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

Table of Contents

SEDAR

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SECTION I: Introduction

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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;

[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.	<u>Quota from 2008-2012</u>: 87.9 mt dw <u>Quota from 2013-Aug. 17, 2015</u>: 116.6 mt dw <u>Quota as of Aug. 18, 2015</u> – 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		

<u>Definitions of Acronyms in Table 1</u>: 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: 1^{st} set ≤ 150 hooks; soak time no more than 2 hours; 2^{nd} set ≤ 300 hooks; no soak time limit	Set limit: two non-concurrent longline sets per trip: 1^{st} set ≤ 150 hooks; soak time no more than 2 hours; 2^{nd} set ≤ 300 hooks; no soak time limit	Set limit: two non-concurrent longline sets per trip: 1^{st} set ≤ 150 hooks; soak time no more than 2 hours; 2^{nd} set ≤ 300 hooks; no soak time limit	Set limit: two non-concurrent longline sets per trip: 1^{st} set ≤ 150 hooks; soak time no more than 2 hours; 2^{nd} 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: 1^{st} set ≤ 75 hooks; soak time no more than 2 hours; 2^{nd} set ≤ 150 hooks; no soak time limit Hook restriction: ≤ 250 hooks on board *Amendment 2*				
					Set limit: two non-concurrent longline sets per trip: 1^{st} set ≤ 150 hooks; soak time no more than 2 hours; 2^{nd} 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		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

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
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	
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
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
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
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
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	
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
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
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	
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	
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
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	

State	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Alabama	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	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	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	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	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	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	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	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 through 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/trip.
Maine	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 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 permit	no new shark regulations	Great hammerhead, smooth	no new shark regulations	no new shark regulations
Maryland	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	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	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 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	no new shark regulations	no new shark regulations
New Jersey	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	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.

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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

SEDAR 54 EXECUTIVE SUMMARY

The sandbar shark is a common, inshore and offshore, large coastal species that occurs in warm temperate and tropical waters mostly on the continental and insular shelves. In the western North Atlantic, it ranges from southern New England to the Caribbean and Gulf of Mexico to southern Brazil. Genetic data indicate no significant differentiation between the Gulf of Mexico and western North Atlantic Ocean (thus gene flow likely occurs between the two areas) and tag-recapture data showed a high frequency of movements between basins. Maximum age for the combined Atlantic Ocean and Gulf of Mexico stock was increased to 31 years (compared to 27 years in the previous, 2011 (SEDAR 21), assessment and 40 years in the 2006 assessment). The maturity ogive and maternal fecundity at length relationship were updated based on new information for the assumed Atlantic Ocean and Gulf of Mexico stock. Based on this new life history information, natural mortality estimates were also updated using several life history invariant methods. Historical catches have been re-estimated, and in general show the same trend and magnitude as the previous assessment (SEDAR 21).

The assessment framework used was Stock Synthesis 3 which was a departure from the previous assessment modeling approach, which used a state space age structured production model (SEDAR 21 conducted in 2011). Stock synthesis is an integrated modeling framework, which means that data from multiple sources (catch, CPUE series, length compositions), as well as parameter estimates for life history components are combined into an overall model which is then optimized via maximum likelihood estimation. Stock synthesis was chosen based on recommendations from the SEDAR 21 CIE Review that noted the next stock assessment should consider modeling frameworks that:

- Can estimate the fishery and survey selectivities within the assessment model
- Can accommodate the development of a two sex model for more direct estimation of the spawning stock
- Can fit 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.

•Do not require an assumption that the population is at virgin levels at some point in time.

By using Stock Synthesis these suggestions were incorporated into the modeling framework. The base case model configuration assumed virgin conditions in 1960 (as in SEDAR 21), with low exploitation (and overall catch) until the early 1980s, followed by a period of high catches that peaked in 1989 and declined steadily until the mid-2000s. Federal management controls were put in place in 1993 and since 2008, when the sandbar research fishery began, the average catch has been approximately 5% of the maximum historic catch. Overall catch was partitioned in the model into four catch series: two commercial longline series (GOM and Atlantic), a combined recreational and Mexican fishery, and bycatch in the menhaden fishery. Catches in weight for the entire period (1960-2015) were approximately equal between the F1 (GOM commercial) and F3 (Recreational and Mexican), at 38.2 and 37.5% respectively. The remaining catch was predominantly from F2 (Atlantic commercial) constituting 24%, while F4 (menhaden bycatch) accounted for only 0.3% of the total catch. The catches from F3 accounted for the bulk of the catch from the late 1970s to the beginning of the commercial fishery in the late 1980s, after which time the catch was approximately equal between F1, F2 and F3, until the year 2000, when the percent contribution of the recreational fisheries catch dropped in comparison to the commercial fisheries. The percent contribution of the catch from the commercial fisheries remained high until 2008 when management actions were put in place. Since that time the F3 fishery has represented the majority of the catch. The model uses this historical reconstructed catch series and updated catch series, updated biological parameters, and CPUE indices, the earliest of which started in 1975. Estimated model parameters were virgin recruitment (R0), recruitment deviations, selectivity coefficients associated with the fisheries and CPUE series, and fleet-specific catchability. A total of eleven indices of relative abundance, all standardized through Generalized Linear Modeling techniques, were recommended for use by the Panel; three indices were fishery dependent. Length-specific selectivity was estimated internally to the model. A total of twelve selectivity curves (3 for the fisheries + 9 for the CPUE series) were estimated. An asymptotic (flat-topped) selectivity was assigned to the menhaden fishery and the other selectivity curves were a combination of double normal (dome-shaped) and cubic splines, assigned to the indices and catch series.

The assessment approach proceeded by completing first a replication analysis, which used the same data and parameterization of biology and life history as the previous assessment (2011, SEDAR 21), but with Stock Synthesis as opposed to the state space age structured production model. A continuity analysis followed the replication analysis, introducing the new catches and new estimates of biology and life history in a stepwise manner.

In addition to computing asymptotic standard errors for estimated parameters, uncertainty was evaluated via an age structured production model (via a replication analysis) to look for systematic bias in key model output quantities over time, likelihood profiling to examine the information content in the data components and where these data are in conflict, and retrospective analysis which sequentially removed 1 to 5 years of data to evaluate the robustness of the results to the recent data. Uncertainty in the parameter estimates was also evaluated through the use of Markov Chain Monte Carlo (MCMC) analysis which allows for the computation of probabilities of derived parameters such as the stock being overfished and overfishing occurring.

Uncertainty in data inputs and model configuration was further examined through sensitivity scenarios, the majority of which also represented alternative plausible “states of nature” to the base case, a subset of which were further used in stock projections. Based upon recommendations from the assessment panel, sensitivity runs included using a grouping of indices that were identified as having the same trend (identified via hierarchal cluster analysis and expert opinion, named POS_1) and a grouping of CPUE indices that were not included in the group with the same trend (named NEG). Similar to the previous assessment the base case model included all of the indices, this grouping was called “Base”. Further sensitivity runs considered lower and higher level of stock productivity, as recommended by the SEDAR 21 CIE reviewers, based on higher and lower levels of natural mortality, gestation period and fecundity. The POS_1 CPUE groupings include the CPUEs from the observer program that is associated with the commercial fisheries as well as the Virginia longline survey, and the NMFS northeast and southeast bottom longline surveys, which have wide geographical coverage. The NEG CPUE grouping includes the Large Pelagic Survey, the northeast and southeast Coastspan surveys, the Pelagic Longline Observer Program index, the South Carolina Red Drum index, and the SEAMAP longline southeast survey. The base case grouping used all of the aforementioned CPUE series with the distributions shown in Figure EX 1.

The model fit a central tendency through most of the indices and fit some, or at least portions, fairly well while others were hard to fit given large interannual fluctuations in most cases. In general, the first part of the fits showed a slightly decreasing tendency to the CPUE series that contained data from 1975 – 1988, after which the fits to the CPUE trend were fairly flat until 2000, followed by decreasing and flat fits until 2008. The model was unable to capture the increases in some of the CPUE series that occurred after 2008. Consequently, predicted abundance and spawning stock fecundity (SSF; defined as numbers *proportion mature * fecundity in numbers) showed slight depletion from 1960 to the beginning of the fishery F3, and later F1 and F2 in 1981, followed by a decreasing trend to about 2005, and a progressive increase in the last decade, which corresponds to decreased effort and catches in all the fisheries and some of the indices of relative abundance showing increasing tendencies in those years. Due to the scale of the fishery and the fact that it is estimated to have caught predominantly age 0 and age 1 fish, the F3 recreational and Mexican fishery is estimated to contribute to the majority of the fishing and exceeded the estimated F_{MSY} of 0.07 in the base case run several years from 1981 to 2004, and again in 2007. The contribution of F4, the menhaden bycatch, was trivial. The remaining fleets' contribution to total F was significant, with F1 exceeding F_{MSY} in 1988-1995, and again in the years 2001, 2002, 2003, 2006. Combined fishing mortality from the two commercial fleets has been less than 0.01 since 2008.

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” and “not experiencing 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 EX 2). 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. 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 entire exploited biomass. There is no CPUE trend available for fishery F3, the recreational and Mexican fisheries; the catches from this fishery have 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 EX 1). This result was robust to the MCMC analysis, with a 97% probability of the stock being in the yellow quadrant (i.e. overfished and overfishing was not occurring) of the Kobe plot (Table EX 2). The results from the MCMC analysis based on the other CPUE groupings estimated the stock was either overfished and overfishing was occurring (NEG CPUE runs) or that the stock was neither overfished nor experiencing overfishing (POS_1 CPUE group). The uncertainty (based on the MCMC analysis) associated with the 2015 stock status is smallest for the NEG CPUE grouping followed by the BASE case and the POS_1 with respect to SSF_{2015}/SSF_{MSY}. The range of uncertainty was reversed for the F_{2015}/F_{MSY} reference point with the NEG CPUE grouping having the greatest uncertainty, followed by the BASE case and POS_1 CPUE grouping s (Figure EX 3). 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 F_{2015}/F_{MSY} at mostly low levels (<0.6). In contrast, the MCMC analysis based on the 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 EX 3).

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 (in whole weight) were used to provide an approach for evaluating total allowable catch (TAC) to account for uncertainty within 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. 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 (Figures Ex 4 & 5 show results from the Base case for the 50% and 70% probabilities). 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 / SSF_{MSY} = 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 30^{th} quantile would be approximately 1 (i.e 70% of the runs >1). MCMC analysis indicates that the shape of the distribution for SSF_{2015} /SSF_{MSY} is not symmetric. Because this 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 from the Hessian. These results are useful because they help to characterize uncertainty in the assessment.

Table EX 1. Reference points for base case model configuration and for alternative state of nature scenarios evaluated for CPUE and productivity as defined in the main report. 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	BASE	**BASE**	BASE	POS_1	POS_1	POS_1	NEG	NEG	NEG
Productivity	Low	**Medium**	High	Low	Medium	High	Low	Medium	High
C2015_msy	0.45	**0.47**	0.52	0.29	0.30	0.33	0.53	0.55	0.60
Y_MSY	437	**417**	380	668	648	588	373	356	327
B_zero	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_zero	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	**0.60**	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/Fmsy	0.71	**0.75**	0.85	0.24	0.24	0.27	1.92	2.00	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
TotalBiomass_2015	28,261	**29,665**	32,698	84,853	91,593	102,886	10,497	11,181	13,693

Table EX 2. 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, 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%**

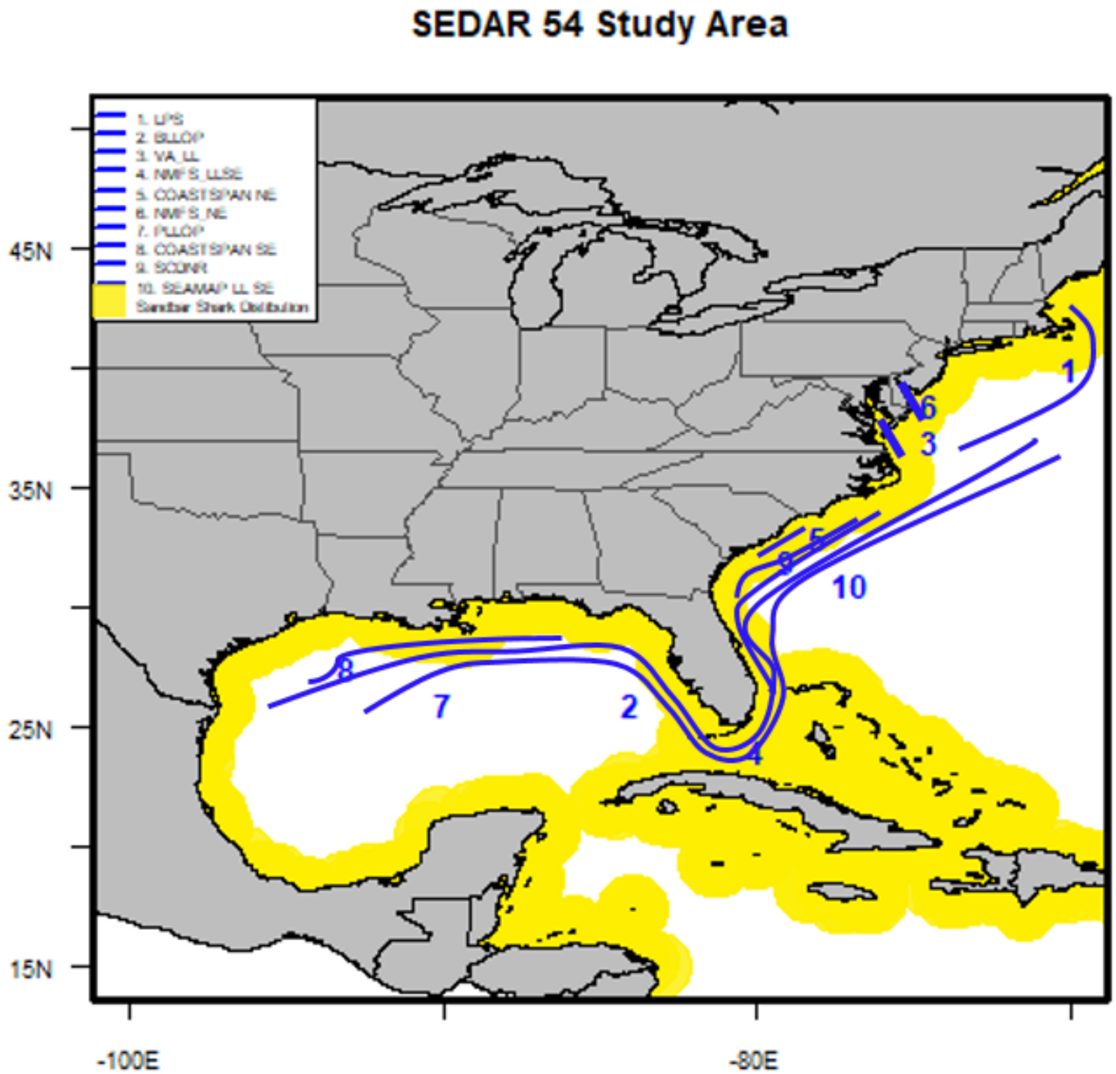

Figure EX 1 Spatial extent of the CPUE data used in the base case model configuration in this assessment (SEDAR 54). The blue lines represent individual CPUE series and the yellow area indicates the distribution of the sandbar shark in the western North Atlantic and Gulf of Mexico.

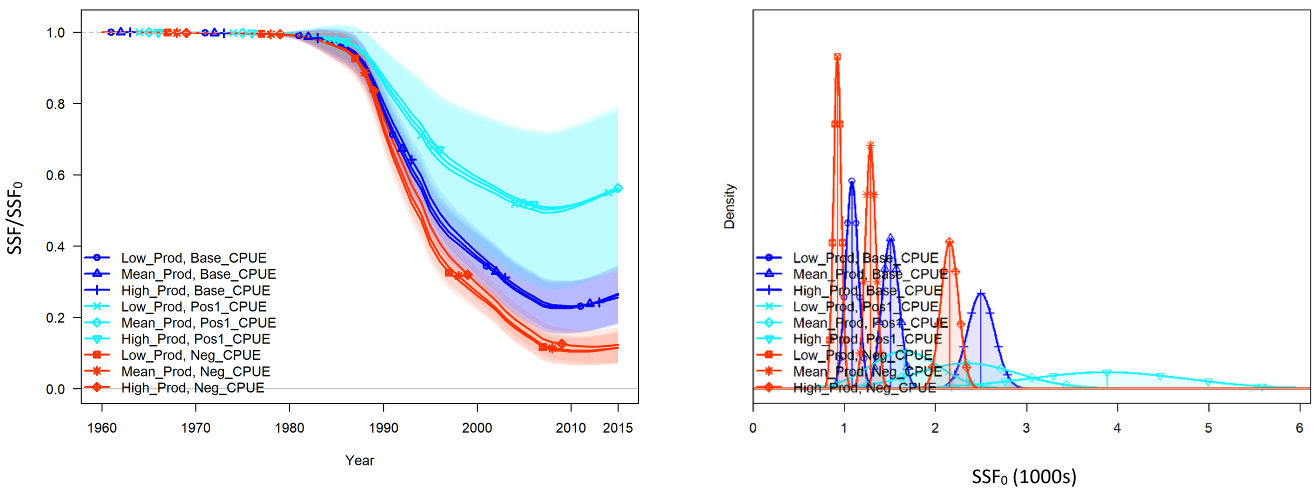

Figure EX 2. Estimated spawning output depletion (SFF/SSF$_0$, left panel) by year and asymptotic uncertainty (bell shaped curves) of estimated virgin spawning output (SSF$_0$, right panel) obtained for each of the nine alternative state of nature scenarios evaluated for CPUE and productivity as defined in the main text. The base case is shown in dark blue with a triangle and denoted “Mean_Prod, BASE_CPUE”.

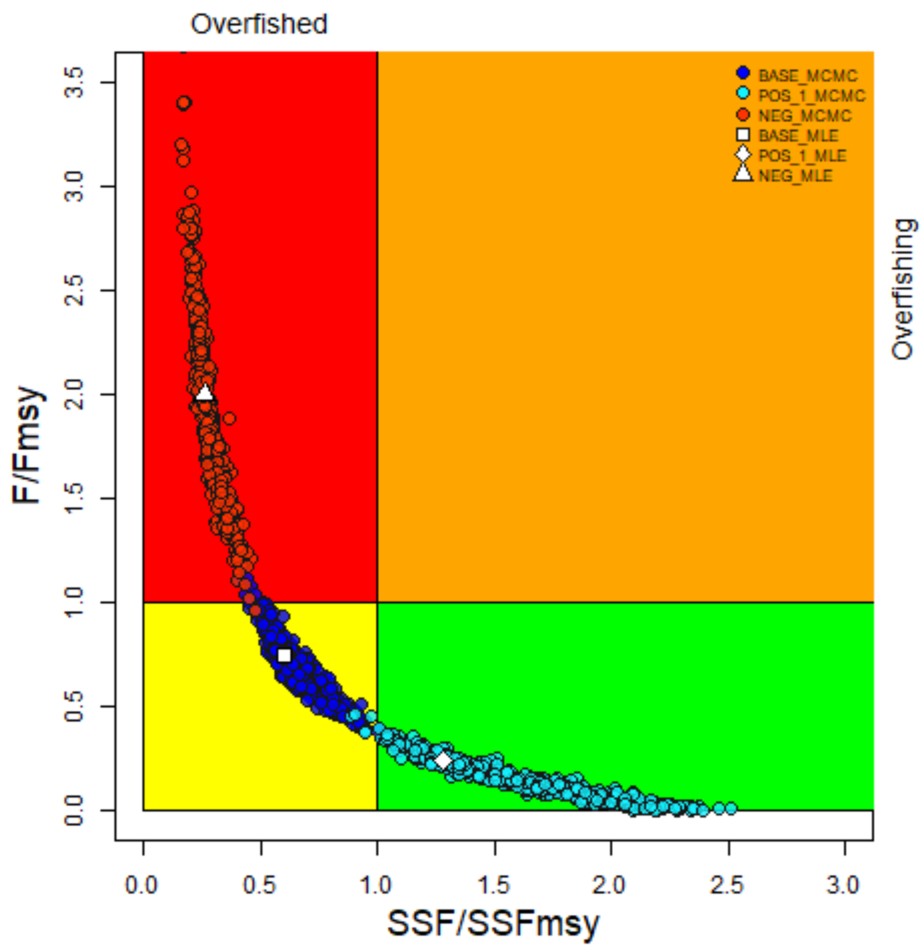

Figure EX 3 Estimated stock status based on MCMC analysis for the base case model configuration (Base, dark blue circles) and for two alternative state of nature scenarios evaluated for CPUE (POS_1, NEG) with the base case productivity. The white square, triangle, and diamond are the MLE estimates.

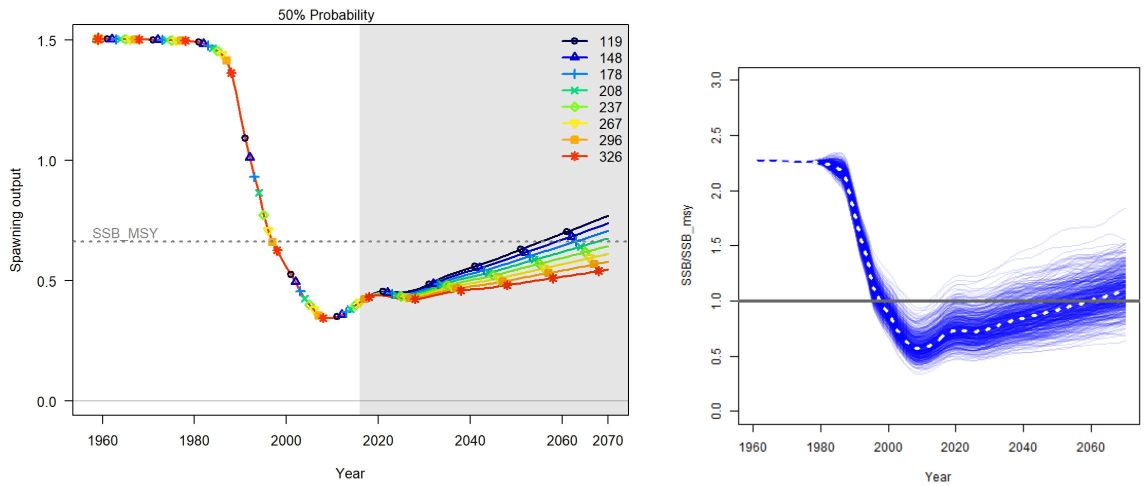

Figure EX4. For the base case, projections were implemented with constant TAC allowing rebuilding of stock by 2070 with 50% and 70% probability (TOR 4A). Base case projections of spawning output (SSF in millions, left panel) under different levels of constant TAC (mt whole weight) indicate that a constant 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.

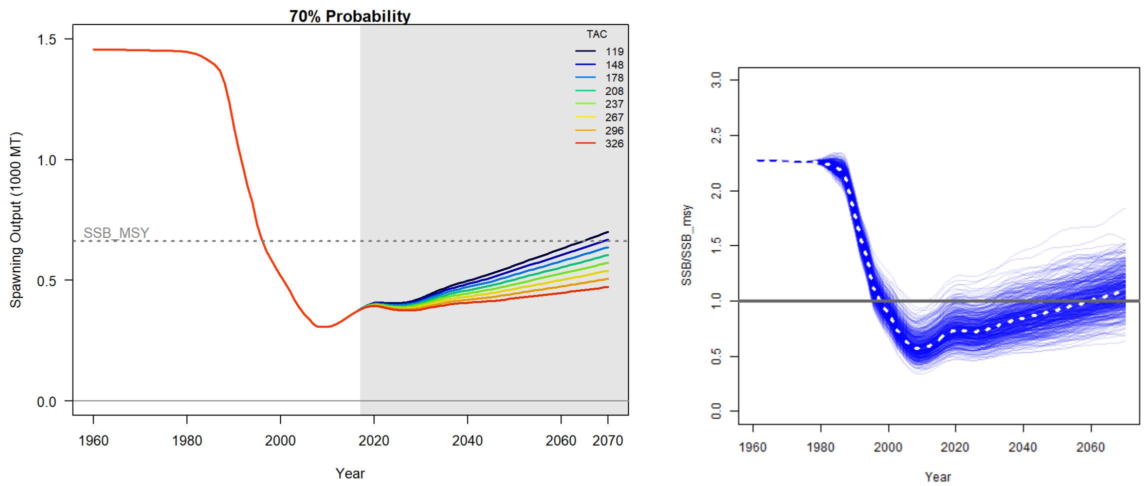

Figure EX 5. Base case projections of spawning output (SSF in millions, left panel) under different levels of constant TAC (mt whole weight) indicate that a constant TAC of 148 mt would allow stock rebuilding by 2070 with a 70% probability. For comparison, the base case MCMC projections at a constant 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 50th quantile of the runs.

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) ($Year_{rebuild}$)

- 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 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.
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John Carlson...NMFS Panama City
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Dean Grubbs ....FSU
Dewey Heilright...Industry Rep
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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

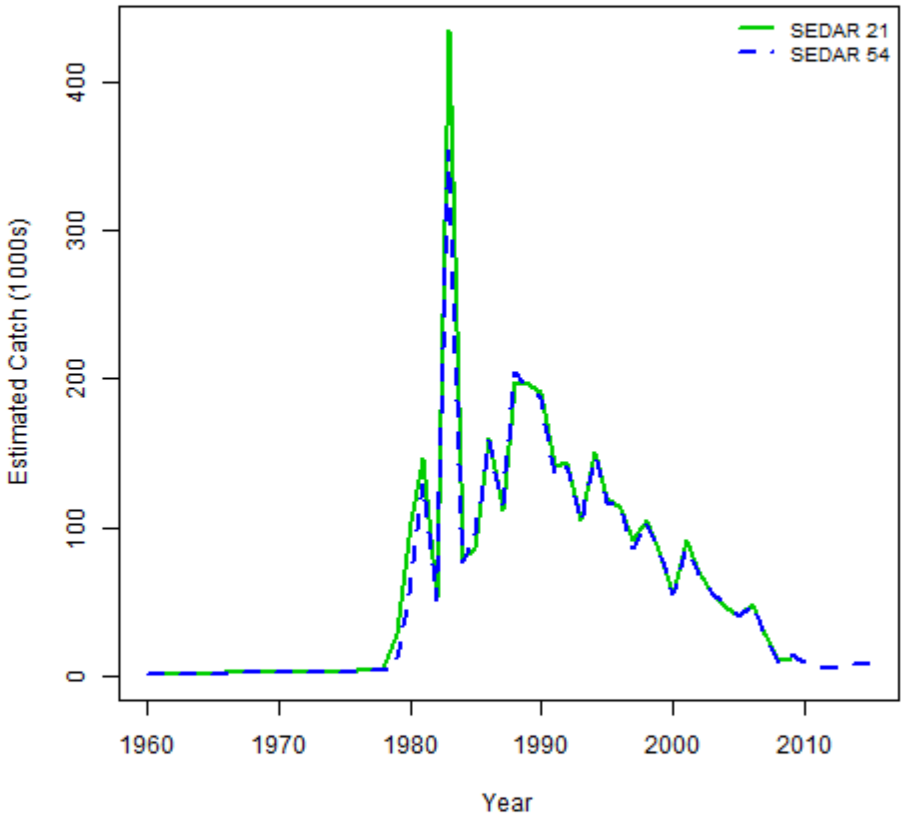

Figure 2.1 Catches of sandbar sharks (numbers) used in the SEDAR 21 (green line) and SEDAR 54 (blue line) assessments.

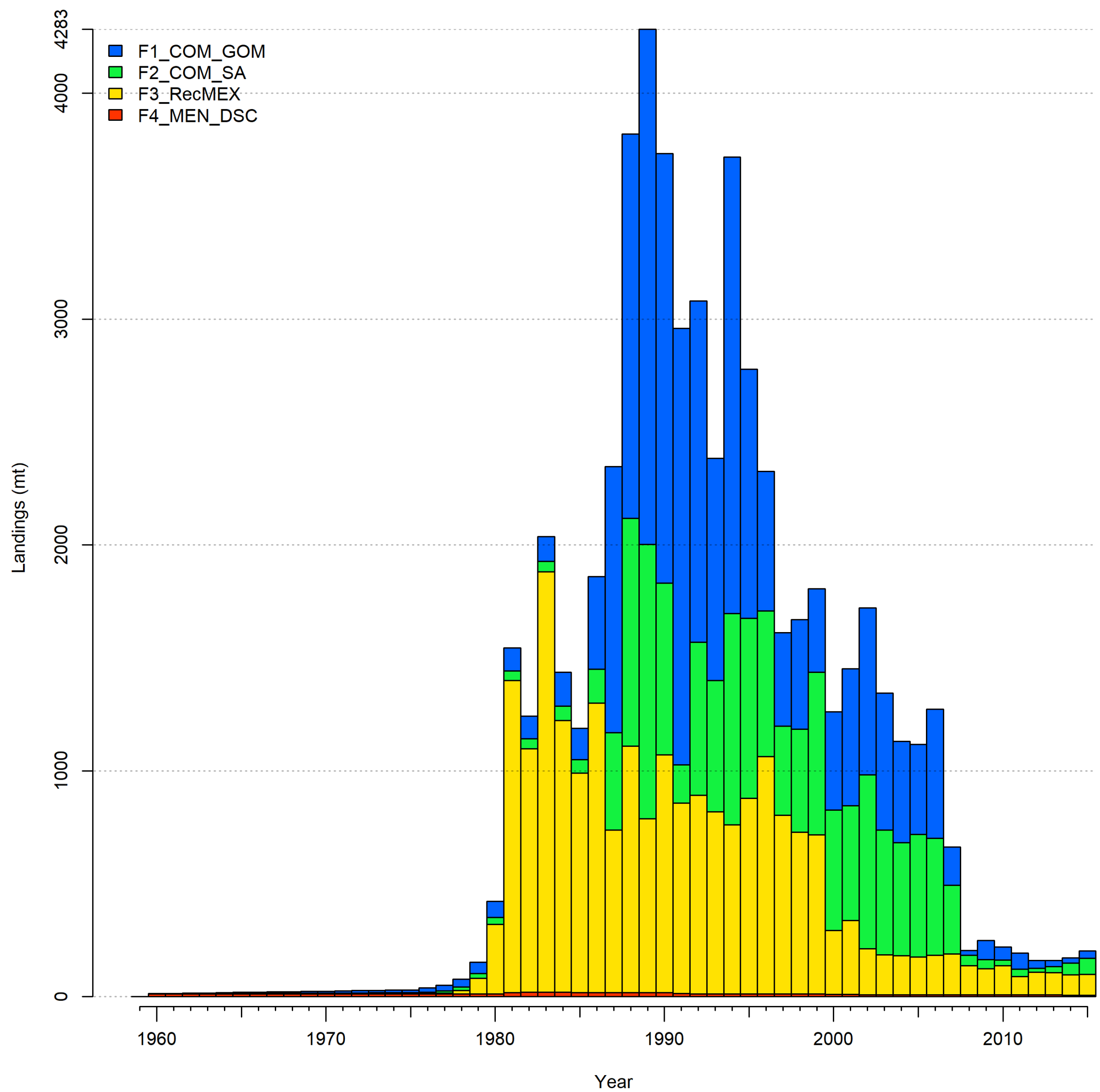

Figure 2.2. Catch of sandbar shark by fleet in metric tons (mt) used in the SEDAR 54 analysis.

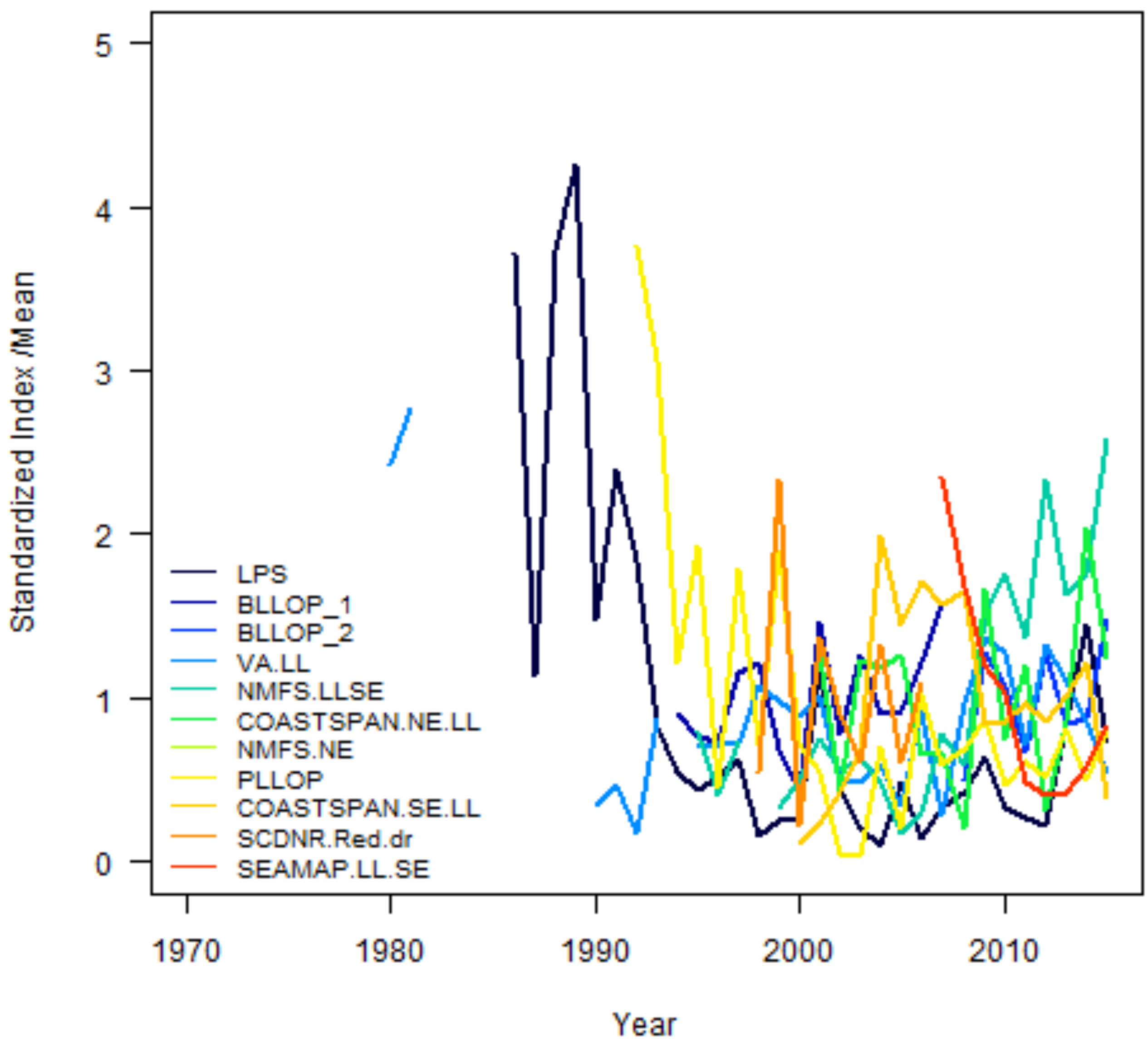

Figure 2.3 Indices of relative abundance used for the SEDAR 54 assessment.

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 50th 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 ($\mu 1$; 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.

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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.

Age	Proportion mature female	Natural Mortality 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	BASE	**BASE**	BASE	POS_1	POS_1	POS_1	NEG	NEG	NEG
Productivity	Low	**Medium**	High	Low	Medium	High	Low	Medium	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

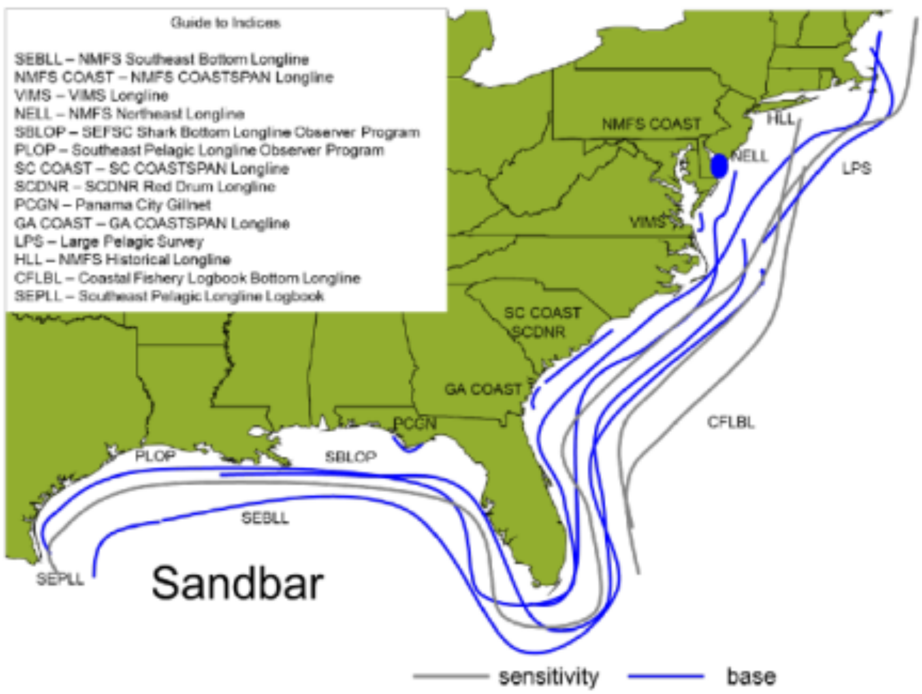


Figure 3.1.1. Approximate linear coverage of specific abundance indices for sandbar sharks *(Carcharhinus plumbeus*) along the coast of the Gulf of Mexico and Atlantic Ocean. Blue lines indicate the indices of abundance used in the SEDAR 21 base case assessment, as well as in the SEDAR 54 replication analysis. Grey lines indicate indices of abundance used in the SEDAR 21 sensitivity analysis.

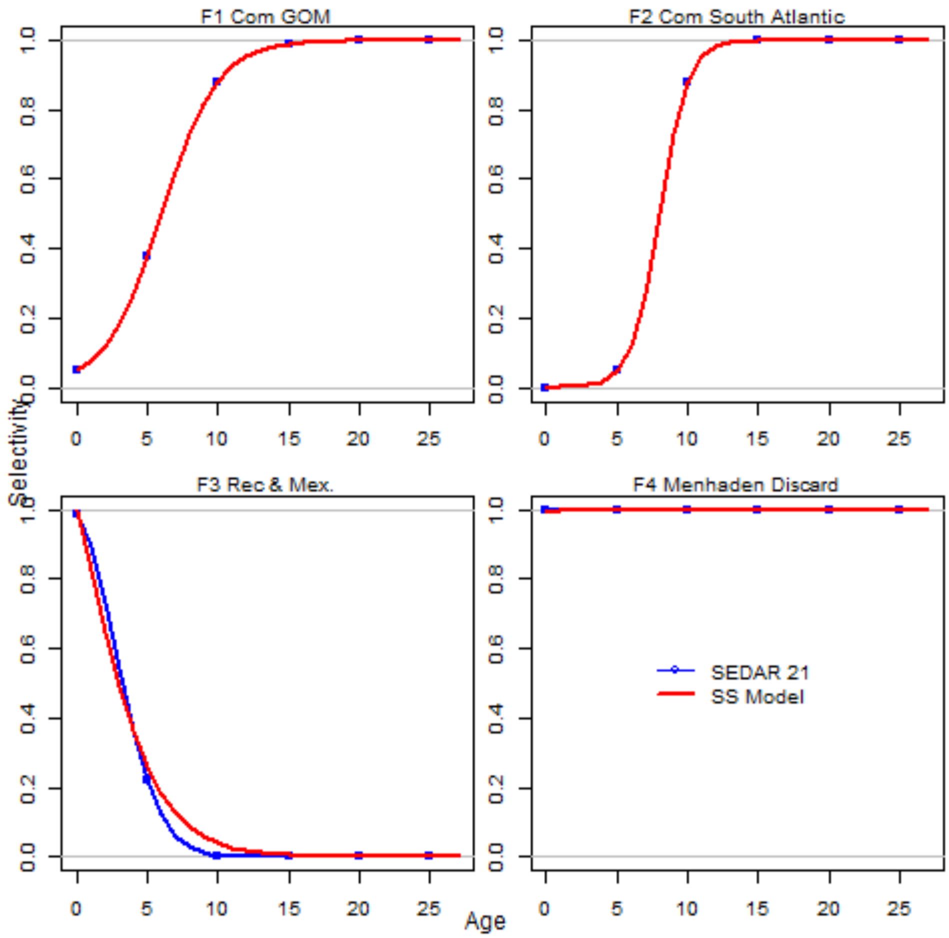


Figure 3.1.2. Selectivity of the catches showing the selectivity forms from SEDAR 21 (blue lines) and the forms used in the SEDAR 54 replication analysis (red lines).

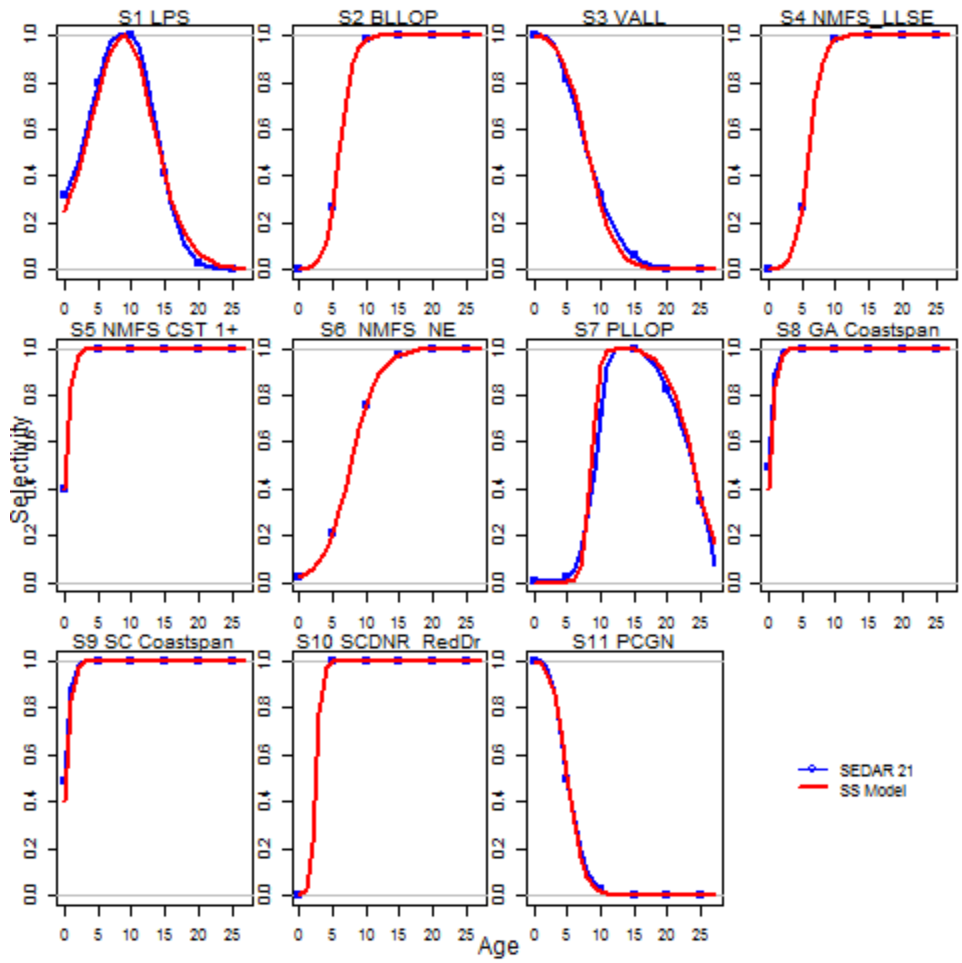


Figure 3.1.3. Selectivity of the indices of abundance showing the SEDAR 21 selectivity forms (blue lines) and the forms used in the SEDAR 54 replication analysis(red lines).

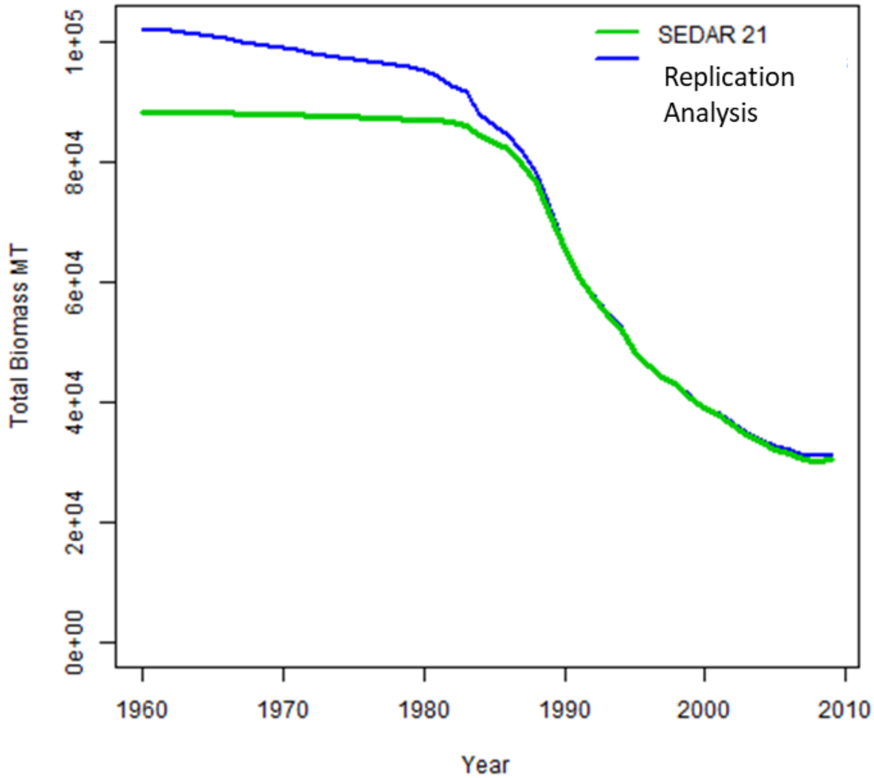


Figure 3.1.4. Comparison of biomass trends from the SEDAR 21 analysis and the SEDAR 54 replication analysis.

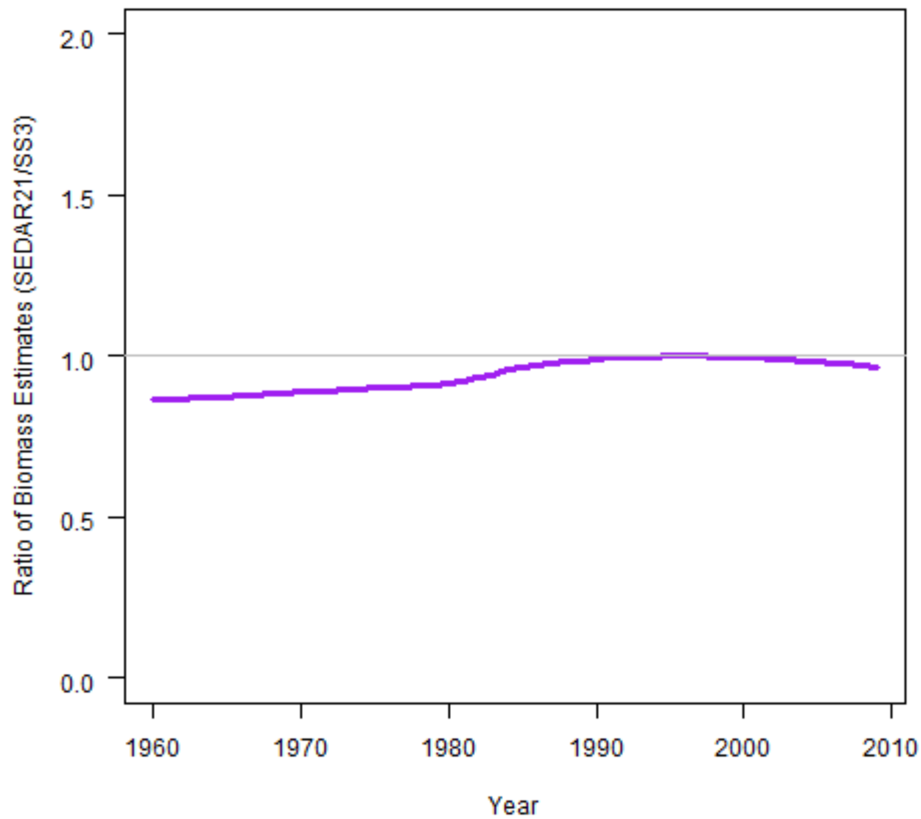


Figure 3.1.5. Ratio of total biomass estimates (SEDAR 21/ SEDAR 54 replication analysis) over the model time frame, the equivalence line is shown in grey.

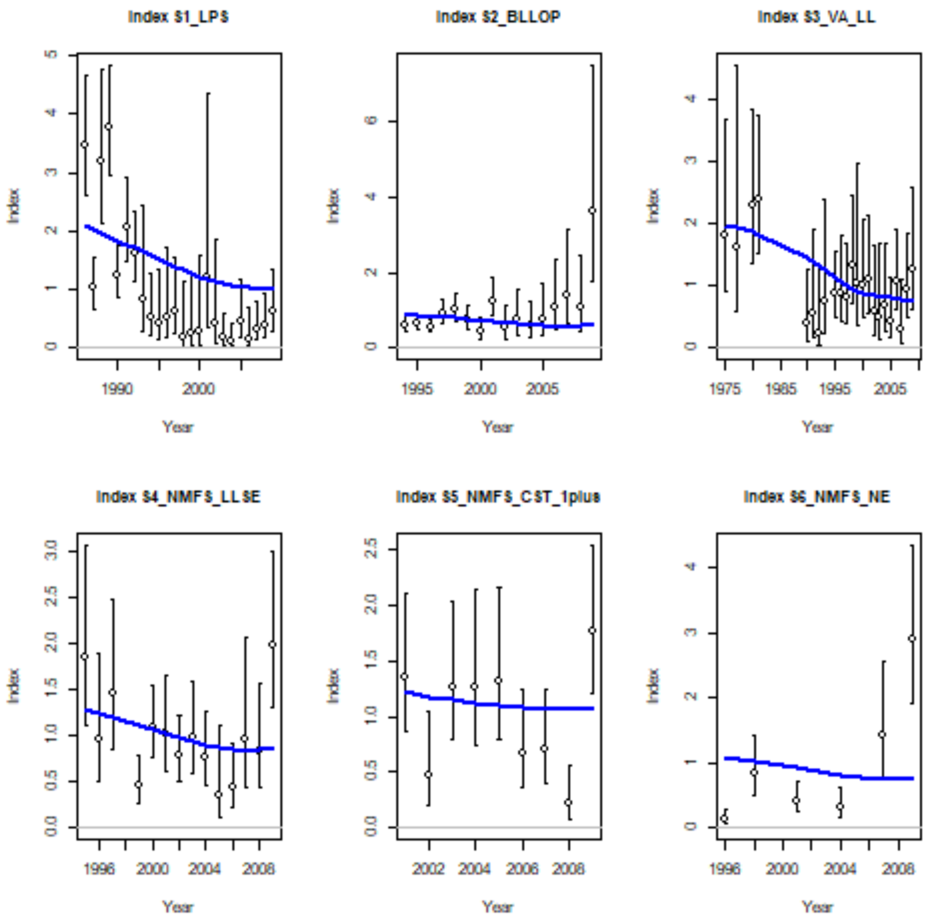


Figure 3.1.6. Model fits (blue line) to the CPUE series from the replication analysis (black circles are observed data) with associated CVs (black vertical lines). Fits for indices S1-S6 are shown.

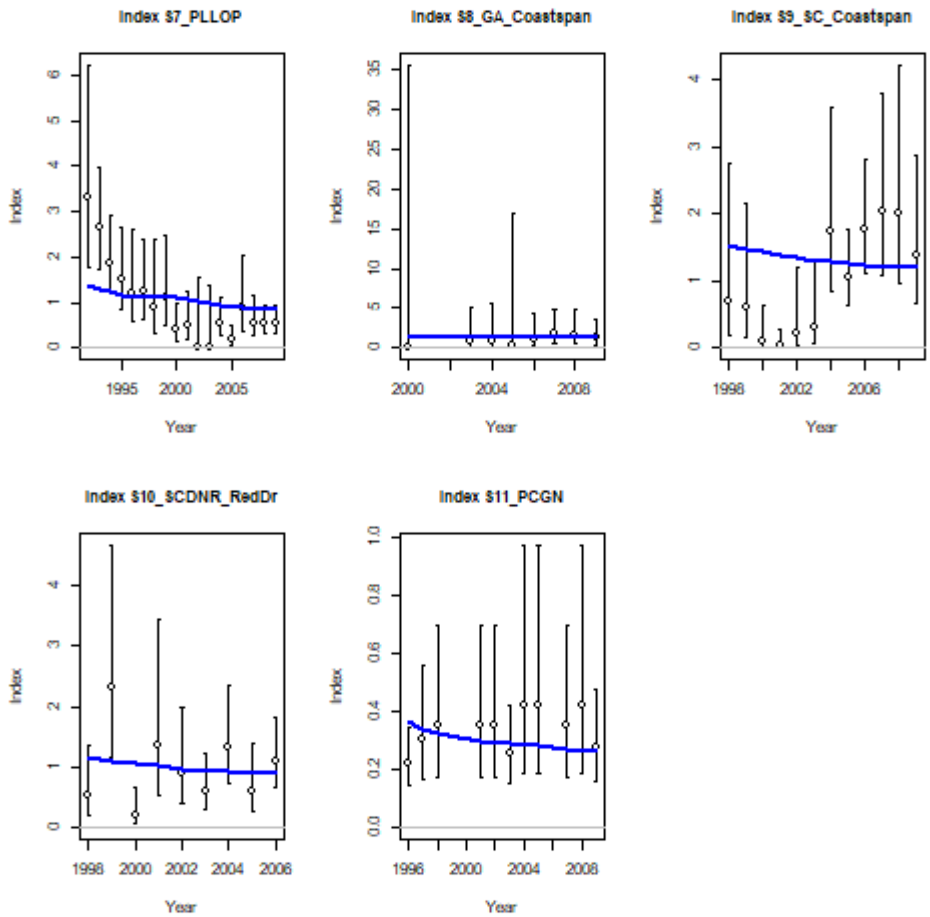


Figure 3.1.7 Model fits (blue line) to the CPUE series from the replication analysis (black circles are observed data) with associated CVs (black vertical lines). Fits for indices S7-S11 are shown.

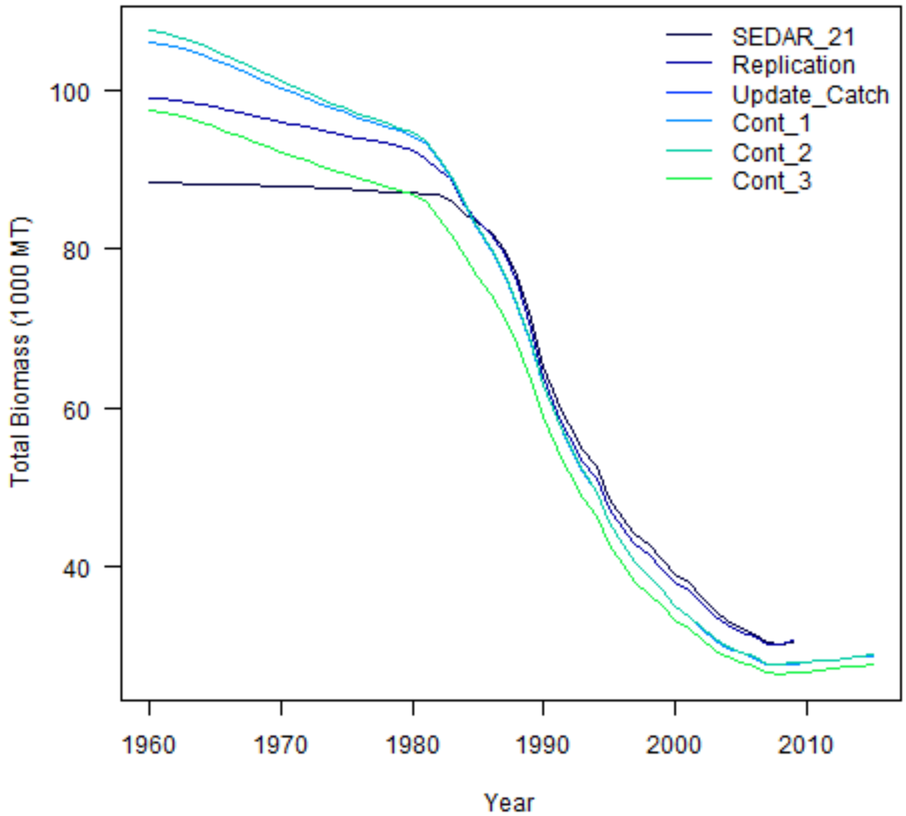


Figure 3.1.8 Estimated total biomass from the SEDAR 21 report, the replication analysis and the four continuity runs (Update_catch, Cont_1, Cont_2, and Cont_3) for the SEDAR 54 assessment. Note that continuity run #1 (Cont_1) overlays the Update_Catch run.

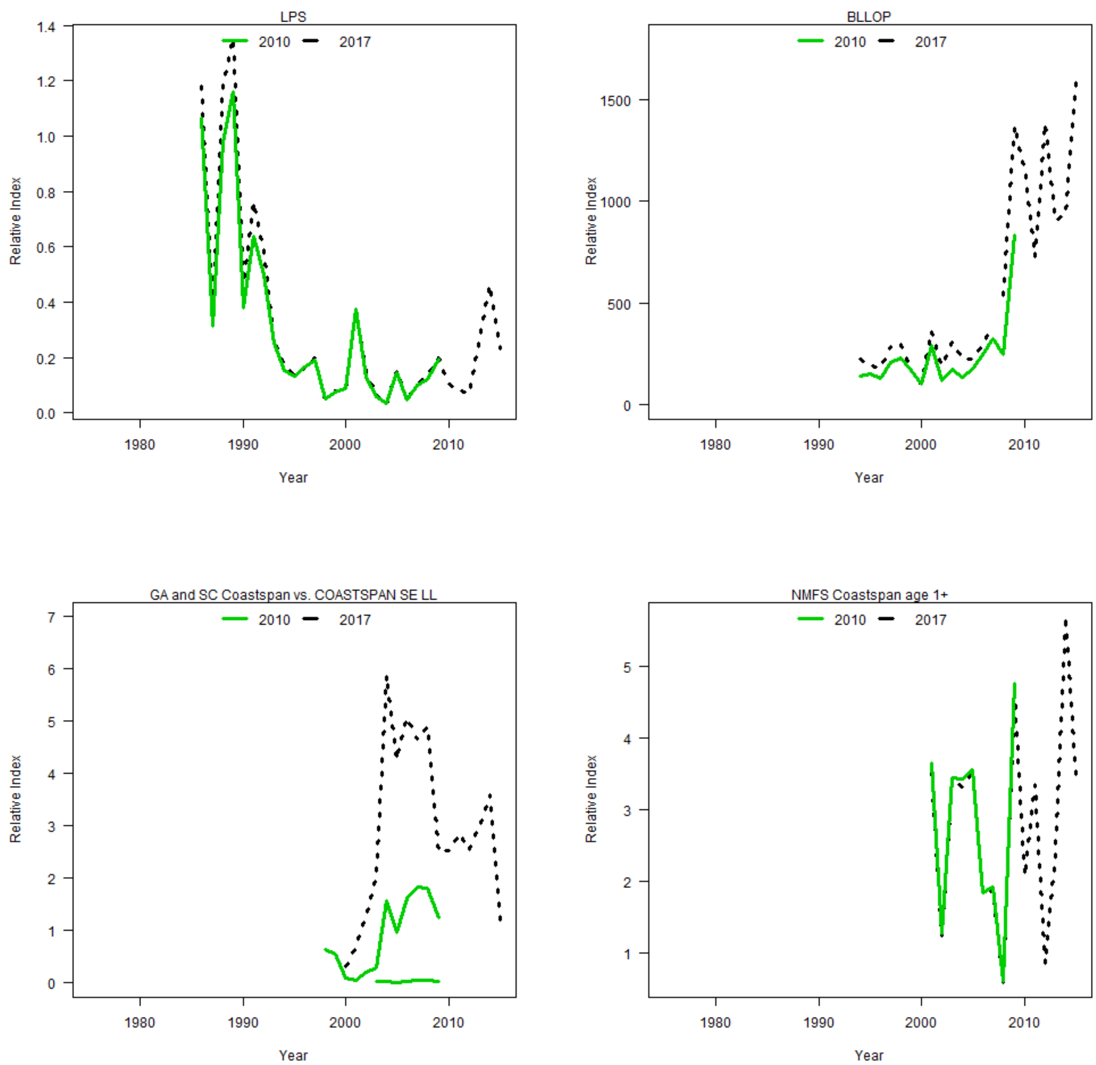


Figure 3.1.9 Comparison of CPUE series used in the SEDAR 21 and the series used in SEDAR 54 assessment; the black dotted line indicates the updated CPUE series used in SEDAR 54 for the base case. The top left panel is S1 LPS, the top right is the S2 and S3 BLLOP series, the bottom left is S9 Coastspan 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.

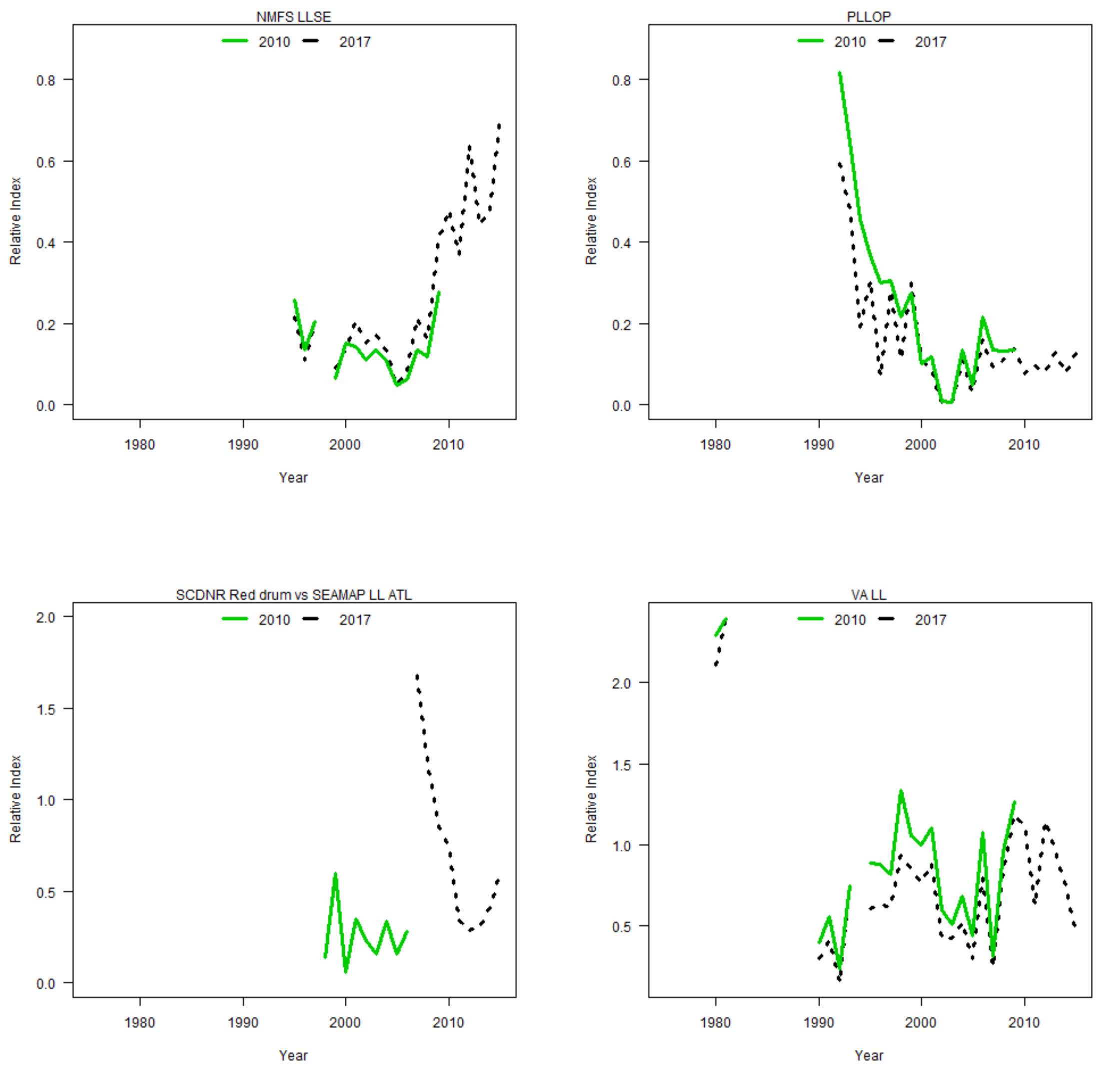


Figure 3.1.10. Comparison of CPUE series used in the SEDAR 21 and the series used in SEDAR 54 assessment; the black dotted line indicates the updated CPUE series used in SEDAR 54 for the base case. The top left panel is S5 NMFS LLSE, the top right is S8 PLLOP, the bottom left is S10 SCDNR Red drum (note 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.

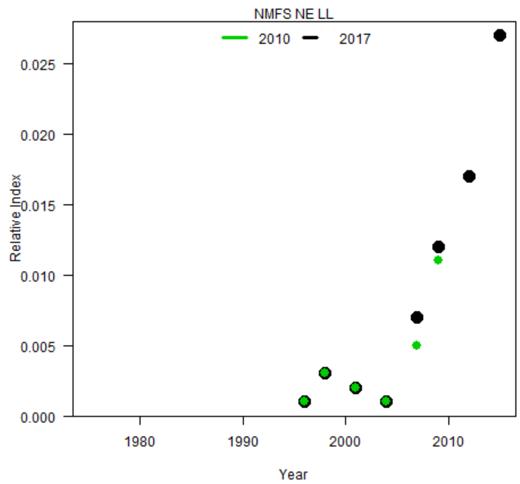


Figure 3.1.11 Comparison of CPUE series used in the SEDAR 21 and the series used in SEDAR 54 assessment; the black dotted line indicates the updated CPUE series used in SEDAR 54 for the base case. This figure shows S7 NMFS NE LL.

6.2 FIGURES FROM SECTION 3.2 BASE CASE

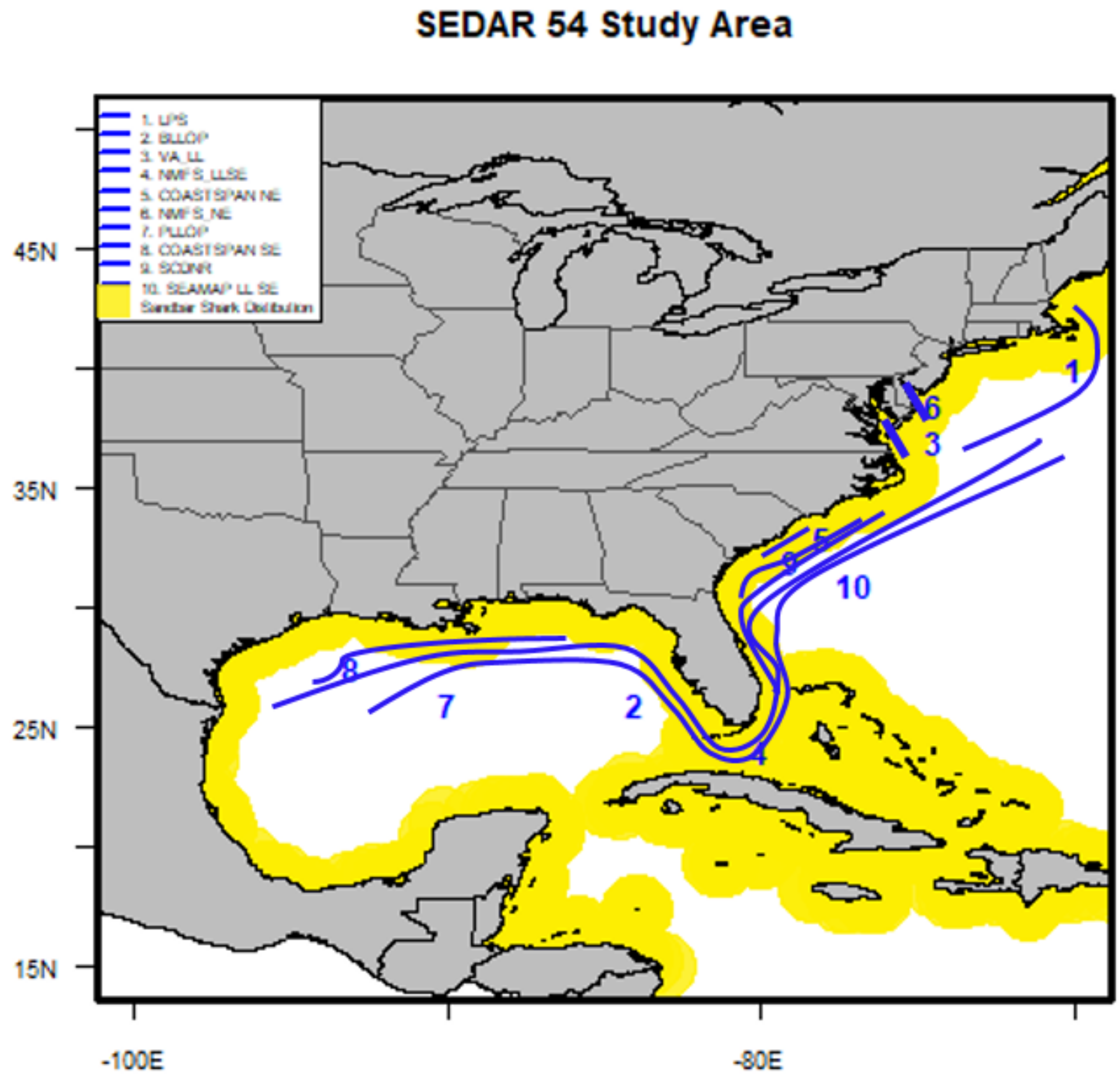


Figure 3.2.1 Spatial extent of the CPUE data used in the base case model configuration in this assessment (SEDAR 54). The blue lines represent individual CPUE series and the yellow area indicates the distribution of the sandbar shark in the western North Atlantic and Gulf of Mexico.

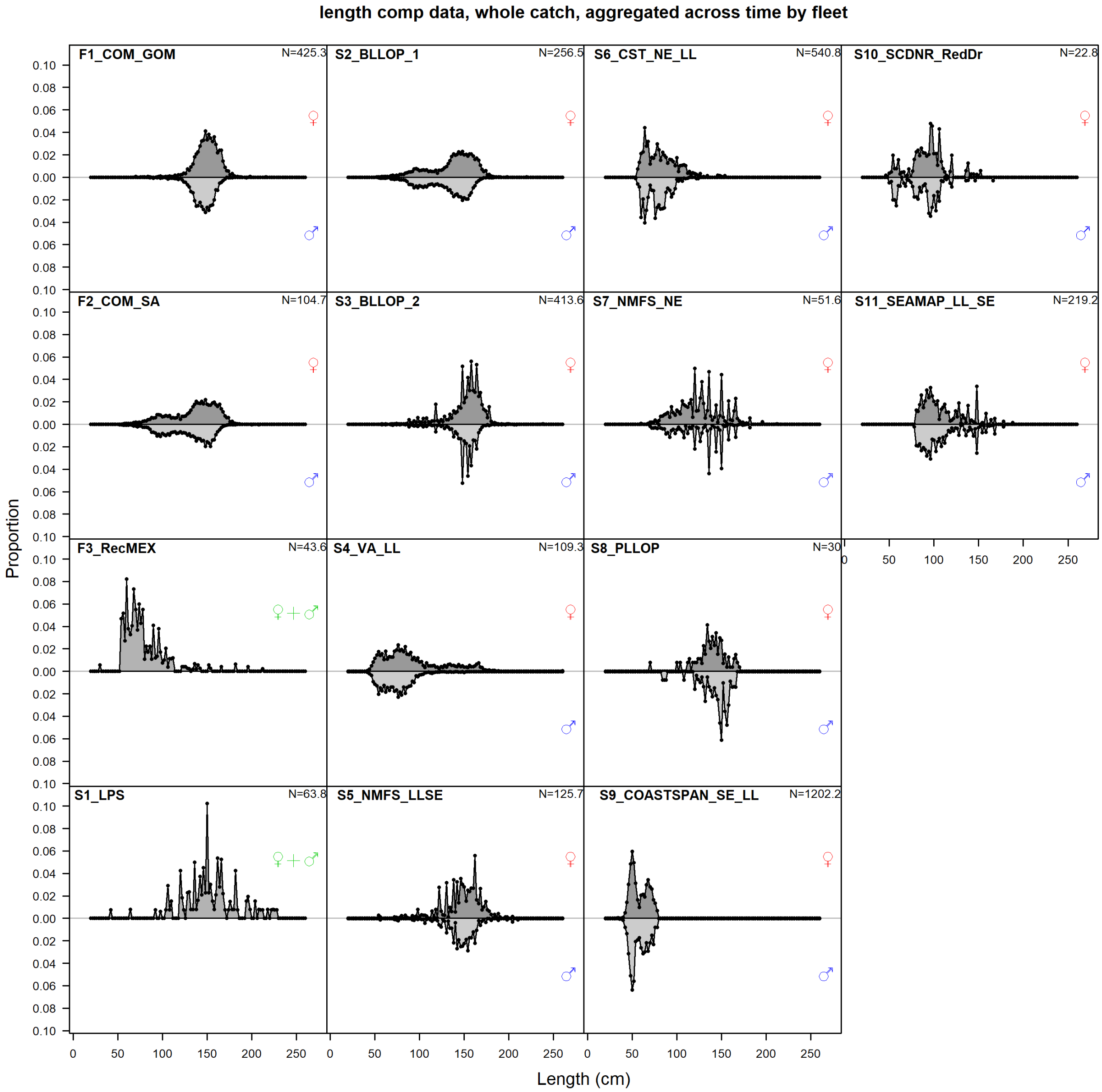


Figure 3.2.2. Available length frequency data by fishery and survey, aggregated across years, used in the base case model configuration

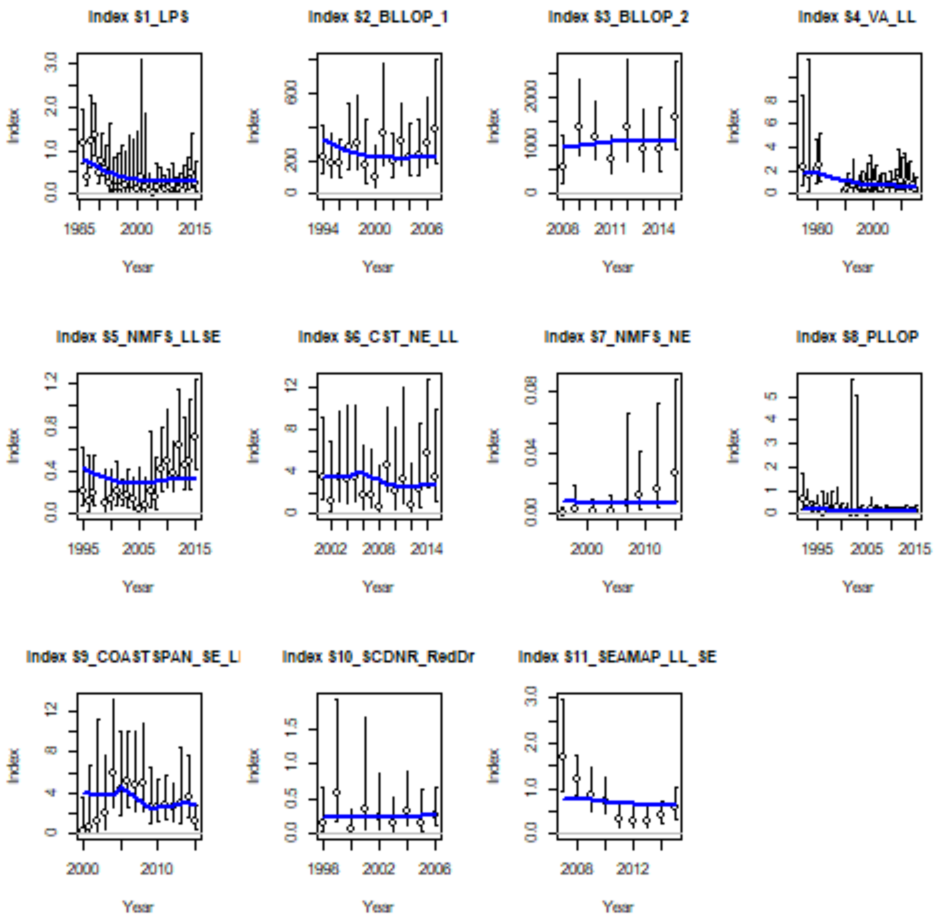


Figure 3.2.3 Fits to indices of abundance for the base case model configuration.

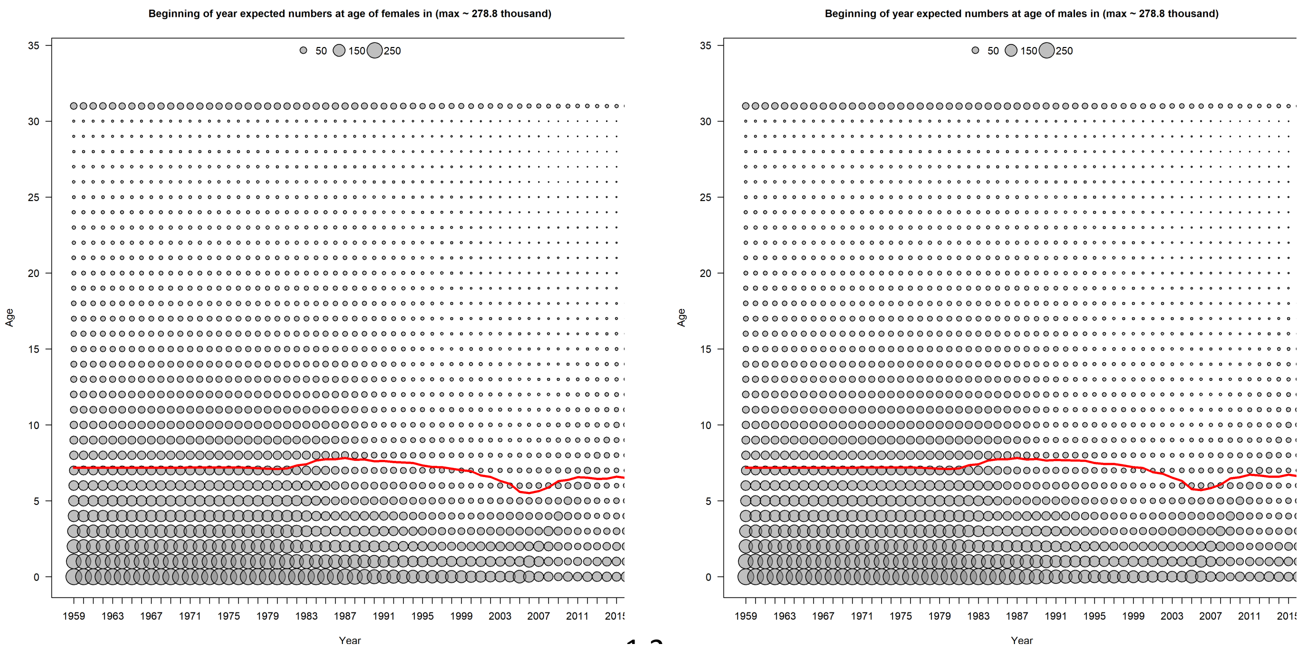


Figure 3.24 Estimated numbers at age of female (left panel) and male (right panel) by year for the base case model configuration.

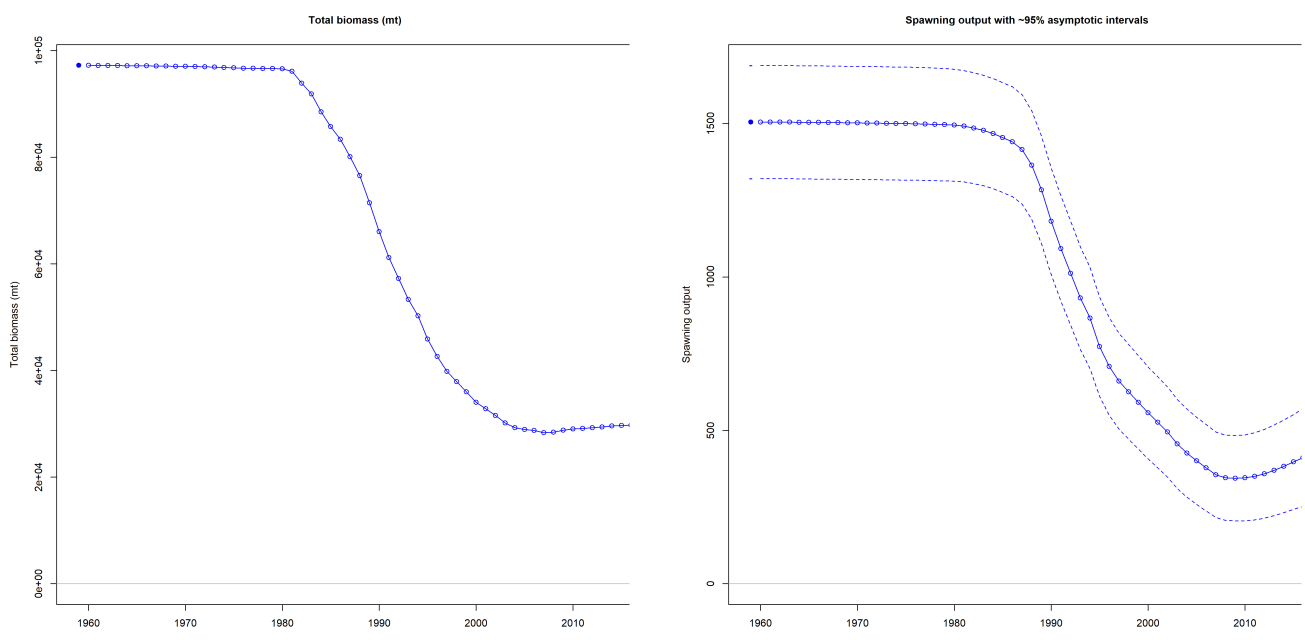


Figure 3.2.5. Estimated total biomass (left panel) and spawning output (SSF, right panel) by year for the base case model configuration.

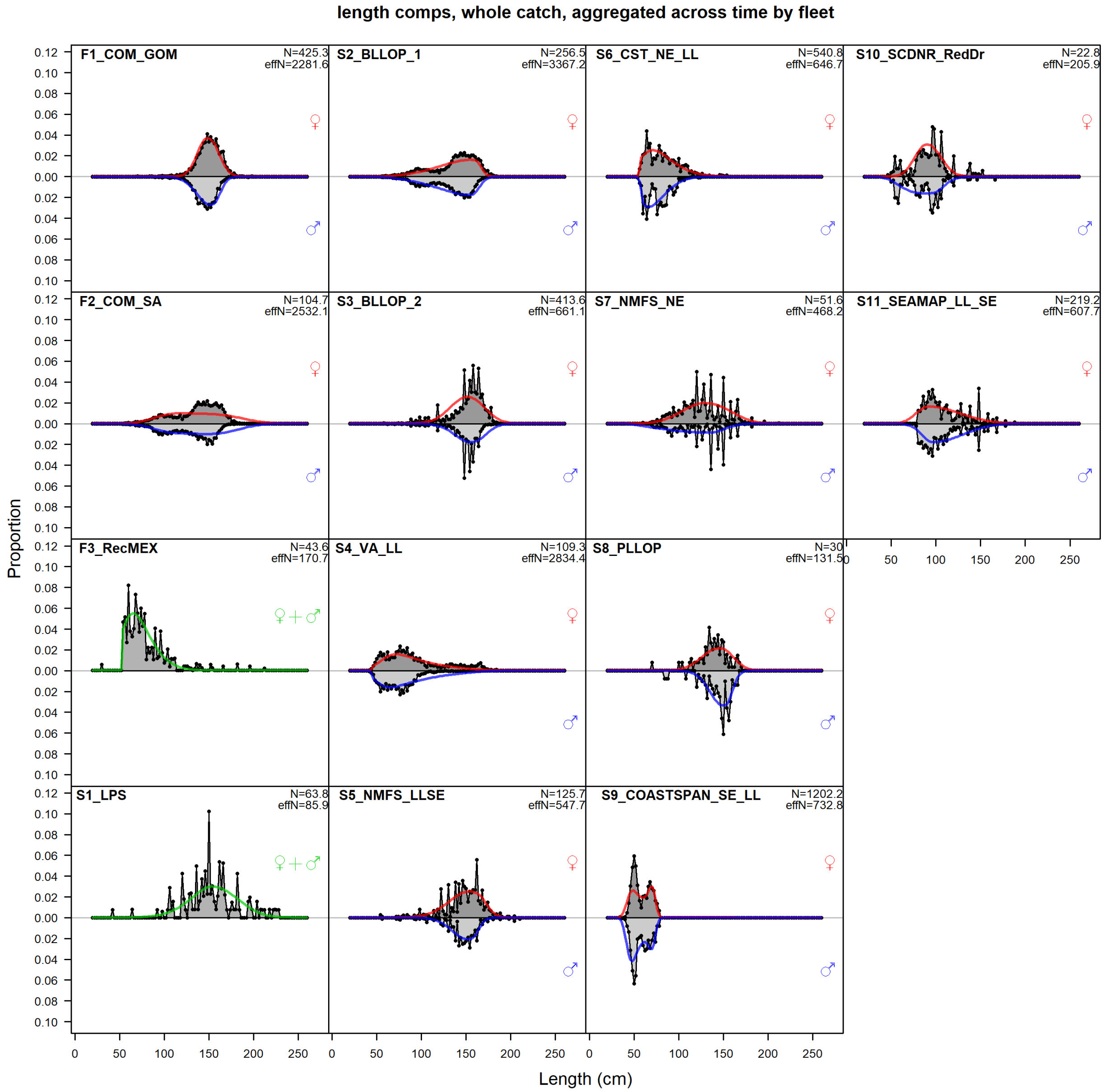
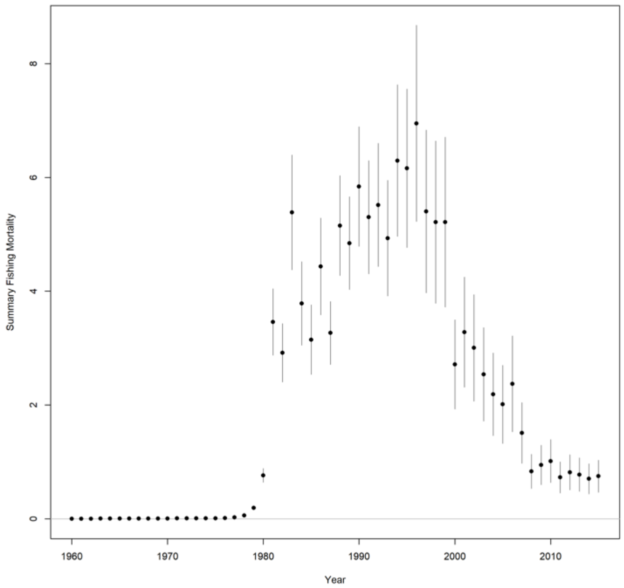


Figure 3.2.6. . Fits of the estimated length compositions to the length composition by fleet for the base case model configuration. Where possible the sex specific selectivity was estimated. For sex specific length compositions (all except F3 and S1) the top half of each panel shows the female length composition and estimated fit, while the bottom shows the male length compositions and corresponding fits.



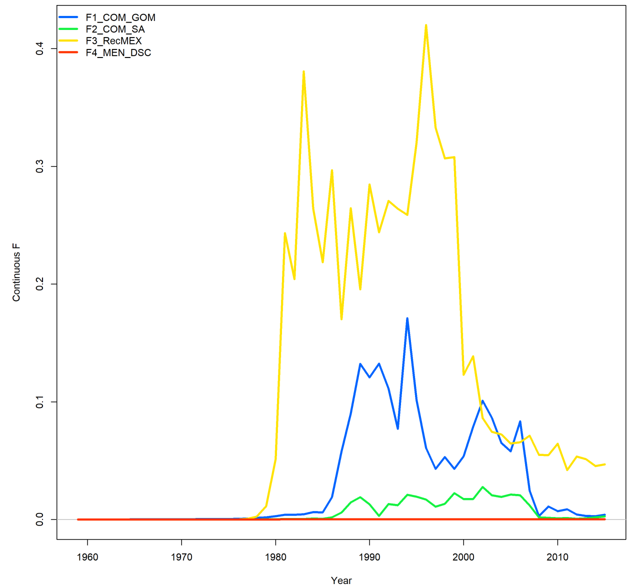
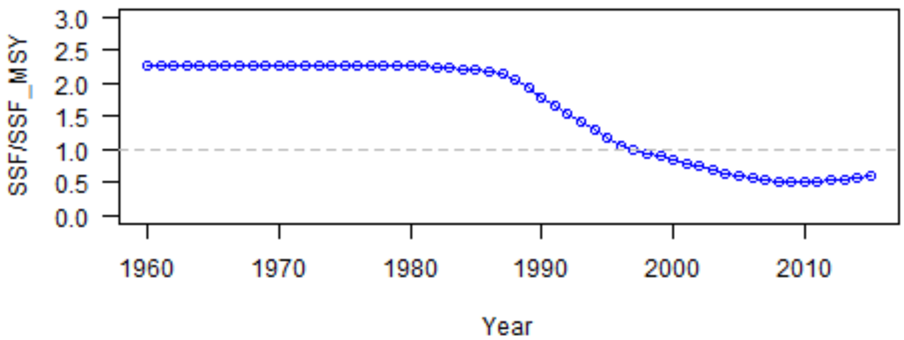


Figure 3.2.7. Estimated F/F_{MSY} (left panel) and fleet specific (right panel) fishing mortality by year for the base case model configuration.



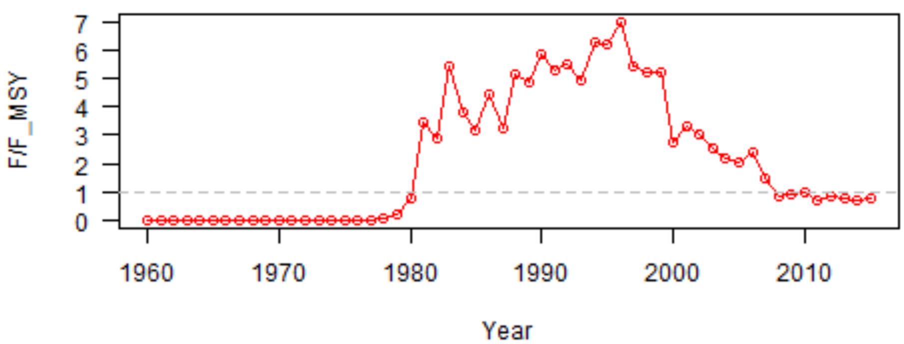


Figure 3.2.8. Time series of stock status parameters F/F_{MSY} and SSF/SSF_{MSY} for the base case configuration of the assessment model.

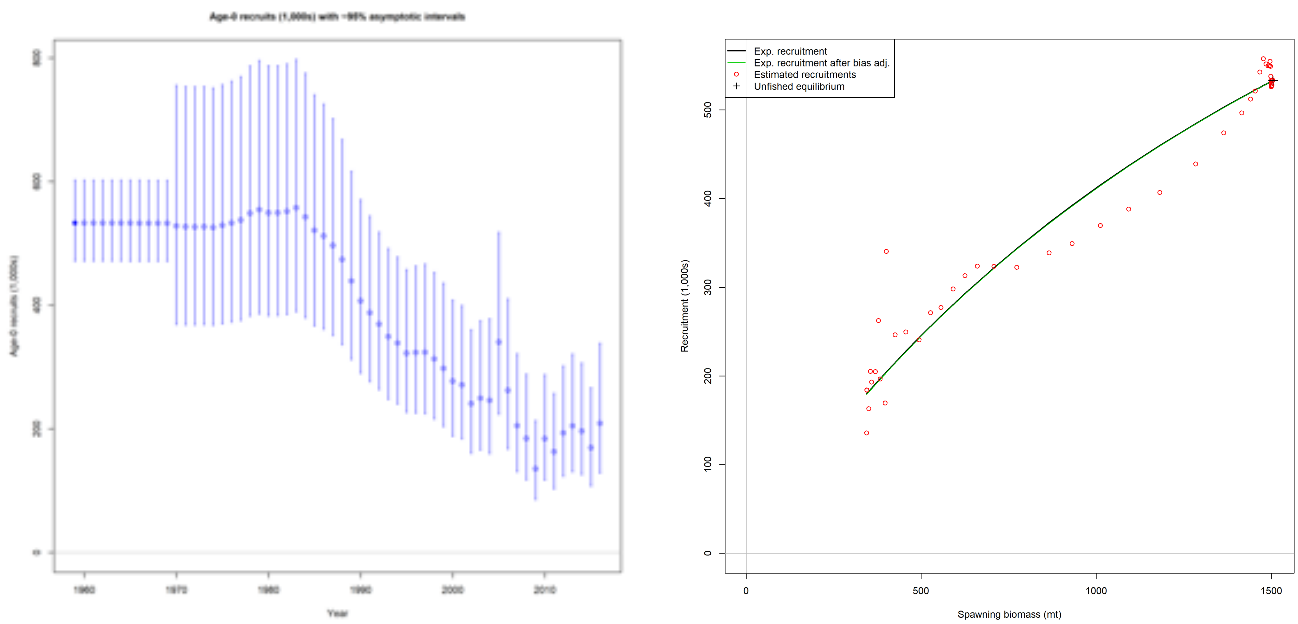


Figure 3.2.9. Estimated annual recruits (left panel) and estimated stock recruitment relationship (right panel) with annual recruitment deviates (red circles in right panel) by year for the base case model configuration.

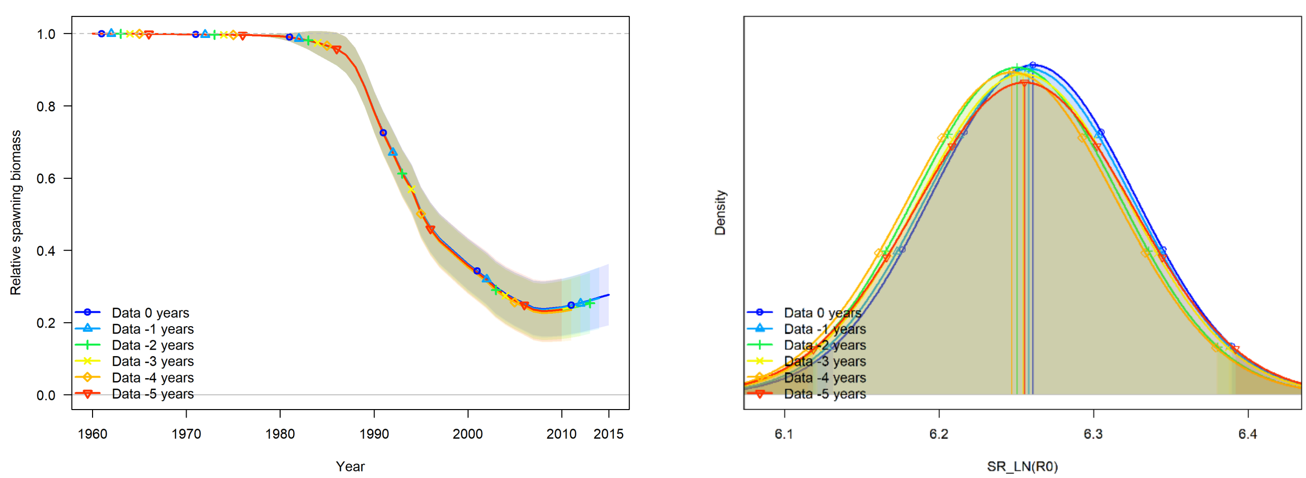
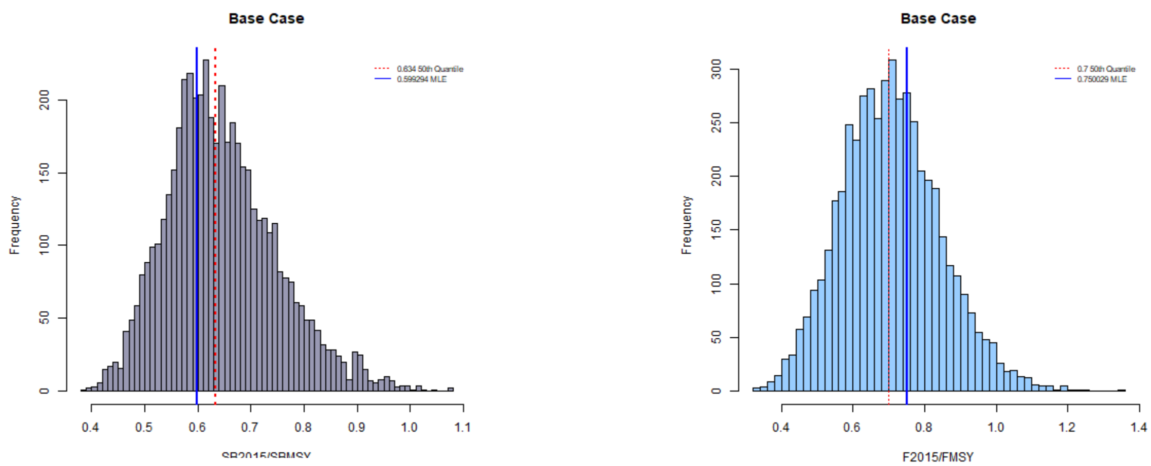


Figure 3.2.10. Estimated spawning output relative to virgin (SSF/SSF_0, left panel) by year along with 95% asymptotic uncertainty (shaded areas) and the maximum likelihood estimate (MLE, vertical lines) and asymptotic uncertainty (bell shaped curves) of the natural log of virgin recruitment size (right 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).

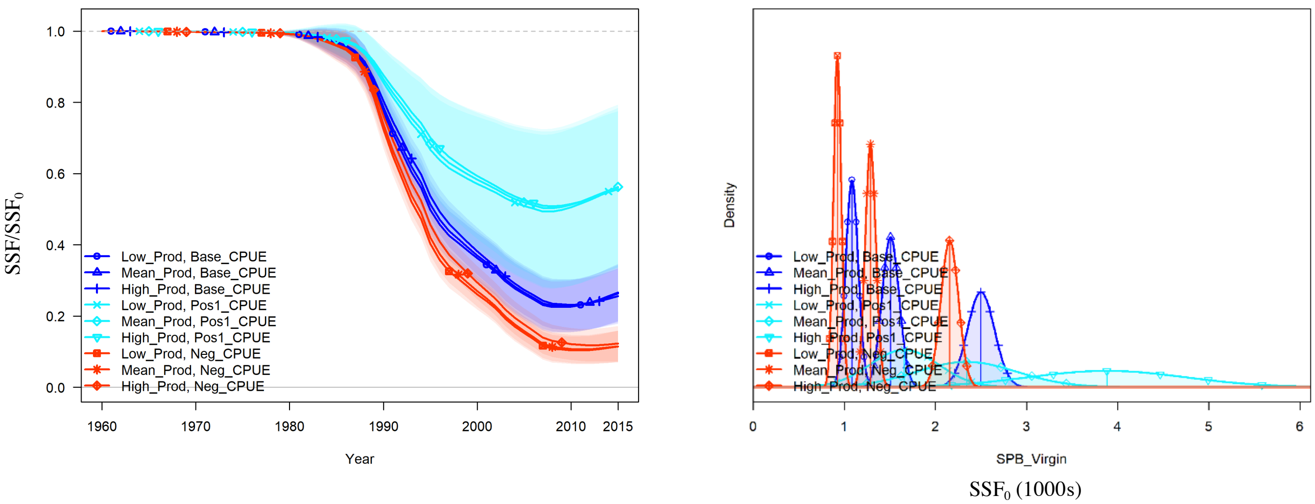


Figure 3.2.12. Estimated spawning output depletion (SFF/SSF_0, left panel) by year and asymptotic uncertainty (bell shaped curves) of estimated virgin spawning output (SSF_0, right panel) obtained for each of the nine alternative states of nature scenarios evaluated for CPUE and productivity as defined 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”.

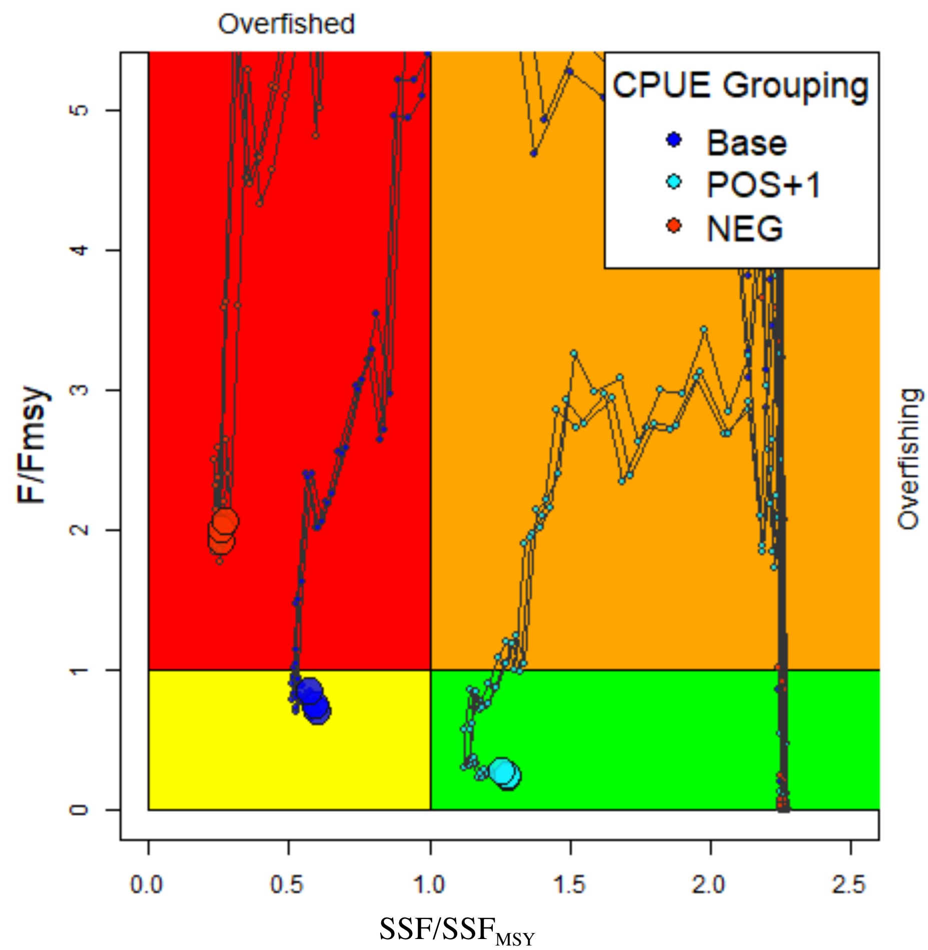


Figure 3.2.13. Time series of stock status based on estimated spawning output each year relative to MSY (SSF/SSF$_{MSY}$, x-axis) and estimated total fishing mortality each year relative to MSY (F/F$_{MSY}$, y-axis) obtained for each of the nine alternative states of nature scenarios evaluated for CPUE 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.

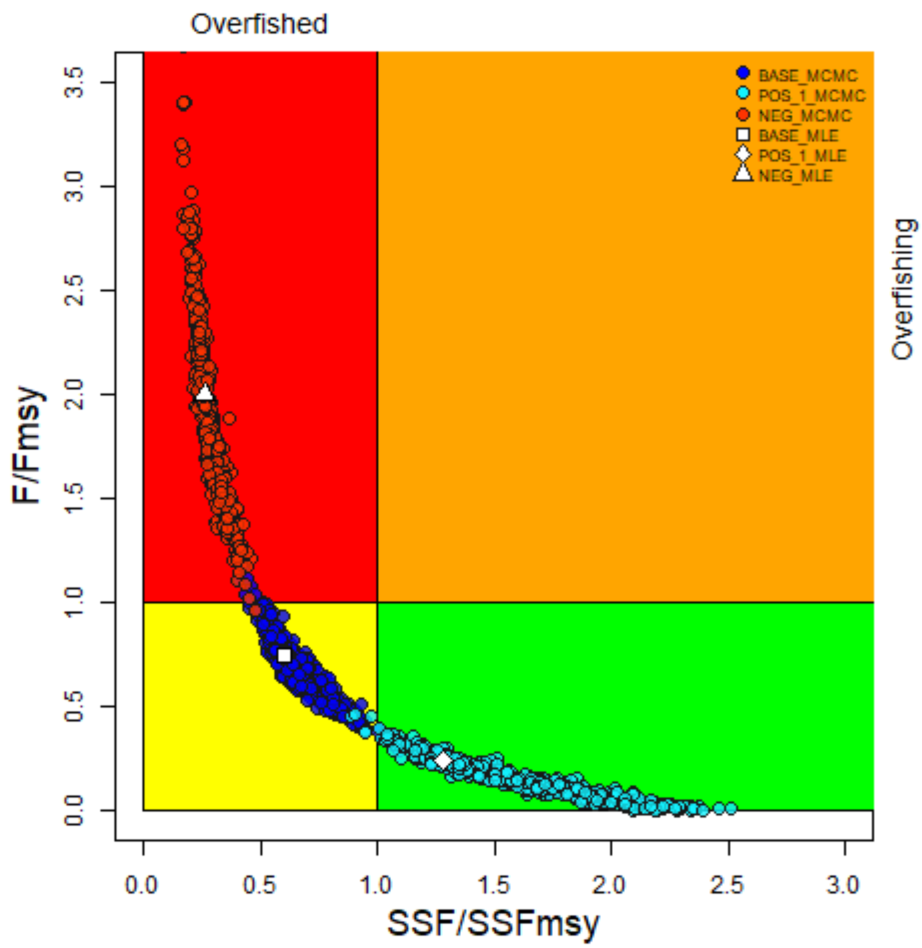


Figure 3.2.14 Estimated stock status based on MCMC analysis for the base case model configuration (Base, dark blue circles) and for two alternative states of nature scenarios evaluated for CPUE (POS_1, NEG) with the base case productivity scenario as defined in the main text and Table 3.2.9. The white square, triangle and diamond are MLE estimates.

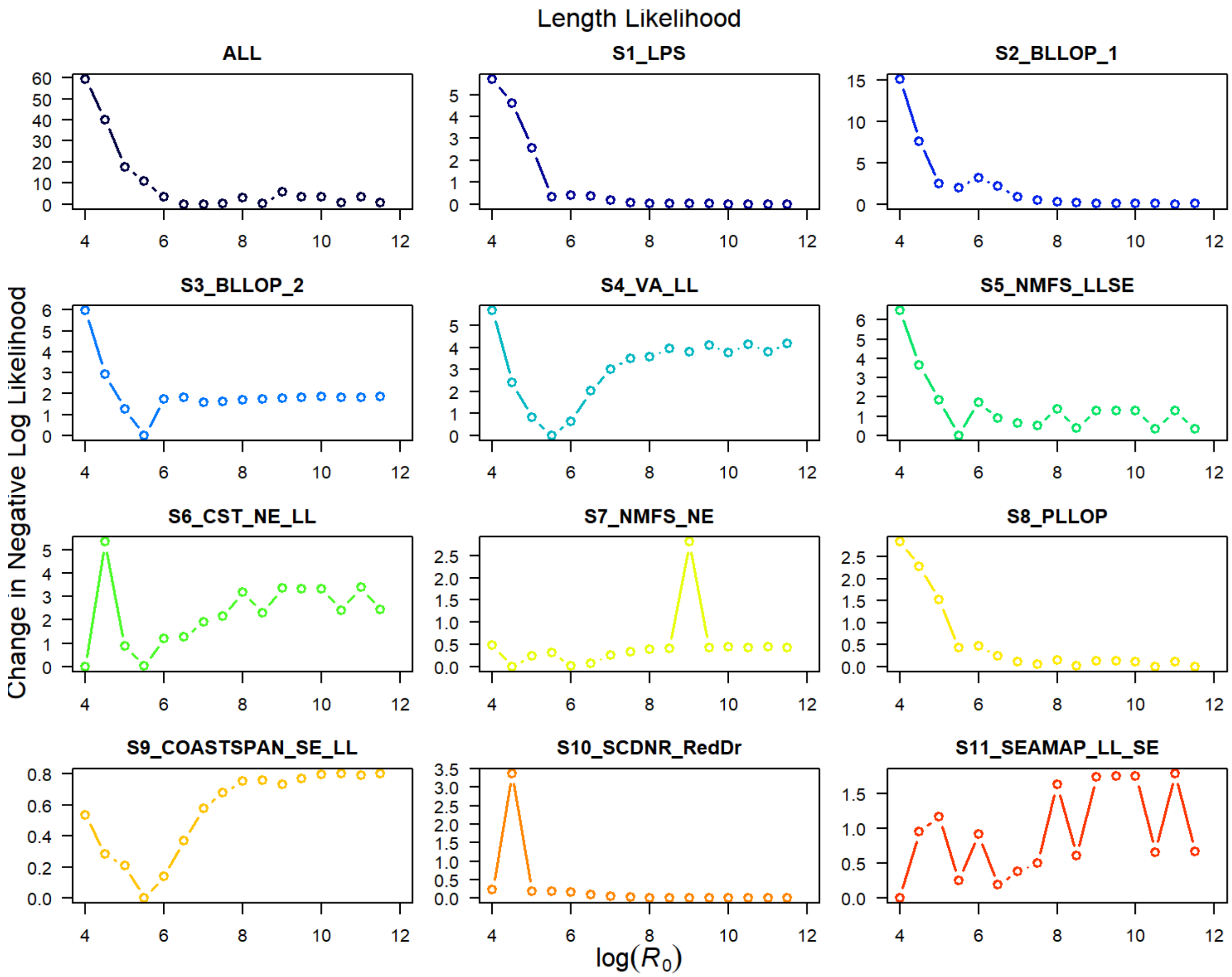


Figure 3.2.15. Profile likelihoods for the length composition associated with the CPUE data from the base case configuration as defined in Table 3.2.3 and the main text.

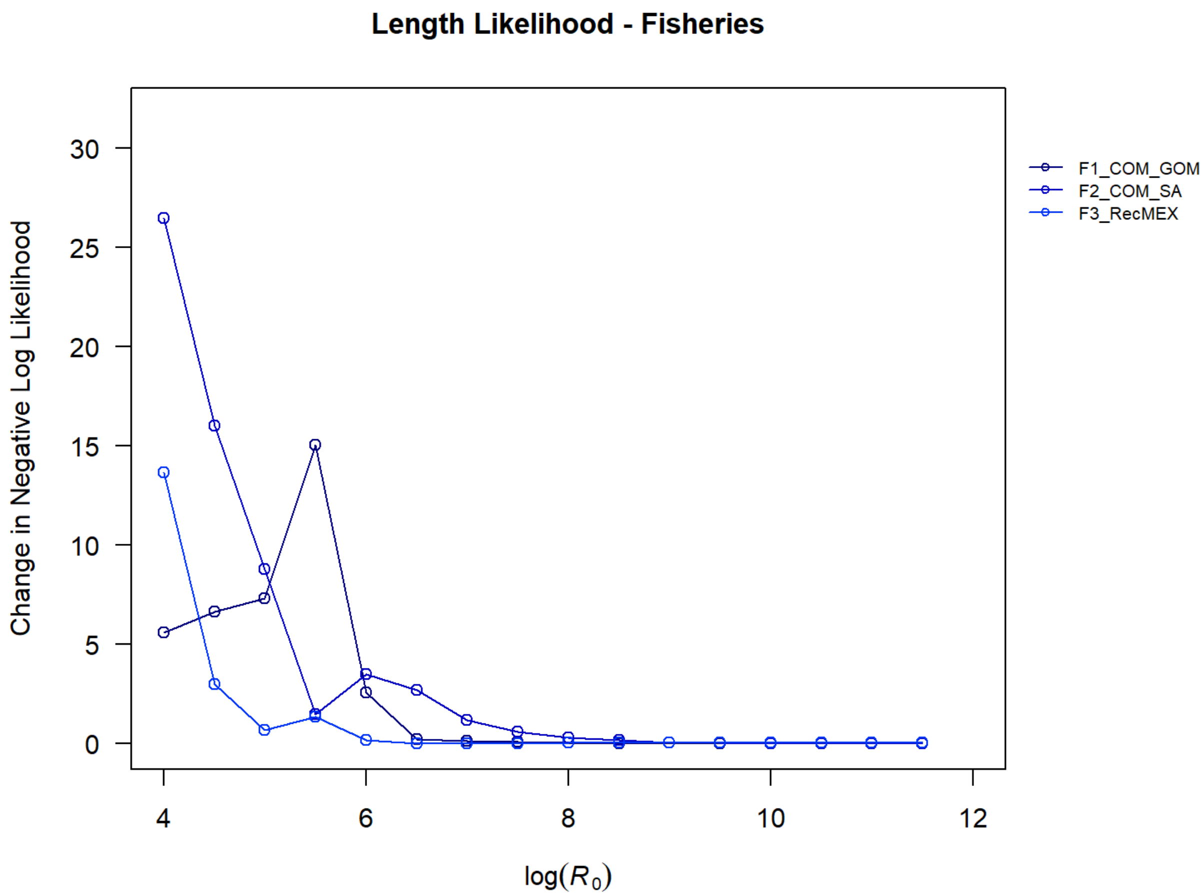


Figure 3.2.16. Profile likelihoods for the length composition data from fisheries F1-F3 for the base case configuration as defined in Table 3.2.3 and the main text.

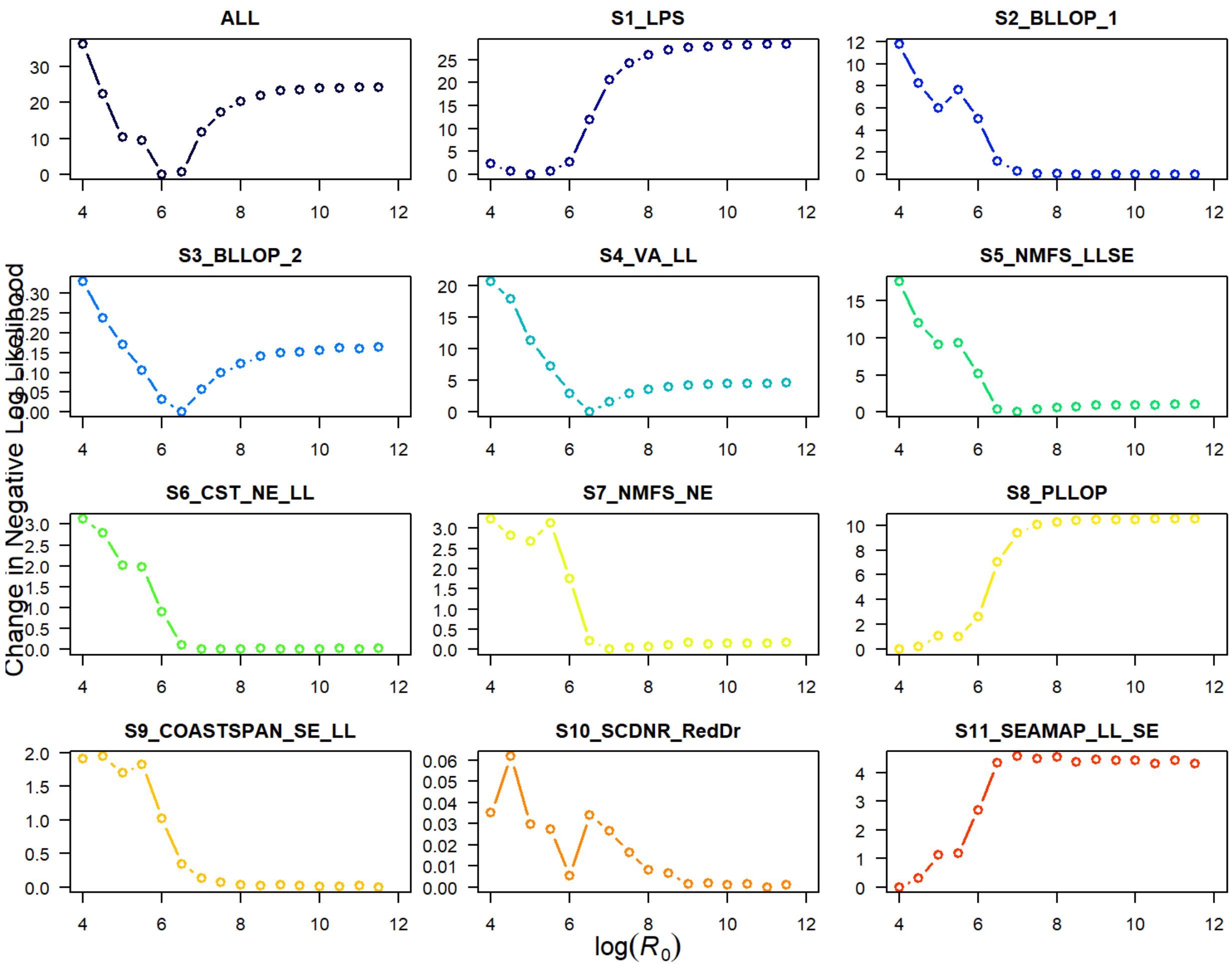


Figure 3.2.17. Profile likelihoods for the CPUE data from the base case configuration defined in table 3.2.1 and the main text above.

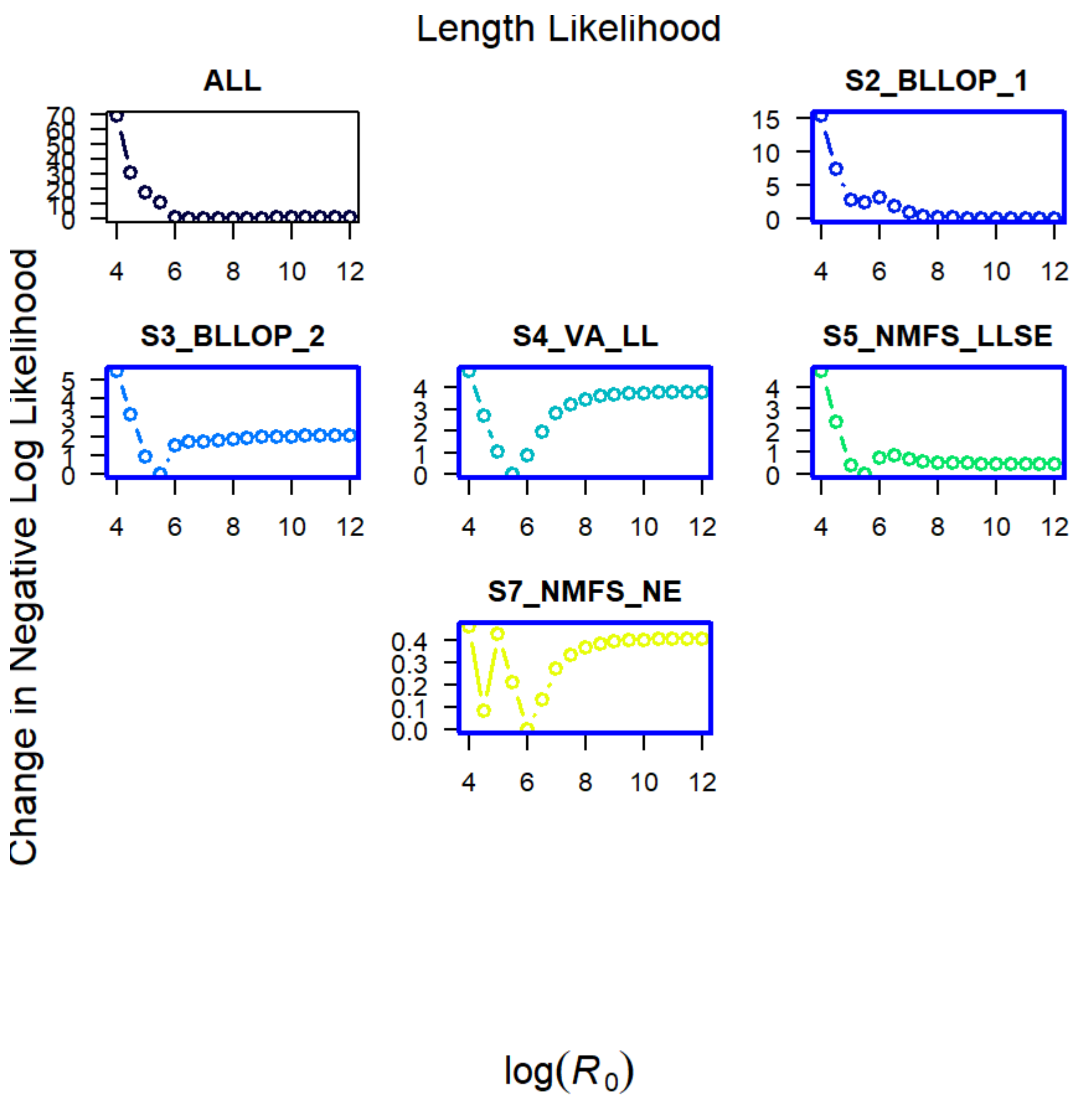


Figure 3.2.18 Profile likelihood values from the POS_1 CPUE grouping on the length composition likelihood associated with the CPUE series.

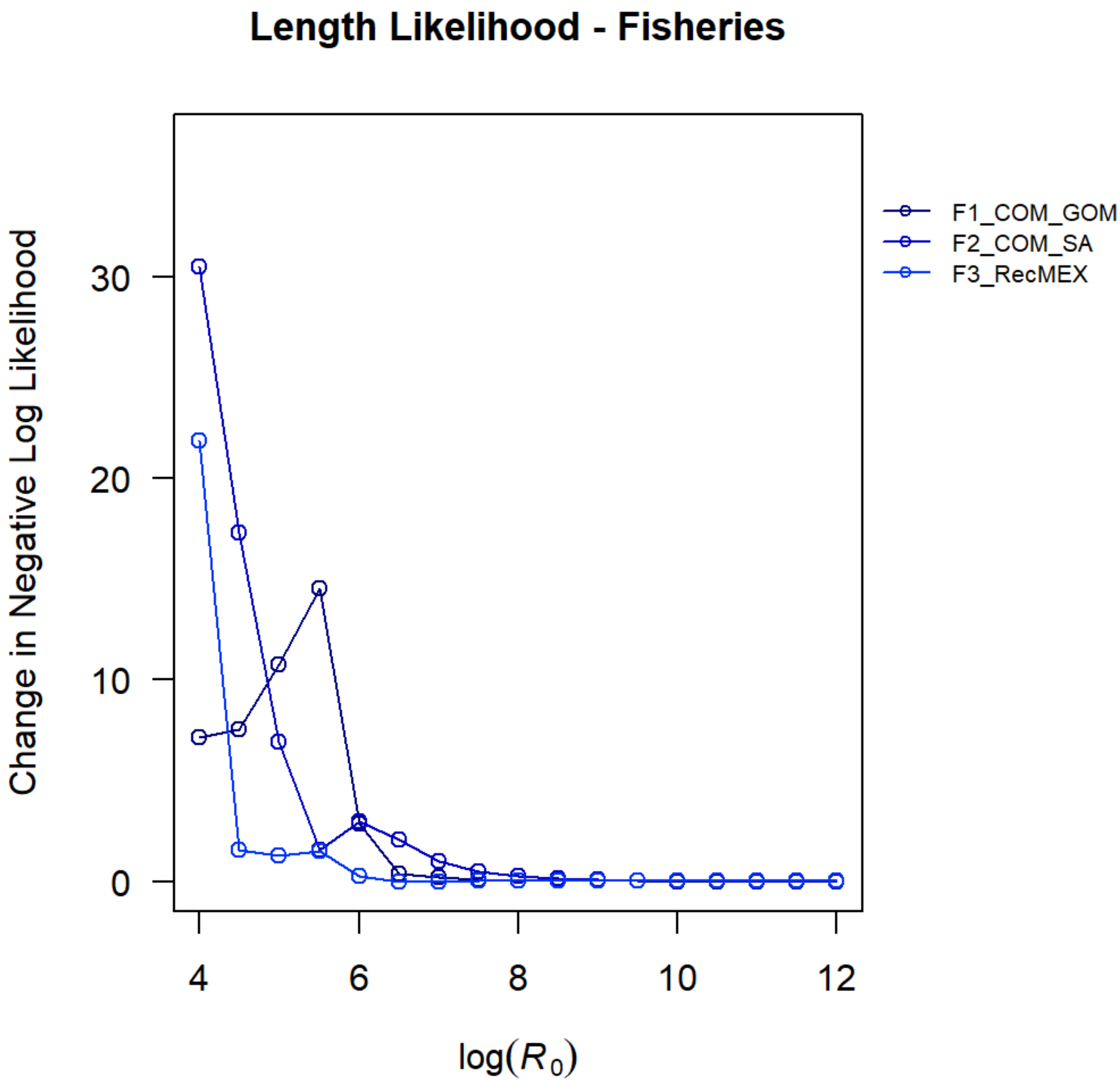


Figure 3.2.19 Profile likelihood values from the POS_1 CPUE grouping on the length composition likelihood from fisheries F1-F3.

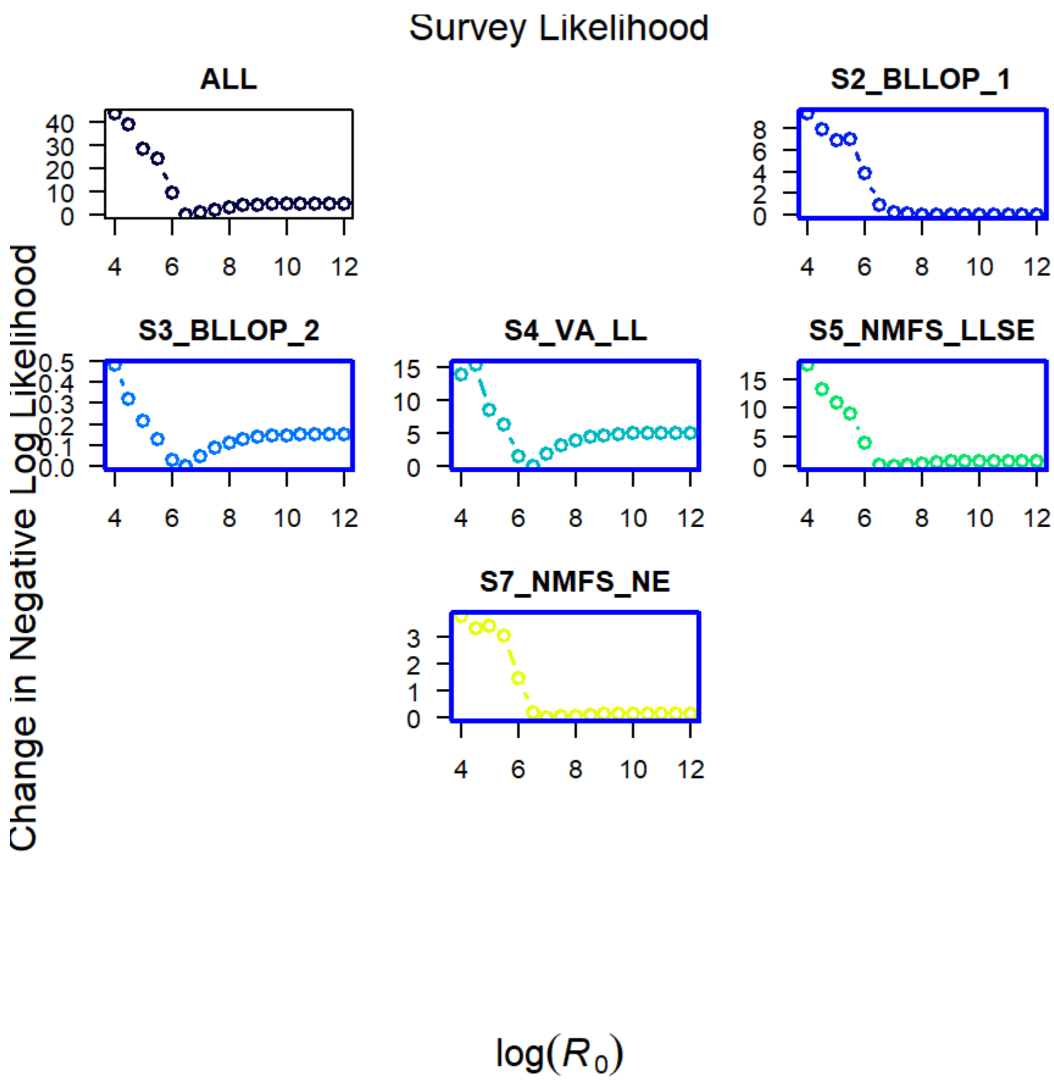


Figure 3.2.20. Profile likelihoods for the CPUE data from the model run with the POS_1 CPUE grouping.

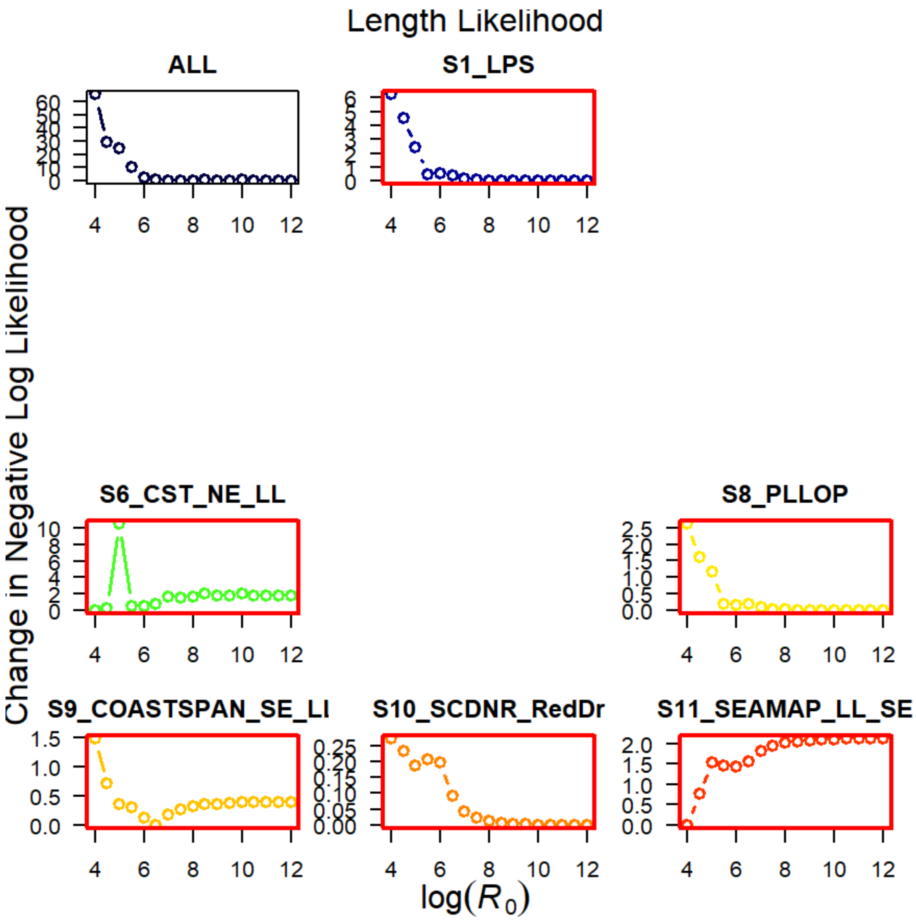


Figure 3.2.21 . Profile likelihoods for the length composition data from the model run with the NEG CPUE grouping for the length compositions associated with the CPUE series.

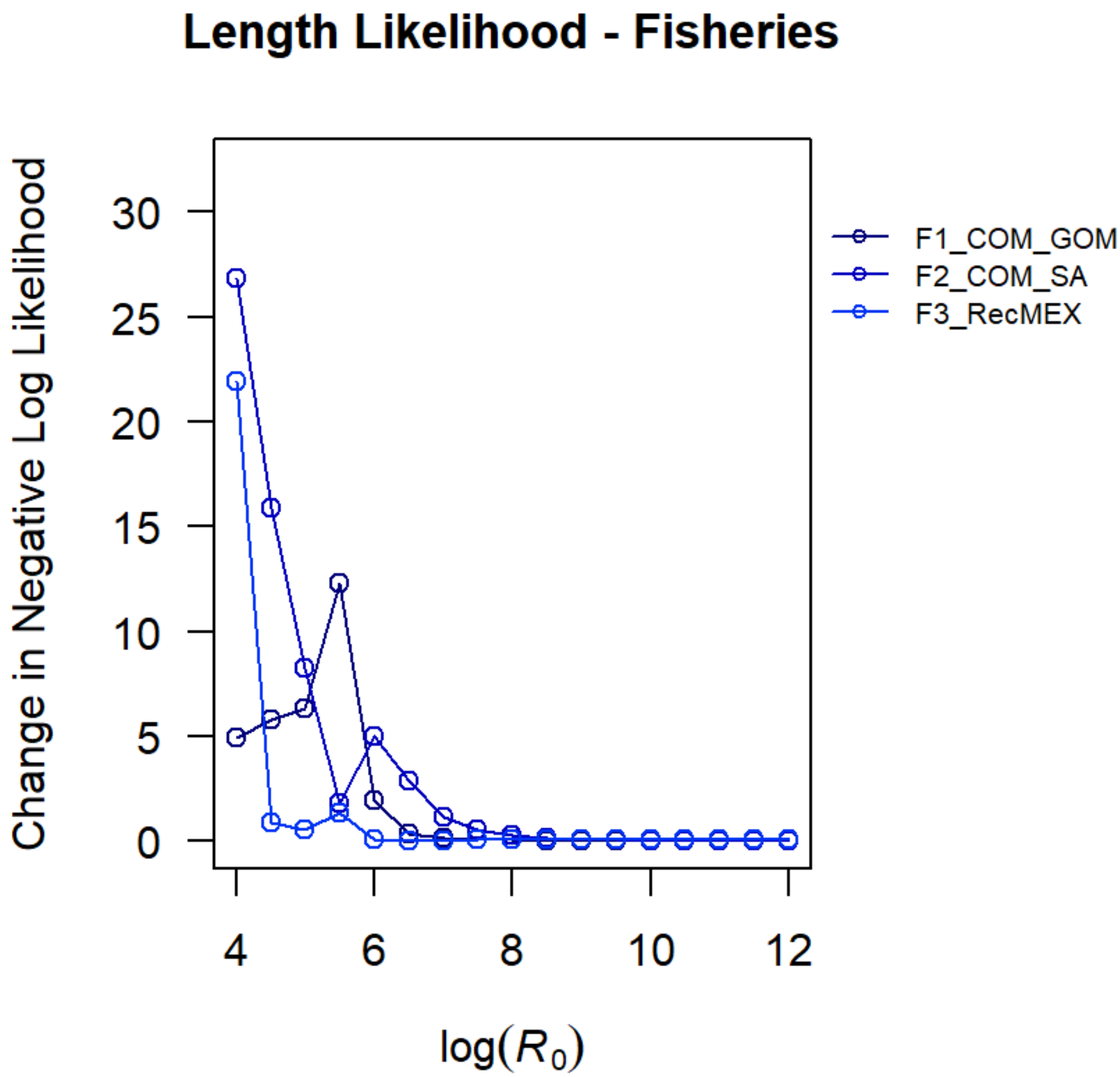


Figure 3.2.22 . Profile likelihoods for the length composition data from the model run with the NEG CPUE grouping for the length compositions associated with fisheries F1-F3.

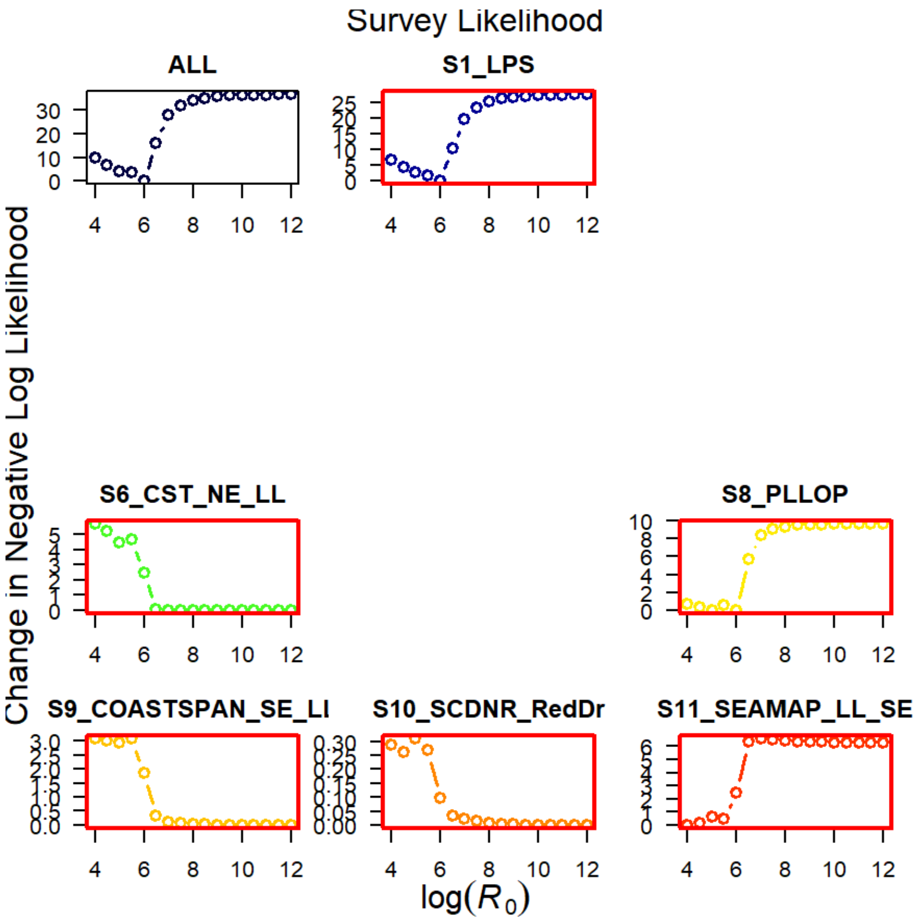


Figure 3.2.23. Profile likelihoods for the CPUE data from the model run with the NEG CPUE grouping.

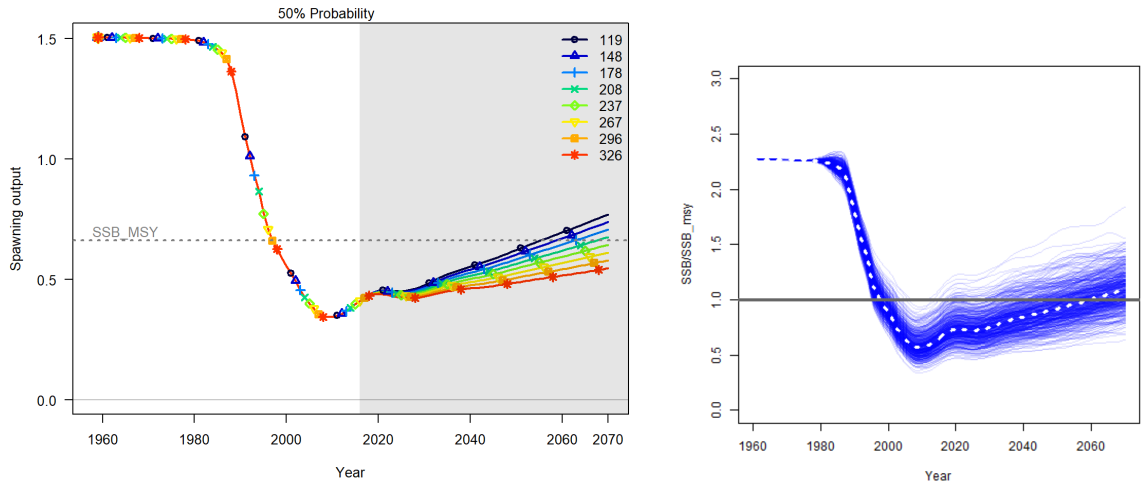


Figure 3.2.24. For the base case, projections were implemented with constant TAC allowing rebuilding of stock by 2070 with 50% and 70% probability (TOR 4A). Base case projections of spawning output (SSF in millions, left panel) under different levels of constant TAC (mt whole weight) indicate that a 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 50^{th} quantile of the runs.

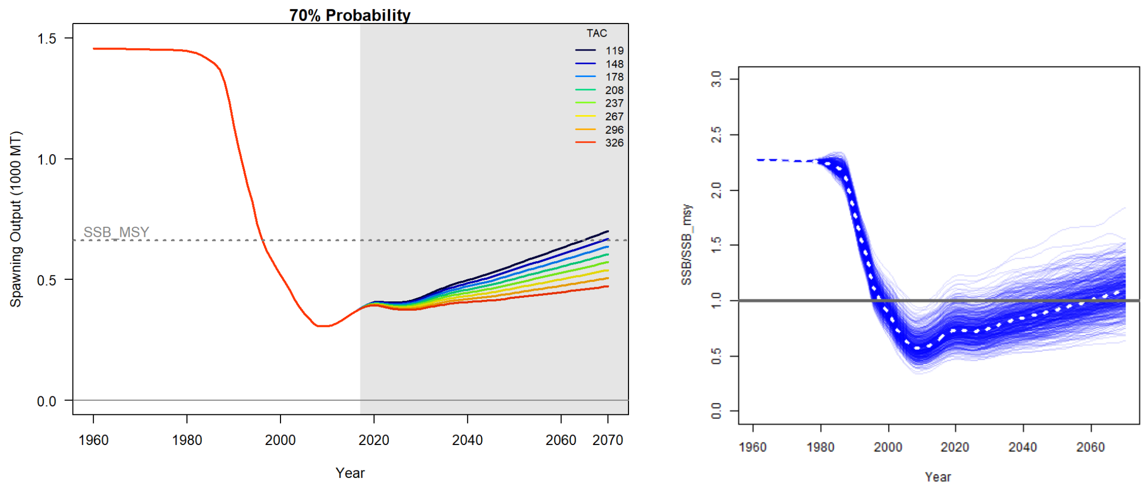
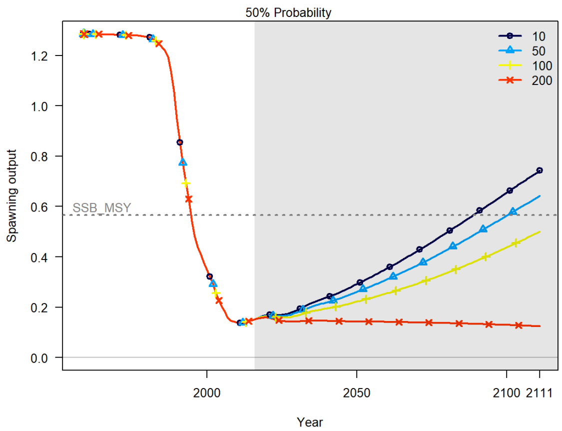


Figure 3.2.25. Base case projections of spawning output (SSF in millions, left panel) under different levels of constant TAC (mt whole weight) indicate that a constant TAC of 148 mt would allow stock rebuilding by 2070 with a 70% probability. For comparison, the base case MCMC projections at a constant 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.



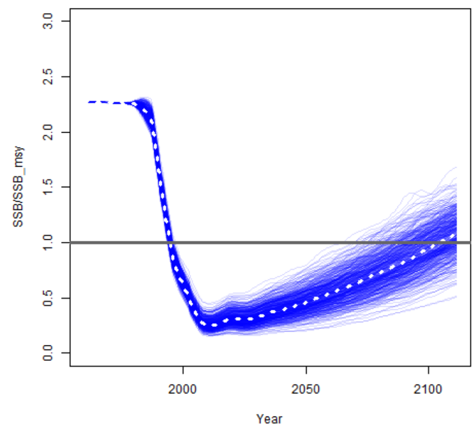


Figure 3.2.26. Under the NEG CPUE grouping, projections were implemented with constant TAC allowing rebuilding of stock by 2111 with 50% and 70% probability (TOR 4B). Projected estimates of spawning output (SSF in millions, left panel) under different levels of constant TAC (mt whole weight) indicate 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 50^{th} quantile of the runs.

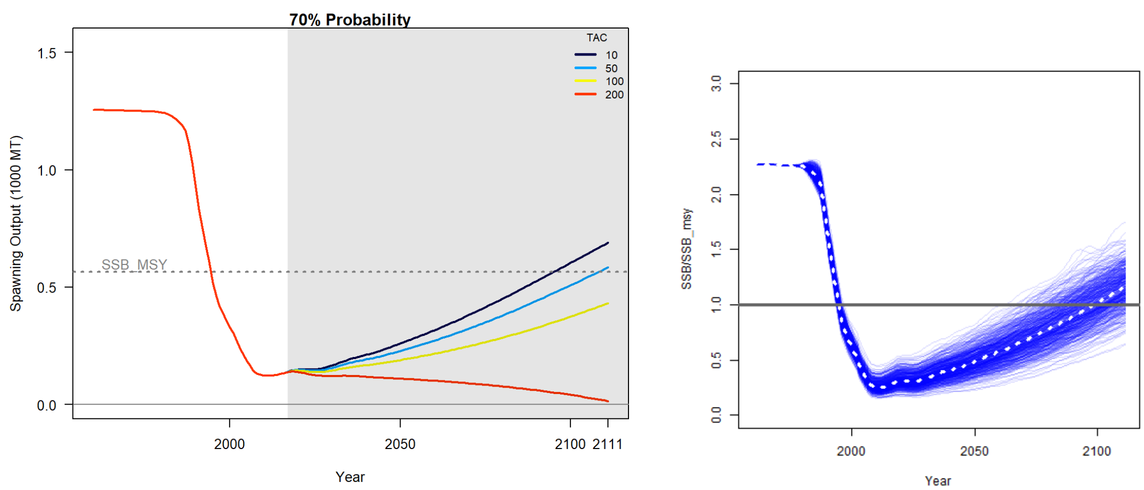
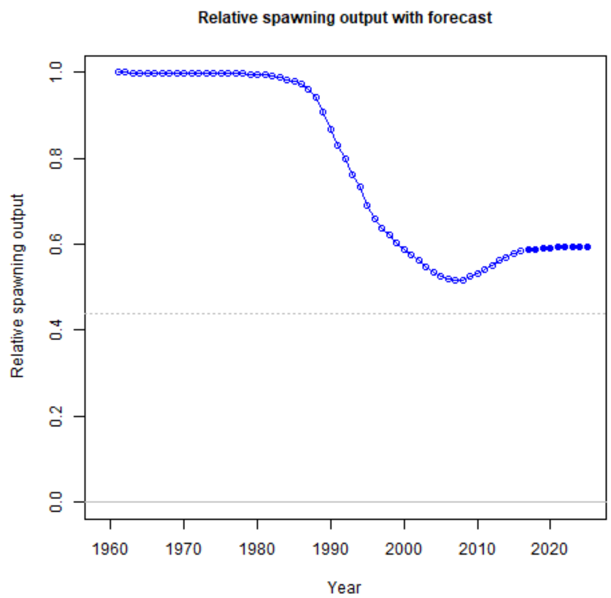


Figure 3.2.27. Projected estimates of the spawning stock biomass based on the NEG CPUE grouping (left panel) under a level of TAC projected until 2111 and estimated SSF/SSF_{MSY} based on MCMC based projections at a TAC of 53 mt which corresponds to the 70% probability of rebuilding by the estimated rebuilding year of 2111 (right panel). The blue lines indicate individual MCMC runs and the stippled line in the right panel represents the 50^{th} quantile of the runs.



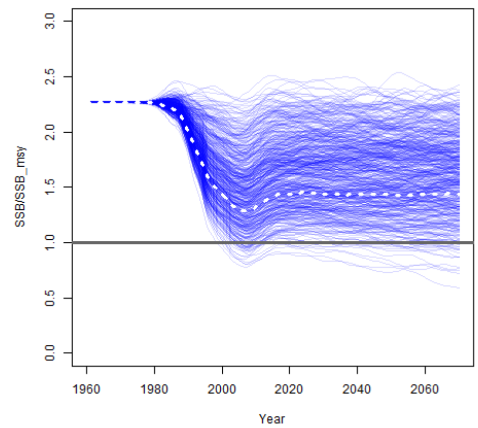


Figure 3.2.28. Under the POS_1 CPUE grouping, a projection model (TOR 4D), analogous to a P* approach associated with a 70% probability of overfishing not occurring (P* = 0.3), was implemented that projected with constant TAC so that the probability of overfishing was less than or equal to 30% in the 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
0.160419 0.160419 0.160419 0.160419 0.160419 0.160419 0.157755 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 0.5 0 0 # SizeSel_1P_1_F1_COM_GOM
-15 15 -10 0 -1 0 -3 0 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 0.5 0 0 # SizeSel_1P_3_F1_COM_GOM
-15 15 5.60819 0 -1 0 3 0 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 0.5 0 0 # SizeSel_1P_5_F1_COM_GOM
-999 -999 -999 0 -1 0 -3 0 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 0 # SzSel_1Male_Peak_F1_COM_GOM
-15 15 0.743742 4 -1 50 4 0 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 0 # SzSel_1Male_Descend_F1_COM_GOM
-15 15 0 4 -1 50 -4 0 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 0 # SzSel_1Male_Scale_F1_COM_GOM
1 200 93.6324 120 -1 0.01 2 0 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 0 # SizeSel_2P_2_F2_COM_SA
35 259 55.0586 55 0 1 2 0 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 0.5 0 0 # SizeSel_3P_2_F3_RecMEX
-15 15 0 0 -1 0 -3 0 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 0.5 0 0 # SizeSel_3P_4_F3_RecMEX
-15 15 -15 0 -1 0 -3 0 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 0.5 0 0 # SizeSel_3P_6_F3_RecMEX
1 200 45.6654 45 -1 99 -2 0 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 0 # SizeSel_4P_2_F4_MEN_DSC
35 259 155.527 50 -1 0 3 0 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 0.5 0 0 # SizeSel_5P_2_S1_LPS
-15 15 7.30304 0 -1 0 3 0 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 0.5 0 0 # SizeSel_5P_4_S1_LPS
-999 -999 -999 0 -1 0 -3 0 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 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

-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

```
 -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.

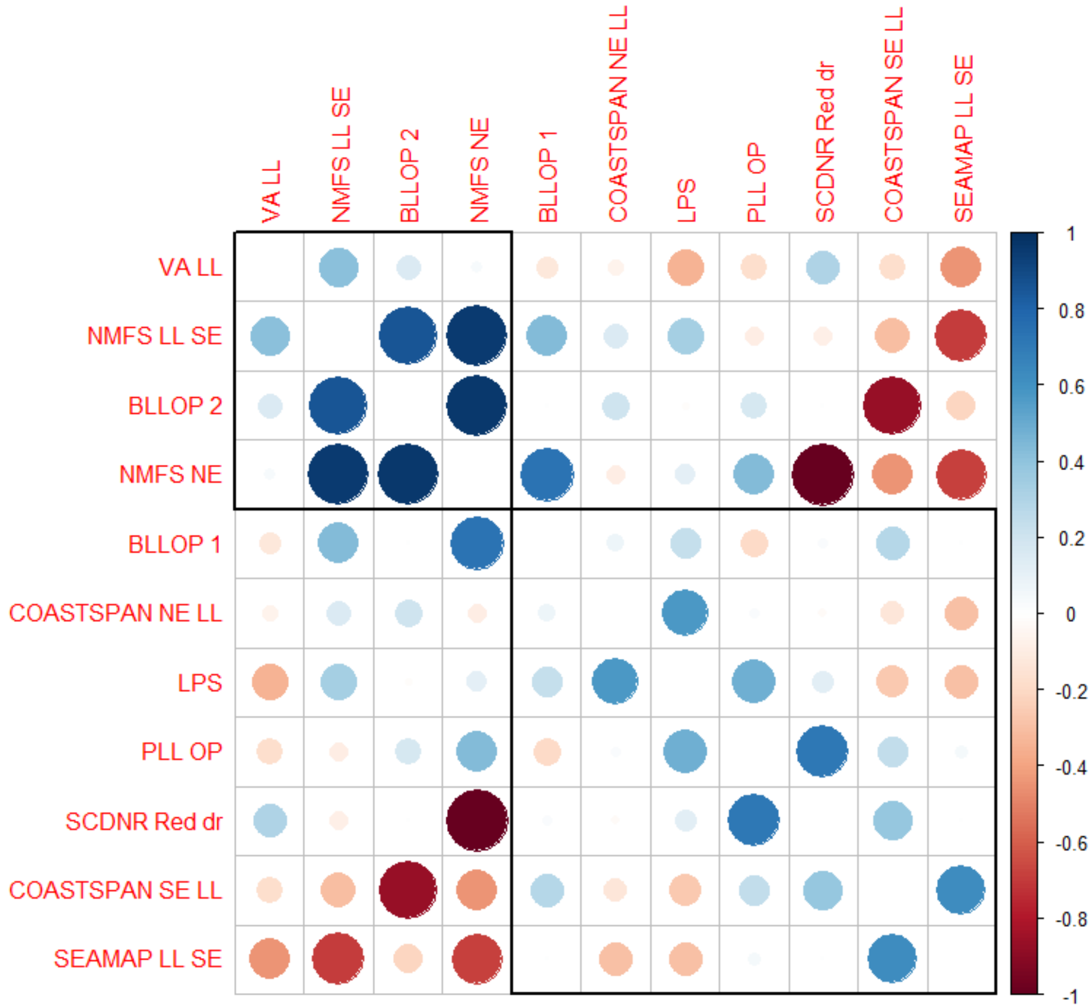


Figure A2.1. Correlation matrix for CPUE indices obtained for the SEDAR 54 assessment for the combined Gulf of Mexico and South Atlantic (GOMSA) region. Blue indicates positive and red negative correlations. The order of the indices and the rectangular boxes are chosen based on a hierarchical cluster analysis using a set of dissimilarities.