from 29% of longline shark catch in 1987-88 to just 3.5% of landings in 2000-04) and also with anecdotal information reporting a marked decrease in sightings of oceanic whitetip sharks off northern and central Maldives (Anderson *et al.,* 2011; FAO 2012). For example, the aforementioned offshore survey conducted in 1987-88 noted that oceanic whitetips frequently approached the vessel (Anderson and Waheed, 1990), while more recent offshore surveys by divers around fish aggregating devices (FADs) reported no sightings of oceanic whitetips off the north or center of the Maldives (Anderson *et al.,* 2011). Ultimately, Anderson *et al*. (2011) determined that the shark stocks that supported the shark fishery were sequentially overfished, with the decline in oceanic shark catches the result of high (and likely unsustainable) levels of fishing by overseas fisheries. The IOTC Working Party on Ecosystems and Bycatch (WPEB) noted the following on the aforementioned studies:

> "Data collected on shark abundance represents a consistent time series for the periods 1987–1988 and 2000–2004, collected with similar longline gear, and that the data was showing a declining trend in oceanic whitetip shark abundance, which is a potential indicator of overall stock depletion."

The WPEB further noted that it could be related to localized effects, although this was deemed unlikely as oceanic whitetip sharks are wide-ranging and abundance trends from long-term research conducted by the former Soviet Union between the 1960s and 1980s indicate a similar decline of oceanic whitetip sharks, and that "sightings of this species in Maldives and Réunion islands is now quite uncommon" (IOTC 2011a).

Other studies on the abundance trends of oceanic whitetip shark, including analyses of standardized CPUE indices from Japanese and Spanish longline fisheries indicate potential population declines ranging from 25-40%, although trends are conflicting. Standardized CPUE for oceanic whitetip shark has been estimated for the Japanese longline fleet operating in the Indian Ocean (Semba and Yokawa 2011; Yokawa and Semba 2012). In the first study, CPUE reached its peak in 2003 and then showed a gradual decline thereafter. (Figure 30 below; Semba and Yokawa (2011)). Prior to 2003, the authors attribute large fluctuations in oceanic whitetip CPUE to changes in reporting requirements as opposed to the actual population trend, as the initial years of the time series reflect the introduction phase of a new records system. The data showed low values in 2000 and 2001 (attributed to extremely low catches), and a gradual decreasing trend from 2003 to 2009. The authors interpreted the 40% decline in CPUE as an indication of a decrease in population abundance (FAO 2012; Semba and Yokawa 2011). In an update of the 2011 study, Yokawa and Semba (2012) used a modified data filtering method, and produced a rather similar and somewhat flattened trend when compared to the results of the 2011 study.

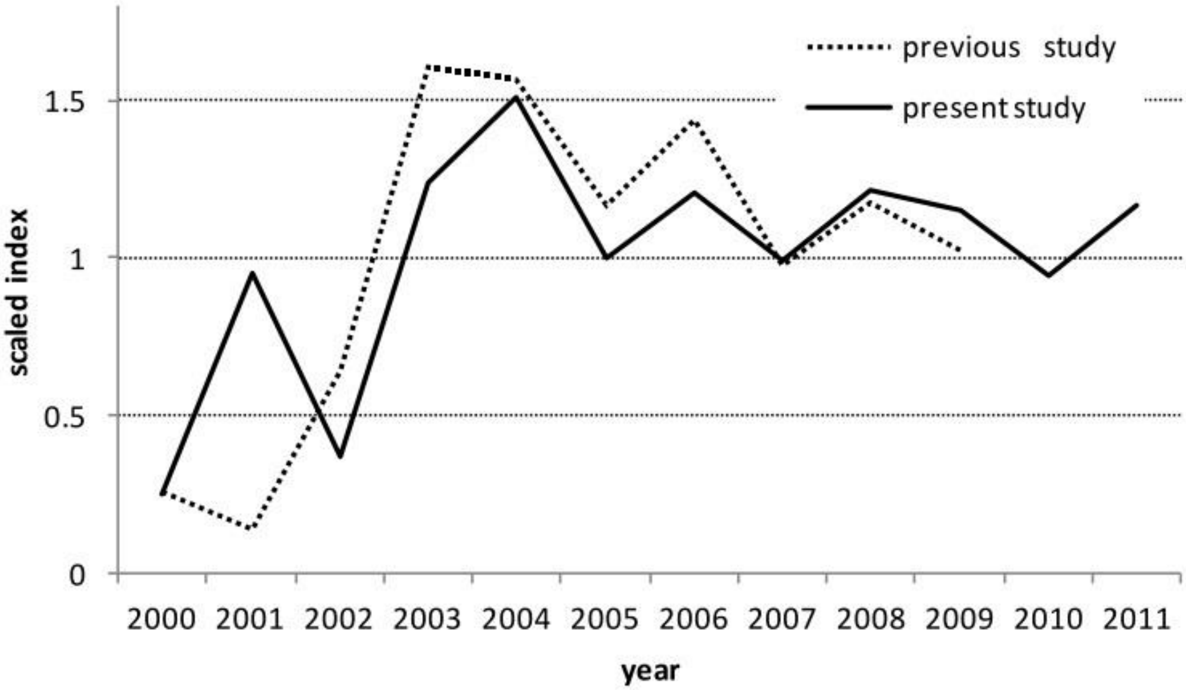

Figure 30 Trends of standardized CPUE of oceanic whitetip shark in the Japanese longline fleet operating in the Indian Ocean (Source: Yokawa and Semba 2012).

Ramos-Cartelle *et al*. (2012) used a General Linear Mixed Model to determine standardized CPUE rates of oceanic whitetip shark in the Spanish longline fishery from 1998-2011 based on 2,806 set records. Results showed large historical fluctuations and a general decreasing trend from 1998-2007, followed by an increase thereafter (Figure 31 below). Overall, the magnitude of decline in this study was estimated to be about 25-30% (Ramos-Cartelle *et al.,* 2012). However, the authors noted that this index may not be a reliable indicator of the species' stock abundance as a whole due to high variability of the standardized catch rates between consecutive years and scarce numbers of specimens in some years (Ramos-Cartelle *et al.,* 2012). However, the data does reaffirm the oceanic whitetip's relatively low prevalence in the surface longline commercial fishery targeting swordfish in waters with lower temperatures than those generally preferred by the species (García-Cortés *et al.,* 2012; Ramos-Cartelle *et al.,* 2012).

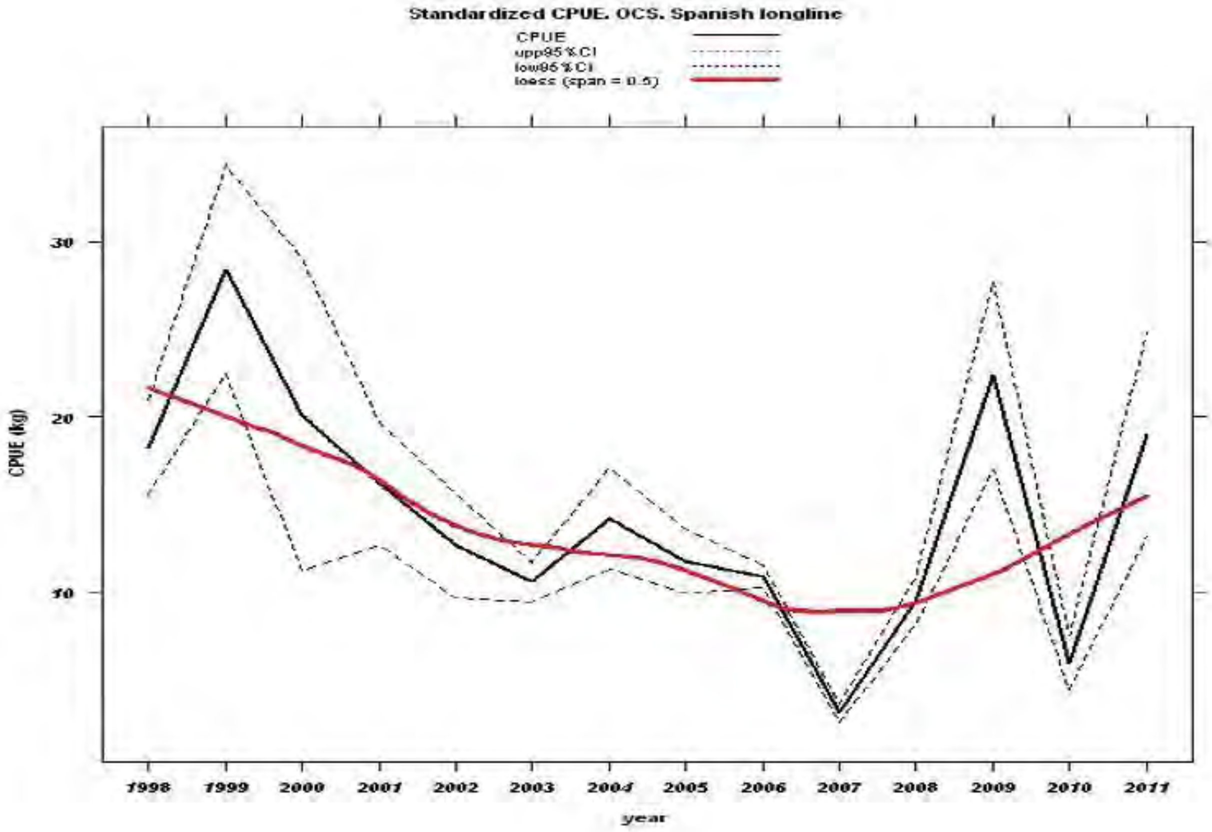

Figure 31 Estimated standardized catch rates of the Spanish longline fleet (kg dressed weight), corresponding 95% confidence limits (bootstrap percentile method) and loess fit (red line) of the oceanic whitetip shark in the Indian Ocean during the 1998-2011 period (Source: Ramos-Cartelle *et al.* 2012).

Finally, Tolotti *et al.,* (2015b) analyzed data from 3,339 purse seine sets conducted by the French tuna fleet in the Indian Ocean. The time series includes data from the mid-1990s (1995 and 1996) and from 2005-2014. Sets covered a large area of the Indian Ocean, from approximately 5°N to 20°S latitude and 70°E to 40°E longitude. Additional historical data from the Soviet Union (USSR) were also incorporated into the analyses in order to examine possible changes in population trends. Interactions between oceanic whitetip sharks and the tropical purse seine fisheries were analyzed in terms of occurrence per set, but did not account for the number of individuals caught per set. Results showed a marked change in the proportion of FAD sets with oceanic whitetips present, fluctuating around 20% in the mid-1980s and 1990s, and then dropping to less than 10% from 2005 onwards (Tolotti *et al*., 2015b; See Figure 32 below).

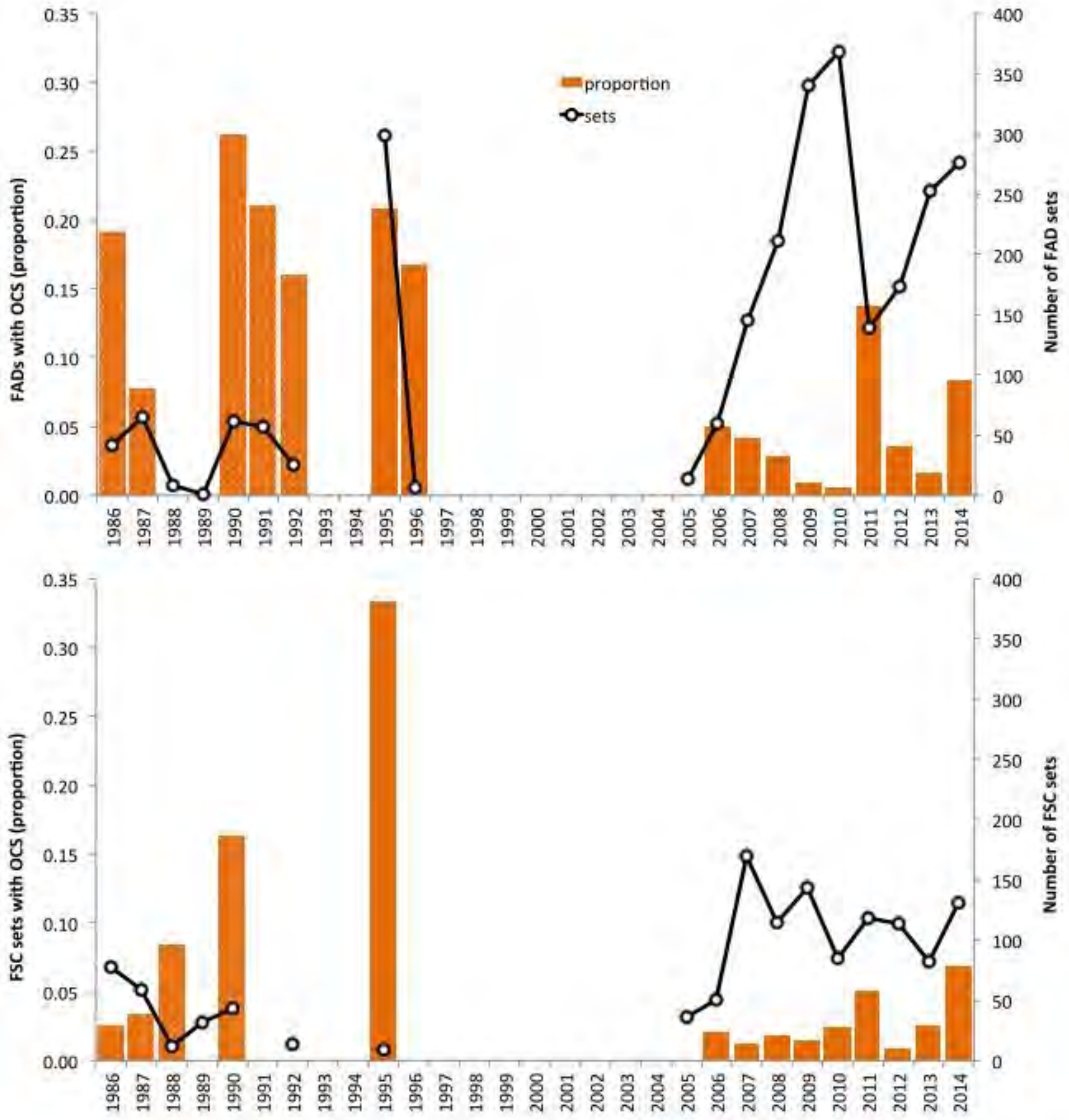

Figure 32 Proportion between sets with the presence of oceanic whitetip sharks (bars) and the total number of sets (points). Top panel shows the proportion on FAD sets and bottom panel on FSC. The shaded bars represent the historic database from USSR. Source: Tolotti *et al.* 2015b.

Considering that the number of FADs has greatly increased since the 1990s (Dagorn *et al.,* 2013; Maufroy *et al.,* 2015; Tolotti *et al.,* 2015b), the authors concluded that the percent change in the proportion of FADs with oceanic whitetip sharks by more than 50% could indicate a population decline (Tolotti *et al.,* 2015b). Alternatively, the authors considered that the decline of oceanic whitetip shark occurrence per FAD could be the result of a sharp increase on FAD densities combined with a small and stable population size. Although it is unclear which scenario is more plausible based on the available data, given the declines indicated in other studies throughout the

Indian Ocean, it seems more likely that the marked decline observed in Tolotti *et al.,* (2015b) is indicative of a declining abundance trend rather than a small, stable population. Overall, while it is likely that the oceanic whitetip shark has experienced some level of decline in the Indian Ocean, there is considerable uncertainty regarding current population abundance and the exact magnitude of decline in this region.

Regional Population Trends Summary

Overall, evidence (both quantitative and qualitative) suggests that while the oceanic whitetip shark was once considered to be one of the most abundant and commonly encountered pelagic shark species wherever it occurred, this oceanic species has likely undergone population abundance declines of varying magnitudes throughout its global range. Where more robust information is available, declines in oceanic whitetip shark abundance range from 86 to greater than 90% in some areas of the Pacific Ocean (with declines observed across the entire basin), and between 57-88% in the Atlantic and Gulf of Mexico. Although information from the Indian Ocean is highly uncertain and much less reliable, the best available information points to varying magnitudes of decline, with the species becoming rare across the basin over the last 20 years. The only population that currently shows a stable trend, based on standardized CPUE observer data, is the Northwest Atlantic. The trend of oceanic whitetip catches in the Hawaii-based pelagic longline fishery may have also potentially stabilized at a post-decline depressed state in recent years. In addition to CPUE trends, which can often be misleading and unreliable due to uncertainties in standardization, stock structure and other factors, other abundance indices such as trends in occurrence and composition of the species in catch data, as well as biological indicators (e.g., mean length or weight, etc.) also indicate significant and continuing declines of oceanic whitetip in a large portion of its range.

4. ESA SECTION 4(a)(1) FACTORS

The ESA requires NMFS to determine whether a species is endangered or threatened due to any one of the five factors specified in section 4(a)(1) of the ESA. The following provides information on each of these five factors as they relate to the current status of the oceanic whitetip shark.

4.1 (A) Present or Threatened Destruction, Modification or Curtailment of Habitat or Range

This section analyzes potential threats to oceanic whitetip shark habitat, including impacts from fishing and climate change.

Habitat in United States

In the U.S. EEZ, the Magnuson-Stevens Fishery Conservation and Management Act (MSA) requires NMFS to identify and describe Essential Fish Habitat (EFH), minimize the adverse effects of fishing on EFH, and identify actions to encourage the conservation and enhancement of EFH. The MSA defines EFH as as "those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity" (16 U.S.C. 1802(10)) and requires the identification of EFH in Fishery Management Plans (FMPs).

Atlantic

Essential fish habitat has been designated for the oceanic whitetip in localized areas in the Atlantic and Gulf of Mexico, as well as the U.S. Caribbean. Insufficient data is available to differentiate EFH between nenonates/juveniles and adults; therefore, the following description of EFH is for all life stages. Currently, designated EFH includes waters greater than 200 m in depth from offshore of the North Carolina/Virginia border to the Blake Plateau. Designated EFH in the Gulf of Mexico includes offshore habitats of the northern Gulf of Mexico at the Alabama/Florida border to offshore habitats of the western Gulf of Mexico south of eastern Texas. Additionally, the entire U.S. Caribbean (waters of Puerto Rico and the U.S. Virgin Islands) is considered to be EFH for the oceanic whitetip (see Figure 33 below; NMFS 2017). However, while we can confirm that the geographical areas occupied by the oceanic whitetip include U.S. waters, there is no information regarding habitat use of oceanic whitetip sharks in any of these areas (J. Carlson, personal communication, 2017), and nurseries and pupping grounds have not been identified (NMFS 2017; CITES 2013).

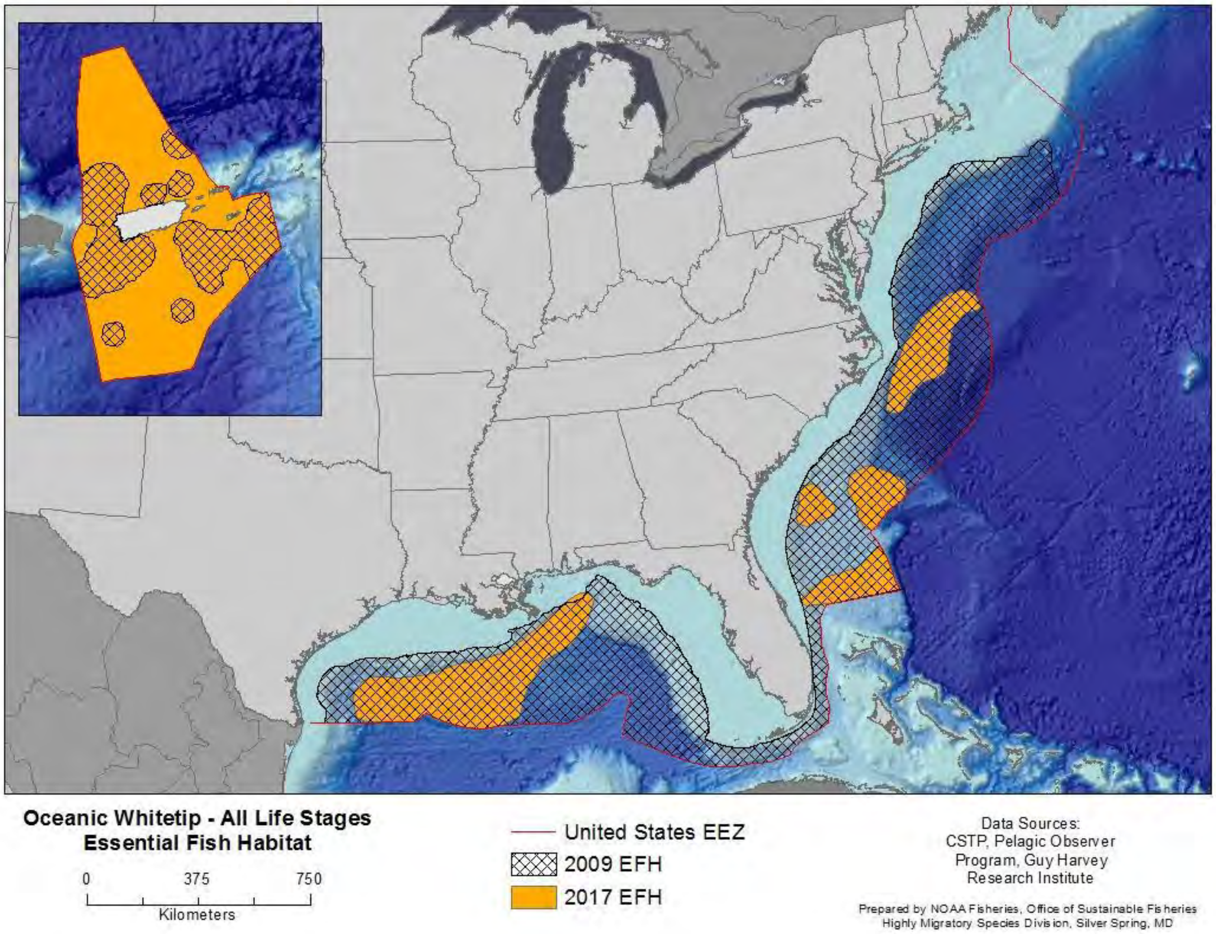

Figure 33 EFH for oceanic whitetip shark in the Northwest Atlantic (Source: NMFS (2009a).

Pacific

In the U.S. western Pacific, including Hawaii, American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands, EFH for oceanic whitetip sharks is broadly defined as the water column down to a depth of 1,000 m (547 fm) from the shoreline to the outer limit of the EEZ (WPFMC 2009). Based on an examination of published literature and anecdotal evidence, NMFS assessed the impact of fishing gears on highly migratory species (HMS) EFH and determined that there are few anticipated impacts from federally regulated and non-federally regulated gears to HMS EFH (which includes oceanic whitetip shark EFH) (NMFS 2006). Since EFH is defined for the oceanic whitetip as the water column or attributes to the water column, cumulative impacts from HMS and non-HMS fishing gears are anticipated to be minimal. However, a better understanding of the specific habitat types and characteristics that influence the abundance of these sharks within those habitats is needed in order to determine the effects of fishing activities on habitat suitability for oceanic whitetip sharks. In addition, EFH regulations also require that FMPs identify non-fishing related activities that may adversely affect EFH of managed species, either quantitatively or qualitatively, or both. These waters are or may be used by humans for a variety of purposes that often result in degradation of these and adjacent habitats, posing threats, either directly or indirectly, to the biota they support (NMFS 2006). These effects, either alone or in combination with effects from other activities within the ecosystem, may contribute to the decline of some species or degradation of the habitat; however, the cumulative anthropogenic effects on the species' continued existence are difficult to quantify. Currently, there is no evidence to suggest a range contraction based on habitat degradation for the oceanic whitetip shark.

Non-U.S. Habitat

Aside from impacts from overfishing, information on threats to oceanic whitetip shark habitat areas outside of the United States is not available.

Climate Change

Studies on the impacts of climate change specific to the oceanic whitetip have not been conducted. However, because oceanic whitetip shark habitat is comprised of open ocean environments occurring over broad geographic ranges, large-scale impacts such as global climate change that affect ocean temperatures, currents, and potentially food chain dynamics, may impact these species. As a proxy, below is a description of available climate change studies on other pelagic shark species that occur in the range of oceanic whitetip sharks. However, without any species-specific studies, climate change impacts to oceanic whitetip sharks are highly uncertain.

In a study to assess the vulnerability of sharks and rays on Australia's Great Barrier Reef (GBR) to climate change, Chin *et al.,* (2010) conducted an Integrated Risk Assessment for Climate Change. The assessment examined individual species but also lumped species together in ecological groups (such as freshwater and estuarine, coastal and inshore, reef, shelf, etc.) to determine which groups may be most vulnerable to climate change. Pelagic shark species (e.g., oceanic whitetip and blue sharks) were considered in the "pelagic" ecological group. The assessment took into account the *in situ* changes and effects that are predicted to occur over the next 100 years in the GBR and assessed each species' exposure, sensitivity, and adaptive capacity to a number of climate change factors. The resulting vulnerability rankings for each species were then collated to calculate the relative vulnerability of the ecological groups.

The climate change factors that were considered in the assessment included water and air temperature, ocean acidification, freshwater input, ocean circulation, sea level rise, severe weather, light, and ultraviolet radiation. Results from the assessment showed that freshwater/estuarine sharks and rays are at highest risk from climate change, with high exposure to the climate change factors. The pelagic ecological group showed relatively low risk, with moderate to high exposure to only a couple of the climate change factors (e.g., oceanographic changes and rising temperatures could affect productivity, migration patterns, and phenology, as well as the physiochemical environment, respectively). Additionally, all of the species within the pelagic group (except the plankton-feeders) had low sensitivity and rigidity (i.e., assessments that considered species' rarity, habitat and trophic specificity, physical-chemical intolerance, immobility, and latitudinal range), which lowered their individual vulnerability to climate change factors.

In another study on potential effects of climate change to sharks, Hazen *et al.,* (2012) used data derived from an electronic tagging project (Tagging of Pacific Predators Project) and output from a climate change model to predict shifts in habitat and diversity in top marine predators in the Pacific out to the year 2100. Results of the study showed significant differences in habitat change among species groups, which resulted in species-specific "winners" and "losers." The shark guild as a whole had the greatest risk of pelagic habitat loss (Figure 34).

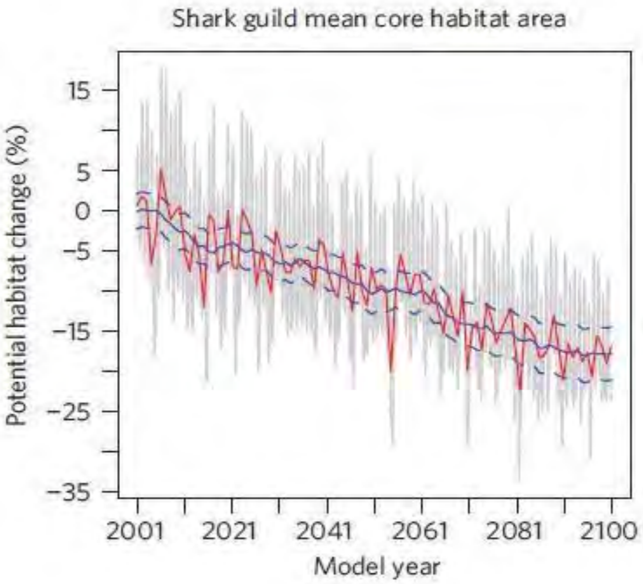

Figure 34 Core habitat area for sharks from the year 2000 to 2100 shown as monthly (grey), yearly (red) and 5-year filtered (blue) time series with 1 standard deviation marked by dashed lines (Source: Hazen *et al.* 2012).

Overall, the model predictions in Hazen *et al.,* (2012) and the vulnerability assessment in Chin *et al.,* (2010) represent only two very broad analyses of how climate change may affect pelagic sharks, and do not account for factors such as species interactions, food web dynamics, and fine-scale habitat use patterns that need to be considered to more comprehensively assess the effects of climate change on the pelagic ecosystem. Further, results of these studies are not specific to the oceanic whitetip shark. Finally, the complexity of ecosystem processes and interactions complicate the interpretation of modeled climate change predictions and the potential impacts on populations. Thus, the potential impacts from climate change on oceanic whitetip shark habitat are highly uncertain, but given their broad distribution in various habitat types, these species can move to areas that suit their biological and ecological needs. Therefore, while effects from climate change have the potential to pose a threat to sharks in general, including habitat changes such as changes in currents and ocean circulation and potential impacts to prey species, species-specific impacts to oceanic whitetip sharks and their habitat are currently unknown, but likely minimal.

4.2 (B) Overutilization for Commercial, Recreational, Scientific or Educational Purposes

Threats to the oceanic whitetip shark related to overutilization stem from commercial fisheries, largely driven by demand of the international shark fin trade, bycatch-related mortality, and illegal, unreported, and unregulated (IUU) fishing. The oceanic whitetip shark is not generally targeted, but the species is regularly caught and taken as bycatch in numerous fisheries around the world. This species is commonly caught with pelagic longlines, purse seines, handlines, troll and occasionally pelagic and even bottom trawls (Compagno 1984). Although thought to be of low commercial value, oceanic whitetip shark meat is utilized fresh, smoked, and dried and salted for human consumption (Compagno 1984). Additionally, oceanic whitetip meat from longline bycatch has been marketed in Europe, North America and Asia (Rose 1996; Vannuccini 1999). Oceanic whitetip sharks are also used for hides, for fins (for shark fin soup), and for liver oil (extracted for vitamins) and fishmeal. In contrast to the low commercial value of the meat (Mundy-Taylor and Crook 2013), oceanic whitetip fins are highly prized in the international shark fin market and sell for USD $45 to USD $85 per kg (CITES 2013).

In addition to mortality caused by retention and finning in commercial fisheries, oceanic whitetip sharks likely experience some level of fishing mortality upon being discarded or released. While several studies throughout the oceanic whitetip shark's range indicate relatively high at-vessel survivorship rates in longline fisheries relative to other pelagic sharks (up to 88% in longline fisheries using circle hooks; Beerkircher *et al.,* (2002); Bromhead *et al.,* (2012); Fernandez-Carvalho *et al.,* (2015)), these numbers can vary among fleets and do not account for potential post-release mortality. These data suggest that oceanic whitetips could benefit from live release as mandated in the shark resolutions passed by most RFMOs (Camhi *et al.,* 2009) if they are fully implemented and enforced; however, this may not always be the case. See *Inadequacy of Existing Regulatory Mechanisms* section for more details. For the purposes of this status review, population dynamic characteristics, such as current population size, abundance trends by regions, and the effects of fisheries and the shark fin trade on the species were considered when evaluating whether the oceanic whitetip shark is currently experiencing overutilization throughout its global range. Much of the data come from localized study sites and over short time periods and thus is difficult to extrapolate to the global population. This section includes relevant information from the following geographic regions: Eastern Pacific, Western and Central Pacific, Northwest and Central Atlantic, South Atlantic, and Indian Ocean.

PACIFIC OCEAN

Eastern Pacific Ocean

In the Eastern Pacific, the oceanic whitetip shark is caught on a variety of gear, including longline and purse seine gear targeting tunas and swordfish. While the range of the oceanic whitetip in the Eastern Pacific is noted as extending as far north as southern California waters, based on the available data, the distribution of the species appears to be concentrated in areas farther south, and in more tropical waters. Observer data of the West-Coast based U.S. fisheries further confirms this finding, with oceanic whitetip sharks not observed in the catches. For example, in the California/Oregon drift gillnet fishery, which targets swordfish and common thresher sharks and operates off the U.S. Pacific coast, observers recorded 0 oceanic whitetip sharks in 8,698 sets conducted over the past 25 years (from 1990-2015[4]).

Oceanic whitetip sharks are commonly caught as bycatch in the tropical tuna purse seine fishery. From 1993-2009, oceanic whitetip comprised approximately 9% of the total shark catch, and was the second most abundant shark in these catches behind the silky shark (Hall and Roman 2013). Fisheries information and catch data for the Eastern Pacific are available from the Inter-American Tropical Tuna Commission (IATTC), which is the RFMO responsible for the conservation and management of tuna and other marine resources in this region. To date, the IATTC has not conducted a stock assessment for the oceanic whitetip shark. The IATTC requires the collection of data on the primary shark species caught as bycatch in its fisheries. Since 1993, observers have recorded shark bycatch data onboard large purse seiners in the Eastern Pacific. However, much of this data is aggregated under the category of "sharks," especially data collected prior to 2005. In an effort to improve species identifications in these data, a one-year Shark Characteristics Sampling Program was conducted to quantify at-sea observer misidentification rates. Oceanic whitetip sharks represented approximately 20.8% of the species observed during this project (Roman-Verdesoto and Orozco-Zoller 2005). More recently, species-specific observer data have become publicly available via the IATTC observer database, upon which estimates of shark catches (tons/year) by species for all purse seines operating in the Eastern Pacific Ocean for all set types combined (floating object + unassociated + dolphin) are based (See Figure 35 below).

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[4] http://www.westcoast.fisheries.noaa.gov/fisheries/wc_observer_programs/sw_observer_program_info/data_summ_report_sw_observer_fish.html

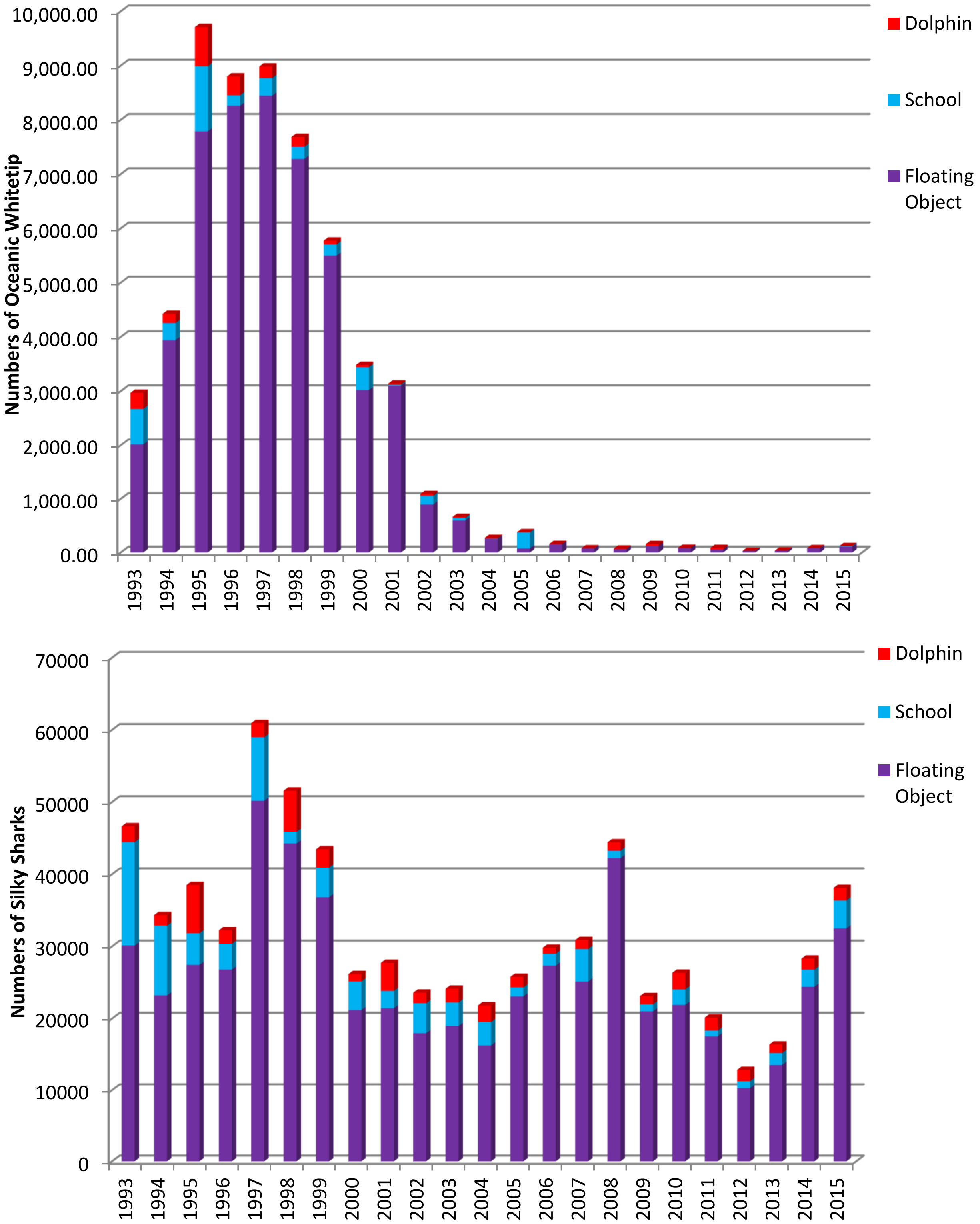

Figure 35 Annual estimated numbers of oceanic whitetip and silky sharks caught as bycatch in the tropical tuna purse seine fishery of the Eastern Pacific Ocean. *Note the differences in scales for the species. Source: IATTC Observer Database.

Floating object sets are responsible for 90% of oceanic whitetip shark catches. The species' capture probability in floating object purse seine sets has decreased over time from a high of 30% capture rate per set between 1994 and 1998, to less than 5% from 2004 to 2008 (Morgan 2014). Estimated catches of oceanic whitetip shark peaked in 1995, with approximately 9,709 individuals caught in all sets. Within 10 years, catches dropped dramatically to only 379 oceanic whitetip sharks caught, with catches continuing to decline thereafter, with only 120 individuals caught in 2015. This is in drastic contrast to catches of the closely related silky shark, which has remained relatively constant over the same time period. As noted previously in the *Regional Population Trends* section of this status review, declines in the nominal CPUE and frequency of occurrence of oceanic whitetip is compatible with a drop of 80–95% from the population levels in the late 1990s (Hall and Román 2013). Further, size trends in this fishery show that small oceanic whitetip sharks, which comprised 21.4% of the oceanic whitetips captured in 1993, have been virtually eliminated from the population, indicating the possibility of recruitment failure in the population (see Figure 36 below).

Capture of oceanic whitetip sharks by size interval in the Eastern Pacific Ocean, 1993–2008

	Number				Percent		
Year	Small	Medium	Large	Total	Small	Med	Large
1993	220	494	310	1024	21.4	48.3	30.3
1994	95	1130	1440	2665	3.5	42.4	54.1
1995	408	2984	2149	5541	7.4	53.9	38.8
1996	647	2765	2483	5895	11.0	46.9	42.1
1997	592	2258	2995	5845	10.1	38.6	51.2
1998	452	1862	2683	4997	9.1	37.3	53.7
1999	340	1213	2210	3764	9.0	32.2	58.7
2000	18	547	1426	1991	0.9	27.5	71.6
2001	80	729	1252	2662	3.9	35.4	60.7
2002	15	122	540	677	2.2	18.0	79.8
2003	0	105	266	371	0.0	28.4	71.6
2004	4	38	132	174	2.3	21.8	75.9
2005	1	23	30	54	1.9	42.6	55.6
2006	1	33	48	82	1.2	40.2	58.5
2007	1	18	23	42	2.4	42.9	54.8
2008	0	11	19	30	0.0	36.7	63.3

Figure 36 Capture of oceanic whitetip sharks by size interval in the Eastern Pacific Ocean from 1993-2008. Note: Small < 90 cm; medium 90-150 cm, large >150 cm. Source: Hall and Roman 2013.

During this same time period, there was an increase in both the total catch of tunas by purse seiners that employ drifting FADs and the number of FADs deployed (Eddy *et al.,* 2016; Hall and Román 2016). Over the past decade, the total number of FADs deployed per year has continued to increase steadily, from about 4,000 in 2005 to almost 15,000 in 2015, which is the highest record observed (Hall and Román 2016). The total number of sets has also continued increasing, with 2015 being the highest record observed.

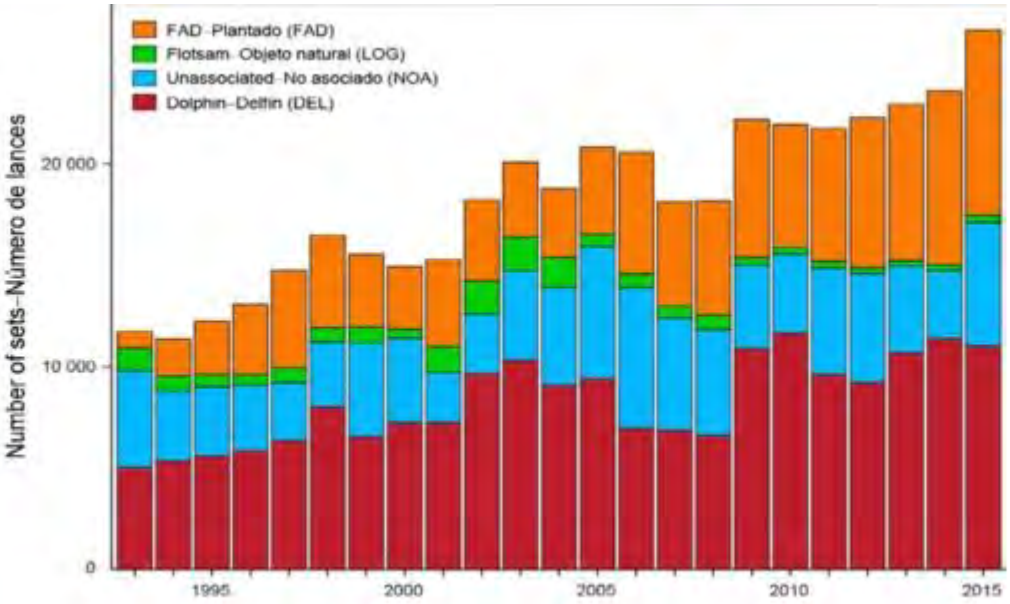

Figure 37 Number of sets, by type, in the Eastern Pacific Ocean. Source: Hall and Roman 2016.

Thus, given that fishing effort in the Eastern Pacific continues to increase, fishing pressure and associated mortality of oceanic whitetip sharks is expected to continue. Though mortality rates of oceanic whitetip in purse seine fisheries are not available, it is likely that oceanic whitetip sharks experience high mortality rates similar to congener *C. falciformis* (silky shark; >85% in Western and Central Pacific and Indian Ocean purse seine fisheries; Poisson *et al.,* (2014); Hutchinson *et al.,* (2015)) during and after interactions with purse seine fisheries. Although management measures are now in place that prohibit retention of oceanic whitetip shark in the Eastern Pacific Ocean (IATTC 2011), this will not likely be sufficient to prevent further population declines due to the likely high bycatch-related mortality rates in purse seine nets (including post-release mortality) (see *Inadequacy of Existing Regulatory Mechanisms* section for more details). Therefore, given the significant decline in catches and virtual disappearance of oceanic whitetip sharks from purse seine fishing grounds in the Eastern Pacific, it appears that these declines are likely the result of overutilization of the species.

Not only are oceanic whitetip sharks commonly encountered in purse seine fisheries, they are sometimes a significant component of the bycatch in longline fisheries and are likely taken in artisanal fisheries in several countries around the Eastern Pacific Ocean (IATTC 2007). While information regarding catch rates of oceanic whitetip shark in these fisheries is not readily available, some limited information is available from various countries that fish in these waters. For example, oceanic whitetip shark was identified as one of several principal species taken by Mexican fisheries targeting pelagic sharks (Sosa-Nishizaki *et al.,* 2008). Farther south in the Eastern Pacific, three countries (Costa Rica, Ecuador and Peru) contribute significantly to shark landings, and are important suppliers of shark fins for the Asian market. In a recent 61-year analysis of Peruvian shark fisheries, Gonzalez-Pestana *et al.,* (2014) reported the oceanic whitetip shark in the Peruvian fishery, but provided no additional information on the level of catch. The oceanic whitetip shark has also been recorded in the catches of the Ecuadorian artisanal fishery. In an analysis of landings from the five principal ports of the Ecuadorian artisanal fishery from 2008-2012, 37.2 mt of oceanic whitetip shark were recorded out of a total

43,492.6 mt of shark catches (Martinez-Ortiz *et al.,* 2015). In Costa Rica, only 10 oceanic whitetip sharks were reported by observers in the Costa Rican longline fishery from 1999 to 2010 (Dapp *et al.,* 2013). However, according to a recent report, landings data from the Costa Rican Fisheries Institute shows that 2,074 oceanic whitetip shark bodies were landed in 2011 alone in Puntarenas, Costa Rica (Arauz 2017). This provides some evidence that the oceanic whitetip shark is much more prevalent in Costa Rican longline fisheries than the observer data indicates; as such, this fishery may be contributing further to the overutilization of the species in the eastern Pacific.

Western and Central Pacific Ocean

The Western and Central Pacific Ocean supports the world's largest industrial tuna fishery. In recent years, several quantitative assessments have become available regarding the impact of this level of fishing on shark populations. Fisheries information and catch data for the Western and Central Pacific Ocean are available from the Western and Central Pacific Fisheries Commission (WCPFC[5]). The WCPFC is the RFMO that seeks the conservation and sustainable use of highly migratory fish stocks in the Western and Central Pacific Ocean. Like other regions, there is a historical lack of shark reporting on logbooks for most fleets in the Pacific, although this has improved in recent years with the implementation of Conservation Management Measures (CMM) that require catches of key shark species to be reported to the Commission. Under CMM 2009-04, members shall include catch information of key shark species in their annual reporting to the Commission, including oceanic whitetip shark. Currently, under CMM 2010-07 (which replaced CMM 2009-04 and was revised in 2014), reporting is only required south of 20°S until biological data shows this or another geographic limit to be appropriate[6]. Despite this requirement, recent catches of key shark species have not been provided to the WCPFC for a number of longline fleets, including Indonesia, which is the top shark fishing nation in the world (Dent and Clarke 2015).

Despite the lack of data, shark catches in this region can be estimated from limited observer data and it is clear that the majority of pelagic sharks are captured by longlines (Lawson 2011). Lawson (2011) describes the longline fishery in the Western and Central Pacific as "comprised of vessels that specifically target sharks, engage in 'mixed targeting' (in which vessels use methods that aim to catch shark and tuna species simultaneously), and target tuna and other non-shark species and take sharks solely as bycatch." Even when sharks are caught as bycatch, survival is often low due to the practice of finning or rough handling during gear retrieval. Although total shark catch in this region is highly uncertain due to caveats related to under-reporting and non-reporting of sharks, estimates form observer data indicate that total catches of sharks have averaged approximately 2 million sharks per year since the mid-1990s (Lawson 2011; Clarke *et al.,* 2012). Overall, with the exception of 2014, total effort in the longline fleet has increased from1995-2014 to the current effort level of approximately 800 million hooks annually; additionally, nearly half this effort occurs in the core tropical habitat area of the oceanic whitetip shark (i.e., regions 3 and 4 shown in Figure 40 below) (Rice *et al.,* 2015).

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[5] http://www.wcpfc.int/wcpfc-data-catalogue-0

[6] http://www.wcpfc.int/doc/data-01/scientific-data-be-provided-commission-revised-wcpfc4-6-7-and-9

Oceanic whitetip sharks commonly interact with the longline fisheries throughout the Pacific, with at least 20 member nations of the WCPFC recording the species in their fisheries. In this region, where sharks represent 25% of the longline fishery catch, a study from 2007 based on observer data showed that the oceanic whitetip shark was the 5th most common species of shark caught as bycatch out of a total 49 species reported by observers, and represents approximately 3% of the total shark catch (Molony 2007). In addition to being caught indirectly as bycatch, observer records indicate that some targeting of oceanic whitetip shark has occurred historically in the waters near Papua New Guinea, and given the high value of oceanic whitetip fins and low level of observer coverage, it is likely that targeting has occurred in other areas as well (Rice and Harley 2012). From 2005-2012, estimates of longline observer coverage in Pacific Island countries' tropical EEZs (10°S – 15°N) and sub-tropical EEZs (10°S – 25°S) ranged only from 0 – 2.4% per year (Clarke 2013). Longline observer coverage data is also lacking for the distant-water fleets of Japan, South Korea, and Chinese Taipei, which comprise a significant proportion of longline effort in the Western and Central Pacific Ocean (SPC 2010). Since 2009, total observer coverage in the longline fishery remains below 2% (Clarke 2013) despite the requirement for a 5% coverage minimum. However, the WCPFC requirement for 5% observer coverage in the longline fishery (established in 2012) has resulted in increased submission of observer longline data in recent years (Williams *et al*. 2015).

The WCPFC also manages the active tuna purse seine fleet in this region, which has expanded significantly since the 1980s and experienced a sharp increase in recent years. Available data suggest oceanic whitetip sharks are frequently encountered by the purse seine fleets (though not as frequently as the longline fishery), with the oceanic whitetip being the 2nd most common species of shark caught as bycatch in purse seine fisheries in this region, and representing nearly 11% of the total shark catch (Molony 2007). Since 2009, the required observer coverage in the purse seine fleet has increased to 100% (Clarke 2013); however, it should be noted that although the required observer coverage level is 100%, the actual achieved level of observer coverage is much less (Williams *et al.,* 2015). Although the oceanic whitetip shark was historically the 2nd most commonly identified shark in associated sets, this species is now rarely observed (Rice *et al*. 2015).

Catches of oceanic whitetip shark have declined significantly in both longline and purse seine fisheries. Lawson (2011) conducted statistical analyses to estimate catches of key shark species in the Western Central Pacific Ocean. In this study, oceanic whitetip shark catches in Western and Central Pacific Ocean longline and purse seine fisheries were estimated based on SPC data for longline and purse seine fleets collected by observers onboard fishing vessels (Figures 38 and 39 below).

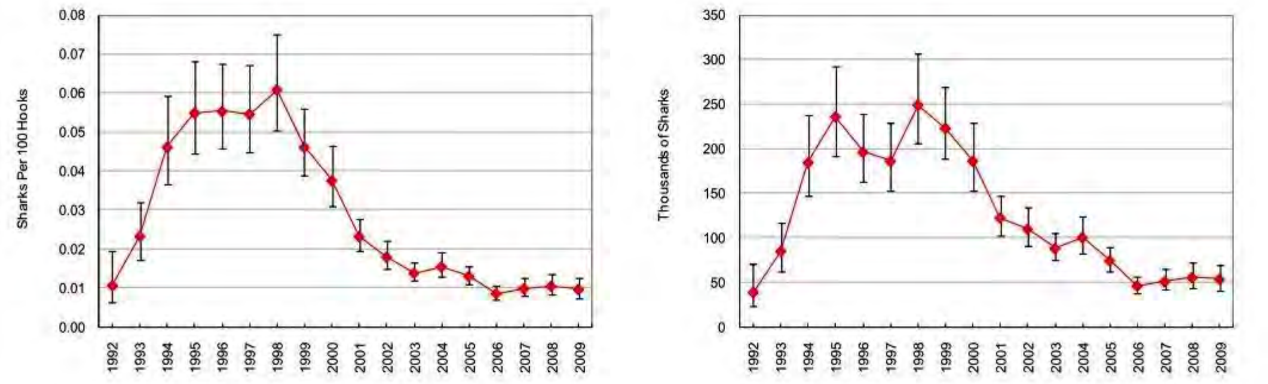


Figure 38 Estimates of longline catch rates (left) and catches (right) of oceanic whitetip sharks in the WCPFC Statistical Area east of 130°E. Source: Lawson 2011.

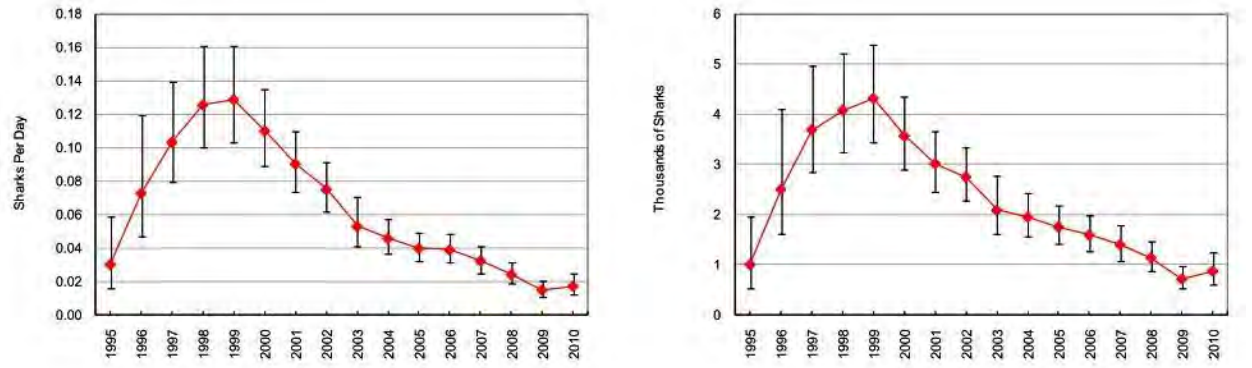


Figure 39 Estimates of purse seine catch rates (left) and catches (right) of oceanic whitetip sharks in the area from 20°S to 20°N and 130°E to 210°W. Source: Lawson 2011.

Oceanic whitetip sharks comprised 6.34% of longline shark catches and the trends in oceanic whitetip catch rates and catches by purse seiners are similar to those for longlines, and show declines from the late 1990s onwards (Lawson 2011). For example, estimated catches of oceanic whitetip shark in the WCPO longline fishery suggest that catches peaked in 1998 at ~249,000 individuals and declined to only ~53,000 individuals in 2009. However, Lawson (2011) notes that the accuracy of the estimates of catch rates shown in Figures 38 and 39 above may be affected by reporting errors early in the time series, and possibly by the targeting of sharks. It should also be noted that catches by the fleets of Indonesia and the Philippines were not included because neither observer nor effort data are available for these fleets. Further, Lawson (2011) notes the following operation changes in longline fishing that likely affected shark catch rates in the region:

- Japan longline fishing in the Australia Fishing Zone ceased in 1997.
- A trip limit for sharks was imposed in Australia in 2000.
- Shark finning was banned in Hawaii in 2000.
- The shallow set longline fishery in Hawaii was closed from 2001 to 2004.
- The use of wire traces generally has declined since 2004.
- Wire traces were banned in Australia in 2005.

Additionally, and as discussed previously, observer coverage in the Western and Central Pacific has been highly variable, ranging from negligible to moderate. Large areas in the WCPFC Statistical Area (including to the west of 130°E, the northwest and the southeast) have not been covered by observer data, which complicates catches and catch rate estimates of sharks and other non-target species. Nonetheless, longline catch estimates of oceanic whitetip sharks in the WCPFC Statistical Area east of 130°E indicate removals have been variable, with estimates fluctuating widely from ~39,000 to ~249,000 individuals, and an overall average of ~127,000 individuals from 1992-2009 (Lawson 2011). Purse seine fishery catch estimates of oceanic whitetip sharks in the WCPFC Statistical Area from 20°S to 20°N and 130°E to 210° averaged 2,267 individuals from 1995-2010 (Lawson 2011). As noted previously (and shown in Figures 38 and 39 above), both fisheries show significant declining trends in catches of oceanic whitetip shark.

Clarke *et al.,* (2011b) conducted a separate analysis of shark data from the North Pacific provided by Japan, including two comprehensive datasets: the North Pacific longline operational data from research training vessel (RTV) surveys (1992-2009; n = 32,053 sets) and commercial longline logbook (LLL) records (1993-2009; n = 1,215,299 sets). In total, 258,824 sharks were recorded in the RTV dataset of which 9,591 individuals (2-4%) were oceanic whitetip sharks (75% were blue sharks). In the LLL dataset, nearly 9.8 million sharks were recorded, with oceanic whitetip sharks comprising less than 1% of the total (Clarke *et al.,* 2011b). As oceanic whitetip sharks are found more frequently in Region 4 than in Regions 1 and 2 (see Figure 40 below), the catch rates for Region 4 are likely the most reliable. Catch rate trends from both filtered and unfiltered RTV datasets show a decline of approximately 75% from 1994-2004 (~0.4 oceanic whitetips sharks per 1,000 hooks in 1994 to ~0.1 sharks per 1,000 hooks in 2004). In contrast, filtered LLL catch rates do not show a clear trend with catch rates near zero in most years and peaks of ~0.1-0.2 oceanic whitetips per 1,000 hooks in some years (Clarke *et al*., 2011b). Overall, catches of this species were most frequently observed in the central North Pacific south of 20^{o} N latitude, but the authors note that this species also occurs in more northerly locations. Oceanic whitetips were rarely recorded after 2005, which may be indicative of a substantial decline in abundance because of overutilization. Catch rates based on RTV data showed substantial declines both north and south of 20^{o} N latitude (Regions 2 and 4) and there was some evidence for a trend of decreasing size of both males and females in recent years (Clarke *et al.,* 2011b).

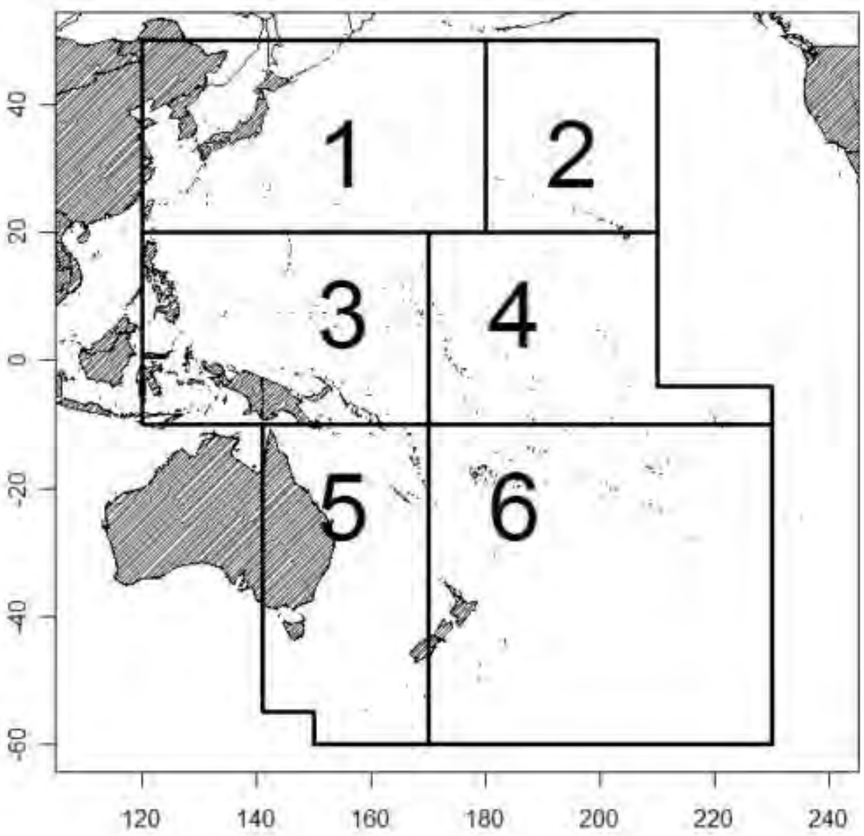
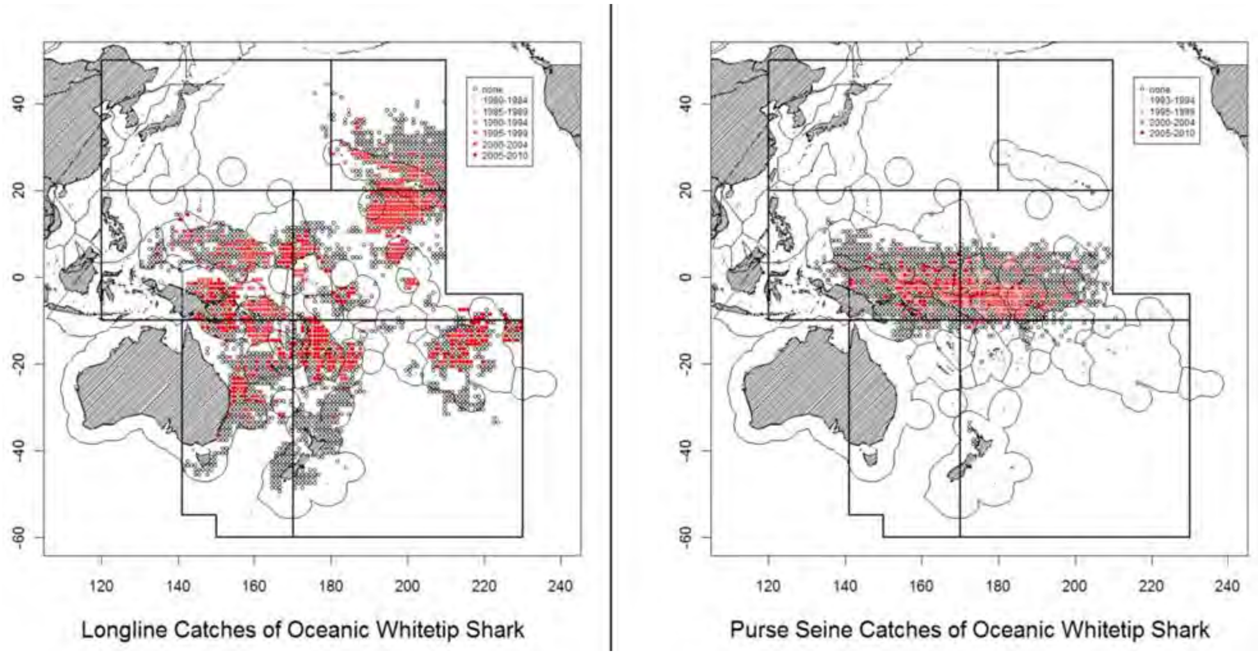


Figure 40 Regional boundaries based on analysis of coverage patterns in the RTV and LLL data sets. Source: Clarke *et al.* 2011b.

Clarke *et al.,* (2011a) conducted an indicator-based analysis to determine the stock status of key shark species in the Western and Central Pacific Ocean by examining data from the SPC–Oceanic Fisheries Programme for sharks taken in longline and purse seine fisheries. However, the authors listed several caveats related to the datasets used in this indicator-based analysis. For example, longline logsheet data only cover ≤35% of the fishery, with major gaps in coverage for certain areas. Non-reporting, under-reporting, and/or lack of species-specific reporting also hinders the data. Further, low levels of observer data coverage (i.e., typically <1%) are not representative of the entire WCPO longline fishery as a whole;

Given the major limitations of logsheet data, the indicator analyses relied primarily on observer data. These data formed the basis for an assessment of a number of shark status indicators in four main classes: range based on fishery interactions, catch composition, catch rates and biological indicators of fishing pressure (e.g., median size, sex ratio). Based on fishery interaction maps (see Figure 41 below; Clarke *et al*., 2011a), the oceanic whitetip shark is found throughout WCPO between 30° N and S latitude, and, as noted previously, is also commonly encountered in the purse seine fishery, particularly in areas just south of the equator.



Longline Catches of Oceanic Whitetip Shark

Purse Seine Catches of Oceanic Whitetip Shark

Figure 41 Fishery interaction maps for oceanic whitetip sharks based on observer records from the WCPO longline (1980-2010) and purse seine fisheries (1993-2010). Colored circles represent positive catches (points are shaded by year with more recent catches in the darkest shades) and empty circles represent zero catch. Source: Clarke *et al.* 2011a.

Based on nominal and standardized catch rates for longline and purse seine fisheries, records of oceanic whitetip sharks in both fisheries have become increasingly rare over time. In fact, standardized catch rates for longline observer data shows a clear, steep decline in abundance. Median size showed a declining trend for both sexes in both fisheries and in all regions until samples became too rare for analysis. These trends were significant in the core tropical habitat areas (Clarke *et al*., 2011a; see Figure 42 below).

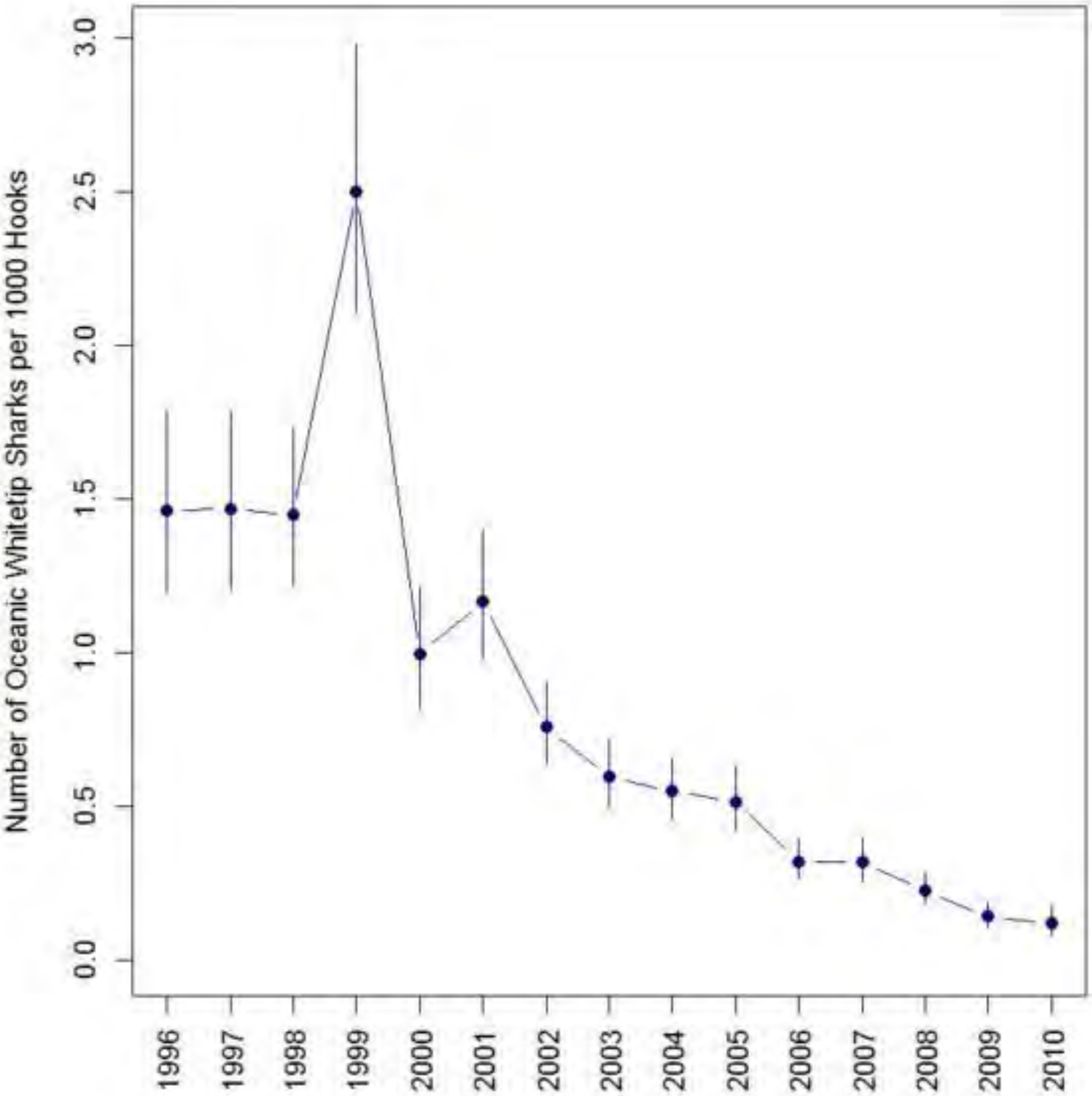


Figure 42 Catch rates for oceanic whitetip sharks in the WCPO standardized using a quasi-Poisson formulation of a generalized linear model. Source: Clarke *et al.,* (2011a).

In fact, annual values in recent years have decreased to one-tenth of those observed in 1996-1998 with minimal uncertainty in the estimates (Clarke *et al.,* 2012). Similar patterns are suggested by nominal catch rates in the purse seine fishery and standardized purse seine catch rates in Lawson (2011); refer back to Figure 39 above).

Finally, the previously discussed stock assessment of oceanic whitetip shark in the Western and Central Pacific (which used the same data as discussed previously in Clarke *et al.,* (2011a) and Clarke *et al*. 2012) analyzed fisheries data from 1995-2009, and determined that the greatest impact on the species is attributed to bycatch from the longline fishery, with less significant impacts from target longline activities and purse-seining (Rice and Harley 2012). From 1995 to 2009, rates of fishing mortality increased consistently, which was driven mainly by increased effort in the longline fleet over the same time period, and remained substantially above the maximum sustainable yield (MSY) (i.e., the point at which there would be an equilibrium) for the species (Rice and Harley 2012). In fact, the stock assessment concluded that fishing mortality on oceanic whitetip sharks in the Western and Central Pacific has increased to levels 6.5 times what is sustainable, thus concluding that overfishing is still occurring. Given that fishing pressure began well before the start of this time series, the authors of the stock assessment noted that it was not assumed that the oceanic whitetip population was at an unfished state of equilibrium at the start of the model (i.e., 1995). Thus, the reported declines (i.e., 86% since 1995) do not reflect total historical population declines for the species in this region. Further, this study does not include removals of oceanic whitetip sharks from Indonesia and the Philippines, which are two major shark catching nations in this region. As previously discussed, a recent study concluded that oceanic whitetip not only continue to decline throughout the tropical waters of the Western and Central Pacific Ocean, but even if the population doubled since the stock assessment, it would still be considered overfished (Rice *et al.,* 2015).

Due to continued and increasing fishing pressure in the Western and Central Pacific, size trends for oceanic whitetip have also declined, which is indicative of overutilization of the species. For example, declining median size trends were observed in all regions and sexes in both longline and purse seine fisheries until samples became too scarce for analysis in the study. These size trends were significant for females in the longline fishery (in Regions 3 and 4), and for the purse seine fishery (in Region 3), which represents the species' core tropical habitat areas (Clarke *et al.,* 2011a). This is particularly concerning due to the potential correlation between maternal length and litter size, which has been documented in the Atlantic and Indian Oceans (Bass *et al.,* 1973; Lessa *et al.,* 1999; Bonfil *et al.,* 2008; Varghese *et al.,* 2016). While Rice *et al*. (2015) more recently report that trends in oceanic whitetip median length are stable, the majority of sharks observed are immature. Likewise, since 2000, 100% of oceanic whitetips sampled in the purse seine fisheries have been immature (Clarke *et al.,* 2012).

In the U.S. Pacific, the oceanic whitetip shark was historically a common bycatch species in the Hawaii-based pelagic longline (PLL) fishery and comprised approximately 3% of the total shark catch from 1995-2006 (Brodziak *et al.,* 2013). This fishery began around 1917, and underwent significant expansion in the late 1980s to become the largest fishery in the state (Boggs and Ito 1993). This fishery currently targets tunas and billfishes and is managed under the auspices of the Western Pacific Fishery Management Council (WPFMC). Of all fisheries managed under the Fishery Ecosystem Plan (FEP) for Pelagic Fisheries of the Western Pacific Region Ecosystem Plan, the Hawaii-based longline fishery is the largest, accounting for the majority of Hawaii's commercial pelagic landings, with 26 million lbs (~12 million kg) resulting in revenue exceeding $92 million in 2012 (WPFMC 2012). An observer program for the Hawaii-based PLL was initiated in 1994, with an observer coverage rate ranging between 3% and 10% from 1994-2000, and increased to a minimum of 20% in 2001. The deep-set fishery targeting tuna is currently observed at a minimum of 20% and the shallow-set fishery targeting swordfish has 100% observer coverage. The Hawaii-based pelagic longline fishery is a limited entry fishery with a maximum of 164 permits available. Current participation is about 125 vessels which target a range of pelagic species.

Catch data compiled from the Hawaii-based logbook annual summary reports also show a declining trend for oceanic whitetip sharks since 2000, with an uptick in the last year (oceanic whitetip sharks were not tallied separately in fisheries logbooks prior to 2000; see Figure 43 below).

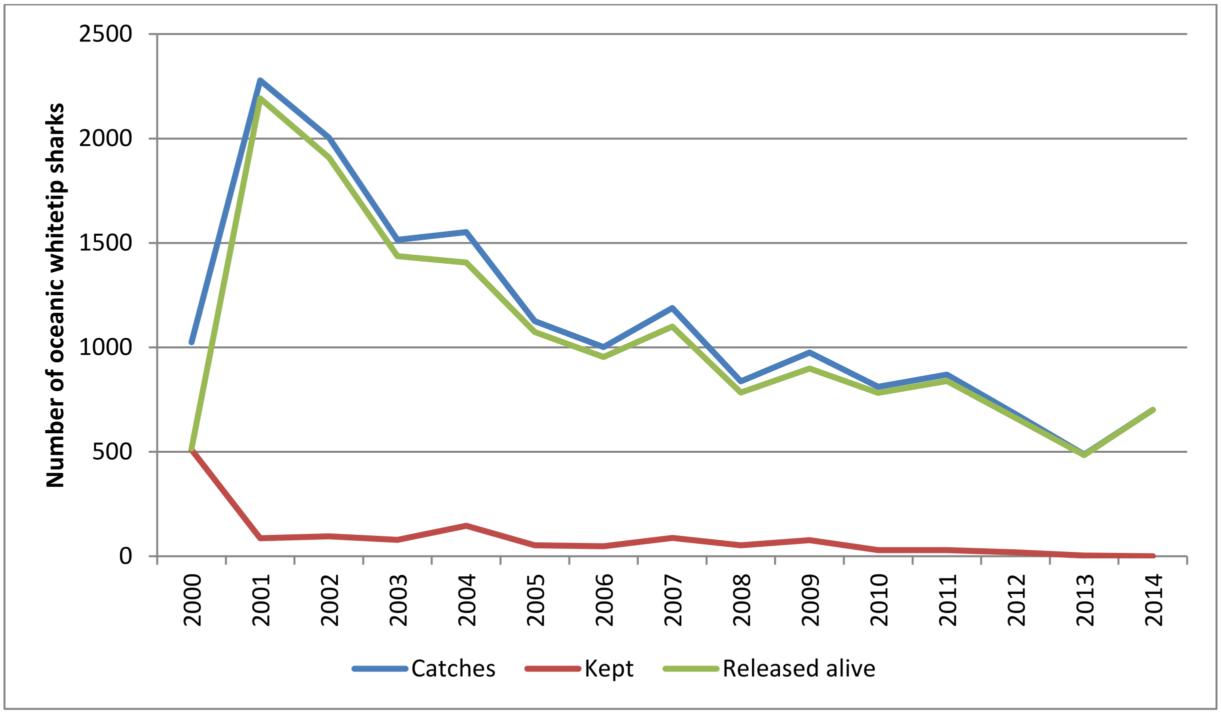


Figure 43 Summary of Pacific Islands Fishery Science Center (PIFSC) fishery logbook reports of oceanic whitetip catches from 2000-2014. Source: NMFS PIFSC[7].

Annual bycatch of approximately 58,402lbs (26.5 mt) and 38,640.lbs (17.5 mt) of oceanic whitetip were estimated for the Hawaii-based deep-set and shallow-set longline fisheries, respectively, based on data from 2005 (NMFS 2011a). Overall, oceanic whitetip sharks were generally not landed or rarely landed in the Pacific Islands region. In the updated report (NMFS 2013), total annual bycatch estimates included 47,553 lbs (21.6 mt) of oceanic whitetip, based on data from 2010. Thus, it appears that overall bycatch estimates have decreased for oceanic whitetip sharks in 2010 compared to 2005, which also coincides with the declines in relative abundance over this same time period. Brodziak *et al*. (2013) concluded that the relative abundance of oceanic whitetip (discussed previously in the *Regional Abundance Trends* section) declined within a few years of the expansion of the longline fishery, which suggests these fisheries are contributing to the commercial overutilization of oceanic whitetip within this portion of its range. It should be noted that the majority of oceanic whitetip sharks are now released alive in this fishery, with the number of individuals kept on a declining trend. Based on fishery logbook data, a total of 701 oceanic whitetip sharks were caught in 2014 and 100% were released. In addition, the U.S. National Bycatch Report First Edition Update 2[8] estimated weight of species caught by the Hawaii-based commercial longline fisheries. These data show that from 2011 to 2013, the shallow-set fishery released an estimated 91-96% of all oceanic whitetip sharks caught alive. During the same time period, the deep-set fishery released an estimated 78-82% of all oceanic whitetip sharks caught alive. However, it is unknown how many of these

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[7] http://www.pifsc.noaa.gov/fmb/reports.php

[8] https://www.st.nmfs.noaa.gov/observer-home/first-edition-update-2

sharks survived after being released. Nonetheless, this particular fishery may be less of a threat to the oceanic whitetip shark in the foreseeable future.

Oceanic whitetip sharks are also caught as bycatch in the American Samoa longline fishery. The American Samoa longline fishery targets albacore tuna and is managed under the Pacific Pelagic FEP. This fishery has had an observer program since 2006, with coverage ranging between 6-8% from 2006-2009, and between 19-33% since 2010. Based on logbook longline summary reports from American Samoa, unstandardized (i.e., nominal) CPUE and catches of oceanic whitetip sharks have trended downward until about 2009, at which point the trend appears to have potentially stabilized (Figure 44). It should be noted that this data is based on nominal catches recorded in fisheries logbooks and may not be reliable.

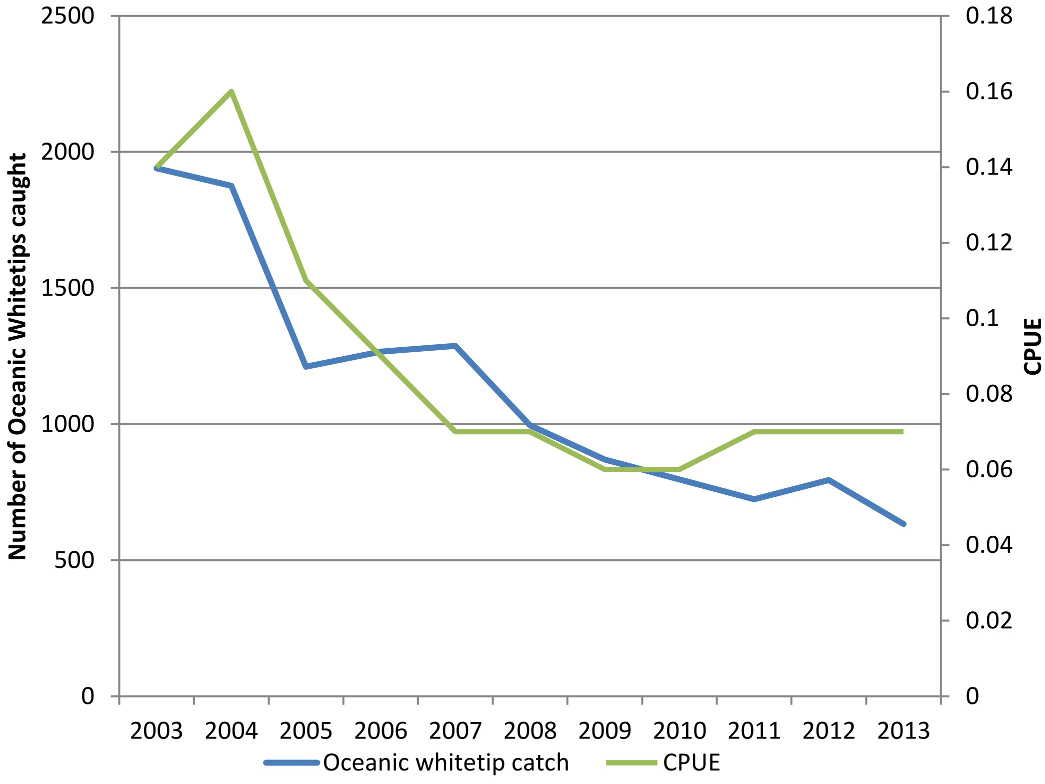

Figure 44 Summary report of unstandardized fishing effort and catch statistics for U.S. longline vessels landing in American Samoa from 2003-2013, compiled from PIFSC Annual Summary Reports as derived from NMFS Western Pacific Daily Longline Fishing Log records. Source: PIFSC American Samoa Longline fishery logbook summary reports[9].

While landings of sharks in general have declined in American Samoa, this trend is largely attributed to regulations pertaining to shark finning (e.g., the Shark Finning Prohibition Act) (NMFS 2011c).

Australia

Several studies have been conducted to assess the ecological risk of species in various fisheries throughout Australia. While oceanic whitetip sharks are known from Australian waters and are

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[9] http://www.pifsc.noaa.gov/fmb/reports/american_samoa/longline_logbook_summary.php

known bycatch in two major fisheries (the Eastern and Western Tuna and Billfish fisheries), they have only been assessed in the Eastern Tuna and Billfish fishery (ETBF). The oceanic whitetip shark is listed as a bycatch species in the ETBF, which operates from the eastern part of the Australian Fishing Zone (AFZ) from the tip of Cape York (142º31’49”E) to the South Australian/Victorian border (141ºE). It includes Commonwealth waters off Queensland, New South Wales, Victoria and Tasmania out to the 200 nmi limit of the AFZ and includes waters around Norfolk Island. The ETBF consists of three main fishing methods (longlining, poling and minor line), of which the most common method is pelagic longlining. A 2009 Shark Assessment Report shows that oceanic whitetip is a prominent species in the Eastern ETBF, with estimated discard rates of up to 77% (Bensley *et al.,* 2010), although no other information was provided. In 2007, an Ecological Risk Assessment (ERA) was conducted for oceanic whitetip in the ETBF. In the ERA, average annual logbook catch of oceanic whitetip was 17,199 kg (17.2 mt) from 2001-2004. The ERA used typical productivity and sensitivity attributes to derive an overall vulnerability score and risk category to overfishing. In this study, oceanic whitetip received a vulnerability score of 2.95 (range for all scores = 1.41 to 4.24) and an overall medium risk ranking to overfishing (Webb *et al.,* 2007). For reference, a medium risk ranking means that overfishing is occurring but the population can be sustainable. In general, catches of oceanic whitetip sharks in Australia have seen a decline from over 25 t in 2002 to less than 5 t in 2012 (Figure 45 below).

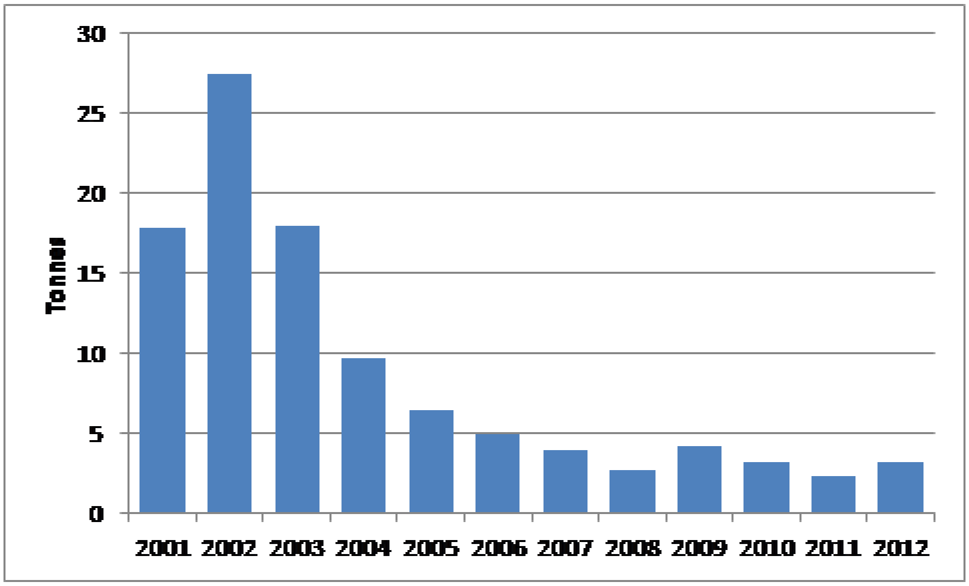

Figure 45 Annual catches (t) of oceanic whitetip shark in Australia from 2001 to 2012. Source: Koopman and Knuckey 2014.

However, this decline in catch has been largely attributed to the implementation of stricter management and regulations (e.g., ban on wire traces, trip/trigger limits, ban on shark finning, carriage of line cutters) and a decrease in effort in both the ETBF and the Western Tuna and Billfish Fishery (WTBF) (Koopman and Knuckey 2014). In accordance with conservation and management measures agreed by the WCPFC and IOTC, retention of oceanic whitetip shark is prohibited in the Commonwealth ETBF and WTBF, the two fisheries most likely to encounter the oceanic whitetip shark (Australia Department of the Environment 2014). Although small numbers of oceanic whitetip shark are possibly caught in state managed fisheries operating far offshore, the total Australian catch of oceanic whitetip shark is estimated to be less than 5 t per year (Koopman and Knuckey 2014). There is also reported take in IUU fishing in Australian waters, with the oceanic whitetip comprising an estimated 5.9% (in numbers, 3.6% in biomass) of the catch by foreign IUU operations (Simpfendorfer 2014). The estimated take by Indonesian based IUU operators in 2006 was about 700 t, and has declined since. As such, current catches in IUU fisheries are probably minimal in Australian waters (Simpfendorfer 2014).

New Zealand

Oceanic whitetip sharks are rarely caught in fisheries operating in New Zealand waters. In a government study aimed at documenting and describing oceanic whitetip shark interactions with commercial fisheries, only 19 observer and two commercial fishery records were located (one of which occurred in both datasets) from 2008-2014. All records came from surface longlines set in the Kermadec Fisheries Management Area (FMA) or off the northeastern coast of the North Island (Francis and Lyon 2014). Catches of oceanic whitetip shark around the North occurred in warmer months of the year whereas catches in the Kermadec FMA occurred primarily in cooler months. Most (84%) of the observed sharks were alive when hauled to the vessel; approximately half were processed in some way with the remainder being discarded. Although few of the observed sharks were sexed or measured, there was an equal number of males and females, with fork lengths ranging between 158 and 190 cm. Given the low commercial reporting rate (only 1 out of 19 observed sharks are actually reported) and the low observer coverage of domestic surface longliners (< 9% up to 2009-2010), Francis and Lyon (2014) estimate that the actual interaction of the surface longline fisheries with oceanic whitetips is substantially underestimated. Nevertheless, the study concluded that oceanic whitetips are not frequently caught in New Zealand, and are therefore not regarded as a high priority species for research or management (Francis and Lyon 2014).

Pacific Island Countries and Territories

Approximately 25% and 45% of longline and purse seine catches, respectively, that occur in the WCPFC Convention Area are taken in the Pacific Islands Countries and Territories (PICT). Observer data for longline fisheries in the PICTs reveal that the 12 highest risk shark species, including oceanic whitetip, comprise less than 15% of the observed shark catch (Lack and Meere 2009). According to a 2009 Regional Shark Assessment, oceanic whitetip sharks have been observed in longline and purse seine fisheries within PICT waters, with oceanic whitetip comprising 6% of the total shark catch in both fisheries (Lack and Meere 2009). In the Pacific Islands Regional Plan of Action for sharks, the oceanic whitetip shark consistently ranked in the top ten shark species identified by observers in PICT longline fisheries, including the Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, New Caledonia, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu, and Vanuatu (Lack and Meere 2009). At the time of the assessment, oceanic whitetip sharks experienced various finning and discard rates throughout PICT waters, ranging from 51% and 68% in the tropical shallow and deep longline fisheries, respectively, to 76% in the tropical albacore fishery (Lack and Meere 2009). It should be noted that this study is several years old and may not represent the current situation.

In the Republic of the Marshall Islands (RMI), average annual catches of sharks are estimated to be between 1,583 and 2,274 mt. The oceanic whitetip is one of only five species that comprises 80% of the total annual shark catch in the RMI. In an analysis of aggregated observer data from RMI and Chinese fleets from 2005-2009, Bromhead *et al.,* (2012) report a CPUE rate (fish/1000 hooks) for oceanic whitetip of 0.2904 in RMI longline fisheries. In these fisheries, oceanic whitetip exhibits a relatively high at-vessel survival rate of approximately 70% (n = 917). However, 97.4% of oceanic whitetips caught in these fisheries were finned and discarded. The RMI prohibited all shark take in late 2011; therefore, the Bromhead *et al.,* (2012) study may not be representative of the current situation.

Oceanic whitetip sharks are also caught as bycatch in the Fijian longline fishery. According to data provided by the Fiji Department of Fisheries, which includes longline sets targeting both tunas and sharks, for the period 2011–2012, 17 oceanic whitetips were captured and discarded after finning (Piovano and Gilman 2016). In 2013, 62 oceanic whitetips were captured, of which 13% were retained, 60% were discarded after finning, 8% were discarded dead and 19% were released alive. Of the 30 oceanic whitetip sharks captured in 2014, 7% were retained, 3% were discarded after finning, 27% were discarded dead and 63% released alive (Piovano and Gilman 2016). This indicates that Fiji did not immediately implement the WCPFC no-retention rule for oceanic whitetip.

Taiwan

Taiwan's fleet has the 4th largest shark catch in the world, with a declared 6 million sharks caught annually, accounting for almost 6% of the global figures. However, these numbers could be greatly underestimated (Liu *et al*. 2013). Although the oceanic whitetip shark is considered to be one of the dominant shark species in Taiwanese landings, it only comprises an average of 0.38% of the sharks landed. Between 1996 and 2006, annual Taiwanese shark landings (coastal, offshore, and pelagic combined) averaged between 39,000 and 55,000 mt. A genetic barcoding study was conducted in 2013 on shark meats from various Taiwan fish markets to determine which species may be vulnerable to high rates of utilization. Amongst the 548 tissue samples collected and sequenced, approximately 80% of the species composition was dominated by four species (*A.pelagicus*, *C. falciformis*, *Isurus oxyrinchus*, and *P. glauca*) indicating that these species might be heavily consumed in Taiwan. Oceanic whitetip sharks were also identified in the shark meat samples, although they comprised a very small percentage of the samples at 0.016% (Liu *et al.,* 2013).

Western and Central Pacific Summary

Based on the best available historical and current information, it appears that the once ubiquitous oceanic whitetip shark has experienced significant and ongoing declines in the Western and Central Pacific Ocean because of unsustainable fishing mortality in both longline and purse seine fisheries operating in the species' core tropical habitat area. Numerous lines of evidence, including a recent stock assessment report and other analyses of species-specific fisheries data, indicate that oceanic whitetip shark abundance has declined across the region, with declines in excess of 90% in some areas, and declining trends in overall biomass and size indices as well. Similar results between analyses of observer data from the Western and Central Pacific SPC observer data and the observer data from the Hawaii-based pelagic longline fishery suggest that the population decline of oceanic whitetip in this portion of its range is not just a localized trend, but rather a Pacific-wide phenomenon. The significant declining trends observed in all available abundance indices (*e.g.,* standardized CPUE, biomass and median size) of oceanic whitetips as a result of fishing mortality in both longline and purse seine fisheries indicate that overutilization of the species is likely occurring throughout the Western and Central Pacific. Given the impacts to the species from significant fishing pressure in this portion of the species' range, with the majority of effort concentrated in the species' core tropical habitat area, and the species' relatively low-moderate productivity, it is likely that the oceanic whitetip shark is experiencing overutilization in this portion of its range.

ATLANTIC OCEAN

Northwest and Western Central Atlantic and Gulf of Mexico

Like the Pacific, the oceanic whitetip shark was once described as the most common pelagic shark throughout the warm-temperate and tropical waters in the Atlantic and beyond the continental shelf in the Gulf of Mexico. The species is caught incidentally as bycatch by a number of fisheries, including the U.S. pelagic longline (PLL) fishery, Cuban longline fishery, Mexican longline, and has been recently recorded in the oceanic industrial longline fishery in the Colombian Caribbean (CITES 2013). An ERA was conducted in 2008 by the ICCAT Standing Committee on Research and Statistics (SCRS) for shark and ray species typically taken in Atlantic pelagic longline fisheries. This ERA categorized the relative risk of overexploitation of the 11 major species of pelagic sharks, including oceanic whitetip sharks, and derived an overall vulnerability ranking for each of the species, defined as "a measure of the extent to which the impact of a fishery on a species will exceed its biological ability to renew itself." The oceanic whitetip shark ranked 5th most susceptible to pelagic fisheries among 11 other Atlantic Ocean species (Cortés 2008a; Cortés *et al.,* 2010). In an update and expansion of the SCRS ERA, the oceanic whitetip shark was found to be a moderately productive species that shows varying levels of susceptibility to the combined pelagic longline fisheries in the Atlantic Ocean, and ranked 8th most vulnerable out of 20 stocks of pelagic sharks (Cortés *et al.,* 2012). In contrast, another recent study determined that oceanic whitetip sharks have relatively low vulnerability to Atlantic fisheries. Gallagher *et al.,* (2014) found the oceanic whitetip shark to be one of the least vulnerable species to longline bycatch mortality, as a result of the species' "combined relatively high fecundity and productivity, moderate age of maturity ranking, and high mean survival rate when caught" (i.e., 77.3%; Gallagher *et al*. 2014). However, it should be noted that the age at maturity used in this study was based on a combination of estimates from the Atlantic and Pacific (i.e., 5.5 years) and was prior to the new estimate from the Pacific of 8.8-8.9 years. Additionally, the high rate of mean survival noted in Gallagher *et al* (2014) refers to the immediate at-haulback mortality and does not account for unknown post-release mortality rates. Thus, the relative vulnerability of oceanic whitetip shark to Atlantic longline fisheries is somewhat unclear. While the oceanic whitetip shark's life history does not make it as vulnerable as other shark species, the species' susceptibility to capture in longline fisheries is likely the main reason for its increased vulnerability overall.

In the United States, oceanic whitetips were caught historically as bycatch in PLL fisheries targeting tuna and swordfish in this region. Although an estimated 8,526 individuals were recorded as captured in U.S. fisheries logbooks from 1992 to 2000 (Baum *et al.,* 2003), pelagic longlining for Atlantic Highly Migratory Species (HMS) began on the East Coast of the U.S. and Atlantic Canada in the early 1960s, with this gear primarily used to target swordfish, yellowfin tuna, and bigeye tuna in various areas and seasons. Secondary target species include dolphin fish, albacore tuna, and to a lesser degree, sharks. The U.S. PLL fishery has been historically comprised of five relatively distinct segments with various fishing practices and strategies. These segments are: 1) the Gulf of Mexico yellowfin tuna fishery; 2) the South Atlantic-Florida east coast to Cape Hatteras swordfish fishery; 3) the Mid-Atlantic and New England swordfish and bigeye tuna fishery; 4) the U.S. distant water swordfish fishery; and 5) the Caribbean Islands tuna and swordfish fishery (NMFS 2008). There are many PLL gear and area restrictions and the fishery is strictly monitored.

Relative to target species, oceanic whitetip sharks are caught infrequently and only incidentally on PLL vessels fishing for tuna and tuna-like species. Landings and dead discards of sharks by U.S. PLL fishers in the Atlantic are monitored every year and reported to the International Commission for the Conservation of Atlantic Tunas (ICCAT). Overall, very few oceanic whitetip sharks have been landed by the commercial fishery, except for two peaks of about 1,250 and 1,800 fish in 1983 and 1998, respectively. Otherwise, total catches never exceeded 450 fish (NMFS 2009b). From 1992-2000, elasmobranchs represented 15% of the total catch in numbers by the PLL fishery, with oceanic whitetip comprising 2.8% of the shark bycatch (Beerkircher *et al.,* 2002). Observer data from the NMFS Pelagic Observer Program recorded 912 oceanic whitetip sharks caught on U.S. PLL gear between 1992 and 2015. The following table (Table 2) shows Atlantic domestic commercial landings of oceanic whitetip sharks, which were compiled from the most recent stock assessment documents.

Table 2 Commercial landings of Atlantic oceanic whitetip sharks (lbs, dressed weight) from 2003-2013. Source: (NMFS 2012; 2014; 2017)

2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
2,559	1,082	713	354	787	1,899	933	769	2,435	258	62	22	0

*Consistent with ICCAT Recommendation 10-07, retention of oceanic whitetip was prohibited for U.S. Atlantic fishermen with pelagic longline gear onboard as of 2011.

Commercial landings of oceanic whitetip sharks in the U.S. Atlantic have been variable, but averaged approximately 1,077.4 lbs (488.7 kg; 0.4887 mt) per year from 2003-2013. Although oceanic whitetip sharks have been prohibited in fisheries with pelagic longline gear onboard since 2011, they can still be caught as bycatch, caught with other gears, and are occasionally landed. However, since the ICCAT retention prohibition was implemented in 2011, estimated commercial landings of oceanic whitetip declined from 1.1 mt in 2011 to only 0.03 mt in 2013 (NMFS 2012; 2014). In 2013, NMFS reported a total of 33 oceanic whitetip interactions to ICCAT, with 88% released alive. Oceanic whitetips are also infrequently caught in buoy gear for swordfish; however, these interactions are relatively minimal, with 11 individuals caught from 2009-2015 (NMFS 2017).

In addition to information from the United States, international fisheries information and catch data for the Atlantic are available from ICCAT. The ICCAT is the RFMO responsible for the conservation of tunas and tuna-like species in the Atlantic Ocean and adjacent seas. Reported catches of oceanic whitetip sharks from ICCAT vessels in the Atlantic are shown below in Figures 46 and 47 (Figure 46 is the same as Figure 47 minus data from Brazil to show the differing scales). Oceanic whitetip sharks are taken in the ICCAT convention area by longlines, purse seine nets, gillnets, trawls, and handlines; however, the large majority of the catch from 1990-2014 was caught by longline gear.

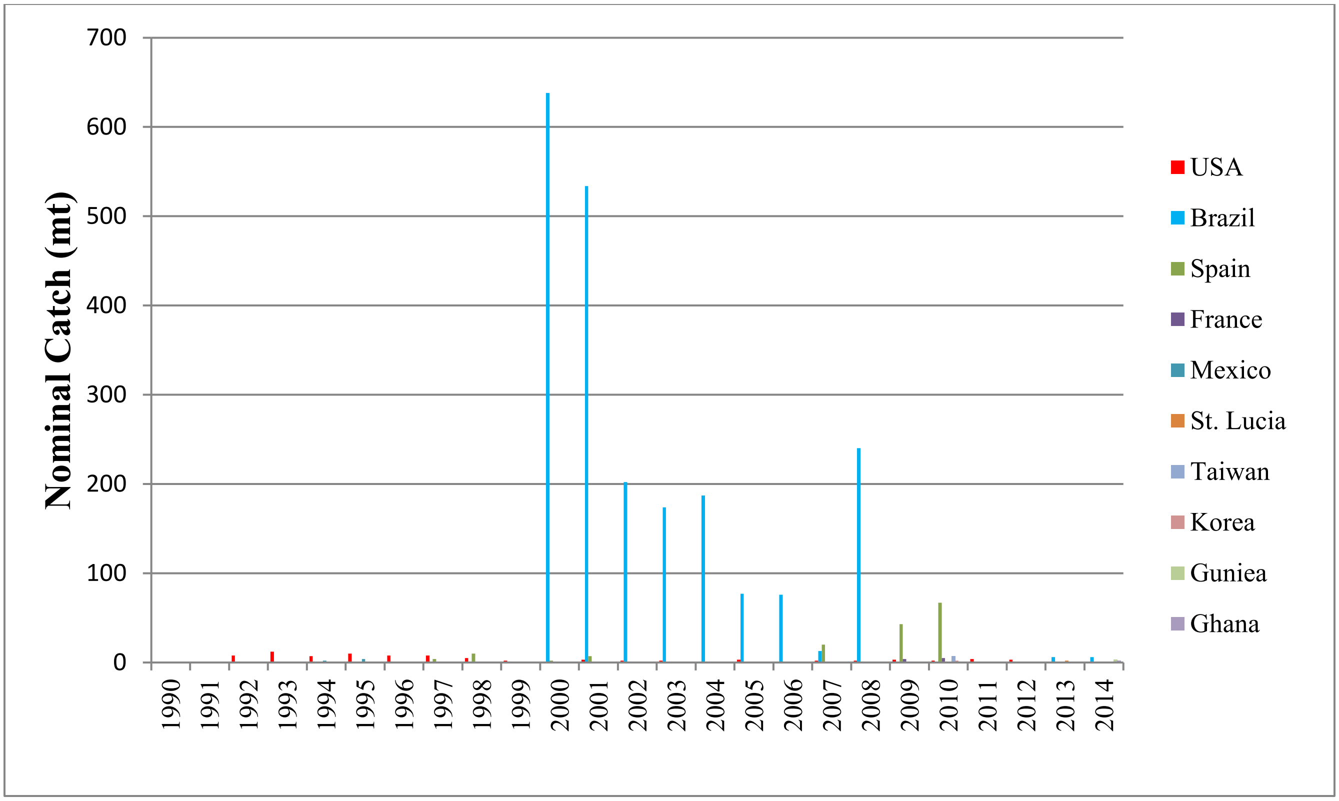

Figure 46 Nominal catches (mt) of oceanic whitetip reported to ICCAT by CPC vessel flag from 1990-2014. Source: ICCAT nominal catch information: Task I web-based application; accessed January 28, 2016.

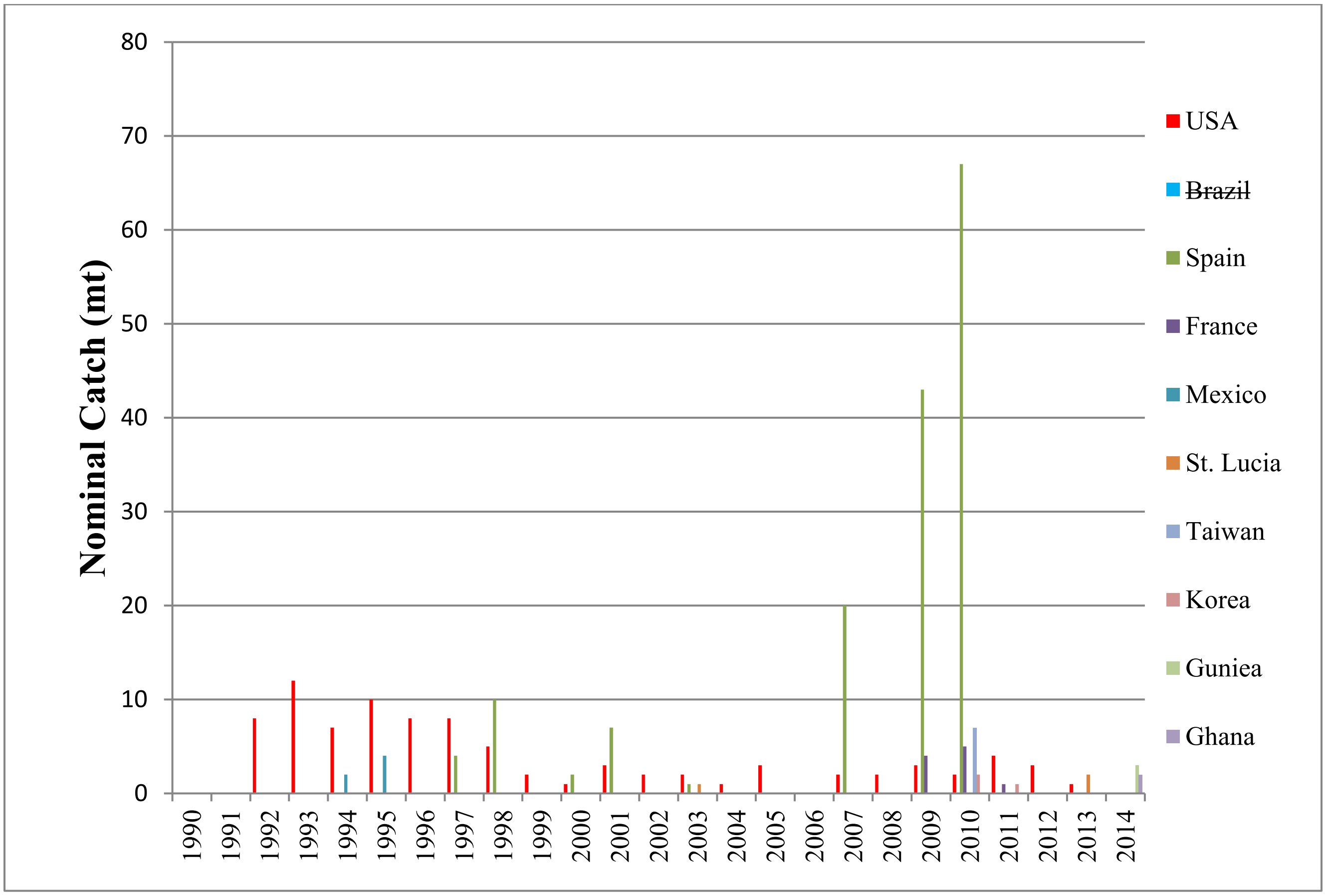

Figure 47 Nominal catches (mt) of oceanic whitetip reported to ICCAT by CPC vessel flag (except Brazil) from 1990-2014. Source: ICCAT nominal catch information: Task I web-based application; accessed January 28, 2016.

In total, approximately 2,430 mt of oceanic whitetip catches were reported to ICCAT from 1990-2014, with approximately 89% of the total catch (n = 2,153 mt) caught by the Brazilian fleet. While catches reported to ICCAT by some countries (e.g., Spain) declined after the implementation of Recommendation 10-07 (which prohibits the retention of oceanic whitetip shark in ICCAT fisheries), significant declines in Brazil's catches occurred prior to Recommendation 10-07 (see South Atlantic section below for more details), and the species is still caught as bycatch. In fact, ICCAT vessels reported catching a total of 29 mt of oceanic whitetip for years 2011-2014, which is after the prohibition was implemented. Only 3 countries reported catching oceanic whitetip sharks in 2014 (Brazil, Guinea and Ghana).

Cuba

Although shark fishing in Cuba most likely commenced at the beginning of the 20th Century, the first official records were not made until 1959 (Cuba NPOA-Sharks 2015). A historical time series on shark production in Cuban waters from 1959–2014 shows a period of growth between 1959 and 1981, with peak production occurring in 1981 of 2,644t (CUBA NPOA-Sharks 2015). In general, shark fishing reached its maximum levels during the first half of the 1980s, with average production of 2,482t from 1980-1985, after which catches showed an unstable but consistently declining trend to a minimal level of 869t in 1993. After another peak of 1,918t produced in 1997, production once again declined to 546t and 541t in 2004 and 2005, respectively. Finally, following a peak of 900t in 2008, production contracted to 469.5t and 487.5t in 2012 and 2013, respectively, and slightly increased in 2014 to 533.6t (Cuba NPOA-Sharks 2015).

According to data from the 1960s, the oceanic whitetip once represented the highest percentage of shark catches in northwestern Cuba by weight (25.4%; Guitart 1975 cited in Cuba Department of Fisheries, 2016). As previously noted, shark catches in Cuba increased until 1981 and have been variable since. Since 1985, a substantial decline was observed in some species, including oceanic whitetip. Variations in fishing effort and changes in the fishery make it difficult to assess the current status of sharks in Cuba, but since 1981 there has been a tendency towards decline (Claro *et al.,* 2001). More recently, Cuba's Department of Fisheries, Fisheries Research Center, determined that the percentage of landings of oceanic whitetip shark relative to that of other shark species has declined from 1963 to 2011 in the northwestern region of Cuba. In a study conducted on the private commercial fishing base of Cojimar during the winter (October-March) between 2008 and 2010, a single oceanic whitetip shark was observed in the samples, which represented 2% of the shark landings with drift longline at night (Cuba Department of Fisheries 2016). In another study on the same base, oceanic whitetip shark landings accounted for 5% of landings of sharks with drift longline with two sampled individuals from October 2010 to May 2011. However, Aguilar *et al.,* (2014) states that a direct comparison between the two time periods can't be made with respect to the relative order of abundance. In the historical reports, relative abundance is given by weight (kg) of landings whereas more recent monitoring results refer to number of individuals. Aguilar *et al*. (2014) also concluded that it is difficult to make a comparative analysis of the shark fishery in these two periods, because the economic crisis in Cuba has had an impact on fishing activity that cannot be adequately measured, and thus it is unknown whether and to what extent fishing effort has declined over time. For these reasons, the available information at this time does not allow for a definitive determination as to why shark catches are currently lower than what was historically reported (Aguilar *et al*. 2014).

In contrast, Valdés *et al.,* (2016) show a stable abundance trend for the oceanic whitetip shark in Cuban fishery landings along the northwestern coast from 2010 to 2016. The authors noted that their findings are consistent with Guitart (1975) who, as previously noted, reported the oceanic whitetip shark as the most abundant species in Northwest Cuba landings in the 1960s. However, the authors noted that the fishery-dependent results are preliminary and should be interpreted with caution. Nonetheless, when sharks are caught in the fishery, they are never discarded but rather utilized for either human consumption or bait. Additionally, in all the aforementioned studies, the majority of oceanic whitetip sharks caught have been juveniles. Valdez *et al*. (2016) concluded that: "the prevalence of small, immature individuals suggests the possibility of an important nursery area for this species in the Northwestern Atlantic region. Because these animals are small and of less value to the fishermen, they are typically using the juvenile *C. longimanus* as bait while at sea, a practice which may be in conflict with sustainable fisheries management and conservation objectives." Given the foregoing information, it is unclear whether the oceanic whitetip shark has declined significantly in Cuban waters; however, the ongoing retention and utilization of immature individuals as bait is concerning and may be contributing to overutilization of the species.

Northwest and Central Atlantic Summary

As previously discussed in the *Regional Population Trends* section of this status review, abundance trend estimates derived from standardized catch rate indices of the U.S. PLL fishery suggest that the oceanic whitetip shark has undergone significant historical declines in abundance in the Northwest Atlantic, likely due to of fishing mortality. Logbook data indicates that the oceanic whitetip population declined sharply from 1986-2000 by approximately 70% in the Northwest and Central Atlantic, and up to 88% in the Gulf of Mexico; however, the claim of such drastic declines was criticized for a lack of understanding of logbook data (Burgess *et al.,* 2005b; Burgess *et al.,* 2005a), and a less pronounced trend (i.e., 9%) in observer data was found, indicating uncertainty in the magnitude of decline of the Atlantic oceanic whitetip population. Given that observer data are generally considered a more reliable indicator of population abundance trends for bycatch species such as sharks, oceanic whitetip abundance may have stabilized in the Northwest Atlantic since 2000 and in the Gulf of Mexico and Caribbean since the late 1990s. Despite historical abundance declines, recent data from the U.S. PLL fishery indicate that landings of oceanic whitetip shark have declined over time and are currently low, particularly since regulations were implemented that prohibit retention of the species in ICCAT associated fisheries in 2011. Whether overutilization is occurring in other fisheries of the Northwest Atlantic (e.g., Cuba) is uncertain at this time, though the reported practice of using small immature individuals as bait is concerning. Given the oceanic whitetip shark appears to have a relatively high at-vessel survivorship rate in Northwest Atlantic longline fisheries, recent management measures, including the retention prohibition by the United States and ICCAT, may confer conservation benefits to the population in this area to some degree. However, given that post-release mortality rates for oceanic whitetip are still unknown, we recognize that the efficacy of these prohibitions is still largely unclear and overutilization may still be a threat to the species.

South Atlantic

Fishing effort has been high in the southern Atlantic Ocean, intensifying after the 1990s (Camhi *et al.,* 2008). However, most of the information on the effect of fishing on large pelagic sharks comes from the North Atlantic Ocean, while data analyses from the South Atlantic Ocean are patchy and typically pertain only to the most abundant species (Barreto *et al.,* 2015). The oceanic whitetip shark is caught as bycatch in a number of fisheries in the South Atlantic region, including Brazilian, Uruguayan, Taiwanese, Japanese, Venezuelan, Spanish and Portuguese longline fisheries; however, the largest oceanic whitetip catching country in this region is Brazil.

As previously discussed in this report, oceanic whitetips were historically reported as the second-most abundant shark, outnumbered only by blue shark, in research surveys from northeastern Brazil between 1992 and 1997 (Lessa *et al*., 1999; FAO 2012). In fact, those research surveys showed that oceanic whitetip shark comprised nearly 30% of total elasmobranch catches (Lessa *et al*. 1999) and averaged a CPUE rate of 2.18 individuals per 1,000 hooks (Domingo *et al.,* 2007). However, recent information indicates that the oceanic whitetip may be experiencing overutilization in this part of its range because of unsustainable fishing mortality. The oceanic whitetip has commercial importance in Brazil mainly due to its fins. As described by Tolotti *et al*. (2013), the Brazilian foreign chartered tuna longline fleet operates in a wide area of the equatorial and southwestern Atlantic Ocean and utilizes two distinct fishing strategies referred to as the "Japanese" strategy (JAP; targets tuna down to >200 m) and "Spanish" strategy (SPA; targets swordfish down to 100 m). Oceanic whitetip CPUE is higher with the SPA strategy than the JAP strategy due to shallower hook depth; in fact, the depth range of the gear used in the SPA fishing strategy corresponds exactly to the oceanic whitetip's preferred vertical distribution

(Tolotti *et al.,* 2013). Additionally, from 1999-2011, the area with the highest effort concentration was bound by the 5°N and the 15°S parallels and by the 040°W and 035°W meridians. Thus, despite the wide distribution of fishing sets, the area of highest effort is clearly concentrated in the equatorial region of northeastern Brazil, which also happens to overlap with the areas of highest habitat utilization by oceanic whitetip sharks. This is evidenced by tagging data from Tolotti *et al.,* (2015a), which indicate that this region off Northeast Brazil is an area where oceanic whitetip shark may have some degree of philopatry (i.e., site fidelity), as well as observer data collected from 14,860 longline sets (21,156,374 hooks), carried out by the Brazilian foreign chartered tuna longline fleet from 2004 to 2010. Thus, it appears that the Brazilian longline fishery area of operation completely overlaps the preferred vertical and horizontal habitat of oceanic whitetip sharks in this region (see Figures 48 and 49 below).

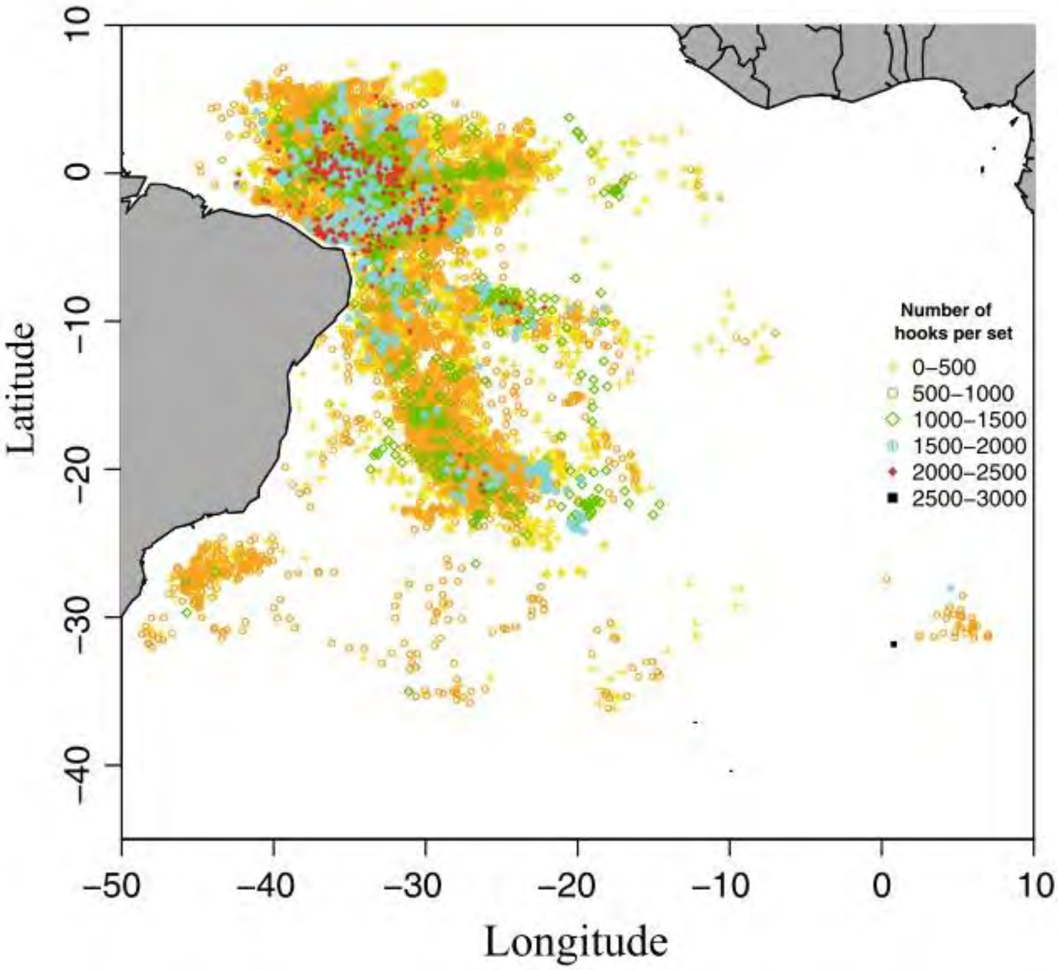

Figure 48 Distribution of fishing effort (number of hooks per set) by the Brazilian chartered tuna longline fleet in the Atlantic Ocean, from 2004 to 2010. Source: Frédou *et al.* 2015.

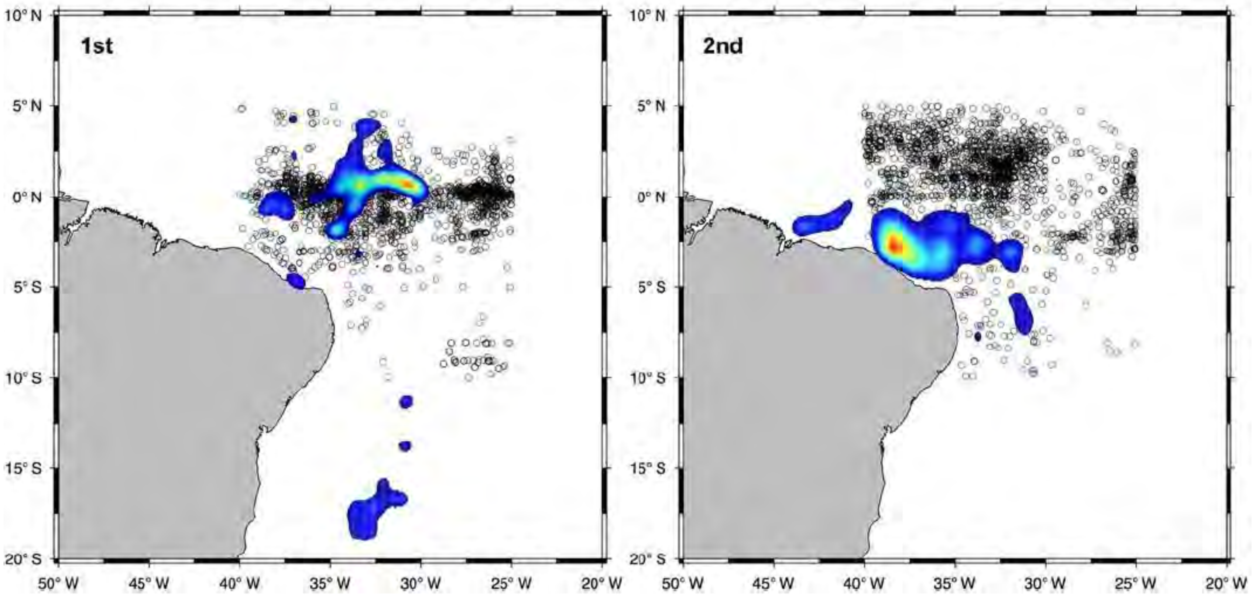

Figure 49 Kernel density estimation of post-processed tracks showing the areas of high utilization by oceanic whitetip sharks tagged in the western Atlantic Ocean between 2010 and 2012. The left panel represents the 1st quarter of the year and the right represents the 2nd. Small circles are fishing set locations from foreign tuna longline vessels chartered by Brazil operating from 2004 to 2010. Source: Tolotti *et al.* 2015a.

Further, many studies show a substantially high percentage of juveniles in the catches from this region (Coelho *et al.,* 2009; Tambourgi *et al.,* 2013; Tolotti *et al.,* 2013; Frédou *et al.,* 2015), which suggests the presence of nursery habitat. For example, the oceanic whitetip was among the most abundant shark species captured during research cruises from November 2000 to September 2002 along the North coast of Brazil, comprising 3% of the total catch in weight (including tunas, billfishes and other sharks); however, more than half of the oceanic whitetip sharks landed were under the size of maturity for this region (Asano-Filho *et al.,* 2004). Likewise, juveniles (<180-190 cm TL) represented 57.1% of the sample in Northeast Brazil (Santana *et al.,* 2004) and 47% of species landings on the North Coast (Asano-Filho *et al*. 2004). A large number of newborns were also sampled in the Southeast region of Brazil (Amorim 1992), further suggesting the existence of nursery grounds in the region. Similarly, Tambourgi *et al*. (2013) found that 80.5% of females were immature and 72.4% of males were immature in the Brazilian pelagic longline fishery between December 2003 and December 2010. Thus, in this region, areas of high fishing effort likely overlap significantly with oceanic whitetip nursery habitat, suggesting that these areas are at a direct risk from the industrial longline fishery (Frédou *et al.,* 2015).

It also appears that the percentage of immature sharks has increased in recent years compared to surveys conducted in the 1990s (See Figures 50 and 51 below).

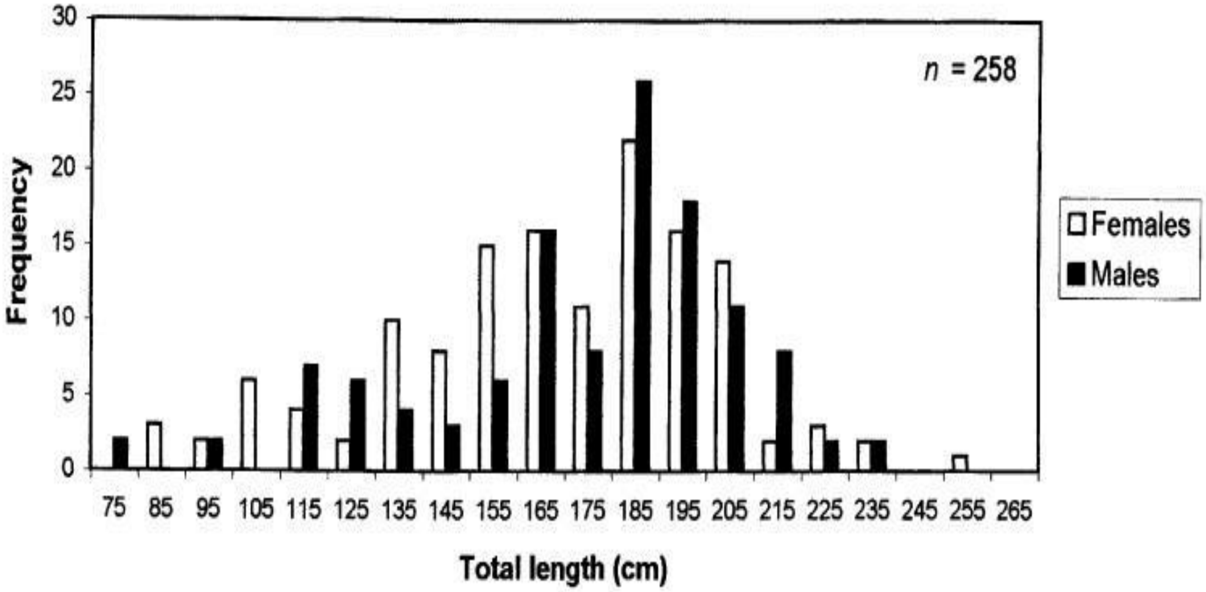

Figure 50 Length-frequency distribution for male and female whitetip shark, *C. longimanus*, caught off northeastern Brazil between 1992 and 1997. Source: Lessa *et al.* 1999.

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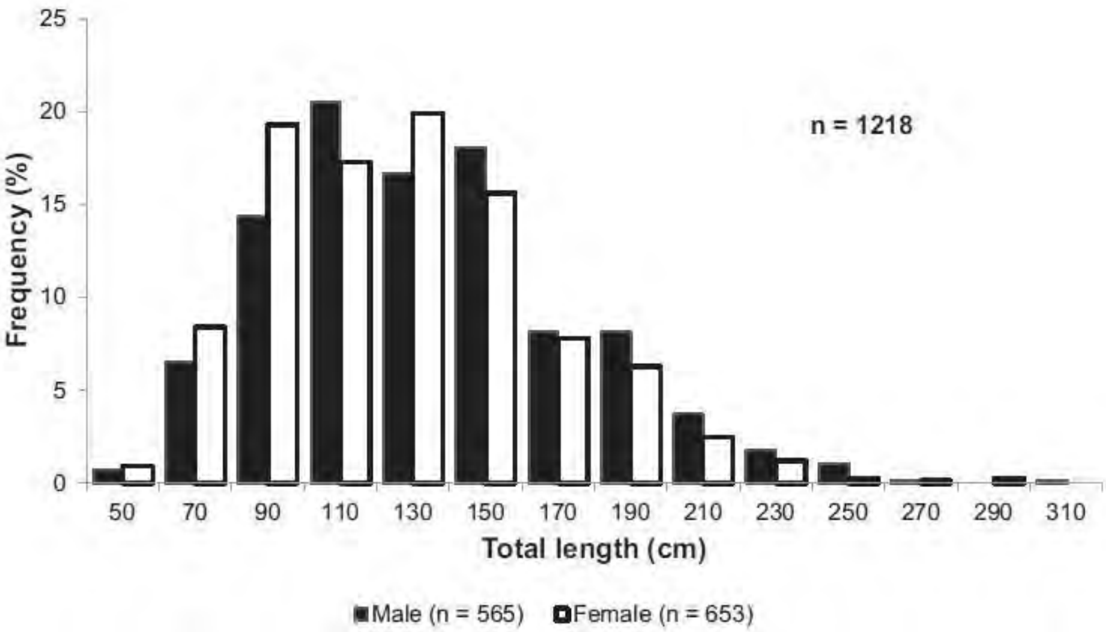

Figure 51 Length–frequency distribution of oceanic whitetip shark, *C. longimanus*, caught in the southwestern equatorial Atlantic Ocean between 2005 and 2009. Source: Tolotti *et al.* 2013.

It should be noted that Figure 50 from Tolotti *et al*. 2013 represents a much larger area of the southwestern and equatorial Atlantic and has a much larger sample size than the results shown in Figure 51 from Lessa *et al*. 1999. However, the two study areas do overlap and provide some indication that the size composition of oceanic whitetip sharks in the southwestern Atlantic is potentially shifting downwards. More recently, Frédou *et al.,* (2015) analyzed catch and effort data of 14,860 longline sets from the Brazilian chartered tuna longline fleet, between 2004 and 2010 and found that oceanic whitetip sharks in the equatorial and southern Atlantic were comprised of the smallest individuals throughout the fishing ground, with 78% measuring <180 cm and most likely juveniles. Coelho *et al.,* (2009) suggested that the high percentage of small individuals in the southwestern equatorial Atlantic (also found in Tolotti *et al*. 2013 and Tambourgi *et al*. 2013), might indicate size segregation in the Atlantic Ocean. Alternatively, Lessa *et al*. (1999) hypothesized that the large proportion of juveniles might be a result of ongoing fishing pressure on the entire population.

As discussed previously in the *Regional Population Trends* section, a demographic analysis of oceanic whitetip sharks off Brazil estimated that fishing mortality of oceanic whitetip is 14 times higher than required for maintaining equilibrium, resulting in an annual decline of 7.2% (Santana *et al.,* 2004). This rate of decline results in a reduction of about 50% of abundance in the course of approximately a decade, which is within the standards known of exploited oceanic whitetip populations in other regions (Santana *et al.,* 2004). The authors concluded that conservation and management are necessary for the species because the high value of initial mortality is accentuated by an excess of fishing effort, such that that these factors contribute to the population reduction of oceanic whitetip shark in northeastern Brazil (Santana *et al*., 2004). Catches of oceanic whitetip in the Brazilian tuna longline fishery have also shown a continuous decline, decreasing from about 640t in 2000 to 80t in 2005 (Hazin *et al.,* 2007). According to the ICCAT nominal catch database, landings of oceanic whitetip shark by Brazilian vessels continued to decline to 0 mt reported from 2009-2012 and 6 mt in 2013 and 2014 (refer back to Figure 46 above). This decline in reported landings also coincides with the previously discussed demographic analysis that reported a 50% population decline in Brazil. Thus, the decline in landings reported to ICCAT by Brazil prior to 2010 may be indicative of a population decline, though this is highly uncertain given the sensitivity of the species to changes in fisheries strategies. Although there was a shift in some fishing effort of the Brazilian chartered foreign longline fleet to more temperate waters in 2006 (Frédou *et al.,* 2015), which may account for some decline in reported catches of the species, other species-specific information (as previously discussed above) suggests the species is still experiencing significant fishing pressure in areas of its preferred habitat where the species exhibits a high degree of site fidelity (Tolotti *et al.,* 2015a).

Although robust CPUE data are not available for the species, making it difficult to evaluate whether the decline in catches resulted from decreased abundance or from changes in catchability (e.g., fishing strategies) (Hazin *et al.,* 2007), it is clear that the majority of fishing effort in Brazil is concentrated in the same areas of highest habitat utilization by oceanic whitetip sharks (Tolotti *et al.,* 2015a), including potential nursery areas. Thus, it is likely that the intensive fishing pressure of oceanic whitetip across its preferred vertical and horizontal habitat areas in Brazilian waters is negatively impacting oceanic whitetip sharks at all life stages. Given the demographic analysis discussed previously indicating a 50% population decline in these waters as a result of unsustainable rates of fishing mortality, combined with the species' relatively low-moderate productivity, it is likely that the oceanic whitetip is experiencing overutilization in this portion of its range.

As discussed previously in the *Regional Population Trends* section, elsewhere across the southern and equatorial Atlantic, the oceanic whitetip shark exhibits extremely low CPUE values and comprises a very small percentage of catches in various fisheries. For example, farther north in the Venezuelan pelagic longline fishery, the oceanic whitetip shark is caught as bycatch in low numbers. Based on observer data from 1994-2000, only 28 individuals were caught, representing 1.5% of the total shark catch. On average, the size of individuals caught was 125.0 cm FL (Arocha *et al.,* 2002), which is well below the size of maturity estimated for this region (i.e., 180-190 cm).

Similarly, observer data from the Uruguayan longline fleet operating farther south in this region reported low CPUE values for oceanic whitetip from 2003 to 2006, with the highest CPUE recorded not exceeding 0.491 individuals/1,000 hooks. In total, only 63 oceanic whitetips were caught on 2,279,169 hooks and 63% were juveniles (see Figure 52 below; Domingo *et al*. 2007). Based on the catches and relative abundance, three zones were determined for the oceanic whitetip, including: Zone 1: Western South Atlantic and southern Brazil; 2: International waters on the Chain of Montes Vitoria- Trindade near the Bank Davis; Zone 3: Northeast Atlantic in the Gulf of Guinea. Average length and CPUE values were analyzed for *C. longimanus* in these areas. The lowest values of average size were observed in Zone 2, which is also where the highest values of CPUE were observed (followed by zone 3 and 1, respectively). CPUE values decrease with increasing median size. The differences in median sizes, from 145 cm FL in Zone 1 (temperate SW) to <100 cm FL in other more tropical and sub-tropical areas could support the idea of spatial patterns and size distribution of the species; alternatively, this could also be a result of differing levels of historical fishing pressure in these regions. For example, while Domingo *et al*. (2007) recorded a CPUE of 0.098 in Zone 3 and only 10 individuals caught in 3 years, Castro and Mejuto (1995) reported a CPUE of 0.26 in this same area 10 years prior in 1993, with 63 oceanic whitetips caught in only 4 months. Though these data do not indicate whether a decline in the oceanic whitetip population has occurred, they clearly show that this species is currently not abundant in these areas (FAO 2012). However, it is possible that the species has always been uncommon in this area of the South Atlantic, especially given the preference of this species to remain in warm, tropical waters.

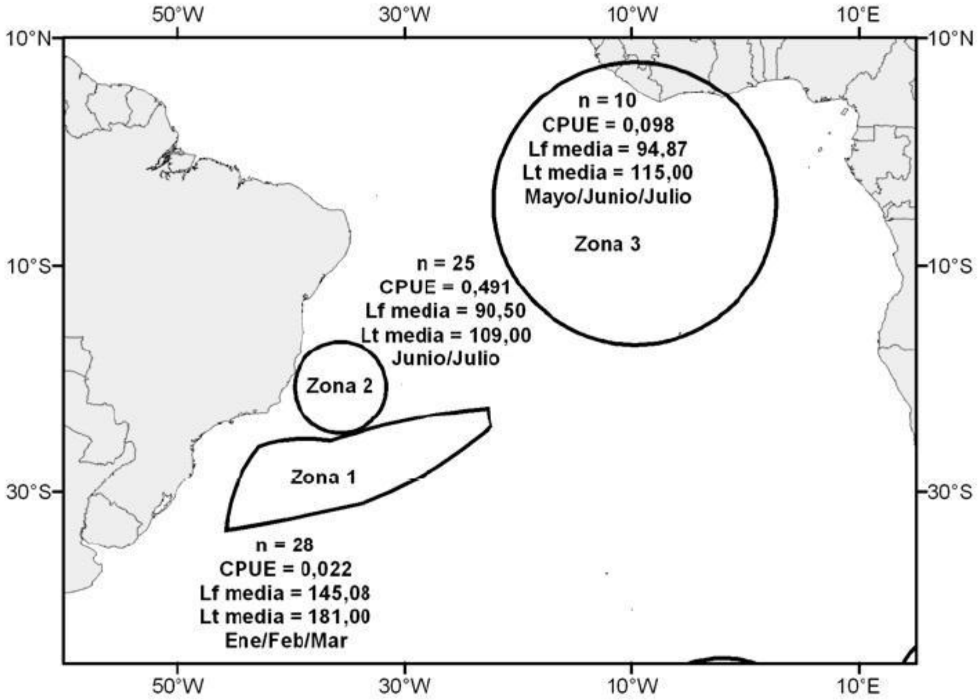

Figure 52 Areas (Zones 1-3), number (n), CPUEs, Lf and Lt media (average lengths) and times of observed oceanic whitetip sharks by the Uruguay National Observer Program from 2003-2006. Source: Domingo *et al.* 2007.

Oceanic whitetip sharks are also caught as bycatch in Taiwanese longline fisheries operating in the South Atlantic. According to Taiwanese observer data, from 1999-2003 oceanic whitetip was the least caught shark species from 5°N-15°S, with only 3 individuals caught, comprising 0.1% in number and 0.1% in weight of total shark catches. However, oceanic whitetip was not found from 15°S-40°S, which are more southern and temperate waters (Joung *et al.,* 2005). Species-specific CPUE for oceanic whitetip was extremely low at 0.003 (n/1,000 hooks) from 5°N-15°S and 0.002 for the entire South Atlantic; however, trends over time are not currently available from this fishery.

A recent study covering a wide area of the Atlantic in both hemispheres from 2008-2011 indicated that the oceanic whitetip shark bycatch in pelagic longline fisheries comprises less than 1% of the total elasmobranch catches (Coelho *et al.,* 2012). This study analyzed observer data from the Portuguese longline fishery targeting swordfish in the Atlantic Ocean, including areas of the temperate NE, tropical NE, equatorial, and southern Atlantic Ocean (see Figure 53 below). Between August 2008 and December 2011, the oceanic whitetip shark comprised only 0.01% of the total elasmobranch catch (n = 281) and exhibited an at-vessel mortality rate of 34.2% (Coelho *et al.,* 2012).

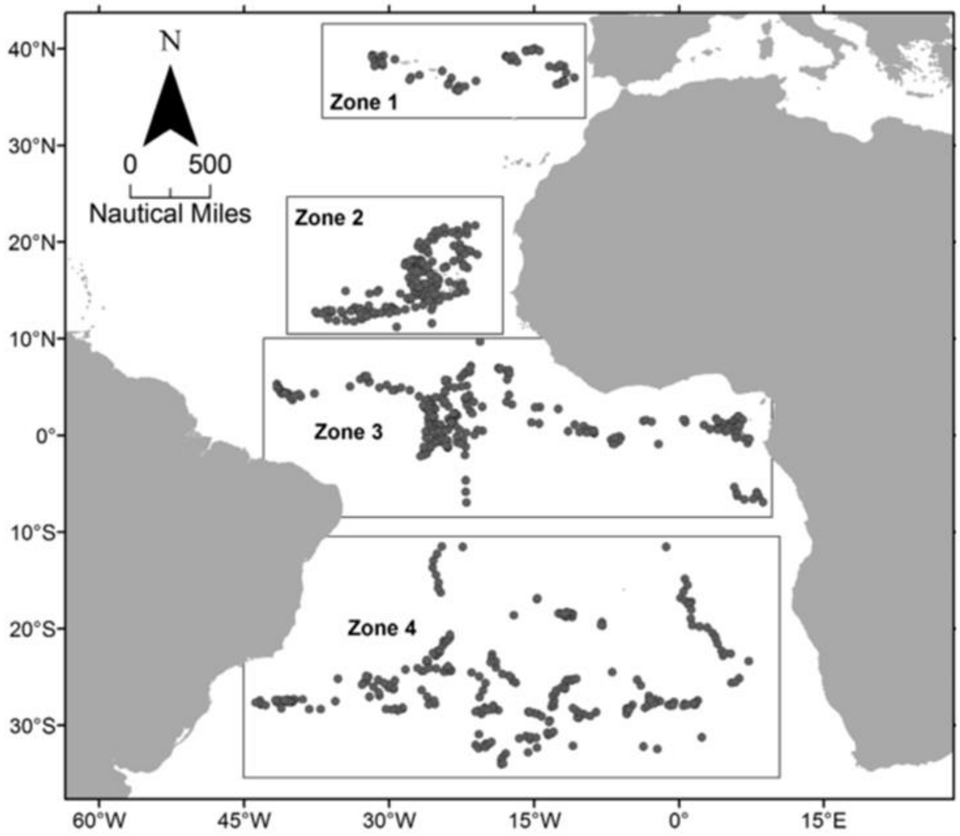

Figure 53 Locations of observed Portuguese longline operations in the Atlantic Ocean from 2008 to 2011. Source: Coelho *et al.* 2012.

Over the same time period (2008-2011), a total of 202 experimental pelagic longline sets were carried out in the Tropical Northeast Atlantic Ocean (corresponding to Zone 2 in Figure 53 above). Fernandez-Carvalho *et al.,* (2015) noted that this area has become a major fishing ground for the European pelagic longline fleets (i.e. Spanish and Portuguese) in recent years. The study compared mortality rates between hook and bait type to determine potential bycatch mitigation methods. Over the course of the study, 152 oceanic whitetip sharks were caught, with higher catch rates observed with the use of circle Gt hooks. The species presented relatively low at-vessel mortality rates (11-28%) compared to other shark species, which ranged from a low of 4-8% for the crocodile shark and a high 61-64% for the smooth hammerhead shark (Fernandez-Carvalho *et al*., 2015).

In the southeastern Atlantic, a study on the impact of longline fisheries in the Benguela Current Large Marine Ecosystem (defined as west of 20º E, north of 35º S and south of 5º S) reported observer data from the South African longline fishery. This study found that oceanic whitetip was only a minor component of the shark bycatch from 2000-2005 (n = 125), and comprised only 1.2% of the shark bycatch composition (Petersen *et al.,* 2007). However, this is not surprising given the species' preference for more tropical waters.

Finally, in a study that synthesized information on shark catch rates (based on 871,177 sharks caught on 86,492 longline sets) for the major species caught by multiple fleets in the South

Atlantic between 1979 and 2011, generalized linear models were used to standardize catch rates and identify trends in three identified fishing phases: a first phase (1979–1997), characterized by a few fleets mainly fishing for tunas; a second phase (1998–2007), where many fleets were fishing for tunas, swordfishes and sharks; and a third phase (2008–2011), where fewer fleets were fishing for multiple species and restrictive measures were being implemented (Barreto *et al.,* 2015). In total, 3,288 oceanic whitetip sharks were reported during the time period. Overall results indicate that most shark populations in the South Atlantic are currently depleted, but can recover where fishing effort is reduced accordingly (Barreto *et al*., 2015). More specifically, results indicate that catch rates for most of the species analyzed, including oceanic whitetip, have declined precipitously from considerable fishing pressure and absence regulatory measures to control fishing effort, particularly in phase B. These declines coincided with significant increases in fishing effort, inadequate regulations to deal with issues such as shark bycatch, finning and directed fishing for sharks by some fleets. Considering the percentage rate of change between the last year of phase A in relation to the last year of the phase B, the authors determined that that with exception of *P. glauca* and *A. superciliosus*, catch rates of all species, including oceanic whitetip, have declined by more than 85% (Barreto *et al.,* 2015). In Phase C (2008-2011), when the presence of onboard observers became mandatory, catch rates of oceanic whitetip declined by 14%, but overall conclusions regarding the status of oceanic whitetip were inconclusive. Figure 54 below shows trends in standardized catch rates for oceanic whitetip for each of the three phases.

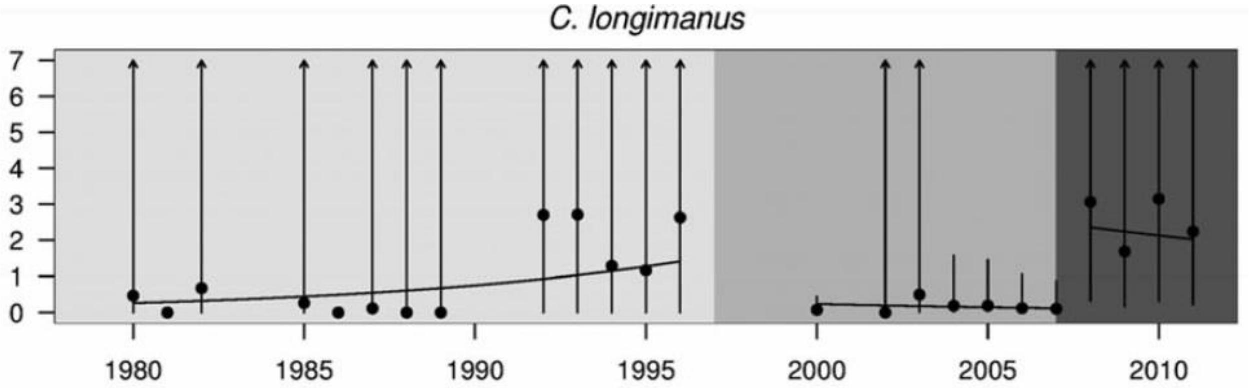

Figure 54 Trends in standardized catch rates of oceanic whitetip sharks (estimated from generalized linear models with a zero truncated negative binomial distribution) in 3 fishing phases (shadings); solid lines, overall trends with year as continuous variable; dots, individual year estimates with year as factor; vertical lines, 95% CI; arrows, CIs larger than the y-axis scale in a particular year. Source: Barreto *et al.* 2015.

Reviewers had some serious concerns regarding the methodologies of the Barreto *et al*. (2015) study, and pointed out several caveats and limitations, including the use of year as a continuous variable and the stripping out of all zero catches. Confidence intervals are extremely high and overlapped in most cases, raising the possibility that the trends may be "noise" rather than truly tracking abundance. Given these caveats and limitations, the ERA team exhibited lower confidence in the results of this study.

South Atlantic Summary

Overall, while quantitative studies regarding catch trends of oceanic whitetip sharks are limited, oceanic whitetip sharks, while once one of the most abundant shark species encountered in longline fisheries in the southern and equatorial Atlantic, are now seemingly rare with low, patchy abundance across the region, and the majority of catches are comprised of immature individuals. Given that both average CPUE and commercial landings of oceanic whitetip shark have likely declined in recent decades, combined with the species' low-moderate productivity, it is likely that overutilization of oceanic whitetip sharks is occurring in the South Atlantic. This is likely a result of the fact that high levels of fishing effort overlap significantly with the preferred vertical and horizontal habitat of the species in this region. Of particular concern is the overlap of fishing effort with potential nurseries and areas where the species shows a high degree of site fidelity. However, without any robust standardized fisheries data to account for various factors that may affect the catch rate of oceanic whitetip, the species' current abundance and trends in this region are uncertain.

Indian Ocean

Despite evidence for high bycatch levels of pelagic sharks in the Indian Ocean (Romanov 2002, Huang and Liu 2010), there is a paucity of reliable data to facilitate assessing historical changes in shark catch rate trends (Smale 2008). In an analysis of long-term trends from research and fisheries data collected in the Indian Ocean from 1961-2009, the oceanic whitetip was recorded in catches from each time series (e.g., 1961-1970; 1971-1980; 1981-1989; 2002-2009) (Romanov *et al.,* 2010). According to the IOTC, the RFMO that manages tuna and tuna-like species in the Indian Ocean and adjacent waters, catches of oceanic whitetip shark are ranked as "High," meaning the accumulated catches from 1950–2010 make up 5% or more of the total catches of sharks recorded (Herrera and Pierre 2011). In fact, a recent study estimated that the oceanic whitetip shark comprises 11% of the total estimated shark catch in the Indian Ocean (Murua *et al.,* 2013a). It is also considered to be the 5th most vulnerable shark species caught in longline fisheries in the region (out of 16 species assessed), and the most vulnerable shark species caught in purse seine gear, due to its high susceptibility (Murua *et al.,* 2012; IOTC 2015a).

The oceanic whitetip is reported as bycatch in all three major fisheries operating in the Indian Ocean; the species is considered "frequent" in both longline and purse seine fisheries, and "very frequent" in the gillnet fishery (Murua *et al.,* 2013b), with gillnet fisheries reporting the highest nominal catches of sharks in 2014, and making up nearly 40% of catches (Ardill *et al.,* 2011; IOTC 2015a). Large numbers of fishing vessels that use gillnets in the Indian Ocean have been identified, with 1,000 estimated for Iran and 2,000 estimated for Sri Lanka; however, due to their small sizes and artisanal status (despite often fishing very far from their countries), the total annual numbers of fishing vessels utilizing gillnets in the Indian Ocean remain largely unknown. Additionally, fishing zones of the gillnet fishery also remain widely or completely unknown, with no logbooks or observers present on these vessels (Fontenau 2011). With an estimated 3,000 vessels that are theoretically supposed to deploy nets of 2.5 miles in length, 6,000 miles of nets may be deployed on a daily basis (Fontenau 2011; Figure 55 below).

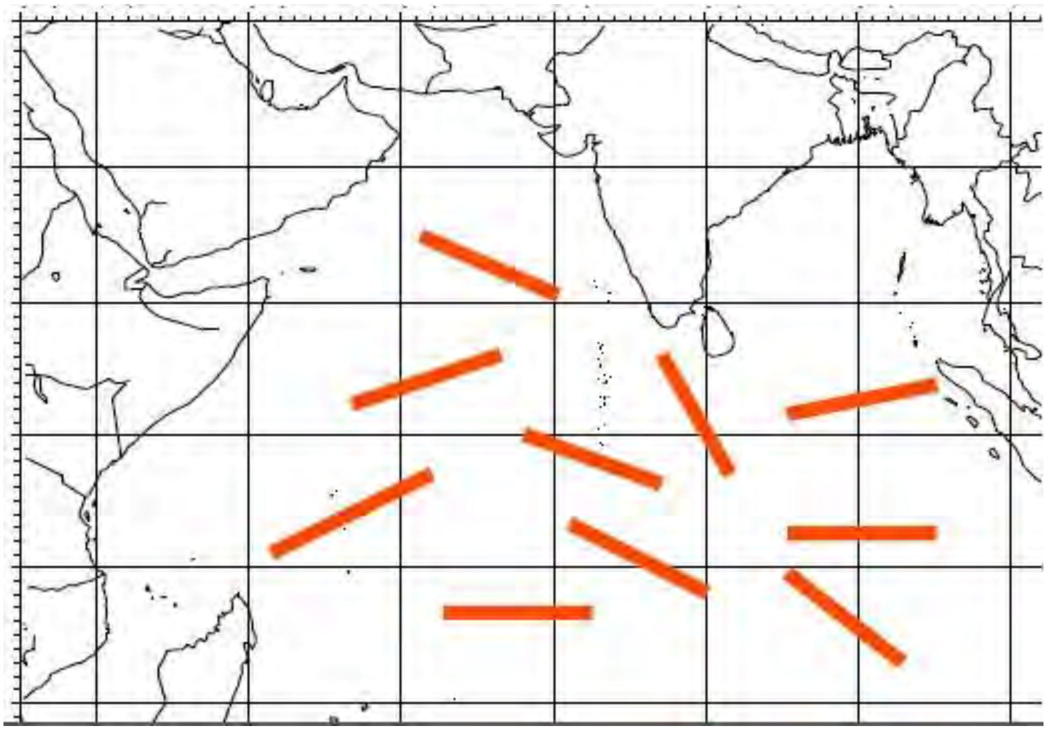

Figure 55 Schematic conceptual view of the total length of drifting nets that may be deployed daily by a fleet of 3,000 vessels using 2.5 miles long nets. Source: Fontenau 2011.

The main fleets catching oceanic whitetip in the Indian Ocean from 2011-2014 include: Indonesia, Sri Lanka, I.R. Iran, EU (Spain), China, Madagascar, and Seychelles. Fisheries catch data for the Indian Ocean are available from the IOTC, which requires CPCs to annually report oceanic whitetip catch data (See IOTC Resolutions 05/05, 10/07, 10/12, 12/09, 13/06). However, prior to the adoption of resolution 05/05 by the IOTC, there was no requirement for sharks to be recorded at the species level in logbooks. As such, it was not until 2008 that some very sporadic statistics become available on shark catch, mostly representing retained catch and not accounting for discards (Ardill *et al.,* 2011). Additionally, the IOTC acknowledges that despite reporting requirements, catches of sharks are usually not reported. In fact, reporting by species is very uncommon for gillnet fleets, where the majority of catches are reported in aggregate (IOTC 2015a). Further, when catch statistics are provided, they may not represent the total catches of the species, but those simply retained on board, with weights that likely refer to processed specimens (IOTC 2011b). Therefore, the current reported catches are thought to be incomplete and largely underestimated. In fact, a recent study estimated possible oceanic whitetip shark catches for fleets/countries based on the ratio of shark catch to target species, and highlighted a potentially significant underestimation of oceanic whitetip shark in the IOTC database. Murua *et al.,* (2013a) concluded that the estimated catch of oceanic whitetip shark is approximately 20 times higher than declared/reported and contained in the IOTC database. In fact, once the requirement to record and report oceanic whitetip incidental catches and discards to the IOTC was implemented in 2013, estimated catches skyrocketed from an annual average of 347 mt from 2007-2011 to 5,413 mt and 5,383 mt in 2013 and 2014, respectively (see Figures 56 and 57 below).

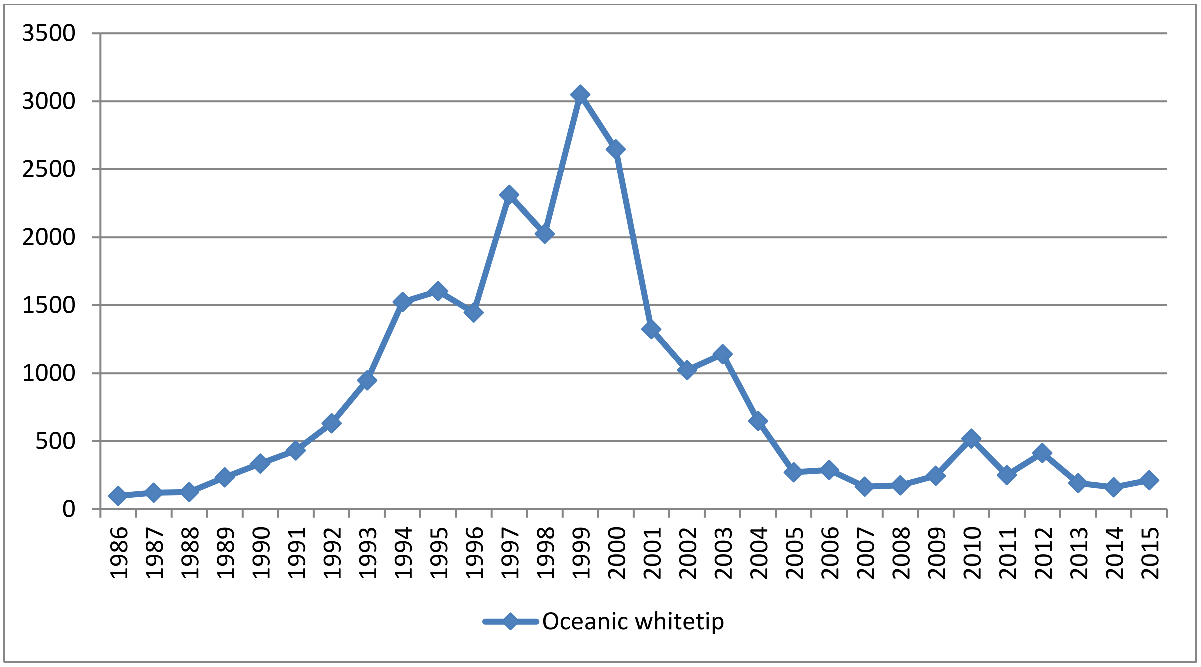

Figure 56 Total catches (mt) (all gears) of oceanic whitetip as reported to the IOTC from 1986-2009. Source: Murua *et al.* 2013(b) and IOTC nominal catch database.

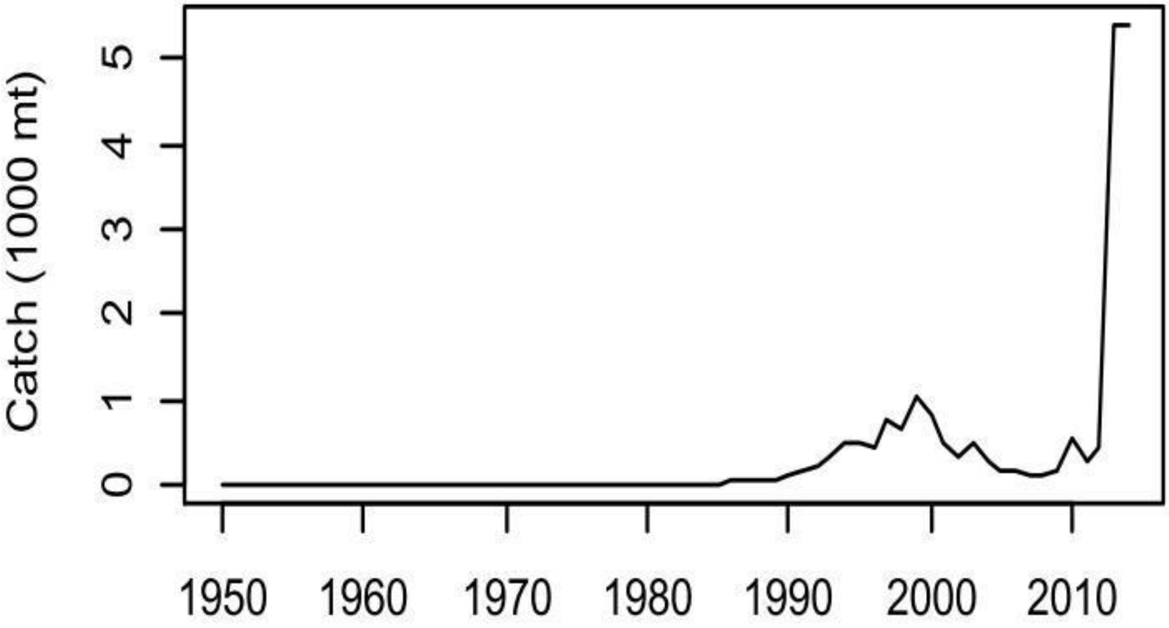

Figure 57 Total nominal catches of oceanic whitetip for all fleets operating in the Indian Ocean (1950-2014). Source: IOTC (2015b).

Only 6 countries reported catches of oceanic whitetip in 2014: Tanzania, Sri Lanka, Maldives, Islamic Republic of Iran, India and Seychelles. The reporting of catches of oceanic whitetip sharks (shown in Figure 57 above) shows an unusual trend dominated by the Sri Lankan combination longline-gillnet fisheries with the addition of proportionately very large catches by India in the last years (2013-2014) (IOTC 2015b). Overall, prior to the unusual trend in 2013 and 2014,the trend in catch shows a substantial increase throughout the 1990s, which likely corresponds with the rise in the shark fin trade (Clarke *et al.,* 2007), a peak at 3,050 mt in 1999, followed by a sharp and continued decline in the 2000s. The IOTC's Working Group on Ecosystems and Bycatch stated that at current catch levels (i.e., average of 347 mt prior to 2013) the Indian Ocean stock of oceanic whitetip was at considerable risk. Given the high level of fishing pressure on oceanic whitetip in the Indian Ocean, and the species' low-moderate productivity, it is therefore likely that the substantially high catches of oceanic whitetip sharks in the Indian Ocean (5,000+ mt estimated for 2013 and 2014) are in excess of what is sustainable and may be contributing to overutilization of the species in the Indian Ocean. Additionally, oceanic whitetip sharks appear to have higher mortality rates on longlines in the Indian Ocean (e.g., 58% mortality in longline fisheries that fish for swordfish (IOTC 2015a) compared to mortality rates observed in other portions of its range (e.g., ~23% in NW Atlantic (Beerkricher *et al*. 2002; Gallagher *et al*. 2014); 11-28% in the South Atlantic (Fernandez-Carvalho *et al*. 2015); 30% in RMI (Bromhead *et al*. 2012)). It should also be noted that these rates only account for at-vessel mortality and do not account for post-release mortality. Information regarding some of the main countries that catch oceanic whitetip shark in the Indian Ocean is provided below where available.

Indonesia

Indonesia is the largest shark-catching country in the world, with an estimated total elasmobranch catch of 110,000 t in 2007 (Camhi *et al.,* 2009). According to a recent study by Dent and Clarke (2015), total captures of chondrichthyan fishes from 2000–2011 averaged 106,034 t. This level of catch has likely caused declines in abundance for many species. For example, research cruise data show that catch rates of elasmobranchs in the Java Sea declined by at least one order of magnitude between 1976 and 1997. Results strongly indicate that many shark and ray species in Indonesia are overfished (Blaber *et al.,* 2009).

The population status of oceanic whitetip shark in Indonesia is unknown because fishers rarely land this species. A 2001-2006 survey conducted in waters south of Java, Lombok and Bali found that few oceanic whitetip sharks were landed either as bycatch of tuna fisheries or as target catch of shark longline fisheries in Lombok (Dermawan *et al*., 2013). The authors noted that specimens landed are mostly juveniles with few adults recorded in this part of Indonesia. Adults are commonly caught in east Indonesia, from Lombok in West Nusa Tenggara to the Leti Islands in Southeast Maluku. The size of sharks can be estimated from the size of its fins, and the shark fins found at fin collectors in east Indonesia indicate that most of the oceanic whitetips landed by fishers in this region are adults. Although all parts of this shark species are utilized in Indonesia, the fins are most sought after due to their high economic value (Dermawan *et al.,* 2013).

In 2014, a study was conducted using DNA barcoding of 582 shark fins collected from numerous traditional fish markets and shark-fin exporters across Indonesia from mid-2012 to mid-2014, including Aceh, Jakarta, West Java, Central Java, East Java, Bali, West Kalimantan, South Sulawesi, North Sulawesi, Maluku, and West Papua. Additional samples were collected from shark fin export warehouses in Cilacap (Central Java) and Tanjung Luar (West Nusa Tenggara). In this study, Sembiring *et al.,* (2015) discovered a fishery that targets particularly vulnerable shark species, including oceanic whitetip sharks. Oceanic whitetip sharks comprised a small portion of the tested fins, representing 1.72%. Additionally, in an analysis of Indonesian longline scientific observer data in the Indian Ocean from 2005-2013, oceanic whitetip sharks represented 1.66% of the total catch (Novianto *et al.,* 2014). In October 2015, Indonesian authorities seized about 3,000 shark fins belonging to oceanic whitetip sharks that were reportedly caught in waters around Java Island. The fins, which were about to be flown to Hong Kong, were seized at the international airport that serves the capital Jakarta (South China Morning Post 2015[10]). The oceanic whitetip is a protected species in Indonesia and banned from export. Thus, based on the genetic results of shark fins from numerous fish markets throughout Indonesia and the evidence of illegal trade of oceanic whitetip fins, it is evident that oceanic whitetip sharks are commonly caught as bycatch and are potentially targeted for fins in this portion of its range.

India

India is the second largest shark producing nation in the world. In one study, survey vessels collected data on the CPUE of sharks in the longline tuna fishery in various regions of the Indian EEZ from 1984-2006 (three vessels operated along the west coast of India, two vessels operated in the east coast and one vessel in the Andaman and Nicobar waters). During the survey, a total of 3.092 million hooks were deployed, with sharks representing 45-50% of the catch, equaling approximately 588.9 t (John and Varghese 2009). A sharp decline in CPUE from all three regions was observed, with the most concerning scenario on the east and west coasts, where the average hooking rate recorded during the last five years was less than 0.1%. The oceanic whitetip represented 0.6% and 4.7% of the catch from the East Coast (Arabian Sea) and Andaman and Nicobar waters, respectively. In the Andaman and Nicobar region, where catch of oceanic whitetip is most prevalent, total shark CPUE declined sharply by approximately 81% from 1992-1997. On the East Coast, total shark CPUE also declined significantly by approximately 89% from 1984-2005. More recently from 2004-2010, Varghese *et al.,* (2015) report that oceanic whitetip shark comprised only 0.23% of the total shark catch and had an extremely low hooking rate (number of sharks caught per 100 hooks) of 0.001 in Andaman and Nicobar waters, which is significantly lower than what John and Varghese (2009) reported for years 1984-2006. Overall, Varghese *et al*. (2015) shows that the index of relative abundance of sharks was considerably lower than earlier studies, indicating a decline in abundance over the years. While the lack of standardized CPUE trend information for oceanic whitetip in these studies makes it difficult to evaluate the potential changes in abundance for this species in this region, based on the best available information, it is likely that oceanic whitetip has experienced some level of population decline in this region as a result of fishing mortality. Additionally, it is important to note that India has objected to the IOTC Resolution prohibiting the retention of oceanic whitetip sharks (since 2013), and thus this Resolution is not binding for India. Therefore, oceanic whitetip sharks may still be retained in Indian fisheries.

Sri Lanka

Although sharks were dominant in the historical large pelagic fish landings in Sri Lanka, their current production is low, with catches mostly a result of bycatch. From 1950 to 1974, more than 45% of the total large pelagic fish production was attributed to sharks (Hasarangi *et al.,* 2012). As of 2014, however, the estimated contribution of sharks to the total large pelagic fish

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[10] http://www.scmp.com/news/asia/southeast-asia/article/1864948/indonesia-seizes-3000-shark-fins-destined-hong-kong

production by weight currently remains at 2% (Jayathilaka and Maldeniya 2015). Previous attempts to estimate the potential sustainable yield in Sri Lankan waters suggested harvest rates of all species of 250,000 t year^{-1}, with around 170,000 t for pelagic species. Reconstructed catches from O'Meara *et al*. (2011) indicate that this sustainable level was likely exceeded as far back as 1974. In this study, O'Meara *et al.,* (2011) highlighted the lack of proper accounting for total fisheries catches and concluded that without a realistic estimate of removals, pelagic fisheries are likely mismanaged and potentially overexploited (O'Meara *et al*. 2011). Among the shark landings in Sri Lanka, silky shark (*C.falciformis*) is the dominant species followed by thresher shark (*Alopias* spp.), blue shark *(P. glauca*) and oceanic whitetip shark (*C.longimanus*), respectively. The oceanic whitetip shark has commercial importance in Sri Lanka, and comprised approximately 5% of the total shark catch in 2014 (down from 6.1% in 2011; Jayathilaka and Maldeniya 2015). From 1996-2004, landings of oceanic whitetip peaked in 1999 at approximately 3,000 mt and show a declining trend thereafter (Hasarangi *et al.,* 2012). More recent information suggests that oceanic whitetip shark landings have seemingly declined continuously from a peak of 3,000 mt in 1999 to less than 300 mt in 2014. It is important to note that the significant decline in shark production can be attributed to regulatory mechanisms only in the last two years. Most recently, Sri Lanka reported only 88 mt of oceanic whitetip shark to IOTC in 2015. Thus, the decline in oceanic whitetip catches occurred prior to the implementation of any regulatory measures, and may therefore be indicative of declining catches due to population decline in Sri Lankan waters.

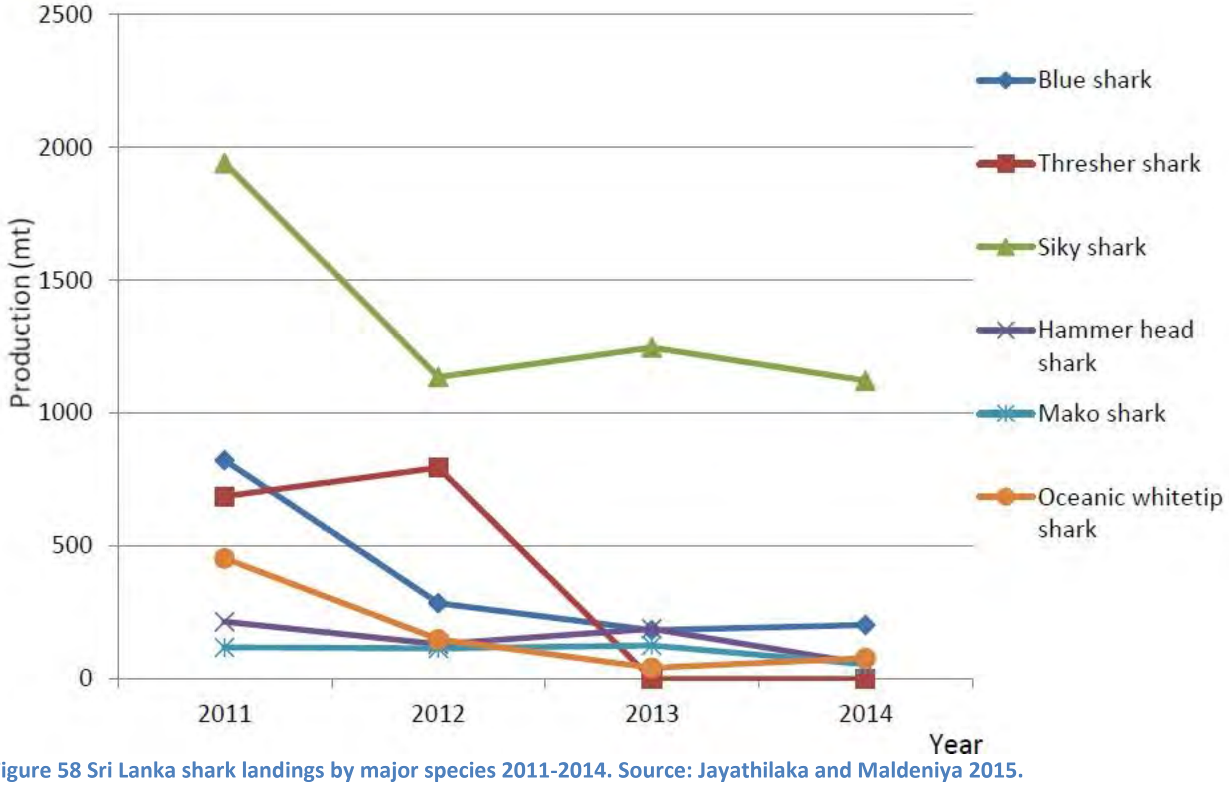

Figure 58 Sri Lanka shark landings by major species 2011-2014. Source: Jayathilaka and Maldeniya 2015.

Taiwan

Oceanic whitetip sharks have also been recorded as bycatch in the Taiwanese longline fishery operating in the Indian Ocean. Estimates of discards and incidental catch are difficult to obtain due to a lack of discard data reporting in captains' logbooks and because the Taiwanese fleet rarely identifies the various shark species (Huang and Liu 2010; Moreno and Herrera 2013). Observer data collected from 77 trips on Taiwanese large-scale longline fishing vessels in the Indian Ocean from June 2004 to March 2008 were used to estimate the extent of bycatch. The oceanic whitetip shark was recorded in the yellowfin, bigeye and albacore tuna fisheries (Huang and Liu 2010). In total, only 77 individuals were recorded during the study period, despite most fishing effort taking place in tropical latitudes between 10˚N and 10˚S, where the species would likely be most prevalent (see Figure 59 below). During the study, the average discard rate for sharks was 54.2% (Huang and Liu 2010).

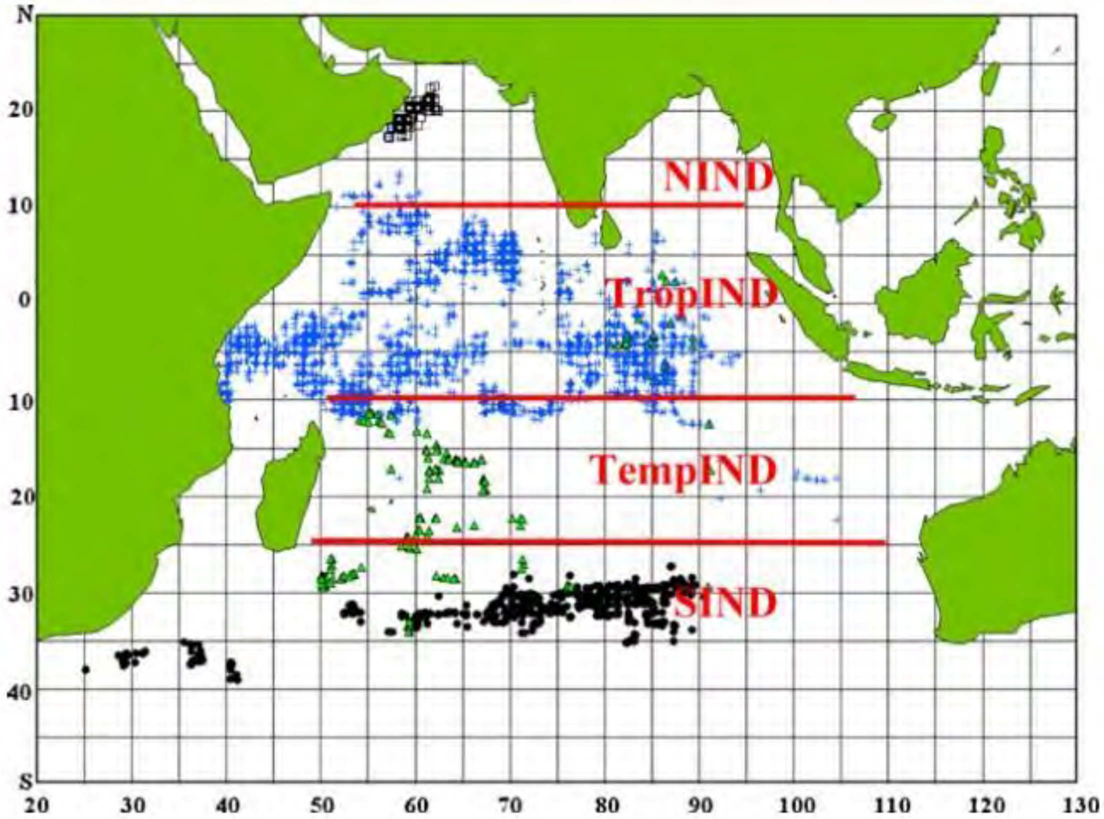

Figure 59 Areas and observed effort distributions of the Taiwanese longline fishery in the Indian Ocean. Black squares, yellowfin tuna fleet; blue crosses, bigeye fleet; green triangles, albacore fleet; black circles, bluefin tuna fleet. Source: Huang and Liu 2010.

African semi-industrial fleet

The African semi-industrial fleet (including Madagascar, Mauritus, Reunion, and Seychelles) is opportunistic and fishes exclusively in the Western Indian Ocean. Seychelles started its fishing operations in 1983 and Reunion in 1991 with one vessel each. The fleet reached a peak of 62 vessels in 2007 and 2012. In 2012, Reunion had 41, Madagascar had 8, Mauritius had 5 and Seychelles had 4 vessels. It was not until 2010 that this fleet reported shark catches down to the species level. Based on reported catches, catches per vessel is low (~1 mt per vessel per year), with the oceanic whitetip shark comprising approximately 52% of the catch (Moreno and Herrera M. (IOTC Secretariat) 2013).

Indian Ocean Summary

Overall, it appears that the oceanic whitetip shark is likely heavily utilized in the Indian Ocean basin due to direct and indirect fishing pressure. The species is highly valued for its fins in this region, comprises an estimated 11% of the total shark catch (Murua *et al*. 2013), and is impacted by all three major fisheries in the region, including longlines, gillnets, and purse seine fisheries. As discussed previously in the *Regional Population Trends* section of this status review, and based on the limited data available, it appears that the Indian Ocean oceanic whitetip shark population has likely experienced varying magnitudes of decline as a result of intense historical and ongoing fishing mortality driven by bycatch-related mortality and economic demand for the fin trade. While there is considerable uncertainty regarding the current status of oceanic whitetip sharks in the Indian Ocean, given the high level of fishing effort in this region and high catches of the species, combined with the species' relatively high mortality on longlines in this region and low-moderate productivity, it is likely that overutilization of oceanic whitetip shark is occurring in the Indian Ocean.

Shark Trade

A demand for shark products has existed since the early 1900s, including liver oil, hides, fins, meat, teeth and jaws. Since the 1980s, much of the demand for shark products focused on fins due to the increasing demand for shark fin soup (Biery and Pauly 2012). Traditionally consumed in Hong Kong, Singapore, Macao, Taiwan, China, and other countries with large ethnic Chinese populations, shark fins are one of the most valuable food items in the world (Fong and Anderson 2000). According to official FAO statistics, the average declared value of total world shark fin imports from 2011–2014 was estimated at USD377.9 million per year from 2000 to 2011, with an average annual volume imported of 16,815 tonnes (Dent and Clarke 2015). From 2000–2011 annual average figures for imported shark meat were 107,145 tonnes, worth a total of USD 239.9 million; while in 2011 alone, the reported figures for total global imports of shark meat were USD379.8 million and 121,641 tonnes for value and volume, respectively (Dent and Clarke 2015). Dent and Clarke (2015) emphasized that: "the significant difference between the unit values of trade in both commodity categories reflects the much higher value of shark fins, which retail as some of the most expensive seafood items in the world." Historically, this disparity in value has sometimes led fishers to remove fins from captured sharks before discarding the less valuable remainder in order to maximize the value of the contents of their limited hold space (Dent and Clarke 2015).

Shark finning makes monitoring catch levels difficult because shark carcasses are not available to be counted or weighed, and these figures are challenging to estimate based solely on the quantity of fins landed. The resulting lack of accurate catch data makes effective shark fishery management on an international scale troublesome, because international fishing pressure on sharks may not be well understood and is therefore commonly underestimated (Jacquet *et al.,* 2008). Clarke *et al.,* (2006b) used the shark fin trade data to estimate the total number of sharks traded worldwide, and found that between 26 and 73 million individual sharks are traded annually in the market (median = 38 million/year), with a median biomass estimate of 1.70 million t/year (range: 1.21 - 2.29 million t/year). This biomass estimate is almost three times higher than the maximum calculated using FAO global shark capture production statistics (0.60 million t/year). In a similar vein, a recent study by Jacquet *et al*. (2008) found that Ecuadorian landings of sharks have also been grossly underestimated compared to what is reported to the FAO. For the period of 1991-2004, reconstructed estimates from government reports and grey literature were 3.6 times greater than what was reported to the FAO. Further, because some countries, such as Spain, do not report shark fins as a separate commodity in the FAO database, but lump them into general "shark" categories, the FAO shark fin export data may not be a good indicator of the global trade in shark fins. These studies indicate that the FAO database, the only source for current international catch statistics, may be drastically under-representing global shark catches. However, this issue is changing as the World Customs Organization now requires countries to create fin-specific commodity codes (Dent and Clarke 2015), though this does not necessarily remedy the under-reporting of sharks that are caught.

Demand from international shark fin trade is the main economic force driving the retention and subsequent finning of oceanic whitetip sharks taken as bycatch, as their large, morphologically distinct fins command high prices on the international market of US $45–85/kg (CITES 2013). Thus, the oceanic whitetip shark is considered a "preferred" species for its fins and make up part of the "first choice" category in the China, Hong Kong SAR fin market (Vannuccini 1999). In order to determine the species composition of the shark fin trade, Clarke *et al.,* (2006a) analyzed 1999-2001 Hong Kong trade auction data in conjunction with species-specific fin weights and genetic information to estimate the annual number of globally traded shark fins. Using this approach, the authors discovered that oceanic whitetip sharks are sold under their own category "*Liu Qiu*" and represent approximately 1.8% of the Hong Kong shark fin market. This level of oceanic whitetip shark fins in the trade translates to an estimated total annual catches of oceanic whitetip of approximately 200,000–1,200,000 individuals (median ~700,000) or ~9,000–48,000 tonnes (median ~21,000 t) (Clarke *et al.,* 2006b). In 2003, a peak year for fin imports to Hong Kong, Clarke (2008) estimated that 80-210,000 oceanic whitetip sharks were sourced from the Atlantic Ocean alone to supply the Hong Kong fin market.

In more recent years, genetic testing conducted in various fish markets provides additional confirmation of the species-specific utilization of oceanic whitetip shark in the shark fin trade. Genetic sampling was conducted on shark fins collected from several fish markets throughout Indonesia that identified oceanic whitetip shark fins as present, and comprised approximately 1.72% of the fins tested (Sembiring *et al.,* 2015). In a genetic barcoding study of shark fins from markets in Taiwan, the oceanic whitetip was 1 of 20 species identified and comprised 0.38% of collected fin samples (Liu *et al.,* 2013). In another genetic barcoding study of fins from United Arab Emirates, oceanic whitetip shark comprised 0.45% of fins tested (Jabado *et al.,* 2015). Although it is uncertain whether these studies are representative of the entire market within each respective country, results of these genetic tests confirm the continued presence of oceanic whitetip shark fins in various markets throughout its range.

From 2000 to 2011, China, Hong Kong Special Administrative Region (SAR) maintained its position as the world's largest trader of shark fins, controlling the majority of global trade (Dent and Clarke 2015). During this time, China, Hong Kong SAR recorded average annual shark fin imports of 10,490 t, worth $302 million and represents about 80% of the global total in value terms (62% of total volume). According to Dent and Clarke (2015), China, Hong Kong SAR reported imports of 3,319 t ($154.9 million) of "dried, unprocessed" fins, 188 tonnes ($1.9 million) of "frozen, unprocessed" fins, and 14 tonnes ($840,000) of dried, processed fins in 2012. In the same year, China, Hong Kong SAR reported a total of 4,959 t of high-valued "frozen shark meat" imports, worth $64.3 million. The majority of these imports originated in Spain or Singapore (Dent and Clarke 2015). Overall, the trade in shark fins through China, Hong Kong SAR, which has served as reliable gauge of the global trade for many years, rose by 10%

in 2011 but fell by 22% in 2012. Dent and Clarke (2015) identified a number of factors that may have contributed to the downturn in the trade of fins through China, Hong Kong SAR, including:

- increased domestic chondrichthyan production by the Chinese fleet;
- new regulations in China government officials' expenditures;
- consumer backlash against artificial shark fin products;
- increased monitoring and regulation of finning;
- a change in trade dynamics related to China's entry into the World Trade Organization in 2001 and subsequent trade agreements with China, Hong Kong SAR;
- other trade bans and curbs; and
- a growing conservation awareness.

A number of indicators also suggest that the decline in the shark fin trade through China, Hong Kong SAR and China will continue. The shark fin trade as a whole has declined slightly since 2003 (see Figure 60 below), and is contrary to expectations of an increase in demand with the continued growth of the Chinese economy (Eriksson and Clarke 2015). The pattern of trade decline closely mirrors the pattern in chondrichthyan capture production; this suggests a strong linkage between the quantity harvested and the quantity traded (Eriksson and Clarke 2015). However, a government-led backlash against "conspicuous consumption" of shark fins in China, combined with increasing momentum of global conservation movements, appears to have had some impact on the trade (Eriksson and Clarke 2015).

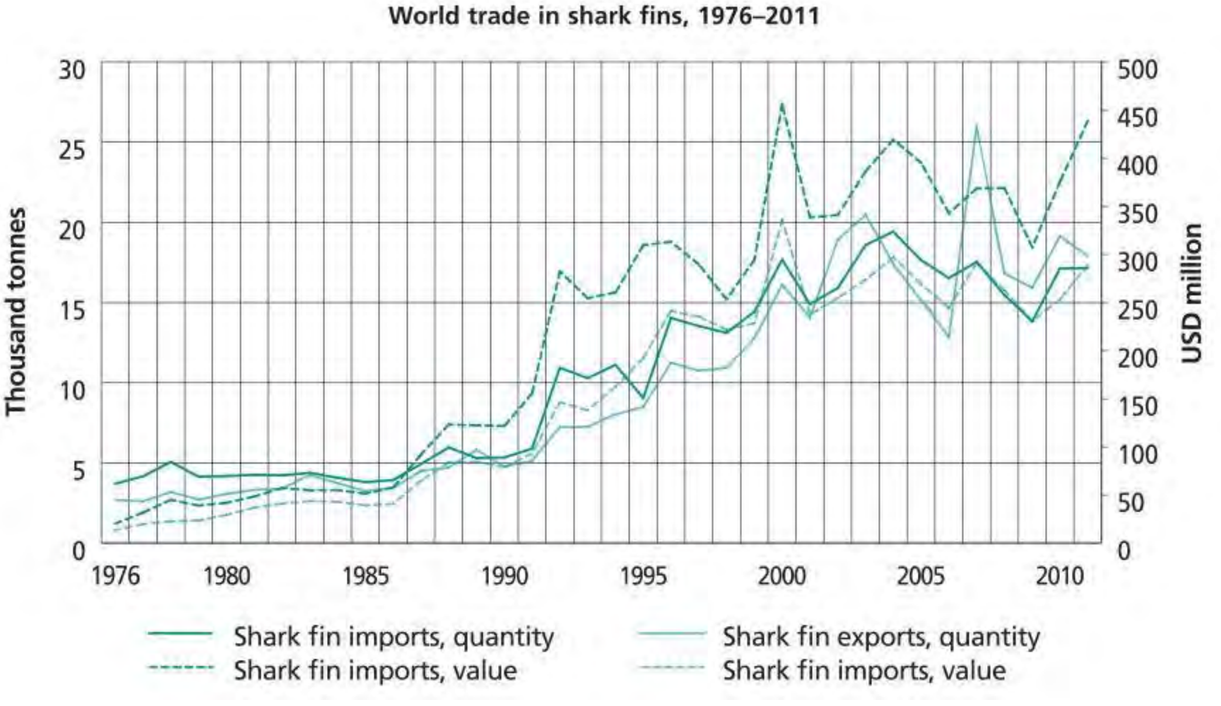

Figure 60 The trend in the global trade in shark fins from 1976 to 2011. Source: Dent and Clarke 2015.

Global data from FAO's Fishery Commodities and Trade Database also reflects a recent decrease in shark fin exports. The export of all shark products has substantially increased since the early 1990s, but appears to have leveled off in the last few years (See Figure 61 below). It should be noted that not all fins in the market originate from shark finning, and there is growing pressure from many countries to stop finning and instead require all fins remain naturally attached to the carcass, which has likely had some effect on the recent surge in the shark meat trade (see section 4.4 on *Inadequacy of Existing Regulatory Mechanisms*).

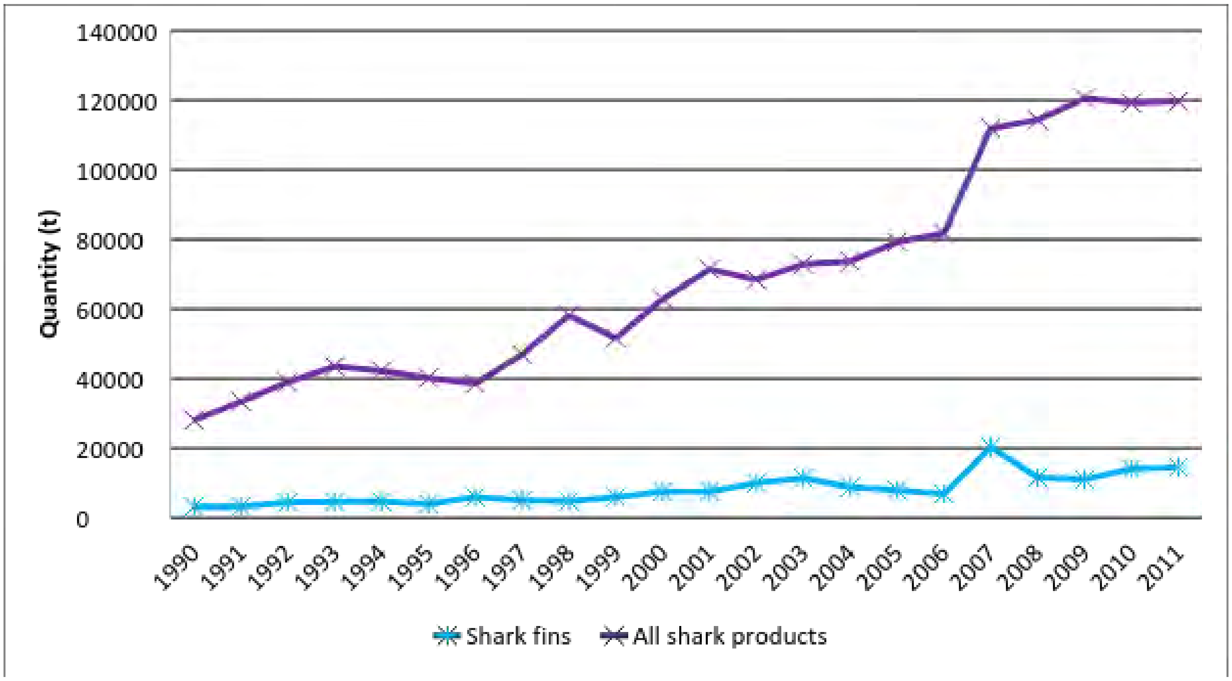

Figure 61 Global exports of shark products from 1990-2011, as reported in the FAO Fishery Commodities and Trade Database. Shark fins include: shark fins dried, salted; shark fins dried, unsalted; shark fins in brine but not dried or smoked; shark fins frozen; and shark fins prepared or preserved. Shark products include: all shark fins (described above); sharks nei, frozen; sharks, rays nei, frozen; shark fillets nei. frozen; sharks, rays, chimaeras nei fillets, frozen; sharks nei, fresh or chilled; sharks rays, skates, fresh or chilled; shark fillets, fresh or chilled; sharks, rays, chimaeras fillets, fresh or chilled; sharks, dried, salted or in brine; sharks, rays, etc., dried, salted or in brine; shark oil; shark liver oil ("nei" = not elsewhere included).

Despite the potential improvements in the trade, it is clear that the shark fin trade has asserted and continues to assert significant pressure on oceanic whitetip sharks, as they are preferred species for their fins and obtain a high price in the international market. Although quantifying the magnitude of impact on the global population abundance of oceanic whitetip shark is difficult, it is likely that the trade has had a significant impact as it has been a main economic driver for retention of oceanic whitetip sharks in commercial fisheries throughout its range. Although the global trade in shark fins appears to have decreased slightly since the early 2000s, it appears that there has been a major surge in the shark meat trade, with global trade data showing a steady expansion of the shark meat trade over the last decade or so (Dent and Clarke 2015). In fact, the latest official FAO figure of chondrichthyan meat imported in 2011 (121,641 t worth $379.8 million) represents a 42% increase by volume compared with 2000. Additionally, the trend observed in shark meat trade unit values in many key trading countries has increased in the past decade, even as the quantity of shark meat being traded has risen substantially. This suggests that underlying demand for these products is increasing. Thus, there are likely to be some areas where demand for shark meat is high enough that even if demand for shark fins wanes, existing fishing pressure will not (Dent and Clarke 2015). However, given that oceanic whitetip shark is prohibited in fisheries of all the relevant RFMOs, it is unlikely new markets would develop for this species.

Summary

Overall, there is a paucity of quantitative data with which to determine global trends in this widely-distributed tropical oceanic shark. However, based on best available scientific and commercial information, it appears that the oceanic whitetip shark has experienced significant population declines throughout a large portion of its range due to pressures associated with bycatch-related retention and mortality in commercial fisheries (e.g., Western and Central Pacific, Northwest and Southwest Atlantic, and Indian Oceans). Although the Northwest Atlantic population may have stabilized, all other populations are likely experiencing some level of decline or their status is currently unknown. All stocks of oceanic whitetip are experiencing some level of exploitation from commercial fisheries, but the level of fishing mortality likely varies, and is unknown for all stocks except one (Western and Central Pacific) due to the general lack of stock assessments on oceanic whitetip sharks. However, a number of other abundance indices are available to make inferences regarding population trends in several areas.

In the Eastern Pacific, fisheries data from the tropical tuna purse seine fishery indicates a significant population decline in this region as a result of bycatch-related mortality in both purse seine and longline fisheries. Based on catches per set as well as presence/absence of oceanic whitetip shark on associated sets in the tuna purse seine fishery, the oceanic whitetip shark population in the tropical Eastern Pacific has potentially declined by 80-95%. However, the reliability of these estimates may be somewhat uncertain as they are derived from nominal catch rates and are not standardized to account for other factors that may affect catch rates not related to changes in abundance (e.g., climate related factors). Nonetheless, based on the known condition of the species, there is no evidence to suggest that other factors besides overutilization have caused the significant observed decline, as the species has seemingly disappeared from fishing grounds here and is now rarely encountered, while catches and encounters of the closely related silky shark have remained relatively constant. Given the continued increase in fishing effort in this region, including a steady increase in the number of FAD sets (which account for 90% of oceanic whitetip catch in this region), oceanic whitetip sharks will likely continue to experience overutilization in the Eastern Pacific Ocean.

In the Northwest Atlantic and Gulf of Mexico, several studies indicate large historical declines in oceanic whitetip shark abundance (e.g., up to 70% from 1992-2000 and up to 88% between the 1950's and 1990's, respectively); but, more recent analyses indicate this population may have stabilized in recent years, with an estimated decline of approximately 4% since 1992. However, fishing pressure on oceanic whitetip sharks began over two decades prior to the start of this time series; thus the estimated declines are not from historical virgin biomass. There is still disagreement in the literature regarding the current status of oceanic whitetip shark in the U.S. Atlantic, and a stock assessment has not been conducted. Currently, the best available scientific information indicates that current catch levels of oceanic whitetip shark in this region are low, which may be a result of past declines; however, landings of the species in this region have also continued to decline since species-specific regulations have been implemented that prohibit this species in U.S. commercial ICCAT-associated fisheries. Therefore, overutilization may not be as significant of a threat in this region in the foreseeable future.

In the Southwest Atlantic, oceanic whitetip sharks were once considered common bycatch in commercial longline fisheries in Brazil, comprising nearly 30% of all shark catches in surveys from the 1990s. Recently, however, it appears that oceanic whitetip shark is less abundant in the

Southwest Atlantic region, with very low CPUE rates across the region and most captures comprised of juveniles. In Brazil, which is the largest oceanic whitetip shark catching country in the region, a combination of tagging data and fisheries information suggests that the species' preferred vertical and horizontal habitat is significantly exploited by the Brazilian longline fishery. A demographic analysis from this region also suggests that the species has undergone at least a 50% population decline as a result of unsustainable fishing effort.

In the Western and Central Pacific, historical information and observations suggest this species was once one of the most abundant pelagic shark species encountered in commercial fisheries; however, several lines of evidence suggest significant and continued population declines of oceanic whitetip shark across the Western and Central Pacific, with some areas exhibiting declines in excess of 90%. In particular, the first and only stock assessment of oceanic whitetip shark determined that the species is experiencing overfishing and the stock is in an overfished state (Rice and Harley 2012). The main cause of these declines identified in the stock assessment was bycatch-related mortality in longline fisheries, with targeted longlining and purse seine fisheries being secondary sources of mortality. These fisheries tend to concentrate their efforts in tropical latitudes, which is the species preferred core habitat, thereby contributing to substantial fisheries-related mortality. Thus, due to the high fishing effort on large pelagic species in this region, with reported increases in fishing effort in recent years, oceanic whitetip sharks are likely experiencing overutilization across the Western and Central Pacific, as evidenced by declines in catch rates as well as biomass and size indices.

In the Indian Ocean, a combination of qualitative and quantitative data suggests that the oceanic whitetip shark has undergone population declines in this region. Oceanic whitetip sharks have been recorded in fisheries data for over 60 years; however, due to a lack of catch and abundance information, the status of oceanic whitetip shark in the Indian Ocean is largely uncertain. While robust species-specific fisheries information is largely unavailable, decreases in nominal CPUE and mean weight of individuals have been demonstrated for the oceanic whitetip shark. Additionally, a few quantitative assessments of various longline and purse seine fisheries operating in the Indian Ocean indicate potential abundance declines between 25-90%, though these estimates are uncertain due to the lack of robust datasets. Overall, catches of oceanic whitetip shark reported to the IOTC are notably high in this region, with high at-vessel mortality rates and no indication of fishing pressure ceasing in the foreseeable future; thus, given the prevalence of oceanic whitetip shark as bycatch in fisheries in this region, representing approximately 11% of the total shark catch, combined with their relatively low-moderate productivity, it is likely that the impact to oceanic whitetip is significant in the Indian Ocean.

Shark trade

Studies found that oceanic whitetip shark represents approximately 2% of the Hong Kong shark-fin market, which has been used as an indicator of the global trade for many years. This level of oceanic whitetip fins in the trade translates to an annual estimate of up to 1.2 million individuals killed and traded per year. Given the relative ease of identifying oceanic whitetip shark fins, it is likely that the estimate is more reliable than for other species. Genetic studies of fins from markets in Indonesia, Taiwan, and United Arab Emirates also recorded oceanic whitetip shark at the species level, indicating the prevalence of oceanic whitetip fins in various markets throughout its range. Thus, it is clear that the shark fin trade is asserting significant pressure on the global oceanic whitetip shark population, as it is the main driving factor behind retention of this species, though the exact magnitude of impact is uncertain. Although demand for shark fins is seemingly on the decline in recent years, it is clear that the demand for oceanic whitetip shark fins is still high, given their high preference and monetary value in the Hong Kong market. This is evidenced by the fact that as recently as October 2015, Indonesian authorities conducted a seizure of 3,000 illegal fins from oceanic whitetip sharks taken from Indonesian waters, despite national and international regulations to protect the species. Additionally, since 2014, several shipments of oceanic whitetip fins have been confiscated upon arrival in Hong Kong because they lacked proper CITES export permits from the countries of origin. In fact, in the first two months of 2017 alone, more than a ton of shark fins from hammerhead and oceanic whitetip sharks were seized by Hong Kong customs[11]. Although the demand for shark meat has increased in recent years, it is unlikely that new markets would develop for oceanic whitetip shark meat, given retention of the species has been prohibited in all relevant RFMOs.

4.3 (C) Disease or Predation

Disease

Disease is not thought to be a factor influencing the status of oceanic whitetip shark. If the oceanic whitetip shark is similar to other shark species, it likely harbors a diverse assemblage of macroparasites including cestodes, nematodes, leeches, copepods, and amphipods. In addition, at least some oceanic whitetip sharks are infected with highly pathogenic *Vibrio harveyi* (Zhang, *et al*., 2009). This bacterium is known to cause deep dermal lesions, gastro-enteritis, eye lesions, infectious necrotizing enteritis, vasculitis, and skin ulcers in marine vertebrates (Austin and Zhang 2006). *Vibrio harveyi* is considered to be more serious in immunocompromised hosts (Austin and Zhang 2006), and therefore may act synergistically with the high pollutant loads that oceanic whitetip sharks potentially experience to create an increased threat to the species. However, there is no additional information available regarding the magnitude of impact these parasites may have on the health of oceanic whitetip populations. Therefore, we cannot conclude that disease is an operative threat to the oceanic whitetip shark.

Predation

Predation is also not thought to be a factor influencing the status of oceanic whitetip sharks; the most significant predator on oceanic whitetip sharks is likely humans. Given that oceanic whitetip pups are born at a small size (about 65 cm), pups born in oceanic tropical waters are more vulnerable to predation. It may take the oceanic whitetip shark 2-3 years to attain a size that would deter predation, , although the larger litter size may serve to counteract the longer exposure and vulnerability to predators (Branstetter (1990) *In:* Pratt (1990)). However, information regarding natural predation rates of oceanic whitetip sharks and how predation may be impacting the global population is unavailable. Therefore, we cannot conclude that predation is an operative threat to the oceanic whitetip shark.

4.4 (D) Inadequacy of Existing Regulatory Mechanisms

Existing regulatory mechanisms for oceanic whitetip shark include federal, state, and international regulations. Below is a description and evaluation of current domestic and international management measures that may affect oceanic whitetip sharks. Though there are numerous regulatory mechanisms that may impact the status of sharks in general, as well as

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[11] https://phys.org/news/2017-03-massive-hong-kong-shark-fin.html

species-specific regulations for oceanic whitetip in particular, the lack of data reporting on oceanic whitetip catches, combined with a the lack of information on implementation of and compliance with management measures in most countries, makes it difficult to measure the adequacy of current regulatory mechanisms as they relate to the global population of the oceanic whitetip shark. The oceanic whitetip shark is a highly migratory species found worldwide and thus requires protection in every ocean basin through international cooperation. Below is an analysis of existing regulatory mechanisms.

United States Regulations

There are a number of management authorities governing U.S. Fisheries, including the Magnuson-Stevens Fisheries Conservation and Management Act (MSA), 16 U.S.C. 1801 *et seq.* The Magnuson-Stevens Act establishes the authority and responsibility of the Secretary of Commerce to develop FMPs and subsequent amendments for managed stocks. The MSA requires NMFS to allocate both overfishing restrictions and recovery benefits fairly and equitably among sectors of the fishery. In the case of an overfished stock, NMFS must establish a rebuilding plan. The FMP or amendment to such a plan must specify a time period for ending overfishing and rebuilding the fishery that shall be as short as possible, taking into account the status and biology of the stock of fish, the needs of fishing communities, recommendations by international organizations in which the U.S. participates, and the interaction of the overfished stock within the marine ecosystem. The rebuilding plan cannot exceed ten years, except in cases where the biology of the stock of fish, other environmental conditions, or management measures under an international agreement in which the U.S. participates dictate otherwise. The U.S. Atlantic tuna and tuna-like species fisheries are managed under the dual authority of the MSA and the Atlantic Tunas Convention Act (ATCA) of 1975, 16 U.S.C. 971 *et seq*. The U.S. vessels that fish for tuna and associated species in the eastern tropical Pacific Ocean may be subject to management measures under the Tuna Conventions Act of 1950 (16 U.S.C. 951 *et seq*.) and potentially the U.S.-Canada Albacore Treaty (Miller *et al*. 2014). U.S. vessels that fish for highly migratory fish species in the Western and Central Pacific Ocean may be subject to management measures under the Western and Central Pacific Fisheries Convention Implementation Act (16 U.S.C. 6901 *et seq*.).

State fishery management agencies have authority for managing fishing activity only in state waters (0-3 miles in most cases; 0-9 miles off Texas and the Gulf coast of Florida). As mentioned above, in the case of federally permitted shark fishers along the Atlantic coast and in the Gulf of Mexico and Caribbean, fishers are required to follow federal regulations in all waters, including state waters. To aid in enforcement and reduce confusion among fishers, the Atlantic States Marine Fisheries Commission (ASMFC), which regulates fisheries in state waters from Maine to Florida, implemented a Coastal Shark FMP that mostly mirrors the federal regulations for sharks (See Appendix 1). Additionally, other states have implemented or are working towards the implementation of fin bans and efforts are being made to allow/preserve subsistence harvest in some of the U.S. territories.

Pacific Ocean

In the U.S. Pacific, HMS fishery management is the responsibility of adjacent states and three regional management councils that were established by the Magnuson-Stevens Act, including: the Pacific Fishery Management Council (PFMC), North Pacific Fishery Management Council (NPFMC), and the Western Pacific Fishery Management Council (WPFMC). However, because of the oceanic whitetip shark's more tropical distribution, only the WPFMC directly manages this species. The WPFMC has jurisdiction over the EEZs of Hawaii, Territories of American Samoa and Guam, Commonwealth of the Northern Mariana Islands, and the Pacific Remote Island Areas, as well as the domestic fisheries that occur on the adjacent high seas. The WPFMC developed the Pelagics FEP (formerly the Fishery Management Plan for the Pelagic Fisheries of the Western Pacific Region) in 1986 and NMFS, on behalf of the U.S. Secretary of Commerce, approved the Plan in 1987. Since that time, the WPFMC has recommended, and NMFS has approved, numerous amendments to the Plan as necessary for conservation and management purposes. The WPFMC manages HMS fisheries pursuant to the FEP, and species that are managed under FMPs or FEPs are called Management Unit Species (MUS) and typically include those species that are caught in quantities sufficient to warrant management or specific monitoring by NMFS and the Council. In the FEP, the oceanic whitetip shark is designated as a Pelagic MUS and, thus, is subject to regulations under the FEP. These regulations are intended to minimize impacts to targeted stocks as well as protected species. Fishery data are also analyzed in annual reports and used to amend the FEP as necessary. As previously described, oceanic whitetip sharks are caught in longline fisheries of both Hawaii and American Samoa. The Hawaii-based and American Samoa longline fisheries are similar, in that they operate under extensive regulatory measures, including gear, permit, logbook requirements, vessel monitoring system, and protected species workshop requirements. In 2002, vessels 50 feet and longer were prohibited from fishing for pelagic fish around Tutuila, the Manua Island, Rose Atoll, and Swains Islands in American Samoa. However, due to a change in fishery conditions, NMFS recently proposed to allow federally-permitted U.S. longline vessels 50 ft and longer to fish in certain portions of the LVPA (80 FR 51527). Specifically, the proposed action would allow large U.S. vessels that hold a Federal American Samoa longline limited entry permit to fish within the LVPA seaward of 12 nm around Swains Island, Tutuila, and the Manua Islands.

In 2015, NMFS issued final regulations to implement decisions of the Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean (WCPFC) to prohibit the retention of oceanic whitetip sharks in fisheries operating within the WCPFC's area of competence (or Convention Area), which comprises the majority of the Western and Central Pacific Ocean. The regulations were published in the *Federal Register* on February 19, 2015 (80 FR 8807) and include prohibitions on the retention of the oceanic whitetip shark, as well as requirements to release any oceanic whitetip caught, and are applicable to all U.S. fishing vessels used for commercial fishing for HMS in the Convention Area (PIRO 2015). Given the relatively higher at-vessel survivorship of oceanic whitetip sharks, adequate implementation of these regulations has the potential to be beneficial for the species. However, given the severely depleted state of the oceanic whitetip shark in the Western and Central Pacific, less than full implementation and enforcement may not be adequate to prevent continued population declines of the species given the high level of fishing mortality the species experiences in this portion of its range (see the *Regional Analysis* section for the Western and Central Pacific below for more details).

Atlantic Ocean (U.S. Northwest Atlantic and Gulf of Mexico)

On November 28, 1990, the President of the United States signed into law the Fishery Conservation Amendments of 1990. This law amended the Magnuson-Stevens Act and gave the Secretary of Commerce the authority to manage HMS in the U.S. EEZ of the Atlantic Ocean, Gulf of Mexico, and Caribbean Sea (16 U.S.C. 1811 and 16 U.S.C. 1854(f)(3)). The Atlantic

HMS Management Division within NMFS develops regulations for Atlantic HMS fisheries and primarily coordinates the management of HMS fisheries in Federal waters (domestic) and the high seas (international), while individual states establish regulations for HMS in state waters. However, in the case of federally permitted shark fishers, as a condition of their permit, the fishers are required to follow Federal regulations in all waters, including state waters, unless the state has more restrictive regulations. For example, the Atlantic States Marine Fisheries Commission (ASMFC) recently developed an interstate coastal shark FMP that coordinates management measures among all states along the Atlantic coast (FL to ME) in order to ensure that the states are following Federal regulations. This interstate shark FMP became effective in 2010.

In the Atlantic, oceanic whitetip sharks are managed under the pelagic species complex of the Consolidated Atlantic HMS FMP. The first FMP for sharks of the Atlantic Ocean (1993) classified the status of pelagic sharks as unknown because no stock assessment had been conducted for this complex. At that time, the Maximum Sustainable Yield (MSY) for pelagic sharks was set at 1,560 mt dressed weight (dw), which was the 1986-1991 commercial landings average for this group. However, as a result of indications that the abundance of Atlantic sharks had declined, commercial quotas for pelagic sharks were reduced in 1997. The quota for pelagic sharks was then set at 580 mt. In 1999, the FMP for Atlantic Tunas, Swordfish, and Sharks[12] implemented the following measures affecting pelagic sharks: 1) a reduction in the recreational bag limit to 1 Atlantic shark per vessel per trip, with a minimum size of 137 cm fork length for all sharks, 2) an increase in the annual commercial quota for pelagic sharks to 853 mt dw, apportioned between porbeagle (92 mt), blue sharks (273 mt dw), and other pelagic sharks (488 mt dw), with the pelagic shark quota being reduced by any overharvest in the blue shark quota, and 3) making the bigeye sixgill, sixgill, sevengill, bigeye thresher, and longfin mako sharks prohibited species that cannot be retained.

The implementing regulations for the conservation and management of the domestic fisheries for Atlantic swordfish, tunas, sharks, and billfish are published in the 2006 Consolidated HMS FMP[13] (71 FR 58058, NMFS 2006). Since 2006, this FMP has been amended ten times. Amendment 2, finalized in June 2008, requires that all fins remain naturally attached through landing in both the commercial and recreational fisheries (June 24, 2008, 73 FR 35778; corrected on July 15, 2008, 73 FR 40658).

Any fisher who fishes for, retains, possesses, sells, or intends to sell, Atlantic sharks needs a Federal Atlantic Directed or Incidental shark limited access permit. Generally, directed shark permits allow fishers to target sharks while incidental permits allow fishers who normally fish for other species to land a limited number of sharks. The limited access permits are administered under a limited access program and NMFS is no longer issuing new shark limited access permits. To enter the directed or incidental shark fishery, fishers must obtain a permit via transfer from an existing permit holder who is leaving the fishery, subject to the vessel upgrading restrictions. Under a directed shark permit, there is no directed numeric retention limit for pelagic sharks, subject to quota limitations. An incidental permit allows fishers to keep up to a total of 16 pelagic or small coastal sharks (all species combined) per vessel per trip. Authorized gear types

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[12] http://www.nmfs.noaa.gov/sfa/hms/documents/fmp/tss_fmp/index.html

[13] http://www.fisheries.noaa.gov/sfa/hms/documents/fmp/consolidated/index.html

include: pelagic or bottom longline, gillnet, rod and reel, handline, or bandit gear. All fins must remain naturally attached. The annual quota for pelagic sharks (other than blue sharks or porbeagle sharks) is currently 488.0 mt dressed weight.

NMFS monitors the different shark quota complexes annually and will close the fishing season for each fishery after 80% of the respective quota has been landed or is projected to be landed. Atlantic sharks and shark fins from federally permitted vessels may be sold only to federally permitted dealers; however, as noted previously, all sharks must have their fins naturally attached through offloading. The head may be removed and the shark may be ◦ and bled, but the shark cannot be filleted or cut into pieces while onboard the vessel. Logbook reporting is required for selected fishers with a federal commercial shark permit. In addition, fishers may be selected to carry an observer onboard, and some fishers are subject to vessel and electronic monitoring systems depending on the gear used and where they fish. Since 2006, pelagic longline, bottom longline and gillnet fishermen fishing for sharks have been required to attend workshops to learn how to release sea turtles, protected species, and prohibited shark species in a manner that maximizes survival. Additionally, NMFS published a final rule on 7 February, 2007 (72 FR 5633), that requires participants in the Atlantic shark bottom longline fishery to possess, maintain, and utilize handling and release equipment for the release of sea turtles, other protected species, and prohibited shark species. Additionally, in efforts to reduce bycatch in the first place, NMFS has implemented a number of time/area closures with restricted access to fishermen with HMS permits who have pelagic longline gear onboard their vessel (see Figure 62 below).

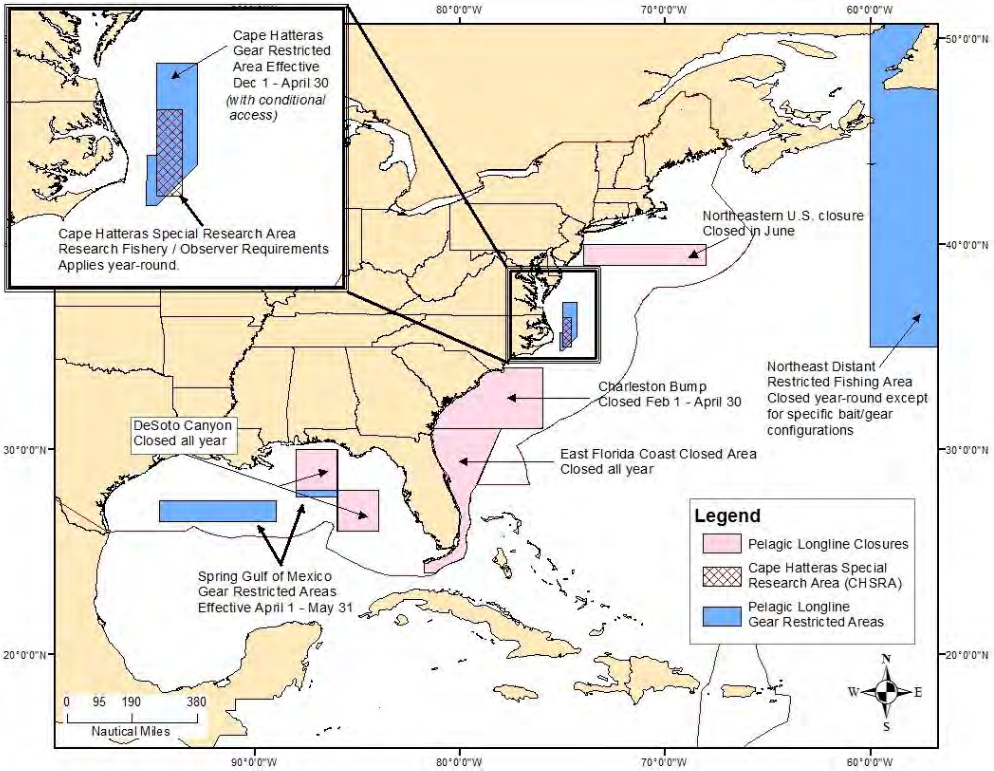

Figure 62 Time/area closures and gear restricted areas in the Atlantic, Gulf of Mexico, and Caribbean Sea that limit use of pelagic longline gear (NMFS 2016).

Although there has been so scientific study conducted to confirm whether these time/area seasonal closures have reduced bycatch of oceanic whitetip sharks, it is possible these regulations have had a positive impact on reducing bycatch of oceanic whitetip shark in the Northwest Atlantic pelagic longline fishery. In particular, the area of the Charleston Bump has historically proven to be a hotspot for oceanic whitetip catches (John Carlson, personal communication 2017); therefore, that particular closure has likely benefited oceanic whitetip sharks to some degree.

The HMS Management Division also published an amendment to the Consolidated Atlantic HMS FMP that specifically addresses Atlantic HMS fishery management measures in the U.S. Caribbean territories (77 FR 59842; Oct. 1, 2012). Due to substantial differences between some segments of the U.S. Caribbean HMS fisheries and the HMS fisheries that occur off the mainland of the United States (including permit possession, vessel size, availability of processing and cold storage facilities, trip lengths, profit margins, and local consumption of catches), the HMS Management Division implemented measures to better manage the traditional small-scale commercial HMS fishing fleet in the U.S. Caribbean Region. Among other things, this rule created an HMS Commercial Caribbean Small Boat (CCSB) permit, which: allows fishing for and sales of bigeye, albacore, yellowfin, and skipjack tunas, Atlantic swordfish, and Atlantic sharks within local U.S. Caribbean market; collects HMS landings data through existing territorial government programs; authorizes specific gears; is restricted to vessels less than or equal to 45 feet (13.7 m) length overall all; and may not be held in combination with any other Atlantic HMS vessel permits. However, at this time, fishermen who hold the CCSB permit are prohibited from retaining Atlantic sharks, and are restricted to fishing with only rod and reel, handline, and bandit gear under the permit. Both the CCSB and Atlantic HMS regulations will help protect oceanic whitetip sharks while in the Northwest Atlantic Ocean, Gulf of Mexico, and Caribbean Sea.

In order to implement the International Commission for the Conservation of Atlantic Tuna (ICCAT) Recommendation 10-07 for the conservation of oceanic whitetip sharks, NMFS published a final rule in 2011 that prohibits retention of oceanic whitetip sharks in the PLL fishery and on recreational (HMS Angling and Charter headboat permit holders) vessels that possess tuna, swordfish, or billfish (76 FR 53652). See Appendix 1 for a table that describes relevant regulatory mechanisms in U.S. states and territories in the Atlantic. The implementation of regulations to comply with ICCAT Recommendation 10-07 for the conservation of oceanic whitetip sharks is likely the most influential regulatory mechanism in terms of reducing mortality of oceanic whitetip sharks in the U.S. Atlantic. It should be noted that oceanic whitetip sharks are still occasionally caught as bycatch and landed in this region despite its prohibited status in ICCAT associated fisheries (NMFS 2012; 2014), as retention is permitted in other authorized gears other than pelagic longlines (e.g., gillnets, bottom longlines); however, these numbers have decreased. Prior to the implementation of the retention prohibition on oceanic whitetip, an analysis of the 2005-2009 HMS logbook data indicated that, on average, a total of 50 oceanic whitetip sharks were kept per year, with an additional 147 oceanic whitetip sharks caught per year and subsequently discarded (133 released alive and 14 discarded dead). Thus, without the prohibition, approximately 197 oceanic whitetip sharks could be caught and 64 oceanic whitetip sharks (32%) could die from being discarded dead or retained each year (NMFS 2011b). However, since the prohibition was implemented in 2011, estimated commercial landings of oceanic whitetip declined from only 1.1 mt in 2011 to only 0.03 mt in 2013 (NMFS 2012;

2014). While the retention ban for oceanic whitetip does not prevent incidental catch or subsequent at-vessel and post-release mortality, it is likely somewhat effective in reducing overall fishing mortality on the species in the Atlantic PLL fishery. In fact, in 2013, NMFS reported a total of 33 oceanic whitetip interactions, with 88% (i.e., 29 individuals) released alive and only 4 discarded dead. It also appears that the relative abundance of oceanic whitetip shark may have stabilized in the region concomitant with pelagic shark management in the early 1990s.

Overall, it's possible these regulations may have had a positive effect on reducing bycatch and fisheries-related mortality of oceanic whitetip shark in the Northwest Atlantic pelagic longline fishery, particularly given the stabilized trend shown by the ERA team's analysis of observer data from the fishery, but there's no way to confirm this assertion. Overall, we do agree that regulatory mechanisms in the Northwest Atlantic in general have likely improved the status of the oceanic whitetip shark in this portion of its range.

U.S. Finning Laws and Regulations

Two influential domestic regulations for the conservation and management of sharks in the United States include the *Shark Finning Prohibition Act* and the *Shark Conservation Act*. The Shark Finning Prohibition Act was enacted in December 2000 and implemented by final rule on February 11, 2002; (67 FR 6194). Section 3 of the Shark Finning Prohibition Act amended the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) to prohibit any person under U.S. jurisdiction from: (i) engaging in the finning of sharks; (ii) possessing shark fins aboard a fishing vessel without the corresponding carcass; and (iii) landing shark fins without the corresponding carcass. In addition, Section 3 of the Shark Finning Prohibition Act contains a rebuttable presumption that any shark fins landed from a fishing vessel or found on board a fishing vessel were taken, held, or landed in violation (of the Act) if the total weight of shark fins landed or found on board exceeds 5% of the total weight of shark carcasses landed or found on board. Section 9 of the Act defines finning as the practice of taking a shark, removing the fin or fins from a shark, and returning the remainder of the shark to the sea. The Shark Conservation Act was signed into law on January 4, 2011, and it amended the High Seas Driftnet Fishing Moratorium Protection Act and the MSA to improve existing domestic and international shark conservation measures. To address concerns over the practice of shark finning, the Shark Conservation Act, among other things, prohibits any person from removing shark fins at sea (with a limited exception for smooth dogfish); or possessing, transferring, or landing shark fins unless they are naturally attached to the corresponding carcass.

After the passage of the Shark Finning Prohibition Act, U.S. exports of dried shark fins dropped substantially (Figure 63), which was expected. With the passage of the U.S. Shark Conservation Act in 2011, exports of dried shark fins dropped again by 58% to 15 mt, which represented the second lowest export amount since 2001. This is in contrast to the price per kg of shark fin, which was at its highest price of ~$100/kg, and suggests that existing regulations have likely been effective at discouraging fishing for sharks solely for the purpose of the fin trade. Thus, although the international shark fin trade is likely a driving force behind the overutilization of many global shark species, the U.S. participation in this trade appears to be diminishing (Miller *et al.* 2014). In 2012, the value of fins also decreased suggesting that the worldwide demand for fins may be on a decline. For example, due to the implementation of fin bans in various U.S. states in 2012 and 2013, U.S. fin prices decreased dramatically and U.S. shark fin exports have continued on a declining trend. However, it should be noted that the continued decline is also likely a result of the waning demand for shark fin altogether (Dent and Clarke 2015).

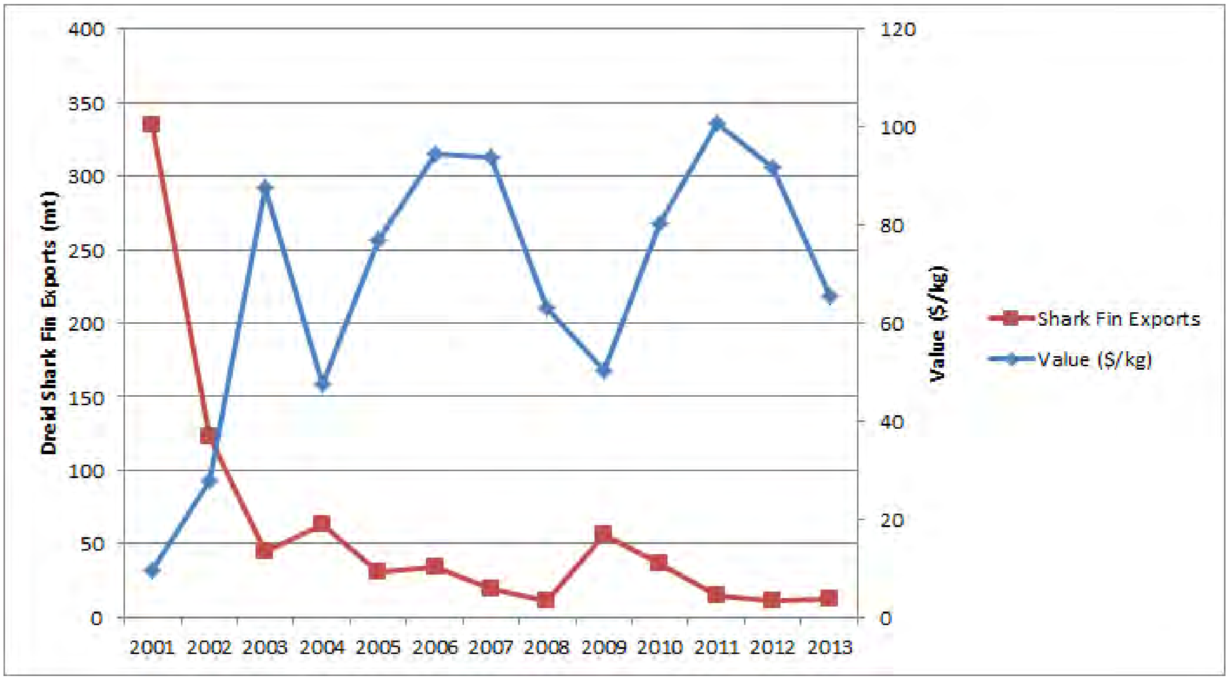

Figure 63 Amount and value of U.S. shark fin exports from 2001 to 2012. Source: Adapted from Miller *et al.* 2014 and NMFS (2012); NMFS (2013a)).

Similarly, many U.S. states, especially on the West Coast, and U.S. Flag Pacific Island Territories have also passed fin bans and trade regulations, which led to a subsequent decline of the United States' contribution to the fin trade. For example, after the state of Hawaii prohibited finning in its waters and required shark fins to be landed with their corresponding carcasses in the state in 2000, the shark fin imports from the U.S. into Hong Kong declined significantly (54% decrease, from 374 to 171 t) as Hawaii could no longer be used as a fin trading center for the international fisheries operating and finning in the Central Pacific (Figure 64) (Clarke *et al.*, 2007).

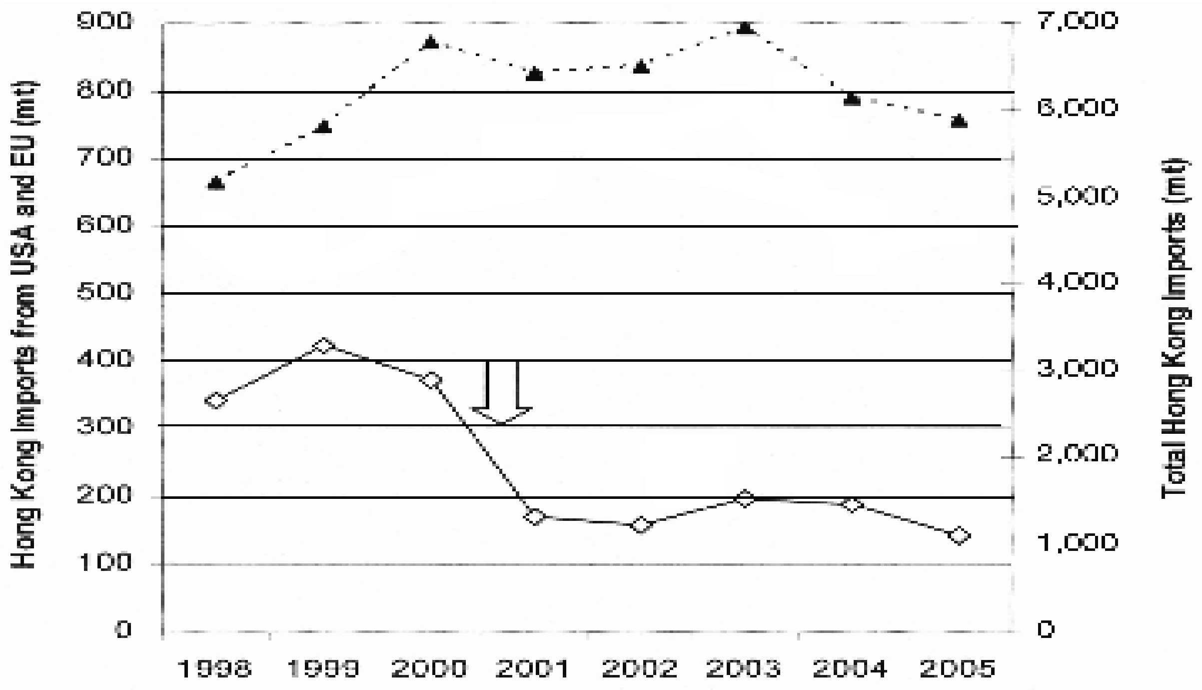

Figure 64 Annual imports of shark fin to Hong Kong from the U.S. (◊) and total Hong Kong imports (▲) from 1998-2005. The large arrow indicates the implementation of finning regulations in the state of Hawaii. Source: Adapted from Clarke *et al.* 2007.

More specifically to oceanic whitetip sharks, the finning regulations introduced in 2001 in the U.S. Hawaii-based longline fishery have reduced mortality on oceanic whitetip and other large shark species (Walsh *et al*. 2009). Prior to the ban from 1995–2000, fins were taken from a large proportion of captured oceanic whitetip sharks, with the remaining carcasses discarded (72.3% in deep sets and 52.7% from shallow sets) (Walsh *et al.,* 2009). Following the implementation of the new regulations, almost all sharks were released from 2004-2006, although some individuals were dead on release. Consequently, minimum mortality estimates declined substantially from 81.9% to 25.6% in deep sets and from 61.3% to 9.1% in shallow sets (Walsh *et al*. 2009).

Aside from this example, there is little information on the level of compliance with the various fisheries management measures for sharks, including oceanic whitetip, with compliance likely variable among other countries and regions. In other parts of the world, finning and retention bans may not be adequate for oceanic whitetip given the continued high value for their large fins. For example, despite being protected in Indonesia, an illegal seizure of approximately 3,000 oceanic whitetip fins occurred as recently as October, 2015 (see the *International Regulatory Mechanisms* section below for more details). This provides some evidence that despite species-specific regulations to protect the species, these regulatory mechanisms are only effective when implemented and enforced adequately.

International Regulations

Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES)[14]

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[14] https://www.cites.org/eng

CITES is an international agreement between governments, with the aim of ensuring that international trade in specimens of wild animals and plants does not threaten their survival. CITES contains three appendices: Appendix I includes species threatened with extinction. Trade in specimens of these species is permitted only in exceptional circumstances; Appendix II includes species not necessarily threatened with extinction, but trade must be controlled to ensure utilization is compatible with their survival; and Appendix III contains species that are protected in at least one country, which has asked other CITES Parties for assistance in controlling the trade. Due to reported population declines driven by the trade of oceanic whitetip shark fins, the oceanic whitetip shark was listed under Appendix II of CITES in 2013. This listing went into effect as of September 2014. International trade in specimens of Appendix-II species may be authorized by the granting of an export permit or re-export certificate. No import permit is necessary for these species under CITES (although a permit is needed in some countries that have taken stricter measures than CITES requires). Because the oceanic whitetip is a pelagic species mostly occurring in waters not under the jurisdiction of any State, introduction from the sea (i.e. transport of captured specimens from international waters to areas under national jurisdiction) would be expected to occur frequently in fisheries regulated by RFMOs that allow the species to be landed (FAO 2012). Under CITES, such transport of specimens listed on Appendix II would require a certificate from the State to whose jurisdiction the specimens are brought, including a Non-detriment finding and a legal acquisition finding. However, given that all RFMOs now prohibit the retention of the oceanic whitetip shark (with the exception of some countries that have taken reservations to the prohibition (e.g., India)), export of oceanic whitetip fins from most RFMO member countries should not be occurring. However, recent data from Hong Kong's Agriculture Fisheries Conservation Department (AFCD) suggests this is not the case. Since the listing of oceanic whitetip sharks under CITES Appendix II went into effect in 2014, approximately 1,263 kg (2,784 lbs) of oceanic whitetip fins have been confiscated upon entry into Hong Kong because the country of origin did not include the required CITES permits. Since 2014, confiscated oceanic whitetip fin shipments included 940.46 kg from Colombia, 10.96 kg from the Seychelles, and 272.49 kg from the United Arab Emirates (AFCD, Unpublished data). Additionally, in the first two months of 2017 alone, more than a ton of shark fins from hammerhead and oceanic whitetip sharks were seized by Hong Kong customs[15].

Convention on the Conservation of Migratory Species of Wild Animals[16]

The Convention of Migratory Species (CMS) is an environmental treaty under the auspices of the United Nations Environment Programme. The CMS provides a global platform for the conservation and sustainable use of migratory animals and their habitats, and works to bring together the Range States (i.e., the States through which migratory species pass), and lay the legal foundation for coordinating international conservation measures throughout a migratory range. However, despite being a highly migratory species in need of international cooperation for its management and conservation, the oceanic whitetip shark is not listed under the Convention.

2009 FAO Port State Measures Agreement (PSMA)

The PSMA was adopted in 2009 as a tool to combat illegal, unreported and unregulated (IUU) fishing. It aims to prevent illegally caught fish from entering international markets through ports. Under the terms of the treaty: foreign vessels will provide advance notice and request permission

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[15] https://phys.org/news/2017-03-massive-hong-kong-shark-fin.html

[16] http://www.cms.int/en

for port entry, countries will conduct regular inspections in accordance with universal minimum standards, offending vessels will be denied use of port or certain port services, and information sharing networks will be created. As IUU fishing is also a threat to vulnerable shark species, implementation of the PSMA can have a positive effect on the conservation of sharks.

International Shark Fishing and Finning Regulations

Finning bans have been implemented by a number of countries including the European Union (EU), as well as by nine RFMOs. These finning bans range from requiring fins remain attached to the body, to allowing fishers to remove shark fins if the weight of the fins does not exceed 5% of the total weight of shark carcasses landed or found onboard. In fact, all of the relevant RFMOS prohibit fins onboard that weigh more than 5% of the weight of sharks to curb the practice of shark finning. Although the fins:body weight ratios have the potential to reduce the practice of finning, these regulations do not prohibit the fishing of sharks and a number of issues associated with reliance on the 5% fins:body weight ratio requirement have been identified. For instance, some disagree that the ratio has a clear scientific basis as a conservation measure for sharks. For example, Lack and Sant (2009) note that: the percentage of fins:body weight varies widely among species, fin types used in calculation, the type of carcass weight used (whole or dressed) and fin cutting techniques. Additionally, under the fins:body weight ratio measure, sharks that are not landed with fins attached to the body make it difficult to match fins to a carcass (Lack and Sant 2009). There are also issues with using the ratios for dried vs. fresh fins, which can affect the ratio substantially. In a Fins Attached report, Arauz (2017) notes inaccurate data recording as a major issue, and provides an example from Costa Rica that demonstrates highly variable fin-to-body-weight ratios for oceanic whitetip sharks from one landing event to another. Again, such controls have no impact on the mortality of sharks that are discarded because their fins have either no or very low market value. Controls on finning also lack the capacity to provide differential protection to those shark species most at risk from overfishing (Lack and Sant 2009). In addition, with the rise in the shark meat market in recent years (Dent and Clarke 2015), retention of the full carcass for commercial purposes may be an advantage for fishers, as the product is worth keeping on board for landing. Overall, despite their existence, laws and regulations are rapidly changing and are not always effectively enforced by countries and RFMOs (Biery and Pauly 2012).

In addition to regulations specific to shark finning, numerous RFMOs and countries have implemented various regulations regarding shark fishing in general, which are described in Appendix 4 and discussed in detail below in the *Regional Analysis* section. A number of countries have enacted complete shark fishing bans (i.e., bans on retention and possession of sharks and shark products), with the Bahamas, Marshall Islands, Honduras, Sabah (Malaysia), and Tokelau (an island territory of New Zealand) adding to the list in 2011, the Cook Islands in 2012, and the Federated States of Micronesia in 2015. So-called "shark sanctuaries" (i.e., locations where harvesting sharks is prohibited) can also be found in the Eastern Tropical Pacific Seascape (which encompasses around two million km^2 and includes the Galapagos, Cocos, and Malpelo Islands), in waters off the Maldives, Mauritania, Palau, French Polynesia, New Caledonia and Raja Ampat, Indonesia. However, it should be noted that sharks can still be caught as bycatch in these areas. See Appendices 2 and 3 for a description of the existing regulatory mechanisms in place for shark fishing and finning, respectively, throughout the range of the oceanic whitetip.

A number of countries and territories also prohibit the sale or trade of shark fins or products, including:

- Bahamas
- Canada - The cities of Brantford, Oakville, Newmarket, Mississauga, London, Pickering and Toronto, as well as six municipalities in British Colombia: Abbotsford, Coquitlam, Nanaimo, Port Moody, North Vancouver, and Maple Ridge, have all passed bans on the sale of shark fins.
- CNMI
- American Samoa
- Cook Islands
- Egypt
- French Polynesia
- Guam (with an exception for subsistence fishing)
- Republic of the Marshall Islands
- Sabah, Malaysia

FAO International Plan of Action for the Conservation and Management of Sharks (IPOA-SHARKS)

Developed in 1998, IPOA-SHARKS aims to ensure the conservation and management of sharks and their long-term sustainable use. Consequently, the FAO recommends that RFMOs carry out regular shark population assessments and that member States cooperate on joint and regional shark management plans, and develop National Plans of Action for sharks (NPOA-Sharks). The FAO reports on implementation of the IPOA-Sharks at each meeting of its Committee on Fisheries. In 2009 and 2011, significant implementation progress of the IPOA-Sharks was observed, indicating that international attention given to conservation and management of sharks positively influenced the motivation of governments to take action (Fischer *et al*. 2012). The most recent comprehensive review of implementation progress was conducted in 2012. Overall, 143 countries, areas, territories and entities report shark catches to FAO; however the 2012 review focused on the top 26 shark catching nations, as they represent approximately 84% of the global shark catches reported to the FAO from 2000-2009[17]. The development of NPOAs provides some indication of the level of commitment of a catching country to manage its shark fisheries; of the 26 key shark catching countries in the world, 18 are known to have developed NPOA-Sharks, and an additional five are in the process of adopting or developing such a plan (three[18] have completed a draft NPOA that is awaiting adoption by parliament and two[19] have initiated drafting of their NPOA). However, three countries (12% of the top shark fishing countries, areas and territories) have not yet addressed an NPOA-Sharks (Fischer *et al*. 2012). See Appendix 5 for a table that describes the current status of development of NPOAs by the top 26 shark-catching countries and territories.

Despite the improvements in development and implementation of IPOA-Sharks in recent years, successful implementation of these plans continues to be hampered by a number of problems and issues. Because of slow progress in the initial implementation of IPOA-Sharks among member countries, the FAO convened an Expert Consultation on the Implementation of the IPOA-Sharks

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[17] http://www.fao.org/fishery/topic/18123/en

[18] Brazil, Peru and Thailand

[19] India and Sri Lanka

in 2005, which focused on the challenges encountered by FAO Members with regard to the conservation and management of sharks. According to Fischer *et al*. (2012), nine areas of particular concern were identified by the Expert Consultation, including:

- lack of appropriate taxonomic guides to identify species;
- lack or insufficient information on the population biology of elasmobranch species, both targeted and bycatch species;
- lack of funds for management;
- lack of human resources;
- competition from other management imperatives;
- lack of effective policy and institutional practices;
- scarce or lacking data, particularly for catch and fishing effort, to inform management decision making;
- weak or non-existent capacity of many developing countries; and
- low political priority for elasmobranch fisheries.

Despite progress achieved since 2005, the main findings of the Expert Consultation were still valid as of 2012, evidenced by pertinent issues raised by respondents in the most recent IPOA-Sharks implementation review questionnaire (Fischer *et al.,* 2012). Overall, the majority of problems encountered regarding conservation and management of sharks were related to problems with fisheries management in general (e.g., institutional weaknesses, lack of trained personnel, inadequate fisheries research, and inadequate monitoring, control and surveillance (MCS)). Further, inadequate data pertaining to shark biological characteristics and fisheries were noted by almost half of the respondents, particularly in developing countries. In addition, many countries need more trained officers for fisheries monitoring and control, and, in some countries, there is also a need for institutional strengthening. In addition, many of the top shark-fishing countries, areas and territories also have difficulties with shark species identification, which considerably affects the reporting of shark catches and discards (Fischer *et al*. 2012). Finally, the quality of the existing NPOA-Sharks varies, and there are no reporting mechanisms on implementation of the NPOAs; thus, it remains uncertain whether a particular plan is being implemented or what impact the plan has had on conservation and management of sharks. Further, while the IPOA-Sharks indicates that NPOAs should be reviewed every five years, and some NPOAs have now been in place for five years or longer, evaluations of progress and revised Plans are lacking (Lack and Sant 2009), though a few revised Plans have been submitted (see Appendix 5 for more details).

Regional Analysis

Pacific

In the Eastern Pacific, the IATTC is the RFMO responsible for the conservation and management of tuna and tuna-like species. As noted previously, the IATTC has passed a no-retention measure for oceanic whitetip sharks by implementing Resolution C-11-10 for the conservation of oceanic whitetip sharks caught in association with fisheries in the Antigua Convention Area. This Resolution prohibits Members and Cooperating non-Members (CPCs) from retaining onboard, transhipping, landing, storing, selling, or offering for sale any part or whole carcass of oceanic whitetip sharks in the fisheries covered by the Antigua Convention. As discussed in the *Overutilization* section of this status review, this measure is not likely adequate to prevent capture and mortality in one of the main fisheries that catches oceanic whitetip sharks in this region (i.e., the tropical tuna purse seine fishery). Though mortality rates of oceanic whitetip in purse seine fisheries are not available, it is likely that oceanic whitetip sharks experience high mortality rates similar to congener *C. falciformis* (i.e., ~85% in Western and Central Pacific and Indian Ocean tropical purse seine fisheries; Poisson *et al.,* (2014); Hutchinson *et al.,* (2015)) during and after interactions with purse seine fisheries. Given that they are captured in a net where they are unable to swim, and subjected to the weight of whatever tonnage is on top of them, oceanic whitetip sharks likely experience high levels of stress that can lead to mortality even if they are released alive. In fact, when oceanic whitetip sharks are released alive in the fishery, they are considered to be dead by the IATTC observer program because there is no evidence of post-release survival (Martín Hall, Pers. Comm. 2016). Some of these issues (i.e., the high level of stress that oceanic whitetip sharks experience when caught in purse seine nets) may be addressed by the 2016 Resolution C-16-05 for the Management of Shark Species. This Resolution will require purse seine vessels to follow safe-release requirements for all sharks, whether alive or dead (with the exception of those retained), including prompt release as soon as the shark is seen in the net or on deck. Considering safety precautions, sharks must be released out of the net directly from the brailer into the ocean and the use of gaffs, hooks, or similar instruments is prohibited. Resolution C-16-05 also bans the use of "shark lines" in longline vessels targeting tuna or swordfish in the Convention Area. However, Resolution C-16-05 does not come into force until January 2018. Additionally, given the depleted status of the population in this region, it is unclear as to how effective these measures will be.

In the Western and Central Pacific, the WCPFC is the main regulatory body for the management of sharks. Like other RFMOs, the WCPFC also has regulatory measures for the conservation of sharks in general, as well as specific measures for the conservation of oceanic whitetip sharks. Clarke (2013) identifies three main objectives of the shark CMMs in this region: 1) promote full utilization and reduce waste of sharks by controlling finning (perhaps as a means to indirectly reduce fishing mortality for sharks); 2) increase the number of sharks that are released alive (in order to reduce shark mortality); and 3) increase the amount of scientific data that is collected for use in shark stock assessments. Clarke (2013) found variable implementation rates of the CMM requirements by the WCPFC members and a lack of effectiveness of these measures in terms of reducing mortality of shark stocks. Clarke (2013) attributes this ineffectiveness to a lack of outcome-focused objectives of the CMM requirements, resulting in increased difficulty and challenges associated with verifying compliance and data monitoring and review. In addition to CMMs for sharks in general, CMM 2011-04 (which prohibits WCPFC vessels from retaining onboard, transshipping, storing on a fishing vessel, or landing any oceanic whitetip shark, in whole or in part, in the fisheries covered by the Convention), is likely the most influential management measure for the conservation of oceanic whitetip sharks in the Western and Central Pacific is. Clarke (2013) reviewed the potential efficacy of the oceanic whitetip retention prohibition measure as follows:

> "With regard to the expected effectiveness of the no-retention measure for oceanic whitetip sharks, a previous analysis of longline observer data from 1995-2010 suggested that without a no-retention measure the mortality rate for oceanic whitetip shark catches would be 87%. Assuming full implementation of no-retention and prompt release

> unharmed requirements for this species the mortality rate was estimated to fall to 31%[20] (Clarke 2011). The recent oceanic whitetip shark stock assessment found that overfishing is occurring (Fcurrent/FMSY = 6.5) and the stock is in an overfished state (SBcurrent/SBMSY = 0.153). Given the severely depleted state of the oceanic whitetip shark population, even if no-retention measures reduced mortality by more than 50% (i.e. from 87% to 31%), it is not clear how quickly and to what extent these conditions would allow the oceanic whitetip shark population to recover because model projections were not conducted (Rice and Harley 2012). Compounding this uncertainty, less-than-full implementation will erode the benefits of any mitigation measure."

Additionally, and as previously noted, finning bans and ratios do not address incidental catch of oceanic whitetip sharks and the subsequent mortality that may result after release; thus, these management measures may not necessarily prevent mortality of oceanic whitetip sharks. Although it is possible that a reduction in finning would coincide with an increase in the percentage of sharks released alive, this is not necessarily the case. In a study of longline fisheries of the Western and Central Pacific, Rice *et al*. (2015) showed a reduction in the percentage of key shark species that were finned from 2010-2013, with the last year of the study showing an increase in finning and a decrease in the number of sharks retained. The reduction in finning from 2010-2013 paralleled a rise in retention, which would be expected if fishers were beginning to retain the carcass to comply with CMM 2010-07 (the 5% fin to carcass rule; Rice *et al*. 2015). However, this could also be due to the growing demand for meat and a waning interest in shark fins, as discussed earlier (see Dent and Clarke (2015) and Eriksson and Clarke (2015) for more details). With respect to oceanic whitetip sharks, Rice *et al*. (2015) concluded that observations of the species in the longline fishery have generally indicated a reduction in the proportion finned since the mid-2000s (See Figure 66 below). For example, data collected by on-board observers from the Fijan longline fishery show that even though the fishery has not fully complied with the measure, a clear improvement was detected from 2011 to 2014; the percentage of oceanic whitetips released alive increased from 0% in 2011 to 63% in 2014 (See Figure 65 below). Also, while 100% of oceanic whitetips were finned in 2011 and 2012, and 60% were finned in 2013, only 3% were finned in 2014 (Piovano and Gilman 2016), though there is no information regarding how many of these sharks survived after their release.

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[20] This lower estimate assumes that mortality only occurs during haulback, not during handling. Any rough handling, e.g. to retrieve the terminal tackle, would tend to increase the mortality rate (Clarke 2013).

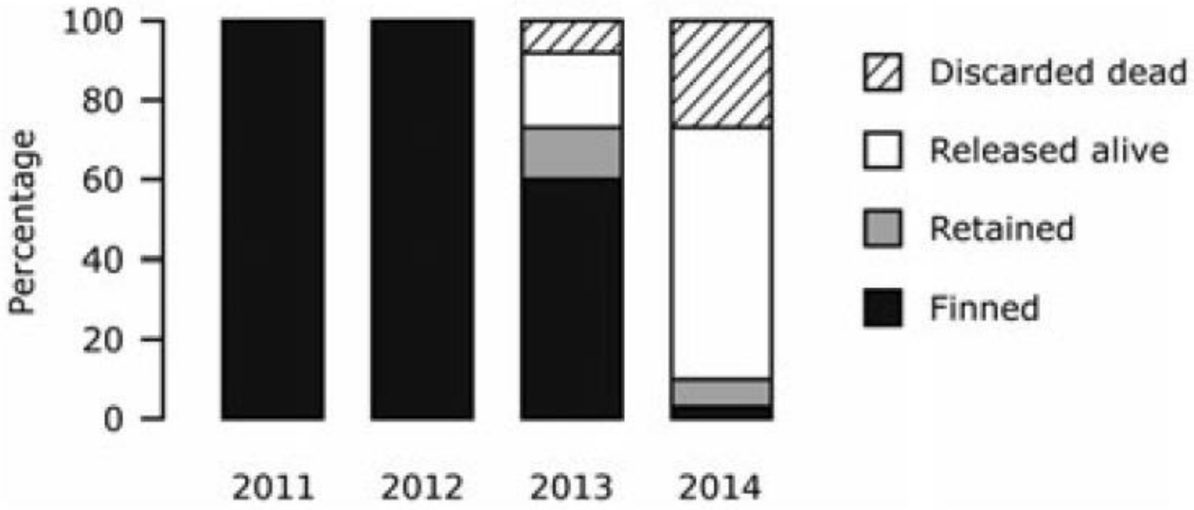

Figure 65 Fate of oceanic whitetip sharks after capture in the longline gear (expressed as percentage per year, N = 109). Source: Poviano and Gilman 2016.

However, in the first year of the CMM (2013) proportionally more oceanic whitetip sharks were retained and, with respect to CMM 2011-04, observations from the longline fishery have shown that the CMM is not being strictly adhered to, with non-negligible proportions of oceanic whitetips retained or finned. More oceanic whitetip sharks were retained in 2013 (the first year of the CMM) both in numbers and proportionally than in 2012 in the longline fishery. Due to recent change in observer coverage and lack of data from U.S. and Australian longline fisheries for years 2012-2014 and 2014, respectively, evaluating the efficacy of this measure in recent years is complicated (Rice *et al*., 2015).

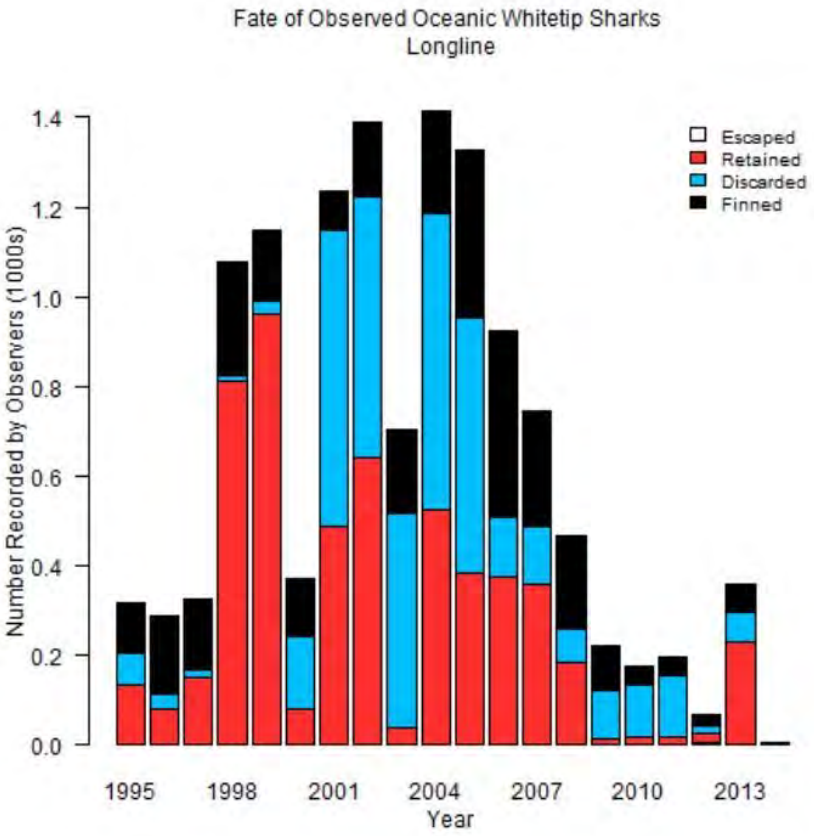

Figure 66 Fate of observed oceanic whitetip sharks caught by longline in the WCPO from 1995-2013. Source: Rice *et al.* 2015.

It remains impossible to evaluate the proportion of sharks released alive in WCPFC purse seine fisheries because purse seine observers do not record the sharks' condition at release. Nonetheless, studies of shark mortalities in various purse seine fisheries have shown that ~60-80% of sharks are dead when they are first observed at net retrieval and approximately half of those which survive retrieval die after release (Poisson *et al.,* 2014; Hutchinson *et al.,* 2015). Therefore, even if live release is strictly practiced in purse seine fisheries, the number of sharks expected to survive is low. The analysis of the oceanic whitetip retention prohibition CMM in the purse seine fishery is also hampered by the fact that there were no available data showing observations of oceanic whitetip sharks in 2014. In 2013, the proportion of oceanic whitetip sharks that were either finned or discarded in the purse seine fishery increased, but the proportion retained decreased. Thus, it appears that this measure is only partially successful (Rice *et al.* 2015).

Overall, while it is likely that existing controls on shark finning and species retention bans are reducing fishing mortality of oceanic whitetip sharks in the Western and Central Pacific to some degree, these conservation measures appear only partially effective, and implementation and enforcement rates are likely variable. Additionally, an increase in the percentage of sharks released alive will not likely translate into substantial increases in survival due to the fact that most sharks have been found to suffer high mortality rates when caught in purse seine nets and on longline gear (Clarke 2013). Although oceanic whitetip sharks have relatively higher at-vessel mortality rates in longlines compared to other shark species, given the severely depleted state of oceanic whitetip shark in this portion of its range, it is likely that anything less than full implementation and enforcement would likely undermine any potential conservation benefit (Clarke 2013), and may not be adequate to prevent further population declines of the species in this region.

In addition to finning controls and species retention bans, the WCPFC has also adopted some conservation measures related to fisheries gear. For example, CMM 2014-05 became effective in July 2015 and requires each national fleet to either ban wire leaders or ban shark lines, both of which have potential to reduce shark bycatch in the first place. However, while it is predicated that oceanic whitetip shark mortality may be reduced by up to 37% if both measures are used, this CMM allows flag-states to choose which fishing technique they exclude. Using Monte Carlo simulations, Harley and Pilling (2016) determined the following: if flag-states choose to exclude the technique least used by their vessels, the median predicted reduction in fishing-related mortality is only 10% for oceanic whitetip shark. If flag-states exclude the technique most used by their vessels, this would reduce the fishing mortality rate by 30%. This compares to a reduction of 37% if choice is removed and both techniques are prohibited. Thus, allowing flag states to choose which fishing technique they exclude under CMM 2014-05 has the potential to significantly undermine any benefits to the oceanic whitetip shark (Harley and Pilling 2016), particularly given the high levels of fishing mortality experienced by this species. It is therefore unlikely that the options under CMM 2014-05 of either banning shark lines or wire traces will result in sufficient reductions in fishing mortality (Harley *et al.,* 2015). Given the foregoing information, we conclude that existing regulatory mechanisms in the Western and Central Pacific are likely inadequate to control for overutilization of the species.

Atlantic

Oceanic whitetip catches have been reported by ICCAT vessels since the 1980s by the United States, but not by other countries until the early 1990s. In 2004, following the FAO International Plan of Action for Sharks (IPOA-Sharks), ICCAT published recommendation 04-10 requiring Contracting Parties, Cooperation non-Contracting Parties, Entities or Fishing Entities (CPCs) to annually report data for catches of sharks, including available historical data. In 2010, ICCAT developed recommendation 10-07, which specifically prohibits the retention, transshipping, landing, storing, selling, or offering for sale any part or whole carcass of oceanic whitetip sharks in any fishery; however, the retention ban implemented by ICCAT does not necessarily prevent all fisheries-associated mortality. Although oceanic whitetip sharks have a relatively higher at-vessel survivorship rate than other pelagic sharks in the Atlantic, some will still likely die due to capture.

According to ICCAT data as shown previously in Figure 46, approximately 89% of the total reported catch for Atlantic oceanic whitetip sharks was caught by Brazil. Countries fishing in the South Atlantic within the ICCAT Convention Area are also required to adhere to management measures implemented by ICCAT, of which the most consequential for oceanic whitetip sharks is the prohibition on retention of the species. As noted previously, regulations that mandate the release of oceanic whitetip sharks back to the sea have the potential to be somewhat effective for their protection, since the majority of the specimens are captured alive and exhibit relatively low at-vessel mortality rates in this region of 11-28% (Fernandez-Carvalho *et al.,* 2015). However, whether the retention ban is fully implemented and enforced is unknown. In Brazil, which is one of the top 26 shark-catching countries in the world and the largest oceanic whitetip catching country in the region, the significant decline in reported catches by the Brazilian fleet (as discussed in the *Overutilization* section of this status review) occurred prior to any management recommendations by ICCAT to prohibit retention of oceanic whitetip sharks in ICCAT-associated fisheries. In any case, despite the retention prohibition, Brazil reported 6 mt of oceanic whitetip in 2014, which indicates the species is still being caught and continues to experience fisheries-related mortality in this portion of its range. In addition to ICCAT regulations, sharks in Brazil must be landed with corresponding fins and a 5% fin-carcass weight ratio is required. In addition, all carcasses and fins must be unloaded and weighed and the weights reported to authorities. Pelagic gillnets and trawls are prohibited in waters less than 3 nmi (5.6 km) from the coast; however, given that the oceanic whitetip is pelagic species, a gillnet ban within 3 nmi of the coast is not likely going to be beneficial. Further, implementation and enforcement of these regulations have been noted as difficult and likely poor (Chiaramonte and Vooren 2007).

In December, 2014, the Brazilian Government's Chico Mendes Institute for Biodiversity Conservation approved the NPOA for the Conservation of Elasmobranchs of Brazil (No 125). However, this plan will not be fully implemented for another five years. In addition, this plan focuses on 12 priority species and does not include specific regulations to manage or protect the oceanic whitetip shark, despite the declining population off Brazil's coast. In 2004, the oceanic whitetip shark was designated as a "species threatened by overexploitation" by Brazil's Ministério do Meio Ambiente (Ministry of Environment), and listed under Annex II of Brazil's Normative Ruling No. 5 of May 21, 2004. In 2014, Brazil finalized its national assessment regarding the extinction risk of Brazilian fauna, and listed the oceanic whitetip shark as "Vulnerable" under Brazil's "Lista Nacional Oficial de Espécies da Fauna Ameaçadas de Extinção - Peixes e Invertebrados Aquáticos" (National Official List of Endangered Species of Fauna - Fish and Aquatic Invertebrate; ICMBio, 2014). Species listed as "Vulnerable" enjoy full protection, including, among other measures, the prohibition of capture, transport, storage, custody, handling, processing and marketing. The capture, transport, storage, and handling of specimens of the species shall only be allowed for research purposes or for the conservation of the species, with the permission of the Instituto Chico Mendes. However, it appears these regulations are not likely complied with or enforced adequately. In fact, a recent study that compared 179 legal instruments implemented for regulating Brazil's fisheries from 1934-2014 with fisheries landings from 1996-2011 concluded that there is a "a complete disrespect for the regulations" and that fleets continued landing prohibited or size limited species, including the oceanic whitetip shark (Fiedler *et al.,* 2017). For example, the prohibition for fishing oceanic whitetip sharks went into effect between 2004 and 2005. However, the species continued to be landed by national and leased foreign fleets, and was one of several species landed in the port of Itajaí despite a prohibition for catching this species (Fiedler *et al*., 2017). This study concluded that the current set of regulations for Brazil's fisheries are inconsistent, thereby rendering any management of fishing activities incompatible with species conservation. Additionally, there is strong opposition from the fishing industry and some ordinances guaranteeing protection to endangered species in the country have recently been canceled (Di Dario *et al.,* 2014). Further, systematic data collection from fleets fishing over Brazilian jurisdiction ended in 2012, and onboard observer programs have been cancelled, which renders any further monitoring of South Atlantic shark populations difficult or impossible (Barreto *et al.,* 2015). Given the foregoing information, it appears that existing regulatory mechanisms in Brazil are not likely adequate to effectively manage the threat of fishing pressure and associated mortality on oceanic whitetip sharks in this region.

In Central American and Caribbean waters, management of shark species remains largely disjointed, with some countries lacking basic fisheries regulations and others lacking the capabilities to enforce what has already been implemented (Kyne *et al*. 2012). The Organization of the Fisheries and Aquaculture Section of the Central American Isthmus (OSPESCA) was established to address this situation by assisting with the development and coordination of fishery management measures in Central America. The OSPESCA recently approved a common regional finning regulation for eight member countries from the Central American Integration System (SICA) (Belize, Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua, and Panama). The regulation specifically requires sharks to be landed with fins still attached for vessels fishing in SICA countries or in international waters flying a SICA country flag. If fins are to be traded in a SICA country, they must be accompanied by a document from the country of origin certifying that they are not the product of finning (Kyne *et al.,* 2012). Other Central American and Caribbean country-specific regulations include the banning or restriction of longlines in certain fishing areas (Bahamas, Belize, Panama), seasonal closures (Guatemala), shark fin bans (Colombia, Mexico, Venezuela) and the prohibition of shark fishing (Bahamas and Honduras). However, enforcement of these regulations is generally weak, with many reports of IUU fishing activities (see below for more information). For example, in May 2012, the Honduran navy seized hundreds of shark fins from fishers operating illegally within the borders of its shark sanctuary. As Kyne *et al.,* (2012) reports, it is basically common practice to move shark fins across borders for sale in countries where enforcement is essentially lacking in this region.

In the Sub Regional Fisheries Council (SRFC) region in the Atlantic (off West Africa), regulations specific to shark fishing are minimal. Fishing occurs year-round, including during shark breeding season, and, consequently, both pregnant and juvenile shark species may be fished (Diop and Dossa 2011). In fact, fins from fetal sharks are included on balance sheets at landing areas (Diop and Dossa 2011). Many of the state-level management measures in this region lack standardization at the regional level (Diop and Dossa 2011), which weakens some of their effectiveness. For example, Sierra Leone and Guinea both require shark fishing licenses; however, these licenses are much cheaper in Sierra Leone. As a result, fishers from Guinea will fish for sharks in Sierra Leone, thereby minimizing the benefits that could have been gained from having mutually supported management measures (Diop and Dossa 2011). In addition, Camara (2008) notes that fishery regulations are usually not adequately enforced due to a lack of funds, trained staff, and proper monitoring equipment. Corruption is also prevalent, especially in Mauritania, whereby enforcement officials are paid off by fishermen caught committing offenses (Camara 2008). However, many fishermen in this region are also unaware (or claim to be unaware) of the current fishing regulations, legal fishing zones, and gear restrictions, which has also contributed to deterioration of the West African fisheries (Camara 2008). However, it is unclear how important oceanic whitetip sharks are in this region’s fisheries. As of 2011, the only member state of the SRFC in which oceanic whitetip sharks have been reported is Cape Verde, which reported the oceanic whitetip as “very rare” (Diop and Dossa 2011), although information from this region is fairly limited and other African countries (Guinea and Ghana) reported catches of oceanic whitetip shark to ICCAT in 2014.

Indian Ocean

In Indian Ocean waters, the main regulatory body is the IOTC, which has management measures in place for sharks in general, and also specifically for the oceanic whitetip shark. The IOTC requires CPCs to annually report shark catch data and provide statistics by species for a select number of sharks, including oceanic whitetip sharks (Resolutions 05/05, 11/04, 08/04, 10/03, 10/02). The IOTC also developed additional shark conservation and management measures that aim to further reduce shark waste and encourages the live release of sharks, especially juveniles or pregnant females, caught incidentally (and not used for food or other purposes) in fisheries for tunas and tuna-like species. However, the efficacy of these measures remain unclear. For example, in a recent status report, the IOTC's Working Party on Ecosystems and Bycatch noted that the International Plan of Action for sharks was adopted in 2000, which requires each CPC to develop a National Plan of Action (NPOA) for sharks; however, despite the time that has elapsed since then, very few CPCs have developed NPOAs for sharks, or even carried out assessments to determine whether the development of a plan is prudent. As of 2014, only 12 of the 35 CPCs had developed NPOAs for sharks (IOTC 2014).

With regard to species-specific management measures for the oceanic whitetip shark, the IOTC passed Resolution 13-06 in 2013 as a pilot measure that prohibits the retention, transshipment, landing, or storing of any part or whole carcass of oceanic whitetip sharks. However, unlike similar regulations implemented by other RFMOs, the IOTC retention prohibition of oceanic whitetip shark exempts "artisanal fisheries operating exclusively in their respective EEZ for the purpose of local consumption." However, the definition of artisanal vessels in the IOTC encompasses a wide array of boats with vastly different characteristics. These vessels range from the pirogue that fishes close to shore for subsistence purposes with no motor, no deck and no holding facilities, to a longliner, gillnetter or purse seiner of less than 24 m with an inboard motor, deck, communications, fish holding facilities, and in some cases chilling or freezing capabilities. This latter vessel could potentially conduct fishing operations offshore, including outside its EEZ (Moreno and Herrera 2013). For example, in 2014 and 2015 the Islamic Republic of Iran and Sri Lanka reported 239 mt of oceanic whitetip sharks caught by gillnets that fall under the definition of "artisanal" fisheries. Additionally, while some no-retention measures ban the "selling or offering for sale" of any products from the specified shark species, the IOTC oceanic whitetip shark measure does not (Clarke 2013). Further, this measure is not binding on India, which is one of the main oceanic whitetip shark catching countries identified by the IOTC in the Indian Ocean. Thus, it appears that the retention ban of oceanic whitetip in the Indian Ocean is limited in scope relative to other RFMO no-retention measures, and only partially protective depending on whether the measure is adequately implemented and enforced. Finally, as an interim pilot measure, it is highly uncertain as to whether this measure will be ongoing into the foreseeable future.

In Indonesia, which is the top shark fishing nation in the world, there are few restrictions pertaining to shark fishing. In fact, Indonesian small-scale fisheries, which account for around 90% of the total fisheries production, are not required to have fishing permits (Varkey *et al.,* 2010), increasing the incentive for shark finning by this sector (Lack and Sant 2012). Although Indonesia adopted an FAO recommended shark conservation plan (National Plan of Action-Shark) in 2010, due to budget constraints, it can only focus its implementation of key conservation actions in one area, East Lombok (Satria *et al.,* 2011). Further, current Indonesian regulations pertaining to sharks are limited to those necessary for fulfilling obligations under international agreements (e.g., trade controls for certain species listed under CITES or prescribed by RFMOs) (Fischer *et al*. 2012). Ultimately, Indonesian fishing activities remain largely unreported (Varkey *et al.,* 2010), which suggests that the estimates of Indonesian shark catches are greatly underestimated. In fact, in Raja Ampat, an archipelago in Eastern Indonesia, Varkey *et al*. (2010) estimated that 44% of the total shark catch in 2006 was unreported (includes small-scale and commercial fisheries unreported catch and IUU fishing). In 2013, the Regency Government of Raja Ampat officially declared its 46,000 km^2 marine waters a shark and manta ray sanctuary, the first established in Indonesia that bans the harvesting and trade of sharks and manta rays from its marine waters. However, for the most part, without proper fishery management regulations in place, many of the larger species in Indonesian waters have been severely overfished and have forced Indonesian fishermen to fish elsewhere. Additionally, despite the fact that oceanic whitetip shark is protected in Indonesia under IOTC Resolution 13-06, evidence suggests that this Resolution may not be strictly followed. For example, in a genetic barcoding study of shark fin samples throughout traditional fish markets in Indonesia from mid-2012 to mid-2014, oceanic whitetip shark was identified as present despite being prohibited as of 2013. In addition, authorities confiscated around 3,000 oceanic whitetip shark fins from sharks caught in waters near Java Island in October 2015 (South China Morning Post 2015)[21].

Thus, while it generally appears that the IOTC has increased its number of management measures for sharks, including the oceanic whitetip, these regulations may only provide partial protection to the oceanic whitetip shark and may not be adequate to prevent further population declines due to overutilization.

Illegal, unregulated and unreported (IUU) Fishing

Despite the number of existing regulatory measures in place to protect sharks and promote sustainable fishing, enforcement tends to be difficult and illegal fishing has emerged as a problem in many fisheries worldwide. In general, illegal fishing occurs when vessels or harvesters operate in violation of the laws of a fishery; however, there are numerous activities that constitute IUU fishing (e.g., misreporting, use of prohibited gear, fishing inside closed waters, fishing without a license, shark finning, illegal transshipping, landing catch in unauthorized ports, etc). For purposes of this review, we focus on illegal finning and trafficking of oceanic whitetip sharks. In order to justify the risks of detection and prosecution involved with illegal fishing, efforts tend to focus on high value products (e.g., shark fins) to maximize returns to the illegal fishing effort. Thus, as the lucrative market for shark products (particularly shark fins) developed, so did increased targeting (both legal and illegal) of sharks around the world. Given that illegal fishing tends to go unreported, it is difficult to determine, with any certainty, the proportion of current fishery-related mortality rates that can be attributed to this activity. A study that provided regional estimates of illegal fishing (using FAO fishing areas as regions) found the Western Central Pacific (Area 71) and Eastern Indian Ocean (Area 57) regions have relatively high levels of illegal fishing (compared to the rest of the regions), with illegal and unreported catch constituting 34% and 32% of the region's catch, respectively (Agnew *et al.,* 2009). In the Pacific tuna fisheries alone, the total volume of product either harvested or transshipped involving IUU activity is estimated to be 306,440t (90% CI: 276,546t to 338,475t)

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[21] http://www.scmp.com/news/asia/southeast-asia/article/1864948/indonesia-seizes-3000-shark-fins-destined-hong-kong

and an estimated value of $616.11m (90% CI: $517.91m to $740.17m) (MRAG Asia Pacific 2016). The annual worldwide economic losses from all IUU fishing is estimated to be between $10 billion and $23 billion (NMFS 2015).

However, as mentioned in the *Overutilization* section of this review, given the recent downward trend in the trade of shark fins (Dent and Clarke 2015; Eriksson and Clarke 2015), illegal fishing for the sole purpose of shark fins may not be as prevalent in the future. It is also a positive sign that most (70%) of the top 26 shark-fishing countries, areas and territories have taken steps to combat IUU fishing, either by signing the Port State Measures Agreement (PSMA) (46%) or by adopting a National Plan of Action to prevent, deter, and eliminate IUU (NPOA-IUU) or similar plan (23%) (Fischer *et al*. 2012). However, whether these agreements or plans translate to less IUU fishing activity is unclear. For example, in many countries, effective implementation of monitoring, control, and surveillance schemes is challenging, often due to a lack of personnel and inadequate financial resources (Fischer *et al.,* 2012), and a number of instances of IUU fishing, specifically involving sharks, have been documented over the past decade. For instance, in 2014, illegal oceanic whitetip shark fins were discovered in a random sample inspection of three 40 kg sacks slated for export from Costa Rica to Hong Kong (Tico Times 2014)[22]. Additionally, and as noted previously, Indonesian authorities confiscated around 3,000 oceanic whitetip shark fins from sharks caught in waters near Java Island as recently as October 2015. This haul was worth an estimated US $72,000 in Indonesia, but would reportedly earn several times that amount in Hong Kong (South China Morning Post, 2015)[23]. In February 2013, oceanic whitetip fins were found in a large seizure of fins from a Taiwanese vessel fishing in the Marshall Islands[24]. In September 2015, Greenpeace activists boarded a Taiwan-flagged boat fishing near Papua New Guinea and found 110 shark fins but only 5 shark carcasses (which was in violation of both the Taiwanese and the WCPFC rules requiring onboard fins to be at most 5% of the weight of the shark carcasses)[25]. Recreational fishermen have also been caught with illegal shark fins. A report from June 2015 identified three unlicensed recreational fishers operating in waters off Queensland, Australia and in possession of 3,200 illegal shark fins most likely destined for the black market[26]. While these reports provide just a few examples of recent illegal fishing activities, more evidence and additional reports of specific IUU fishing activities throughout the world can be found in Miller *et al.,* (2014).

In terms of tracking IUU fishing, most of the RFMOs maintain lists of vessels they believe to be involved in illegal fishing activities, with the latest reports on this initiative seeming to indicate some improvement in combatting IUU fishing. In the most recent 2015 Biennial Report to Congress, which highlights U.S. findings and analyses of foreign IUU fishing activities, NMFS reports that all 10 nations that were previously identified in the 2013 Biennial Report for IUU activities took appropriate actions to address the violations (e.g., through adoption of new laws and regulations or by amending existing ones, sanctioning vessels, and improving monitoring

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[22] http://www.ticotimes.net/2014/11/25/illegal-shark-fins-destined-for-hong-kong-seized-at-costa-rica-airport#comments-53192

[23] http://www.scmp.com/news/asia/southeast-asia/article/1864948/indonesia-seizes-3000-shark-fins-destined-hong-kong

[24] http://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=11119560

[25] http://www.msn.com/en-us/news/world/taiwan-boat-caught-with-huge-illegal-shark-fin-haul/ar-AAeuKhd

[26] http://www.abc.net.au/news/2015-06-12/fishers-caught-with-shark-fin/6541278

and enforcement) (NMFS 2015). In the current report, 6 countries were identified for having vessels engaged in IUU fishing activities; however, no countries were identified for engaging in protected living marine resources bycatch or for catching sharks on the high seas (although NMFS caveats this by noting the inability to identify nations due primarily to the restrictive time frames and other limitations in the statute) (NMFS 2015).

Overall, it is clear that the oceanic whitetip shark is subject to IUU fishing, particularly for its valuable fins. Given the recent downturn in the shark fin trade (Dent and Clarke, 2015; Eriksson and Clarke 2015), the threat of this IUU fishing for the sole purpose of shark fins may not be as significant into the future. However, based on the best available information on the species' declining population trends throughout its range, as well as current utilization levels, the present mortality rates associated with illegal fishing and impacts on oceanic whitetip shark populations may be contributing to the overutilization of the species.

Marine Protected Areas (MPAs) and Shark Sanctuaries

Marine protected areas are a popular tool to enhance fisheries management. Effectiveness of protected areas depends on implementation and enforcement of regulations, as well as reserve design. Reserves are not always created or designed with an understanding of how they will affect biological factors or how they can be designed to meet biological goals more effectively (Halpern 2003). Since 2009, 15 countries have declared their EEZs as "shark sanctuaries," with primary goals of protecting and recovering shark populations by reducing fishing mortality and eliminating local contributions to the global market for shark products (Ward-Paige 2017). Currently, shark sanctuaries cover approximately 3% of ocean area. However, a variety of limitations exists regarding the size, location, compliance and enforcement of these protected areas. For example, much of the range and habitat of oceanic whitetip sharks overlap with large areas of unregulated fishing activities (e.g., high seas) where there are limited protections for sharks aside from the regulations of RFMOs. Therefore, because the oceanic whitetip shark is a highly migratory species, they only benefit from protected areas when they are actually inside the protected area's boundaries. Additionally, while many of these MPAs prohibit directed shark fishing, incidental bycatch and subsequent mortality of sharks can still occur in these areas. Nonetheless, given the species has exhibited a tendency of site fidelity in certain areas (e.g., Cat Island, Bahamas) this information could prove useful in the location and design of MPAs for the purposes of oceanic whitetip shark management. As mentioned previously, effectiveness of these protected areas also relies on the level of implementation and enforcement of regulations therein. Thus, while MPAs may provide some benefit to sharks in various locations around the world (Ward-Paige and Worm 2017), it is unclear whether and to what degree they confer conservation benefits to oceanic whitetip sharks, specifically.

Summary

A wide variety of existing laws and regulations have been implemented throughout the range of the oceanic whitetip shark that may positively affect the conservation status of the species. For example, all relevant RFMOs have taken steps towards implementing regulations to protect the oceanic whitetip shark, including prohibiting retention of the species, improving data reporting, and expanding research. Measures prohibiting retention of oceanic whitetip, if adequately implemented and enforced, could reduce the overall bycatch mortality of oceanic whitetip to some extent, because the species has relatively higher at-vessel survivorship compared to other shark species (Musyl *et al*. 2011); therefore, a large proportion of individuals caught and released alive may be able to survive. However, as previously emphasized several times, no-retention measures do not entirely mitigate for any potential post-release mortality that may occur. Thus, these measures may only be partially effective. As an additional caveat, the rarity of a particular species could be capitalized upon. Due to their large rounded shape and distinctive white markings, the fins of the oceanic whitetip shark are among the easiest to identify (Clarke *et al.,* 2006a); this means its vulnerability could increase to dangerous levels should their rarity become an attractive quality (Tolotti *et al*., 2015c). Additionally, in light of the numerous conservation regulations set forth for this species of late, awareness regarding its threatened status has clearly increased. Although future scenarios are difficult to predict and highly uncertain, it seems that many of the rarity-associated black market factors described above are possible for the oceanic whitetip, especially given the global ban on its retention in pelagic fisheries under tuna RFMO management (Tolotti *et al.,* 2015c). Additionally, issues of non-reporting and non-compliance remain problematic. Of note is the fact that compliance with and enforcement of species-specific retention bans are not necessarily adequate, as evidenced by the fact that non-negligible proportions of oceanic whitetips are being retained or finned in areas that prohibit these actions (e.g., Western and Central Pacific and Indian Oceans). In addition, they do not address potential post-release mortality that may occur after the shark is released.

Likewise, although various shark fishing and finning regulations and bans have been increasing in recent years globally, levels of compliance and enforcement are highly variable, as evidenced by numerous incidents of IUU fishing throughout the world's oceans due to the high demand for lucrative shark products, particularly fins. While there has been a recent downturn in the shark fin market, and more information is necessary to determine the magnitude of impact the shark trade is having specifically on oceanic whitetip sharks, the demand for *C. longimanus* fins is evident by the recent incidents of illegal finning and trafficking of oceanic whitetip in places like Indonesia and Costa Rica. Further, while reporting of shark catches to FAO has improved in the last decade (e.g., shark catches reported at species level doubled from 14% in 1995 to 29% in 2010), data collection and research on sharks is still lacking in many regions and many of the top shark-catching countries still report most of their catches at a very high aggregated level. On the other hand, complete bans on shark fishing have been implemented in some areas, which can help reduce fishing pressure on oceanic whitetip sharks while in these areas (e.g., the Bahamas). Regulatory mechanisms for oceanic whitetip shark in the U.S. Atlantic are seemingly adequate in achieving their intended purpose, with the Northwest Atlantic population of oceanic whitetip potentially stabilized. There is also a declining trend of oceanic whitetip mortality in Hawaii fisheries due to various regulations. Overall, we recognize the mere existence of regulatory mechanisms does not necessarily equate to their effectiveness in achieving their intended purpose. Issues related to community awareness, compliance, enforcement, regional priorities, and complex political climates within many countries in which oceanic whitetip sharks occur can limit the effectiveness of well-intended statutes and legislation.

4.5 (E) Other Natural or Manmade Factors

Information regarding the potential impacts of climate change on pelagic shark habitat is described in Section 4.1 (A) *Present or Threatened Habitat Destruction, Modification, or Curtailment*. Below we discuss environmental pollutants and toxins and their potential impacts to oceanic whitetip sharks.

Pollution and Toxins

Environmental pollutants may have negative impacts on the oceanic whitetip shark, but this has not yet been demonstrated by any scientific study. Many pollutants in the environment, such as brevotoxins, heavy metals, and polychlorinated biphenyls (PCBs), have the ability to bioaccumulate in fish species. A number of studies have shown that because of the higher trophic level position and longevity of some sharks, these pollutants tend to biomagnify in liver, gill, and muscle tissues (Storelli *et al.,* 2003; García-Hernández *et al.,* 2007; Escobar-Sanchez *et al.,* 2010; Gelsleichter and Walker 2010; Lee *et al.,* 2015). These studies have also attempted to quantify the concentration levels of these pollutants in fish species, but with a focus on human consumption and safety. As such, many of the results from these studies may indicate either "high" or "low" concentrations in fish species, but this is primarily in comparison to recommended safe concentrations for human consumption and does not necessarily infer any impact on the biological status of the species. Most reports of pollutant concentrations in elasmobranch tissues that exceed safe limits for animal health and/or human consumption are restricted to a small number of large upper trophic level sharks (Gelsleichter and Walker 2010). In fact, only one study exists that analyzed the pollutant composition of a liver oil sample from an oceanic whitetip shark, which was an amalgamated liver oil sample that also included two other shark species (silky *C. falciformis* and nurse *Ginglymostoma cirratum* sharks). This sample was used to analyze levels of dioxins and dioxin-like PCBs and found very high levels of both of these pollutants in the tested liver oil (Cruz-Nuñez *et al.,* 2009). Based on a comparison of levels found in smooth hammerhead sharks (which were much lower) (Storelli *et al.,* 2003), the levels found in oceanic whitetip shark may have a high potential for causing PCB effects in the species, as these levels that would likely exceed threshold levels of PCBs for some cell- and molecular-level effects seen in aquatic vertebrates (Gelsleichter and Walker, 2010). However, the aquatic vertebrate threshold levels referenced in Gelsleichter and Walker (2010) originate from a study on the California sea otter (Kannan *et al.,* 2000), and, at this time, there is no information to confirm that PCB threshold levels in marine mammals are comparable to threshold levels for shark species. Specifically, threshold PCB concentrations at which detrimental effects may occur in cartilaginous fish are virtually unknown (Gelsleichter and Walker, 2010). In fact, it is hypothesized that sharks can actually handle higher body burdens of anthropogenic toxins due to the large size of their livers which "provides a greater ability to eliminate organic toxicants than in other fishes" (Storelli *et al*. 2003) or may even be able to limit their exposure by sensing and avoiding areas of high toxins (like during *K. brevis* red tide blooms) (Flewelling *et al.,* 2010). The large size and vast lipid stores in the elasmobranch liver provide the capacity for a substantial sequestration of lipophilic contaminants.

Overall, although oceanic whitetip sharks are likely exposed to a number of pollutants and contaminants in their habitat that have the potential to cause negative physiological impacts to the species, the effects of these pollutants in oceanic whitetip shark populations and potential risk to the viability of the species remain unknown. In fact, there is no information on the lethal concentration limits of toxins or metals in oceanic whitetip sharks or evidence to suggest that current concentrations of environmental pollutants are causing detrimental physiological effects to the point where the species may be at an increased risk of extinction. As such, the best available information does not indicate that the present bioaccumulation rates and concentrations of environmental pollutants in the tissues of oceanic whitetip sharks are significant threats to the species, such that it substantially increases the species' risk of extinction throughout its global range.

5. EXTINCTION RISK ANLAYSIS

5.1 Introduction

The Endangered Species Act (ESA) (Section 3) defines endangered species as "any species which is in danger of extinction throughout all or a significant portion of its range." Threatened species is defined as "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." Neither the National Marine Fisheries Service (NMFS) nor the U.S. Fish and Wildlife Service (USFWS) have developed any formal policy guidance about how to interpret the definitions of threatened or endangered species in the ESA. In many previous NMFS status reviews, a team has been convened, often referred to as a "Biological Review Team," in order to compile the best available information on the species and conduct a risk assessment through evaluation of the demographic risks, threats, and extinction risk facing the species or distinct population segment (DPS). This information is ultimately used by the NMFS Office of Protected Resources, after consideration of the legal and policy dimensions of the ESA standards and benefits of ongoing conservation efforts, to make a listing determination. For purposes of this risk assessment, an Extinction Risk Analysis (ERA) team, comprised of fishery biologists, managers, and shark experts, was convened to review the best available information in this Status Review document and evaluate the overall risk of extinction facing the oceanic whitetip shark.

5.2 Distinct Population Segments

Criteria for Identification of Distinct Population Segments

Under the ESA, a listing determination may address a "species," which is defined to also include subspecies and, for any vertebrate species, any DPS that interbreeds when mature (16 U.S.C. 1532(16)). The joint policy of the USFWS and NMFS provides guidelines for defining DPSs below the taxonomic level of species (61 FR 4722; February 7, 1996). The policy identifies two elements to consider in a decision regarding whether a population qualifies as a DPS: discreteness and significance of the population segment to the species.

Discreteness
A DPS may be considered discrete if it is markedly separate from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors, or if it is delimited by international governmental boundaries. Genetic differences between the population segments being considered may be used to evaluate discreteness.

Significance
If a population segment is considered discrete, its biological and ecological significance must then be evaluated. Significance is evaluated in terms of the importance of the population segment to the overall welfare of the species. Some of the considerations that can be used to determine a discrete population segment's significance to the taxon as a whole include:

1) Persistence of the population segment in an unusual or unique ecological setting;
2) Evidence that loss of the population segment would result in a significant gap in the range of the taxon; and
3) Evidence that the population segment differs markedly from other populations of the

species in its genetic characteristics.

However, NMFS determined at the 90-day finding stage that the petition to list the oceanic whitetip shark was warranted for the global species. As such, we (the ERA team) conducted the extinction risk analysis on the global oceanic whitetip shark population.

5.3 Extinction Risk Analysis

The ability to measure or document risk factors to a marine species is often limited, where quantitative estimates of abundance and life history information are often lacking altogether. Therefore, in assessing extinction risk of a data limited species, it is important to include both qualitative and quantitative information. In previous NMFS status reviews, Biological Review Teams have used a risk matrix method to organize and summarize the professional judgment of a panel of knowledgeable scientists. This approach is described in detail by Wainright and Kope (1999) and has been used in Pacific salmonid status reviews as well as in reviews of Pacific hake, walleye pollock, Pacific cod, Puget Sound rockfishes, Pacific herring, and black abalone (see http://www.nmfs.noaa.gov/pr/species/ for links to these reviews). In the risk matrix approach, the condition of the species is summarized according to four demographic risk criteria: abundance, growth rate/productivity, spatial structure/connectivity, and diversity. These viability criteria, outlined in McElhany *et al*. (2000), reflect concepts that are well-founded in conservation biology and that individually and collectively provide strong indicators of extinction risk. Using these concepts, the ERA team estimated the extinction risk of the oceanic whitetip shark after conducting a demographic risk analysis. Likewise, the ERA team performed a threats assessment for the species by scoring the severity of current threats to the species and their impact on the species through the foreseeable future. The summary of the demographic risks and threats obtained by this approach was then considered by the ERA team in determining the species' overall level of extinction risk. Specifics on each analysis for the species are provided below.

Foreseeable future – ERA team discussion

For the purpose of this extinction risk analysis, the term "Foreseeable future" was defined as the timeframe over which threats can be predicted reliably to impact the biological status of the species. In determining an appropriate "foreseeable future" timeframe, we first considered the life history of the oceanic whitetip shark. The most recent longevity estimate for the oceanic whitetip is approximately 20 years (Rodrigues *et al*. 2015). Generation time, which is defined as the time it takes, on average, for a sexually mature female oceanic whitetip shark to be replaced by offspring with the same spawning capacity, is estimated to be around 11 years (Smith *et al*. 2008). As a long-lived species that matures relatively late, has relatively slow growth rates and low to moderate productivity, it would likely take several generation times for any conservative management action to be realized and reflected in population abundance indices. Thus, we determined that 30 years would reflect the species' life history and encompass 3 generation times. We then discussed whether we could confidently predict the impact of threats on the species out to 30 years and agreed that since the main threats to the species were likely fisheries and the regulatory measures that manage these fisheries, we had the background knowledge and expertise to confidently predict the impact of these threats on the biological status of the species within this timeframe. For the foregoing reasons, we agreed that a biologically reasonable foreseeable future timeframe would be 30 years for the oceanic whitetip.

Methods

Demographic Risks Analysis

After reviewing all relevant biological and commercial information for the species, including: current abundance of the species in relation to historical abundance and trends in abundance based on indices such as catch statistics; the species growth rate and productivity in relation to other species and its potential effect on survival rates; its spatial and temporal distribution; natural and human-influenced factors that cause variability in survival and abundance; and possible threats to genetic integrity; each ERA team member assigned a risk score to each of the four demographic criteria (abundance, growth rate/productivity, spatial structure/connectivity, diversity). Risks for each demographic criterion were ranked on a scale of 0 (unknown risk) to 3 (high risk). Below are the definitions that the team used for each ranking:

> 0 = Unknown: The current level of information is either unavailable or unknown for this demographic factor, such that the contribution of this factor to the extinction risk of the species cannot be determined.
>
> 1 = Low risk: It is unlikely that the particular factor contributes or will contribute significantly to the species' risk of extinction.
>
> 2 = Moderate risk: It is likely that the particular factor contributes or will contribute significantly to the species' risk of extinction.
>
> 3 = High risk: It is highly likely that the particular factor contributes or will contribute significantly to the species' risk of extinction.

The team members were given a template to fill out and asked to rank the risk of each demographic factor. After scores were provided, the team discussed the range of perspectives for each of the demographic risks and the supporting data on which they were based, and was given the opportunity to revise scores if desired after the discussion. The scores were reviewed by the ERA team and considered in making the overall risk determination, which is presented at the end of this section. Although this process helps to integrate and summarize a large amount of diverse information, there is no simple way to translate the risk matrix scores directly into a determination of overall extinction risk. Thus, it should be emphasized that this exercise was used simply as a tool to help the ERA team members organize the information and assist in their thought processes for determining overall risk of extinction for the species. Other descriptive statistics, such as mean, variance, and standard deviation, were not calculated as the ERA team felt these metrics would add artificial precision or accuracy to the results.

Table 3 Template for the Demographics Risk Analysis Worksheet used in ERA team deliberations. The matrix is divided into four sections that correspond to the parameters for assessing population viability (McElhany *et al.* 2000).

Name	*Abundance*	Notes	*Growth/ Productivity*	Notes	*Spatial Structure/ Connectivity*	Notes	*Diversity*	Notes

Threats Assessment

Section 4(a)(1) of the ESA requires the agency to determine whether the species is endangered or threatened because of any of the following factors:

1) destruction or modification of habitat;
2) overutilization for commercial, recreational, scientific, or educational purposes;
3) disease or predation;
4) inadequacy of existing regulatory mechanisms; or
5) other natural or human factors

Similar to the demographics risk analysis, the ERA team members were given a template to fill out and asked first to determine the relative importance of each identified potential threat in terms of whether that threat rose to the level of having any impact on the extinction risk of the species. Below are the relative importance levels of the threats.

0 = It is unknown whether this is a threat to the species
1 = It is unlikely that this is a threat to the species
2 = It is likely that this is a threat to the species
3 = It is highly likely that this is a threat to the species

The ERA team members were then asked to rank each threat in terms of the magnitude of impact each threat has on the extinction risk of the species. Below are the specific definitions of the threat effect levels:

0 = Unknown: The current level of information is either unavailable or unknown for this particular threat, such that the contribution of this threat to the extinction risk of the species cannot be determined.
1 = Low: It is unlikely that this factor contributes significantly to risk of extinction.
2 = Moderate: This factor contributes significantly to long-term risk of extinction, but does not in itself constitute a danger of extinction in the near future.
3 = High: This factor contributes significantly to long-term risk of extinction and is likely to significantly contribute to short-term risk of extinction.

After scores were provided, the team discussed the range of perspectives for each of the threats, and the supporting data on which they were based, and was given the opportunity to revise scores if desired after the discussion. The scores were then reviewed by the ERA team and considered in making the overall risk determination that is presented at the end of this section. Again, it should be emphasized that this exercise was used simply as a tool to help the ERA team members organize the information and assist in their thought processes for determining the overall risk of extinction for the oceanic whitetip shark.

Table 4 Template for the threats assessment used in ERA team deliberations.

ESA Factor 4(a)	Threat	Relative importance of threat	Likelihood of impact on trajectory of species	Rationale
Habitat destruction, modification or curtailment	Loss or degradation of habitat			
Overutilization	Bycatch (incl. at-vessel and post-release mortality) Shark trade			
Disease, predation				
Inadequacy of existing regulatory mechanisms	Current regulations			
Other natural or manmade factors	Climate change			

Overall Level of Extinction Risk Analysis

Guided by the results from the demographics risk analyses as well as the threats assessments, the ERA team members used their informed professional judgment to make an overall extinction risk determination for both species. For these analyses, the ERA team defined three levels of extinction risk:

> 1 = Low risk: A species or DPS is at low risk of extinction if it is not at moderate or high level of extinction risk (see "Moderate risk" and "High risk" above). A species or DPS may be at low risk of extinction if it is not facing threats that result in declining trends in abundance, productivity, spatial structure, or diversity. A species or DPS at low risk of extinction is likely to show stable or increasing trends in abundance and productivity with connected, diverse populations.
>
> 2 = Moderate risk: A species or DPS is at moderate risk of extinction if it is on a trajectory that puts it at a high level of extinction risk in the foreseeable future (see description of "High risk" above). A species or DPS may be at moderate risk of extinction due to projected threats or declining trends in abundance, productivity, spatial structure, or diversity. The appropriate time horizon for evaluating whether a species or DPS is more likely than not to be at high risk in the foreseeable future depends on various case- and species-specific factors.
>
> 3 = High risk: A species or DPS with a high risk of extinction is at or near a level of abundance, productivity, spatial structure, and/or diversity that places its continued persistence in question. The demographics of a species or DPS at such a high level of risk may be highly uncertain and strongly influenced by stochastic or depensatory processes. Similarly, a species or DPS may be at high risk of extinction if it faces clear and present threats (e.g., confinement to a small geographic area; imminent destruction, modification, or curtailment of its habitat; or disease epidemic) that are likely to create present and substantial demographic risks.

To allow individuals to express uncertainty in determining the overall level of extinction risk facing the oceanic whitetip, the ERA team adopted the "likelihood point" (FEMAT) method (see Table 3 below for template). This approach has been used in previous status reviews (e.g., Pacific salmon, Southern Resident Killer Whale, Puget Sound Rockfish, Pacific herring, and black abalone) to structure the team's thinking and express levels of uncertainty in assigning threat risk categories. For this approach, each team member distributed 10 'likelihood points' among the three extinction risk levels. After scores were provided, the team discussed the range of perspectives for the species, and the supporting data on which it was based, and was given the opportunity to revise scores if desired after the discussion.

Finally, the ERA team did not make recommendations as to whether the oceanic whitetip shark should be listed as threatened or endangered. Rather, the ERA team drew scientific conclusions about the overall risk of extinction faced by the species under present conditions and in the foreseeable future based on an evaluation of the species' demographic risks and assessment of threats.

Table 5 Template for the overall level of extinction risk analysis used in ERA team deliberations.

	1 = Low risk	2 = Moderate Risk	3= High Risk	Rationale
Number of likelihood points				

ERA Team's Extinction Risk Results and Conclusion for the Oceanic Whitetip Shark

Evaluation of Demographic Risks

Out of the four demographic factors analyzed in this ERA, we identified abundance as most concerning in terms of demographic risks that may contribute to the extinction risk of the oceanic whitetip shark. The other demographic factors, including growth rate/productivity, spatial structure/connectivity, and diversity also garnered some concern by the ERA team. Below is a brief discussion of the rationale for our ERA team's conclusions regarding the demographic risk assessment for the oceanic whitetip shark.

<u>Abundance</u>
While there is currently no reliable global population size estimate for the oceanic whitetip shark, the ERA team evaluated numerous sources of information, including the results of a recent stock assessment and several other abundance indices including: trends in occurrence and composition in fisheries catch data, CPUE, and biological indicators to assess current abundance and trends. The ERA team agreed that while the oceanic whitetip shark was historically one of the most abundant and ubiquitous shark species in tropical seas around the world, numerous lines of evidence suggest the species has not only undergone significant historical declines throughout its range, but likely continues to experience declines in abundance globally.

In the Eastern Pacific, oceanic whitetip sharks were historically the third most abundant shark species after blue sharks (*P. glauca*) and silky sharks (*C. falciformis*), and comprised approximately 20% of the total shark catch in the tropical tuna purse seine fishery. However, both nominal catches and encounters with oceanic whitetip sharks in all set types in the purse seine fishery have declined significantly since 1994. In fact, these declines are compatible with an 80-95% population decline compared to the late 1990s, and the species has virtually disappeared from the fishing grounds (Hall and Roman 2013). Similar levels of decline have also been observed throughout the Western and Central Pacific Ocean. Like the Eastern Pacific, the oceanic whitetip shark was once one of the most abundant pelagic shark species throughout the Western and Central Pacific Ocean, comprising up to 28% of the shark catch during the 1950s (Strasburg 1958). A recent stock assessment conducted in the Western and Central Pacific estimated an 86% decline in spawning biomass from 1995 to 2009, with total biomass reduced to just 6.6% of the theoretical equilibrium virgin biomass (Rice and Harley 2012). An updated assessment analyzing various abundance indices, including standardized CPUE, concluded that the oceanic whitetip shark continues to decline throughout the tropical waters of the Western and Central Pacific (Rice *et al*. 2015), indicating a severely depleted population of oceanic whitetip across the region with observations of the species becoming increasingly rare. Similar results were found in analyses of CPUE data from the Hawaii-based pelagic longline fishery, where oceanic whitetip shark showed a decline in relative abundance on the order of 90% (Clarke *et al.,* 2012; Brodziak *et al.,* 2013). An update of this time series conducted by the ERA team in this report indicates a relative stability in the population size at the post-decline depressed state with no signs of recovery. The ERA team agreed that the levels of significant population decline observed in these studies indicate that these declines are not just local or regional, but rather a Pacific-wide phenomenon, with no significant indication that these trends have reversed.

Similar levels of historical decline have been observed for oceanic whitetip sharks in the Atlantic Ocean. While there is some debate regarding the exact magnitude of decline in the Northwest Atlantic, the best available data indicates that the oceanic whitetip experienced a significant historical decline ranging from 50-88% (Baum *et al.,* 2003; Baum and Myers 2004; Cortés *et al.,* 2007). In order to discern the species' current abundance trend in this area, we conducted an analysis of the most recent observer data from the U.S. Northwest Atlantic Pelagic Longline Fishery from 1992-2015. We determined that the population experienced a small decline of 4% over the time series, with the overall trend indicative that the population may have stabilized. An earlier analysis of the same data series from 1992-2005 showed a 9% decline in abundance (Cortés *et al.,* 2007). Farther south, while robust abundance data is lacking in the South Atlantic, the best available information, including analyses of fisheries data from 1980-2011, indicate the oceanic whitetip shark has undergone at least an 85% decline (Santana *et al.,* 2004; ICMBio; Barreto *et al.,* 2015). In addition, demographic analyses from the largest oceanic whitetip shark catching country in the South Atlantic (i.e., Brazil) indicate declines similar to the Northwest Atlantic of 50-79% in recent decades, though some of this decline may be attributed to a shift in effort distribution to more temperate waters since 2006. Elsewhere across the South Atlantic, the oceanic whitetip shark appears to be relatively rare, with low patchy abundance. Overall, the ERA team determined that while the Northwest Atlantic population of oceanic whitetip shark has likely begun to stabilize, it is at a significantly diminished abundance. Elsewhere in the Atlantic, the ERA team agreed that declines of oceanic whitetip shark are likely ongoing, although we acknowledge some uncertainty regarding the available data from this region.

Abundance information from the Indian Ocean is relatively deficient and unreliable. However, historical research data shows overall declines in both CPUE and mean weight of oceanic whitetip sharks, with anecdotal reports suggesting that the species has become rare throughout much of the Indian Ocean over the past 20 years (Romanov *et al.,* 2008). In addition, the IOTC reports that despite limited data, oceanic whitetip shark abundance has likely declined significantly over recent decades. Quantitative studies on various fisheries operating in the Indian Ocean indicate population declines ranging from 25-90%. Despite the varying magnitudes of reported declines, the ERA team agreed that given the high fishing pressure and catches of oceanic whitetip shark in the Indian Ocean (which are likely severely underreported), combined with the species' high at-vessel mortality rates in longlines in this area and the species' low-moderate productivity, it is likely that the species will continue to experience population declines in this region into the foreseeable future.

Overall, in areas where oceanic whitetip shark data are available, trends from throughout the species' global range show large historical declines in abundance (e.g., Eastern Pacific, Western and Central Pacific, Atlantic and Indian Oceans). Recent evidence suggests that most populations are still experiencing various levels of decline due to continued fishing pressure and associated mortality. The potential stabilization of the abundance trends at depleted levels seen in pelagic longline observer data from the Northwest Atlantic and Hawaiian pelagic longline fisheries represents a small contingent of the global population and has not shown any signs of recovery. Thus, the best available data included in this Status Review document suggest that the global population of oceanic whitetip continues to experience various levels of decline throughout the majority of its range.

Growth rate/productivity

The ERA team noted that this species has some life history parameters that are typically advantageous, and some that are likely detrimental to the species' resilience to excessive levels of exploitation. For example, in comparison to other shark species, the oceanic whitetip is relatively productive, with an intrinsic rate of population increase (*r*) of 0.121 per year (Cortés *et al*. 2012). The oceanic whitetip also ranked among the highest in productivity when compared with other pelagic shark species in terms of its pup production, rebound potential, potential for population increase, and for its stochastic growth rate (Chapple and Botsford 2013). However, although the oceanic whitetip shark has a relatively high productivity rate relative to other sharks, it is still considered low for a fish species ($r < 0.14$). Additionally, the species has a fairly late age of maturity (~6-9 years for females depending on the location), has a lengthy gestation period of 9-12 months, and only produces an average of 5-6 pups every two years. Thus, while this species may generally be able to withstand low to moderate levels of exploitation, given the high level of fishing mortality this species has and continues to experience throughout the majority of its range, its life history characteristics may only provide the species with a limited ability to compensate. Therefore, based on the best available information, the ERA team concluded that these life history characteristics likely pose a risk to this species in combination with threats that reduce its abundance, such as overutilization.

Spatial structure/connectivity

The oceanic whitetip shark is a relatively widespread species that may be comprised of distinct stocks in the Pacific, Indian, and Atlantic oceans. The population exchange between these stocks is unknown; however, based on genetic information, telemetry data, and temperature preferences it is unlikely that there is much exchange between populations in the Atlantic and Indo-Pacific Oceans. However, recent genetic data suggests potentially significant population structure within the Atlantic, which may be underpinned by the fact that this species exhibits a high degree of philopatry in some locations (i.e., the species returns to the same site for purposes of breeding or feeding, etc). For example, the population structure observed in the Atlantic, despite no physical or oceanographic barrier, could result in localized depletions in areas where fishing pressure is high. However, habitat characteristics that are important to this species are unknown. The species is highly mobile, and there is little known about specific migration routes. It is also unknown if there are source-sink dynamics at work that may affect population growth or species' decline. There is no information on critical source populations to suggest spatial structure and/or loss of connectivity are presently posing demographic risks to the species. Thus, based on the best available information, there is insufficient information to support the conclusion that spatial structure and connectivity currently pose a significant demographic risk to this species.

Diversity

Preliminary research suggests the oceanic whitetip has low genetic diversity (0.33% ± 0.19%; Ruck 2016; Camargo *et al*. 2016), which is about half that of silky sharks (0.61% ± 0.32%; Clarke *et al.,* (2015a)). The ERA team noted that the relatively low mtDNA genetic diversity of the oceanic whitetip raises potential concern for the future genetic health of this species, particularly in concert with steep global declines in abundance. Based on the fact that exploitation of the oceanic whitetip shark began with the onset of industrial fishing in the 1950s, only 5-7 generations of oceanic whitetip have passed since the beginning of this exploitation. Thus, the low genetic diversity of oceanic whitetip shark likely reflects historical levels, and the significant global declines are not yet reflected genetically (Ruck 2016). The ERA team noted that this may be a cause for concern in the foreseeable future, since a species with already relatively low genetic diversity undergoing significant levels of exploitation may increase the species' risk in terms of evolutionary adaptability to a rapidly changing oceanic environment as well as potential extirpations (Camargo *et al*., 2016). However, the ERA team also noted that low genetic diversity does not necessarily equate to a risk of extinction in and of itself for all species; but, in combination with low levels of abundance and continued exploitation, low genetic diversity may pose a viable risk to the species in the foreseeable future.

Threats Assessment

Out of the five ESA section 4(a)(1) factors, based on the best available information, we identified overutilization and inadequate regulatory mechanisms as most concerning in terms of threats that may contribute to the extinction risk of the species. The other factors, including habitat destruction, modification, or curtailment; disease and predation; and other natural or manmade factors were not identified as threats to the species. Below is a brief discussion of the rationale for our ERA team's conclusions regarding the threats assessment for the oceanic whitetip shark.

Habitat Destruction, Modification, or Curtailment

The ERA team did not identify habitat destruction, modification, or curtailment as a threat that contributes significantly to the species' risk of extinction. The ERA team emphasized that the oceanic whitetip shark is a highly migratory, pelagic species of shark that likely spends much of its lifecycle in the open ocean. As such, the oceanic whitetip shark is likely more confined by temperature and prey distributions, and is not reliant on any particular habitat type that would be affected by threats such as climate change or physical destruction, etc. Additionally, due to their highly migratory nature, they can modify their distributional range to remain in an environment conducive to their physiological and ecological needs. The oceanic whitetip shark is also an extremely opportunistic feeder. It is therefore very unlikely that the loss or degradation of any particular habitat type would have a substantial effect on the oceanic whitetip population. As a result, and given the best available information, the ERA team concluded that habitat destruction, modification, or curtailment is not a threat that contributes to the species' extinction risk, now or in the foreseeable future.

Overutilization

The ERA team concluded that overutilization is the single most important threat contributing to the extinction risk of the oceanic whitetip shark globally. The ERA team assessed various factors that may contribute to the overutilization of the oceanic whitetip shark, including incidental bycatch in commercial fisheries (considering impacts of at-vessel and post-release mortality), retention and finning for purposes of the international fin trade, and impacts of IUU fishing. The oceanic whitetip shark is generally not a targeted species, but because of its tendency to remain in surface waters (0-152 m depth) and in tropical latitudes where fishing pressure is often most concentrated for target species such as tuna, the species is frequently encountered and suffers high mortality rates in numerous fisheries throughout its global range. Although the ERA team recognized that the oceanic whitetip shark has relatively lower at-vessel mortality rates in longlines than other shark species, the species still exhibits a range of mortality from 11-28% in the Atlantic to upwards of 60% in the Indian Ocean (Fernandez-Carvalho *et al*. 2015; IOTC 2015b), and these rates do not account for post-release mortality. In addition to bycatch-related mortality, the oceanic whitetip shark is a preferred species for retention because its large fins obtain a high price per kg in the Asian fin market, and comprises approximately 2% of the global fin trade (Clarke *et al.,* 2006a). This high value and demand for oceanic whitetip fins incentivizes the retention and subsequent finning of oceanic whitetip sharks when caught, and thus represents the main economic driver of mortality of this species in commercial fisheries throughout its global range. In fact, growth in demand from the fin trade during the 1990s coincided with a pattern of soaring catches of oceanic whitetip sharks in numerous fisheries across the globe. Catches generally peaked between 1995 to 2000 followed by precipitous declines over the next 10 years due to severe overfishing (Hazin *et al.,* 2007; Lawson 2011; Clarke *et al.,* 2012; Hasarangi *et al.,* 2012; Brodziak *et al.,* 2013; Hall and Román 2013).

The ERA team concluded that overutilization is likely a significant threat to the oceanic whitetip shark throughout the Pacific Ocean basin. In the Eastern Pacific, the oceanic whitetip shark was historically caught in large numbers in the tropical tuna purse seine fishery. However, in recent years, oceanic whitetip shark catches declined dramatically despite a generally increasing trend in fishing effort (both in geographic scope and number of sets). In total, oceanic whitetip catches declined drastically from a peak of 9,000+ individuals caught in 1995 to only 120 individuals in 2015 (refer back to Figure 35). In addition, their capture probability in floating object purse seine sets (the set type responsible for 90% of catches) has decreased from a high of 30% capture rate per set between 1994 and 1998, to less than 5% from 2004 to 2008 (Morgan 2014). This is in stark contrast to catches of the closely related silky shark, which have remained relatively constant over the same time period (Hall and Roman 2013). This indicates that the large decline in catches of oceanic whitetip shark in the purse seine fishery has largely been driven by unsustainable fishing mortality. Thus, given the increase in fishing effort in the Eastern Pacific over time, combined with the decline in catches and virtual disappearance of oceanic whitetip sharks from purse seine fishing grounds in the Eastern Pacific, the ERA team agreed that the oceanic whitetip shark population in the Eastern Pacific is likely experiencing overutilization.

In the Western and Central Pacific Ocean, numerous analyses indicate that the oceanic whitetip shark is experiencing overutilization across the region. The ERA team concluded that the once ubiquitous oceanic whitetip shark has experienced significant and ongoing declines in the Western and Central Pacific Ocean as a direct result of unsustainable fishing mortality in both longline and purse seine fisheries operating in the species' core tropical habitat area. The ERA team accepted the results of a recent stock assessment report that determined fishing mortality of oceanic whitetip throughout the Western and Central Pacific has increased to levels that are 6.5 times what is sustainable. Because of this fishing mortality, oceanic whitetip biomass declined by 86% (Rice and Harley 2012). Currently, the population is overfished and overfishing is still occurring. As a result, catch trends of oceanic whitetip shark in both longline and purse seine fisheries have significantly declined, with declining trends also detected in some biological indicators, such as biomass and size indices. Similar results between analyses of SPC observer data from the larger Western and Central Pacific and the observer data from the Hawaii-based pelagic longline fishery suggest that the population decline of oceanic whitetip in this portion of its range is not just a localized trend, but rather a region-wide phenomenon across the Pacific Ocean basin. Updated analyses of the Hawaii observer data indicate a stabilized trend at depleted levels in recent years. The significant declining trends observed in all available abundance indices (e.g., standardized CPUE, biomass and median size) of oceanic whitetips occurred as a result of increased fishing effort in the longline fishery, with lesser impacts from targeted longline fishing and purse-seining. Because of the significant fishing mortality in both longline and purse seine fisheries that has contributed to large abundance declines of the species, the ERA team concluded that overutilization of the species is likely occurring throughout the Western and Central Pacific.

As discussed in the *Abundance* section above, there has been debate in the literature regarding the exact magnitude of decline of oceanic whitetip shark in the Northwest Atlantic and Gulf of Mexico (with estimates of up to 50-70% in the Northwest Atlantic from 1986-2005 and estimates of up to 88% in the Gulf of Mexico from the 1950s to the late 1990s). Nonetheless, the ERA team agreed that the oceanic whitetip shark suffered significant historical declines in abundance as a result of overexploitation since the onset of industrial fishing in the 1950s. Because these data are largely based on fisheries logbooks and have been openly criticized in the scientific literature, the ERA team conducted its own species-specific analysis of observer data from the Northwest Atlantic, which were deemed more reliable and accurate by the ERA team than fisheries logbook data. Based on this updated analysis, the Northwest Atlantic population of oceanic whitetip shark has declined by 4% since 1992, but has likely begun to stabilize (albeit at a significantly diminished abundance). Reported landings for oceanic whitetip in the Northwest Atlantic have been variable over the last 10 years of available data, with a decrease since the implementation of ICCAT Recommendation 10-07 in 2011. This indicates that these regulatory mechanisms may be effective in reducing retention in the region. Furthermore, the Northwest Atlantic population of oceanic whitetip shark may have stabilized since the 1990s, which coincides with the first Federal Fishery Management Plan for Sharks in the Northwest Atlantic Ocean and Gulf of Mexico. The plan directly manages oceanic whitetip shark under the pelagic shark group, and includes regulations on trip limits and quotas; therefore, under current management measures, including the implementation of ICCAT Recommendation 10-07, the ERA team concluded that the threat of overutilization is not likely as significant in this area relative to other portions of the species' range.

In contrast, the ERA team agreed that overutilization is likely a significant threat to oceanic whitetip sharks in the South Atlantic, and in particular, the population that appears to show site fidelity to a specific area off the northeastern coast of Brazil. While robust quantitative studies regarding catch trends of oceanic whitetip sharks are limited, the oceanic whitetip was once one of the most abundant shark species encountered in longline fisheries in the southern and equatorial Atlantic; however, this species is now seemingly rare with low, patchy abundance across the region. Additionally, the large majority of catches across the region are comprised of immature individuals. The team considered trends in several indicators, including average CPUE, commercial catches, and size composition of oceanic whitetip that show significant declines in recent decades that are indicative of overutilization of the species. The high fishing pressure across the South Atlantic that occurred concomitantly with a lack of regulations to control fishing from the mid-1990s through the mid-2000s likely led to the overutilization of oceanic whitetip shark. The team agreed that overutilization is likely still occurring given that the highest levels of fishing effort in this region overlap significantly with the preferred vertical and horizontal habitat of the species, including potential nursery grounds and areas where the species shows a high degree of site fidelity.

Finally, the ERA team agreed that overutilization of oceanic whitetip is likely occurring in the Indian Ocean. This species is caught as bycatch in all three major commercial fisheries in the Indian Ocean, including pelagic longline, purse seine and gillnet fisheries. Although information from this region is limited and catch data are severely underreported, the IOTC reports that catches of oceanic whitetip shark are high, and comprise a significant proportion of the total estimated shark catch in this region at 11% (Murua *et al*. 2013). The oceanic whitetip also suffers from a relatively high at-vessel mortality rate in longlines in this region (i.e., 58%). In 2013, the IOTC reported average catches of ~347 t over the previous 5 years and noted that this level of catch put the oceanic whitetip population at considerable risk. The IOTC also noted that maintaining or increasing this level of catch would likely result in further declines of the species. The ERA team noted that these conclusions were made before improved species-specific reporting of incidental catches and discards of oceanic whitetip to the IOTC was required. Once the IOTC Resolution for the conservation of oceanic whitetip shark was implemented, catch estimates for the species skyrocketed, with 5,000+ mt of oceanic whitetip shark catches estimated for 2013 and 2014. While the ERA team acknowledges a level of uncertainty with these estimates, given the significantly high level of fishing pressure in this region, the species' relatively high mortality in longline and purse seine fisheries in this region (with unknown levels of mortality in the region's gillnet fisheries), combined with the species' low-moderate productivity, the ERA team concluded that the oceanic whitetip shark is likely experiencing ongoing threats of overutilization that may contribute to continued population declines in this region into the foreseeable future.

As described in this Status Review, the main economic driver for overutilization of the oceanic whitetip shark throughout its global range has been its high value and demand in the international shark fin trade. The oceanic whitetip shark has been reported as a preferred species for the international fin trade and is a species often categorized as "first choice" in the China Hong Kong SAR fin market. The morphologically distinct oceanic whitetip fins are sold under the name "*Liu Qiu*," fetching a high price of $45-85/kg and comprising approximately 2% (by weight) of the global shark fin trade based on data from 2000. Although 2% may seem like a relatively small portion of the trade, this equated to an estimated 220,000 -1.2 million oceanic whitetip sharks traded globally in 2000. Clarke (2008) estimated 80-210,000 oceanic whitetip sharks were sourced from the Atlantic Ocean alone to supply the Hong Kong fin market in 2003. At this rate, a species with life history characteristics like the oceanic whitetip would not likely be able to sustain continued pressure of that magnitude. Recent genetic analyses of fins in markets of major shark fin exporting countries throughout the range of the species, including Taiwan, Indonesia, and UAE, confirm the continued presence of oceanic whitetip shark fins in various markets throughout its range. Although the ERA team recognizes that the situation regarding the fin trade may be improving, as evidenced by an overall decline in the fin trade and increased regulations, the recent incidents of illegal trafficking and exports of oceanic whitetip fins from places like Costa Rica, Egypt, India, Indonesia, and other locations as recently as 2017 indicate that oceanic whitetip sharks are still sought after for their fins and continue to experience pressure from demands of the fin trade. Thus, the ERA team concluded that based on the best available information, the incentive to take oceanic whitetip sharks for their fins remains high and is an ongoing threat contributing to the overutilization of the species. The ERA team also considered whether the recent shift in demand away from shark fins to shark meat would have any considerable impact on the oceanic whitetip shark. Although there are markets for low-value shark meat such as oceanic whitetip, the retention bans for the species in all relevant RFMOs will likely dampen this threat. Thus, the ERA team did not think this shift in demand from shark fins to meat would create a significant new threat to the species.

Disease or Predation

We could find no information linking disease to declines in oceanic whitetip shark populations.

Predation also does not appear to be increasing this species' risk of extinction, as the oceanic whitetip is a large shark with limited numbers of predators. Therefore, based on the best available information, we concluded that neither disease nor predation is contributing to the species' risk of extinction, now or in the foreseeable future.

Inadequacy of Existing Regulatory Mechanisms

In discussions regarding existing regulatory mechanisms for the oceanic whitetip, the ERA team noted that the most influential regulations currently in place are likely the species-specific retention prohibition measures recently implemented by all RFMOs throughout the species' range. In fact, the oceanic whitetip shark is currently the only shark species protected by RFMO's in all oceans, which underscores the conservation needs of the species. In addition, the oceanic whitetip was also recently added to Appendix II of CITES, which went into effect in 2014. However, the team emphasized the difficulty in analyzing the efficacy of these regulations, as many have been in place for only a couple of years and implementation and enforcement across international boundaries are likely highly variable and/or lacking altogether. Despite this difficulty, the ERA team largely agreed that these prohibition measures may only be partially effective and thus inadequate for significantly reducing the threat of overutilization to the species.

For all of the retention prohibitions enacted by RFMOs, the ERA team acknowledged that these measures do not prevent oceanic whitetip sharks from being caught or any at-vessel and post-release mortality that may result. For example, the ERA team agreed that the retention prohibition enacted for oceanic whitetip sharks in the Eastern Pacific would not likely be effective for the tropical tuna purse seine fishery (the main fishery that catches this species in this region), as individuals probably suffer from high mortality rates in this fishery, even if they are released. In the Western and Central Pacific, observations from the longline fishery have shown that CMM 2011-04 for the retention prohibition of oceanic whitetip is not being strictly followed (or not yet fully implemented), with non-negligible proportions of oceanic whitetips still being retained or finned. In fact, more oceanic whitetip sharks were retained in 2013 (the first year of the CMM) than 2012 in the longline fishery (Rice *et al*., 2015). The ERA team agreed that despite the increasing management measures in this region, given the severely depleted state of the oceanic whitetip population, less-than-full implementation erodes the benefits of any mitigation measures. In the Indian Ocean, the ERA team expressed significant concern regarding the inadequacy of management measures. In particular, the IOTC's Resolution 13-06 on the retention prohibition of oceanic whitetip shark is limited in terms of its scope and effectiveness. This is because the IOTC Resolution 13-06 is not binding on India (one of the main oceanic whitetip shark catching countries identified by the IOTC), does not apply to artisanal fisheries operating within their EEZs for the purposes of local consumption, and does not explicitly prohibit selling or offering for sale any oceanic whitetip products.

We noted that in some locations, regulatory measures may be effective for reducing the threat of overutilization. For example, in the U.S. Northwest Atlantic and Pacific Island States and

Territories, oceanic whitetip sharks are managed under comprehensive management plans and regulations. In Hawaii for example, finning regulations have resulted in a significant decline in the number of oceanic whitetip sharks finned and an increase in the number of sharks released alive. In the Northwest Atlantic, oceanic whitetip sharks are managed under the pelagic species complex of the Atlantic HMS FMP, with commercial quotas imposed that restrict the overall level of oceanic whitetip sharks taken in this part of its range. Pelagic longline gear is heavily managed and strictly monitored. The use of pelagic longline gear (targeting swordfish, tuna and/or shark) also requires specific permits, with all required permits administered under a limited access program. Presently, no new permits are being issued; thus, persons wishing to enter the fishery may only obtain these permits by transferring the permit from a permit holder who is leaving the fishery, and are currently subject to vessel upgrading restrictions. These national regulations, as detailed in the 2006 Consolidated HMS FMP and described in this Status Review Report, combined with ICCAT's Recommendation 10-07 on the retention prohibition of oceanic whitetip shark have likely led to the recent stabilization of the Northwest Atlantic population. In contrast, the ERA team had significant concerns regarding the inadequacy of regulatory mechanisms in the South Atlantic, and in particular, the most significant oceanic whitetip shark catching country in the region (i.e., Brazil). Specifically, the ERA team expressed concern regarding the end of systematic data collection in 2012 from fleets fishing over Brazilian jurisdiction, and the cancellation of onboard observer programs, which renders any further monitoring of South Atlantic shark populations difficult or impossible.

The ERA team also deemed inadequate regulations to control for overutilization via the shark fin trade a concern, because the shark fin trade has and continues to be the main economic driver for retention and mortality of oceanic whitetip shark in commercial fisheries throughout the globe. As noted previously in the *Overutilization* section above, the ERA team recognized that the situation regarding the fin trade is showing a general improvement, with recent studies indicating a decline in the shark fin market due to a waning interest in fins and an increase in regulations to curb shark finning. For example, many countries and RFMOs have implemented shark finning bans or have prohibited the sale or trade of shark fins or products (as described in detail in this Status Review document), with declining trends in finning and catches of oceanic whitetip sharks evident in some locations as a result of these regulations (e.g., Fiji, Australia and the United States). In fact, the trade in shark fins through China, Hong Kong Special Administrative Region (SAR), which has served as an indicator of the global trade for many years, rose by 10% in 2011 but fell by 22% in 2012. Additionally, current indications are that the shark fin trade through Hong Kong SAR and China will continue to contract (Dent and Clarke 2015). However, despite the slight improvement regarding the decline of the shark fin trade, the ERA team expressed concern that the high demand for oceanic whitetip fins is ongoing, as evidenced by recent genetic studies that confirm the presence of oceanic whitetip shark fins in several markets throughout its range, as well as several incidents of illegal finning and trafficking of oceanic whitetip fins in places like Indonesia and Costa Rica. Additionally, while the species was listed under Appendix II of CITES in 2014, there have since been several shipments of oceanic whitetip fins confiscated upon entry into Hong Kong due to a lack of proper permitting paperwork from the countries of origin. Based on the foregoing information, the ERA team concluded that despite national and international protections for oceanic whitetip, illegal finning and exportation activities are ongoing. As such, and based on the best available information, existing regulatory mechanisms to control for overutilization by the shark fin trade are likely inadequate to significantly reduce this threat to the oceanic whitetip shark at this time.

Other Natural or Manmade Threats

The ERA team did not identify any other natural or manmade threats that may affect the continued existence of the oceanic whitetip shark. As described in this Status Review, although oceanic whitetip sharks are likely exposed to a number of pollutants and contaminants in their habitat that have the potential to cause negative physiological impacts to the species, the effects of these pollutants in oceanic whitetip shark populations and potential risk to the viability of the species remain unknown. In fact, there is no information on the lethal concentration limits of toxins or metals in oceanic whitetip sharks or evidence to suggest that current concentrations of environmental pollutants are causing detrimental physiological effects to the point where the species may be at an increased risk of extinction. As such, the best available information does not indicate that the present bioaccumulation rates and concentrations of environmental pollutants in the tissues of oceanic whitetip sharks are significant threats to the species, such that it substantially increases the species' risk of extinction throughout its global range.

Overall Risk Summary

Guided by the results and discussions from the demographics risk analysis and threats assessment, we analyzed the overall risk of extinction to the global oceanic whitetip shark population. In this process, the ERA team considered the best available scientific and commercial information regarding the oceanic whitetip shark from all regions of the species' global range, and analyzed the collective condition of these populations to assess the species' global extinction risk. The following table gives the results of our likelihood point distributions. Likelihood points were tallied and the totals (n = 60) are presented for the overall level of extinction risk.

Table 6 Results of the ERA team's overall extinction risk analysis

Overall Level of Extinction Risk for the Oceanic Whitetip Shark			
	1 = Low risk	2 = Moderate risk	3= High risk
# of Likelihood Points	20	34	6

The ERA team was fairly confident in determining the overall level of extinction risk for the oceanic whitetip shark, placing the majority of our likelihood points in the "moderate risk" category. Due to some uncertainty regarding abundance trends and catch data for populations in certain areas (e.g., South Atlantic and Indian Ocean), as well as stabilizing trends observed in two areas (e.g., Northwest Atlantic and Hawaii), the team expressed uncertainty by placing some of their likelihood points in the "low risk" and "high risk" categories as well.

During discussions, the ERA team reiterated that the once abundant and ubiquitous oceanic whitetip shark has likely experienced significant historical population declines throughout its global range, with multiple data sources and analyses, including a stock assessment and trends in relative abundance, suggesting declines in excess of 80% in most areas. The ERA team concluded that declining abundance trends of varying magnitudes are likely ongoing in all three ocean basins. The ERA team noted that the species' ability to avoid extirpation in the Northwest Atlantic and Hawaii after significant declines and persist at a low population size, likely precludes the species from a current high risk of extinction. However, the ERA team noted that the most significant threat to the continued existence of the oceanic whitetip shark in the foreseeable future is ongoing and significantly high rates of fishing mortality driven by demands of the international trade in shark fins and meat, as well as impacts related to incidental bycatch and IUU fishing. The team emphasized that the oceanic whitetip shark's vertical and horizontal distribution significantly increases its exposure to industrial fisheries, including pelagic longline and purse seine fisheries operating within the species' core tropical habitat throughout its global range. In addition to declines in oceanic whitetip catches throughout its range, there is also evidence of declining average size over time in some areas, which is particularly concerning given that litter size has been shown to be correlated with maternal length. With such extensive declines in the species' global abundance and the ongoing threat of overutilization, the species' slow growth and low fecundity may limit its ability for compensation. Related to this, the low genetic diversity of oceanic whitetip is also cause for concern and a viable risk over the foreseeable future for this species. This is particularly concerning since it is possible (though uncertain) that a reduction in genetic diversity following the large reduction in population size due to overutilization has not yet manifested in the species. Loss of genetic diversity can lead to reduced fitness and a limited ability to adapt to a rapidly changing environment, thus increasing the species' overall risk of extinction.

Finally, the species' extensive distribution, ranging across entire oceans and across multiple international boundaries complicates management of the species. The ERA team agreed that implementation and enforcement of management measures that could reduce the threat of overutilization to the species are likely highly variable and/or lacking altogether across the species' range. The ERA team acknowledged a significant increase in species-specific management measures to control for overutilization of oceanic whitetip shark across its range; however, the ERA team also noted that most of these regulations, particularly the retention prohibitions enacted by all relevant RFMOs throughout the range of the species, are too new to truly determine their efficacy in reducing mortality of oceanic whitetip shark. Despite this limitation, and with the exception of the Northwest Atlantic and Pacific Island States and Territories, the ERA team was not confident in the adequacy of these regulations to reduce the threat of overutilization and prevent further abundance declines in the foreseeable future. First, the ERA team discussed the fact that retention prohibitions do not prevent at-vessel and post-release mortality, which is likely high in some fisheries. In addition, the biggest concern to the ERA team with regard to these regulatory mechanisms going forward is the lack of full implementation and enforcement. The ERA team noted that proper implementation and enforcement of these regulations would likely result in a reduction in overall mortality of the species over time. However, the best available information suggests that this may not currently be the case. Given the species' depleted state throughout its range, the ERA team agreed that less than full implementation and enforcement of current regulations is likely undermining any conservation benefit to the species.

Based on all of the foregoing information, which represents the best scientific and commercial data available regarding current demographic risks and threats to the species, the ERA team concluded that the oceanic whitetip shark currently has a moderate risk of extinction. We concluded that the species does not currently have a high risk of extinction because of the following: (1) the species has a significantly broad distribution and does not seem to have been extirpated in any region, even in areas where there is heavy harvest bycatch and utilization of the species' high-value fins; (2) there appears to be a potential for relative stability in population sizes on the order of 5-10 years at the post-decline depressed state. This suggests that this species is potentially capable of persisting at a low population size; (3) two populations seem to have stabilized, which reduces the global population's overall extinction risk; (4) the overall reduction of the fin trade as well as increasing management regulations will likely reduce overall mortality to some extent, and thus reduces the species' current risk of extinction. However, given the species' significant historical and ongoing abundance declines in all three ocean basins, slow growth, low fecundity, and low genetic diversity, combined with ongoing threats of overutilization and largely inadequate regulatory mechanisms, we concluded that over the next 30 years, the oceanic whitetip shark has a moderate risk of extinction throughout its global range.

Appendix 1

Current and relevant shark regulations by U.S. state and territory in the Atlantic and Pacific (Source: Adapted from Miller *et al*. 2014; NMFS (2011a); NMFS (2013a); HMSMT Report 2008).

U.S. Atlantic States	**Shark Regulations**
Maine	Although part of the Atlantic States Marine Fisheries Commission (ASMFC), both Maine and New Hampshire were granted de minimis status for the Interstate FMP for Atlantic Coastal Sharks (see further details below) that was adopted by the ASFMC in 2008 (ASFMC 2008). These states implement the following rules that uphold the goals and objectives of the FMP: require federal dealer permits for all dealers purchasing Coastal Sharks; prohibit the take or landings of prohibited species in the plan; close the fishery for porbeagle sharks when the NMFS quota has been harvest; prohibit the commercial harvest of porbeagle sharks in State waters; require that head, fins and tails remain attached to the carcass of all shark species, except smooth dogfish, through landing.
New Hampshire	
Massachusetts	Also a part of the ASMFC, and was granted de minimis status for the Interstate FMP for Atlantic Coastal Sharks. Granted an exemption from the possession limit for non-sandbar large coastal sharks and closures of the non-sandbar large coastal shark fisheries.
Rhode Island Connecticut New York New Jersey Delaware Maryland Virginia	Fishers must abide by the Interstate FMP for Atlantic Coastal Sharks adopted by the ASMFC (ASFMC 2008). This FMP requires that all sharks harvested by commercial or recreational fishers within state waters have the tail and fins attached naturally to the carcass. While there are no set quotas for the pelagic group, ASFMC opens and closes the fishery when NMFS opens and closes the corresponding federal fisheries. Sharks caught in the recreational fishery must have a fork length of at least 4.5 feet (54 inches) and they must be caught using a handline or rod and reel. Each recreational shore-angler is allowed a maximum harvest of one shark from the federal recreationally permitted species per calendar day. Recreational fishing vessels are allowed a maximum harvest of one shark from the federal recreationally permitted species per trip, regardless of the number of people on board the vessel. An annual recreational seasonal closure is imposed in state waters of Virginia, Maryland, Delaware and New Jersey from May 15 through July 15 during which time fishers are prohibited from possessing certain species - regardless of where the shark was caught. Fishers who catch any of these species in federal waters may not transport them through the state waters of Virginia, Maryland, Delaware, and New

U.S. Atlantic States	Shark Regulations
	Jersey during the seasonal closure. New York amended its Environmental Conservation Law to prohibit sharks (excluding spiny dogfish) from being taken for commercial or recreational purposes by baited hooking except with the use of non-stainless steel non-offset circle hooks. New York, Maryland, and Delaware have shark fin laws that ban the possession, sale, or distribution of shark fins. All three laws in these states exempt Spiny dogfish and Smooth dogfish fins from the ban. Each state law also includes other exceptions including for education, research, and other situations.
North Carolina	Adopted the ASMFC Coastal Shark Interstate FMP. Additionally, the Director may impose restrictions for size, seasons, areas, quantity, etc. via proclamation. The longline in the shark fishery shall not exceed 500 yds or have more than 50 hooks. Requires reporting of all recreationally landed sharks through state administered HMS catch card program.
South Carolina	Adopted the ASMFC Coastal Shark Interstate FMP. Additionally, defers to federal regulations. Gillnets may not be used in the shark fishery in state waters.
Georgia	Adopted the ASMFC Coastal Shark Interstate FMP. Additionally, commercial/recreational regulations: 2 sharks/person or boat, whichever is less, with a minimum size of 48” FL (122 cm). It is unlawful to have in possession more than one shark greater than 84" TL (213 cm). All sharks must be landed with the head and fins intact. Sharks may not be landed in Georgia if harvested using gillnets.
Florida	Adopted the ASMFC Coastal Shark Interstate FMP.
Alabama	Recreational and commercial: bag limit – 1 shark/person/day with a minimum size of 54” FL (137 cm) or 30” dressed (76 cm). State waters close when federal season closes and no shark fishing on weekends, Memorial Day, Independence Day, or Labor Day. Restrictions on chumming and shore-based angling if creating unsafe bathing conditions. Regardless of open or closed season, gillnet fishers targeting other fish may retain sharks with a dressed weight not exceeding 10% of total catch.

U.S. Atlantic States	**Shark Regulations**
Louisiana	Recreational: bag limit 1 shark/person/day with a minimum size of 54" FL (137 cm). Commercial: 33 sharks/vessel/day limit and no minimum size. Commercial and recreational harvest of sharks prohibited from April 1st through June 30th. Fins must remain naturally attached to carcass through off-loading. Owners/operators of vessels other than those taking sharks in compliance with state or federal commercial permits are restricted to no more than one shark from either the large coastal, small coastal, or pelagic group per vessel per trip within or without Louisiana waters.
Mississippi	Recreational: bag limit - LCS/Pelagics 1 shark/person (possession limit) up to 3 sharks/vessel (possession limit) with a minimum size of 37" TL (94 cm). Finning is prohibited.
Texas	Commercial/recreational: bag limit – 1 shark/person/day; Commercial/recreational possession limit is twice the daily bag limit (i.e., 2 sharks/person/day)
Illinois	Bans the possession, sale, or distribution of detached shark fins.
U.S. Atlantic and Caribbean Territories:	
U.S. Virgin Islands	Federal regulations and federal permit requirements apply in territorial waters.
Puerto Rico	Federal regulations and federal permit requirements apply in territorial waters.

U.S. Pacific States	
California	California's Shark Fin Prohibition law prohibits the sale, purchase, or possession of detached shark fins. The law exempts licensed shark fishers that land sharks in California from the possession ban. Includes an education and research exemption. Sharks may not be taken with drift gillnets of mesh size eight inches (20 cm) or greater except under a revocable permit issued by the California Department of Fish and Game.
Hawaii	It is unlawful to possess, sell, offer for sale, trade, or distribute shark fins. Includes exemptions for education and research.
U.S. Pacific	

Territories:	
American Samoa	Prohibits the possession, delivery, or transportation of any shark species or shark body part. Includes an exemption for research. Shark fishing and possession of sharks within 3 nmi of shoreline was banned in Nov 2012.
Guam	Bans the possession, sale, offer for sale, take, purchase, barter, transport, export, import, trade or distribution of shark fins. Includes exemptions for research and subsistence fishing.
CNMI	Bans the possession, sale, offer for sale, trade, or distribution of shark fins. Includes exemptions for research and subsistence fishing.

Appendix 2

Summary of Global Shark Fishing Regulations (excluding the United States)

Country	Date	Prohibited Shark Fishing
Bahamas	2011	Commercial shark fishing in the approximately 630,000 square kilometers (243,244 square miles) of the country's waters is prohibited.
British Virgin Islands	2014	No commercial fishing of sharks or rays
Brunei	2013	No harvest or importation of shark products
Colombia	1995	Shark fishing is prohibited in the Malpelo Wildlife Sanctuary
Cook Islands	2012	Commercial shark fishing banned. Created a sanctuary in its waters, contiguous with the sanctuary in French Polynesia and bans the possession or sale of shark products.
Congo-Brazzaville	2001	Shark fishing is prohibited.
Costa Rica	1978	Shark fishing is prohibited in Cocos Island National Park.
Ecuador	2004	Directed fishing for sharks is banned in all Ecuadorian waters, but sharks caught in "continental" (i.e., not Galapagos) fisheries may be landed if bycaught (finning is banned).
Egypt	2005	Shark fishing is prohibited throughout the Egyptian Red Sea territorial waters to 12 miles from the shore, as is the commercial sale of sharks.
French Polynesia	2012	All shark fishing banned. Created shark sanctuary in its waters contiguous with the sanctuary in Cook Islands, and banned trade in all sharks.

Country	Date	Prohibited Shark Fishing
Guinea-Bissau	2009	Ban on shark fishing in Marine Protected Areas (two parks covering 2,077 km^2).
Honduras	2010	No shark fishing
Indonesia	2010	No shark fishing in Raja Ampat
Israel	1980	No shark fishing
Kiribati	2015	No commercial shark fishing in the Phoenix Islands Protected Area and Southern Line Islands
Maldives	2010	Bans fishing, trade and export of sharks and shark products in the country, effectively converting its 35,000-square-mile (90,000-square-kilometer) EEZ into a sanctuary for sharks, a swath of the Indian Ocean about the size of the U.S. State of Maine.
Marshall Islands	2011	No commercial shark fishing or sale of shark products
Mauritania	2003	Created a 6000 km^2 coastal sanctuary for sharks and rays (Banc d'Arguin National Park - PNBA). Targeted shark fishing is prohibited.
Micronesia Region	2015	Established the Micronesia Regional Shark Sanctuary, which prohibits the commercial fishing and trade of sharks and rays and their parts. The sanctuary includes the waters of the Republic of Marshall Islands, Republic of Palau, Guam, CNMI, Federated States of Micronesia and its four member states, Yap, Chuuk, Pohnpei, and Kosrae.
Micronesia	2015	Passed Public Law No. 18-108 in early 2015 to implement the Micronesia Regional Shark Sanctuary, which prohibits the commercial fishing and trade of sharks and rays and their parts.
New Caledonia	2013	Passed regulations to prohibit all shark fishing in its EEZ. Regulations also ban the taking, possession, sale or export of all species of sharks. The Pacific waters of this French overseas territory are roughly the size of South Africa and can protect upwards of 50 species of sharks.

Country	Date	Prohibited Shark Fishing
Palau	2009	Created a shark sanctuary that encompasses 240,000 square miles (621,600 square kilometers, roughly size of France) of protected waters. Prohibits the commercial fishing of sharks.
Republic of the Marshall Islands	2011	Bans commercial fishing of sharks in all 1,990,530 square kilometers (768,547 square miles) in the country's waters, an ocean area four times the landmass of California. A complete prohibition on the commercial fishing of sharks as well as the sale of any sharks or shark products. Any shark caught accidentally by fishing vessels must be set free. A ban on the use of wire leaders, a longline fishing gear which is among the most lethal to sharks.
Sabah, Malaysia	2011	Prohibits shark fishing.
Spain	2011	Prohibits the capture, injury, trade, import and export of specific shark species, and requires periodic evaluations of their conservation status.
Tokelau (an island territory of New Zealand in the South Pacific)	2011	Created a shark sanctuary which encompasses all 319,031 square kilometers (123,178 square miles) of Tokelau's exclusive economic zone; however, dead sharks may be retained.
Venezuela	2012	Commercial shark fishing is prohibited throughout the 3,730 square kilometers (1,440 square miles) of the Caribbean Sea that make up the Los Roques and Las Aves archipelagos.

Appendix 3

Summary of Global Shark Finning Regulations (excluding U.S.)

Country	Date	Prohibited Shark Finning
Argentina	2009	Ban on shark finning.
Australia	Various	States and Territories govern their own waters. Central government regulates 'Commonwealth' or Federal waters, from 3 to 200 nautical miles offshore. Sharks must be landed with fins naturally attached in Commonwealth, NSW and Victorian waters, and must be landed with corresponding fins in a set fin to carcass ratio in Tasmanian, Western Australian, Northern Territory and Queensland waters.
Brazil	1998	Sharks must be landed with corresponding fins. Fins must not weigh more than 5% of the total weight of the carcass.

Country	Date	Prohibited Shark Finning
		All carcasses and fins must be unloaded and weighed and the weights reported to authorities. Pelagic gillnets and trawls are prohibited in waters less than 3 nautical miles (5.6 km) from the coast.
Canada	1994	Finning in Canadian waters and by any Canadian licensed vessel fishing outside of the EEZ is prohibited.When landed, fins must not weigh more than 5% of the dressed weight of the shark.
Cape Verde	2005	Finning prohibited throughout the EEZ.
Chile	2011	Bans shark finning in Chilean waters. Sharks must be landed with fins naturally attached.
Colombia	2007	Sharks must be landed with fins naturally attached to their bodies.
Costa Rica	2006	Ban on shark finning.
El Salvador	2006	Shark finning is prohibited. Sharks must be landed with at least 25% of each fin still attached naturally. The sale or export of fins is prohibited without the corresponding carcass.
England and Wales	2009	Ban on shark finning.
European Union	2003 (finning) 2013 (fins-attached)	Shark finning is prohibited by all vessels fishing in EU waters and on all EU vessels fishing in oceans worldwide since 2003. Sharks must be landed with fins naturally attached since 2013.
Gambia	2004	Ban on finning in all territorial waters. Mandatory to land sharks caught in Gambian waters on Gambian soil.
Guinea	2009	Ban on finning in all territorial waters.
India	2013	Bans removal of shark fins on board a vessel in the sea.
Japan	2008	Ban on shark finning by Japanese vessels; however, Japanese vessels operating and landing outside Japanese waters are exempt.
Mexico	2007	Shark finning is prohibited. Shark fins must not be landed unless the bodies are on board the vessel. In 2011, Mexico banned shark fishing from May 1 to July 31 in Pacific Ocean and from May 1 to June 30 in Gulf of Mexico and Caribbean Seas.
Namibia	2003	Generally prohibits the discards of harvested or bycaught marine resources. Prohibits shark finning.

Country	Date	Prohibited Shark Finning
New Zealand	2009/2016	Finning of live sharks (and disposing of carcasses at sea) is prohibited. By 2016, all species of sharks must be released alive or brought to shore with fins naturally attached (with the exception of some species that may be landed in accordance with a gazette fin to "greenweight" ratio)[27].
Nicaragua	2004	Fins must not weigh more than 5% of the total weight of the carcass. Export of fins allowed only after proof that carcass has been sold as the capture of sharks for the single use of their fins is prohibited.
Oman	1999	Prohibits the throwing of any shark part or shark waste in the sea or on shore. It is also prohibited to separate shark fins and tails unless this is done according to the conditions set by the competent authority.
Pakistan		Require that all parts of the shark are used and fins be landed naturally attached.
Panama	2006	Shark finning is prohibited. Industrial fishers must land sharks with fins naturally attached. Artisanal fishers may separate fins from the carcass but fins must not weigh more than 5% of the total weight of the carcass.
Seychelles	2006	Fins may not be removed onboard a vessel unless authorized. Must produce evidence that they have the capacity to utilize all parts or the shark. Fins may not be transshipped. Fins must not weigh more than 5% of the total weight of the carcass (after evisceration) or 7% (after evisceration and beheading).
Sierra Leone	2008	Ban on shark finning.
South Africa	1998	Sharks must be landed, transported, sold, or disposed of whole (they can be headed and gutted). Sharks from international waters may be landed in South Africa with fins detached.
Sri Lanka	2001	Ban on shark finning.
Taiwan	2012	Enacted a shark finning ban with the exception of vessels not landing in Taiwan.
Venezuela	2012	Sharks caught in Venezuelan waters must be brought to port with fins naturally attached.

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[27] http://www.fish.govt.nz/en-nz/Environmental/Sharks/Eliminating+shark+finning+in+New+Zealand.htm

Appendix 4

Summary of RFMO Shark Regulations pertinent to the oceanic whitetip shark

RFMO	Date	Shark Regulations
International Commission for the Conservation of Atlantic Tunas (ICCAT)[28]	2010	Recommendation 10-07 specifically prohibits the retention, transshipping, landing, storing, selling, or offering for sale any part or whole carcass of oceanic whitetip sharks (*C. longimanus*) in any fishery.
Inter-American-Tropical-Tuna-Commission (IATTC)[29]	2011	Resolution C-11-10 on the conservation of oceanic whitetip sharks caught in association with fisheries in the Antigua Convention Area prohibits retaining onboard, transhipping, landing, storing, selling, or offering for sale any part or whole carcass of oceanic whitetip sharks in the fisheries covered by the Antigua Convention.
Western and Central Pacific Fisheries Commission (WCPFC)[30]	2013	Conservation Management Measure (CMM) 2011-04 prohibits vessels flying their flag and vessels under charter arrangements to the CCM from retaining onboard, transshipping, storing on a fishing vessel, or landing any oceanic whitetip shark, in whole or in part, in the fisheries covered by the Convention. WCPFC also adopted a CMM 2014-05 (effective July 2015) that requires each national fleet to choose either banning wire leaders or banning the use of shark lines.
Indian Ocean Tuna Commission (IOTC)[31]	2013	Resolution 13/06 prohibits, as an interim pilot measure, all fishing vessels flying their flag and on the IOTC Record of Authorized Vessels, or authorized to fish for tuna or tuna-like species managed by the IOTC on the high seas to retain onboard, transship, land or store any part or whole carcass of oceanic whitetip sharks with the exception of scientific observers collecting biological samples. The provisions of this measure do not apply to artisanal fisheries operating exclusively in their respective Exclusive Economic Zone (EEZ) for the purpose of local

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[28] https://www.iccat.int/en/RecsRegs.asp

[29] https://www.iattc.org/ResolutionsActiveENG.htm

[30] https://www.wcpfc.int/conservation-and-management-measures

[31] http://www.iotc.org/cmms/basic

RFMO	Date	Shark Regulations
		consumption. This measure is also not binding on India.
Indian Ocean Tuna Commission (IOTC)	2005	Requires that fishers fully utilize any retained catches of sharks. Full utilization is defined as retention by the fishing vessel of all parts of the shark excepting head, guts, and skins, to the point of first landing. Onboard fins cannot weigh more than 5% of the weight of sharks onboard, up to the first point of landing (HSI 2014).
Inter-American Tropical Tuna Commission (IATTC)	2005	
North Atlantic Fisheries Organization (NAFO)	2005	
Southeast Atlantic Fisheries Commission (SEAFO)	2006	
Western and Central Pacific Fisheries Commission (WCPFC)	2008	
North East Atlantic Fisheries Commission (NEAFC)	2007	

Appendix 5

Status and Development of National Plans of Action-Sharks by top 26 shark-catching countries/territories and regulatory mechanisms in each country (Source: Adapted by Fischer *et al*. (2012) and updated via http://www.fao.org/fishery/ipoa-sharks/npoa/en).

Rank and Country/Territory	NPOA-Sharks
1. Indonesia	Yes, released in 2010
2. India	No, under development as at October 2004; current status unknown
3. Spain	Yes, European Community (EC) Action Plan on the Conservation and Management of Sharks
4. Taiwan	Yes, released in 2006
5. Argentina	Yes, released in 2004
6. Mexico	Yes, released in 2004
7. USA	Yes, released in 2001
8. Pakistan	No; status unknown
9. Malaysia	Yes, released in 2006; revised in 2014
10. Japan	Yes, released in 2001; revised in 2009
11. France	Yes, see EC Action Plan

Rank and Country/Territory	NPOA-Sharks
12. Thailand	No, drafted in 2005, but current status unknown
13. Brazil	No, draft available but not approved
14. Sri Lanka	Yes, released in 2013
15. New Zealand	Yes, released in 2008; revised in 2013
16. Portugal	Yes, see EC Action Plan
17. Nigeria	No
18. Iran	Yes, but unavailable
19. United Kingdom	Yes, see EC Action Plan
20. Republic of Korea	Yes, released in 2011
21. Canada	Yes, released in 2007
22. Peru	No, drafted in 2005, but awaiting adoption
23. Yemen	No
24. Australia	Yes, released in 2004; revised in 2012
25. Senegal	Yes, released in 2005
26. Venezuela	Yes, released in 2006

References

Agnew, D.J., Pearce, J., Pramod, G., Peatman, T., Watson, R., Beddington, J.R. and Pitcher, T.J. (2009) Estimating the Worldwide Extent of Illegal Fishing. *PloS one,* **4,** e4570-e4570.

Aguilar, C., González-Sansón, G., Hueter, R.E., Rojas, E., Cabrera, Y., Briones, A., Borroto, R., Hernández, A. and Baker, P. (2014) Captura de tiburones en la región noroccidental de Cuba. *Lat. Am. J. Aquat. Res.,* **42,** 477-487.

Amorim, A.F. (1998) Elasmobranchs caught by longlines off Brazil. *Marine and Freshwater Research,* **49,** 621-632.

Anderson, R.C. and Waheed, A. (1990) Exploratory fishing for large pelagic species in the Maldives. *Ministry of Fisheries and Agriculture. Republic of Maldives Bay of Bengal Programme For Fisheries Development.***,** 17 pp.

Anderson, R.C., Adam, M.S. and Saleem, M.R. (2011) Shark longline fishery in the northern Maldives. IOTC-2011-WPEB07-27 Rev_1.

Arauz, R. (2017) Report: oceanic whitetip shark (Carcharhinus longimanus) landing information from Costa Rica, inadequacy of existing domestic and regional regulatory regimes, and recommendations for oceanic whitetip shark protective regulations. Fins Attached Marine Research and Conservation. 16pp.

Ardill, D., Itano, D. and Gillett, R. (2011) A review of bycatch and discard issues in Indian Ocean tuna fisheries. *SmartFish Working Papers No. 00X. Indian Ocean Commission-SmartFish Programme.***,** 48 pp.

Arocha, F., Arocha, O. and Marcano, L.A. (2002) Observed shark bycatch from the Venezuelan tuna and swordfish fishery from 1994 through 2000. *Col. Vol. Sci. Pap. ICCAT,* **54,** 1123-1131.

Asano-Filho, M., Fonteles Holanda, F.C.A., da Silva Santos, F.J., Lucena, F. and de Sousa Lima Pantaleão, G. (2004) A short note on the catch composition and weight-length relationship of tunas, billfishes and sharks of North Brazil. *Brazilian Journal of Oceanography,* **52,** 249-253.

Austin, B. and Zhang, X.H. (2006) Vibrio harveyi: a significant pathogen of marine vertebrates and invertebrates. *Lett. Appl. Microbiol.,* **43,** 119-124.

Australia Department of the Environment (2014) Non-Detriment finding for the export of shark species listed in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and harvested from Australian waters: *Sphyrna lewini* - scalloped hammerhead shark, *Sphyrna mokarran* -great hammerhead shark, *Sphyrna zygaena* -smooth hammerhead shark, *Lamna nasus* -porbeagle shark, *Carcharhinus longimanus* - oceanic whitetip shark. p. 56.

Backus, R.H., Springer, S. and Arnold Jr., E.L. (1956) A contribution to the natural history of the white-tip shark, *Pterolamiops longimanus* (Poey). *Deep-sea Research,* **3,** 178-188.

Barreto, R., Ferretti, F., Mills, J., Amorim, A., Andrade, H., Worm, B. and Lessa, R. (2015) Trends in the exploitation of South Atlantic shark populations. *Conservation Biology,* **30,** 792-804.

Bass, A.J., D' Aubrey, J.D. and Kistnasamy, N. (1973) *Sharks of the east coast of southern Africa. I. The genus Carcharhinus (Carcharhinidae).* Durban, Republic of South Africa: South African Association for Marine Biological Research, The Oceanographic Institute, 168pp.

Baum, J., Medina, E., Musick, J.A. and Smale, M. (2006) *Carcharhinus longimanus*. The IUCN Red List of Threatened Species. Version 2015.2. Downloaded on 24 June 2015.: IUCN.

Baum, J.K., Myers, R.A., Kehler, D.G., Worm, B., Harley, S.J. and Doherty, P.A. (2003) Collapse and conservation of shark populations in the Northwest Atlantic. *Science,* **299,** 389-392.

Baum, J.K. and Myers, R.A. (2004) Shifting baselines and the decline of pelagic sharks in the Gulf of Mexico. *Ecol. Lett.,* **7,** 135-145.

Baum, J.K. and Blanchard, W. (2010) Inferring shark population trends from generalized linear mixed models of pelagic longline catch and effort data. *Fisheries Research,* **102,** 229-239.

Beerkircher, L.R., Cortés, E. and Shivji, M. (2002) Characteristics of shark bycatch observed on pelagic longlines off the Southeastern United States, 1992–2000. *Marine Fisheries Review,* **64,** 40-49.

Beerkircher, L.R., Brown, C.J., Abercrombie, D.L. and Lee, D.W. (2004) SEFSC Pelagic observer program data summary for 1992-2002. *NOAA Technical Memorandum NMFS-SEFSC-522***,** 25.

Bensley, N., Woodhams, J., Patterson, H., Rodgers, M., McLoughlin K, Stobutzki, I. and Begg, G. (2010) 2009 Shark Assessment Report for the Australian National Plan of Action for the Conservation and Management of sharks, Final Report to the Department of Agriculture, Fisheries and Forestry, Bureau of Rural Sciences. Canberra, Australia.

Berkeley, S.A. and Campos, W.L. (1988) Relative abundance and fishery potential of pelagic sharks along Florida's East Coast. *Marine Fisheries Review,* **50.**

Blaber, S.J.M., Dichmont, C.M., White, W., Buckworth, R., Sadiyah, L., Iskandar, B., Nurhakim, S., Pillans, R., Andamari, R., Dharmadi and Fahmi (2009) Elasmobranchs in southern Indonesian fisheries: the fisheries, the status of the stocks and management options. *Rev. Fish Biol. Fish.,* **19,** 367-391.

Boggs, C.H. and Ito, R.Y. (1993) Hawaii's pelagic fisheries. *Marine Fisheries Review,* **55,** 69-82.

Bonfil, R., Clarke, S. and Nakano, H. (2008) The biology and ecology of the oceanic whitetip shark, *Carcharhinus longimanus*. In: *Sharks of the Open Ocean: Biology, Fisheries, and Conservation.* M.D. Camhi, E.K. Pikitch and E.A. Babcock (eds): Blackwell Publishing. pp. 128-139.

Bradai, M.N., Saidi, B. and Enajjar, S. (2012) Elasmobranchs of the Mediterranean and Black Sea: status, ecology and biology bibliographic analysis. *General Fisheries Commission for the Mediterranean Studies and Reviews,* **91,** 116.

Branstetter, S. (1990) Early life-history implications of selected carcharhinoid and lamnoid sharks of the Northwest Atlantic. In: *Elasmobranchs as living resources: advances in the biology, ecology, systematics, and the status of the fisheries. NOAA Tech. Rep. NMFS 90.* J. Pratt, Harold L. , S.H. Gruber and T. Taniuchi (eds): U.S. Dep. Commer., NOAA NMFS. pp. 17-28.

Brodziak, J., Walsh, W.A. and Hilborn, R. (2013) Model selection and multimodel inference for standardizing catch rates of bycatch species: a case study of oceanic whitetip shark in the Hawaii-based longline fishery. *Canadian Journal of Fisheries and Aquatic Sciences,* **70,** 1723-1740.

Bromhead, D., Clarke, S., Hoyle, S., Muller, B., Sharples, P. and Harley, S. (2012) Identification of factors influencing shark catch and mortality in the Marshall Islands tuna longline fishery and management implications. *Journal of fish biology,* **80,** 1870-1894.

Burgess, G.H., Beerkircher, L.R., Cailliet, G.M., Carlson, J.K., Cortés, E., Goldman, K.J., Grubbs, R.D., Musick, J.A., Musyl, M.K. and Simpfendorfer, C.A. (2005a) Reply to "Robust estimates of decline for pelagic shark populations in the Northwest Atlantic and Gulf of Mexico". *Fisheries,* **30,** 30-31.

Burgess, G.H., Beerkircher, L.R., Cailliet, G.M., Carlson, J.K., Cortés, E., Goldman, K.J., Grubbs, R.D., Musick, J.A., Musyl, M.K. and Simpfendorfer, C.A. (2005b) Is the collapse of shark populations in the Northwest Atlantic Ocean and Gulf of Mexico real? *Fisheries,* **30,** 19-26.

Camara, M.B. (2008) Quelle gestion des peches artisanales en Afrique de l'Ouest ? Etude de la complexite de l'espace halieutique en zone littoral senegalaise., Universite Cheikh Anta Diop Dakar.

Camargo, S.M., Coelho, R., Chapman, D., Howey-Jordan, L., Brooks, E.J., Fernando, D., Mendes, N.J., Hazin, F.H., Oliveira, C., Santos, M.N., Foresti, F. and Mendonca, F.F. (2016) Structure and genetic variability of the oceanic whitetip shark, *Carcharhinus longimanus*, determined using mitochondrial DNA. *PloS one,* **11,** 1-11.

Camhi, M.D., Pikitch, E.K. and Babcock, E.A. (2008) *Sharks of Open Ocean: Biology, Fisheries and Conservation.* Blackwell Publishing, 536pp.

Camhi, M.D., Valenti, S.V., Fordham, S.V., Fowler, S.L. and Gibson, C. (2009) The conservation status of pelagic sharks and rays: report of the IUCN Shark Specialist Group Pelagic Shark Red List Workshop. Newbury, UK., IUCN Species Survival Commission’s Shark Specialist Group. 78pp.

Carlson, J.K. and Gulak, S.J.B. (2012) Habitat use and movements patterns of oceanic whitetip, bigeye thresher, and dusky sharks based on archival satellite tags. *Collect. Vol. Sci. Pap. ICCAT,* **68,** 1922-1932.

Castro, A.L., Stewart, B.S., Wilson, S.G., Hueter, R.E., Meekan, M.G., Motta, P.J., Bowen, B.W. and Karl, S.A. (2007) Population genetic structure of Earth's largest fish, the whale shark (Rhincodon typus). *Mol. Ecol.,* **16,** 5183-5192.

Castro, J.A. and Mejuto, J. (1995) Reproductive parameters of blue shark, *Prionace glauca*, and other sharks in the Gulf of Guinea. *Marine Freshwater Research,* **46,** 967-973.

Cavanagh, R.D. and Gibson, C. (2007) Overview of the conservation stuats of cartilaginous fishes (Chondrichthyans) in the Mediterranean Sea. The World Conservation Union (IUCN). vi + 42.pp.

Chapple, T.K. and Botsford, L.W. (2013) A comparison of linear demographic models and fraction of lifetime egg production for assessing sustainability in sharks. *Conservation biology : the journal of the Society for Conservation Biology,* **27,** 560-568.

Chiaramonte, C. and Vooren, C.M. (2007) Squatina guggenheim, Hidden Angelshark. The IUCN Red List of Threatened Species 2007: e.T39330A10202558. http://dx.doi.org/10.2305/IUCN.UK.2007.RLTS.T39330A10202558.en.

Chin, A., Kyne, P.M., Walker, T.I. and McAuley, R.B. (2010) An integrated risk assessment for climate change: analysing the vulnerability of sharks and rays on Australia's Great Barrier Reef. *Glob. Chang. Biol.,* **16,** 1936-1953.

Chin, A., Simpfendorfer, C., Tobin, A. and Heupel, M. (2013) Validated age, growth and reproductive biology of Carcharhinus melanopterus, a widely distributed and exploited reef shark. *Marine and Freshwater Research,* **64**.

CITES (2013) Convention on International Trade in Endangered Species of Wild Fauna and Flora consideration of proposals for amendment of Appendices I and II. Sixteenth meeting of the Conference of the Parties Bangkok (Thailand), 3-14 March 2013.

Clarke, C.R., Karl, S.A., Horn, R.L., Bernard, A.M., Lea, J.S., Hazin, F.H., Prodöhl, P.A. and Shivji, M.S. (2015a) Global mitochondrial DNA phylogeography and population structure of the silky shark, *Carcharhinus falciformis*. *Marine Biology,* **162,** 945-955.

Clarke, S., Milner-Gullande, J. and Bjorndal, T. (2007) Perspectives social, economic, and regulatory drivers of the shark fin trade. *Marine Resource Economics,* **22,** 305-327.

Clarke, S. (2008) Use of shark fin trade data to estimate historic total shark removals in the Atlantic Ocean. *Aquatic Living Resources,* **21,** 373-381.

Clarke, S. (2009) An alternative estimate of catches of five species of sharks in the Western and Central Pacific Ocean based on shark fin trade data. Western and Central Pacific Fisheries Commission Scientific Committee Fifth Regular Session. WCPFC-SC5-2005/EB-WP-02. 31 pp.

Clarke, S. (2011) A status snapshot of key shark species in the Western and Central Pacific and potential management options. Western and Central Pacific Fisheries Commission Scientific Committee Seventh Regular Session. WCPFC-SC7-2011/EB-WP-04. 36 pp.

Clarke, S., Harley, S., Hoyle, S. and Rice, J. (2011a) An indicator-based analysis of key shark species based on data held by SPC-OFP. Western and Central Pacific Fisheries Commission Scientific Committee Seventh Regular Session. WCPFC-SC7-2011/EB-WP-01. 1-88.

Clarke, S., Yokawa, K., Matsunaga, H. and Nakano, H. (2011b) Analysis of North Pacific shark data from Japanese commercial longline and research/training vessel records. Western and Central Pacific Fisheries Commission Scientific Committee Seventh Regular Session. WCPFC-SC7-2011/EB-WP-02. 87 pp.

Clarke, S. (2013) Towards an Integrated Shark Conservation and Management Measure for the Western and Central Pacific Ocean. Western and Central Pacific Fisheries Commission Scientific Committee Ninth Regular Session. WCPFC-SC9-2013/ EB-WP-08. 36 pp.

Clarke, S., Rui, C., Francis, M., Kai, M., Kohin, S., Liu, K.-M., Simpfendorfer, C., Tovar-Avila, J., Rigby, C. and Smart, J. (2015b) Report of the Pacific Shark Life History Expert Panel Workshop 28-30 April 2015. Western and Central Pacific Fisheries Commission Scientific Committee Eleventh Regular Session. 116pp.

Clarke, S.C., Magnussen, J.E., Abercrombie, D.L., Mcallister, M.K. and Shivji, M.S. (2006a) Identification of shark species composition and proportion in the Hong Kong shark fin market based on molecular genetics and trade records. *Conservation Biology,* **20,** 201-211.

Clarke, S.C., McAllister, M.K., Milner-Gulland, E.J., Kirkwood, G.P., Michielsens, C.G., Agnew, D.J., Pikitch, E.K., Nakano, H. and Shivji, M.S. (2006b) Global estimates of shark catches using trade records from commercial markets. *Ecol. Lett.,* **9,** 1115-1126.

Clarke, S.C., Harley, S.J., Hoyle, S.D. and Rice, J.S. (2012) Population trends in Pacific Oceanic sharks and the utility of regulations on shark finning. *Conservation Biology,* **27,** 197-209.

Claro, R., Baisre, J.A., Lindeman, K.C. and García-Arteaga, J.P. (2001) Cuban fisheries: historical trends and current status. In: *Ecology of the Marine Fishes of Cuba.* R. Claro, K.C. Lindeman and L.R. Parenti (eds): Washington DC: Smithsonian Institution Press. pp. 194-218.

Coelho, R., Hazin, F.H.V., Rego, M., Tambourgi, M., Oliveira, P., Travassos, P., Carvalho, F. and Burgess, G. (2009) Notes of the reproduction of the oceanic whitetip shark, Carcharhinus longimanus, in the southwestern equatorial Atlantic Ocean. *Collect. Vol. Sci. Pap. ICCAT,* **64,** 1734-1740.

Coelho, R., Fernandez-Carvalho, J., Lino, P.G. and Santos, M.N. (2012) An overview of the hooking mortality of elasmobranchs caught in a swordfish pelagic longline fishery in the Atlantic Ocean. *Aquatic Living Resources,* **25,** 311-319.

Compagno, L.J.V. (1984) FAO Species Catalogue. Vol 4. Sharks of the world: an annotated and illustrated catalogue of shark species known to date. Parts 1 and 2. FAO Fisheries Synopsis No. 125. FAO, Rome, Italy. p. 655.

Correia, J.P.S. and Smith, M.F.L. (2001) Elasmobranch landings for the Portuguese Commercial Fishery from 1986 to 2001. *Marine Fisheries Review***,** 32-40.

Cortés, E. (1999) Standardized diet compositions and trophic levels of sharks. *ICES Journal of Marine Science,* **56,** 707-717.

Cortés, E. (2002) Incorporating uncertainty into demographic modeling: application to shark populations and their conservation. *Conservation biology : the journal of the Society for Conservation Biology,* **16,** 1048-1062.

Cortés, E., Brown, C.A. and Beerkircher, L.R. (2007) Relative abundance of pelagic sharks in the western and north Atlantic ocean, including the Gulf of Mexico and Caribbean Sea. *Gulf and Caribbean Research,* **19,** 37-52.

Cortés, E. (2008a) Catches of pelagic sharks from the Western North Atlantic Ocean, including the Gulf of Mexico and Caribbean Sea. *SCRS/2007/072 Collect. Vol. Sci. Pap. ICCAT,* **62,** 1434-1446.

Cortés, E. (2008b) Comparative life history and demography of pelagic sharks. In: *Sharks of the open ocean: biology, fisheries and conservation.* M.D. Camhi, E.K. Pikitch and E.A. Babcock (eds): Blackwell Publishing Ltd. pp. 309-320.

Cortés, E., Arocha, F., Beerkircher, L., Carvalho, F., Domingo, A., Heupel, M., Holtzhausen, H., Santos, M.N., Ribera, M. and Simpfendorfer, C. (2010) Ecological risk assessment of pelagic sharks caught in Atlantic pelagic longline fisheries. *Aquatic Living Resources,* **23,** 25-34.

Cortés, E., Domingo, A., Miller, P., Forselledo, R., Mas, F., Arocha, F., Campana, S., Coelho, R., DaSilva, C., Hazin, F.H.V., Holtzhausen, H., Keene, K., Lucena, F., Ramirez, K., Santos, M.N., Semba-Murakami, Y. and Yokawa, K. (2012) Expanded ecological risk assessment of pelagic sharks caught in Atlantic pelagic longline fisheries. *SCRS/2012/167***,** 1-56.

Cragg, J.G. (1971) Some statistical models for limited dependent variables with application to the demand for durable goods. *Econometrica,* **39,** 829-844.

Cruz-Nuñez, G., Palmadóttir, H., Jónsdóttir, R. and García- Rodríguez, E. (2009) Quality of Cuban shark liver oil. Comparison with Icelandic cod liver oil. *REDVET. Revista electrónica de Veterinaria,* **10,** 1-10.

Cuba Department of Fisheries (2016) Analysis of catches of Oceanic Whitetip sharks Carcharhinus longimanus in Cuba. Cuba Department of Fisheries Fisheries Research Center.

Cuba NPOA-Sharks (2015) National plan of action for the conservation and management of Chondrichthyes in the Republic of Cuba. Havana, Cuba: Ministry of the Food Industry. p. 51.

D'Alberto, B.M., Chin, A., Smart, J.J., Baje, L., White, W.T. and Simpfendorfer, C.A. (2017) Age, growth and maturity of oceanic whitetip shark (Carcharhinus longimanus) from Papua New Guinea. *Marine and Freshwater Research,* **68**.

Dagorn, L., Holland, K.N., Restrepo, V. and Moreno, G. (2013) Is it good or bad to fish with FADs? What are the real impacts of the use of drifting FADs on pelagic marine ecosystems? *Fish and Fisheries,* **14,** 391-415.

Dapp, D., Arauz, R., Spotila, J.R. and O'Connor, M.P. (2013) Impact of Costa Rican longline fishery on its bycatch of sharks, stingrays, bony fish and olive ridley turtles (Lepidochelys olivacea). *Journal of Experimental Marine Biology and Ecology,* **448,** 228-239.

De Young, C. (2006) Review of the state of world marine capture fisheries management: Indian Ocean. Rome, FAO. 458pp.

Dent, F. and Clarke, S. (2015) State of the global market for shark products. FAO Fisheries and Aquaculture Technical Paper No. 590. Rome, FAO. 187pp.

Dermawan, A., Sadili, D., Suharsono and Kasasiah, A. (2013) A review of the status of shark fisheries and shark conservation in Indonesia. Directorate of Marine and Aquatic Resources Conservation Directorate General of Marine, Coasts and Small Islands Ministry of Marine Affairs and Fisheries. p. 94.

Di Dario, F., Alves, C.B.M., Boos, H., Frédou, F.L., Lessa, R.P.T., Mincarone, M.M., Pinheiro, M.A.A., Polaz, C.N.M., Reis, R.E., Rocha, L.A., Santana, F.M., Santos, R.A., Santos, S.B., Vianna, M. and Fábio, V. (2014) A better way forward for Brazil's fisheries. *Sci. Transl. Med.,* **347**.

Diop, M. and Dossa, J. (2011) 30 years of shark fishing in West Africa. In: *Development of fisheries, catch trends, and their conservation status in Sub-Regional Fishing Commission member countries* Corlet/Condé-sur-Noireau, France.

Domingo, A. (2004) ¿Adonde fue el longimanus? In: *Elasmovisor*: Sociedade Brasileira para o Estudo de Elasmobrânquios.

Domingo, A., Miller, P., Forselledo, R., Pons, M. and Berrondo, L. (2007) Abundancia del tiburon loco (Carcharhinus longimanus) el el Atlantico Sur. *Col. Vol. Sci. Pap. ICCAT,* **60,** 561-565.

Driggers, W.B., Carlson, J.K., Cullum, B., Dean, J.M., Oakley, D. and Ulrich, G. (2004) Age and growth of the blacknose shark, Carcharhinus acronotus, in the western North Atlantic Ocean with comments on regional variation in growth rates. *Environmental Biology of Fishes,* **71,** 171-178.

Driggers, W.B., Carlson, J.K., Cortés, E. and Ingram Jr., G.W. (2011) Effects of wire leader use and species-specific distributions on shark catch rates off the southeastern United States. *IOTC-2011-SC14 – INF08. www.iotc.org/files/proceedings/2011/sc/IOTC-2011-SC14-INF08[E].pdf.*

Eddy, C., Brill, R. and Bernal, D. (2016) Rates of at-vessel mortality and post-release survival of pelagic sharks captured with tuna purse seines around drifting fish aggregating devices (FADs) in the equatorial eastern Pacific Ocean. *Fisheries Research,* **174,** 109-117.

Eriksson, H. and Clarke, S. (2015) Chinese market responses to overexploitation of sharks and sea cucumbers. *Biological Conservation,* **184,** 163-173.

Escobar-Sanchez, O., Galvan-Magana, F. and Rosiles-Martinez, R. (2010) Mercury and selenium bioaccumulation in the smooth hammerhead shark, Sphyrna zygaena Linnaeus, from the Mexican Pacific Ocean. *Bull. Environ. Contam. Toxicol.,* **84,** 488-491.

FAO (2012) Report of the fourth FAO expert advisory panel for the assessment of proposals to amend Appendices I and II of CITES concerning commercially-exploited aquatic species. In: *FAO Fisheries and Aquaculture Report No. 1032* Rome. p. 169.

Fernandez-Carvalho, J., Coelho, R., Santos, M.N. and Amorim, S. (2015) Effects of hook and bait in a tropical northeast Atlantic pelagic longline fishery: Part II—Target, bycatch and discard fishes. *Fisheries Research,* **164,** 312-321.

Fiedler, F.N., Port, D., Giffoni, B.B., Sales, G. and Fisch, F. (2017) Pelagic longline fisheries in southeastern/south Brazil. Who cares about the law? *Marine Policy,* **77,** 56-64.

Filmalter, J., Forget, F., Poisson, F., Vernet, A.L., Bach, P. and Dagorn, L. (2012) Vertical and horizontal behaviour of silky, oceanic white tip and blue sharks in the western Indian Ocean. *IOTC–2012–WPEB08–23.*

Fischer, J., Erikstein, K., D'Offay, B., Guggisberg, S. and Barone, M. (2012) Review of the implementation of the Internatinoal Plan of Action for the Conservation and Mangement of Sharks. Rome, Food and Agricultural Organization of the United Nations.

Flewelling, L.J., Adams, D.H., Naar, J.P., Atwood, K.E., Granholm, A.A., O'Dea, S.N. and Landsberg, J.H. (2010) Brevetoxins in sharks and rays (Chondrichthyes, Elasmobranchii) from Florida coastal waters. *Marine Biology,* **157,** 1937-1953.

Fong, Q.S.W. and Anderson, J.L. (2000) Assessment of the Hong Kong shark fin trade. *INFOFISH International,* **1,** 28-32.

Fontenau, A. (2011) Potential impact of gillnets fisheries on Indian ocean ecosystems? Indian Ocean Tuna Commission. IOTC-2011-WPEB07-INF32.

Francis, M.P. and Lyon, W.S. (2014) Review of commercial fishery interactions and population information for the oceanic whitetip shark, a protected New Zealand species. National Institute of Water & Atmospheric Research Ltd.

Frédou, F.L., Tolotti, M.T., Frédou, T., Carvalho, F., Hazin, H., Burgess, G., Coelho, R., Waters, J.D., Travassos, P. and Hazin, F.H.V. (2015) Sharks caught by the Brazilian tuna longline fleet: an overview. *Rev. Fish Biol. Fish.,* **25,** 365-377.

Gaither, M.R., Bowen, B.W., Rocha, L.A. and Briggs, J.C. (2015) Fishes that rule the world: circumtropical distributions revisited. *Fish and Fisheries***,** n/a-n/a.

Gallagher, A.J., Orbesen, E.S., Hammerschlag, N. and Serafy, J.E. (2014) Vulnerability of oceanic sharks as pelagic longline bycatch. *Global Ecology and Conservation,* **1,** 50-59.

García-Cortés, B. and Mejuto, J. (2002) Size-weight relationships of the swordfish (Xiphias gladius) and several pelagic shark species caught in the Spanish surface longline fishery in the Atlantic, Indian, and Pacific Oceans. *Col. Vol. Sci. Pap. ICCAT,* **54,** 1132-1149.

García-Cortés, B., Ramos-Cartelle, A., González-González, I. and Mejuto, J. (2012) Biological observations of oceanic whitetip shark (Carcharhinus longimanus) on Spanish surface longline fishery targeting swordfish in the Indian Ocean over the period 1993-2011. *IOTC-2012-WPEB08-25.*

García-Hernández, J., Cadena-Cárdenas, L., Betancourt-Lozano, M., García-De-La-Parra, L.M., García-Rico, L. and Márquez-Farías, F. (2007) Total mercury content found in edible tissues of top predator fish from the Gulf of California, Mexico. *Toxicol. Environ. Chem.,* **89,** 507-522.

Gelsleichter, J. and Walker, C.J. (2010) Pollutant exposure and effects in sharks and their relatives. Taylor and Francis Group, LLC. p. 37.

Goldman, K. and Cailliet, G. (2004) Age Determination and Validation in Chondrichthyan Fishes. In: *Biology of Sharks and Their Relatives*. pp. 399-447.

Gonzalez-Pestana, A., Kouri J, C. and Velez-Zuazo, X. (2014) Shark fisheries in the Southeast Pacific: A 61-year analysis from Peru. *F1000 Research,* **3,** 19.

Hall, M. and Román, M. (2013) Bycatch and non-tuna catch in the tropical tuna purse seine fisheries of the world. *Food and Agricultural Organizaiton of the United Nations, Rome 2013,* **568,** 262.

Hall, M. and Román, M.H. (2016) The fishery on fish-aggregating devices (FADS) in the Eastern Pacific Ocean - Update. Inter-American Tropical Tuna Commission Scientific Advisory Committee, Seventh Meeting, La Jolla, California (USA, 09-13 May 2016. DOCUMENT SAC-07-03e.

Harley, S., Caneco, B., Donovan, C., Tremblay-Boyer, L. and Brouwer, S. (2015) Monte Carlo simulation modelling of possiblemeasures to reduce impacts of longlining on oceanic whitetip and silky sharks. Western and Central Pacific Fisheries Commission Scientific Committee Eleventh Regular Session. WCPFC-SC11-2015/EB-WP-02.

Harley, S. and Pilling, G. (2016) Potential implications of the choice of longline mitigation approach allowed within CMM 2014-05. Western and Central Pacific Fisheries Commission Scientific Committee Twelfth Regular Session. WCPFC-SC12-2016/EB-WP-06.

Hasarangi, D.G.N., Maldeniya, R. and Haputhantri, S.S.K. (2012) A Review on shark fishery resources in Sri Lanka. *IOTC–2012–WPEB08–15 Rev_1*, 15 p.

Hazen, E.L., Jorgensen, S., Rykaczewski, R.R., Bograd, S.J., Foley, D.G., Jonsen, I.D., Shaffer, S.A., Dunne, J.P., Costa, D.P., Crowder, L.B. and Block, B.A. (2012) Predicted habitat shifts of Pacific top predators in a changing climate. *Nature Climate Change,* **3,** 234-238.

Hazin, F.H.V., Hazin, H.G. and Travassos, P. (2007) CPUE and catch trends of shark species caught by Brazilian longliners in the Southwestern Atlantic Ocean. *Col. Vol. Sci. Pap. ICCAT,* **60,** 636-647.

Herrera, M. and Pierre, L. (2011) Review of the statistical data available for the bycatch species. IOTC–2011–WPEB07–08.

Hoelzel, A.R., Shivji, M.S., Magnussen, J. and Francis, M.P. (2006) Low worldwide genetic diversity in the basking shark (Cetorhinus maximus). *Biol. Lett.,* **2,** 639-642.

Howey-Jordan, L.A., Brooks, E.J., Abercrombie, D.L., Jordan, L.K.B., Brooks, A., Williams, S., Gospodarczyk, E. and Chapman, D.D. (2013) Complex Movements, philopatry and expanded depth range of a severely threatened pelagic shark, the oceanic whitetip (Carcharhinus longimanus) in the western North Atlantic. *PloS one,* **8,** 1-12.

Howey, L.A., Tolentino, E.R., Papastamatiou, Y.P., Brooks, E.J., Abercrombie, D.L., Watanabe, Y.Y., Williams, S., Brooks, A., Chapman, D.D. and Jordan, L.K.B. (2016) Into the deep: the functionality of mesopelagic excursions by an oceanic apex predator. *Ecol. Evol.*

Huang, H.-W. and Liu, K.-M. (2010) Bycatch and discards by Taiwanese large-scale tuna longline fleets in the Indian Ocean. *Fisheries Research,* **106,** 261-270.

Hutchinson, M.R., Itano, D.G., Muir, J.A. and Holland, K.N. (2015) Post-release survival of juvenile silky sharks captured in a tropical tuna purse seine fishery. *Marine Ecology Progress Series,* **521,** 143-154.

IATTC (2007) Proposal for a comprehensive assessment of key shark species caught in assocaition with fisheries in the eastern Pacific Ocean. Document SAR-8-15. Inter-American Tropical Tuna Commission Working Group to Review Stock Assessments. La Jolla, California.

IATTC (2011) Resolution C-11-10 - Resolution on the conservatino of oceanic whitetip sharks caught in association with fisheries in the Antigua Convention Area. Inter-American Tropical Tuna Commission 82nd Meeting, La Jolla, California (USA).

ICES (2014) Report of the Working Group on Elasmobranch Fishes (WGEF). Lisbon, Portugal. 681pp.

ICMBio (2014) Lista de Especies Ameacadas - Peixes Carcharhinus longimanus (Poey, 1861) - Tubarão-galha-branca. Ministerio do Meio Ambiente Instituto Chico Mendes de Conservacao de Biodiversidade. Accessed: http://www.icmbio.gov.br/portal/faunabrasileira/lista-de-especies/6526-especie-6526.

IOTC (2011a) Report of the seventh session of the IOTC Working Party on Ecosystems and Bycatch. Lankanfinolhu, North Malé Atoll, Republic of Maldives, IOTC–2011–WPEB07–R[E]. p. 99.

IOTC (2011b) Report of the 14th Session of the IOTC Scientific Committee. Mahé, Seychelles, Indian Ocean Tuna Commission. 259pp.

IOTC (2014) Report of the Seventeenth Session of the IOTC Scientific Committee. IOTC–2014–SC17–R[E]. 357.

IOTC (2015a) Status of the Indian Ocean oceanic whitetip shark (OCS: Carcharhinus longimanus). *IOTC–2015–SC18–ES18[E]*.

IOTC (2015b) Review of the statistical data available for bycatch species. Indian Ocean Tuna Commission. IOTC–2015–WPEB11–07. 39pp.

Jabado, R.W., Al Ghais, S.M., Hamza, W., Henderson, A.C., Spaet, J.L.Y., Shivji, M.S. and Hanner, R.H. (2015) The trade in sharks and their products in the United Arab Emirates. *Biological Conservation,* **181,** 190-198.

Jacquet, J., Alava, J.J., Ganapathiraju, P., Henderson, S. and Zeller, D. (2008) In hot soup: sharks captured in Ecuador's waters. *Environ. Sci.,* **5**.

Jayathilaka, R.A.M. and Maldeniya, R. (2015) Impact of policies on the conservation of sharks in the large pelagic fishery. IOTC–2015–WPEB11–18 Rev_1. National Aquatic Resources Research and Development Agency (NARA), Crow Island, Colombo 15, Sri Lanka.

John, M.E. and Varghese, B.C. (2009) Decline in CPUE of oceanic sharks in the Indian EEZ : urgent need for precautionary approach. Mobasa, Kenya, IOTC Working Party on Ecosystems and Bycatch.

Joung, S.-J., Liu, K.-M., Liao, Y.-Y. and Hsu, H.-H. (2005) Observed by-catch of Taiwanese tuna longline fishery in the South Atlantic Ocean. *J. Fish. Soc. Taiwan,* **32,** 69-77.

Joung, S.-J., Chen, N.-F., Hsu, H.-H. and Liu, K.-M. (2016) Estimates of life history parameters of the oceanic whitetip shark,Carcharhinus longimanus, in the Western North Pacific Ocean. *Mar. Biol. Res.***,** 1-11.

Kannan, K., Blankenship, A.L., Jones, P.D. and Giesy, J.P. (2000) Toxicity reference values for the toxic effects of Polychlorinated Biphenyls to aquatic mammals. *Hum. Ecol. Risk Assess.,* **6,** 181-201.

Kirby and Hobday (2007) Ecological risk assessment for the effects of fishing in the Western & Central Pacific Ocean: productivity-susceptibility anlysis. Western and Central Pacific Fisheries Commission, Scientific Committee Third Regular Session. 20pp.

Kohler, N.E., Casey, J.G. and Turner, P.A. (1998) NMFS cooperative shark tagging program, 1962-1993: an atlas of shark tag and recapture data. *Marine Fisheries Review,* **60,** 1-87.

Koopman, M. and Knuckey, I. (2014) Advice on CITES Appendix II Shark Listings. Fishwell Consulting Pty Ltd 2014.

Kyne, P.M., Carlson, J.K., Ebert, D.A., Fordham, S.V., Bizzarro, J.J., Graham, R.T., Kulka, D.W., Tewes, E.E., Harrison, L.R. and Dulvy, N.K. (2012) The conservation status of North American, Central American, and Caribbean Chondrichthyans. Vancouver, Canada, IUCN Species Survival Commission Shark Specialist Group.

Lack, M. and Meere, F. (2009) Pacific Islands Regional Plan of Action for sharks: guidance for Pacific Island countries and territories on the conservation and management of sharks. 123 pp.

Lack, M. and Sant, G. (2012) An overview of shark utilisation in the Coral Triangle region. TRAFFIC and WWF.

Lawson, T. (2011) Estimation of catch rates and catches of key shark species in tuna fisheries of the Western and Central Pacific Ocean using observer data. Western and Central Pacific Fisheries Commission, Scientific Committee Seventh Regular Session.

Lee, H.K., Kim, S.J., Jeong, Y., Lee, S., Jeong, W., Lee, W.C., Choy, E.J., Kang, C.K. and Moon, H.B. (2015) Polybrominated diphenyl ethers in thirteen shark species from offshore and coastal waters of Korea. *Mar. Pollut. Bull.,* **95,** 374-379.

Lessa, R., Santana, F.M. and Paglerani, R. (1999) Age, growth and stock structure of the oceanic whitetip shark, Carcharhinus longimanus, from the southwestern equatorial Atlantic. *Fisheries Research,* **42,** 21-30.

Liu, K.-M. and Tsai, W.-P. (2011) Catch and life history parameters of pelagic sharks in the Northwestern Pacific. Keelung, Chinese Taipei, ISC Shark Working Group Workshop. 12pp.

Liu, S.Y., Chan, C.L., Lin, O., Hu, C.S. and Chen, C.A. (2013) DNA barcoding of shark meats identify species composition and CITES-listed species from the markets in Taiwan. *PloS one,* **8,** e79373.

Lombardi-Carlson, L.A., Cortés, E., Parsons, G.R. and Manire, C.A. (2003) Latitudinal variation in life-history traits of bonnethead sharks, Sphyrna tiburo, (Carcharhiniformes:Sphyrnidae) from the eastern Gulf of Mexico. *Marine and Freshwater Research,* **54,** 875-883.

Madigan, D.J., Brooks, E.J., Bond, M.E., Gelsleichter, J., Howey, L.A., Abercrombie, D.L., Brooks, A. and Chapman, D.D. (2015) Diet shift and site-fidelity of oceanic whitetip sharks Carcharhinus longimanus along the Great Bahama Bank. *Marine Ecology Progress Series,* **529,** 185-197.

Martinez-Ortiz, J., Aires-da-Silva, A.M., Lennert-Cody, C.E. and Maunder, M.N. (2015) The Ecuadorian Artisanal Fishery for Large Pelagics: Species Composition and Spatio-Temporal Dynamics. *PloS one,* **10,** e0135136.

Mather, F.J. and Day, C.G. (1954) Observations of pelagic fishes of the tropical Atlantic. *Copeia,* **1954, No. 3,** 179-188.

Maufroy, A., Chassot, E., Joo, R. and Kaplan, D.M. (2015) Large-Scale Examination of Spatio-Temporal Patterns of Drifting Fish Aggregating Devices (dFADs) from Tropical Tuna Fisheries of the Indian and Atlantic Oceans. *PloS one,* **10,** e0128023.

Maunder, M.N. and Punt, A.E. (2004) Standardizing catch and effort data: a review of recent approaches. *Fisheries Research,* **70,** 141-159.

Mazzoleni, R.C. and Schwingel, P.R. (1999) Elasmobranch species landed in Itajaí Harbor, southern Brazil. *Notas TÉC. Facimar,* **3,** 111-118.

Megalofonu, P., Yannopoulos, C., Damalas, D., De Metrio, G., Deflorio, M., se la Serna, J.M. and Macias, D. (2005) Incidental catch and estimated discards of pelagic sharks from the swordfish and tuna fisheries in the Mediterranean Sea. *Fishery Bulletin,* **103,** 620-634.

Mejuto, J., García-Cortés, B. and Ramos-Cartelle, A. (2005) Tagging-recapture activities of large pelagic sharks carried out by Spain or in collaboration with the tagging programs of other countries. *Col. Vol. Sci. Pap. ICCAT,* **58,** 974-1000.

Miller, M.H., Carlson, J., Hogan, L. and Kobayashi, D. (2014) Status Review Report: Great Hammerhead Shark (Sphyrna mokarran). Final Report to National Marine Fisheries Service, Office of Protected Resources. June 2014. 116.

Molony, B. (2007) Commonly captured sharks and rays for consideration of the ecosystem and bycatch SWG at SC3. Western and Central Pacific Fisheries Commission Scientific Committee Third Regular Session. WCPFC-SC3-EB SWG/IP-19.

Moreno, G. and Herrera M. (IOTC Secretariat) (2013) Estimation of fishing capacity by tuna fishing fleets in the Indian Ocean. *Report presented at the 16th Session of the Scientific Committee of the Indian Ocean Tuna Commission. Busan, Republic of Korea, 2–6 December 2013. IOTC–2013–SC16–INF04.*

MRAG Asia Pacific (2016) Towards the quantification of illegal, unreported and unregulated (IUU) fishing in the Pacific Islands region. p. 101.

Mundy-Taylor, V. and Crook, V. (2013) Into the deep: Implementing CITES measures for commercially-valuable sharks and manta rays. Report prepared for the European Commission.

Murua, H., Coelho, R., Santos, M.N., Arrizabalaga, H., Yokawa, K., Romanov, E., Zhu, J.F., Kim, Z.G., Bach, P., Chavance, P., Delgado de Molina, A. and Ruiz, J. (2012) Preliminary Ecological Risk Assessment (ERA) for shark species caught in fisheries managed by the Indian Ocean Tuna Commission (IOTC). IOTC-2012-WPEB08-31 Rev_2. 16pp.

Murua, H., Abascal, F.J., Amande, J., Ariz, J., Bach, P., Chavance, P., Coelho, R., Korta, M., Poisson, F., Santos, M.N. and Seret, B. (2013a) Provision of scientific advice for the purpose of the implementation of the EUPOA sharks. Final Report. European Commission, Studies for Carrying out the Common Fisheries Policy (MARE/2010/11 -LOT 2).

Murua, H., Santos, M.N., Chavance, P., Amande, J., Abascal, F.J., Ariz, J., Bach, P., Korta, M., Poisson, F., Coelho, R. and Seret, B. (2013b) EU project for the provision of scientific advice for the purpose of the implementation of the EUPOA sharks: a brief overview of the results for Indian Ocean. *IOTC–2013–WPEB09–19 Rev_1***,** 21 pp.

Musyl, M.K., Brill, R.W., Curran, D.S., Fragoso, N.M., McNaughton, L.M., Nielsen, A., Kikkawa, B.S. and Moyes, C.D. (2011) Postrelease survival, vertical and horizontal movements, and thermal habitats of five species of pelagic sharks in the central Pacific Ocean. *Fishery Bulletin,* **109,** 341-368.

NMFS (2006) Final Consolidated Atlantic Highly Migratory Species Fishery Management Plan. Highly Migratory Species Management Division, Office of Sustainable Fisheries. NOAA Fisheries. U.S. Department of Commerce.

NMFS (2008) Final Amendment 2 to the Consolidated Atlantic Highly Migratory Species Fishery Managment Plan. Silver Spring, MD: Office of Sustainable Fisheries, Highly Migratory Species Management Division. NOAA Fisheries. U.S. Department of Commerce. p. 726.

NMFS (2009a) Amendment 1 to the Consolidated HMS FMP. Essential Fish Habitat. Chapter 5. 59-263pp.

NMFS (2009b) Annual Report of the United States of America. U.S. Department of Commerce, NOAA Fisheries. 62pp.

NMFS (2011a) U.S. National Bycatch Report First Edition. U.S. Dep. Comm., NOAA Tech. Memo. NMFS-F/SPO-117C. 528pp.

NMFS (2011b) Final environmental assessment, regulatory impact review, and final regulatory flexibility analysis for a final rule to implement the 2010 International Commission for the Conservation of Atlantic Tunas recommendations on Sharks. United States Department of Commerce National Oceanic and Atmospheric Administration National Marine Fisheries Service Office of Sustainable Fisheries Highly Migratory Species Management Division.

NMFS (2011c) Shark finning report to Congress purusant to the Shark Finning Prohibition Act (Public Law 106-557). *U.S. Department of Commerce National Oceanic and Atmospheric Administration*, 112 pp.

NMFS (2012) 2012 Stock Assessment and Fishery Evaluation report (SAFE) for Atlantic Highly Migratory Species. *Atlantic Highly Migratory Species Management Division. NOAA Fisheries. U.S. Department of Commerce*.

NMFS (2013) U.S. National Bycatch Report First Edition Update 1. L.R. Benaka, C. Rilling, E.E. Seney and H. Winarsoo (eds) U.S. Dep. of Commerce. p. 57.

NMFS (2014) 2014 Stock Assessment and Fishery Evaluation (SAFE) Report for Atlantic Highly Migratory Species. *Atlantic Highly Migratory Species Management Division. NOAA Fisheries. U.S. Department of Commerce*, 195 pp.

NMFS (2015) Improving international fisheries management: Report to Congress pursuant to section 403(a) of the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006. U.S. Department of Commerce. p. 107.

NMFS (2016) HMS commercial compliance guide: guide for complying with the Atlantic tunas, swordfish, shark, and billfish regulations. Office of Sustainable Fisheries, Highly Migratory Species Management Division: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service p. 77.

NMFS (2017) 2016 Stock Assessment and Fishery Evaluation (SAFE) Report for Atlantic Highly Migratory Species. Silver Spring, MD, Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Atlantic Highly Migratory Species Management Division. 203pp.

Novianto, D., Rochman, F. and Nugraha, B. (2014) Species composition, CPUE and length frequency of oceanic sharks based on observer data from the Indonesian longline fishery in the Indian Ocean.

O'Meara, D., Harper, S., Perera, N. and Zeller, D. (2011) Reconstruction of Sri Lanka's fisheries catches 1950-2008. In: *Fisheries Centre Research Reports Fisheries Catch Reconstructions: Islands Part II.* S. Harper and D. Zeller (eds) British Columbia, Canada: Fisheries Centre, University of British Columbia.

Petersen, S., Nel, D. and Omardien, A. (2007) Towards an ecomsystem approach to longline fisheries in the Benguela: an assessment of impcats on seabirds, sea turtles, and sharks. WWF South Africa Report Series – 2007/Marine/001. World Wildlife Fund.

Piovano, S. and Gilman, E. (2016) Elasmobranch captures in the Fijian pelagic longline fishery. *Aquatic Conservation: Marine and Freshwater Ecosystems,* **2016,** 13.

PIRO (2015) Compliance guide: Fishing restrictions related to the oceanic whitetip shark, the silky shark and the whale shark. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service Pacific Islands Regional Office. p. 7.

Poisson, F., Filmalter, J.D., Vernet, A.-L., Dagorn, L. and Jech, J.M. (2014) Mortality rate of silky sharks (*Carcharhinus falciformis*) caught in the tropical tuna purse seine fishery in the Indian Ocean. *Canadian Journal of Fisheries and Aquatic Sciences,* **71,** 795-798.

Ramos-Cartelle, A., García-Cortés, B., Ortíz de Urbina, J., Fernández-Costa, J., González-González, I. and Mejuto, J. (2012) Standardized catch rates of the oceanic whitetip shark (*Carcharhinus longimanus*) from observations of the Spanish longline fishery targeting swordfish in the Indian Ocean during the 1998-2011 period. IOTC-2012-WPEB08-27. 15pp.

Rice, J. and Harley, S. (2012) Stock assessment of oceanic whitetip sharks in the western and central Pacific Ocean. Western and Central Pacific Fisheries Commission Scientific Committee Eighth Regular Session. WCPFC-SC8-2012/SA-WP-06 Rev 1. 53pp.

Rice, J., Tremblay-Boyer, L., Scott, R., Hare, S. and Tidd, A. (2015) Analysis of stock status and related indicators for key shark species of the Western Central Pacific Fisheries Commission. *Western and Central Pacific Fisheries Commission, Scientific Committee Eleventh Regular Session. WCPFC-SC11-2015/EB-WP-04-Rev 1***,** 146 pp.

Rodrigues, J., Freitas, D., Fernandes, Í. and Lessa, R. (2015) Estrutura populacional do tubarao estrangeiro (*Carcharhinus longimanus*) no Atlantico Sul. 3.

Roman-Verdesoto, M. and Orozco-Zoller, M. (2005) Bycatches of sharks in the tuna purse-seine fishery of th eastern Pacific ocean reported by observers of the Inter-American Tropical Tuna Commission, 1993-2004. La Jolla, California, Inter-American Tropical Tuna Commission.

Romanov, E. (2002) Bycatch in the tuna purse-seine fisheries of the western Indian Ocean. *Fishery Bulletin,* **100,** 90-105.

Romanov, E., Bach, P. and Romanova, N.y. (2008) Preliminary estimates of bycatches in the western equatorial Indian Ocean in the traditional multifilament longline gears (1961-1989). Bangkok, Thailand: IOTC Working Party on Environment and Bycatch (WPEB). IOTC-2008-WPEB-10.

Romanov, E. and Romanova, N. (2009) Size distribution and length-weight relationships for some large pelagic sharks in the Indian Ocean. IOTC Working Party on Ecosystems and Bycatch (WPEB). Mombasa, Kenya. IOTC-2009-WPEB-06.

Romanov, E., Bach, P., Rabearisoa, N., Rabehagasoa, N., Filippi, T. and Romanova, N. (2010) Pelagic elasmobranch diversity and abundance in the Indian Ocean: an analysis of long-term trends from research and fisheries longline data. IOTC-2010-WPEB-16. 19pp.

Rose, D.A. (1996) An overview of world trade in sharks and other cartilaginous fishes. A TRAFFIC Network Report. 112pp.

Ruck, C. (2016) Global genetic connectivity and diversity in a shark of high conservation concern, the oceanic whitetip, *Carcharhinus longimanus*. Master of Science, Nova Southeastern University, 64pp.

Santana, F.M., Duarte-Neto, P.J. and Lessa, R.P. (2004) *Carcharhinus longimanus*. In: *Dinâmica de Populações e Avaliação de Estoques dos Recursos Pesqueiros da Região Nordeste. Vol II.* R.P. Lessa, M.F. de Nóbrega and J.L. Bezerra Jr. (eds): Universidade Federal Rural de Pernambuco Deoartanebti de Pesca. Laboratório de Dinâmica de Populações Marinhas - DIMAR.

Satria, F., Nugroho, W., Sadiyah, D., Nugraha, L., Barata, B. and Suryanto, A. (2011) National report Indonesia southern bluefin tuna fisheries. Bali, Benoa 19 - 28th July 2011. CCSBT – ESC/1107/SBT FISHERIES – Indonesia (revised).

Seki, T., Taniuchi, T., Nakano, H. and Shimizu, M. (1998) Age, growth and reproduction of the oceanic whitetip Shark from the Pacific Ocean. *Fisheries Science,* **64,** 14-20.

Semba, Y. and Yokawa, K. (2011) Trend of standardized CPUE of oceanic whitetip shark (*Carcharhinus longimanus*) caught by Japanese longline fishery in the Indian Ocean. IOTC–2011–WPEB07–35.

Sembiring, A., Pertiwi, N.P.D., Mahardini, A., Wulandari, R., Kurniasih, E.M., Kuncoro, A.W., Cahyani, N.K.D., Anggoro, A.W., Ulfa, M., Madduppa, H., Carpenter, K.E., Barber, P.H. and Mahardika, G.N. (2015) DNA barcoding reveals targeted fisheries for endangered sharks in Indonesia. *Fisheries Research,* **164,** 130-134.

Simpfendorfer, C. (2014) Information for the development of Non Detriment Findings for CITES listed sharks. Report to Department of the Environment. Centre for Sustainable Tropical Fisheries and Aquaculture & School of Earth and Environmental Sciences, James Cook University, Queensland, Australia. 39pp.

Smale, M.J. (2008) Pelagic shark fisheries in the Indian Ocean. In: *Sharks of the Open Ocean.* M.D. Camhi, E.K. Pikitch and E.A. Babcock (eds) Oxford, U.K.: Blackwell Publishing Ltd. pp. 247-259.

Smith, S.E., Au, D.W. and Show, C. (1998) Intrinsic rebound potentials of 26 species of Pacific sharks. *Marine and Freshwater Research,* **49,** 663-678.

Smith, S.E., Au, D.W. and Show, C. (2008) Intrinsic rates of increase in pelagic elasmobranchs. In: *Sharks of the open ocean: biology, fisheries and conservation.* M.D. Camhi, E.K. Pikitch and E.A. Babcock (eds): Blackwell Publishing Ltd.

Sosa-Nishizaki, O., Marquez-Farias, J.F. and Villavincencio-Garayzar, C.J. (2008) Case study: pelagic shark fisheries along the west coast of Mexico. In: *Sharks of the open ocean: biology, fisheries, and conservation.* M. Camhi, E.K. Pikitch and E.A. Babcock (eds): Blackwell Publishing. pp. 60-68.

SPC (2010) Non-target species interactions with the tuna fisheries of the Western and Central Pacific Ocean. In: *Scientific Committee Sixth Annual Session* Nuku'alofa Tonga: Western and Central Pacific Fisheries Commission. p. 59.

Storelli, M.M., Ceci, E., Storelli, A. and Marcotrigiano, G.O. (2003) Polychlorinated biphenyl, heavy metal and methylmercury residues in hammerhead sharks: contaminant status and assessment. *Marine Pollution Bulletin,* **46,** 1035-1039.

Strasburg, D. (1958) Distribution, abundance, and habits of pelagic sharks in the Central Pacific ocean. . *Fishery Bulletin 138 Washington, U.S. Govt. Print. Off.,* **58,** 335-361.

Tambourgi, M.R.d.S., Hazin, F.H.V., Oliveira, P.G.V., Coelho, R., Burgess, G. and Roque, P.C.G. (2013) Reproductive aspects of the oceanic whitetip shark, *Carcharhinus longimanus* (Elasmobranchii: Carcharhinidae), in the equatorial and southwestern Atlantic Ocean. *Brazilian Journal of Oceanography,* **61,** 161-168.

Taniuchi, T. (1990) The role of elasmobranchs in Japanese fisheries. In: *Elasmobranchs as living resources: advances in the biology, ecology, systematics, and the status of the fisheries.* J. Pratt, Harold L., S.H. Gruber and T. Taniuchi (eds): NOAA Dept. of Commerce. p. 12.

Testerman, C. (2014) Molecular ecology of globally distributed sharks. Doctoral Dissertation. Nova Southeastern University. Retrieved from NSUWorks, Oceanographic Center. (6) http://nsuworks.nova.edu/occ_stuetd/6.

Tolotti, M.T., Travassos, P., Frédou, F.L., Wor, C., Andrade, H.A. and Hazin, F. (2013) Size, distribution and catch rates of the oceanic whitetip shark caught by the Brazilian tuna longline fleet. *Fisheries Research,* **143,** 136-142.

Tolotti, M.T., Bach, P., Hazin, F., Travassos, P. and Dagorn, L. (2015a) Vulnerability of the Oceanic Whitetip Shark to Pelagic Longline Fisheries. *PloS one,* **10,** e0141396.

Tolotti, M.T., Bach, P., Romanov, E. and Dagorn, L. (2015b) Interactions of oceanic whitetip sharks with the tuna purse seine fishery in the Indian Ocean. *IOTC-2015-WPEB11-29.*

Tolotti, M.T., Filmalter, J.D., Bach, P., Travassos, P., Seret, B. and Dagorn, L. (2015c) Banning is not enough: The complexities of oceanic shark management by tuna regional fisheries management organizations. *Global Ecology and Conservation,* **4,** 1-7.

Valdés, J.A., Abierno, A.R. and Hueter, R.E. (2016) Catches of oceanic whitetip sharks (Carcharhinus longimanus) off the Northwest Coast of Cuba. Center for Marine Research, University of Havana, Cuba and Mote Marine Laboratory, Sarasota, Florida USA.

Vannuccini, S. (1999) Shark utilization, marketing, and trade. *FAO Fisheries Technical Paper 389,* **Accessed online: http://www.fao.org/docrep/005/x3690e/x3690e00.htm**.

Varghese, S.P., Vijayakumaran, K., Tiburtius, A. and Mhatre, V.D. (2015) Diversity, abundance and size structure of pelagic sharks caught in tuna longline survey in the Indian seas. *Indian Journal of Geo-Marine Science,* **44,** 11.

Varghese, S.P., Unnikrishnan, N., Gulati, D.K. and Ayoob, A.E. (2016) Size, sex and reproductive biology of seven pelagic sharks in the eastern Arabian Sea. *Journal of the Marine Biological Association of the United Kingdom,* **97,** 181-196.

Varkey, D.A., Ainsworth, C.H., Pitcher, T.J., Goram, Y. and Sumaila, R. (2010) Illegal, unreported and unregulated fisheries catch in Raja Ampat Regency, Eastern Indonesia. *Marine Policy,* **34,** 228-236.

Walsh, W., Bigelow, K. and Sender, K. (2009) Decreases in shark catches and mortality in the Hawaii-based longline fishery as documented by fishery observers. In: *Western and Central Pacific Fisheries Commission Scientific Committee Fifth Regular Session. WCPFC-SC5-2009/EB- IP-8.* Port Vila, Vanuatu. p. 36.

Walsh, W.A., Kleiber, P. and McCracken, M. (2002) Comparison of logbook reports of incidental blue shark catch rates by Hawaii-based longline vessels to fishery observer data by application of a generalized additive model. *Fisheries Research,* **58,** 79-94.

Walsh, W.A. and Clarke, S.C. (2011) Analyses of catch data for oceanic whitetip and silky sharks reported by fishery observers in the Hawaii-based longline fishery in 1995−2010. Pacific Islands Fisheries Science Center Administrative Report H-11-10. 76pp.

Ward-Paige, C.A. (2017) A global overview of shark sanctuary regulations and their impact on shark fisheries. *Marine Policy,* **82,** 87-97.

Ward-Paige, C.A. and Worm, B. (2017) Global evaluation of shark sanctuaries. *Global Environmental Change,* **47,** 174-189.

Webb, H., Hobday, A., Dowdney, J., Bulman, C., Sporcic, M., Smith, T., Furlani, D., Fuller, M., Williams, A. and Stobutzki, I. (2007) Ecological Risk Assessment for the Effects of Fishing: Eastern Tuna & Billfish Fishery: Longline Sub-fishery. Report for the Australian Fisheries Management Authority.

White, W.T. (2007) Biological observations on lamnoid sharks (Lamniformes) caught by fisheries in eastern Indonesia. *Journal of the Marine Biological Association of the UK,* **87,** 781.

Williams, P., Tuiloma, I. and Falasi, C. (2015) Status of ROP Data Management with tables on ROP longline coverage. Western and Central Pacific Fisheries Commission Scinetific Committee Eleventh Regular Session. Pohnpei, Federated States of Micronesia. p. 18.

WPFMC (2009) Fishery ecosystem plan for Pacific pelagic fisheries of the Western Pacific Region. Honolulu, Hawaii., Western Pacific Regional Fishery Management Council.

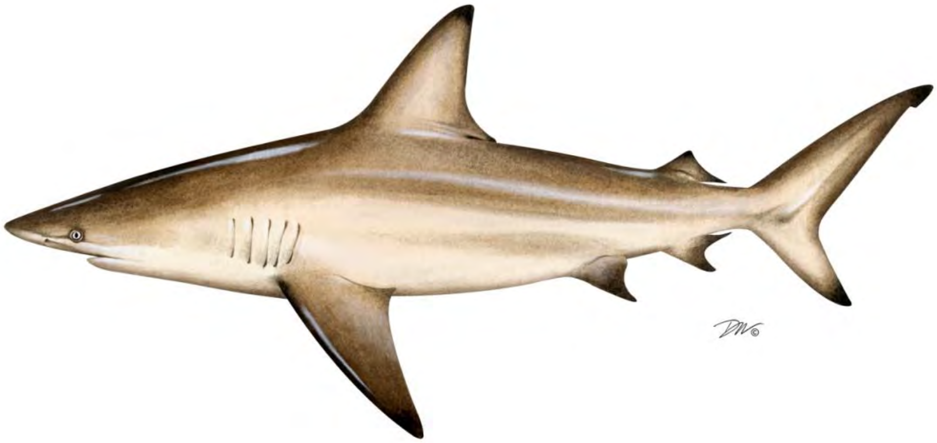
WPFMC (2012) Pelagic Fisheries of the Western Pacific 2012 Annual Report. Honolulu, Hawaii, Western Pacific Regional Fishery Management Council. 292pp.

Yokawa, K. and Semba, Y. (2012) Update of the standardized CPUE of oceanic whitetip shark (Carcharhinus longimanus) caught by Japanese longline fishery in the Indian Ocean. IOTC–2012–WPEB08–26.

2016 REVIEW OF THE
ATLANTIC STATES MARINE FISHERIES COMMISSION
FISHERY MANAGEMENT PLAN FOR

COASTAL SHARKS

2015 and 2016 FISHING YEAR



Coastal Sharks Plan Review Team

Bryan Frazier, South Carolina Department of Natural Resources
Tina Moore, North Carolina Department of Environmental Quality
Kirby Rootes-Murdy, Atlantic States Marine Fisheries Commission, Chair

Table of Contents

I. Status of the Fishery Management Plan

Date of FMP Approval: August 2008

Amendments None

Addenda Addendum I (September 2009)
Addendum II (May 2013)
Addendum III (October 2013)
Addendum IV (August 2016)

Management Unit: Entire coastwide distribution of the resource from the estuaries eastward to the inshore boundary of the EEZ

States With Declared Interest: Maine, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia, Florida

Active Boards/Committees: Coastal Shark Management Board, Advisory Panel, Technical Committee, and Plan Review Team

a) Goals and Objectives

The Interstate Fishery Management Plan for Coastal Sharks (FMP) established the following goals and objectives.

GOALS

The goal of the Interstate Fishery Management Plan for Coastal Sharks is “to promote stock rebuilding and management of the coastal shark fishery in a manner that is biologically, economically, socially, and ecologically sound.”

OBJECTIVES

In support of this goal, the following objectives proposed for the FMP include:

1. Reduce fishing mortality to rebuild stock biomass, prevent stock collapse, and support a sustainable fishery.
2. Protect essential habitat areas such as nurseries and pupping grounds to protect sharks during particularly vulnerable stages in their life cycle.
3. Coordinate management activities between state and federal waters to promote complementary regulations throughout the species’ range.
4. Obtain biological and improved fishery related data to increase understanding of state water shark fisheries.
5. Minimize endangered species bycatch in shark fisheries.

b) Fisheries Management Plan Summary

The Atlantic States Marine Fisheries Commission (Commission) adopted its first fishery management plan (FMP) for coastal sharks in 2008. Coastal sharks are managed under this plan as six different complexes: prohibited, research, small coastal, non-sandbar large coastal, pelagic and smooth dogfish. The Board does not actively set quotas for any shark species. The Commission follows National Oceanic and Atmospheric Administration's (NOAA Fisheries) openings and closures for small coastal sharks, non- sandbar large coastal shark, and pelagic sharks. Species in the prohibited category may not be possessed or taken. Sandbar sharks may only be taken with a shark fishery research permit. All species must be landed with their fins attached to the carcass by natural means.

The FMP has been adapted through the following addenda:

Addendum I (2009) modified the FMP to allow limited smooth dogfish processing at sea (removal of fins from the carcass), as long as the total wet weight of the shark fins does not exceed 5 percent of the total dressed weight. In addition, smoothhound recreational possession limits and gill net check requirements for smoothhound fishermen were removed. These restrictions were removed because they were intended for large coastal sharks. The removal allowed smoothhound fishermen to continue operations while upholding the conservation measures of the FMP.

Addendum II (2013) modified the FMP to allow year round smooth dogfish processing at sea. If fins are removed the total wet weight of the shark fins may not exceed 12 percent of the total dressed weight. State-shares of the smoothhound coastwide quota were allocated. The goal of Addendum II was to implement an accurate fin-to-carcass ratio and prevent any one state from harvesting the entire smoothhound quota.

Addendum III (2013) modified the species groups in the FMP to ensure consistency with NOAA Fisheries (Table 1). The recreational size limit for the hammerhead species group was increased to 78" fork length.

Addendum IV (2016) was added to reflect measures outlined in the Shark Conservation Act into state regulations. It amends the Coastal Sharks FMP to allow smooth dogfish carcasses to be landed with corresponding fins removed from the carcass as long as the total retained catch, by weight, is composed of at least 25 percent smooth dogfish. Fishermen can retain smooth dogfish in an amount less than 25 percent of the total catch provided the smooth dogfish fins remain naturally attached to the carcass.

Table 1. List of commercial shark management groups

Species Group	Species within Group
Prohibited	Sand tiger, bigeye sand tiger, whale, basking, white, dusky, bignose, Galapagos, night, reef, narrowtooth, Caribbean sharpnoes, smalltail, Atlantic angel, longfin mako, bigeye thresher, sharpnose sevengill, bluntnose sixgill and bigeye sixgill sharks
Research	Sandbar sharks
Non-Blacknose Small Coastal	Atlantic sharpnose, finetooth, and bonnethead sharks
Blacknose	Blacknose sharks
Aggregated Large Coastal	Silky, tiger, blacktip, spinner, bull, lemon, and nurse
Hammerhead	scalloped hammerhead, great hammerhead and smooth hammerhead
Pelagic	Shortfin mako, porbeagle, common thresher, oceanic whitetip and blue sharks
Smoothhound	Smooth dogfish and Florida smoothhound

II. Status of the Stocks

Stock status is assessed by species or by species complex if there is not enough data for an individual assessment. Fourteen species have been assessed domestically, three species have been assessed internationally, and the rest have not been assessed. Table 2 describes the current stock status of several shark species along with references for the stock assessment.

The 2017 International Commission on the Convention of Atlantic Tunas (ICCAT) assessment of the North Atlantic population of shortfin mako indicates that the stock is overfished and overfishing is occurring. Multiple models were explored and new data sources integrated. Combined probability of overfishing occurring and the stock being in an overfished state was 90% across all models.

The 2017 Southeast Data and Assessment Review (SEDAR 54) stock assessment for sandbar sharks indicates the stock is overfished and not experiencing overfishing. This assessment used a new approach (Stock Synthesis) instead of the State Space Age Structure Production Model that was used in the previous assessment (SEDAR 21). A replication analysis conducted using the prior model (updated with data through 2015) resulted in the same stock status as the new model (overfished, no overfishing occurring).

The 2016 stock assessment update (SEDAR 21) for Atlantic dusky sharks indicates the stock is overfished and experiencing overfishing. This latest review functioned an update to the 2011 assessment, so no new methodology was introduced. However, all model inputs were updated with more recent data (i.e. 2010-2015 effort, observer, and survey data).

In 2015, a benchmark stock assessment (SEDAR 39) was conducted for the smoothhound complex, including smooth dogfish, the only species of smoothhound occurring in the Atlantic. The assessment indicates Atlantic smooth dogfish (*Mustelus canis*) are not overfished and not experiencing overfishing.

The North Atlantic blue shark (*Prionace glauca*) stock was assessed by ICCAT's Standing Committee on Research and Statistics (SCRS) in 2015. Similar to results of the 2008 stock assessment, ICCAT's 2015 analysis The assessment indicated the stock is not overfished and not experiencing overfishing, as was also concluded in the 2008 stock assessment. However, scientists acknowledge there is a high level of uncertainty in the data inputs and model structural assumptions; therefore, the assessment results should be interpreted with caution.

SEDAR 34 (2013) assessed the status of Atlantic sharpnose (*Rhizoprionodon terraenovae*) and bonnethead (*Sphyrna tiburo*) sharks. The Atlantic sharpnose stock is not overfished and not experiencing overfishing. The stock status of bonnethead shark stocks (Atlantic and Gulf of Mexico) is unknown. A benchmark assessment is recommended for both stocks.

A 2011 benchmark assessment (SEDAR 21) of dusky (*Carcharhinus obscures*), sandbar (*Carcharhinus plumbeus*), and blacknose (*Carcharhinus acrontus*) sharks indicates that dusky and blacknose sharks are overfished and experiencing overfishing. Sandbar sharks continued to be overfished. As described in the Magnuson-Stevens Act, NOAA Fisheries must establish a rebuilding plan for an overfished stock. As such, the rebuilding date for dusky sharks is 2108, sandbar sharks is 2070, and blacknose sharks is 2043. A dusky stock assessment update is scheduled for 2016.

Porbeagle sharks (*Lamna nasus*) were assessed by the ICCAT's SCRS in 2009. The assessment found the Northwest Atlantic stock is increasing in biomass, however the stock is considered to be overfished with overfishing not occurring. NOAA Fisheries established a 100-year rebuilding plan for porbeagle sharks; the expected rebuilding date is 2108.

A 2009 stock assessment for the Northwest Atlantic and Gulf of Mexico populations of scalloped hammerhead sharks (*Sphyrna lewini*) indicated the stock is overfished and experiencing overfishing. This assessment was reviewed by NOAA Fisheries and deemed appropriate to serve as the basis for U.S. management decision. In response to the assessment findings, NOAA Fisheries established a scalloped hammerhead rebuilding plan that will end in 2023.

SEDAR 11 (2006) assessed the Large Coastal Sharks (LCS) complex and blacktip sharks (*Carcharhinus limbatus*). The LCS assessment suggested that it is inappropriate to assess the LCS complex as a whole due to the variation in life history parameters, different intrinsic rates of increase, and different catch and abundance data for all species included in the LCS complex.

Based on these results, NMFS changed the status of the LCS complex from overfished to unknown. As part of SEDAR 11, blacktip sharks were assessed for the first time as two separate populations: Gulf of Mexico and Atlantic. The results indicated that the Gulf of Mexico stock is not overfished and overfishing is not occurring, while the current status of blacktip sharks in the Atlantic region is unknown.

Table 2. Stock Status of Atlantic Coastal Shark Species and Species Groups

Species or Complex Name	Stock Status		References/Comments
	Overfished	Overfishing	
Pelagic			
Porbeagle	Yes	No	Porbeagle Stock Assessment, ICCAT Standing Committee on Research and Statistics Report (2009); Rebuilding ends in 2108 (HMS Am. 2)
Blue	No	No	ICCAT Standing Committee on Research and Statistics Report (2015)
Shortfin mako	Yes	Yes	ICCAT Standing Committee on Research and Statistics Report (2017)
All other pelagic sharks	Unknown	Unknown	
Aggregated Large Coastal Sharks (LCS)			
Atlantic Blacktip	Unknown	Unknown	SEDAR 11 (2006)
Aggregated Large Coastal Sharks - Atlantic Region	Unknown	Unknown	SEDAR 11 (2006); difficult to assess as a species complex due to various life history characteristics/ lack of available data
Non-Blacknose Small Coastal Sharks (SCS)			
Atlantic Sharpnose	No	No	SEDAR 34 (2013)
Bonnethead	Unknown	Unknown	SEDAR 34 (2013)
Finetooth	No	No	SEDAR 13 (2007)
Hammerhead			
Scalloped	Yes	Yes	SEFSC Scientific Review by Hayes et al. (2009); Rebuilding ends in 2023 (HMS Am. 5a)
Blacknose			
Blacknose	Yes	Yes	SEDAR 21 (2010); Rebuilding ends in 2043 (HMS Am. 5a)
Smoothhound			
Atlantic Smooth Dogfish	No	No	SEDAR 39 (2015)
Research			
Sandbar	Yes	No	SEDAR 54 (2017)
Prohibited			
Dusky	Yes	Yes	SEDAR 21 (2016); Rebuilding ends in 2108 (HMS Am. 2)
All other prohibited sharks	Unknown	Unknown	

III. Status of the Fishery

Specifications (Opening, closures, quotas)

NOAA Fisheries sets quotas for coastal sharks through the 2006 Consolidated Atlantic Highly Migratory Species Fishery Management Plan. The opening dates, closures dates and quotas are detailed in Table 3. All non-prohibited coastal shark management groups, except aggregated large coastal and hammerheads shark groupings, opened on January 1, 2015. NOAA Fisheries closes commercial shark fisheries when 80% of the available quota is reached. Commercial shark dealer reports indicate the following commercial fisheries exceeded 80% of the available quota and had an early closure: blacknose, non-blacknose small coastals, aggregated large coastal and hammerhead fisheries. When the fishery closes in federal waters, the Interstate FMP dictates that the fishery also closes in state waters.

Table 3. Commercial quotas and opening dates for 2015 and 2016 shark fishing season

2015 Season

Species Group	Region	2015 Annual Quota (mt dw)	Season Opening Dates	Closing Date
Aggregated Large Coastal Sharks (LCS)	Atlantic	168.9	June 1, 2015	
Hammerhead Sharks	Atlantic	27.1	June 1, 2015	
Non-Blacknose Small Coastal Sharks (SCS)	Atlantic	176.1	January 1, 2015	June 7, 2015; Re-opened August 18
Blacknose Sharks	Atlantic	17.5	January 1, 2015	June 7, 2015
Blue Sharks	No regional quotas	273.0	January 1, 2015	
Porbeagle Sharks	No regional quotas	1.7	January 1, 2015	
Pelagic Sharks other than Porbeagle or Blue	No regional quotas	488.0	January 1, 2015	
Shark Research Quota (Aggregated LCS)	No regional quotas	50.0	January 1, 2015	
Sandbar Research Quota	No regional quotas	116.6	January 1, 2015	

2016 Season

Species Group	Region	2016 Annual Quota (mt dw)	Season Opening Date	Closing Date
Aggregated Large Coastal Sharks (LCS)	Atlantic	168.9	January 1, 2016	
Hammerhead Sharks	Atlantic	27.1		
Non-Blacknose Small Coastal Sharks (SCS)	Atlantic	264.1		May 29, 2016
Blacknose Sharks	Atlantic	15.7		May 29, 2016
Blue Sharks	No regional quotas	273.0		
Porbeagle Sharks	No regional quotas	1.7		
Pelagic Sharks other than Porbeagle or Blue	No regional quotas	488.0		
Shark Research Quota (Aggregated LCS)	No regional quotas	50.0		
Sandbar Research Quota	No regional quotas	90.7		

Commercial Landings

Commercial landings of Atlantic large coastal sharks species in 2016 were 465,936 pounds (lbs) dressed weight (dw), 25% decrease from 2015 landings and 20% decrease from 2014 landings (Table 4). Commercial landings of small coastal shark species in 2016 were 210,067 lbs dw, a 40% decrease from 2015 landings and 21% lower than 2014 landings (Table 5). 2016 Landings are a new low in landings for the time series over the last 9 years. Commercial landings of Atlantic pelagic sharks was 239,655 lbs dw, which represents an increase of 11% from 2015 landings but below the 2014 landings which were a time series peak (Table 6). The increase in pelagic shark landings can be attributed to an increase in the commercial harvest of Atlantic shortfin mako sharks.

Table 4. Commercial landings of authorized Atlantic large coastal sharks by species (pounds dw), 2008-2016. Source: HMS SAFE Report, 2017.

	2008	2009	2010	2011	2012	2013	2014	2015	2016
Great hammerhead	0	0	0	0	371	7,406	13,538	36,892	20,454
Scalloped hammerhead	0	0	0	0	15,800	27,229	24,652	13,197	12,329
Smooth hammerhead		4,025	7,802	110	3,967	1,521	601	304	125
Unclassified	21,631	62,825	43,345	35,618	9,617	0	0	0	0
Hammerhead Total	**21,631**	**66,850**	**51,147**	**35,728**	**29,755**	**36,156**	**38,791**	**50,393**	**32,908**
Blacktip	258,035	229,267	246,617	176,136	215,403	256,277	282,009	229,823	248,470
Bull	43,200	61,396	56,901	49,927	24,504	33,980	32,372	33,737	31,417
Lemon	22,530	30,909	25,316	45,448	21,563	16,791	13,047	18,158	19,205
Nurse	10	0	71	0	81	0	0	24	0
Silky	306	1,386	1,049	992	29	186	289	1,246	446
Spinner	1,265	20,022	13,544	4,113	10,643	26,892	25,716	33,002	55,610
Tiger	14,119	15,172	43,145	36,425	23,245	16,561	29,062	28,460	14,896
Unclassified	187,670	70,894	2,229	50,711	53,705	0	0	0	0
Aggregated LCS Total	**527,135**	**429,046**	**388,872**	**363,766**	**349,345**	**350,687**	**382,495**	**344,450**	**370,044**
Sandbar	63,035	54,141	84,339	94,295	46,446	46,868	82,308	112,610	62,984
Hammerhead, Aggregated LCS, Sandbar Total	**611,801**	**550,037**	**524,358**	**493,775**	**425,374**	**433,710**	**464,803**	**507,453**	**465,936**

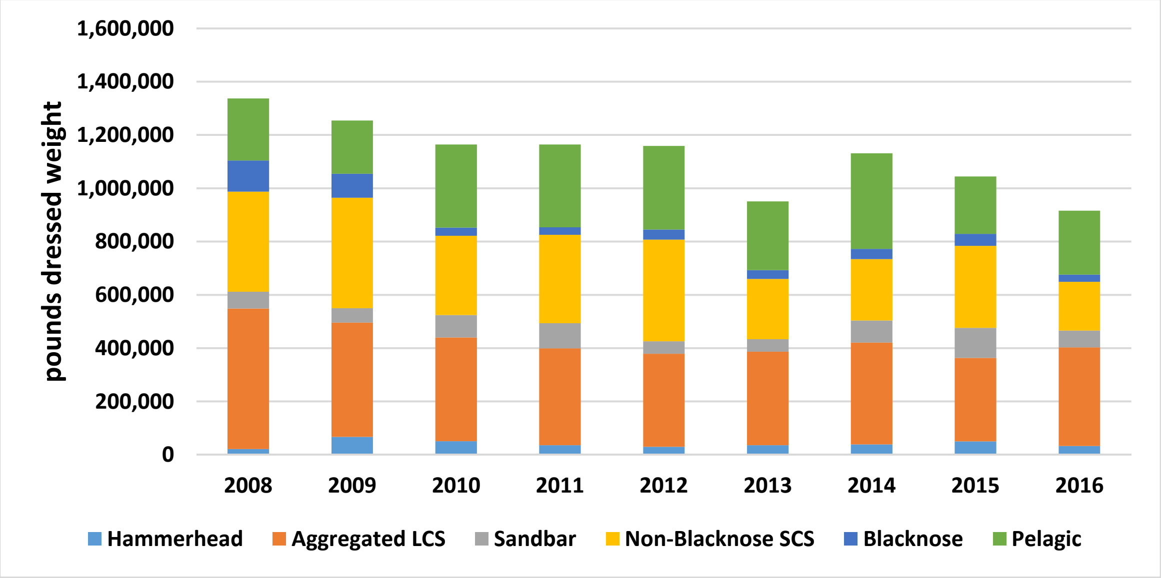
Table 5. Commercial landings of authorized Atlantic small coastal sharks by species (lbs dw), 2008-2016. Source: HMS SAFE Report, 2017.

	2008	2009	2010	2011	2012	2013	2014	2015	2016
Blacknose	117,197	90,023	30,287	28,373	37,873	33,382	38,437	45,405	26,842
Bonnethead	61,549	53,912	9,069	28,284	19,907	22,845	13,221	5,885	1,688
Finetooth	28,872	63,359	76,438	52,318	15,922	19,452	19,026	8,712	5,647
Atl. Sharpnose	261,788	262,508	211,190	214,382	345,625	183,524	198,568	293,128	175,890
Unclassified	23,077	34,429	851	36,639	492	0	0	0	0
SCS Total	**490,483**	**504,231**	**327,835**	**359,996**	**419,819**	**259,203**	**269,252**	**353,130**	**210,067**

Table 6. Commercial landings of authorized pelagic sharks by species off the Atlantic coast of the United States (lbs dw), 2008-2016. Source: HMS SAFE Report, 2017.

	2008	2009	2010	2011	2012	2013	2014	2015	2016
Blue	3,229	4,793	9,135	13,370	17,200	9,767	17,806	1,114	607
Porbeagle	5,259	3,609	4,097	5,933	4,250	54	6,414	0	0
Shortfin Mako	120,255	141,456	220,400	207,630	198,841	199,177	218,295	141,720	160,829
Unclassified	39,661	9,383	0	0	0	0	0	0	0
Oceanic	1,899	933	796	2,435	258	62	22	0	0
Thresher	47,528	33,333	61,290	47,462	63,965	48,768	116,012	72,463	78,219
Unclassified	14,819	6,650	16,160	33,884	28,932	0	0	0	0
Pelagic Total	**232,650**	**200,157**	**311,878**	**310,714**	**313,446**	**257,828**	**358,549**	**215,297**	**239,655**

Figure 1: Commercial landings of coastal sharks off the east coast of the United States by species complex, 2008-2016. Source: HMS SAFE Report, 2017.



Recreational Landings

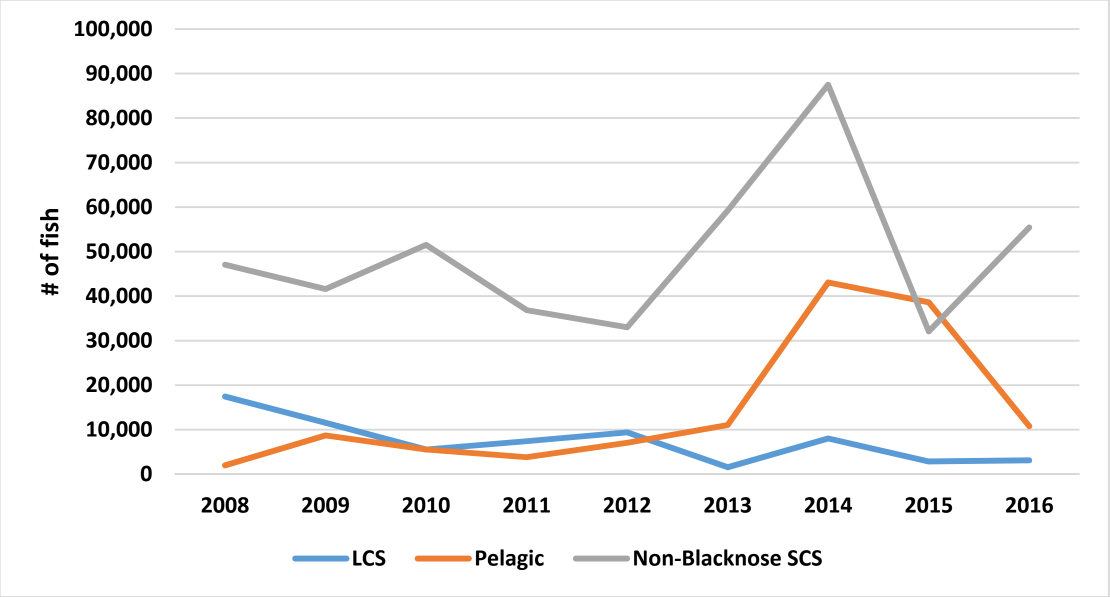
Approximately 69,543 sharks were harvested during the 2016 recreational fishing season, below 2015 landings but similar to 2013 and 2015 harvest levels (Table 7). The non-blacknose small coastal shark group comprised 55% of the overall recreational harvest, specifically Atlantic sharpnose, and bonnethead.

Table 7. Estimated recreational harvest of all Atlantic shark species by species group in numbers of fish, 2008-2016. Source: Updated based HMS SAFE Report, 2017.

	2008	2009	2010	2011	2012	2013	2014	2015	2016
Aggregated LCS	17,441	11,536	5,540	7,397	9,386	1,547	8,010	2,852	3,100
Hammerhead	4	574	13	178	41	600	900	1	0
Pelagic*	1,972	8,694	5,529	3,806	7,034	11,057	43,047	38,470	10,789
Blacknose	2	947	0	573	0	70	4,146	1,211	223
Non-Blacknose SCS	47,059	41,577	51,529	36,851	33,005	59,208	87,480	32,065	55,426
Sandbar	4,210	6,461	2,193	1,125	857	399	1,873	1,252	5
Prohibited	1,502	506	4	23	15	16	2	0	0
Total	72,190	70,295	64,808	49,952	50,338	72,895	145,461	75,983	69,543

*Pelagic sharks include Gulf of Mexico landings.

Figure 2: Estimated recreational harvest for LCS, SCS and pelagic species by species group, in numbers of fish, 2008-2016. Source: HMS SAFE Report, 2017.



IV. Status of Research and Monitoring

Under the Interstate Fishery Management for Coastal Sharks, the states are not required to conduct any fishery dependent or independent studies; however, states are encouraged to submit any information collected while surveying for other species. This section describes the research and monitoring efforts through the 2016 fishing year, where available.

The Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) appears in multiple state monitoring efforts, a brief description is below. The survey monitors the presence of young-of-year and juvenile sharks along the east coast. It is managed and coordinated by NOAA's Northeast Fisheries Science Center (NEFSC) through the Apex Predators Program based at the NEFSC's Narragansett Laboratory in Rhode Island. Longline and gillnet sampling, along with mark-recapture techniques are used to determine relative abundance, distribution and migration of sharks utilizing nursing grounds from Massachusetts to Florida. In 2016, COASTSPAN program participants were the University of North Florida (samples Georgia and North Florida state waters) and the South Carolina Department of Natural Resources. In addition, the survey is conducted in summer months in Narragansett and Delaware Bays, and in Massachusetts waters. Standardized indices of abundance from COASTPAN surveys are used in the stock assessments for large and small coastal sharks.

Massachusetts

Movement and Habitat Studies: With external funding from private and federal grants, *MarineFisheries* personnel continued in 2015 and 2016 to collaborate with federal and academic researchers on the study of broad and fine-scale movements of numerous shark species using pop-up satellite tags (PSAT), real-time satellite tags (SPOT), acoustic transmitters, and conventional tags. These species include white (data through 2016), basking, blue, shorfin mako, tiger, and sand tiger sharks (data through 2015).

Basking Shark: Since 2004, 57 basking sharks have been tagged with PSAT tags and 10 with SPOT tags. The broad- and fine-scale horizontal and vertical movements of this species are being examined by Tobey Curtis as part of his PhD project at University of Massachusetts–Dartmouth, School for Marine Science and Technology (SMAST). In 2015, Tobey conducted a quantitative analysis of the broad-scale movements of PSAT-tagged basking sharks as they relate to international boundaries and Exclusive Economics Zones.

White Shark: Our efforts to study the movement ecology of white sharks off Massachusetts and the eastern seaboard of the US continued in 2016. An additional 23 white sharks were tagged in 2015, bringing the total number tagged since 2009 to 102 individuals. These sharks were tagged with one or more of the following technologies: PSAT, SPOT, coded acoustic transmitters, autonomous underwater vehicle transponders, active acoustic transmitters, and NOAA Fisheries conventional tags. Tagged sharks ranged from roughly 7.5 to 18.5 feet in total length.

> Work continued on a five-year study initiated in 2014 to quantify the regional population size and relative abundance of white sharks in Massachusetts waters. With funding and logistical support from local non-profits, aerial and vessel surveys were conducted from mid-June through October off the eastern coast of Cape Cod. During 40 vessel surveys, a total of 572 white sharks comprising 147 individuals were sighted and cataloged in 2016; 40% were re-sighted from previous years. As was the case in 2015, the distribution of white sharks shifted throughout the season in 2016 (Figure 1).Throughout the summer and fall, 36

white sharks were detected by *MarineFisheries'* acoustic receivers. This quantitative study is being conducted by UMass-SMAST student Megan Winton as part of her PhD research.

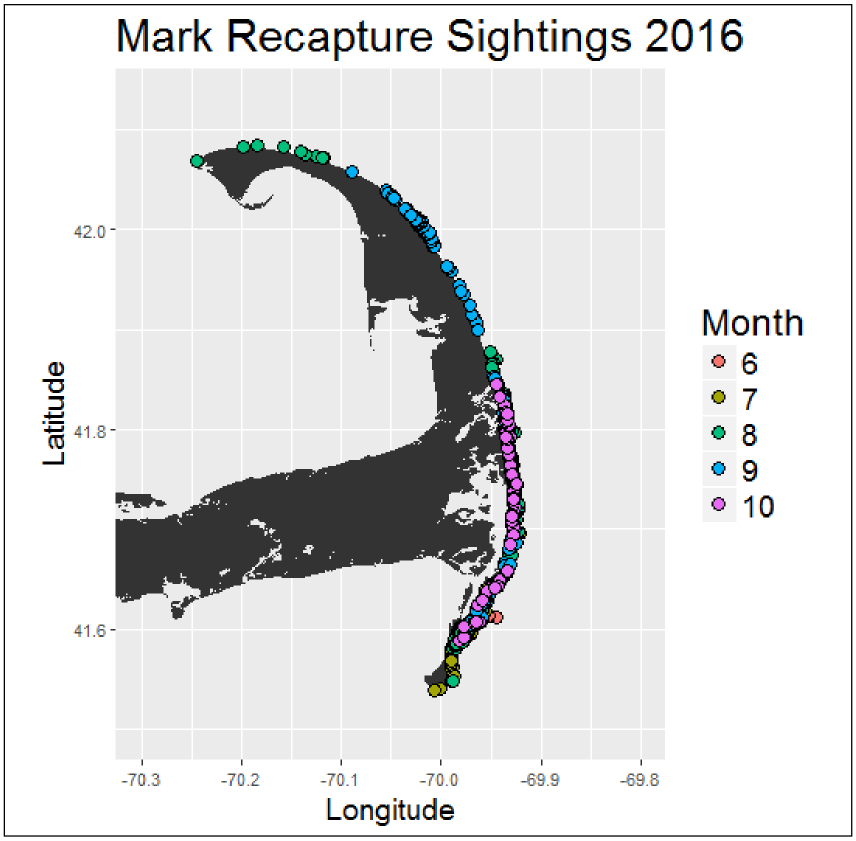


Figure 1. Monthly distribution of white sharks sighted off the coast of Cape Cod in 2016.

Blue and Shortfin Mako Sharks: In cooperation with the MIT/WHOI PhD student Camrin Braun, blue and shortfin mako sharks were tagged with SPOT and PSAT tags during the summer of 2015 to study the fine-scale movements of these species as they relate to eddy fields in the North Atlantic.

Post-release Survivorship Studies: In 2015, work continued with University of Massachusetts researcher Diego Bernal and PhD student Heather Marshall to study the physiological effects of longline capture in sandbar and dusky sharks. Funding for the study was obtained from the Saltonstall-Kennedy Program. In 2015, a manuscript resulting from this research was published in *Fisheries Research*:

Marshall, H, L., G. Skomal , P.G. Ross, and D. Bernal. 2015. At-vessel and post-release mortality of the dusky (Carcharhinus obscurus) and sandbar (C. plumbeus) sharks after longline capture. Fisheries Research. 172:373-384.

Life History: Working with NOAA Fisheries and WHOI researchers, Project personnel generated age and growth estimates for the white shark in the western North Atlantic. Using bomb-produced radiocarbon, vertebral growth bands were counted and validated as annual. In 2015, this research was published in *Marine and Freshwater Research*:

Natanson, L.J. and G.B. Skomal. 2015. Age and growth of the white shark, Carcharodon carcharias, in the western North Atlantic Ocean. Marine and Freshwater Research, DOI: dx.doi.org/10.1071/MF14127.

Publications: Four other peer-reviewed papers, with *MarineFisheries* personnel as a co-author, were published in 2015:

Ashe, J.L., K.A. Feldheim, A.T. Fields, E.A. Reyier, E.J. Brooks, M.T. O'Connell, G.B. Skomal, S.H. Gruber, and D.D. Chapman. 2015. Local population structure and context-dependent isolation by distance in a large coastal shark. Marine Ecology Progress Series, 520:203-216, doi: 10.3354/meps11069.

Braun, C.D., et al. 2015. Movements of the reef manta ray (Manta alfredi) in the Red Sea using satellite and acoustic telemetry. Marine Biology 162:2351-2362.

Legare, B, J. Kneebone, B. DeAngelis, and G. Skomal. 2015. The spatiotemporal dynamics of habitat use by blacktip (Carcharhinus limbatus) and lemon (Negaprion brevirostris) sharks in nurseries of St. John, United States Virgin Islands. Marine Biology, DOI 10.1007/s00227-015-2616-x.

Skomal, G.B., E.M. Hoyos-Padilla, A. Kukulya, and R. Stokey. 2015. Subsurface observations of white shark predatory behaviour using an autonomous underwater vehicle. Journal of Fish Biology 87:1293-1312.

Rhode Island

Fishery independent monitoring is limited to coastal shark species taken in the RI Division of Fish & Wildlife, Marine Fisheries Section monthly and seasonal trawl survey. During the 2015 and 2016 calendar year the only coastal shark species captured in the trawl survey was smooth dogfish (*Mustelus canis*). A summary of fishery independent monitoring for coastal sharks is summarized in Table 8 & 9 below.

Table 8. Total number of smooth dogfish caught per month and during the seasonal trawl surveys during the 2015 fishing year. Smooth dogfish are the only coastal shark captured by the RI DFW trawl survey during the 2015.

					Average	
Year	Month	Tows conducted	Total weight (kg)	Total number	Number per tow	kg per tow
Monthly Coastal Trawl Survey			-	-	-	-
2015	JAN	12	0	0	0	0
2015	FEB	0	0	0	0	0
2015	MAR	12	0	0	0	0
2015	APR	13	0	0	0	0
2015	MAY	13	0	0	0	0
2015	JUN	13	6.9	4	0.31	0.53
2015	JUL	13	16.4	27	2.08	1.26
2015	AUG	13	23.5	28	2.15	1.81
2015	SEP	13	5.8	7	0.54	0.44
2015	OCT	13	16.4	13	1.00	1.27
2015	NOV	13	0	0	0	0
2015	DEC	13	0	0	0	0
Seasonal Coastal Trawl Survey			-	-	-	-
2015	Spring	43	0	0	0	0
2015	Fall	43	58.98	54	1.26	1.37

Table 9. Total number of smooth dogfish caught per month and during the seasonal trawl surveys during the 2016 fishing year. Smooth dogfish are the only coastal shark captured by the RI DFW trawl survey during the 2016.

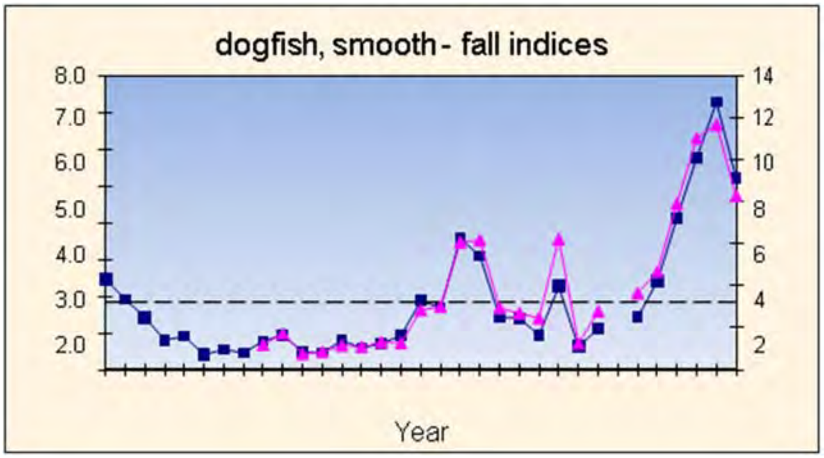
Year	Time Period	Species	Number of Tows	Total Weight (kg)	Total Number Caught
Monthly Coastal Trawl Survey					
2016	MAY	Smooth Dogfish	13	0.0	0
2016	JUN	Smooth Dogfish	11	0.0	0
2016	JUL	Smooth Dogfish	12	0.0	0
2016	AUG	Smooth Dogfish	13	0.0	0
2016	SEP	Smooth Dogfish	13	11.4	4
2016	OCT	Smooth Dogfish	13	13.5	17
2016	NOV	Smooth Dogfish	13	38.6	52
2016	DEC	Smooth Dogfish	13	5.6	4
2016	JAN	Smooth Dogfish	13	8.4	7
2016	FEB	Smooth Dogfish	13	33.9	23
2016	MAR	Smooth Dogfish	13	0.0	0
2016	APR	Smooth Dogfish	13	0.0	0
Seasonal Coastal Trawl Survey					
2016	Spring	Smooth Dogfish	44	5.0	2
2016	Fall	Smooth Dogfish	44	35.7	26

Connecticut

The Connecticut Department of Energy and Environmental Protection monitors the abundance of marine resources in nearby coastal waters with the Long Island Sound Trawl Survey. Spring (April, May and June) and fall (September and October) surveys are conducted each year. Other than smooth dogfish, coastal sharks are not encountered by the Long Island Sound Trawl Survey. Smooth dogfish are caught most often in the fall and the fall indices are presented below. See the link below for the latest Long island Sound Trawl Survey report.

Table 10. Long Island Trawl Survey Fall Smooth Dogfish indices (geometic mean catch/tow)

Year	Kg/tow	Count/tow
1996	1.16	0.80
1997	1.09	0.59
1998	1.32	0.72
1999	1.27	0.93
2000	2.85	1.88
2001	3.02	1.69
2002	6.09	3.58
2003	6.18	3.10
2004	2.95	1.44
2005	2.70	1.41
2006	2.46	0.94
2007	6.23	2.27
2008	1.25	0.63
2009	2.8	1.13
2010	-	-
2011	3.66	1.43
2012	4.69	2.41
2013	7.93	4.13
2014	11.05	5.78
2015	11.70	7.30
2016	8.30	5.24



New York

While NY DEC does not currently conduct fishery-independent monitoring programs for Atlantic Coastal Sharks, a research permit was issued in 2015 and 2016 for the collection of information on sand tiger sharks (*Carcharias taurus*) and blue sharks (*Prionace glauca*). In 2015, 18 sand tiger sharks and two blue sharks were caught and released; in 2016, 23 sand tiger sharks, 1 smooth dogfish, 7 sandbar sharks, 1 shortfin mako, and 1 blue shark were caught and released. In both years, information on each (morphometrics and sex) as well location, date, biological samples collected, telemetry gear deployed, and final disposition of the animals were recorded.

New Jersey

New Jersey does not currently conduct any fishery-independent monitoring programs specifically for Atlantic Coastal Sharks, but does receive sharks from the State's Ocean Stock Assessment Survey. In 2015, the Survey caught approximately 157lbs of Atlantic Angel Sharks, 59lbs of Atlantic Sharpnose Sharks, 24lbs of Dusky Sharks, 769lbs of Sand Tiger Sharks, 41lbs of Sandbar Sharks, 9,567lbs of Smooth Dogfish, and 451lbs of Thresher Sharks. In 2016, the Survey caught approximately 125lbs of Atlantic Angel shark, 8lbs of Atlantic Sharpnose, 2,015lbs of Sand Tiger, 4,097lbs of Smooth Dogfish, and 22lbs of Thresher. Sharks from the New Jersey Ocean Stock Assessment Survey have collected by a 30-meter otter trawl every January, April, June, August, and October since 1989. Tows are approximately 1 nautical mile and are performed via a stratified random sampling design. Latitudinal strata are identical to those used by the National Marine Fisheries Service groundfish survey. Longitudinal boundaries are defined by the 18-30, 30-60, and 60-90 foot isobaths. Smooth Dogfish are cumulatively weighed and measured by total length in centimeters. All other shark species are sorted by gender, weighed individually, and measured by total length in centimeters.

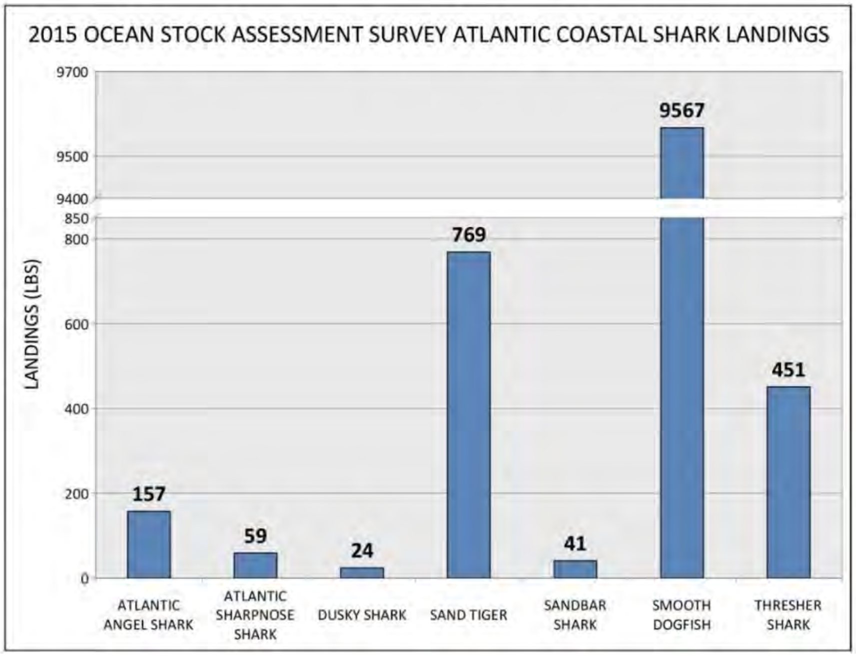


Figure 3. NJ 2015 Ocean Stock Assessment Survey- Atlantic Coastal Sharks

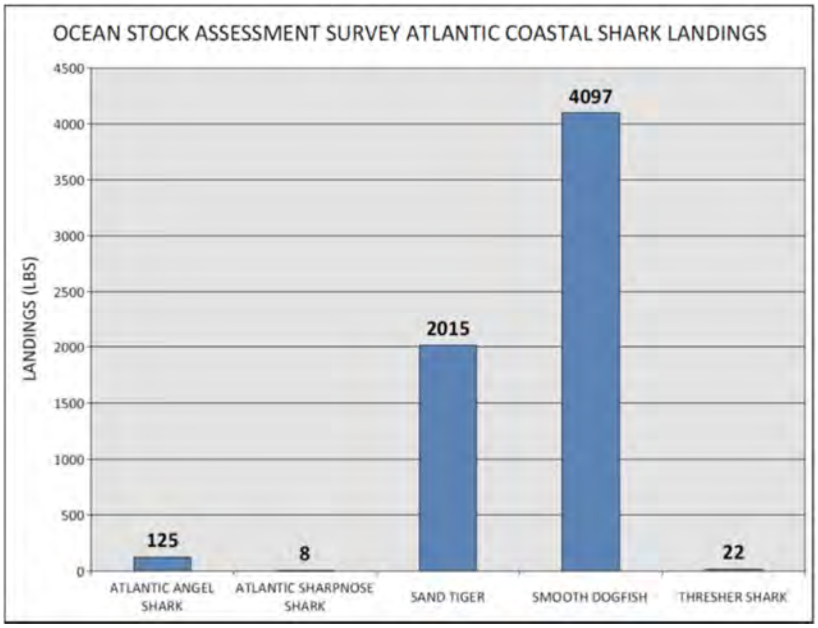


Figure 4. NJ 2016 Ocean Stock Assessment Survey- Atlantic Coastal Sharks

Delaware

Delaware conducts a 30’ adult trawl survey and a 16’ juvenile trawl survey in the Delaware Bay. In the adult trawl survey, Smoothhound are the most common shark species caught (Figure 5), with Sand Tiger Shark (Figure 6) and Sandbar Sharks (Figure 7) taken in low numbers. Thresher, Atlantic Angel, Atlantic Sharpnose (Figure 8) and Dusky shark were caught in the past, but rarely. Sand Tiger Shark catch per nautical mile increased in 2016 and was the highest number taken since 1983. Sandbar Shark catch per nautical mile increased in 2016 but remained high for the recent time series. Smoothhound catch per nautical mile increased slightly in 2016. In the juvenile trawl, the species caught were sand tiger shark (Figure 9), Sandbar Sharks (Figure 10) and Smoothhound (Figure 11). With the exception of Smoothhound, the capture of coastal sharks in the juvenile trawl is a rare occurrence.

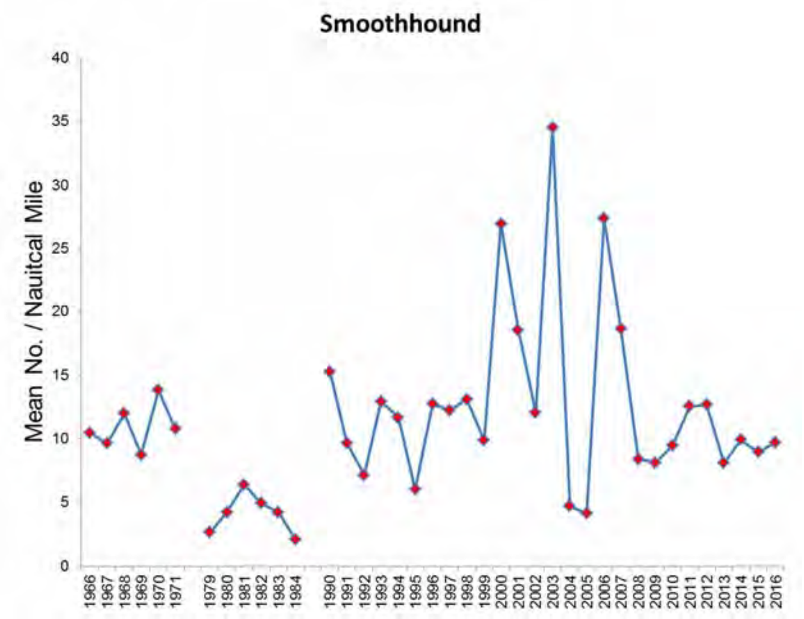


Figure 5. Smoothhound relative abundance (mean number per nautical mile), time series (1966 – 2016) as measured in 30-foot trawl sampling in the Delaware Bay.

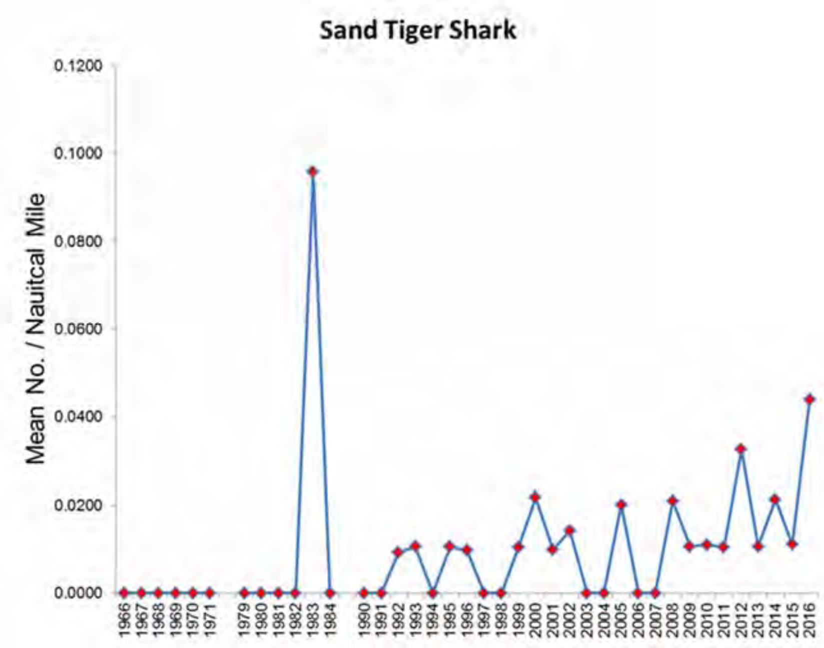


Figure 6. Sand Tiger Shark relative abundance (mean number per nautical mile), time series (1966 – 2016) as measured in 30-foot trawl sampling in the Delaware Bay.

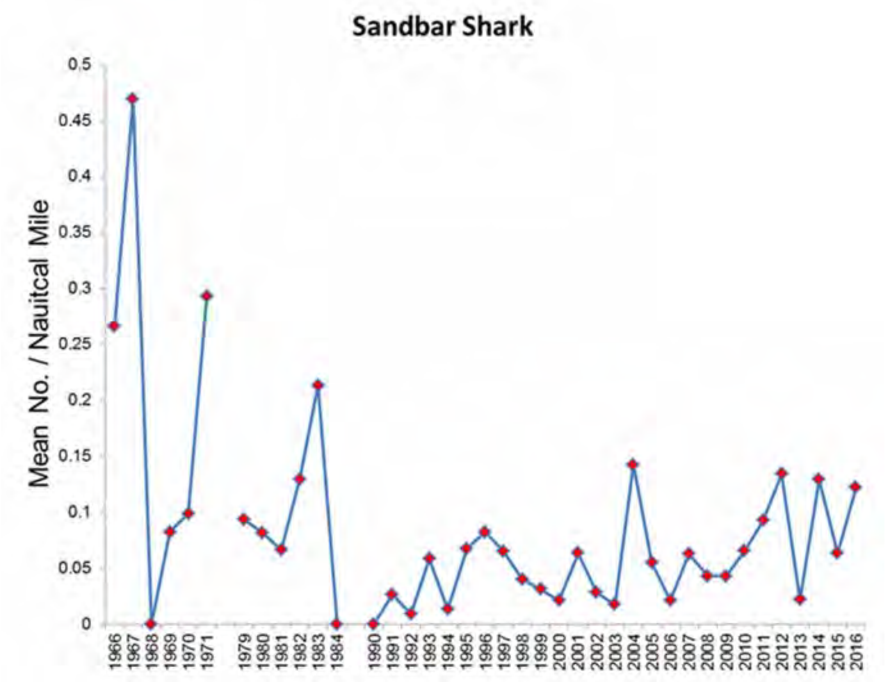


Figure 7. Sandbar Shark relative abundance (mean number per nautical mile), time series (1966 – 2016) as measured in 30-foot trawl sampling in the Delaware Bay.

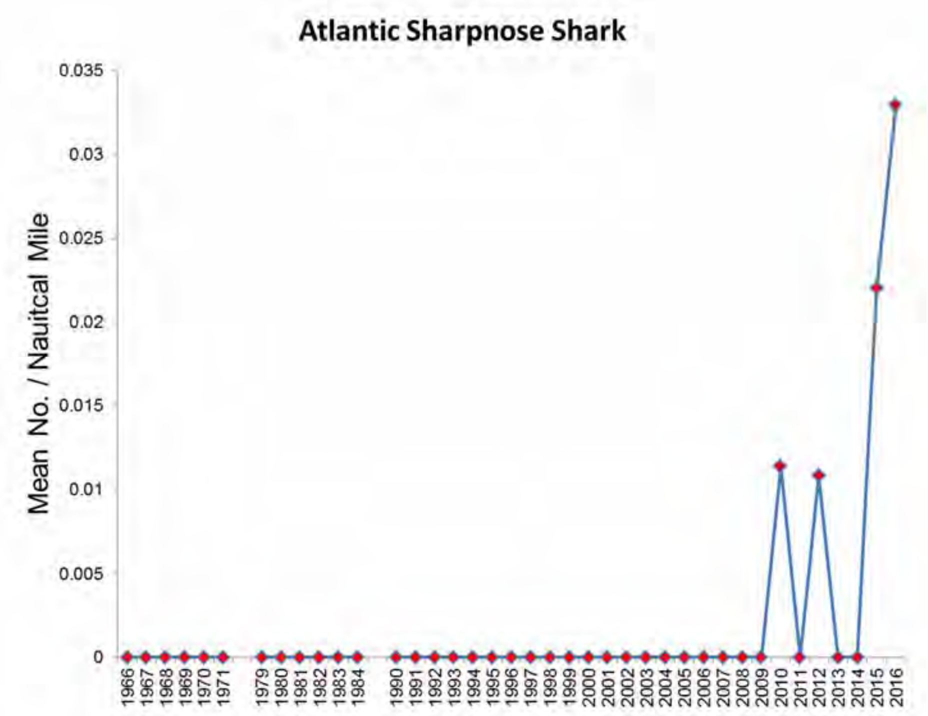


Figure 8. Atlantic Sharpnose Shark relative abundance (mean number per nautical mile), time series (1966 – 2016) as measured in 30-foot trawl sampling in the Delaware Bay.

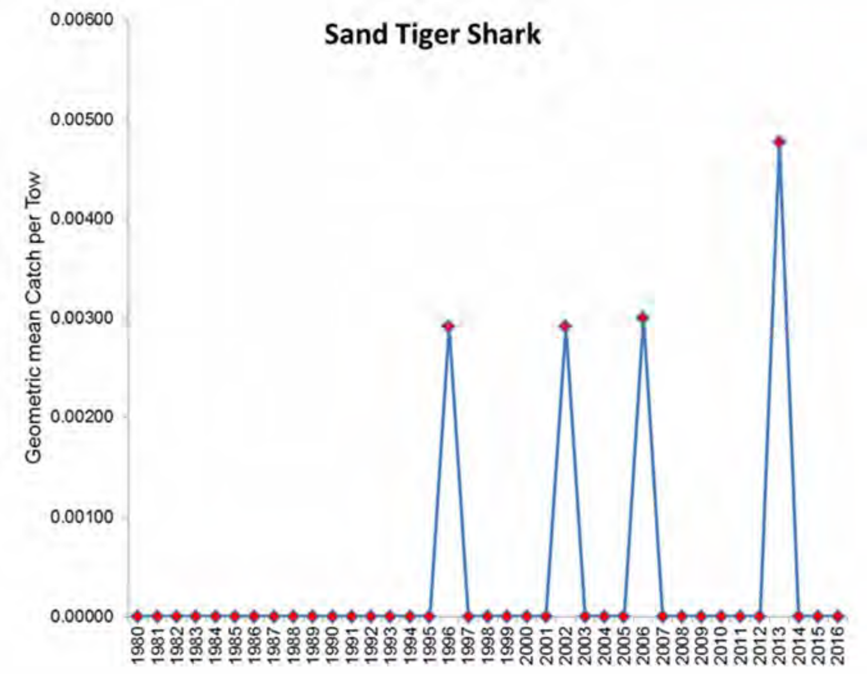


Figure 9. Index of Sand Tiger Shark, time series (1980 – 2016) as measured by 16-foot trawl sampling in the Delaware estuary.

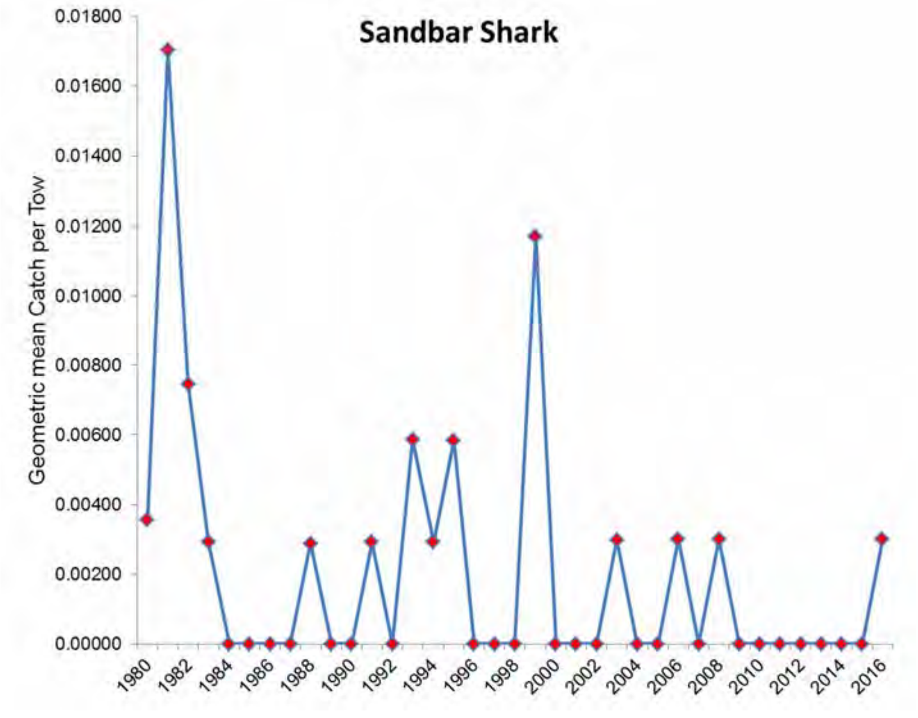


Figure 10. Index of Sandbar Shark, time series (1980 – 2016) as measured by 16-foot trawl sampling in the Delaware estuary.

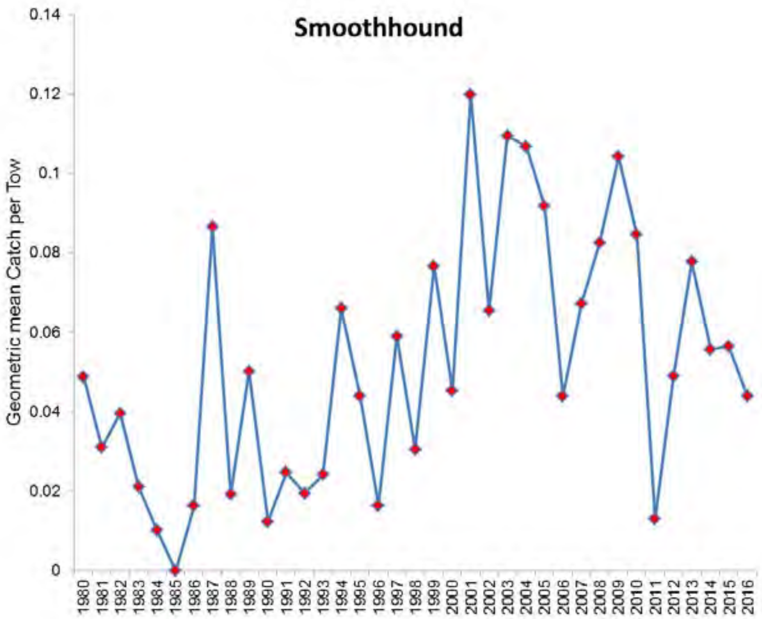


Figure 11. Index of young-of-the-year Smoothhound abundance, time series (1980 – 2016) as measured by 16-foot trawl sampling in the Delaware estuary.

Maryland

There was no specific at sea sampling program for coastal sharks in Maryland. Limited biological sampling of catch onboard a commercial offshore trawler targeting horseshoe crabs occurred at night in June, July, August, and October. While sharks were encountered through a scientific permit, information regarding species and number encountered are confidential.

Virginia

The Virginia Institute of Marine Science Shark Research Program began in 1973 and is one of the longest running longline surveys in the world. The program has provided data on habitat utilization, age, growth, reproduction, trophic interactions, basic demographics, and relative abundance for dominant shark species. Cruise times have been variable over the time series, but generally sampling has occurred monthly from May through October. The survey utilizes a fixed station design with nine core sampling locations, although additional auxiliary locations have been sampled frequently over the years.

Beginning in 2012 a separate longline survey, conducted by the Virginia Institute of Marine Science designed specifically to target YOY sandbar sharks in the lower Chesapeake Bay and Eastern Shore, was initiated. The new survey follows a stratified random sampling design, rather than a fixed survey design, and falls under the broader COASTSPAN umbrella survey.

North Carolina

The North Carolina Division of Marine Fisheries (NCDMF) conducts both fishery-dependent and independent sampling within state waters. Fishery-dependent sampling of North Carolina commercial fisheries has been ongoing since 1982 (conducted under Title III of the Interjurisdictional Fisheries Act and funded in part by the U.S. Department of Commerce, National Marine Fisheries Service). Predominate fisheries sampled included the ocean gill net, estuarine gill net, ocean trawl, long haul seine/swipe net, beach seine and pound net fisheries.

A total of 9 fishery-dependent samples containing sharks were collected from the ocean gill net, ocean trawl and estuarine gill net fisheries in 2016 (Table 11). This sample number is down compared to the 64 samples obtained in 2015, this is due in large part to a change in staff in the Manteo office, where most shark catches are landed. Whole weights and lengths for sharks other than spiny dogfish are rarely obtained during sampling. Sharks are typically dressed or processed when sampling occurs therefore the number of processed individuals and aggregate weights are obtained during sampling. Atlantic sharpnose and smoothhound sharks were the most abundant species in dependent sampling by numbers and weight (Table 12).

Table 11. North Carolina fishery-dependent shark sampling summary by month for the 2016 fishing year.

Month	# of Samples
January	2
February	1
March	1
April	1
May	3
June	0
July	0
August	0
September	0
October	0
November	0
December	0
Total	9

Table 12. North Carolina fishery-dependent shark sampling summary by species, number of individuals, and sum of sample weight (lb) for the 2015 fishing year.

Species	# Indv.	Sum of Sample Wgt. (lb)
Atlantic Sharpnose Shark (*R. terraenovae*)	29	93
Smoothhound Shark (*M. canis*)	41	230
Thresher Shark (*A. vulpinus*)	30	502
Total	100	825

Fishery-Independent

The NCDMF initiated a fishery-independent red drum longline survey in 2007 for developing an index of abundance for adult red drum (*S. ocellatus*); this project also allows for capture and tagging of Atlantic coastal sharks in cooperation with the North East Fisheries Science Center's (NEFSC) Cooperative Shark Tagging Program. The red drum longline survey in the Pamlico Sound resulted in a catch of 3 sharks in 2016. Two species of shark were captured; two blacktip (*C. limbatus*), and one bonnethead (S. tiburo). Only one (1) of the blacktip sharks was measured and tagged with M-tags from the NOAA Fisheries Cooperative Shark Tagging Program.

The NCDMF initiated a fishery-independent gill net survey in 2001 and expanded its coverage in 2008 to include the Cape Fear and New Rivers and the near shore (0-3 miles) Atlantic Ocean from New River Inlet south to the South Carolina state line. The Atlantic Ocean portion of the survey was discontinued in June of 2015 due to low catches of target species, none of which were sharks (see next paragraph). The objective of this project is to provide annual, independent, relative abundance indices for key estuarine species in the near shore Atlantic Ocean, Pamlico Sound, Pamlico, Pungo, Neuse, New, and Cape Fear Rivers. The survey employs a stratified random sampling design and utilizes multiple mesh gill nets (3.0 inch to 6.5 inch stretched mesh, by ½ inch increments). Sharks from the 2016 Pamlico Sound independent gill net survey catch included: two (2) smooth dogfish, one (1) Atlantic sharpnose, one (1) bonnethead, six (6) sandbar and 12 bull sharks [(C. leucas) Table 13]. Catch from the 2016 Cape Fear, New and Neuse River independent gill net survey catch included: 55 Atlantic sharpnose, and seven (7) bonnethead shark (Table 14).

Table 13. Species, number of individuals, minimum, maximum and average total length [TL (mm)] of sharks caught in the 2016 North Carolina Pamlico Sound gill net survey.

Species	Number Measured	Min of TL (mm)	Max of TL (mm)
Atlantic Sharpnose Shark	1	932	932
Bonnethead Shark	1	714	714
Bull Shark	12	665	1,288
Sandbar Shark	6	448	945
Smooth Dogfish	2	594	861
Total	22		

Table 14. Species, number of individuals, minimum, maximum, and average total length [TL (mm)] of sharks caught in the 2016 North Carolina Cape Fear, Neuse and New River gill net survey.

Species	Number Measured	Min of TL (mm)	Max of TL (mm)
Atlantic Sharpnose Shark	55	290	516
Bonnethead Shark	7	855	1,122
Total	62		

South Carolina

Data related to the presence and movement of sharks in South Carolina's coastal waters will continue to be collected as encountered within the context of existing fishery dependent or fishery independent programs conducted by the SCDNR. Currently, data are collected from estuarine waters by the SCDNR Cooperative Atlantic States Shark Pupping and Nursery Habitat survey (COASTSPAN) and the SCDNR trammel net survey. The COASTSPAN survey monitors the presence and abundance of young-of-year and juvenile sharks in the estuaries and bays of South Carolina. The survey operates from April-September using gillnets, longlines, and drumlines to sample index stations. Species captured are measured, sexed, tagged, released, and physical and water quality parameters are recorded (Table 14).

The SCDNR trammel net survey is designed to sample recreationally important species in shallow estuarine waters. Sharks are not a target species, but their abundance as well as length and sex data are recorded (Table 15). Stations selected based on suitable habitats are randomly sampled using a multi-panel gillnet to encircle a section of marsh. Species captured are measured, sexed if possible, select species (no sharks) are tagged and released and physical and water quality data are recorded.

The presence and abundance of juvenile and adult coastal sharks in the bays, sounds and coastal waters of South Carolina are documented by the Adult Red Drum and Coastal Shark Longline survey. This survey uses a stratified-random approach to sample for adult red drum and coastal sharks. The survey operates annually from August to December using longlines to sample suitable habitat for targeted species. Species captured are measured, sexed, tagged and released, and physical and water quality parameters are recorded. Species encountered and tagged for all surveys are reported in Table 15. The data gathered from these programs are shared with the NMFS apex predators program and are utilized in stock assessments and management decisions in South Carolina.

Table 15. Number of sharks captured by South Carolina Department of Natural Resources' Cooperative Atlantic States Shark Pupping and Nursery Habitat Survey (COASTSPAN), the Trammel Net Survey, and Adult Red Drum and Coastal Sharks Longline survey in 2016

	COASTSPAN		Trammel Net		Adult Red Drum and Coastal Sharks	
Shark Species	Captured	Tagged	Captured	Tagged	Captured	Tagged
Atlantic Sharpnose	241	0	188	0	909	0
Blacknose	10	8	0	0	107	103
Blacktip	139	97	20	0	55	46
Bonnethead	144	113	242	0	14	14
Bull	17	16	0	0	7	4
Finetooth	454	271	124	0	69	59
Great Hammerhead	1	1	0	0	1	0
Lemon	17	15	4	0	1	1
Nurse	-	0	0	0	6	0
Sandbar	141	127	1	0	106	94
Sand Tiger	8	8	0	0	0	0
Scalloped Hammerhead	67	2	0	0	3	0
Smooth Dogfish	1	1	0	0	0	0
Spinner	1	0	0	0	26	24
Tiger	15	13	0	0	5	4
Total	1256	672	579	0	1309	349

Georgia

Although a directed fishery for sharks does not exist in Georgia waters, there are a several fishery dependent sampling surveys conducted by the Coastal Resources Division that could result in the incidental capture of coastal sharks. In 2016, coastal sharks were found in the following fishery independent surveys.

Sampling for the *Adult Red Drum Survey (via SEAMAP)* Sampling occurs in inshore and nearshore waters of southeast Georgia and in offshore waters of northeast Florida. Sampling occurs from mid-May through the end of December. Sampling gear consists of a bottom set 926m, 600lb test monofilament mainline configured with 60, 0.5 m gangions made of 200lb test monofilament. Each gangion consists of a longline snap and a 15/0 circle hook. Thirty hooks of each size are deployed during each set. All hooks are baited with squid or mullet. Soak time for each set is 30 minutes. During 2016, CRD staff deployed 175 sets consisting of 10,500 hooks and 87.5 hours of soak time. A total of 825 sharks, representing 9 species were captured (Table 16).

Sampling for the *Shark Nursery Survey (via COASTSPAN)* The University of North Florida assumed field operations for this survey in 2016. Data for the complete time series are maintained by the National Marine Fisheries Service's Apex Predator Program in Narragansett, RI (contact: Cami McCandless).

Each month the *Ecological Monitoring Trawl Survey (EMTS)*, a 40-foot flat otter trawl with neither a turtle excluder device nor bycatch reduction device is deployed at up to 42 stations across six estuaries. At each station, a standard 15 minute tow is made. During this report period, 482 tows/observations were conducted, totaling 120.41 hours of tow time. A total of 247 sharks, representing 5 species, were captured during 2016 (Table 16).

Monitoring of estuarine finfish and crustaceans in the lower salinity, upriver sectors of selected estuaries is done monthly as part of the *Juvenile Trawl Survey* conducted onboard the research vessel *Navigator*. A 20-foot, semi-balloon otter trawl is towed for 5 minutes at up to 18 stations within three Georgia estuaries. In 2016, 130 tows (observations) were conducted, totaling 10.75 hours of tow time. No sharks were observed during the 2016 season.

The Marine Sportfish Population Health Survey (MSPHS) is a multi-faceted ongoing survey used to collect information on the biology and population dynamics of recreationally important finfish. Currently two Georgia estuaries are sampled on a seasonal basis using entanglement gear. During the June to August period, young-of-the-year red drum in the Altamaha/Hampton River and Wassaw estuaries are collected using gillnets to gather data on relative abundance and location of occurrence. During the September to November period, fish populations in the Altamaha/Hampton River and Wassaw estuaries are monitored using monofilament trammel nets to gather data on relative abundance and size composition. In 2016, a total of 216 gillnet and 150 trammel net sets were made, resulting in the capture of 119 individuals representing five species of coastal sharks (Table 16).

Table 16. Numbers of coastal sharks captured in Georgia fishery independent surveys in 2016 by species and by survey.

	SEAMAP	EMTS	MSPHS
Atlantic sharpnose shark	539	188	21
Blacknose shark	180	---	---
Bonnethead	44	54	82
Blacktip shark	11	2	5
Sandbar shark	22	---	---
Tiger shark	4	---	---
Spinner shark	2	---	---
Scalloped Hammerhead	6	2	---
Lemon shark	---	---	3
Finetooth shark	17	1	8
All Species Combined	825	247	119

V. Status of Management Measures and Issues

Fishery Management Plan

Coastal Sharks are managed under the Interstate FMP for Coastal Sharks, which was implemented in August 2008, Addendum I (2009), Addendum II (2013), and Addendum III (2013).The FMP addresses the management of 40 species and establishes a suite of management measures for recreational and commercial shark fisheries in state waters (0 – 3 miles from shore). In 2016, Smooth dogfish was added to NOAA Fisheries' Atlantic Highly Migratory Species FMP through Amendment 9; as part of the Amendment, a new requirement that smooth dogfish harvest need to make up at least 25% of the retained catch in order for fishermen to be able to remove their fins at sea. The Commission later in the year approved Addendum IV (2016) to maintain consistency between state and federal FMP.

ASMFC will continue to respond to changes in the Atlantic Highly Migratory Species FMP and make changes as necessary to the interstate FMP.

VI. Implementation of FMP Compliance Requirements for 2015 and 2016

Addendum III to the Coastal Sharks FMP was implemented in March 2014. All states must demonstrate through the inclusion of regulatory language that the following management measures were implemented.

i. Recreational Minimum Size Limits

This modifies Section 4.2.4 Recreational Minimum Size Limits in the FMP.

Sharks caught in the recreational fishery must have a minimum fork length of 4.5 feet (54 inches) with the exception of smooth hammerhead, scalloped hammerhead, great hammerhead, smoothhound, Atlantic sharpnose, blacknose, finetooth, and bonnethead.

Smooth hammerhead, scalloped hammerhead and great hammerhead must have a minimum fork length of 6.5 feet (78 inches).

Smoothhound, Atlantic sharpnose, blacknose, finetooth and bonnethead do not have recreational minimum size limits.

Table 4.4. Recreational minimum size limits, 2015 and 2016.

No Minimum Size	Minimum Fork Length of 4.5 Feet		Minimum Fork Length of 6.5 Feet
Smoothhound	Tiger	Shortfin mako*	
Atlantic sharpnose	Blacktip	Porbeagle	Scalloped hammerhead
Finetooth	Spinner	Thresher	Smooth hammerhead
Blacknose	Bull	Oceanic whitetip	Great hammerhead
Bonnethead	Lemon	Blue	
	Nurse		

***Per emergency rule measures implemented in March 2018 in response to the 2017 Assessment, minimum size limit (fork length) for Shortfin makos is now 83 inches or 6.9 feet**

ii. Commercial Species Groupings

This modifies Section 4.3.3 Commercial Species Groupings (and the appropriate sub-sections, outlined below). Two new species groups ('Blacknose' and 'Hammerhead') are created.

This FMP establishes eight commercial 'species groups' for management (Table 1): Prohibited, Research, Smoothhound, Non-Blacknose Small Coastal, Blacknose, Aggregated Large Coastal, Hammerhead and Pelagic. These groupings apply to all commercial shark fisheries in state waters.

VII. PRT Recommendations

State Compliance

All states with a declared interest in the management of sharks have submit compliance reports and have regulations in place that meet or exceed the requirements of the Interstate Fisheries Management Plan for Coastal Sharks and associated addenda.

De Minimis Status

This FMP does not establish specific *de minimis* guidelines that would exempt a state from regulatory requirements contained in this plan. *De minimis* shall be determined on a case-by case basis. *De minimis* often exempts states from monitoring requirements in other fisheries but this plan does not contain any monitoring requirements.

De minimis guidelines are established in other fisheries when implementation and enforcement of a regulation is deemed unnecessary for attainment of the fishery management plan's objectives and conservation of the resource. Due to the unique characteristics of the coastal shark fishery, namely the large size of sharks compared to relatively small quotas, the taking of a single shark could contribute to overfishing of a shark species or group. Therefore, exempting a state from any of the regulatory requirements contained in this plan could threaten attainment of this plans' goals and objectives.

States that have been granted *de minimis* status are Maine and Massachusetts. New Hampshire has renounced management interest and is therefore no longer a member of the coastal shark management board. These states do not land sharks in any significant quantity and very few of the species managed by this plan are ever encountered in their state waters. These states can continue to have *de minimis* status until their landings patterns change or they request a discontinuation.

In some cases, it is unnecessary for states with *de minimus* status to implement all regulatory requirements in the FMP.

A. Massachusetts has implemented all regulations with two exceptions, it is exempt from the possession limit and closures of the aggregated large coastal and hammerhead shark fisheries.
B. Maine has implemented the following regulations to comply with the goals and objectives of the FMP:
    - Require federal dealer permits for all dealers purchasing a permitted species
    - Prohibit the take or landings of prohibited species
    - Close the fishery for porbeagle sharks when the NMFS quota has been harvested
    - Prohibit the commercial harvest of porbeagle sharks in state waters
    - Require that head, fins and tails remain attached to the carcass of all shark species, except smoothhound, through landing

Research Priorities

Species-Specific Priorities

- Investigate the appropriateness of using vertebrae for ageing adult sandbar sharks. If appropriate, implement a systematic sampling program that gathers vertebral samples from entire size range for annual ageing to allow tracking the age distribution of the catch as well as updating of age-length keys.[1]

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[1] Recent bomb radiocarbon research has indicated that past age estimates based on tagging data for sandbar sharks may be correct and that vertebral ageing may not be the most reliable method for mature individuals. See Andrews *et al.* 2011.

- Determine what is missing in terms of experimental design or/and data analysis to arrive at incontrovertible conclusions on the reproductive periodicity of sandbar sharks
- Continue work on reconstruction of historical catches of sandbar sharks, especially catches outside of the US EEZ
- Investigate the length composition of the F3 Recreational and Mexican fisheries for sandbar sharks more in depth as this fishery is estimated to have a large impact on the stock mainly due to selecting age-0 fish.
- Research to estimate the degree of connectivity between the portions of the sandbar stock within the US and outside of the US EEZ. •
- Study the distribution and movements of the sandbar stock relative to sampling coverage. It is possible that none of the indices alone track stock-wide abundance trends.
- Develop and conduct tagging studies on dusky and blacknose stock structure with increased international collaboration (e.g., Mexico) to ensure wider distribution and returns of tags. Expand research efforts directed towards tagging of individuals in south Florida and Texas/Mexico border to get better data discerning potential stock mixing.

General Priorities

- Generally update age and growth and reproductive studies for all species currently assessed, especially for studies with low sample sizes or over 20 years old.
- Determine gear-specific post-release mortality estimates for all species currently assessed
- Determine life history information for data-poor species that are currently not assessed
- Examine female sharks during the pupping periods to determine the proportion of reproductive females. Efforts should be made to develop non-lethal methods of determining pregnancy status
- Expand or develop monitoring programs to collect appropriate length and age samples from the catches in the commercial sector by gear type, from catches in the recreational sector, and from catches taken in research surveys to provide reliable length and age compositions for stock assessment
- Continue investigations into stock structure of coastal sharks using genetic, conventional and electronic tags to determine appropriate management units
- Evaluate to what extent the different CPUE indices track population abundance (e.g., through power analysis)
- Explore modeling approaches that do not require an assumption that the population is at virgin level at some point in time.
- Increase funding to allow hiring of additional HMS stock assessment scientists. There are currently inadequate staff to conduct stock assessments on more than one or two stocks/species per year.

References

Andrews et al. 2011. Bomb radiocarbon and tag-recapture dating of sandbar shark (*Carcharhinus plumbeus*). Fisheries Bulletin. 109: 454-465.

Stock Assessment and Fishery Evaluation (SAFE) Report for Atlantic Highly Migratory Species. 2014. NOAA Fisheries, December 18, 2015.
< http://www.nmfs.noaa.gov/sfa/hms/hmsdocument_files/SAFEreports.htm>

APPENDIX 1. OVERVIEW OF COASTAL SHARK REGULATIONS

Coastal Sharks FMP Regulatory Requirements

1. Recreational seasonal closure (Section 4.2.1)
    a. Recreational anglers are prohibited from possessing silky, tiger, blacktip, spinner, bull, lemon, nurse, scalloped hammerhead, great hammerhead, and smooth hammerhead in the state waters of Virginia, Maryland, Delaware and New Jersey from May 15 through July 15—regardless of where the shark was caught.
    b. Recreational fishermen who catch any of these species in federal waters may not transport them through the state waters of VA, MD, DE, and NJ during the seasonal closure.
2. Recreationally permitted species (Section 4.2.2)
    a. Recreational anglers are allowed to possess aggregated large coastal sharks, hammerheads, tiger sharks, SCS, and pelagic sharks. Authorized shark species include: aggregated LCS (blacktip, bull, spinner, lemon, and nurse); hammerhead (great hammerhead, smooth hammerhead, scalloped hammerhead); tiger sharks; SCS (blacknose, finetooth, Atlantic sharpnose, and bonnethead sharks); and, pelagic sharks (blue, shortfin mako, common thresher, oceanic whitetip, and porbeagle). Sandbar sharks and silky sharks (and all prohibited species of sharks) are not authorized for harvest by recreational anglers.
3. Landings Requirements (Section 4.2.3)
    a. All sharks (with exception) caught by recreational fishermen must have heads, tails, and fins attached naturally to the carcass. Anglers may still gut and bleed the carcass by making an incision at the base of the caudal peduncle as long as the tail is not removed. Filleting sharks at sea is prohibited.
    b. All sharks (with exception) harvested by commercial fishermen within state boundaries must have the tails and fins attached naturally to the carcass through landing. Fins may be cut as long as they remain attached to the carcass (by natural means) with at least a small portion of uncut skin. Sharks may be eviscerated and have the heads removed. Sharks may not be filleted or cut into pieces at sea.
    c. Exception: Fishermen holding a valid state commercial permit may process smooth dogfish sharks at sea out to 50 miles from shore, as long as the total weight of smooth dogfish shark fins landed or found on board a vessel does not exceed 12 percent of the total weight of smooth dogfish shark carcasses landed or found on board.
4. Recreational Minimum Size Limits (Section 4.2.4)
    a. Sharks caught in the recreational fishery must have a fork length of at least 4.5 feet with the exception of Atlantic sharpnose, blacknose, finetooth, bonnethead

and smoothhound which have no minimum size. Hammerhead species must have a fork length of 6.5 feet.

5. Authorized Recreational Gear (Section 4.2.5)
    a. Recreational anglers may catch sharks only using a handline or rod & reel. Handlines are defined as a mainline to which no more than two gangions or hooks are attached. A handline must be retrieved by hand, not by mechanical means.
6. Possession limits in one twenty-four hour period (Section 4.2.7 and 4.3.6)
    a. Recreational and commercial possession limits as specified in Table 9.
    b. Smooth dogfish harvest is not limited in state waters and recreational shore-anglers may harvest an unlimited amount of smooth dogfish.
7. Commercial Seasonal Closure (Section 4.3.2)
    a. All commercial fishermen are prohibited from possessing silky, tiger, blacktip, spinner, bull, lemon, nurse, scalloped hammerhead, great hammerhead, and smooth hammerhead in the state waters of Virginia, Maryland, Delaware and New Jersey from May 15 through July 15. Fishermen who catch any of the above species in a legal manner in federal waters may transit through the state waters listed above is allowed if all gear is stowed.
8. Quota Specification (Section 4.3.4)
    a. When NOAA Fisheries closes the fishery for any species, the commercial landing, harvest, and possession of that species will be prohibited in state waters until NOAA Fisheries reopens the fishery.
9. Permit requirements (Section 4.3.8)
    a. State: Commercial shark fishermen must hold a state commercial license or permit in order to commercially catch and sell sharks in state waters.
    b. Federal: A federal Commercial Shark Dealer Permit is required to buy and sell any shark caught in state waters.
    c. Display and research permit is required to be exempt from seasonal closure, quota, possession limit, size limit, gear restrictions, and prohibited species restrictions. States are required to include annual information for all sharks taken for display throughout the life of the shark.
10. Authorized commercial gear (Section 4.3.8.3)
    a. Commercial fishermen can only use one of the following gear types (and are prohibited from using any gear type not listed below) to catch sharks in state waters.
        i. **Rod & reel**

ii. **Handlines.** Handlines are defined as a mainline to which no more than two gangions or hooks are attached. A handline is retrieved by hand, not by mechanical means, and must be attached to, or in contact with, a vessel.
iii. **Small Mesh Gillnets.** Defined as having a stretch mesh size smaller than 5 inches.
iv. **Large Mesh Gillnets.** Defined as having a stretch mesh size equal to or greater than 5 inches.
v. **Trawl nets.**
vi. **Shortlines.** Shortlines are defined as fishing lines containing 50 or fewer hooks and measuring less than 500 yards in length. A maximum of 2 shortlines are allowed per vessel.
vii. **Pounds nets/fish traps.**
viii. **Weirs.**

11. Bycatch Reduction Measures (Section 4.3.10)
    a. Any vessel using a shortline must use corrodible circle hooks. All shortline vessels must practice the protocols and possess the recently updated federally required release equipment for pelagic and bottom longlines for the safe handling, release, and disentanglement of sea turtles and other non-target species; all captains and vessel owners must be certified in using handling and release equipment.
12. Smooth Dogfish
    a. Each state must identify their percentage of the overall quota (Addendum II, 3.1)
    b. Smooth dogfish must make up at least 25%, by weight, of total catch on board at time of landing. Trips that do not meet the 25% catch composition requirement can land smooth dogfish, but fins must remain naturally attached to the carcass. (Addendum IV, 3.0; modifies Addendum II Section 3.5)

Table 10. Possession/retention limits for shark species in state waters

Recreational	*Shore-angler*	1 shark (of any species except prohibited) per person per day; plus one Atlantic sharpnose, bonnethead and smoothhound
	Vessel-fishing	1 shark (of any species except prohibited) per vessel per trip; plus one Atlantic sharpnose, bonnethead and smoothhound per person, per vessel
Commercial	*Directed permit*	Variable possession limit for aggregated large coastal sharks and hammerhead shark management groups, the Commission will follow NMFS for in-season changes to the possession limit. The possession limit range is 0-55, the default is 45 sharks per trip. No limit for SCS or pelagic sharks.
	Incidental permit	3 aggregated LCS per vessel per trip, 16 pelagic or SCS (combined) per vessel per trip