SEDAR

Southeast Data, Assessment, and Review

SEDAR 21

Stock Assessment Report

HMS Sandbar Shark

September 2011

SEDAR
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North Charleston, SC 29405

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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

2.1 *FISHERY MANAGEMENT PLAN AND AMENDMENTS*

Given the interrelated nature of the shark fisheries, the following section provides an overview of shark management primarily since 1993 through 2009 for sandbar, dusky, and blacknose sharks. The following summary focuses only on those management actions that likely affect these three species. The latter part of the document is organized according to individual species. 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 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). 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 and a daily bag limit of five sharks per person for sharks in the SCS species group;
- Requiring that all sharks not taken as part of a commercial or recreational fishery be released uninjured;

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

- 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 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 and SCS quotas;
- Establishing ridgeback and non-ridgeback categories of LCS;
- Implementing a commercial minimum size for ridgeback LCS;
- Establishing blue shark, porbeagle shark, and other pelagic shark subgroups of the pelagic sharks and establishing a commercial quota for each subgroup;
- Reducing recreational retention limits for all sharks;
- Establishing a recreational minimum size for all sharks except Atlantic sharpnose;
- Expanding the list of prohibited shark species to 19 species, including dusky sharks[2];
- Added deepwater sharks to the fishery management unit;
- Established 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 1999 FMP for Atlantic Tunas, Swordfish, and Sharks (Amendment 1)

In 2002, additional LCS and SCS 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

[2] In addition to white, basking, sand tiger, bigeye sand tiger, whale sharks, which were already prohibited, NMFS prohibited Atlantic angel, bigeye sixgill, bigeye thresher, bignose, Caribbean reef, Caribbean sharpnose, dusky, Galapagos, longfin mako, narrowtooth, night, sevengill, sixgill, and smalltail sharks.

shark management. The final management measures (December 24, 2003, 68 FR 74746) selected in Amendment 1 included, among other things:

- 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;
- Removing the deepwater/other sharks from the management unit;
- Establishing a mechanism for changing the species on the prohibited species list;
- Updating essential fish habitat identifications for five species of sharks; 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.

The 2006 Consolidated HMS FMP also included a plan for preventing overfishing of finetooth sharks by expanding observer coverage, collecting more information on where finetooth sharks are being landed, and coordinating with other fisheries management entities that are contributing to finetooth shark fishing mortality.

2008 Amendment 2 to the 2006 Consolidated HMS FMP

In 2005/2006, new stock assessments were conducted on the LCS complex, sandbar, blacktip, porbeagle, and dusky sharks. Based on the results of those 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. Assessments for dusky (*Carcharhinus obscurus*) and sandbar (*C. plumbeus*) sharks indicated that these species were overfished with overfishing occurring and that porbeagle sharks (*Lamna nasus*) were overfished. NMFS implemented management measures consistent with recent stock assessments for sandbar, porbeagle, dusky, blacktip (*C. limbatus*) and the LCS complex. 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 rebuilding plans for porbeagle, dusky, and sandbar sharks consistent with stock assessments;
- Implementing commercial quotas and retention limits consistent with stock assessment recommendations to prevent overfishing and rebuild overfished stocks;
- Modifying recreational measures to reduce fishing mortality of overfished/overfishing stocks;
- Modifying reporting requirements;
- Modifying timing of shark stock assessments;
- Clarifying timing of release for annual Stock Assessment and Fishery Evaluation (SAFE) reports;
- Updating dehooking requirements for smalltooth sawfish;
- Requiring that all Atlantic sharks be offloaded with fins naturally attached;
- Collecting shark life history information via the implementation of a sandbar shark research program; and,
- Implementing time/area closures recommended by the South Atlantic Fishery Management Council.

2010 Amendment 3 to the 2006 Consolidated HMS FMP (Amendment 3)

An SCS stock assessment was finalized during the summer of 2007, which assessed finetooth, Atlantic sharpnose, blacknose, and bonnethead sharks separately. Based on these assessments, NMFS determined that blacknose sharks were overfished with overfishing occurring; however, Atlantic sharpnose, bonnethead, and finetooth sharks were not overfished and overfishing was not occurring, and NMFS issued a Notice of Intent (NOI) announcing its intent to amend the 2006 Consolidated HMS FMP in order to rebuild blacknose sharks, among other things (May 7, 2008, 73 FR 25665).

On July 24, 2009 (74 FR 36706 and 74 FR 36892), the draft EIS and proposed rule were released, which considered a range of alternative management measures from several different topics including small coastal sharks (SCS) commercial quotas, commercial gear restrictions, pelagic shark effort controls, recreational measures for SCS and pelagic sharks, and smooth dogfish management measures. In order to rebuild blacknose sharks, NMFS proposed to establish a new blacknose shark specific quota of 14.9 mt dw and establish a new non-blacknose SCS quota of 56.9 mt dw. In addition, NMFS proposed to prohibit the landings of all sharks from South Carolina south using gillnet gear, and prohibit the landing of blacknose sharks in the recreational shark fishery. However, based on additional data and analyzes and public comment, in the final EIS (75 FR 13276, March 19, 2010), NMFS preferred to implement a blacknose shark specific quota of 19.9 mt dw and establish a new non-blacknose SCS quota of 221.6 mt dw while allowing sharks to be landed with gillnet gear and recreational anglers to be able to retain blacknose sharks, as long as they meet the minimum recreational size limit. The final rule for this action is anticipated in early summer of 2010. Therefore, while these regulations will not be in place during the time series of data considered for the 2010 blacknose assessment; however, changes in fishing practices in 2009 by SCS fishermen, particularly in the gillnet fishery, may have occurred even in the absence of regulation due to the proposed actions in the draft EIS for Amendment 3.

Table 1 FMP Amendments and regulations affecting sandbar, dusky, and blacknose 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 and a daily bag limit of 5 SCS/person; • 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; application and appeals processed over the next year (measures in italics were delayed)	FMP for Atlantic Tunas, Swordfish and Sharks	• Implemented limited access in commercial fisheries; • Reduced commercial LCS and SCS quotas to 1,285 mt dw and 1,760 mt dw, respectively; • 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); • Expanded the list of prohibited shark species (in addition to sand tiger, bigeye sand tiger, basking, whale, and white sharks, prohibited Atlantic angel, bigeye sixgill, bigeye thresher, bignose, Caribbean reef, Caribbean sharpnose, **dusky**, galapagos, longfin mako, narrowtooth, night, sevengill, sixgill, smalltail sharks) (*effective July 1, 2000)*; • Established blue shark, porbeagle shark, and other pelagic shark subgroups of the pelagic sharks and establishing a commercial quota for each subgroup(blue shark=273 mt dw; porbeagle shark=92 mt dw; other pelagics=488 mt dw) *(effective January 1, 2001)*; • Established new procedures for counting dead discards and state landings

Effective Date	FMP/Amendment	Description of Action
		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	• Removed the deepwater/other sharks from the management unit; • 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; SCS quota = 454 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 plans for porbeagle, dusky, and sandbar sharks consistent with stock assessments; • Established a shark research fishery which collects shark life history information; • Implemented commercial quotas and retention limits consistent with stock assessment recommendations to prevent overfishing and rebuild overfished stocks (sandbar research annual quota = 87.9 mt dw; non-sandbar LCS annual research quota = 37.5 mt dw; GOM regional non-sandbar LCS annual quota = 390.5 mt dw; ATL regional non-sandbar LCS annual quota = 187.8 mt dw; retention limit = 33 non-sandbar

Effective Date	FMP/Amendment	Description of Action
		LCS/vessel/trip outside of shark research fishery with no sandbar shark retention; sandbar retention only allowed within shark research fishery. Trip limits within research fishery were as follows: 2008-2,750 lb dw/trip of LCS of which no more than 2,000 lb dw could be sandbar sharks; 2009-45 sandbar and 33 non-sandbar LCS/trip: 2010-33 sandbar/trip and 33 non-sandbar/trip; • Modified recreational measures to reduce fishing mortality of overfished/overfishing stocks (prohibiting the retention of silky and sandbar sharks for recreational anglers); • 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.
Expected 2010	Amendment 3 to the 2006 Consolidated HMS FMP	• Preferred actions include establishing a non-blacknose SCS quota of 221.6 mt and a blacknose-specific quota of 19.9 mt; and, • Proposed a prohibition of landing sharks in gillnets from South Carolina south in July 2009.

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) and pelagic sharks (580 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). In this same rule, NMFS established an annual commercial quota for SCS of 1,760 mt dw and prohibited possession of five LCS: sand tiger, bigeye sand tiger, whale, basking, and white sharks. 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. A year later, on June 12, 2000, the court issued an order clarifying that NMFS could proceed with implementation and enforcement of the 1999 prohibited species provisions (64 FR 29090, May 28, 1999).

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.

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 the pelagic shark, prohibited species, or recreational shark fisheries. Once the injunction was lifted, on January 1, 2001, the pelagic shark quotas adopted in the 1999 FMP were implemented (66 FR 55). Additionally, 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 (1,285 mt dw) and SCS commercial quotas (1,760 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), maintained the 1997 SCS commercial quota (1,760 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 no longer overfished but that overfishing was still occurring and that blacktip sharks were rebuilt and overfishing was not occurring. In addition, on May 8, 2002, NMFS announced the availability of a SCS stock assessment (67 FR 30879). The Mote Marine Laboratory and the University of Florida provided NMFS with another SCS assessment in

August 2002. Both of these stock assessments indicated that finetooth sharks were experiencing overfishing while the three other species in the SCS complex (Atlantic sharpnose, bonnethead, and blacknose) were not overfished and overfishing was not occurring.

Based on the results of both the 2002 SCS and LCS stock assessments, 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, and reduced the SCS annual commercial quota to 325 mt dw. 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. Shortly after the final rule for Amendment 1 was published, NMFS conducted a rulemaking that adjusted the percent quota for each region, changed the seasonal split for the North Atlantic based on historical landing patterns, 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.

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 a new Biological Opinion (BiOp) (June 30, 2000) that concluded that the operation of the PLL fishery as proposed was likely to jeopardize the continued existence of ESA-listed leatherback and loggerhead sea turtles. As a result, NMFS implemented certain measures to avoid jeopardy by reducing sea turtle bycatch in the PLL fishery.

NMFS decided that further analyses of observer data and additional population modeling of loggerhead sea turtles were needed to determine more precisely the impact of the PLL fishery on turtles. Because of this, NMFS reinitiated consultation on the HMS fisheries on September 7, 2000. In the interim, NMFS implemented emergency regulations, based on historical data on sea turtle interactions, to reduce the short-term effects of the PLL fishery on sea turtles. An emergency rule that closed a portion of the Northeast Distant Statistical Area (NED) and required dipnets and line clippers to be carried and used on PLL vessels to aid in the release of any captured sea turtle published on October 13, 2000 (65 FR 60889).

NMFS issued a BiOp on June 8, 2001 (revised on June 14, 2001), that again concluded that the operation of the Atlantic PLL fishery as proposed was likely to jeopardize the continued existence of loggerhead and leatherback sea turtles. Accordingly, the BiOp provided a reasonable and prudent alternative (RPA) to avoid jeopardy. This BiOp concluded “no jeopardy” for other HMS fisheries, but required additional management measures to reduce sea turtle takes in these fisheries. The RPA included the following elements: closing the NED area effective July 15, 2001, and conducting a research experiment in this area to reduce sea turtle bycatch and bycatch mortality in the PLL fishery; requiring gangions to be placed no closer than twice the average gangion length from the suspending floatlines effective August 1, 2001; requiring gangion lengths to be 110 percent of the length of the floatline in sets of 100 meters or less in depth effective August 1, 2001; and, requiring the use of corrodible hooks effective August 1, 2001. Also, the BiOp included a term and condition for the ITS that recommended that NMFS issue a regulation requiring that all vessels permitted for HMS fisheries, commercial and recreational, post the sea turtle guidelines for safe handling and release following longline interactions inside the wheelhouse by September 15, 2001. The requirement that all vessels permitted for HMS fisheries post sea turtle handling and release guidelines was modified to specify only BLL and PLL vessels by an August 31, 2001 memorandum from the Office of Protected Resources.

On July 13, 2001, NMFS published an emergency rule (66 FR 36711) to implement several of the BiOp recommendations. NMFS published an amendment to the emergency rule to incorporate the change in requirements for the handling and release guidelines that was published in the Federal Register on September 24, 2001 (66 FR 48812). On July 9, 2002, NMFS published the final rule (67 FR 45393) implementing measures required under the June 14, 2001 BiOp on Atlantic HMS to reduce the incidental catch and post-release mortality of sea turtles and other protected species in HMS Fisheries, with the exception of the gangion placement measure. The rule implemented the NED closure, required the length of any gangion to be 10 percent longer than the length of any floatline if the total length of any gangion plus the total length of any floatline is less than 100 meters, and prohibited vessels from having hooks on board other than corrodible, non-stainless steel hooks. In the HMS shark gillnet fishery, both the observer and vessel operator are responsible for sighting whales, the vessel operator must contact NMFS regarding any listed whale takes as defined under MMPA, and shark gillnet fishermen must conduct net checks every 0.5 to 2 hours to look for and remove any sea turtles or marine mammals caught in their gear. The final rule also required all HMS BLL and PLL vessels to post sea turtle handling and release guidelines in the wheelhouse. NMFS did not implement the gangion placement requirement because it appeared to result in an unchanged number of interactions with loggerhead sea turtles and an apparent increase in interactions with leatherback sea turtles.

In 2001, 2002, and 2003, NMFS in conjunction with the fishing industry conducted an experiment in the NED to see if certain gear restrictions or requirements could reduce sea turtle captures and mortality. The results of this experiment indicated that certain gear types could reduce sea turtle interactions and mortality and that certain methods of handling and releasing turtles could further reduce mortality. For example, using 16/0 non-offset or 18/0 offset hooks of at least 10 degrees could reduce leatherback interactions by approximately 50 percent; however loggerhead sea turtle interactions were expected to stay the same. Using 18/0 hooks flat or offset up to 10 degrees could reduce leatherback and loggerhead sea turtle interactions by approximately 50 and 65 percent, respectively.

On November 28, 2003, based on the conclusion of the experiment in the NED, which examined ways to reduce bycatch and bycatch mortality of loggerhead and leatherback sea turtles in the PLL fishery, and based on preliminary data that indicated that the Atlantic PLL fishery may have exceeded the ITS in the June 14, 2001 BiOp, NMFS published a NOI to prepare a Supplemental Environmental Impact Statement (SEIS) to assess the potential effects on the human environment of proposed alternatives and actions under a proposed rule to reduce sea turtle bycatch (68 FR 66783).

In January 2004, NMFS reinitiated consultation after receiving data that indicated the Atlantic PLL fishery exceeded the incidental take statement for leatherback sea turtles in 2001 – 2002 and for loggerhead sea turtles in 2002. In the Spring of 2004, NMFS released a proposed rule that would require fishermen to use certain hook and bait types and take other measures to reduce sea turtle takes and mortality. The resulting June 1, 2004 BiOp considered these measures and concluded that the PLL fishery was not likely to jeopardize the continued existence of loggerhead sea turtles, but was still likely to jeopardize the continued existence of leatherback sea turtles. NMFS published a final rule implementing many gear and bait restrictions and requiring certain handling and release tools and methods on July 6, 2004 (69 FR 40734).

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.

NMFS implemented the final rule on June 25, 2007 (72 FR 34632), that prohibits gillnet fishing, including shark gillnet fishing, from November 15 to April 15, between the NC/SC border and 29° 00' N. The action was taken to prevent the significant risk to the wellbeing of endangered right whales from entanglement in gillnet gear in the core right whale calving area during calving season. Limited exemptions to the fishing prohibitions are provided for gillnet fishing for sharks and for Spanish mackerel south of 29°00' N. lat. Shark gillnet vessels fishing between 29° 00' N and 26° 46.5' N have certain requirements as outlined 50 CFR § 229.32 from December 1 through March 31 of each year. These include vessel operators contacting the Southeast Fisheries Science Center (SEFSC) Panama City Laboratory at least 48 hours prior to departure of a fishing trip in order to arrange for an observer.

In addition, a 2007 rule (October 5, 2007, 72 FR 57104) amended restrictions in the Southeast U.S. Monitoring Area from December 1 through March 31. In that area, no person may fish with or possess gillnet gear for sharks with webbing of 5" or greater stretched mesh unless the operator of the vessel is in compliance with the VMS requirements found in 50 CFR 635.69. The Southeast U.S. Monitoring Area is from 27°51' N. (near Sebastian Inlet, FL) south to 26°46.5' N. (near West Palm Beach, FL), extending from the shoreline or exemption line eastward to 80°00' W. In addition, NMFS may select any shark gillnet vessel regulated under the ALWTRP to carry an observer. When selected, the vessels are required to take observers on a mandatory basis in compliance with the requirements for at-sea observer coverage found in 50 CFR 229.7. Any vessel that fails to carry an observer once selected is prohibited from fishing pursuant to 50 CFR § 635. There are additional gear marking requirements that can be found at 50 CFR § 229.32.

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, equipment required for BLL vessels is now consistent with the requirements for the PLL fishery. Furthermore, this action implemented several year-round BLL closures to protect EFH to maintain consistency with the Caribbean Fishery Management Council.

Table 2. Chronological list of most of the Federal Register publications relating to Atlantic 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.

Federal Register Cite	**Date**	**Rule or Notice**
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
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

Federal Register Cite	Date	Rule or Notice
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
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

Federal Register Cite	Date	Rule or Notice
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
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

Federal Register Cite	Date	Rule or Notice
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
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 6966	2/14/2007	Notice of closure of the Small Coastal Shark fishery for the Gulf of Mexico
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 19701	4/19/2007	Notice of Small Costal Shark stock assessment workshop
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 39606	7/18/2007	Notice of Small Costal Shark 2007 peer review workshop
72 FR 41392	7/27/2007	Proposed rule for Amendment 2 to the Consolidated Atlantic Highly

Federal Register Cite	**Date**	**Rule or Notice**
		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 63888	11/13/2007	Notice of Small Coastal Shark Stock Assessment - notice of availability
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 24922	5/6/2008	Proposed rule for Atlantic tuna fisheries; gear authorization and turtle control devices
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
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 37932	7/2/2008	Notice of availability; notice of public scoping meetings; Extension of comment period for Amendment 3 to the 2006 Consolidated HMS FMP
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 54721	9/23/2008	Final rule for Atlantic tuna fisheries; gear authorization and turtle control devices
73 FR 63668	10/27/2008	Proposed rule for 2009 shark fishing season
73 FR 64307	10/29/2008	Extension of scoping comment period for Amendment 3 to the 2006 Consolidated HMS FMP
2009		
74 FR 8913	2/27/2009	Notice of Atlantic shark identification workshops and protected species safe handling, release, and identification workshops

Federal Register Cite	Date	Rule or Notice
74 FR26803	6/4/2009	Inseason action to close the commercial Gulf of Mexico non-sandbar large coastal shark fishery
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 36892	7/24/2009	Proposed rule for Amendment 3 to the 2006 Consolidated HMS FMP
74 FR 39914	8/10/2009	Extension of Comment Period for Amendment 3 to the 2006 Consolidated HMS FMP
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

Table 3. List of Large Coastal Shark Seasons, 1993-2010

Year	Open dates	Adjusted 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

Year	Open dates	Adjusted Quota (mt dw)
	GOM: July 6 – July 31 S. Atl: July 6 – Aug. 16 N. Atl: July 6 – Aug. 6	180 151.7 66.3
	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 All SHKs except LCS opened Jan 1; LCS opened July 24; Porbeagle closed Nov. 18	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)
	NSB GOM: July 24 - Dec. 31 NSB Atlantic: July 24 - Dec. 31 NSB Research: July 24 - Dec. 31 SB Research: July 24 - Dec. 31	390.5 187.5 37.5 87.9
2009	NSB GOM: Jan 23 - June 6 NSB Atl: Jan 23 - July 1 NSB Research: Jan 23 - July 1 SB: Jan 23 – Oct 14	390.5 187.8 37.5 87.9
2010	NSB GOM: Feb 4 – March 17 NSB Atl: July 15 – TBD NSB Research: Jan 5 – TBD SB: Jan 5 - TBD	390.5 169.7 37.5 87.9

Note: SB=sandbar shark; NSB=non-sandbar LCS

Table 4 List of Small Coastal Shark Seasons, 1993-2010

Year	Open Dates	Adjusted Quota (mt dw)
1993	No season	No Quota
1994	No season	No Quota
1995	No season	No Quota
1996	No season	No Quota
1997	Jan. 1 – June 30	880
	July 1 - Dec 31	880
1998	Jan. 1 – June 30	880
	July 1 - Dec 31	880
1999	Jan. 1 – June 30	880
	July 1 - Dec 31	880
2000	Jan. 1 – June 30	880
	July 1 - Dec 31	880
2001	Jan. 1 – June 30	880
	July 1 - Dec 31	880
2002	Jan. 1 – June 30	880
	July 1 - Dec 31	880
2003	Jan. 1 – June 30	163
	July 1 - Dec 31	163
2004	GOM: Jan. 1 – March 18 S. Atl: Jan 1 - June 30 N. Atl: Jan 1 - June 30	11.2 233.2 36.5
	GOM: July 1 – Dec. 31 S. Atl: July 1 – Dec. 31 N. Atl: July 1 – Dec. 31	10.2 210.2 33.2
2005	GOM: Jan 1 – April 30 S. Atl: Jan. 1 - April 30 N. Atl: Jan. 1 - April 30	13.9 213.5 18.6
	GOM: May 1 – Aug. 31 S. Atl: May 1 – Aug. 31 N. Atl: May 1 – Aug. 31	31 281 23
	GOM: Sept. 1 – Dec. 31 S. Atl: Sept. 1 – Dec. 31 N. Atl: Sept. 1 – Dec. 31	32 201.1 16
2006	GOM: Jan 1 – April 30 S. Atl: Jan 1 – April 30 N. Atl: Jan 1 – April 30	14.8 284.6 18.7
	GOM: May 1 – Aug. 31 S. Atl: May 1 – Aug. 31 N. Atl: May 1 – Aug. 31	38.9 333.5 35.9
	GOM: Sept. 1 – Dec. 31 S. Atl: Sept. 1 – Dec. 31 N. Atl: Sept. 1 – Dec. 31	30.8 263.7 28.2

Year	Open Dates	Adjusted Quota (mt dw)
2007	GOM: Jan. 1 – Feb. 23 S. Atl: Jan 1 – April 30 N. Atl: Jan 1 – April 30	15.1 308.4 18.8
	GOM: May 1 – Aug. 31 S. Atl: May 1 – Aug. 31 N. Atl: May 1 – Aug. 31	72.6 291.6 36.2
	GOM: September 1 – Dec. 31 S. Atl: September 1 – Dec. 31 N. Atl: September 1 – Dec. 31	80.4 297.5 29.4
2008	GOM: Jan 1 – April 30, 2008 S. Atl: Jan 1 – April 30, 2008 N. Atl: Jan 1 – April 30, 2008	73.2 354.9 19.3
	GOM: May 1 – July 24, 2008 S. Atl: May 1 – July 24, 2008 N. Atl: May 1 – July 24, 2008	72.6 74.1 12.0
	July 24 – Dec. 31, 2008	454
2009	January 23, 2009	454
2010	Open upon effective date of final rule for Amendment 3	TBD

Table 5 List of species that are LCS, SCS and 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*	
Great hammerhead	*Sphyrna mokarran*	
Smooth hammerhead	*Sphyrna zygaena*	
SCS		
Atlantic sharpnose	*Rhizoprionodon terraenovae*	
Blacknose	*Carcharhinus acronotus*	
Bonnethead	*Sphyrna tiburo*	
Finetooth	*Carcharhinus isodon*	
Pelagic Sharks		
Blue	*Prionace glauca*	
Oceanic whitetip	*Carcharhinus longimanus*	
Porbeagle	*Lamna nasus*	
Shortfin mako	*Isurus oxyrinchus*	
Common thresher	*Alopias vulpinus*	
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
Atlantic angel	*Squatina dumerili*	Part of SCS complex until 1999
Caribbean sharpnose	*Rhizoprionodon porosus*	Part of SCS complex until 1999
Smalltail	*Carcharhinus porosus*	Part of SCS complex until 1999
Bigeye sixgill	*Hexanchus nakamurai*	Part of Pelagics complex until 1999
Bigeye thresher	*Alopias superciliosus*	Part of Pelagics complex until 1999
Longfin mako	*Isurus paucus*	Part of Pelagics complex until 1999

Common name	Species name	Notes
Sevengill	*Heptranchias perlo*	Part of Pelagics complex until 1999
Sixgill	*Hexanchus griseus*	Part of Pelagics complex until 1999

<table>
<tr><th>Requirement for Specific Fishery</th><th>Retention Limits</th><th>Quotas</th><th>Other Requirements</th></tr>
<tr><td>Inside the Commercial Shark Research Fishery</td><td>Sandbar: Trip limit is specific to each vessel and owner(s) combination and is listed on the Shark Research Permit.
Non-sandbar LCS: Trip limit is specific to each vessel and owner (s) combination and is listed on the Shark Research Permit.
SCS & Pelagic Sharks:
Directed Permits:
No trip limit for pelagic sharks & SCS
Incidental Permits:
16 pelagic sharks/SCS combined</td><td>Sandbar:
Quota from 2008-2012: 87.9 mt dw
Quota starting in 2013: 116.6 mt dw
Non-sandbar LCS:
Quota from 2008-2012: 37.5 mt dw
Quota starting in 2013: 50 mt dw
SCS:454 mt dw/year
Pelagic Sharks:
Pelagic sharks (not blue and porbeagle): 273 mt dw/year
Blue sharks: 488 mt dw
Porbeagle sharks: 1.7 mt dw/year</td><td>- Need Shark Research Fishery Permit
-100 percent observer coverage when participating in research fishery
- Adjusted quotas (established through Dec. 31, 2012) may be further adjusted based on future overharvests, if any.</td></tr>
<tr><td>Outside the Commercial Shark Research Fishery</td><td>Non-sandbar LCS Until Dec. 31, 2012:
Directed Permit: 33 non-sandbar LCS/vessel/trip
Incidental Permit: 3 non-sandbar LCS/vessel/trip
Non-sandbar LCS As of Jan. 1, 2013:
Directed Permit: 36 non-sandbar LCS/vessel/trip
Incidental Permit: 3 non-sandbar LCS/vessel/trip
SCS & Pelagic Sharks:
Directed Permits:
No trip limit for pelagic sharks & SCS
Incidental Permits:
16 pelagic sharks/SCS combined</td><td>Non-sandbar LCS:
Quota from 2008-2012:
Gulf of Mexico Region: 390.5 mt dw/year;
Atlantic Region: 187.8 mt dw/year
Quota starting in 2013:
Gulf of Mexico Region: 439.5 mt dw/year;
Atlantic Region: 188.3 mt dw/year
SCS: 454 mt dw/year
Pelagic Sharks:
Pelagic sharks (not blue and porbeagle): 273 mt dw/year
Blue sharks: 488 mt dw
Porbeagle sharks: 1.7 mt dw/year</td><td>-Vessels subject to observer coverage, if selected
- Adjusted quotas (established through Dec. 31, 2012) may be further adjusted based on future overharvests, if any.</td></tr>
<tr><td rowspan="5">All Commercial Shark Fisheries</td><td colspan="3">Gears Allowed: Gillnet; Bottom/Pelagic Longline; Rod and Reel; Handline; Bandit Gear</td></tr>
<tr><td colspan="3">Authorized Species: Non-sandbar LCS (silky, blacktip, spinner, bull, lemon, nurse, great hammerhead, scalloped hammerhead, smooth hammerhead, and tiger sharks), pelagic sharks (porbeagle, common thresher, shortfin mako, oceanic whitetip, and blue sharks), and SCS (bonnethead, finetooth, blacknose, and Atlantic sharpnose sharks)</td></tr>
<tr><td colspan="3">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.</td></tr>
<tr><td colspan="3">Permits Required: Commercial Directed or Incidental Shark Permit</td></tr>
<tr><td colspan="3">Reporting Requirements: All commercial fishermen must submit commercial logbooks; all dealers must report bi-weekly</td></tr>
<tr><td rowspan="6">All Recreational Shark Fisheries</td><td colspan="3">Gears Allowed: Rod and Reel; Handline</td></tr>
<tr><td colspan="3">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)</td></tr>
<tr><td colspan="3">Landing condition: Sharks must be landed with head, fins, and tail naturally attached</td></tr>
<tr><td colspan="3">Retention limits: 1 shark > 54” FL vessel/trip, plus 1 Atlantic sharpnose and 1 bonnethead per person/trip (no minimum size)</td></tr>
<tr><td colspan="3">Permits Required: HMS Angling; HMS Charter/Headboat; and, General Category Permit Holders (fishing in a shark tournament)</td></tr>
<tr><td colspan="3">Reporting Requirements: Participate in MRIP and LPS if contacted</td></tr>
</table>

Table 6 Summary of current shark regulations

Definitions of Acronyms in Table 1: Fork Length (FL); Highly Migratory Species (HMS); Large Coastal Sharks (LCS); Large Pelagic Survey (LPS); Marine Recreational Information Program (MRIP); Small Coastal Sharks (SCS).

Control Date Notices

February 22, 1994 (59 FR 8457)

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
Current stock biomass status	Overfished

Table 8 General management information for the dusky shark

Species	Dusky shark (*Carcharhinus obscurus*)
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
Current stock biomass status	Overfished

Table 9 General management information for the blacknose shark

Species	Blacknose shark (*Carcharhinus acronotus*)
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
Current stock biomass status	Overfished

Table 10 Specific management criteria for sandbar shark

Criteria	Sandbar - Current		Sandbar - Proposed	
	Definition	Value	Definition	Value
MSST	MSST = [(1-M)*B_{MSY} when M<0.5; 0.5* B_{MSY} when M≥0.5	4.75-5.35E+05	MSST = [(1-M)*B_{MSY} when M<0.5; 0.5* B_{MSY} when M≥0.5	SEDAR 21
MFMT	F_{MSY}	0.015	F_{MSY}	SEDAR 21
MSY	Yield at F_{MSY}	4.03E+05(kg)	Yield at F_{MSY}	SEDAR 21
F_{MSY}	MFMT	0.015	MFMT	SEDAR 21
OY	Yield at F_{OY}	Not Specified	Yield at F_{OY}	SEDAR 21
F_{OY}	0.75F_{MSY}	0.011	0.75F_{MSY}	SEDAR 21
$F_{current}$	Current Fishing Mortality rate	0.06	$F_{current}$	SEDAR 21
M	n/a	Varied (see SEDAR 11)	n/a	SEDAR 21
OFL	n/a	n/a	MFMT*$B_{current}$	SEDAR 21
ABC*	n/a	n/a	P*; probability level TBD	SEDAR 21
SSF_{2004}	Current Spawning Stock fecundity	4.28E+0.5	$SSF_{current}$	SEDAR 21
SSF_{MSY}	Spawning Stock fecundity at MSY	5.94E+05	SSF_{MSY}	SEDAR 21
B_{2004}	Current biomass	3.06E+07	$B_{current}$	SEDAR 21
B_{MSY}	Biomass at MSY	Not Specified	B_{MSY}	SEDAR 21

*Acceptable Biological Catch

Table 11 Specific management criteria for dusky shark.

Criteria	Dusky - Current		Dusky - Proposed	
	Definition	Value	Definition	Value
MSST	MSST = [(1-M)*B_{MSY} when M<0.5; 0.5* B_{MSY} when M≥0.5	Not Specified	MSST = [(1-M)*B_{MSY} when M<0.5; 0.5* B_{MSY} when M≥0.5	SEDAR 21
MFMT	F_{MSY}	0.00005-0.0115	F_{MSY}	SEDAR 21
MSY	Yield at F_{MSY}	152 (kg)	Yield at F_{MSY}	SEDAR 21
F_{MSY}	MFMT	0.00005-0.0115	MFMT	SEDAR 21
OY	Yield at F_{OY}	Not Specified	Yield at F_{OY}	SEDAR 21
F_{OY}	0.75F_{MSY}	0.000038-0.0086	0.75F_{MSY}	SEDAR 21
F_{2003}		0.0194 (BSP model)	$F_{current}$	SEDAR 21
M	n/a	Varied (see Cortés et al., 2006)	n/a	SEDAR 21
OFL	n/a	n/a	MFMT*$B_{current}$	SEDAR 21
ABC	n/a	n/a	P*; probability level TBD	SEDAR 21
B_{2003}	Current Biomass	687,290 lb dw (BSP model)	$B_{current}$	SEDAR 21
B_{MSY}	Biomass at MSY	4,409,144 (BSP model)	B_{MSY}	SEDAR 21

Table 12 Specific management criteria for blacknose shark.

Criteria	Blacknose - Current		Blacknose - Proposed	
	Definition	Value	Definition	Value
MSST	MSST = [(1-M)*B_{MSY} when M<0.5; 0.5* B_{MSY} when M≥0.5	4.3 E+05	MSST = [(1-M)*B_{MSY} when M<0.5; 0.5* B_{MSY} when M≥0.5	SEDAR 21
MFMT	F_{MSY}	0.07	F_{MSY}	SEDAR 21
MSY	Yield at F_{MSY}	89,415 (number of sharks)	Yield at F_{MSY}	SEDAR 21
F_{MSY}	MFMT	0.07	MFMT	SEDAR 21
OY	Yield at F_{OY}	Not Specified	Yield at F_{OY}	SEDAR 21
F_{OY}	0.75F_{MSY}	0.053	0.75F_{MSY}	SEDAR 21
F_{2005}		0.24	$F_{current}$	SEDAR 21
M	n/a	Varied (see SEDAR 13)	n/a	SEDAR 21
OFL	n/a	n/a	MFMT*$B_{current}$	SEDAR 21
ABC	n/a	n/a	P*; probability level TBD	SEDAR 21
N_{MSY}	Number of sharks at MSY	570,753 (number of sharks)	N_{MSY}	SEDAR 21
N_{2005}	Current number of sharks	349,308 (number of sharks)	$N_{current}$	SEDAR 21
SSF_{MSY}	Spawning Stock fecundity at MSY	349,060 (number of sharks)	SSF_{MSY}	SEDAR 21
SSF_{2005}	Current Spawning Stock fecundity	168,140 (number of sharks)	$SSF_{current}$	SEDAR 21

Stock Rebuilding Information

<u>Sandbar Sharks</u>

The following rebuilding information is requested:

- Include information regarding significance of catch-per-unit effort (CPUE) trend series for sandbar sharks. The HMS Management Division finds these series helpful for management;
- Estimate the acceptable biological catch (ABC) according to the control rule guidelines established by the SEFSC in both weight and numbers of sharks. A table showing different values of ABC at various P* levels is acceptable;
- Determine the probability of rebuilding sandbar sharks by 2070, which is the current rebuilding timeframe for sandbars under Amendment 2 to the 2006 Consolidated HMS FMP. Such projections should consider current harvest (including commercial landings, discards, and recreational landings) as well as the current total allowable catch (TAC) of 220 mt ww (158 mt dw);

- If the current TAC would not allow rebuilding by 2070, calculate the TAC corresponding to 50 and 70 percent probability of rebuilding by 2070 in both weight and number of sharks and the corresponding F value;
- If rebuilding could occur before 2070, please provide the appropriate TAC (in both weight and number of sharks) to ensure a 50 and 70 percent probability of rebuilding and the new timeframe. Please also estimate the corresponding F value;
- Provide the average weight of sandbar sharks caught in the commercial (by gear type) and recreational fisheries in 2008 and 2009; and,
- It is requested that the analysts provide estimates of the following items in both weight and numbers of sharks:
    - MSY;
    - Reduction in harvest needed to reach MSY (if harvest needs to be different from current management regime);
    - Commercial landings through 2009;
    - Dead discard estimates through 2009; and
    - Recreational harvest through 2009.

<u>Dusky Sharks</u>

The following rebuilding information is requested:

- Include information regarding significance of CPUE trend series for dusky sharks. The HMS Management Division finds these series helpful for management;
- Estimate the ABC according to the control rule guidelines established by the SEFSC in both weight and numbers of sharks. A table showing different values of ABC at various P* levels is acceptable;; although dusky sharks have been prohibited in the commercial and recreational fisheries since 2000, it would be helpful to have this estimate to determine if levels of discards are sustainable;
- Determine the probability of rebuilding within at least 100 years, which is the current rebuilding timeframe for dusky sharks under Amendment 2 to the 2006 Consolidated HMS FMP. Such projections should consider current harvest (including commercial landings, discards, and recreational landings). In addition, the HMS Management Division requests that the analysts investigate how decreased or increased landings/discards would affect rebuilding for this species;
- If rebuilding will not occur within at least 100 years, calculate the new rebuilding timeframe and an associated TAC (in both weight and number of sharks) and F value that would allow a 50 and 70 percent probability of rebuilding. Again, although dusky sharks have been prohibited since 2000, this information would be helpful for determining whether or not current discard levels are sustainable;
- Provide the average weight of dusky sharks caught in the commercial (by gear type) and recreational fisheries in 2008 and 2009; and,
- It is requested that the analysts provide estimates of the following items in both weight and numbers of sharks:
    - MSY;

  - Reduction in landings and discards needed to reach MSY (if harvest needs to be different from current management regime);
  - Commercial landings through 2009;
  - Dead discard estimates through 2009; and
  - Recreational harvest through 2009.

Blacknose Sharks

The following rebuilding information is requested:

- Include information regarding significance of CPUE trend series for blacknose sharks. The HMS Management Division finds these series helpful for management;
- Estimate the ABC according to the control rule established by the SEFSC in both weight and numbers of sharks;
- Determine the probability of rebuilding blacknose sharks by 2027, which is the current rebuilding timeframe for sandbars under Amendment 3 to the 2006 Consolidated HMS FMP. Such projections should consider current harvest (including commercial landings, discards, and recreational landings) as well as the current total allowable catch (TAC) of 19,200 blacknose sharks;
- If the current TAC would not allow rebuilding by 2027, calculate the TAC corresponding to 50 and 70 percent probability of rebuilding by 2027 in both weight and number of sharks and the corresponding F value;
- If rebuilding could occur before 2027, please provide the appropriate TAC (in both weight and number of sharks) to ensure a 50 and 70 percent probability of rebuilding and the new timeframe. Please also estimate the corresponding F value;
- Provide the average weight of blacknose sharks caught in the commercial (by gear type) and recreational fisheries in 2008 and 2009; and,
- It is requested that the analysts provide estimates of the following items in both weight and numbers of sharks:
  - MSY;
  - Reduction in harvest needed to reach MSY (if harvest needs to be different from current management regime);
  - Commercial landings through 2009;
  - Dead discard estimates through 2009; and
  - Recreational harvest through 2009.

Table 13 Stock Projection Information for Sandbar Sharks

Requested Information	Value
First year under current rebuilding program	2008
End year under current rebuilding program	2070
First Year of Management based on this assessment	2013
Projection Criteria during interim years should be based on (e.g., exploitation or harvest)	F=0; Fixed Exploitation; Modified Exploitation; Fixed Harvest*; F=220 mt ww (current TAC)
Projection criteria values for interim years should be determined from (e.g., terminal year, avg of X years)	Average landings of previous 2 years (2008, 2009)

Table 14 Stock Projection Information for Dusky Sharks

Requested Information	Value
First year under current rebuilding program	2008
End year under current rebuilding program	>2108
First Year of Management based on this assessment	2013
Projection Criteria during interim years should be based on (e.g., exploitation or harvest)	F=0; Fixed Exploitation; Modified Exploitation; Fixed Harvest*
Projection criteria values for interim years should be determined from (e.g., terminal year, avg of X years)	Average landings of previous 2 years (2008, 2009)

Table 15 Stock Projection Information for Blacknose Sharks

Requested Information	Value
First year under current rebuilding program	2010
End year under current rebuilding program	2027
First Year of Management based on this assessment	2013
Projection Criteria during interim years should be based on (e.g., exploitation or harvest)	F=0; Fixed Exploitation; Modified Exploitation; Fixed Harvest*; F=19,200 blacknose sharks (current TAC)
Projection criteria values for interim years should be determined from (e.g., terminal year, avg of X years)	Average landings of previous 2 years (2008, 2009)

*Fixed Exploitation would be $F=F_{MSY}$ (or $F<F_{MSY}$) that would rebuild overfished stock to B_{MSY} in the allowable timeframe. Modified Exploitation would be allow for adjustment in $F<=F_{MSY}$, which would allow for the largest landings that would rebuild the stock to B_{MSY} in the allowable timeframe. Fixed harvest would be maximum fixed harvest with $F<=F_{MSY}$ that would allow the stock to rebuild to B_{MSY} in the allowable timeframe.

First year of Management: Earliest year in which management changes resulting from this assessment are expected to become effective

Interim years: Those years between the terminal assessment year and the first year that any management could realistically become effective.

Projection Criteria: The parameter which should be used to determine population removals, typically either an exploitation rate or an average landings value or a pre-specified landings target.

Quota Calculations

Sandbar Sharks

Table 16 Quota calculation details for sandbar sharks.

Current Quota Value	Commercial Quota = 87.9 mt dw (2008-2012)
Next Scheduled Quota Change	2013; commercial quota = 116.6 mt dw
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 landings

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). Based on that TAC, the HMS Management Division subtracted average annual recreational landings 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. 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 is scheduled to increase to 116.6 mt dw in 2013.

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.

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 3 shows the history of shark quotas adjusted for under and overharvest. Underharvests are no longer applied to stocks that have been determined to be overfished, have overfishing occurring, or an unknown stock status.

Dusky Sharks

Table 17 Quota calculation details for dusky sharks.

Current Quota Value	0
Next Scheduled Quota Change	N/A
Annual or averaged quota?	N/A
If averaged, number of years to average	-
Does the quota include bycatch/discard ?	N/A

How is the quota calculated - conditioned upon exploitation or average landings?

Dusky sharks have been prohibited from commercial and recreational harvest since 2000. The commercial quota set for this species is 0 mt dw; however, they are caught and discarded in the shark fisheries, and also show up in the commercial logbooks and in recreational landings.

Does the quota include bycatch/discard estimates? If so, what is the source of the bycatch/discard values? What are the bycatch/discard allowances?

As mentioned above, there is no commercial quota.

Are there additional details of which the analysts should be aware to properly determine quotas for this stock?

The HMS Management Division requests the analysts to estimate discards of dusky sharks in both the shark fisheries and other fisheries and how discards may have changed since the implementation of Amendment 2 (July 2008).

Blacknose Sharks

Table 18 Quota calculation details for blacknose sharks.

Current Quota Value	Commercial Quota = (SCS complex) 454 mt dw
Next Scheduled Quota Change	Summer 2010; preferred commercial quota = 19.9 mt dw (blacknose specific)
Annual or averaged quota?	Annual quota
If averaged, number of years to average	-
Does the quota include bycatch/discard ?	Current quota does not include discards

How is the quota calculated - conditioned upon exploitation or average landings?

The quota was determined in 2003 for the SCS complex under Amendment 1 to the 1999 FMP. The quota was based upon 75 percent of the average MSY for the complex, multiplied by the percent contribution of the commercial catch to total catch of the SCS complex.

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.

Are there additional details of which the analysts should be aware to properly determine quotas for this stock?

The HMS Management Division requests that the analysts keep in mind that Amendment 3 will be implemented for the SCS fishery during the summer of 2010, and blacknose sharks will be subject to a new quota of 19.9 mt dw, which is a 64 percent reduction in blacknose shark landings relative to average landings from 2004-2008.

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 19 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

*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 20 Annual commercial dusky shark regulatory summary (managed in LCS complex until 2000 when placed on the prohibited species complex).

Year	*Base Quota (LCS complex)*	*Fishing Year*	*Possession Limit*
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	0-prohibited	None	0-prohibited
2001	0-prohibited	None	0-prohibited
2002	0-prohibited	None	0-prohibited
2003	0-prohibited	None	0-prohibited
2004	0-prohibited	None	0-prohibited
2005	0-prohibited	None	0-prohibited
2006	0-prohibited	None	0-prohibited
2007	0-prohibited	None	0-prohibited
2008	0-prohibited	None	0-prohibited
2009	0-prohibited	None	0-prohibited

*Limited Access Permits (LAPs) were implemented for the shark and swordfish fisheries under 1999 FMP

Table 21 Annual commercial blacknose shark regulatory summary (managed within the SCS complex).
Note: Regions = Gulf of Mexico, South Atlantic, and North Atlantic

		Fishing Year			**Possession Limit**
Year	*Base Quota (SCS complex)*	*N. Atlantic*	*S. Atlantic*	*Gulf*	*All regions*
1993	No quota	One region; calendar year with two fishing periods			No trip limit
1994	No quota	One region; calendar year with two fishing periods			No trip limit
1995	No quota	One region; calendar year with two fishing periods			No trip limit
1996	No quota	One region; calendar year with two fishing periods			No trip limit
1997	1,760 mt dw	One region; calendar year with two fishing periods			No trip limit
1998	1,760 mt dw	One region; calendar year with two fishing periods			No trip limit
1999	1,760 mt dw	One region; calendar year with two fishing periods			No trip limit for SCS/pelagics for directed permit holders; 16 SCS & pelagic sharks combined/trip for incidental permit holders*
2000	1,760 mt dw	One region; calendar year with two fishing periods			No trip limit for SCS/pelagics for directed permit holders; 16 SCS & pelagic sharks combined/trip for incidental permit holders
2001	1,760 mt dw	One region; calendar year with two fishing periods			No trip limit for SCS/pelagics for directed permit holders; 16 SCS & pelagic sharks combined/trip for incidental permit holders
2002	1,760 mt dw	One region; calendar year with two fishing periods			No trip limit for SCS/pelagics for directed permit holders; 16 SCS & pelagic sharks combined/trip for incidental permit holders
2003	326 mt dw	One region; calendar year with two fishing periods but ridgeback and non-ridgeback split-see Table 3)			No trip limit for SCS/pelagics for directed permit holders; 16 SCS & pelagic sharks combined/trip for incidental permit holders
2004	454 mt dw	Regions with two fishing seasons	Regions with two fishing seasons	Regions with two fishing seasons (fishery closed on March 18, 2004 – see Table 4)	No trip limit for SCS/pelagics for directed permit holders; 16 SCS & pelagic sharks combined/trip for incidental permit holders
2005	454 mt dw	Trimesters/Regions	Trimesters/Regions	Trimesters/Regions	No trip limit for SCS/pelagics for directed permit holders; 16 SCS & pelagic sharks combined/trip for incidental permit holders
2006	454 mt dw	Trimesters/Regions	Trimesters/Regions	Trimesters/Regions	No trip limit for SCS/pelagics for directed permit holders; 16 SCS & pelagic sharks combined/trip for incidental permit holders
2007	454 mt dw	Trimesters/Regions	Trimesters/Regions	Trimesters/Regions (fishery closed on Feb. 23, 2007 – see Table 4)	No trip limit for SCS/pelagics for directed permit holders; 16 SCS & pelagic sharks combined/trip for incidental permit holders
2008**	454 mt dw	One region; calendar year			No trip limit for SCS/pelagics for directed permit holders; 16 SCS & pelagic sharks combined/trip for incidental permit holders

2009**†	454 mt dw	One region; calendar year	No trip limit for SCS/pelagics for directed permit holders; 16 SCS & pelagic sharks combined/trip for incidental permit holders

*Limited Access Permits (LAPs) were implemented for the shark and swordfish fisheries under 1999 FMP

**Sharks required to be offloaded with all fins naturally attached under Amendment 2.

†DEIS for Amendment 3 proposed a blacknose-specific quota of 14.9 mt dw and a non-blacknose SCS quota of 56.9 mt dw and prohibition of landing sharks with gillnet gear from South Carolina south.

Table 22. 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	0
2009*	Prohibited	N/A	0

*Retention prohibited in recreational fishery under Amendment 2.

Table 23. Annual recreational dusky shark regulatory summary (managed within the LCS complex until 2000 when prohibited in commercial and recreational fisheries).

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	Prohibited	N/A	0
2001	Prohibited	N/A	0
2002	Prohibited	N/A	0
2003	Prohibited	N/A	0
2004	Prohibited	N/A	0
2005	Prohibited	N/A	0
2006	Prohibited	N/A	0
2007	Prohibited	N/A	0
2008	Prohibited	N/A	0
2009	Prohibited	N/A	0

Table 24. Annual recreational blacknose shark regulatory summary (managed within the SCS complex).

Year	Fishing Year	Size Limit	Bag Limit
1993	Calendar Year	No size limit	5 SCS sharks/person
1994	Calendar Year	No size limit	5 SCS sharks/person
1995	Calendar Year	No size limit	5 SCS sharks/person
1996	Calendar Year	No size limit	5 SCS sharks/person
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	Calendar Year	Minimum size =4.5 ft	1 LCS/SCS/pelagic shark combined/vessel/trip
2009	Calendar Year	Minimum size =4.5 ft	1 LCS/SCS/pelagic shark combined/vessel/trip

Table 7. State Regulatory History

Alabama *(not confirmed by state):*

Pre-1995: No shark regulations

1996: First shark regulations implemented: state shark fishery closes with the federal shark fishery

1998: By 1998: only short lines in state waters; time/area and size restrictions on the recreational use of gillnets

2004: 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

2006: 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

2007: No new shark regulations

2008: No new shark regulations

2009: 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

Connecticut *(confirmed by state):*

Pre-1995 - 2008: No shark regulations

2009: July: No possession or landing of large coastal shark species by any commercial fishing gear or for commercial purposes.

2010: 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

Delaware *(confirmed by state):*

Pre-1995: No shark regulations

1998: 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

2000: 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)

2009: ASMFC Plan

Florida *(confirmed by state):*

Pre-1995: 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 without corresponding carcass; released sharks should be released in a manner that maximizes survival; recreationally caught sharks cannot be transferred at sea; recreationally caught 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

1998: By 1998: ban on longlines; 1998: Added sand tiger, bigeye sandtiger, and white sharks to prohibited species list; prohibition on filleting sharks at sea.

2006: March: Same prohibited species as federal regulations, except Caribbean sharpnose is not included

2010: 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.

Georgia *(confirmed by state):*

Pre-1995: 1950s: ban on gillnets and longlines; All finfish spp. must be landed with head and fins intact

1998: 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

2000: Sharks may not be landed in Georgia if harvested using gillnets

2009: 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.

Louisiana *(not confirmed by state):*

Pre-1995:

1997: Ban on entanglement nets

1998: No new shark regulations

2004: 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

2006: 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

2008: By Oct 2008: Commercial: 33 per vessel per trip limit, no min size

Maine *(not confirmed by state):*

Pre-1995: No shark regulations

1998: By 1998: large state water closures to gillnets resulting in virtually no gillnet fishery; 1998: no shark regulations

2009: Maximum 5 % fin-to-carcass ratio

Maryland *(not confirmed by state):*

1996: 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

1998: 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.

2004: 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.

2009: ASMFC Plan

Massachusetts *(not confirmed by state):*

Pre-1995 - 2006: No shark regulations

2006: By May 2006: Prohibition on harvest, catch, take, possession, transportation, selling or offer to sell any basking, dusky, sand tiger, or white sharks.

Mississippi *(not confirmed by state):*

1997: 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

2008: By Oct 2008: Recreational bag limit - LCS/Pelagics 1/person up to 3/vessel; SCS 4/person; Commercial & Prohibited Species - Reference to federal regulations

New Hampshire *(not confirmed by state):*

Pre-1995-2008: No shark regulations

2009: No commercial take of porbeagle

New Jersey *(not confirmed by state):*

Pre-1995: No shark regulations

1998: No shark-specific regulations; by 1998: no longline fishing; restrictions on the use of gillnets

2004: 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

2006: By May 2006: no sale during federal closures; Finning prohibited; Prohibited Species: basking, bigeye sand tiger, sand tiger, whale and white sharks

New York *(not confirmed by state):*

1998: By 1998: prohibition on finning sharks; no other shark regulations

2004: By Feb 2004: reference to federal regs 50 CFR part 635; prohibited sharks listed

North Carolina *(confirmed by state):*

Pre-1995: 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%

1997: 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 possess or land dried shark fins

2000: 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

2003: April: Prohibited ridgebacks (sandbar, silky, and tiger sharks) from Large Coastal Group

2006: 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

2008: July: Adopted federal regulations of 33 Large Coastal sharks per trip and fins must be naturally attached to carcass

2009: Fins must be naturally attached to shark carcass

Puerto Rico *(confirmed by state):*

Pre-1995-2004: No shark regulations

2004: 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.

Rhode Island *(not confirmed by state):*

No shark regulations

South Carolina *(not confirmed by state):*

1998: By 1998: federal regs adopted by reference; use of gillnets prohibited in the shark fishery

2004: 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

2006: By May 2006: non-Atlantic sharpnose/bonnethead sharks – 1 shark/boat/trip, min size – 54" FL

Texas *(confirmed by state):*

Pre-1995: 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

2004: 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

2009: 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

Virginia *(not confirmed by state):*

Pre-1995: 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

1997: 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

1998: By 1998: no longlining in state waters

2006: 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

2009: ASMFC Plan

3. ASSESSMENT HISTORY AND REVIEW

The sandbar shark was first assessed individually in 1998 and later in 2002 and 2006. 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.

References

Cortés, E., L. Brooks, and G. Scott. 2002. Stock assessment of large coastal sharks in the U.S. Atlantic and Gulf of Mexico. Sustainable Fisheries Division Contribution SFD-02/03-177. 222 pp.

NMFS (National Marine Fisheries Service). 1998. Report of the Shark Evaluation Workshop. NOAA/NMFFS Panama City Laboratory.

NMFS (National Marine Fisheries Service). 2006. Southeast Data, Assessment and Review (SEDAR) 11. Large Coastal Shark complex, blacktip and sandbar shark stock assessment report. NOAA/NMFS Highly Migratory Species Division, Silver Spring, MD.

4. ASSESSMENT SUMMARY

The Summary Report provides a broad but concise view of the salient aspects of the stock assessment. It recapitulates: (a) the information available to and prepared by the Data Workshop; (b) the application of those data, development and execution of one or more assessment models, and identification of the most reliable model configuration as the base run by the Assessment Process (AP); and (c) the findings and advice determined during the Review Workshop.

Stock Status and Determination Criteria

Assessment results showed that the stock was overfished and therefore subject to rebuilding. Current F values over most sensitivities indicated that the stock was not currently subject to overfishing (F_{2009}/F_{MSY} 0.29 to 0.93). However, the low productivity scenario indicated overfishing (F_{2009}/F_{MSY} of 2.62).

Table 1. Summary of stock status determination criteria.

Criteria	Recommended Values from SEDAR 21	
	Definition	Value*
M (Instantaneous natural mortality; per year)	Arithmetic mean of the age-specific values of M used for the baseline run	0.136
F_{2009} (per year)	Apical Fishing mortality in 2009	0.013
F_{MSY} (per year)	F_{MSY}	0.021
N_{MSY} (numbers)	Abundance at MSY	1,928,165
SSF_{2009} (numbers)	Spawning Stock Fecundity** in 2009	312,890
SSF_{MSY} (numbers)	Spawning Stock Fecundity at MSY	477,590
MSST (numbers)	$(1\text{-}M)SSF_{MSY}$	412,638
MFMT (per year)	F_{MSY}	0.021
MSY (numbers)	Maximum Sustainable Yield	160,643
F_{Target} (per year)	75%F_{MSY}	0.016
Biomass Status	SSF_{2009}/SSF_{MSST}	0.76
Exploitation Status	F_{2009}/F_{MSY}	0.62

* Values presented are from the base model configuration but it is important to note that that the Review Panel recommended all runs in the addendum be considered equally plausible
** SSF is spawning stock fecundity (sum of number at age times pup production at age)

Stock Identification and Management Unit

After considering the available data, the Data Workshop Life History working group decided that sandbar sharks occurring in the U.S. waters of the western North Atlantic Ocean (including the

Gulf of Mexico) should be considered as a single stock. 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.

Species Distribution:

The sandbar shark is a common inshore and offshore coastal-pelagic 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. The largest nursery area for sandbar sharks is reported to be in the Chesapeake Bay, with known smaller nursery areas along the east coast of the US in Delaware, Virginia, South Carolina, and Florida, and also in the Gulf of Mexico. Sandbar sharks are known to migrate large distances, with seasonal north-south migrations off the US eastern coast and into the Gulf of Mexico.

Stock Life History

- There are currently no natural mortality estimates for sandbar shark available based on direct empirical data, therefore the Data Workshop Panel concluded that the range of survivorship estimates at age to be used for priors were to be based on Peterson and Wroblewski and Lorenzen estimates without using the Lorenzen-Hoenig hybrid.
- A 2.5 year reproductive cycle was incorporated in the base model configuration, providing a balance between the biennial and triennial reproductive periods discussed.
- Given there is a positive relationship between maternal age and litter size, the Data Workshop Panel recommended using this relationship instead of an average litter size estimate for all age classes. The sex ratio of embryos was not significantly different from 1:1 for all data sources discussed.
- Three-parameter von Bertalanffy growth curves were fitted to male and female sandbar shark data separately and growth parameters were estimated as male $L_\infty = 172.97 \pm 1.30$ cm FL, female $L_\infty = 181.15 \pm 1.45$ cm FL, male $k = 0.15 \pm 0.005$, female $k = 0.12 \pm 0.004$, male $t_0 = -2.33 \pm 0.19$, and female $t_0 = -3.09 \pm 0.16$.
- The oldest aged sandbar shark was a 27 year old female.

Assessment Methods

The state-space, age-structured production model (ASPM) was used as the primary assessment modeling approach. The ASPM allows incorporation of many of the important biological (mortality, growth, reproduction) and fishery (selectivity, effort) processes in conjunction with observed catches and CPUE indices (and age compositions if available).

- The base case model configuration downweighted the historical catches (1960-1980), giving them ½ of the weight of catches from 1981-2009, on the rationale that they were less well known (as was done in the last assessment in 2006).
- The model started in 1960 and ended in 2009, with the historic period covering 1960-1980, and the modern period spanning 1981-2009.
- Estimated model parameters were pup (age-0) survival, virgin recruitment (R_0), catchability coefficients associated with catches and indices (q_i), and fleet-specific effort (e_i).
- Virgin recruitment was given a uniform prior distribution ranging from 1000 to 10 billion individuals, whereas pup survival was given an informative lognormal prior with median=0.81 (mean=0.85, mode=0.77), a CV of 0.3, and bounded between 0.50 and 0.99. The mean value for pup survival matched closely that derived using life-history based methods.

Assessment Data

- Commercial landings were split into a Gulf of Mexico and an Atlantic component.
- Recreational annual catch estimates are the sum of estimates reported in the MRFSS (fish landed [A] and discarded dead [B1]), Headboat survey (fish landed) and Texas Parks and Wildlife Department survey (fish landed).
- Catches of sandbar sharks caught in the states of Tamaulipas and Veracruz in Mexico, 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 2001-2009.
- Eleven indices were included in the base assessment: eight fishery-independent series (VIMS LL, NELL, NMFS Coastspan age-1+ LL, GA Coastspan LL, SC Coastspan LL, SCDN Historic red drum LL, PCGN, and NMFS SE LL) and three fishery-dependent series (the commercial BLLOP and PLLOP observer indices and the recreational LPS).
- Length-frequency information from animals caught in scientific observer programs, recreational fishery surveys, and various fishery-independent surveys was used to generate age-frequency distributions through age-length keys.
- The life history inputs used in the assessment included age and growth, as well as several parameters associated with reproduction, including sex ratio, reproductive frequency, fecundity at age, maturity and maternity at age, and month of pupping, and natural mortality. The ASPM uses most life history characteristics as constants (inputs) and others are estimated parameters, which are given priors and initial values.

Catch Trends

- The commercial landings of sandbar sharks increased overall from 1981 to a peak in 1994 (126,300 sharks) and steadily declined thereafter.
- Although sandbar sharks were caught in a variety of different gear types, since 1987 the majority of landings occurred in longline and gillnet fisheries.

- Landings of sandbar sharks were reported in the North Atlantic (Maine to New Jersey), Mid-Atlantic (New Jersey to Virginia), South Atlantic (North Carolina to east coast of Florida) and Gulf of Mexico (west coast of Florida to Texas) regions.
- The majority of sandbar shark landings from 1987 to 2009 occurred in the Gulf of Mexico (53%) and in the South Atlantic (31%) regions with a minority of landings in the Mid-Atlantic (16%). Most landings were along the east and west coasts of Florida and in North Carolina.

Fishing Mortality Trends

Fishing mortality was very low in 1960-1981 in accordance with very reduced catches and effort during that period. Starting in 1982, fishing mortality widely oscillated but always exceeded the estimated F_{MSY} of 0.021. Fishing mortality dropped below F_{MSY} in 2008 and 2009 in accordance with reduced catches imposed by management and increasing trends of some of the indices.

Stock Abundance and Biomass Trends

- All trajectories show little depletion from 1960 to 1982 (a few years later for SSF), corresponding to very reduced catches, effort and estimated F in the historic period, and a marked decline until 2007, followed by stabilization until 2009.
- Decreasing biomass and abundance in 1983-2007 correspond to increased catches 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 tendencies for some of the indices in those years.
- The first six age classes made up about 50% of the population in any given year and mean age by year varied very little (min=6.80, max=7.73).
- The ASPM does not model age 0s and thus no predicted age-0 recruits are produced, only the estimated virgin number of age-1 recruits. The predicted virgin recruitment (R_0; number of age 1 pups) was 563,000 animals.
- The predicted steepness was 0.29 and the maximum lifetime reproductive rate was 1.64. The estimated pup (age-0) survival was 0.84 (see next section for further discussion on pup survival).

Projections

A new projection methodology was used to better incorporate the uncertainties observed in the stock assessment model. The method uses a multivariate normal bootstrap around pup survival, fishing mortality and spawning stock biomass to project stock status under various fishing and catch scenarios.

- The target year for rebuilding ranged between 2047 and 2360 depending on the state of nature of the stock. When excluding the low productivity scenario (RW-4), which seems unrealistic, the rebuilding year ranged between 2047 and 2083, thus it was lower than for the previous assessment (2070), except for S6 (3-yr cycle).

- All scenarios suggested that fishing mortality needed to be reduced with respect to the 2009 level to meet rebuilding targets with a 70% probability, except for scenarios RW-1(high catch) and RW-3(high productivity), likely due to the fact that these two scenarios modeled the stock as more productive.
- The TAC-based projections to meet rebuilding targets with 70% probability mirrored the general trends of the F-based projections. The three scenarios with higher inferred productivity (S5, RW-1, and RW-3) resulted in higher estimates than the current TAC.
- The results over all scenarios ranged from 168 to 522 mt whole weight (using a dressed to whole weight conversion ratio of 2.0) or 84 to 261 mt dressed weight.
- The low and high productivity scenarios were meant to encapsulate all the other scenarios by pushing the lower and upper bounds on the life history parameters. For projection purposes, both scenarios are unlikely to represent a true state of nature.

Scientific Uncertainty

- Uncertainty in parameter estimates was quantified by computing asymptotic standard errors for each parameter.
- Likelihood profiling was performed to examine posterior distributions for several model parameters and to provide probabilities of the stock being overfished and overfishing occurring.
- Uncertainty in data inputs and model configuration was examined through the use of sensitivity scenarios. Sixteen alternative runs, along with retrospective analyses were also examined.
- The reviewers identified four additional sensitivity analyses to run to provide verification that the results of the assessment were robust to assumptions about underlying stock productivity and assumed level of removals.
- Reviewers also requested that projections be run for several of the sensitivity runs, noting that the uncertainty will be underestimated if only one of several equally plausible “states of nature” is used for projection purposes.

Significant Assessment Modifications

The Review Panel requested four additional sensitivity runs but no significant changes to the base model configuration were required. Additionally, the Review Panel requested that projections be undertaken for sandbar stocks using a method similar to that applied to dusky shark. This differed from the ProBox2 methodology presented in the Assessment Workshop Report. This method was applied and results can be found in the Addendum of the Final Stock Assessment Report.

Sources of Information

All information was copied directly or generated from the information available in the final Stock Assessment Report for SEDAR 21: HMS Sandbar shark.

Table 2: Life history inputs used in the assessment. All these quantities are treated as constants in the model. (*Table 2.4 from the Assessment Workshop Report*)

Age	Proportion mature	Proportion maternal	M	Fecundity
1	0.00035	0.0024	0.15431	4.2488
2	0.00068	0.0036	0.15431	4.5079
3	0.00131	0.0054	0.15431	4.7670
4	0.00253	0.0082	0.15431	5.0261
5	0.00487	0.0124	0.15431	5.2852
6	0.00935	0.0186	0.15431	5.5443
7	0.01788	0.0279	0.15431	5.8034
8	0.03393	0.0417	0.15323	6.0625
9	0.06346	0.0618	0.14812	6.3216
10	0.11562	0.0908	0.13116	6.5807
11	0.20141	0.1313	0.13116	6.8398
12	0.32730	0.1863	0.13116	7.0989
13	0.48418	0.2575	0.13116	7.3580
14	0.64424	0.3443	0.13116	7.6171
15	0.77746	0.4430	0.13099	7.8762
16	0.87079	0.5464	0.12942	8.1353
17	0.92858	0.6460	0.12806	8.3944
18	0.96166	0.7343	0.12688	8.6535
19	0.97975	0.8071	0.12586	8.9126
20	0.98940	0.8637	0.12497	9.1717
21	0.99448	0.9057	0.12419	9.4308
22	0.99713	0.9356	0.12351	9.6899
23	0.99851	0.9566	0.12291	9.9490
24	0.99923	0.9709	0.12239	10.2081
25	0.99960	0.9806	0.12193	10.4672
26	0.99979	0.9871	0.12153	10.7263
27	0.99989	0.9914	0.12117	10.9854

Sex ratio at birth:	1:1
Reproductive frequency:	2.5 yr
Pupping month:	June
Age vs litter size relation:	pups = 0.2591*age + 3.9897
L_{inf}	181.15 cm FL
k	0.12
t_0	-2.33
Weight vs length relation:	$W=0.000010885L^{3.0124}$

Table 3: Catches of sandbar shark by fleet in numbers. 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 discards. (*Table 2.1 from the Assessment Workshop Report*)

Year	Com+Un (GOM)	Com + Un (SA)	REC+MEX	Menhaden discards
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 4: Estimated total and fleet-specific instantaneous fishing mortality rates by year. (*Table 3.13 from the Assessment Workshop Report*)

Year	Total F	Fleet-specific F			
		Com+Un (GOM)	Com + Un (SA)	REC+MEX	Menhaden disc
1960	0.00016	0.00002	0.00001	0.00003	0.00013
1961	0.00030	0.00006	0.00004	0.00017	0.00013
1962	0.00044	0.00011	0.00006	0.00031	0.00013
1963	0.00058	0.00015	0.00009	0.00045	0.00013
1964	0.00072	0.00019	0.00011	0.00059	0.00013
1965	0.00086	0.00023	0.00014	0.00072	0.00013
1966	0.00101	0.00028	0.00017	0.00086	0.00013
1967	0.00115	0.00032	0.00019	0.00100	0.00013
1968	0.00129	0.00036	0.00022	0.00114	0.00013
1969	0.00143	0.00041	0.00024	0.00128	0.00013
1970	0.00157	0.00045	0.00027	0.00142	0.00013
1971	0.00171	0.00049	0.00029	0.00156	0.00013
1972	0.00185	0.00053	0.00032	0.00170	0.00013
1973	0.00200	0.00058	0.00034	0.00184	0.00013
1974	0.00214	0.00062	0.00037	0.00198	0.00013
1975	0.00228	0.00066	0.00039	0.00212	0.00013
1976	0.00242	0.00071	0.00042	0.00226	0.00013
1977	0.00256	0.00075	0.00045	0.00239	0.00013
1978	0.00270	0.00079	0.00047	0.00253	0.00013
1979	0.00284	0.00084	0.00050	0.00267	0.00013
1980	0.00299	0.00088	0.00052	0.00281	0.00013
1981	0.00319	0.00092	0.00055	0.00295	0.00019
1982	0.03147	0.00247	0.00147	0.03128	0.00019
1983	0.11148	0.00273	0.00161	0.11141	0.00019
1984	0.05108	0.00377	0.00221	0.05086	0.00020
1985	0.05654	0.00360	0.00210	0.05636	0.00018
1986	0.09998	0.01079	0.00537	0.09931	0.00018
1987	0.04807	0.03186	0.01597	0.02936	0.00020
1988	0.08935	0.04901	0.04001	0.05560	0.00020
1989	0.12463	0.07083	0.05332	0.02778	0.00022
1990	0.10083	0.06380	0.03662	0.05619	0.00022
1991	0.07743	0.06798	0.00910	0.03907	0.00018
1992	0.09286	0.05572	0.03682	0.04012	0.00017
1993	0.07254	0.03834	0.03394	0.03203	0.00018
1994	0.12910	0.07559	0.05302	0.02418	0.00020
1995	0.09653	0.04609	0.05009	0.03834	0.00020
1996	0.08070	0.03150	0.04885	0.05478	0.00021
1997	0.06348	0.02169	0.03068	0.06188	0.00022
1998	0.08074	0.03375	0.04663	0.05568	0.00023
1999	0.07637	0.02010	0.05586	0.03810	0.00026
2000	0.05355	0.01932	0.03394	0.02594	0.00023
2001	0.06846	0.03087	0.03723	0.06163	0.00022
2002	0.08490	0.03405	0.05049	0.02038	0.00023
2003	0.07068	0.03043	0.03993	0.01465	0.00023
2004	0.06467	0.02466	0.03970	0.01197	0.00024
2005	0.05830	0.01959	0.03840	0.01014	0.00025
2006	0.07207	0.03065	0.04107	0.00864	0.00026
2007	0.03205	0.00883	0.02293	0.01817	0.00026
2008	0.01323	0.00103	0.00326	0.01297	0.00026
2009	0.01305	0.00395	0.00275	0.01257	0.00027

Table 5: Predicted abundance (numbers), total biomass (kg), and spawning stock fecundity (numbers) of sandbar shark for the base run. (*Table 3.12 from Assessment Workshop Report*)

Year	N	B	SSF
1960	4,136,052	88,307,548	1,157,184
1961	4,135,480	88,294,090	1,157,010
1962	4,134,619	88,274,185	1,156,732
1963	4,133,523	88,249,192	1,156,395
1964	4,132,124	88,217,597	1,155,981
1965	4,130,510	88,180,897	1,155,490
1966	4,128,645	88,138,044	1,154,922
1967	4,126,575	88,089,966	1,154,274
1968	4,124,267	88,035,502	1,153,528
1969	4,121,738	87,975,820	1,152,724
1970	4,119,018	87,911,547	1,151,850
1971	4,116,115	87,842,350	1,150,900
1972	4,113,000	87,767,679	1,149,871
1973	4,109,733	87,689,191	1,148,772
1974	4,106,229	87,604,799	1,147,593
1975	4,102,552	87,516,177	1,146,338
1976	4,098,701	87,423,467	1,145,037
1977	4,094,689	87,326,255	1,143,642
1978	4,090,482	87,224,521	1,142,178
1979	4,086,122	87,119,246	1,140,667
1980	4,081,608	87,010,124	1,139,070
1981	4,076,893	86,896,459	1,137,423
1982	4,071,819	86,773,595	1,135,623
1983	4,025,192	86,137,310	1,130,645
1984	3,882,774	84,458,374	1,123,653
1985	3,834,516	83,300,472	1,115,474
1986	3,784,642	82,110,607	1,107,222
1987	3,671,804	79,837,404	1,086,772
1988	3,603,422	76,582,667	1,034,921
1989	3,442,693	71,293,576	946,597
1990	3,269,287	65,311,505	837,586
1991	3,088,063	60,884,602	758,891
1992	2,949,985	57,897,374	704,227
1993	2,805,026	54,684,577	644,964
1994	2,692,431	52,540,571	603,754
1995	2,530,868	48,700,128	536,991
1996	2,391,551	46,166,875	494,628
1997	2,259,984	44,116,196	464,346
1998	2,154,324	42,800,641	449,447
1999	2,041,650	40,720,368	425,258
2000	1,954,665	38,982,212	405,796
2001	1,894,891	37,912,155	397,026
2002	1,806,557	36,256,021	383,467
2003	1,740,611	34,525,532	365,366
2004	1,688,826	33,268,064	353,121
2005	1,645,191	32,247,512	343,206

2006	1,608,720	31,436,577	335,358
2007	1,565,308	30,383,263	323,068
2008	1,541,327	30,139,700	322,934
2009	1,539,102	30,431,026	330,902

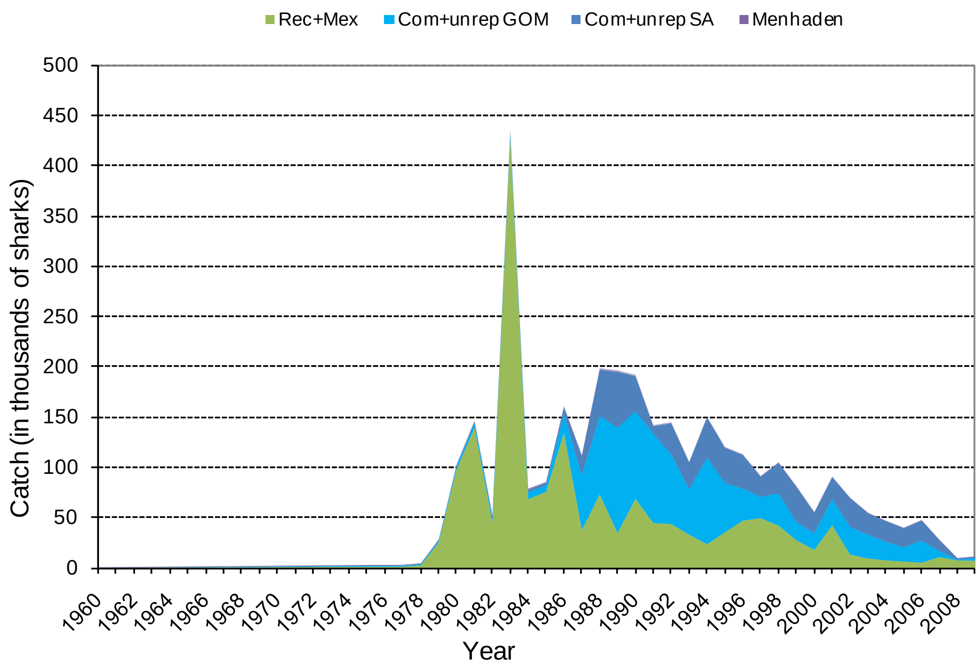


Figure 1: Catches of sandbar shark by fleet. Catches are separated into four fisheries: commercial landings + unreported commercial catches in the GOM, commercial landings + unreported commercial catches in the ATL, recreational + Mexican catches, and menhaden fishery discards (this last series does not show up in the figure due to its small magnitude). (*Figure 2.1 from the Assessment Workshop Report*)

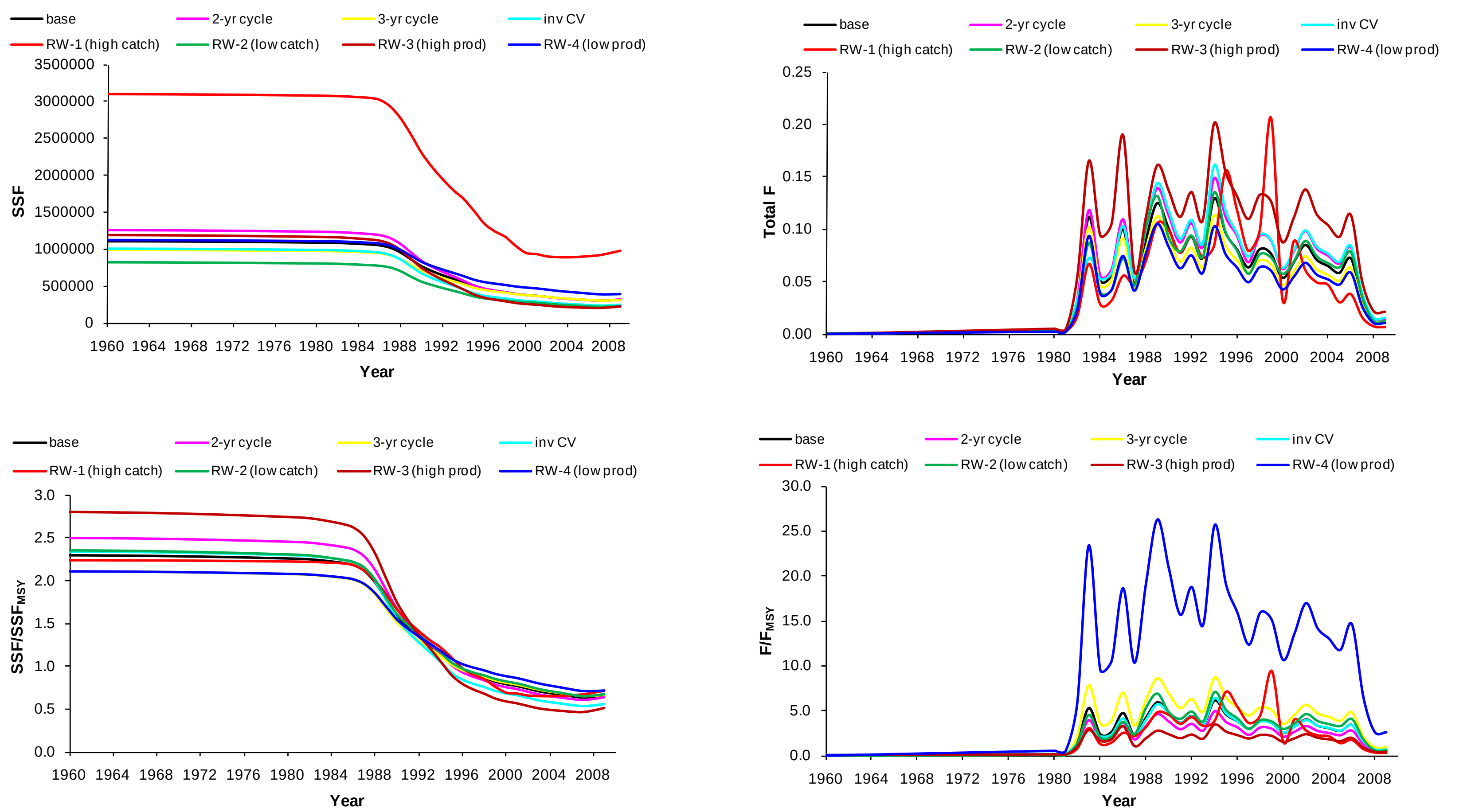


Figure 2: Scenarios selected to explore the range of model outputs for sandbar shark at the Review Workshop. Base is baseline scenario; S1 is inverse CV weighting; S5 is 2-year reproductive cycle; S6 is 3-year reproductive cycle; RW-1 (high catch) is modified high catch; RW-2 (low catch) is modified low catch; RW-3 (high prod) is high productivity; RW-4 (low prod) is low productivity. Four time series trajectories are shown: SSF (spawning stock fecundity; top left panel), total apical F (top right panel), relative biomass (bottom left panel), and relative fishing mortality (bottom right panel). (*Figure 6.2 in the Addendum*)

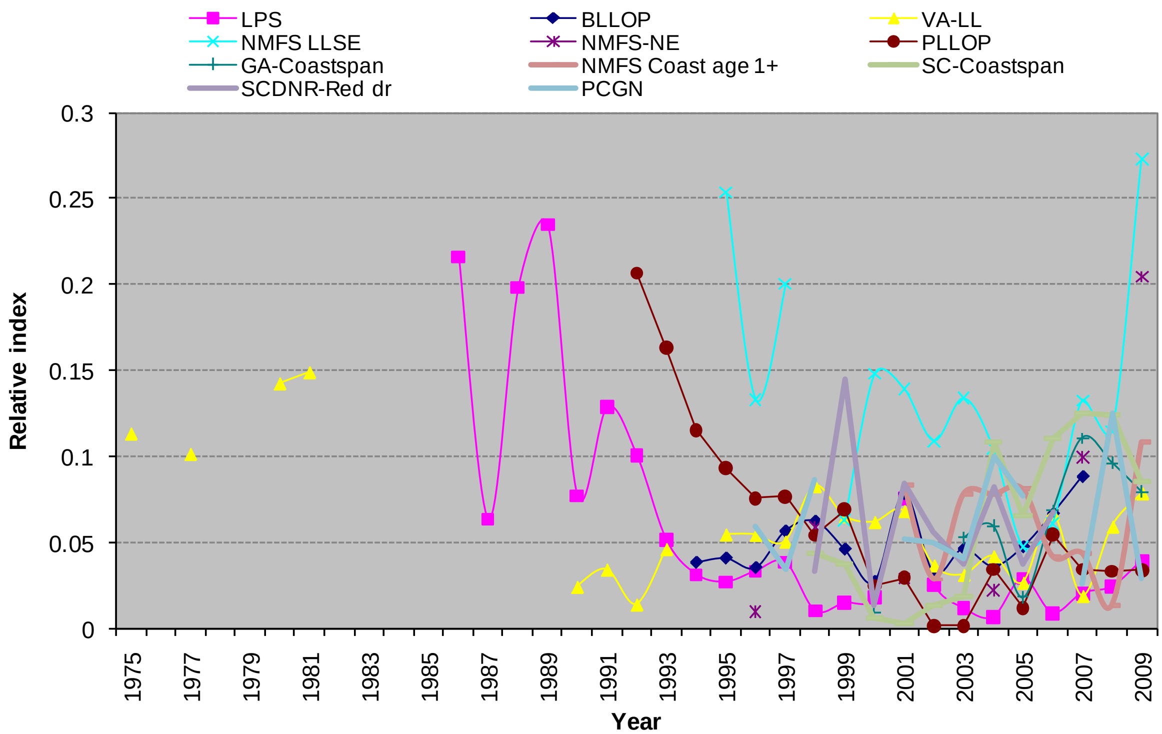


Figure 3: Indices of relative abundance used for the baseline scenario. All indices are statistically standardized and scaled (divided by their respective mean and a global mean for overlapping years for plotting purposes). (*Figure 2.8 from the Assessment Workshop Report*)

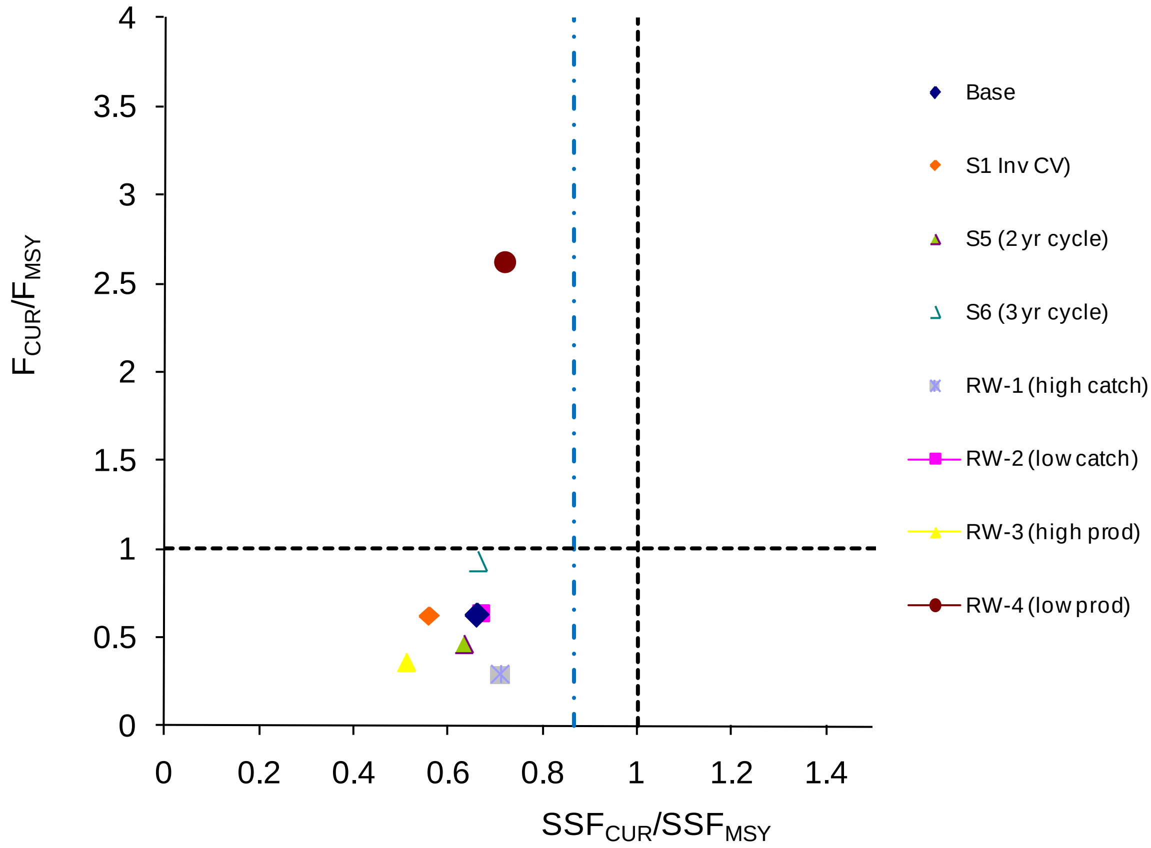


Figure 4: Phase plot summarizing stock status in 2009 for original base run and scenarios selected to explore the range of model outputs for sandbar shark at the Review Workshop. Base is baseline scenario; S1 is inverse CV weighting; S5 is 2-year reproductive cycle; S6 is 3-year reproductive cycle; RW-1 (high catch) is modified high catch; RW-2 (low catch) is modified low catch; RW-3 (high prod) is high productivity; RW-4 (low prod) is low productivity. The vertical dashed line denotes MSST ((1-M)*SSF_{MSY}) (*Figure 6.1 from the Addendum*)

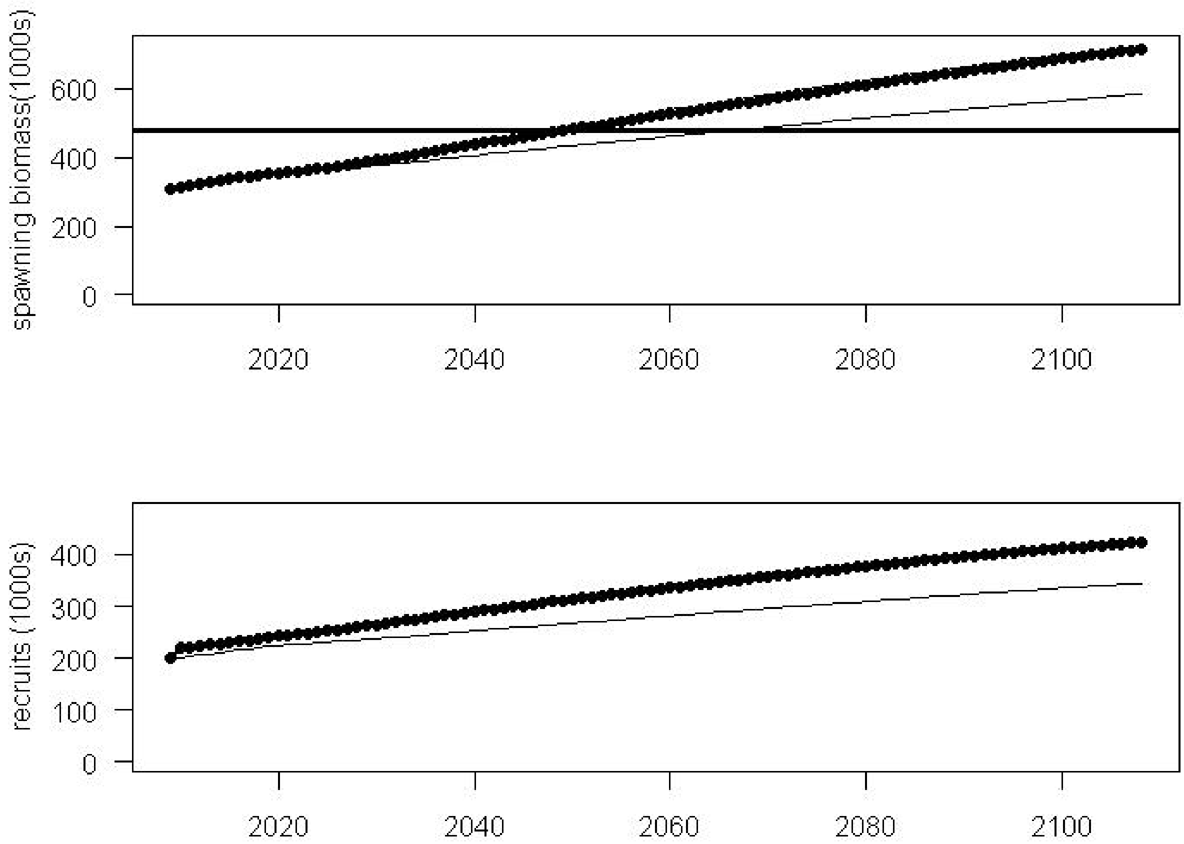


Figure 5: Base model projections. The top panel is the spawning stock fecundity and recruitment estimates for the Frebuild 70 scenario. Frebuild70 is the fishing mortality permitted in order to attain a 70% probability of recovery by the rebuilding year. The bottom panel is the spawning stock fecundity and recruitment estimates for the TACrebuild70 scenario under the base case model assumptions. The TACrebuild 70 is the total allowable catch permitted to attain recovery by the rebuilding year. The heavy dotted line is the median and the thin lines are the 70% and 30% quantiles. In this case the median and 70% quantiles overlap. The solid horizontal line is the SSFmsy or the Rmsy. Where the horizontal lines are absent for recruitment, the projection does not reach the Rmsy during the projection time period.

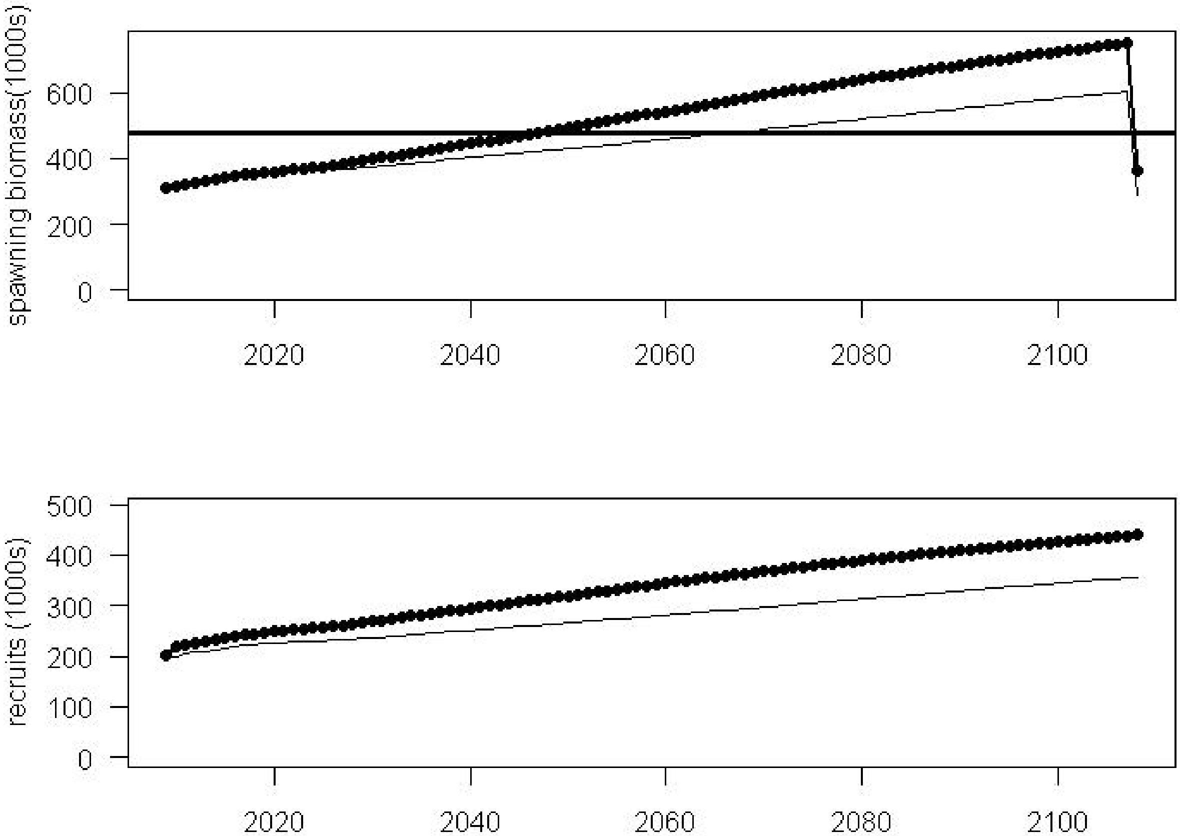


Figure 5. (Continued)

5. 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
ASMFC	Atlantic States Marine Fisheries Commission
B	stock biomass level
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
F	fishing mortality (instantaneous)
F_{MAX}	fishing mortality that maximizes the average weight yield per fish recruited to the fishery
F_{MSY}	fishing mortality to produce MSY under equilibrium conditions
F_{OY}	fishing mortality rate to produce Optimum Yield under equilibrium
$F_{XX\%\ SPR}$	fishing mortality rate that will result in retaining XX% of the maximum spawning production under equilibrium conditions
F_0	a fishing mortality close to, but slightly less than, Fmax
FL FWCC	Florida Fish and Wildlife Conservation Commission
FWRI	(State of) Florida Fisheries 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
M	natural mortality (instantaneous)
MARMAP	Marine Resources Monitoring, Assessment, and Prediction
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
SEDAR	Southeast Data, Assessment and Review
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
SSC	Science and Statistics Committee
TIP	Trip Incident Program; biological data collection program of the SEFSC and Southeast States.
Z	total mortality, the sum of M and F

SEDAR

Southeast Data, Assessment, and Review

SEDAR 21
Highly Migratory Species

Sandbar Shark

SECTION II: Data Workshop Report

October 2011

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

Table of Contents

1. INTRODUCTION

1.1. *WORKSHOP TIME AND PLACE*

The SEDAR 21 Data Workshop was held June 21-25, 2010 in Charleston, South Carolina.

1.2. *TERMS OF REFERNCE*

1. Characterize stock structure and develop a unit stock definition. Provide maps of species and stock distribution.

2. Review, discuss and tabulate available life history information (e.g., age, growth, natural mortality, reproductive characteristics); provide appropriate models to describe growth, maturation, and fecundity by age, sex, or length as applicable. Evaluate the adequacy of available life-history information for conducting stock assessments and recommend life history information for use in population modeling.

3. Provide measures of population abundance that are appropriate for stock assessment. Consider and discuss all available and relevant fishery dependent and independent indices. Document all programs evaluated, addressing program objectives, methods, coverage, sampling intensity, and other relevant characteristics. Provide maps of survey coverage. Develop CPUE and index values by appropriate strata (e.g., age, size, area, and fishery); characterize uncertainty. Evaluate the degree to which available indices adequately represent fishery and population conditions. Consider implications of changes in gear, management, fishing effort, etc. in relationship to the different indices. Recommend which indices are considered statistically adequate and biologically plausible for use in assessment modeling.

4. Characterize commercial and recreational catch by gear. Include both landings and discards, in pounds and number by gear type as feasible. Provide estimates of dead discard proportions by fishery and other strata as appropriate or feasible. Evaluate and discuss the adequacy of available data for accurately characterizing fishery removals by species, area, gear type, and fishery sector. Consider implications of changes in gear, management, fishing effort, etc. in reconstructing historic catches. Provide length and age distributions if feasible. To provide context and spatial scale of species distribution, fishery effort, and data coverage, provide maps of fishery effort and harvest, as available.

5. Provide recommendations for future research in areas such as sampling, fishery monitoring, and stock assessment. Include specific guidance on sampling intensity (number of samples including age and length structures) and appropriate strata and coverage.

6. Develop a spreadsheet of assessment model input data that reflects the decisions and recommendations of the Data Workshop. Review and approve the contents of the input spreadsheet.

7. Prepare the Data Workshop report providing complete documentation of workshop actions and decisions (Section II. of the SEDAR assessment report). Provide a list of tasks that were not completed during the meeting week, who is responsible for completing each task, and when each task will be completed.

1.3. *LIST OF PARTICIPANTS*

Workshop Panel

Alan Bianchi .... NCDMF
Andrew Piercy .... UF
Beth Babcock .... RSMAS
Bill Gazey .... LGL Ecological Research Associates, Inc.
Bryan Frazier .... SCDNR
Cami McCandless .... NMFS Narragansett
Carolyn Belcher .... GADNR
Chris Hayes .... ACCSP
Chris Vonderweidt .... ASFMC
Christian Jones .... NMFS Pascagoula
David Stiller .... Alabama (Industry Representative)
Enric Cortés .... NMFS Panama City
Frank Hester .... Southeast Fishery Association - East Coast Section
George Burgess .... UF
Heather Balchowsky .... NMFS Miami
Ivy Baremore .... NMFS Panama City
Jason Romine .... Western Fisheries Research Center
John K. Carlson .... NMFS Panama City
Jose Castro .... NMFS/Mote Marine Laboratory
Katie Andrews .... NMFS Panama City
Ken Keene .... NMFS - Miami
Kevin McCarthy .... NMFS Miami
Kristene Parsons .... VIMS
Lori Hale .... NMFS Panama City
Marcus Drymon .... Univ. of AL
Michelle Passerotti .... NMFS Panama City
Rusty Hudson .... DSF, Inc.
Trey Driggers .... NMFS Pascagoula
Walter Ingram .... NMFS Pascagoula

CIE Reviewer

Robin Cook .... FRS Marine Laboratory

HMS Representation

Karyl Brewster-Geisz.. NMFS – Silver Spring

Observers

Dewey Hemilwright..North Carolina
Glen Hopkins ....North Carolina
Charlie Locke...North Carolina
Joe Klostermann..Fort Pierce, Florida
Benny Galloway... LGL

Staff

Julie A. Neer .... SEDAR
Rachael Lindsay.. SEDAR
Tyree Davis...NMFS Miami

1.4. *LIST OF DATA WORKSHOP WORKING PAPERS AND REFERNCE DOCUMENTS*

Document #	Title	Authors	Working Group
Documents Prepared for the Data Workshop			
SEDAR21-DW-01	Standardized catch rates of sandbar and blacknose shark from a fishery independent survey in northwest Florida, 1996-2009.	John Carlson and Dana Bethea	Indices
SEDAR21-DW-02	Standardized catch rates of sandbar, dusky and blacknose sharks from the Commercial Shark Fishery Longline Observer Program, 1994-2009	John Carlson, Loraine Hale, Alexia Morgan and George Burgess	Indices
SEDAR21-DW-03	Standardized Catch Rates of Blacknose Shark from the Southeast Shark Drift Gillnet Fishery: 1993-2009	John Carlson and Michelle Passerotti	Indices
SEDAR21-DW-04	Standardized Catch Rates of Blacknose Shark from the Southeast Sink Gillnet Fishery: 2005-2009	John Carlson and Michelle Passerotti	Indices
SEDAR21-DW-05	The effect of turtle excluder devices (TEDS) on the bycatch of small coastal sharks in the Gulf of	S.W. Raborn, K.I. Andrews, B.J. Gallaway, J.G. Cole,	Catch Statistics

	Mexico Peneid shrimp fishery	and W.J. Gazey	
SEDAR21-DW-06	Reproduction of the sandbar shark *Carcharhinus plumbeus* in the U.S. Atlantic Ocean and Gulf of Mexico	Baremore, I.E. and L.F. Hale	Life History
SEDAR21-DW-07	Description of data sources used to quantify shark catches in commercial and recreational fisheries in the U.S. Atlantic Ocean and Gulf of Mexico	Baremore, I.E., Balchowski, H., Matter, V, Cortes, E.	Catch Statistics
SEDAR21-DW-08	Standardized catch rates for dusky and sandbar sharks from the US pelagic longline logbook and observer programs using generalized linear mixed models.	Enric Cortés	Indices
SEDAR21-DW-09	Updated catches	Enric Cortés	Catch Statistics
SEDAR21-DW-10	Large and Small Coastal Sharks Collected Under the Exempted Fishing Program Managed by the Highly Migratory Species Management Division	Jackie Wilson	Catch Statistics
SEDAR21-DW-11	Abundance series from the MRFSS data set	Beth Babcock	Indices
SEDAR21-DW-12	Catches of Sandbar Shark from the Southeast US Gillnet Fishery: 1999-2009	Michelle S. Passerotti and John K. Carlson	Catch Statistics
SEDAR21-DW-13	Errata Sheet for 'CATCH AND BYCATCH IN THE SHARK GILLNET FISHERY: 2005-2006', NOAA Technical Memorandum NMFS-SEFSC-552	Michelle S. Passerotti and John K. Carlson	Catch Statistics
SEDAR21-DW-14	Data Update to Illegal Shark Fishing off the coast of Texas by Mexican Lanchas	Karyl Brewster-Geisz, Steve Durkee, and Patrick Barelli	Catch Statistics
SEDAR21-DW-15	An update of blacknose shark bycatch estimates taken by the Gulf of Mexico penaeid shrimp	W.J. Gazey and K. Andrews	Catch Statistics

	fishery from 1972 to 2009		
SEDAR21-DW-16	A Negative Binomial Loglinear Model with Application for the Estimation of Bycatch of Blacknose Shark in the Gulf of Mexico Penaeid Shrimp Fishery	W.J. Gazey, K. Andrews, and B.J. Gallaway	Catch Statistics
SEDAR21-DW-17	Life history parameters for the sandbar shark in the Northwest Atlantic and Eastern Gulf of Mexico	Romine and Musick	Life History
SEDAR21-DW-18	Standardized catch rates of sandbar sharks and dusky sharks in the VIMS Longline Survey: 1975-2009	Romine, Parsons, Grubbs, Musick, and Sutton	Indices
SEDAR21-DW-19	Updating the blacknose bycatch estimates in the Gulf of Mexico using the Nichols method	Katie Andrews	Catch Statistics
SEDAR21-DW-20	Tag and recapture data for blacknose, *Carcharhinus acronotus*, sandbar, *C. plumbeus*, and dusky shark, *C. obscurus*, as kept in the NOAA Fisheries Southeast Fisheries Science Center Elasmobranch Tagging Management System, 1999-2009	D. Bethea and Carlson, J.K.	Life History
SEDAR21-DW-21	Age and growth of the sandbar shark, *Carcharhinus plumbeus*, in the Gulf of Mexico and southern Atlantic Ocean.	L. Hale and I. Baremore	Life History
SEDAR21-DW-22	Catch and bycatch in the bottom longline observer program from 2005 to 2009	Hale, L.F., S.J.B. Gulak, and J.K. Carlson	Catch Statistics
SEDAR21-DW-23	Identification and evaluation of shark bycatch in Georgia's commercial shrimp trawl fishery with implications for management	C. N. Belcher and C. A. Jennings	Catch Statistics
SEDAR21-DW-24	Increases in maximum observed	Bryan S. Frazier,	Life History

	age of blacknose sharks, *Carcharhinus acronotus*, based on three long term recaptures from the Western North Atlantic	William Driggers, and Christian Jones	
SEDAR21-DW-25	Catch rates and size distribution of blacknose shark *Carcharhinus acronotus* in the northern Gulf of Mexico, 2006-2009	J. M. Drymon, S.P. Powers, J. Dindo and G.W. Ingram	Indices
SEDAR21-DW-26	Reproductive cycle of sandbar sharks in the northwestern Atlantic Ocean and Gulf of Mexico	Andrew Piercy	Life History
SEDAR21-DW-27	Standardized catch rates for juvenile sandbar sharks caught during NMFS COASTSPAN longline surveys in Delaware Bay	Camilla T. McCandless	Indices
SEDAR21-DW-28	Standardized catch rates for sandbar and dusky sharks caught during the NEFSC coastal shark bottom longline survey	Camilla T. McCandless and Lisa J. Natanson	Indices
SEDAR21-DW-29	Standardized catch rates for sandbar and blacknose sharks caught during the Georgia COASTSPAN and GADNR red drum longline surveys	Camilla T. McCandless and Carolyn N. Belcher	Indices
SEDAR21-DW-30	Standardized catch rates for sandbar and blacknose sharks caught during the South Carolina COASTSPAN and SCDNR red drum surveys	Camilla T. McCandless and Bryan Frazier	Indices
SEDAR21-DW-31	Standardized catch rates of sandbar and dusky sharks from historical exploratory longline surveys conducted by the NMFS Sandy Hook, NJ and Narragansett, RI Labs	Camilla T. McCandless and John J. Hoey	Indices

SEDAR21-DW-32	Standardized catch rates of dusky and sandbar sharks observed in the gillnet fishery by the Northeast Fisheries Observer Program	NOT RECEIVED	Indices
SEDAR21-DW-33	Standardized catch rates for blacknose, dusky and sandbar sharks caught during a UNC longline survey conducted between 1972 and 2009 in Onslow Bay, NC	Frank J. Schwartz, Camilla T. McCandless, and John J. Hoey	Indices
SEDAR21-DW-34	Sandbar and blacknose shark occurrence in standardized longline, drumline, and gill net surveys in southwest Florida coastal waters of the Gulf of Mexico	Robert Hueter, John Morris, and John Tyminski	Indices
SEDAR21-DW-35	Atlantic Commercial Landings of blacknose, dusky, sandbar, unclassified, small coastal, and requiem sharks provided by the Atlantic Coastal Cooperative Statistics Program (ACCSP)	Christopher Hayes	Catch Statistics
SEDAR21-DW-36	Life history and population structure of blacknose sharks, *Carcharhinus acronotus*, in the western North Atlantic Ocean	William B. Driggers III, John K. Carlson, Bryan Frazier, G. Walter Ingram Jr., Joseph M. Quattro, James A. Sulikowski and Glenn F. Ulrich	Life History
SEDAR21-DW-37	Movements and environmental preferences of dusky sharks, *Carcharhinus obscurus*, in the northern Gulf of Mexico	Eric Hoffmayer, James Franks, William Driggers, and Mark Grace	Life History
SEDAR21-DW-38	Preliminary Mark/Recapture Data for the Sandbar Shark (*Carcharhinus plumbeus*), Dusky	Nancy E. Kohler and Patricia A. Turner	Life History

	Shark (*C. obscurus*), and Blacknose Shark (*C. acronotus*) in the Western North Atlantic		
SEDAR21-DW-39	Catch rates, distribution and size composition of blacknose, sandbar and dusky sharks collected during NOAA Fisheries Bottom Longline Surveys from the U.S. Gulf of Mexico and U.S. Atlantic Ocean	Walter Ingram	Indices
SEDAR21-DW-40	Standardized catch rates of the blacknose shark (*Carcharhinus acronotus*) from the United States south Atlantic gillnet fishery, 1998-2009	Kristin Erickson and Kevin McCarthy	Indices
SEDAR21-DW-41	Index of Abundance of Sandbar Shark (*Carcharinus plumbeus*) in the Southeast Region, 1992-2007, From United States Commercial Fisheries Longline Vessels	Heather Balchowsky and Kevin McCarthy	Indices
SEDAR21-DW-42	Examination of commercial bottom longline data for the construction of indices of abundance of dusky shark in the Gulf of Mexico and US South Atlantic	Kevin McCarthy	Indices
SEDAR21-DW-43	Indices of abundance for blacknose shark from the SEAMAP trawl survey	Walter Ingram	Indices
SEDAR21-DW-44	Standardized catch rates of sandbar sharks (*Carcharhinus plumbeus*) and dusky sharks (*Carcharhinus obscurus)* from the large pelagic rod and reel survey 1986-2009	John F. Walter and Craig Brown	Indices
SEDAR21-DW-45	A note on the number of pups for two blacknose sharks (*Carcharhinus acronotus*) from	David Stiller	Life History

	the Gulf of Mexico		
SEDAR21-DW-46	Mote LL index	Walter Ingram	Indices

Reference Documents

SEDAR21-RD01	SEDAR 11 (LCS) Final Stock Assessment Report	SEDAR 11 Panels
SEDAR21-RD02	SEDAR 13 (SCS) Final Stock Assessment Report	SEDAR 13 Panels
SEDAR21-RD03	Stock assessment of dusky shark in the U.S. Atlantic and Gulf of Mexico	E. Cortés, E. Brooks, P. Apostolaki, and C.A. Brown
SEDAR21-RD04	Report to Directed Shark Fisheries, Inc. on the 2006 SEDAR 11 Assessment for Sandbar Shark	Frank Hester and Mark Maunder
SEDAR21-RD05	Use of a Fishery-Independent Trawl Survey to Evaluate Distribution Patterns of Subadult Sharks in Georgia	Carolyn Belcher and Cecil Jennings
SEDAR21-RD06	Demographic analyses of the dusky shark, *Carcharhinus obscurus*, in the Northwest Atlantic incorporating hooking mortality estimates and revised reproductive parameters	Jason G. Romine & John A. Musick & George H. Burgess
SEDAR21-RD07	Observations on the reproductive cycles of some viviparous North American sharks	José I. Castro
SEDAR21-RD08	Sustainability of elasmobranchs caught as bycatch in a tropical prawn (shrimp) trawl fishery	Ilona C. Stobutzki, Margaret J. Miller, Don S. Heales, David T. Brewer
SEDAR21-RD09	Age and growth estimates for the dusky shark, *Carcharhinus obscurus*, in the western North Atlantic Ocean	Lisa J. Natanson, John G. Casey and Nancy E. Kohler

SEDAR21-RD10	Reproductive cycle of the blacknose shark *Carcharhinus acronotus* in the Gulf of Mexico	J. A. Sulikowski, W. B. Driggers III, T. S. Ford, R. K. Boonstra and J. K. Carlson
SEDAR21-RD11	A preliminary estimate of age and growth of the dusky shark Carcharhinus obscurus from the south-west Indian Ocean, with comparison to the western north Atlantic population	L.J. Natanson and N.E. Kohler
SEDAR21-RD12	Bycatch and discard mortality in commercially caught blue sharks *Prionace glauca* assessed using archival satellite pop-up tags	Steven E. Campana, Warren Joyce, Michael J. Manning
SEDAR21-RD13	Short-term survival and movements of Atlantic sharpnose sharks captured by hook-and-line in the north-east Gulf of Mexico	C. W. D. Gurshin and S. T. Szedlmayer
SEDAR21-RD14	Plasma catecholamine levels as indicators of the post-release survivorship of juvenile pelagic sharks caught on experimental drift longlines in the Southern California Bight	Barbara V. Hight, David Holts, Jeffrey B. Graham, Brian P. Kennedy, Valerie Taylor, Chugey A. Sepulveda, Diego Bernal, Darlene RamonB, Randall Rasmussen and N. Chin Lai
SEDAR21-RD15	The physiological response to capture and handling stress in the Atlantic sharpnose shark, *Rhizoprionodon terraenovae*	Eric R. Hoffmayer & Glenn R. Parsons
SEDAR21-RD16	The estimated short-term discard mortality of a trawled elasmobranch, the spiny dogfish (*Squalus acanthias*)	John W. Mandelman & Marianne A. Farrington
SEDAR21-RD17	At-vessel fishing mortality for six species of sharks caught in the northwest Atlantic and Gulf of Mexico	Alexia Morgan and George H. Burgess

SEDAR21-RD18	Evaluating the physiological and physical consequences of capture on post-release survivorship in large pelagic fishes	G.B. Skomal
SEDAR21-RD19	The Physiological Response of Port Jackson Sharks and Australian Swellsharks to Sedation, Gill-Net Capture, and Repeated Sampling in Captivity	L. H. Frick, R. D. Reina, and T. I. Walker
SEDAR21-RD20	Serological Changes Associated with Gill-Net Capture and Restraint in Three Species of Sharks	C. Manire, R. Hueter, E. Hull and R. Spieler
SEDAR21-RD21	Differential sensitivity to capture stress assessed by blood acid–base status in five carcharhinid sharks	John W. Mandelman & Gregory B. Skomal
SEDAR21-RD22	Review of information on cryptic mortality and the survival of sharks and rays released by recreational fishers	Kevin McLoughlin and Georgina Eliason
SEDAR21-RD23	Pathological and physiological effects of stress during capture and transport in the juvenile dusky shark, *Carcharhinus obscurus*	G. Cliff and G.D. Thurman
SEDAR21-RD24	Pop-off satellite archival tags to chronicle the survival and movements of blue sharks following release from longline gear	Michael Musyl and Richard Brill
SEDAR21-RD25	Evaluation of bycatch in the North Carolina Spanish and king mackerel sinknet fishery with emphasis on sharks during October and November 1998 and 2000 including historical data from 1996-1997	Chris Jensen and Glen Hopkins

2. LIFE HISTORY

2.1. *OVERVIEW*

The sandbar shark life history working group was led by Dr. John Carlson, NOAA Fisheries Panama City, and rapporteured by Loraine Hale, NOAA Fisheries Service-Panama City Laboratory. Members of the group included George Burgess, University of Florida, Dr. Jose Castro, NOAA Fisheries Service-Miami Laboratory, Dr. William Driggers, NOAA Fisheries Service-Mississippi Laboratories, Christian Jones, NOAA Fisheries Service-Mississippi Laboratories, Dr. Andrew Piercy, University of Florida, Bryan Frazier, South Carolina Department of Natural Resources, Dr. Jason Romine, USGS, and Dr. Frank Hester, consultant for Directed Shark Fisheries.

2.2. *REVIEW OF WORKING PAPERS*

SEDAR21-DW-06 - Reproduction of the sandbar shark *Carcharhinus plumbeus* in the U.S. Atlantic Ocean and Gulf of Mexico – I. Baremore and L. Hale

A total of 1,194 (701 females, 493 males) sandbar sharks *Carcharhinus plumbeus* were examined for reproductive assessment. Size and age at 50% maturity for males was 151.6 cm FL (13.1 years) and 154.9 cm FL (14.1 years) for females, while the size at which 50% of females were in reproductive condition was 162.6 cm FL (15.5 years). Males and females showed distinct seasonal reproduction patterns, with peak mating and parturition occurring from April through June. Female fecundity averaged 8.0 pups, and there was a weakly significant increase in fecundity with size and a significant increase in fecundity with age. Patterns of maximum ova diameter and gonadosomatic indices in females suggest that sandbar sharks may have a triennial reproductive cycle.

SEDAR21-DW-17 - Life history parameters for the sandbar shark in the Northwest Atlantic and Eastern Gulf of Mexico – J. Romine and J. Musick

Age and growth parameters of the sandbar shark, *Carcharhinus plumbeus*, were estimated through analyses of vertebral centra collected from 2000 to 2004 in the Northwest Atlantic Ocean and Gulf of Mexico. Samples were collected from both fishery-dependent and fishery-independent surveys. Fishing gears included longline, trawl, gillnet, and recreational fishing gear. Five models were fit to age estimates for both sexes from 464 vertebral samples consisting of 250 females and 206 males. The three parameter von Bertalanffy model provided the best fit for the female age estimates. The logistic model provided a better fit for male age estimates, but the model underestimated empirical asymptotic length. The three parameter von Bertalanffy model growth parameter estimates were L_∞ =163.6 cm pre-caudal length (PCL) for females and 158.8 cm PCL for males, K= 0.1055 for females and 0.1124 for males, and t_0= -3.26 for females and -3.16 for males. Maximum likelihood estimation of age at 50% maturity for females was approximately 12.49 years, which corresponded to approximately 132 cm PCL.

SEDAR21-DW-20 - Tag and recapture data for blacknose, *Carcharhinus acronotus*, sandbar, *C. plumbeus*, and dusky shark, *C. obscurus*, as kept in the NOAA Fisheries Southeast Fisheries Science Center Elasmobranch Tagging Management System, 1999-2009 - D. Bethea and J. Carlson

Tag and recapture information for blacknose, *Carcharhinus acronotus*, sandbar, *C. plumbeus*, and dusky shark, *C. obscurus*, is summarized from the NOAA Fisheries Cooperative Gulf of Mexico States Shark Pupping and Nursery (GULFSPAN) survey at the Panama City Laboratory from 1999 to 2009 and the NOAA Fisheries Mississippi Laboratories bottom and pelagic longline cruises 2004-2009. Summary information includes number of males and females tagged by life stage, number of sharks recaptured, and overall recapture rate, time at liberty, and distance traveled per recaptured individual.

SEDAR21-DW-21 - Age and growth of the sandbar shark, *Carcharhinus plumbeus*, in the Gulf of Mexico and southern Atlantic Ocean - L. Hale and I. Baremore

Age and growth analysis of the sandbar shark, *Carcharhinus plumbeus*, from the Gulf of Mexico and southern Atlantic Ocean was completed with vertebral samples primarily gathered from the sandbar shark research fishery (n = 1,194). Three parameter von Bertalanffy growth curves were run for male and female sandbar sharks separately and growth parameters were estimated as a male $L\infty = 172.97 \pm 1.30$ cm FL, female $L\infty = 181.15 \pm 1.45$ cm FL, male $k = 0.15 \pm 0.005$, female $k = 0.12 \pm 0.004$, male $t0 = -2.33 \pm 0.19$, and female $t0 = -3.09 \pm 0.16$. The oldest aged sandbar shark was a 27 year old female. The age and growth analysis of the sandbar shark in this study represented a concerted effort to collect current samples from the commercial shark bottom longline fishery to better describe the age structure of the sandbar shark population based on recommendations from SEDAR 11.

SEDAR21-DW-26 - Reproductive cycle of sandbar sharks in the northwestern Atlantic Ocean and Gulf of Mexico – A. Piercy

The goal of this study was to gather contemporary data on the reproduction of the sandbar shark in the northwestern Atlantic Ocean and Gulf of Mexico. Specific objectives were to determine the size of maturity for male and female sandbar sharks, determine the timing of reproductive events (e.g. sperm production, vitellogenesis, ovulation, mating, and gestation), and determine if regional variations exist in reproductive parameters. Male sharks exhibited sizes at 50% and 100% maturity of 140 cm FL and 170 cm FL respectively. Female sharks exhibited sizes at 50% and 100% maturity of 148 cm FL and 165 cm FL respectively. Both male and female sharks have a defined reproductive cycle. Male reproductive tracts were active from January to June. Mature female sharks exhibited a 3 year reproductive cycle. Egg development occurs from January/February to June. The gestation period for shark embryos is approximately 12 months, with the placental stage beginning in late September after approximately 3 months of development, and parturition occurring in late June. A mean litter size of 9.65 embryos was recorded and no relationship between maternal size and litter size was observed. No variation in reproductive cycles was seen between sharks caught in the Gulf of Mexico and those in the northwestern Atlantic.

SEDAR-DW-XX - Preliminary Mark/Recapture Data for the sandbar Shark (*Carcharhinus plumbeus*), dusky shark (*C. obscurus*), and blacknose shark (*C. acronotus*) in the western North Atlantic – N. Kohler and P. Turner

Mark/recapture information from the National Marine Fisheries Service (NMFS) Cooperative Shark Tagging Program (CSTP) covering the period from 1962 through 2009 are summarized for the sandbar shark (*Carcharhinus plumbeus*), dusky shark (*C. obscurus*), and blacknose shark (*C. acronotus*) in the western North Atlantic. The extent of the tagging effort, areas of release and recapture, movements, and length frequencies of tagged sharks are reported. Areas were distinguished in order to identify regional trends in size and quantify exchange between the Atlantic and Gulf of Mexico. Only data with information on size and mark/recapture location were included in these regional analyses. Data synopses include overall recapture rates, maximum and mean distances traveled, maximum times at liberty, and numbers of fish tagged and recaptured, mean lengths, and length frequencies by region. Overall, movement between the Atlantic and Gulf of Mexico and between the US and the Mexican-managed portion of the Gulf of Mexico occurred for the sandbar and dusky shark. Blacknose sharks showed no movement between regions. The true extent of these movements is unclear due to the possibility of under-reporting of recaptures.

2.3. *STOCK DEFINITION AND DESCRIPTION*

After considering the available data, the working group decided that sandbar sharks inhabiting the U.S. waters of the western North Atlantic Ocean (including the Gulf of Mexico) should be considered as a single stock. Genetic data indicate no significant differentiation between the Gulf of Mexico and western North Atlantic Ocean (Heist et al. 1995, Heist and Gold 1999) and tag-recapture data showed a high frequency of movements between basins (SEDAR21-DW-38).

2.4. *NATURAL MORTALITY*

There are currently no natural mortality estimates for sandbar shark available based on direct empirical data. To determine the most appropriate indirect method, a member of the analyst group discussed with the life history group the methods and assumptions to be used for estimating survivorship and mortality. It was determined that survivorship of age 1 and adult sharks should be based on the maximum estimate from methods described in Hoenig (1983), Chen and Watanabe (1989), Peterson and Wroblewski (1984), and Lorenzen (1996). Theoretical estimates indicate the Hoenig model produces lower survivorship estimates in later ages than the Peterson and Wroblewski method, but higher than the Chen and Watanabe method. The group concluded that the range of survivorship estimates by age to be used for priors are to be based on Peterson and Wroblewski and Lorenzen estimates without using the Lorenzen-Hoenig hybrid because the models for Lorenzen and Hoenig produced similar results. Mortality schedules by age are in section 2.8.

2.5. *DISCARD MORTALITY (SCIENTIFIC STUDIES)*

To attempt to determine post-release survivorship the working group reviewed 16 papers examining at-vessel and discard mortality, involving both field and laboratory studies. Values of discard survival were available for mako (longline), blue (longline), blacktip (gillnet), tiger (hook and line), dusky (hook and line) and Atlantic sharpnose (hook and line) sharks. Because at least two publications (Mandleman and Skomal 2009; Morgan and Carlson 2010) provided evidence that mortality rates vary among species, even those that are closely related, the working group chose to provide the following estimates of discard mortality. One paper on blue sharks (Campana et al. 2009) had values for both at-vessel (13%) and post-release (19%) mortality. This represented a 6% difference in mortality. Assuming the relationship between these two mortality rates is applicable to other species, we applied this 6% increase in mortality to the at-vessel mortality estimates for sandbar sharks from observer data collected during 1994 to 2009 in the longline fishery. This resulted in an estimate of discard mortality for longline captured sandbar sharks of 38.24%.

To develop estimates of hook and line post-release mortality, we reviewed the available literature and projected values based on the data presented by Cliff and Thurman (1984). They reported 6% post-release mortality rate for dusky sharks. We then used at-vessel hooking mortality from Morgan and Burgess (2007) and two observer program data sets (CSFOP and SBLOP) as proxies for a comparison of the survival of sandbar sharks compared to dusky sharks. Sandbar sharks exhibited 54% less at-vessel mortality than dusky sharks. Using these relationships, we calculated that sandbar sharks have hook and line post-release mortality of 3.25%.

2.6. *AGE AND GROWTH*

Two studies were presented with age and growth analyses of the sandbar shark (SEDAR21-DW-17, SEDAR21-DW21). Both studies found similar results in age and growth. As the assessment requires the most up to date information, the working group concluded that document SEDAR21-DW21 would be used as the source of life history parameter inputs. Life history parameter estimates are listed in section 2.8.

2.7. *REPORDUCTION*

The working group agreed to use the sandbar shark maturity ogive from Baremore and Hale (SEDAR 21-DW-6). The reproductive periodicity for female sandbar sharks has been historically considered to be biennial (females reproducing every other year). However, data presented by Piercy (SEDAR 21-DW-26), Baremore and Hale (SEDAR 21-DW-6) and a reference document by Merson (SEDAR11-DW-47) suggested a triennial cycle (females reproducing every three years) for female sandbar sharks in U.S. waters of the western North Atlantic Ocean (including the Gulf of Mexico). These documents were intensely debated within the life history working group with some proponents suggesting there was sufficient to data to indicate a 3-year reproductive cycle while others felt that data was insufficient and would not be accepted under a peer-reviewed system. However, some individuals felt that the SEDAR process is a peer reviewed system and in some cases research is subjected to a higher level of scrutiny than manuscripts submitted to a professional journal. After discussion, there was a general recommendation to propose a 2-year reproductive cycle for a baseline stock assessment run and a 3-year reproductive cycle as a sensitivity run but in the end because of the lack of consensus, the chair of the life history group proposed to take the discussion to plenary. During plenary, similar debate occurred. While data indicated a 3-year reproductive cycle, it was also suggested that only a portion of the population may exhibit a 3 year reproductive whereas other individuals may use a 2 year cycle. As there was insufficient data to determine the percentage of individuals with a 3-year cycle, it was agreed that a 2.5 year reproductive cycle would be accepted, providing a balance between a biennial and triennial reproductive period.

Several estimates of fecundity were also discussed within the working group. However, new data from Baremore and Hale (SEDAR 21-DW-6) indicate a positive relationship between maternal age and litter size (#pups = 0.2591*age + 3.9897). Taking this into account the group recommended using this relationship instead of an average litter size estimate for all age classes. The sex ratio of embryos was not significantly different from 1:1 for all data sources discussed.

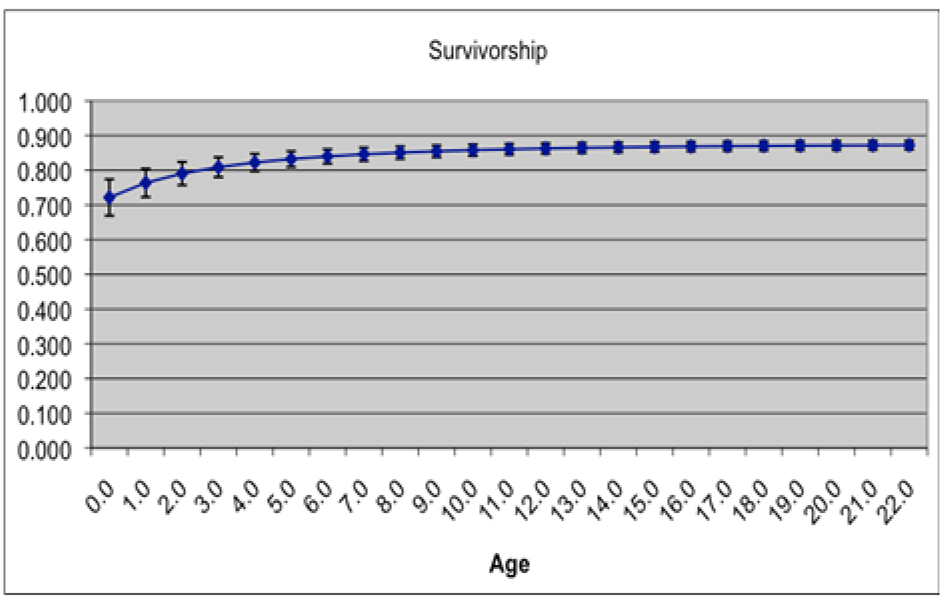
2.8. *SUMMARY OF LIFE HISTORY PARAMETERS*

Summary of sandbar -- Biological Inputs for 2010 Assessment

Life history Workgroup	**Sandbar**	
1st year (age-0) survivorship	male = 0.72, female = 0.61	Section 2.4
Juvenile survivorship	male = 0.76 – 0.86 , female = 0.69 – 0.85	Section 2.4
Adult survivorship	male = 0.86-0.87, female = 0.857-0.87	Section 2.4
S-R function	Beverton Holt	From SEDAR11
S-R parameters, priors		
steepness or alpha	0.25 - 0.4	From SEDAR11
Pupping month	June	SEDAR21-DW-06
Growth parameters	Male | Female | Combined sexes	
L_∞ (cm FL)	172.97 | 181.15 | 177.89	SEDAR21-DW-21
k	0.15 | 0.12 | 0.13	SEDAR21-DW-21
t_o	-2.33 | -3.09 | -2.76	SEDAR21-DW-21
Maximum observed age	27 female, 22 male	SEDAR21-DW-21, SEDAR21-DW-17
Sample size	1194 (701 female, 493 male)	SEDAR21-DW-21
Length-weight relationships	Females: FL=1.07(PCL) + 3.21 r2=0.99	SEDAR21-DW-17
FL in cm	Males: FL=1.07(PCL) + 3.07 r2=0.99	SEDAR21-DW-17
WT in kg	FL = (0.8175)TL + 2.5675	Kohler et al. (1996)
	WT = (1.0885^-5)*FL^3.0124	Kohler et al. (1996)
Median age at maturity or maternity	males 13.1, females 14.1, maternal females 15.5	SEDAR21-DW-06
Reproductive cycle	2.5	SEDAR21-DW-06, SEDAR21-DW-26, decided at plenary
Fecundity	# pups = 0.2591*age + 3.9897 ;mean = 9.65 (S.D. = 1.87, range = 6-14), mean=8 (S.D. = 2.39, range 3-12))	SEDAR21-DW-06, SEDAR21-DW-26
Gestation	12 months	SEDAR21-DW-06, SEDAR21-DW-26
Sex-ratio	1:01	SEDAR21-DW-17, Castro (2009)
Stock structure	high exchange between Atlantic and Gulf based on tagging data, genetic information suggests one stock	SEDAR21-DW-38 , Heist and Gold (1999)

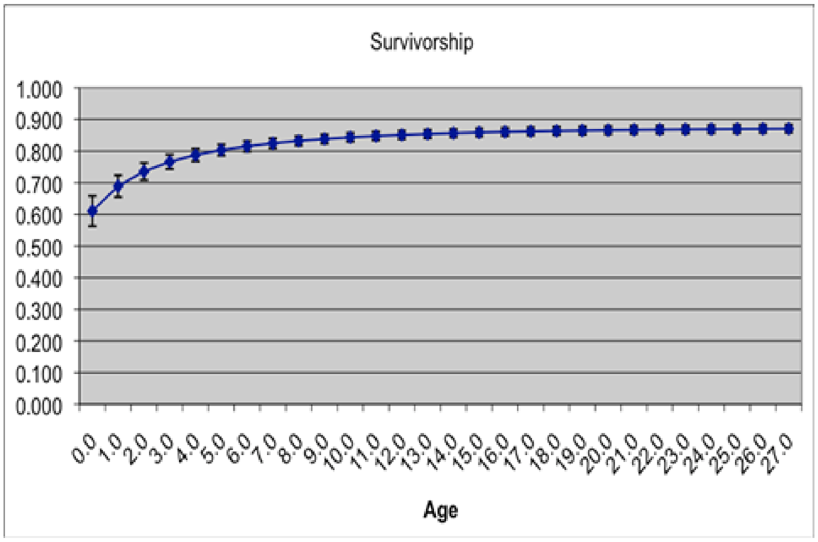
Survivorship by age for male and female sandbar sharks

MaleAge	Mortality	Survival StDev	Survivorship
0.0	0.278	0.052	0.722
1.0	0.236	0.041	0.764
2.0	0.209	0.033	0.791
3.0	0.191	0.029	0.809
4.0	0.178	0.025	0.822
5.0	0.168	0.023	0.832
6.0	0.160	0.021	0.840
7.0	0.154	0.019	0.846
8.0	0.149	0.018	0.851
9.0	0.145	0.017	0.855
10.0	0.142	0.016	0.858
11.0	0.139	0.016	0.861
12.0	0.137	0.015	0.863
13.0	0.135	0.015	0.865
14.0	0.134	0.014	0.866
15.0	0.133	0.014	0.867
16.0	0.131	0.014	0.869
17.0	0.131	0.014	0.869
18.0	0.130	0.014	0.870
19.0	0.129	0.013	0.871
20.0	0.129	0.013	0.871
21.0	0.128	0.013	0.872
22.0	0.128	0.013	0.872



Female

Age	Mortality	Survival StDev	Survivorship
0.0	0.389	0.048	0.611
1.0	0.311	0.034	0.689
2.0	0.264	0.027	0.736
3.0	0.234	0.022	0.766
4.0	0.213	0.020	0.787
5.0	0.197	0.018	0.803
6.0	0.185	0.017	0.815
7.0	0.175	0.016	0.825
8.0	0.168	0.015	0.832
9.0	0.162	0.014	0.838
10.0	0.157	0.014	0.843
11.0	0.152	0.014	0.848
12.0	0.149	0.013	0.851
13.0	0.146	0.013	0.854
14.0	0.143	0.013	0.857
15.0	0.141	0.013	0.859
16.0	0.139	0.013	0.861
17.0	0.138	0.013	0.862
18.0	0.136	0.013	0.864
19.0	0.135	0.013	0.865
20.0	0.134	0.013	0.866
21.0	0.133	0.013	0.867
22.0	0.132	0.013	0.868
23.0	0.132	0.012	0.868
24.0	0.131	0.012	0.869
25.0	0.130	0.012	0.870
26.0	0.130	0.012	0.870
27.0	0.129	0.012	0.871



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2.10. ***TABLES***

Table 1: Maturity schedule (proportion mature) for ages of *Carcharhinus plumbeus*. The parameters for the model are a and b, avg pr mat is the average proportion mature for each size bin, and SE is standard error.

	Females	a=-8.6056	b=0.6571		Males	a=-11.3954	b=0.9411		Maternity	a=-6.4554	b=0.4151	
Age	Avg pr mat	SE a	SE b	n	Avg pr mat	SE a	SE b	n	Avg pr mat	SE a	SE b	n
0	0.000	0.716	0.509	11	0.000	1.185	0.09	9	0.002	0.507	0.035	11
1	0.000			5	0.000			5	0.002			5
2	0.001			2	0.000			1	0.004			2
3	0.001			4				0	0.005			4
4	0.003			4	0.000			2	0.008			4
5	0.005			4	0.001			1	0.012			4
6	0.009			6	0.003			3	0.019			5
7	0.018			10	0.008			14	0.028			9
8	0.034			16	0.021			17	0.042			15
9	0.063			49	0.051			33	0.062			48
10	0.116			73	0.121			55	0.091			70
11	0.201			67	0.261			44	0.131			66
12	0.327			57	0.474			38	0.186			57
13	0.484			58	0.698			40	0.257			57
14	0.644			43	0.856			44	0.344			43
15	0.777			63	0.938			29	0.443			60
16	0.871			37	0.975			26	0.546			37
17	0.929			38	0.990			34	0.646			38
18	0.962			25	0.996			22	0.734			25
19	0.980			27	0.998			18	0.807			26
20	0.989			19	0.999			5	0.864			19
21	0.994			17	1.000			4	0.906			16
22	0.997			7	1.000			5	0.936			7
23	0.999			3					0.957			2

24	0.999			7					0.971			7
25	1.000			2					0.981			2
26	1.000			1					0.987			1
27	1.000			1								

3. COMMERCIAL FISHERY STATISTICS

3.1. *OVERVIEW*

3.1.1. Membership

Ivy Baremore (chair, SEFSC), Elizabeth Babcock (RSMAS), Heather Balchowsky (HMS), Carolyn Belcher (GADNR), Alan Bianchi (NCDENR), Enric Cortés (SEFSC), Bill Gazey (LGL), Chris Hayes (ACCSP), Rusty Hudson (DSF), Michelle Passerotti (SEFSC), David Stiller (Fisherman-Alabama)

3.1.2. Issues

The catch working group (WG) discussed a number of issues concerning the catch data for sandbar sharks including: 1) creating the commercial landings stream; 2) estimation of the Mexican catches; 3) post release discard mortality rates; 4) setting the year for virgin biomass; and 5) estimating commercial landings back to the year of virgin biomass (catch reconstruction).

3.2. *REVIEW OF WORKING PAPERS*

SEDAR 21-DW-07 Description of data sources used to quantify shark catches in commercial and recreational fisheries in the U.S. Atlantic Ocean and Gulf of Mexico.
I.E. Baremore, H. Balchowsky, V. Matter, E. Cortes
Quantitative information on the marine resources caught and sold commercially in the United States (U.S.) Atlantic Ocean and Gulf of Mexico (GOM) is collected by a variety of state and federal agencies. These data are collated by the National Oceanic and Atmospheric Administration (NOAA) Fisheries Service (henceforth called "NOAA Fisheries") Northeast Fisheries Science Center (NEFSC) for Atlantic states Virginia and north (referred to as the "northeast region"), and by the Southeast Fisheries Science Center (SEFSC) for states along the GOM and Atlantic states of North Carolina and south (referred to as the "southeast region"). Data from many sources are used to evaluate trends in shark catches and to assess changes in size over time since limited biological information is collected in some of these programs.

SEDAR 21-DW-09 Updated catches of sandbar, dusky, and blacknose sharks
E. Cortés and I.E. Baremore

This document presents updated commercial and recreational landings and discard estimates of sandbar, dusky and blacknose sharks up to 2009. Information on the geographical distribution of both commercial and recreational catches is presented along with gear-specific information of commercial landings. Length-frequency information and trends in average size of the catches from several commercial and recreational sources are also included.

SEDAR 21-DW-10 Large and Small Coastal Sharks Collected Under the Exempted Fishing Program Managed by the Highly Migratory Species Management Division.
J. Wilson
The National Marine Fisheries Service (NMFS) may grant individuals exemptions from fishing regulations in Federal waters, consistent with provisions of the Magnuson-Stevens Fishery Conservation and Management Act, such as exemptions from species size limits, closed seasons, and prohibited species, for activities like limited testing of fishing gear, collection of specimens for public display, scientific data collection, investigating bycatch, and methods to improve safety at sea. The Highly Migratory Species (HMS) Management Division monitors the take of sharks in the Atlantic Ocean, Gulf of Mexico, and Caribbean Sea under the exempted fishing program. This working document describes the number of sandbar, dusky, and blacknose sharks taken under the exempted fishing program from 2000 to 2009 and includes descriptive statistics (e.g., mean and median length) by gear type of these takes.

SEDAR 21-DW-12 Catches of Sandbar Shark from the Southeast US Gillnet Fishery: 1999-2009.
M.S. Passerotti and J.K. Carlson
This document presents information on catch and discards of sandbar sharks in the southeast commercial gillnet fishery from 1999 through 2009. Average sizes of sandbar sharks caught are also presented by gear type and year, when available.

SEDAR 21-DW-13 Errata Sheet for 'CATCH AND BYCATCH IN THE SHARK GILLNET FISHERY: 2005-2006', NOAA Technical Memorandum NMFS-SEFSC-552.
M.S. Passerotti and J.K. Carlson

Since the publication of 'Catch and Bycatch in the Shark Gillnet Fishery: 2005-2006', March 2007, we have become aware of a number of errors within the catch information reported. This document corrects those errors and provides revised catch tables.

SEDAR 21-DW-14 Update to Illegal Shark Fishing off the coast of Texas by Mexican Lanchas.
K. Brewster-Geisz, S. Durkee, and P. Barelli
This document updates the United States Coast Guard detected fishery-related lancha incursions data reported in Illegal Shark Fishing off the Coast of Texas by Mexican Lanchas document (LCS05/06-DW-07) from SEDAR-11 Large Coastal Shark Complex, Blacktip, and Sandbar Shark Stock Assessment

SEDAR 21-DW-22 Catch and bycatch in the bottom longline observer program from 2005 to 2009.
L.F. Hale, S.J.B. Gulak, and J.K. Carlson
Data gathered from observation of the bottom longline fishery in the southern U.S. Atlantic Ocean and Gulf of Mexico from 2005 through 2009 are reported. Number caught, disposition, and percentages of the large and small coastal complex for sandbar sharks, blacknose sharks, and dusky sharks are reported by year, area, and target when available.

SEDAR 21-DW-23 Identification and evaluation of shark bycatch in Georgia's commercial shrimp trawl fishery with implications for management.
C. N. Belcher and C. A. Jennings
Many US states have recreational and commercial fisheries that occur in nursery areas occupied by subadult sharks and can potentially affect their survival. Georgia is one of few US states without a directed commercial shark fishery, but the state has a large, nearshore penaeid shrimp trawl fishery in which small sharks occur as bycatch. During a 1995-1998 investigation of bycatch in fishery-dependent sampling events, 34% of 127 trawls contained sharks. This bycatch totaled 217 individuals from six species, with Atlantic sharpnose shark, *Rhizoprionodon terraenovae* (Richardson), the most common and finetooth shark, *Carcharhinus isodon* (Müller and Henle), and spinner shark, *Carcharhinus brevipinna* (Müller and Henle), the least common. The highest catch rates for sharks occurred during June and July and coincided with the peak

months of the pupping season for many species. Trawl tow speed and tow time did not significantly influence catch rates for shark species. Gear configurations (net type, turtle excluder device, bycatch reduction device) affected catch rates for shark species. Management strategies that may reduce shark bycatch in this fishery include gear restrictions, a delayed season opening, or reduced bar spacing on turtle excluder devices.

SEDAR 21-DW-35 Atlantic Commercial Landings of blacknose, dusky, sandbar, unclassified, small coastal, and requiem sharks provided by the Atlantic Coastal Cooperative Statistics Program (ACCSP).
C. Hayes
This working document was developed by the Atlantic Coastal Cooperative Statistics Program (ACCSP) to provide commercial landings of blacknose, dusky, sandbar, unclassified, small coastal, and requiem sharks from 1950 to 2009 to the Southeast Fisheries Science Center for the Southeast Data, Assessment, and Review (SEDAR) 21. Species-specific and non-specific data are presented by year, annually by gear, and annually by subregion.

3.3. *COMMERCIAL LANDINGS*

3.3.1. Commercial U.S. catches

Sandbar commercial landings are summarized in SEDAR 21-DW-09. U.S. commercial landings of sandbar sharks in 1996-2009 were compiled based on Northeast regional general canvass landings data and Southeast regional general canvass landings data (now known as Accumulated Landings System, ALS), and the SEFSC Quota Monitoring System (QMS) data based on southeastern region permitted shark dealer reports (now known as Pelagic Dealer Compliance, PDC). The larger of the two values reported for sandbar sharks in the southeast general canvass and the SEFSC quota monitoring was taken as the value of sandbar shark landings for the southeast. The landings from the northeast general canvass data were then added to the southeast landings to produce total U.S. estimates. Unclassified sharks in 1996-2009 attributed to the LCS grouping were proportionally allocated to sandbar sharks by using the proportion of sandbar sharks in the large coastal shark (LCS) complex (in the total U.S. landings estimates) and multiplying the unclassified sharks by that value to estimate the weight of sandbar sharks likely listed as unclassified. The value was then added to the value reported from the total U.S. estimates to determine the final total landings for sandbar sharks.

The data are collected in landed or dressed weight. Various conversions were used to convert dressed weight to number of sharks. From 1981 to 1985, an average weight of 35.9 was used (SEDAR 11). From 1986 to 1993, an average weight of 34.5, the average of the average weights from 1994 to 1996 from the bottom longline shark fishery observer program (BLLOP), was used. From 1994 onward, the average weight was determined from data provided directly by the bottom longline shark fishery observer program (Table 1). All weights were predicted from fork length measurements taken by observers in the directed shark bottom longline fishery. Predicted weights (obtained by back-transforming from fork lengths) are preferred over directly measured weights because the latter are hard to take during observer operations and are thus very rare. Average weights were calculated by applying a published length-weight regression (Kohler et al. 1995). The commercial landings of sandbar sharks increased overall from 1981 to a peak in 1994 (126,300 sharks) and has since declined overall (Table 2, Fig. 1).

Although sandbar sharks were caught in a variety of different gear types, since 1987 the majority occurred in longline and gillnet fisheries. Landings of sandbar sharks were reported in the North Atlantic (Maine to New Jersey), Mid-Atlantic (New Jersey to Virginia), South Atlantic (North Carolina to east coast of Florida) and Gulf of Mexico (west coast of Florida to Texas) regions. The majority of sandbar shark landings from 1987 to 2009 occurred in the Gulf of Mexico (53%) and in the South Atlantic (31%) regions with a minority of landings in the Mid-Atlantic (16%). Most landings were along the east and west coast of Florida and in North Carolina (SEDAR21-DW-09).

Decision 1. Landings as provided in SEDAR21-DW-09 were recommended for use in the assessment.

3.3.2. Mexican Catches

Mexican commercial catches of sandbar sharks were also considered as in previous assessments. Catches of small sharks (“cazón” <1.5m) and large sharks (“tiburón” >1.5 m) are available in the annual fisheries statistics from Conapesca (http://www.conapesca.sagarpa.gob.mx/wb/cona/cona_anuario_estadistico_de_pesca). Bonfil and Babcock (LCS05/06-DW-06) used these data to estimate the number of sandbar sharks caught in the Mexican fishery by assuming that sandbar sharks were only caught in the “large shark” category and only in the states of Tamaulipas, Veracruz and Yucatán. They assumed that sandbar sharks were 7% of large sharks (in live weight) in Yucatán, and 7.3% in Tamaulipas and Veracruz. They assumed average weights of 38 kg in Tamaulipas and Veracruz and 29.5 kg in Yucatán to convert catch in weight to catch in numbers. The time series was updated through 2008 using the same methodology. Commercial catches of sandbars in Mexico declined from 2000 to 2003 and remained relatively stable from 2003 to 2007 at approximately 4,000 sharks and then declined to about 2,500 sharks in 2008. Catches in 2009 were assumed to be equal to those in 2008.

Decision 2. The same method from SEDAR 11 was used to estimate sandbar shark catch in Mexico and to update that data series.

3.3.3. Unreported Catches

For the previous sandbar shark stock assessment (SEDAR 11), unreported catches of large coastal sharks were brought forward by Mr. Chris Brannon for the years of 1986 to 1991 for both the Gulf of Mexico and South Atlantic fisheries. For the Gulf of Mexico, Brannon estimated that landings were approximately 2/3 blacktip sharks, with the remaining third being a combination of sandbar sharks and other large coastal species (LCS) species. For the Atlantic, Brannon reported that landings were approximately 80% sandbar sharks, with the remaining being a combination of blacktip sharks and other LCS species. Given the general belief that landings before the current reporting systems were underreported, the WG made the assumption that none of the catches were included and kept these data separate, listing them as unreported.

Following the information provided by Mr. Brannon, for the years 1986, 1987, 1990, and 1991, it was assumed that 11% (0.33x0.33) of the total landings in the Gulf of Mexico consisted of sandbar sharks. For 1988 and 1989, 40% (0.5x0.8) of the total landings in the Atlantic consisted of sandbar sharks. We thus kept the catch history derived in SEDAR 11 for 1986-1991.

Decision 3. Unreported catches were estimated using the same methods from SEDAR 11.

3.3.4. Reconstruction of Historical Catches

In the previous assessment (SEDAR 11), the commercial catches (commercial landings + unreported commercial catches) were assumed to be of the same magnitude from 1975 to 1980 as they were in 1981. However, a new definition of the year of virgin biomass led to discussion of another method employing an exponential decline back to 1975, preceded by a linear decline from 1975 back to 1960. The Gulf of Mexico menhaden fishery bycatch estimates were also extrapolated back to 1960 by taking the average bycatch estimates from 1981 to 2009 and applying that value from 1960 to 1980.

Decision 4. An exponential decline was implemented back to 1975 and then a linear decline from 1975 to 1960 was used to estimate historical catches. Bycatch estimates in the Gulf of Mexico menhaden purse seine fishery were also calculated back to 1960 by applying the average bycatch estimate from 1981 to 2009 to 1960 through 1980.

3.3.5. Year of Virgin Biomass

Expert opinion from the industry representatives was elicited regarding the year when the sandbar shark stock could be considered virgin. The previously estimated year of virgin biomass (1975) was thought to be inaccurate and, based on that expert opinion, it was moved back from 1975 to 1960. A linear increase in catches corresponding to an increase in effort was further assumed from 1960 to 1975 (see section 3.3.4 above).

Decision 5. The year of virgin biomass for sandbar sharks was changed from 1975 to 1960.

3.4. *COMMERCIAL DISCARDS*

3.4.1. Fishery Discards

3.4.1.1. Commercial Fisheries

U.S. commercial discards of sandbar sharks were negligible until 2007 because a targeted fishery existed until this time, and because the value of the product was high. Discard rates of sandbar sharks after 2007 were not considered due to the low numbers of observations and because of the short time period between the closure of the targeted fishery and the assessment.

3.4.1.2. Gulf Menhaden Fishery Bycatch

For the previous assessment, effort-adjusted estimates of dead discards were calculated for the Gulf of Mexico menhaden purse seine fishery. De Silva et al. (2001) reported that sandbar sharks represented 1.8% of the total observed shark bycatch in 1994-1995. Considering the reported 75% mortality rate among all sharks, this resulted in an estimated bycatch of 486 (36,000*0.018*0.75) and 445 (33,000*0.018*0.75) dead sandbar sharks in 1994 and 1995, respectively. The number of vessels operating in the fishery each year (1981-2004) was divided by 53.5 vessels, the average number of vessels operating for the years in which bycatch estimates were available (1994 and 1995). The year-specific multipliers were then multiplied by the average number of sandbar sharks discarded dead (465), as determined previously. This provided for year-specific bycatch estimates adjusted for the annual number of vessels in the fleet for the period 1981-2004. Because more recent effort estimates for the menhaden fleet were not available and there were no other reasonable methods available to change the estimates, the same estimate for the last year of data (374 fish) was used to populate the rest of the series (2005-2009) (Table 2).

Decision 6. The discard estimate for sandbar sharks from the last year of data for the Gulf menhaden fishery was applied to the remainder of the time series.

3.4.2. *Post-Release Mortality*

3.4.2.1. Recommendations

At-vessel mortality can be approximated using observer data. However, there is very little data on which to base an estimate of post-release discard mortality for shark species. The catch group invited industry representatives from both bottom longline and gillnet fisheries to provide observational data on this topic. Industry representatives were asked to give a probability (%) that a shark would die after being released alive. Gear-specific recommendations are as follows:

Gillnet: 5%

Bottom longline: 5%

Pelagic longline: 2%

3.4.2.2. Justifications:

The industry representatives noted the robustness of sandbar sharks, indicating that sharks boated alive were very likely to survive if released.

3.4.2.3. Decisions

The life history (LH) WG was tasked with a literature search on post-release mortality. Based on Campana et al. (2009), the LH WG reported that post-release mortality of blue sharks was approximately 6% greater than the percentage of sharks that were boated dead (at-vessel mortality). Therefore, the group applied a '6% rule' to the boated dead portion of the catch (estimate of boated dead portion is available from observer reports). The LH WG stated that the percent of at-vessel mortality was used as a proxy for discard mortality. The LH WG expressed an opinion that this rate would most likely be higher for sandbar, blacknose, and dusky sharks due to increased water temperatures in the western North Atlantic Ocean and the notable robustness of blue sharks. The plenary discussion focused on whether the blue shark was an appropriate model species for mortality rates, and the LH representatives stated that it was the only species for which actual post-release discard mortality data were available.

The catch WG presented the estimates of post-release discard mortality provided by the industry. Due to confusion about the terms 'discard mortality,' and 'post-release discard mortality' among most of the panel members at plenary, there was much discussion as to the wide disparity in the numbers presented by each group. Members of the LH WG insisted that the total numbers they presented (% at-vessel mortality + 6%) only represented post-release mortality. Many panel members expressed hesitation at using these numbers as a proxy for post-release mortality, but LH WG members stated that sharks released alive were not uninjured and therefore were more likely to suffer mortality. One industry representative expressed his opinion that sandbar sharks were very robust, and therefore the rates should be lower than those presented by the LH WG.

Other panel members expressed skepticism about the '6% rule' introduced by the LH WG. The LH members stated that they knew it was a poor approximation, but that a little information was better than a blind guess. There was also some discussion about using mortality rates from a pelagic longline to inform estimates from bottom longline, but it was again noted that very little data were available.

A panel member noted that gear and regulatory changes would also have an impact on post-release mortality. Circle hooks were mandated in the pelagic fishery in 2004, which would most likely decrease injury and mortality. The bottom longline fishery has also undergone drastic gear changes, mostly due to regulations. An analyst stated that changes in mortality due to gear/management changes could be incorporated into the model, however mortality rates before and after changes were not further discussed.

The numbers that were eventually decided upon for bottom longline and pelagic longline actually represent total discard mortality, though many members of the panel thought that the discussion only centered on the post-release discard mortality. Due to the wide-spread confusion on this topic, it would be prudent to revisit these numbers at the assessment workshop.

Because of a lack of literature, the LH WG mostly deferred to the catch WG discard mortality estimates for gillnet gear.

Bottom longline

The LH WG estimated discard mortality to be 38% (32% at vessel plus 6% post-release) for sandbar sharks caught by bottom longline, and the catch group suggested a rate of 5% post-release discard mortality. A consensus number could not be reached, but all agreed that mortality would be higher for bottom longline gear than for pelagic gear. Therefore, a range between the pelagic longline discard mortality rate and the discard mortality estimate provided by the LH group was chosen. The discard mortality for sandbar sharks on bottom longline was between 28.5-38.0%.

Pelagic longline

The LH WG provided an estimate for discard mortality for sandbar sharks caught by bottom longline of 38% (32% at vessel plus 6%), but did not present any other gear-specific estimates. The catch group suggested a post-release discard mortality (percentage of sharks that would die after being released alive) of 2% for sandbar sharks on pelagic longline. At-vessel mortality for pelagic longline gear from the PLLOP was calculated at plenary. It was stated that discard mortality would be lower for pelagic longline than for bottom longline. Therefore the difference between at-vessel mortality for pelagic and bottom longlines was applied to the overall discard mortality estimated by the LH WG. The at-vessel mortality rate from the PLLOP was 24%, and was 32% for the BLLOP. The difference between these two mortality estimates was 25%, therefore 38% (the LH WG estimate) was multiplied by 0.75 (taking the 25% difference between gears into account) to get a discard mortality rate of 28.5%.

Gillnet

The catch group estimated a 5% post-release discard mortality for sandbar sharks caught in gillnet gear. A new paper was introduced by the catch group at plenary (Jensen and Hopkins 2001), which estimated at-vessel mortality of 10% for sandbar sharks. The final discard mortality rate was a range of 5-10%, which took both the catch group estimates and literature into account. It should be noted that gillnet observer data were not used for discard mortality estimates.

Decision 7: Post-release discard mortality for sandbar sharks caught on commercial bottom longline gear was estimated to range between 28.5-38.0%.

Decision 8: Post-release mortality for sandbar sharks caught on commercial pelagic longline gear was estimated to be 28.5%.

Decision 9: Post-release discard mortality for sandbar sharks caught on commercial gillnet gear was estimated to be between 5-10%.

3.5. *COMMERCIAL EFFORT*

Commercial effort was not taken into account because commercial effort directed to sharks is not reported for the various coastal commercial fisheries that catch sandbar sharks. However, the Indices WG calculated effort estimates and catch-per-unit effort estimates to develop various indices of abundance.

3.6. *BIOLOGICAL SAMPLING*

Biological samples of sandbar sharks were available from three main sources: BLLOP, PLLOP, and SGNOP. Biological samples are available from the BLLOP from 1994 to 2009, from the PLLOP 1992 to 2009 and from the SGNOP from 1992 to 2009 (SEDAR 21-DW-07, SEDAR 21-DW-09, SEDAR 21-DW-12, SEDAR 21-DW-22).

3.6.1. Sampling Intensity Length/Age/Weight

The number of samples of sandbar sharks obtained from the BLLOP and PLLOP were reported in SEDAR 21-DW-09. For the BLLOP, the number of sandbar shark samples ranged from a low of 68 animals in 1993 to a maximum of 3,106 in 2001 (SEDAR 21-DW-09). For the PLLOP, the number of sandbar shark samples ranged from 1 animal in 2000 and 2001 to 59 in 1995 (SEDAR 21-DW-09)

3.6.2. Length/Age Distributions

The average length trends from the BLLOP and PLLOP were illustrated in SEDAR 21-DW-09. The predicted average weight and observed fork length of sandbar shark from the BLLOP showed a declining trend in 1993-1998, but followed an increasing trend since then (SEDAR21-DW-09). Sample size was low in the PLLOP (n=248), which showed no trend. Data from the dealer weighout (for animals weighed individually) revealed a fairly stable trend for the period with a large number of observations (1992-2006).

Length-frequency distributions of sandbar sharks observed in the BLLOP show that both immature and mature animals (ca. > 152-155 cm FL) are caught in the directed shark fishery (SEDAR21-DW-09). Although based on few observations, a similar trend is seen in the PLLOP.

3.6.3. Adequacy for Characterizing Catch

The commercial fishery data for the sandbar commercial shark fishery was considered to be adequate to characterize the fishery. The commercial landings data are provided directly from dealer reports. The conversion factors used to create the commercial landings stream in numbers are based on data gathered from the observer programs and are therefore a good characterization of the size distribution of the sandbar sharks typically encountered in the commercial fishery. The Mexican catches have the most uncertainty around them because the estimates are based on an assumption that the species catch composition and length-frequency distribution remained unchanged since the mid 1990s. The Catch WG agreed that this is an adequate estimation of the Mexican catches.

3.6.4. Alternatives for Characterizing Discard Length/Age

The Catch WG did not discuss any alternatives for characterizing discard length or age for sandbar sharks because of the historic lack of discards. However, these should be taken into account after 2007, when the species was listed as prohibited and the sandbar shark research fishery was established.

3.7. *COMMERCIAL CATCH AT AGE/LENGTH; DIRECTED, DISCARDS*

Length-frequency information of the catch from the observer programs (BLLOP and PLLOP) will be converted to age-frequency data through age-length keys. Length- and age-frequency distributions will be used to fit selectivity curves for use in the assessment model(s).

3.8. *COMMENTS ON ADEQUACY OF DATA FOR ASSESSMENT ANALYSES*

The commercial data gathered to illustrate the landings trends for the commercial sandbar shark fishery were considered to be adequate for assessment analyses by the Catch WG. The commercial landings data were considered to be reliable as they are generated from dealer reports and since this fishery has little misidentification issues. Perhaps the weakest set of data that the Catch WG discussed were the estimation of Mexican catches but the commercial group felt that the estimates were still reliable and adequate for assessment analyses, as they are consistent with what was done in SEDAR 11.

3.9. *LITERATURE CITED*

Jensen, C.F. and G.A. Hopkins. 2001. Evaluation of bycatch in the North Carolina Spanish and king mackerel sinknet fishery with emphasis on sharks during October and November 1998 and 2000 including historical data from 1996-1997. Report to North Carolina Sea Grant. Project # 98FEG-47.

3.10. *TABLES*

Table 1. Average weight (lb dw) of sandbar sharks by year from the Bottom Longline Observer Program.

Year	Mean wt	SE
1993	39.10	1.12
1994	37.15	0.31
1995	35.69	0.34
1996	30.59	0.38
1997	30.96	0.45
1998	23.85	0.29
1999	32.47	0.55
2000	41.21	0.74
2001	36.73	0.30
2002	42.49	0.39
2003	40.67	0.27
2004	38.48	0.29
2005	44.77	0.39
2006	41.03	0.36
2007	44.39	0.39
2008	49.18	0.47
2009	49.46	0.20

Table 2. Baseline scenario: Catches of sandbar sharks (in numbers of individuals) in the Gulf of Mexico, 1960-2009.

Year	Commercial Landings	Recreational catches	Unreported catches	Menhaden fish. Bycatch	Mexican catches	Total	**Com+Unrep**	**Rec+Mex**	**Menhaden**
1960							**0.085**	**0.065**	**0.5**
1961							**0.169**	**0.129**	**0.5**
1962							**0.254**	**0.194**	**0.5**
1963							**0.339**	**0.259**	**0.5**
1964							**0.424**	**0.323**	**0.5**
1965							**0.508**	**0.388**	**0.5**
1966							**0.593**	**0.453**	**0.5**
1967							**0.678**	**0.517**	**0.5**
1968							**0.763**	**0.582**	**0.5**
1969							**0.847**	**0.647**	**0.5**
1970							**0.932**	**0.711**	**0.5**
1971							**1.017**	**0.776**	**0.5**
1972							**1.101**	**0.841**	**0.5**
1973							**1.186**	**0.905**	**0.5**
1974							**1.271**	**0.970**	**0.5**
1975							**1.356**	**1.0**	**0.5**
1976							**1.383**	**1.0**	**0.5**
1977							**1.474**	**1.1**	**0.5**
1978							**1.764**	**2.3**	**0.5**
1979							**2.581**	**25.4**	**0.5**
1980							**4.309**	**98.0**	**0.5**
1981	6.6	128.9		0.7	10.1	146.3	6.6	138.9	0.7
1982	6.6	33.6		0.7	11.8	52.8	6.6	45.4	0.7
1983	7.2	415.9		0.7	11.1	434.9	7.2	427.0	0.7
1984	9.8	56.4		0.7	11.7	78.6	9.8	68.1	0.7
1985	9.1	67.7		0.6	7.9	85.3	9.1	75.6	0.6
1986	23.1	124.8	2.739	0.6	9.4	160.6	25.8	134.2	0.6
1987	**66.3**	30.5	7.733	0.7	7.0	112.1	74.0	37.4	0.7
1988	**79.4**	63.6	45.32	0.6	9.1	198.1	124.7	72.8	0.6
1989	**122.2**	26.2	38.52	0.7	8.3	195.9	160.7	34.5	0.7
1990	**116.7**	57.7	5.731	0.7	10.7	191.6	122.4	68.5	0.7
1991	**95.4**	35.4	1.243	0.5	9.1	141.6	96.7	44.4	0.5
1992	**100.6**	33.8		0.4	9.7	144.5	100.6	43.5	0.4
1993	**72.0**	23.8		0.5	9.1	105.4	72.0	32.9	0.5
1994	**126.3**	14.6		0.5	8.8	150.2	126.3	23.4	0.5
1995	**84.4**	25.3		0.4	9.9	120.0	84.4	35.2	0.4

1996	65.5	36.1	0.4	10.7	112.8	65.5	46.8	0.4
1997	41.5	41.0	0.5	8.4	91.2	41.5	49.3	0.5
1998	62.7	34.6	0.4	7.2	104.9	62.7	41.8	0.4
1999	53.3	19.4	0.5	8.0	81.1	53.3	27.3	0.5
2000	37.3	10.8	0.4	**7.03**	55.5	37.3	17.8	0.4
2001	48.2	35.7	0.4	**6.41**	90.7	48.2	42.1	0.4
2002	56.4	8.0	0.4	**5.03**	69.8	56.4	13.1	0.4
2003	45.2	4.9	0.4	**4.33**	54.8	45.2	9.3	0.4
2004	39.1	3.2	0.4	**4.23**	46.9	39.1	7.4	0.4
2005	33.4	1.7	0.4	**4.42**	39.9	33.4	6.1	0.4
2006	42.1	0.4	0.4	**4.65**	47.6	42.1	5.1	0.4
2007	16.9	6.6	0.4	**4.08**	27.9	16.9	10.6	0.4
2008	2.2	4.8	0.4	**2.57**	9.9	2.2	7.3	0.4
2009	4.0	4.5	0.4	**2.57**	11.4	4.0	7.0	0.4

3.11. *FIGURES*

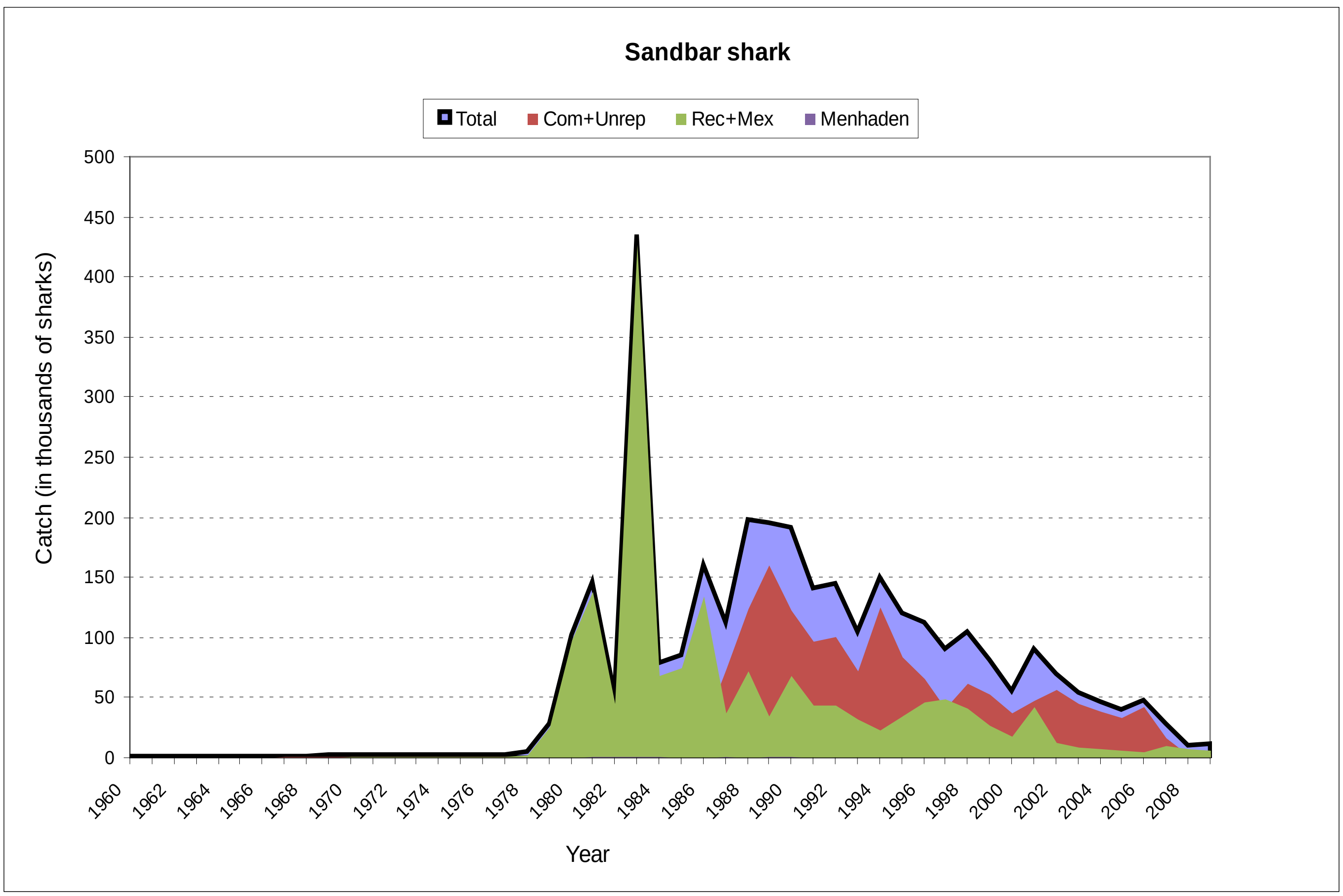

Figure 1. Catches of sandbar sharks (in thousands of individuals), 1960-2009.

4. RECREATIONAL FISHERY STATISTICS

4.1. *OVERVIEW*

4.1.1. Members

Ivy Baremore (chair, SEFSC), Elizabeth Babcock (chair, RSMAS), Heather Balchowsky (HMS), Carolyn Belcher (GADNR), Alan Bianchi (NCDENR), Enric Cortés (SEFSC), Bill Gazey (LGL), Chris Hayes (ACCSP), Rusty Hudson (DSF), Michelle Passerotti (SEFSC), David Stiller (Fisherman-Alabama)

4.1.2. Issues

Several issues were discussed by the recreational catch working group (WG), including: 1) Changes to the catch data were made from the previous assessment. 2) The year of virgin biomass and increase in fishing effort. 3) Post-release discard mortality for sandbar sharks caught by recreational hook and line. 4) Number of live releases from the recreational fishery.

4.2. *REVIEW OF WORKING PAPERS*

SEDAR21-DW-07. Description of data sources used to quantify shark catches in commercial and recreational fisheries in the U.S. Atlantic Ocean and Gulf of Mexico.
I.E. Baremore, H. Balchowsky, V. Matter, V, E. Cortes
This document presents descriptions of the available data sources. Recreational landings data are collected by state and federal agencies. Currently three databases exist, from which recreational landings of sharks are estimated: the Marine Recreational Fishery Statistics Survey (MRFSS), the NOAA Headboat Survey (Headboat), and the Texas Parks and Wildlife Department's (TXPWD) survey. There is a fourth recreational data source, the Large Pelagic Survey (LPS), which also collects shark data but from which catch estimates for sandbar sharks have not typically been produced as observations for sandbar sharks in this dataset are low.

SEDAR21-DW-09. Updated catches of sandbar, dusky and blacknose sharks.
E. Cortés and I.E. Baremore
This document presents updated commercial and recreational landings and discard estimates of sandbar, dusky and blacknose sharks up to 2009. Information on the geographical distribution of both commercial and recreational catches is presented along with gear-specific information of

commercial landings. Length-frequency information and trends in average size of the catches from several commercial and recreational sources are also included.

4.3. *RECREATIONAL LANDINGS*

4.3.1. Recreational Fisheries

Recreational catches of sandbar sharks (Table 1) correspond to estimates from three data collection programs: the Marine Recreational Fishery Statistics Survey (MRFSS), the NMFS Headboat Survey (HBOAT) operated by the SEFSC Beaufort Laboratory, and the Texas Parks and Wildlife Department Recreational Fishing Survey (TXPWD). As explained in the SEDAR 11 Data Workshop report, during 1998-1999, the MRFSS tested a new methodology for the estimation of charterboat effort, the For Hire Survey (FHS), which was deemed to provide better estimates of charterboat fishing effort and was officially adopted in 2000. The MRFSS catches reported for the period 1981-2009 are thus those incorporating the "new' methodology described in SEDAR 11 and detailed in SEDAR7-AW-03. Total, annual recreational catch estimates of sandbar sharks are the sum of the MRFSS (A+B1=fished landed or killed), HBOAT (fish landed), and TXPWD (fish landed) survey estimates. Only sharks that have been identified as sandbar shark are included; there is a large catch of unidentified carcharhinid sharks in the recreational fishery, some of which could be sandbar sharks.

4.3.2. Reconstruction of historical catches

In the previous assessment (SEDAR 11), recreational catches were assumed to decrease linearly from 1981 to 1975. However, a new definition of the year of virgin biomass led to discussion of another method employing an exponential decline back to 1975, preceded by a linear decline from 1975 back to 1960. This was based on the perception that there were a few headboat vessels, and perhaps some shore-based fishing, but very little private fishing for sharks in the 1960s and early 1970s.

Decision 1. Based on the perception that there were a few headboat vessels, and perhaps some shore-based fishing, but very little private fishing for sharks in the 1960s and early

1970s, the catches of sharks in the recreational fishery were assumed to increase linearly from 1960 to 1975 and then exponentially from 1975 to 1981.

Decision 2. As a potential sensitivity analysis, the catch in 1983, which looked like an outlier, was replaced with the geometric mean of the catches in 1982 and 1984.

4.4. *RECREATIONAL DISCARDS*

4.4.1. Historic discards

The total catches of sandbar sharks (Table 1) include individuals that were discarded dead in the MRFSS data set (catch type B1), but discards are not included for the HBOAT and TXPWD data sets. For the MRFSS data (SEDAR21-DW-11), the catches can be divided into types A1 (landings), B1 (dead discards) and B2 (live releases). Previous assessments assumed that all of the live releases survived.

4.4.2. Post-release mortality

Recommendations

Because sandbar sharks tend to be alive and in very good shape when they are caught by recreational fishers, the catch WG considered that the post release survival of sharks released alive (type B2) would be high. The life history WG was tasked with a literature search on post-release mortality, and suggested a mortality rate of 3.25% be applied to the sandbar sharks released alive. This was calculated in a two step process. First, the post-release mortality of dusky sharks was reported to be 6% (Cliff and Thurman 1984). The at-vessel mortalities from the bottom longline observer program were used to calculate the relative vulnerability of sandbar, dusky and blacknose sharks (32%, 59%, 65%, respectively). Because sandbar shark discard mortality was only 54% (32/59) of dusky mortality, the post release mortality of sandbar shark was estimated to be 3.25% (6 x 0.54). The live release (type B2) catches from MRFSS, multiplied by this mortality rate, are shown in Table 2 and Fig. 2. No information was available on live releases from the HBOAT and TXPDWD data sets.

Decision 3. A 3.25% post-release mortality rate was applied to B2 (released alive) sandbar sharks.

4.5. *BIOLOGICAL SAMPLING*

4.5.1. Sampling Intensity Length/Age/Weight

There were 422 length and weight observations for sandbar shark from MRFSS. There were 97 size observations in the HBOAT survey and 41 in TXPWD (SEDAR21-DW-9).

4.5.2. Length – Age distributions

Length distributions were available from MRFSS data, though in low numbers (SEDAR21-DW-09). Length data were too few to report from HBOAT and TXPWD.

4.5.3. Adequacy for characterizing catch

Because samplers are only able to measure fish that are landed (Type A catch), the sample size of the length and weight data is low and they are only useful for characterizing size/age distributions in the landed catch. The average sizes were stable through 2000 and increased through 2009 (SEDAR21-DW-9).

4.5.4. Alternatives for characterizing discards

No biological data is available for the dead discarded and live released sharks.

4.6. *RECREATIONAL CATCH-AT-AGE/LENGTH; DIRECTED DISCARD*

Length-frequency information of the catch from MRFSS will be converted to age-frequency data through an age-length key. Length- and age-frequency distributions will be used to fit selectivity curves for use in the assessment model(s).

4.7. *RECREATIONAL EFFORT*

Recreational effort data are available from MRFSS, HBOAT, and TXPWD, and are used to calculate the total catches from these fisheries (SEDAR21-DW-9, SEDAR21-DW-11).

4.8. *COMMENTS ON ADEQUACY OF DATA FOR ASSESSMENT ANALYSES*

Because the recreational data are based on extrapolations from a subsample of the fishery, they are highly uncertain, particularly in the 1980s. However, given the paucity of recreational data, the catch group determined the data to be the best available.

4.9. *LITERATURE CITED*

Cliff, G. and G. D. Thurman. 1984. Pathological and physiological effects of stress during capture and transport in the juvenile dusky shark, Carcharhinus obscurus. Comp Biochem Physiol 78A(1):167-173.

4.10. *TABLES*

Table 1. Catches of sandbar sharks (in numbers of individuals), 1960-2009.

Year	Commercial Landings	Recreational catches	Unreported catches	Menhaden fish. Bycatch	Mexican catches	Total	**Com+Unrep**	**Rec+Mex**	**Menhaden**
1960							**0.085**	**0.065**	**0.5**
1961							**0.169**	**0.129**	**0.5**
1962							**0.254**	**0.194**	**0.5**
1963							**0.339**	**0.259**	**0.5**
1964							**0.424**	**0.323**	**0.5**
1965							**0.508**	**0.388**	**0.5**
1966							**0.593**	**0.453**	**0.5**
1967							**0.678**	**0.517**	**0.5**
1968							**0.763**	**0.582**	**0.5**
1969							**0.847**	**0.647**	**0.5**
1970							**0.932**	**0.711**	**0.5**
1971							**1.017**	**0.776**	**0.5**
1972							**1.101**	**0.841**	**0.5**
1973							**1.186**	**0.905**	**0.5**
1974							**1.271**	**0.970**	**0.5**
1975							**1.356**	**1.0**	**0.5**
1976							**1.383**	**1.0**	**0.5**
1977							**1.474**	**1.1**	**0.5**
1978							**1.764**	**2.3**	**0.5**
1979							**2.581**	**25.4**	**0.5**
1980							**4.309**	**98.0**	**0.5**
1981	6.6	128.9		0.7	10.1	146.3	6.6	138.9	0.7
1982	6.6	33.6		0.7	11.8	52.8	6.6	45.4	0.7
1983	7.2	415.9		0.7	11.1	434.9	7.2	427.0	0.7
1984	9.8	56.4		0.7	11.7	78.6	9.8	68.1	0.7
1985	9.1	67.7		0.6	7.9	85.3	9.1	75.6	0.6
1986	23.1	124.8	2.739	0.6	9.4	160.6	25.8	134.2	0.6
1987	66.3	30.5	7.733	0.7	7.0	112.1	74.0	37.4	0.7

1988	**79.4**	63.6	45.32	0.6	9.1	198.1	124.7	72.8	0.6
1989	**122.2**	26.2	38.52	0.7	8.3	195.9	160.7	34.5	0.7
1990	**116.7**	57.7	5.731	0.7	10.7	191.6	122.4	68.5	0.7
1991	**95.4**	35.4	1.243	0.5	9.1	141.6	96.7	44.4	0.5
1992	**100.6**	33.8		0.4	9.7	144.5	100.6	43.5	0.4
1993	**72.0**	23.8		0.5	9.1	105.4	72.0	32.9	0.5
1994	**126.3**	14.6		0.5	8.8	150.2	126.3	23.4	0.5
1995	**84.4**	25.3		0.4	9.9	120.0	84.4	35.2	0.4
1996	65.5	36.1		0.4	10.7	112.8	65.5	46.8	0.4
1997	41.5	41.0		0.5	8.4	91.2	41.5	49.3	0.5
1998	62.7	34.6		0.4	7.2	104.9	62.7	41.8	0.4
1999	53.3	19.4		0.5	8.0	81.1	53.3	27.3	0.5
2000	37.3	10.8		0.4	**7.03**	55.5	37.3	17.8	0.4
2001	48.2	35.7		0.4	**6.41**	90.7	48.2	42.1	0.4
2002	56.4	8.0		0.4	**5.03**	69.8	56.4	13.1	0.4
2003	45.2	4.9		0.4	**4.33**	54.8	45.2	9.3	0.4
2004	39.1	3.2		0.4	**4.23**	46.9	39.1	7.4	0.4
2005	33.4	1.7		0.4	**4.42**	39.9	33.4	6.1	0.4
2006	42.1	0.4		0.4	**4.65**	47.6	42.1	5.1	0.4
2007	16.9	6.6		0.4	**4.08**	27.9	16.9	10.6	0.4
2008	2.2	4.8		0.4	**2.57**	9.9	2.2	7.3	0.4
2009	4.0	4.5		0.4	**2.57**	11.4	4.0	7.0	0.4

Table 2. Estimates of live-discarded sandbar sharks (B2) from MRFSS, with a 3.25% post-release discard mortality (DM) applied by year.

Year	B2	DM
1981	120767	3925
1982	323516	10514
1983	1010991	32857
1984	347103	11281
1985	200630	6520
1986	410681	13347
1987	172402	5603
1988	118659	3856
1989	35179	1143
1990	74844	2432
1991	86335	2806
1992	93588	3042
1993	92785	3016
1994	66790	2171
1995	81880	2661
1996	128973	4192
1997	157999	5135
1998	176110	5724
1999	127209	4134
2000	99499	3234
2001	173188	5629
2002	249095	8096
2003	161777	5258
2004	55355	1799
2005	145734	4736
2006	38174	1241
2007	224561	7298
2008	80128	2604
2009	243615	7917

4.11. *FIGURES*

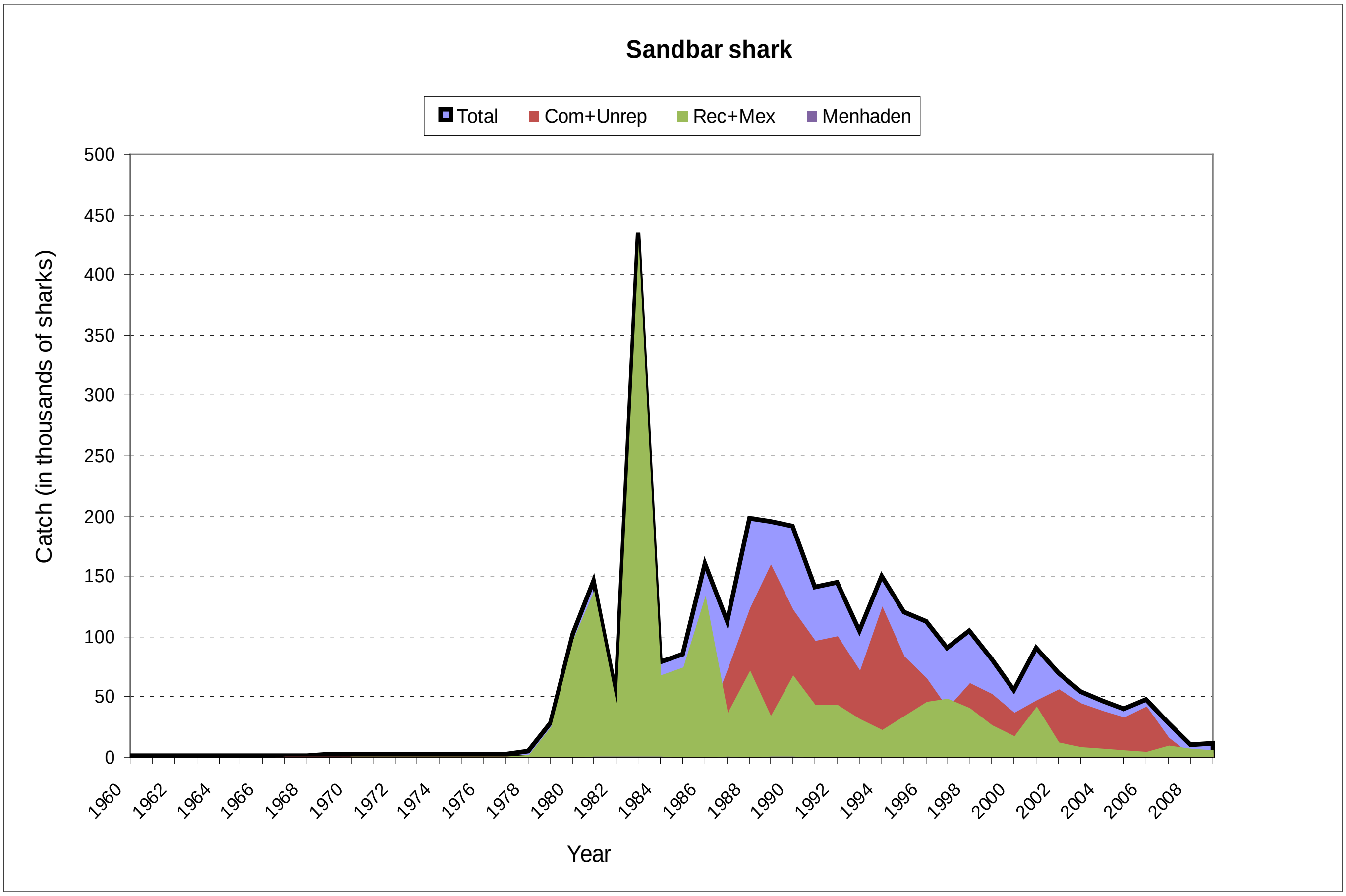

Figure 1. Catches of sandbar sharks (in thousands of sharks), 1960-2009.

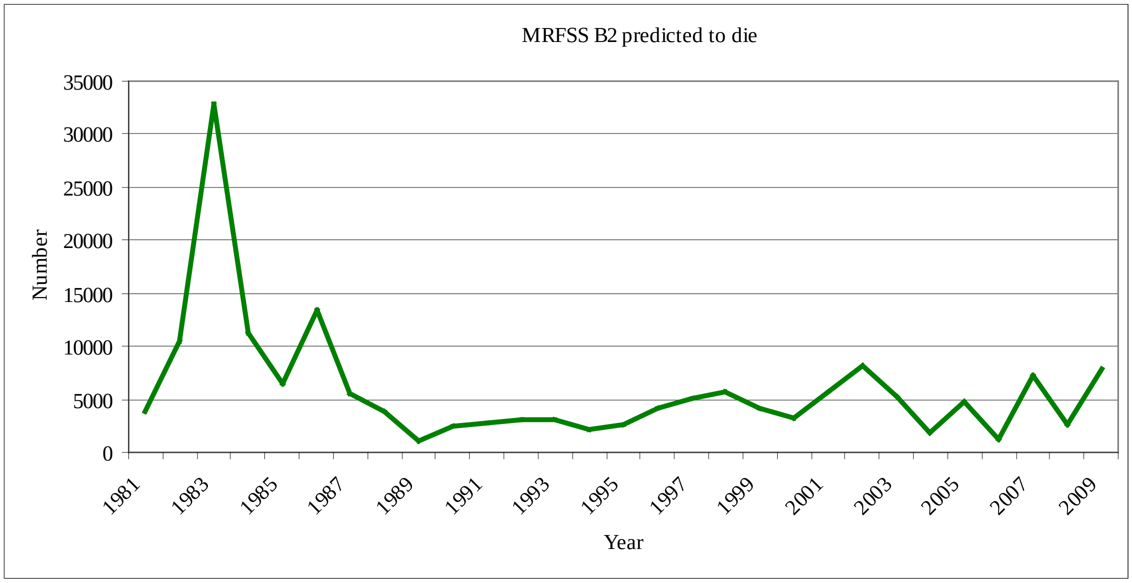

Figure 2. Number of sandbar sharks released alive (B2) from MRFSS that are predicted to die based on a 3.25% post-release discard mortality.

5. INDICES OF POPULATION ABUNDANCE

5.1. *OVERVIEW*

Fifty-eight indices of abundance were considered for use in the assessment models for blacknose, sandbar and dusky sharks. Indices were constructed using both fishery independent and dependent data. Following the Data Workshop (DW) separate models for blacknose sharks were recommended for Gulf of Mexico (GOM) and Atlantic Ocean (ATL). For the GOM stock of blacknose sharks, the DW recommended the following indices for use in the stock assessment model for the base run: NMFS Southeast Bottom Longline, NMFS SEAMAP Groundfish Trawl (Summer and Fall), Panama City Gillnet (Adult and Juvenile), Mote Marine Lab Longline, SEFSC Shark Bottom Longline Observer Program and Dauphin Island Sea Lab Bottom Longline. For the ATL stock of blacknose sharks, the DW recommended the following indices for use in the stock assessment model for the base run: NMFS Southeast Bottom Longline, SCDNR Red Drum Longline (Historical), SEFSC Shark Bottom Longline Observer Program, Drift Gillnet Observer Program, UNC Longline, GADNR Red Drum Longline, and Coastal Fishery Logbook Gillnet. The Sink Gillnet Observer Program index was recommended for a sensitivity run for blacknose sharks. For sandbar sharks, the DW recommended the following indices for use in the stock assessment model for the base run: NMFS Southeast Bottom Longline, NMFS COASTSPAN Longline (Total juveniles, YOY and Age 1+), VIMS Longline, NMFS Northeast Longline, SEFSC Shark Bottom Longline Observer Program, Southeast Pelagic Longline Observer Program, SC COASTSPAN Longline, SCDNR Red Drum Longline (Historical), Panama City Gillnet (Juvenile), GA COASTSPAN Longline (Juvenile) and Large Pelagic Survey. The NMFS Historical Longline, Coastal Fishery Logbook Bottom Longline and Southeast Pelagic Longline Logbook indices were recommended for a model sensitivity run for sandbar sharks. For dusky sharks, the DW recommended the following indices for use in the stock assessment model for the base run: NMFS Northeast Longline, SEFSC Shark Bottom Longline Observer Program, Southeast Pelagic Longline Observer Program, VIMS Longline and Large Pelagic Survey. The NMFS Historical Longline and UNC Longline indices were recommended for a sensitivity run for dusky sharks. Four indices were reviewed, but not recommended for use: the SCDNR red drum longline survey index (sandbar shark), GADNR red drum longline survey index (sandbar shark), UNC longline sampling program index (sandbar shark), and the SCDNR red drum longline survey index (blacknose shark). Those indices were not recommended for use because they had either a short time series, very low sample size, or were not conducted in appropriate habitat.

5.1.1. Group Membership

Membership of this DW working group included Heather Balchowsky, John Carlson, Marcus Drymon, Kristin Erickson, Walter Ingram (leader), Cami McCandless, Kevin McCarthy, Kristene Parsons, Adam Pollack and John Walter. Enric Cortes assisted with ranking the abundance indices during a follow-up webinar.

5.2. *REVIEW OF INDICES*

The working group reviewed sixteen working papers describing index construction:

SEDAR21-DW-01 (Panama City Gillnet)
SEDAR21-DW-02 (SEFSC Shark Bottom Longline Observer Program)
SEDAR21-DW-03 (Drift Gillnet Observer Program)
SEDAR21-DW-04 (Sink Gillnet Observer Program)
SEDAR21-DW-08 (Southeast Pelagic Longline Observer Program / Southeast Pelagic Longline Logbook)
SEDAR21-DW-11 (MRFSS)
SEDAR21-DW-18 (VIMS Longline)
SEDAR21-DW-25 (Dauphin Island Sea Lab Bottom Longline)
SEDAR21-DW-27 (NMFS COASTSPAN Longline (total juveniles, YOY and age 1+))
SEDAR21-DW-28 (NMFS Northeast Longline)
SEDAR21-DW-29 (GA COASTSPAN Longline / GADNR Red Drum Longline)
SEDAR21-DW-30 (SC COASTSPAN Longline / SCDNR Red Drum Longline (Historical and Recent))
SEDAR21-DW-32 (Northeast Gillnet Observer Program)
SEDAR21-DW-33 (UNC Longline)
SEDAR21-DW-34 (Mote Marine Lab Longline)
SEDAR21-DW-39 (NMFS Southeast Bottom Longline)
SEDAR21-DW-40 (Coastal Fishery Logbook Gillnet)
SEDAR21-DW-41 (Coastal Fishery Logbook Bottom Longline (Sandbar))

SEDAR21-DW-42 (Coastal Fishery Logbook Bottom Longline (Dusky))

SEDAR21-DW-43 (NMFS SEAMAP Groundfish Trawl)

SEDAR21-DW-44 (Large Pelagic Survey)

The working group also conducted analyses on one other data source after the data workshop. The following working paper was reviewed during a webinar following the data workshop.

SEDAR21-DW-31 (NMFS Historical Longline)

5.3. *FISHERY INDEPENDENT INDICES*

5.3.1. Panama City Gill Net (SEDAR21-DW-01)

Fishery-independent catch rates were standardized using a two-part generalized linear model analysis. One part modeled the proportion of sets that caught any sharks (at least one shark was caught) assuming a binomial distribution with a logit link function while the other part modeled the catch rates of sets with positive catches assuming a lognormal distribution. Standardized indices were developed for sandbar shark and juvenile (age 1+) and adult for blacknose shark. Depending on species, the final models varied with factors area, season, year. Although factors such as area and season were significant in most models, results from this study indicate any bias associated with these aspects did not significantly change the trends between nominal and standardized data. Trends in abundance declined for sandbar shark, juvenile blacknose shark but were stable for adult blacknose shark.

5.3.2. VIMS Longline (SEDAR21-DW-18)

The Virginia Institute of Marine Science (VIMS) has conducted a fishery-independent longline survey during summer months since 1974. Data for sandbar sharks and dusky sharks captured in the survey between 1975 and 2009 were presented. Most of the sandbar sharks encountered by the survey were immature, with females composing almost all of the mature sandbar catch. Almost all dusky sharks captured were immature. Most of the catch since the early 1990’s has been composed of 0-4 year age classes. Nominal and standardized catch rates were presented. CPUE for both species decreased from the early 1980’s to minima in 1992. CPUE then slightly increased and has oscillated since. The Indices working group 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. The Indices working group recommended the VIMS sandbar and dusky indices be used as base indices.

5.3.3. Dauphin Island Sea Lab Bottom Longline (SEDAR21-DW-25)

Blacknose sharks, *Carcharhinus acronotus*, were one of the most frequently caught sharks on a monthly longline survey initiated off the coast of Alabama in 2006. Between May 2006 and December 2009, 623 blacknose sharks (389 male, 234 female) were captured during 475 bottom longline sets. Nominal and delta lognormal standardized catch per unit effort (CPUE, sharks/100 hooks/hour) and length frequency distributions by sex were presented. It was decided by the working group to exclude stations deeper than 20 m (n=55) due to the truncated times series. Stations north of 30.2 degrees north latitude (n=39) were excluded because they occur in areas not inhabited by blacknose shark. Reanalysis of standardized CPUE values showed a decline from 2006 through 2009, with increasing coefficients of variation each year. The Indices working group suggested these data be included as a baseline, and recommended the continuation of this time series for future assessments.

5.3.4. NMFS COASTSPAN Longline (SEDAR21-DW-27)

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 2009. 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 and ended with an increase in relative abundance in 2009.

5.3.5. NMFS Northeast Longline (SEDAR21-DW-28)

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 1996-2009. 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, and 2009. 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 2009. Dusky sharks showed an increasing trend in relative abundance across the time series.

5.3.6. GA COASTSPAN Longline / GADNR Red drum Longline (SEDAR21-DW-29)

This document detailed the shark catches from the Georgia Department of Natural Resources (GADNR), Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) survey conducted in Georgia's estuarine waters from 2000-2009 and the GADNR adult red drum survey conducted in Georgia's estuarine and nearshore waters from 2007-2009. Catch per unit effort (CPUE) in number of sharks per hook hour for GA COASTSPAN longline sets and in number of sharks per number of hooks for the GADNR red drum sets were used to examine blacknose and/or sandbar shark relative abundance in Georgia's coastal waters. 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. Sandbar sharks from the GADNR COASTSPAN survey showed a fairly stable trend in relative abundance throughout the time series. Blacknose and sandbar sharks from the GADNR red drum survey also showed a relatively stable trend during the three year time frame this survey has been in existence.

5.3.7. SC COASTSPAN / SCDNR Red drum Longline (SEDAR21-DW-30)

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 blacknose and/or 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 and blacknose sharks appeared to be stable throughout the time series. Blacknose and 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.

5.3.8. NMFS Historical Longline (SEDAR21-DW-31)

This document detailed shark catch from the exploratory longline surveys conducted by the National Marine Fisheries Service, Sandy Hook, NJ and Narragansett, RI labs from 1961-1996. Data from these surveys 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 was used to examine trends in relative abundance. 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. The resulting time series for sandbar sharks showed an initial decline in relative abundance in the early 1960s, followed by a sharp increase in 1964. Sandbar shark relative abundance then dropped down again to lower levels and held steady until the mid-1980s when a slight increase in relative abundance was seen. For dusky sharks, the time series also began with a decreasing trend, but it continued throughout the 1960s followed by a more stable trend throughout the remainder of the time series with a few small peaks in the early 1970s, mid 1980s and early 1990s.

5.3.9. UNC Longline (SEDAR21-DW-33)

This document detailed the blacknose, sandbar and dusky shark catch from the University of North Carolina bottom longline survey conducted biweekly from April-November, 1972-2009, at two fixed stations in Onslow Bay south of Shackleford Banks, North Carolina. Catch per unit effort (CPUE) by set in number of sharks/number of hooks were examined by year. 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 species showed a declining trend from the mid-1970s to the mid-1990s followed by a more stable trend into the 2000s.

5.3.10. Mote Marine Lab Longline (SEDAR21-DW-34)

Mote Marine Laboratory's Center for Shark Research (CSR) has conducted relative abundance studies of coastal sharks along the Florida Gulf coast since 1991. In 2001, the CSR launched a new series of studies on larger sharks inhabiting southwest Florida offshore waters utilizing standardized, stratified drumline and longline surveys. This offshore sampling was conducted as regular quarterly surveys and continued through 2009. Although large coastal sharks were the primary target of these fishing efforts, small coastal species also were a regular component of the catch. The dataset from these surveys includes sandbar (*Carcharhinus plumbeus*) and blacknose (*C. acronotus*) sharks. No dusky sharks (*C. obscurus*) were found in these surveys; in fact, no dusky sharks had been observed in Mote Marine Laboratory's area of coverage in the eastern Gulf of Mexico since 1992, including all sampling efforts by the CSR and other Mote research centers and all fishing and collecting activities of the Mote Aquarium. The DW recommended the use of the blacknose longline index for a base run.

5.3.11. NMFS Southeast Bottom Longline (SEDAR21-DW-39)

The Southeast Fisheries Science Center (SEFSC) Mississippi Laboratories has conducted standardized bottom longline surveys in the Gulf of Mexico, Caribbean Sea, and Western North Atlantic Ocean 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, which was conducted annually in U.S. waters of the Gulf of Mexico (GOM) and/or the western north Atlantic Ocean (Atlantic), provided an important source of fisheries independent information on dusky shark in the GOM and Atlantic. The entire time series of data was used to develop abundance indices for blacknose, sandbar and dusky sharks for both the GOM and Atlantic. To develop standardized indices of annual average CPUE for blacknose and sandbar sharks for both the GOM and Atlantic, a delta-lognormal model, as described by Lo *et al.* (1992), was employed. Due to the extremely low catches of dusky shark, no abundance indices were developed for this species.

5.3.12. NMFS SEAMAP Groundfish Trawl (SEDAR21-DW-43)

The Southeast Fisheries Science Center (SEFSC) Mississippi Laboratories has been conducting groundfish surveys in the northern Gulf of Mexico under the Southeast Area Management and Assessment Program (SEAMAP) since 1987. This survey, which was conducted twice a year (summer and fall), provided an important source of fisheries independent information on blacknose sharks (*Carcharhinus acronotus*). A total of 122 blacknose sharks were collected from 1987-2009, with length frequency data indicating a wide range of sizes captured. Simple abundance indices were reported for two of the time series (summer and fall). The Indices working group suggested that the NMFS SEAMAP Groundfish trawl (Summer) and NMFS SEAMAP Groundfish trawl (Fall) be used as a base run for blacknose sharks.

5.4. *FISHERY DEPENDENT INDICES*

5.4.1. SEFSC Shark Bottom Longline Observer Program (SEDAR21-DW-02)

Catch rate series were developed from the data collected by on-boards observers in the shark bottom longline fishery for the period 1994-2009 for sandbar, dusky, and blacknose shark. 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. Because observations of the fishery had been conducted using two different non- overlapping sampling strategies (i.e. voluntary and mandatory), catch rates were modeled independently for two time series representing periods of 1994-2001 (voluntary) and 2002-2009 (mandatory). In addition to spatio-temporal factors, a factor reflecting the addition of a special sandbar shark fishery was added to the mandatory series. Year, depth and time 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. For dusky shark, the abundance trend declined over the length of the series but an increase in abundance was observed in latter years. The time series for blacknose shark indicated an increase in abundance since 1994. Based on discussion at the 2010 SEDAR 21, the stock of blacknose shark was split to a NW Atlantic Ocean and Gulf of Mexico population. A new catch rate series for blacknose shark for the NW Atlantic Ocean and Gulf of Mexico was provided in an addendum to SEDAR21-DW-02.

5.4.2. Drift Gillnet Observer Program (SEDAR21-DW-03)

A standardization of catch rate series data from the directed shark drift gillnet fishery was developed based on observer programs from 1993-1995 and 1998-2009. Depending on season and area, small coastal species, including blacknose shark, were targeted and harvested. The final model assumed a binomial distribution for the proportion of positive trips and a lognormal distribution for positive catch rates. Year and area were significant as a main effect in the binomial model and lognormal model. The relative abundance index showed a slight increase in abundance since 1993. Based on discussion at the 2010 SEDAR 21, the stock of blacknose shark was split between a NW Atlantic Ocean and Gulf of Mexico population. A revised standardized catch rate series was produced for blacknose shark for the NW Atlantic Ocean stock only. Samples in the Gulf of Mexico were insufficient to provide a useful series. However, with the reduction in samples per cell the convergence of the binomial model was questionable. The final model was run but the validity of the model fit was questionable.

5.4.3. Sink Gillnet Observer Program (SEDAR21-DW-04)

A standardization of catch rate series data for blacknose shark from the directed shark sink gillnet fishery was developed based on observer program data collected from 2005-2009. Data 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. Year, target and season and meshsize were significant as main effects in the binomial model and lognormal model. The relative abundance index series was stable. Based on discussion at the 2010 SEDAR 21, the stock of blacknose shark was been split to a NW Atlantic Ocean and Gulf of Mexico population. A revised standardized catch rate series was produced for blacknose shark for the NW Atlantic Ocean stock only. Samples in the Gulf of Mexico were insufficient to provide a useful series.

5.4.4. Southeast Pelagic Longline Observer Program / Southeast Pelagic Longline Logbook (SEDAR21-DW-08)

Updated indices of abundance were developed for dusky shark (*Carcharhinus obscurus*) and sandbar sharks (*Carcharhinus plumbeus*) from two commercial sources, the US pelagic longline logbook program (1992-2009) and the US pelagic longline observer program (1992-2009). 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. For dusky sharks, the logbook and observer time series showed a similar trend, marked by an initial decrease in the 1990s followed by a more stable trend in the 2000s. The trends form the two sources differed for sandbar sharks, with the logbook index showing a very sharp initial increase from 1994 to 1995 and a decreasing trend thereafter, whereas the observer index decreased from 1992 to 2003, after which it showed an upward trend.

5.4.5. MRFSS (SEDAR21-DW-11)

The Marine Recreational Fisheries Statistics Survey (MRFSS) dockside intercept survey data set was used to derive standardized indices of abundance for sandbar and dusky sharks. Catch per unit of effort, defined as the total catch including live releases (catch types A+B1+B2) per angler hour, was standardized using a delta lognormal generalized linear model, treating second order interactions as random effects. For sandbar sharks, only the data from May through October, for the Mid-Atlantic, South Atlantic, and Gulf of Mexico, and trips using hook and line gear, for private boats only. The explanatory variables were year, area (offshore, coastal and inland waters), target species guild (carcharhinid, other and unknown), and region (Mid Atlantic vs. Gulf of Mexico and South Atlantic combined). For dusky sharks, only the data from May through October, for the Mid-Atlantic, South Atlantic, and Gulf of Mexico, and trips using hook and line gear. The explanatory variables were year, mode (private boat or charter/party boat) area (offshore, coastal and inland waters), target species guild (carcharhinid, other and unknown), and region (Mid Atlantic, South Atlantic and Gulf of Mexico). There was a trend over the last twenty years of increasing reported catches of carcharhinids that are only identified to genus or family, mainly because the majority of carcharhinid sharks were released alive. Thus, the standardized CPUE was likely to be biased as an index of abundance, and the author did not recommend that either index be used. Finally, it was not possible to extract an index from the MRFSS data for blacknose sharks because only 322 blacknose sharks have been recorded in the intercept surveys, and 4 of the 29 years reported no catches of blacknose sharks.

5.4.6. Northeast Gillnet Observer Program (SEDAR21-DW-32)

Data from this report were not received in time to be reviewed by the Indices Working Group during the SEDAR 21 Data Workshop.

5.4.7. Coastal Fishery Logbook Gillnet (SEDAR21-DW-40)

The Coastal Fisheries Logbook Program available catch per unit effort data from 1998-2009 were used to construct a standardized abundance index for the blacknose shark gillnet fishery in the U.S. south Atlantic (south of Virginia) (SEDAR21 DW40). A modified Stephens and MacCall (2004) method was used to estimate the likelihood that blacknose shark could have been encountered given the presence or absence of other species reported from the trip. A score was assigned to each trip, and trips with scores above a critical value were included in the catch per unit effort analysis. The delta-lognormal model approach of Lo *et al.* (1992) was then used to construct a standardized index of abundance. Diagnostic plots indicated that the fit of the data to the lognormal and binomial models was acceptable. Blacknose shark standardized catch rates and nominal catch rates for gillnet vessels were similar throughout the time series. Annual mean CPUE had no clear trend over the initial seven years of the time series, but were higher during most of the final five years of the series. The working group has recommended the blacknose gillnet index from the U.S. south Atlantic be used in the base run of the assessment model.

5.4.8. Coastal Fishery Logbook Bottom Longline (Sandbar) (SEDAR21-DW-41)

This document presented an index of abundance from the Coastal Fisheries Logbook (CFL) database. The index was calculated for sandbar shark from commercial longline trips in the southeast region (Texas to North Carolina). Sandbar shark data were sufficient to construct an index of abundance including the years 1992-2007 throughout the eastern Gulf of Mexico to North Carolina. Ten factors were tested: year, season, subregion, longline length, days at sea, crew size, permit type, vessel length, distance between hooks, and numbers of hooks fished. CPUE was defined as pounds landed per hook. The final model for the binomial on proportion positive trips was: Year + Subregion + Hookdist + Tothooks + Subregion*Hookdist + Year*Hookdist. The final model for the lognormal on CPUE of successful trips was: Year + DaysatSea + TotHooks + Subregion + VesselLength + Subregion*Year + Year*VesselLength + HookDist*Subregion. The delta lognormal model approach (Lo *et al.* 1992) was used to develop the standardized index of abundance. A drop exists in annual CPUE during 1993-1995 which may be the direct result of a change in reporting. During those years the number of sharks reported as "unclassified shark" increased substantially, while species-specific reports had a concomitant decline. Standardized annual CPUE may change markedly during 1993-1995 if a portion of the unclassified sharks could be categorized as sandbar shark. This may be accomplished by applying the ratio of sandbar sharks to all sharks recorded in the bottom longline observer data from the appropriate year-area combination. CPUE was essentially flat during the remainder of the time series.

5.4.9. Coastal Fishery Logbook Bottom Longline (Dusky) (SEDAR21-DW-42)

Commercial logbook data were examined for their utility in constructing an index of abundance of dusky shark. Landings, not total catch, were available in the data set. A small number of commercial trips did report landings of dusky shark, however after 2000 landings of dusky shark were prohibited and no trips with dusky shark landings were identified in the coastal logbook data after that year. Only seven years during the time series (1990-2009) had dusky shark landings. Of those, four years had 10 or fewer positive trips. With such limited data, neither a useful nor reliable index of dusky shark abundance could be produced using the commercial coastal logbook data.

5.4.10. Large Pelagic Survey (SEDAR21-DW-44)

This paper presented an update to two abundance indices for sandbar (*Carcharhinus plumbeus*) sharks off the coast of the United States from Virginia through Massachusetts were developed using data obtained during interviews of rod and reel anglers in 1986-2009.

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 were used in this paper for the binomial and Poisson submodels for both shark species. The indices both showed a pattern of declines from the 1980s into the 1990s and a recent pattern of slight increases.

5.5. *CONSENSUS RECOMMENDATIONS AND SURVEY EVALUATIONS*

Indices were initially reviewed based upon the criteria established at the SEDAR Abundance Indices Workshop held in 2008. The data source, index construction methodology, adherence to statistical assumptions, and model diagnostics were examined for each index. All indices reviewed were judged to be appropriately constructed, although in some cases revisions were recommended. Each index was then recommended for either a base run of the assessment model or for use in a model sensitivity run. The criteria for recommendation included sample size, proportion of positive trips, length of the time series, spatial extent of the index, and region sampled (e.g. was the index restricted to marginal habitat or at the limit of a species range). Four indices were not recommended for use: SCDNR red drum longline survey (sandbar shark index), GADNR red drum longline survey (sandbar shark index), UNC longline study (sandbar shark index), and the SCDNR red drum longline survey (blacknose shark index). Those indices were not recommended due to short time series, very low sample size, or were not sampling the habitat of the species of interest.

After the data workshop, following recommended index revision and once additional indices were constructed using late arriving data sets, a webinar was held to rank the indices. Index ranking was completed at the request of the assessment biologists for the purpose of weighting the indices in the model runs. Indices could, and frequently did, have the same ranking. When determining rankings of the indices (1 = best), the primary consideration was that an index reflects the population trend of the species (or a portion of the population, e.g. juveniles). That judgment was made by considering characteristics of the data used in the construction of each index. In general, the working group ranked fishery independent indices higher than fishery dependent indices. Indices constructed from observer reported fishery dependent data were more highly ranked than self-reported fishery dependent data. Fishery independent indices were not always ranked more highly than fishery dependent indices, however. The extent of temporal and spatial coverage encompassed by an index was also very important for the ranking process. Short time series or limited spatial coverage frequently reduced the ranking of an index. For specific reasoning behind the individual index rankings, see 'Justification of Working Group Recommendation' located in the index scorecards in Appendix 5.9.

For the GOM stock of blacknose sharks, the DW recommended the following indices for use in the stock assessment model for the base run: NMFS Southeast Bottom Longline, NMFS SEAMAP Groundfish Trawl (Summer and Fall), Panama City Gillnet (Adult and Juvenile), Mote Marine Lab Longline, SEFSC Shark Bottom Longline Observer Program and Dauphin Island Sea Lab Bottom Longline. For the ATL stock of blacknose sharks, the DW recommended the following indices for use in the stock assessment model for the base run: NMFS Southeast Bottom Longline, SCDNR Red Drum Longline (Historical), SEFSC Shark Bottom Longline Observer Program, Drift Gillnet Observer Program, UNC Longline, GADNR Red Drum Longline, and Coastal Fishery Logbook Gillnet. The Sink Gillnet Observer Program index was recommended for a sensitivity run for blacknose sharks. The spatial coverage of each index is presented in Figure 5.8.1. The rankings for the recommended indices for the GOM stock of blacknose sharks can be seen in Table 5.7.1. Fishery independent index values and coefficients of variation (CV) are presented in Table 5.7.2 and the fishery dependent index vales are presented in Table 5.7.3. A plot of all the indices recommended for analysis is in Figure 5.8.2. The ranking of the indices for the ATL stock of blacknose are seen in Table 5.7.4. (base run) and Table 5.7.5 (sensitivity run). The index values and coefficients of variation for the ATL stock are presented in Table 5.7.6. (fishery independent) and Table 5.7.7. (fishery dependent). A plot of all the indices recommended for analysis is in Figure 5.8.3. At the request of the analysts, the combined rankings for blacknose sharks (single stock between the Atlantic Ocean and Gulf of Mexico), are presented in Table 5.7.8, along with the index values and CVs in Table 5.7.9 (fishery independent) and Table 5.7.10 (fishery dependent). A plot of all the indices is in Figure 5.8.4.

For sandbar sharks, the DW recommended the following indices for use in the stock assessment model for the base run: NMFS Southeast Bottom Longline, NMFS COASTSPAN Longline (Total juveniles, YOY and Age 1+), VIMS Longline, NMFS Northeast Longline, SEFSC Shark Bottom Longline Observer Program, Southeast Pelagic Longline Observer Program, SC COASTSPAN Longline, SCDNR Red Drum Longline (Historical), Panama City Gillnet (Juvenile), GA COASTSPAN Longline (Juvenile) and Large Pelagic Survey. The NMFS Historical Longline, Coastal Fishery Logbook Bottom Longline and Southeast Pelagic Longline Logbook indices were recommended for a sensitivity run for sandbar sharks. The spatial coverage of each index is presented in Figure 5.8.5. The ranking of the indices are provided in Table 5.7.115 (base run) and Table 5.7.12 (sensitivity run). Fishery independent index values and coefficients of variation are presented in Table 5.7.13 and the fishery dependent index values are presented in Table 5.7.14. A plot of all the indices is in Figure 5.8.6.

For dusky sharks, the DW recommended the following indices for use in the stock assessment model for the base run: NMFS Northeast Longline, SEFSC Shark Bottom Longline Observer Program, Southeast Pelagic Longline Observer Program, VIMS Longline and Large Pelagic Survey. The NMFS Historical Longline and UNC Longline indices were recommended for a sensitivity run for dusky sharks. The spatial coverage of each index is presented in Figure 5.8.7. The ranking of the indices are seen in Table 5.7.15 (base run) and Table 5.7.16 (sensitivity run). Fishery independent index values and coefficients of variation are presented in Table 5.7.17 and the fishery dependent index vales are presented in Table 5.7.18. A plot of all the indices is in Figure 5.8.8. The scorecards for all the indices (recommended and excluded) are in Appendix 5.9.

5.6. *LITERATURE CITED*

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

Stephens, A. and A. MacCall. 2004. A multispecies approach to subsetting logbook data for purposes of estimating CPUE. Fisheries Research 70:299-310.

5.7. *TABLES*

Table 5.7.1. Indices recommended by the Indices Working Group for a model base run for the Gulf of Mexico stock of blacknose sharks (*Carcharhinus acronotus*), including the corresponding SEDAR document number, index type (fishery independent or dependent) and overall ranking. Rankings are the working group's recommendation for index weighting.

Index Name	SEDAR Document Number	Index Type	Rank
NMFS Southeast Bottom Longline (GOM)	SEDAR21-DW-39	Independent	1
NMFS SEAMAP Groundfish Trawl (Summer)	SEDAR21-DW-43	Independent	2
NMFS SEAMAP Groundfish Trawl (Fall)	SEDAR21-DW-43	Independent	2
Panama City Gillnet (Adult)	SEDAR21-DW-01	Independent	3
Panama City Gillnet (Juvenile)	SEDAR21-DW-01	Independent	3
Mote Marine Lab Longline	SEDAR21-DW-34	Independent	3
SEFSC Shark Bottom Longline Observer Program	SEDAR21-DW-02	Dependent	4
Dauphin Island Sea Lab Bottom Longline	SEDAR21-DW-25	Independent	5

Table 5.7.2. Fishery independent indices recommended by the Indices Working Group for the Gulf of Mexico stock of blacknose sharks (*Carcharhinus acronotus*), including the corresponding SEDAR document number, overall ranking and run type (base or sensitivity). Rankings are the working group's recommendation for index weighting.

	NMFS Southeast Bottom Longline SEDAR21-DW-39 Base (Rank=1)		NMFS SEAMAP Groundfish Trawl (Summer) SEDAR21-DW-43 Base (Rank=2)		NMFS SEAMAP Groundfish Trawl (Fall) SEDAR21-DW-43 Base (Rank=2)		Panama City Gillnet (Adult) SEDAR21-DW-01 Base (Rank=3)	
Year	Index Values	CV	Index Values	CV	Index Values	CV	Index Values	CV
1987			0.002331	0.784212784	0.003216	0.919465174		
1988			0.002418	0.835814723	0.002896	0.887085635		
1989			0.005522	0.611915972	0.002526	0.886777514		
1990			0.002122	0.817624882	0.004368	0.670787546		
1991			0.00359	0.700835655	0.004096	0.692871094		
1992			0.002635	0.840986717	0.004641	0.76405947		
1993			0.004889	0.659439558	0.002307	0.745557		
1994			0.002853	0.688047669	0.003436	0.694412107		
1995	0.13599	0.42835	0.002482	0.914585012	0.007061	0.620450361		
1996	0.31007	0.41434	0.004021	0.666003482	0.003897	0.771105979	0.023	0.31
1997	0.2095	0.32307	0.004177	0.727076849	0.003668	0.789803708	0.013	0.43
1998			0.003396	0.737926973	0.003771	0.726067356	0.033	0.31
1999	0.17092	0.25831	0.002502	0.847322142	0.005087	0.687831728		
2000	0.18041	0.26186	0.004224	0.642282197	0.004348	0.732060718		
2001	0.23484	0.24244	0.008831	0.645906466	0.002811	0.804695838	0.020	0.43
2002	0.18332	0.26621	0.003607	0.725533685	0.003412	0.745896835	0.019	0.36
2003	0.44848	0.21178	0.006501	0.585140748	0.00457	0.575929978	0.016	0.36
2004	0.41957	0.21511	0.004821	0.629744866	0.003577	0.805703103	0.038	0.36
2005	0.13646	0.78751	0.005295	0.743720491	0.004996	0.572658127	0.029	0.36
2006	0.45839	0.27942	0.004284	0.68487395	0.003208	0.771820449		
2007	0.19454	0.31226	0.003567	0.736753574	0.005754	0.740354536	0.010	0.43
2008	0.32122	0.33208	0.005391	0.596920794	0.007182	0.465329992	0.048	0.31
2009	0.41606	0.25081	0.01164	0.293041237	0.004807	0.623465779	0.011	0.58

Table 5.7.2. (continued)

	Panama City Gillnet (Juvenile) SEDAR21-DW-01 Base (Rank=3)		Mote Marine Lab Longline SEDAR21-DW-34 Base (Rank=3)		Dauphin Island Sea Lab Bottom Longline SEDAR21-DW-25 Base (Rank=5)	
Year	Index Values	CV	Index Values	CV	Index Values	CV
1987						
1988						
1989						
1990						
1991						
1992						
1993						
1994						
1995						
1996	0.44	0.32				
1997	0.26	0.42				
1998	0.12	0.62				
1999	0.43	0.50				
2000	0.02	4.14				
2001	0.16	0.68				
2002	0.21	0.52				
2003	0.2	0.47	0.09192	0.64933		
2004	0.15	0.61	0.29474	0.3696		
2005	0.11	1.29	0.24632	0.33322		
2006	0.14	0.93	0.17269	0.61566	1.92036	0.24655
2007	0.19	0.58	0.26844	0.32904	0.98698	0.30785
2008	0.17	0.68	0.4925	0.3722	0.76021	0.36994
2009	0.12	1.07	0.05931	0.8667	0.33245	0.55653

Table 5.7.3. Fishery dependent indices recommended by the Indices Working Group for the Gulf of Mexico stock of blacknose sharks (*Carcharhinus acronotus*), including the corresponding SEDAR document number, overall ranking and run type (base or sensitivity). Rankings are the working group's recommendation for index weighting.

	SEFSC Shark Bottom Longline Observer Program SEDAR21-DW-02 Base (Rank=4)	
Year	Index Values	CV
1993		
1994	4.89	0.77
1995	15.71	0.6
1996	10.24	0.74
1997	12.49	0.78
1998	20.73	0.61
1999	51.85	0.62
2000		
2001	7.97	0.74
2002	101.13	0.42
2003	62.98	0.4
2004	94.07	0.43
2005	193.75	0.43
2006	192.75	0.41
2007	98.19	0.46
2008	82.92	0.53
2009	25.58	0.56

Table 5.7.4. Indices recommended by the Indices Working Group for a model base run for the Atlantic Ocean stock of blacknose sharks (*Carcharhinus acronotus*), including the corresponding SEDAR document number, index type (fishery independent or dependent) and overall ranking. Rankings are the working group's recommendation for index weighting.

Index Name	SEDAR Document Number	Index Type	Rank
NMFS Southeast Bottom Longline	SEDAR21-DW-39	Independent	1
SCDNR Red Drum Longline (Historical)	SEDAR21-DW-30	Independent	2
SEFSC Shark Bottom Longline Observer Program	SEDAR21-DW-02	Dependent	3
Drift Gillnet Observer Program	SEDAR21-DW-03	Dependent	3
UNC Longline	SEDAR21-DW-33	Independent	4
GADNR Red Drum Longline	SEDAR21-DW-29	Independent	4
Coastal Fishery Logbook Gillnet	SEDAR21-DW-40	Dependent	4

Table 5.7.5. Indices recommended by the Indices Working Group for a model sensitivity run for the Atlantic Ocean stock of blacknose sharks (*Carcharhinus acronotus*), including the corresponding SEDAR document number, index type (fishery independent or dependent) and overall ranking. Rankings are the working group's recommendation for index weighting.

Index Name	SEDAR Document Number	Index Type	Rank
Sink Gillnet Observer Program	SEDAR21-DW-04	Dependent	1

Table 5.7.6. Fishery independent indices recommended by the Indices Working Group for the Atlantic Ocean stock of blacknose sharks (*Carcharhinus acronotus*), including the corresponding SEDAR document number, overall ranking and run type (base or sensitivity). Rankings are the working group's recommendation for index weighting.

	NMFS Southeast Bottom Longline SEDAR21-DW-39 Base (Rank=1)		SCDNR Red Drum Longline (Historical) SEDAR21-DW-30 Base (Rank=3)	
Year	Index Values	CV	Index Values	CV
1972				
1973				
1974				
1975				
1976				
1977				
1978				
1979				
1980				
1981				
1982				
1983				
1984				
1985				
1986				
1987				
1988				
1989				
1990				
1991				
1992				
1993				
1994				
1995	0			
1996	0			
1997	0.01606	0.74952		
1998			0.203788734	0.281162092
1999	0.24712	0.6003	0.27815916	0.405424048
2000	0.05795	0.42504	0.177385407	0.242336909
2001			0.168005468	0.347193623
2002	0.14587	0.3121	0.341851293	0.250009688
2003			0.357409365	0.20868598
2004	0.03574	0.84049	0.130662017	0.383893531
2005	0		0.145767541	0.530906086
2006	0.1532	0.5494	0.160742768	0.290953067
2007				
2008	0.27004	0.56699		
2009	0.0543	1.15715		

Table 5.7.6. (continued)

Year	UNC Longline SEDAR21-DW-33 Base (Rank=5)	GADNR Red Drum Longline SEDAR21-DW-29 Base (Rank=5)

	Index Values	CV	Index Values	CV
1972	0.057079647	0.879797		
1973	0.088494355	0.585293		
1974	0.032027555	0.900346		
1975	0.039308515	0.458022		
1976	0.035680408	0.530198		
1977	0.056460396	0.29584		
1978	0.056812849	0.343711		
1979	0.031989155	0.340532		
1980	0.018205313	0.332184		
1981	0.009121157	0.522268		
1982	0.013861563	0.291329		
1983	0.011455218	0.309014		
1984	0.014930413	0.329129		
1985	0.008526004	0.461483		
1986	0.005211507	0.69739		
1987	0.010132829	0.55377		
1988	0.020980523	0.60706		
1989	0.00751782	0.651812		
1990	0.004069541	0.7845		
1991	0.009567187	0.537649		
1992	0.018396819	0.644476		
1993	0.017079747	0.601881		
1994	0.008628579	0.71548		
1995	0.004251396	0.784229		
1996	0.006948694	0.690177		
1997	0.003426	0.769764		
1998	0.001900595	0.850587		
1999	0.002283724	1.012023		
2000	0.002496924	0.795336		
2001	0.004031893	0.838254		
2002	0.001982096	0.854264		
2003	0.001278037	1.151028		
2004	0.003478401	0.796945		
2005	0.003738323	0.860331		
2006	0.006521078	0.571284		
2007	0.01517777	0.465167	0.064351199	0.540976092
2008	0.004092476	0.795925	0.161105846	0.445554107
2009	0.008101659	0.716968	0.144848049	0.475400056

Table 5.7.7. Fishery dependent indices recommended by the Indices Working Group for the Atlantic Ocean stock of blacknose sharks (*Carcharhinus acronotus*), including the corresponding SEDAR document number, overall ranking and run type (base or sensitivity). Rankings are the working group's recommendation for index weighting.

	SEFSC Shark Bottom Longline Observer Program SEDAR21-DW-02 Base (Rank=4)		Drift Gillnet Observer Program SEDAR21-DW-03 Base (Rank=4)		Coastal Fisheries Logbook Gillnet SEDAR21-DW-40 Base (Rank=5)		Sink Gillnet Observer Program SEDAR21-DW-04 Sensitivity (Rank=1)	
Year	Index Values	CV	Index Values	CV	Index Values	CV	Index Values	CV
1993			102.32	0.74				
1994	79.03	1.15	242.69	0.31				
1995	45.34	0.42	101.61	0.67				
1996	69	0.4						
1997	9.22	0.64						
1998	25.96	0.55	59.98	0.59	0.001103754	0.6963795		
1999	148.6	0.57	78.31	0.27	0.001144843	0.7030089		
2000	275.58	0.48	355.07	0.31	0.001926084	0.6684202		
2001	172.08	0.81	151.28	0.28	0.000973698	0.6804639		
2002	80.04	0.51	115.41	0.28	0.001183764	0.6926486		
2003	5.99	1.02	117.9	0.36	0.002007794	0.6896288		
2004	6.32	0.8	68.61	0.33	0.000744868	0.7144613		
2005	41.21	0.56	317.74	0.35	0.002375108	0.7085882	216.32	0.72
2006	21.68	0.67	29.11	0.75	0.002753644	0.6715055	60.53	0.78
2007	82.83	1.01	88.94	0.75	0.001467736	0.720916	1262.5	0.58
2008	22.26	0.99	0		0.012040469	0.6396446	98.26	0.91
2009	9.98	0.99	0		0.003850332	0.6729216	20.23	0.88

Table 5.7.8. Indices recommended by the Indices Working Group for a model base run for the combined stock (Atlantic Ocean and Gulf of Mexico) of blacknose sharks (*Carcharhinus acronotus*), including the corresponding SEDAR document number, index type (fishery independent or dependent) and overall ranking. Rankings are the working group's recommendation for index weighting.

Index Name	SEDAR Document Number	Index Type	Rank
NMFS Southeast Bottom Longline	SEDAR21-DW-39	Independent	1
NMFS SEAMAP Groundfish Trawl (Summer)	SEDAR21-DW-43	Independent	2
NMFS SEAMAP Groundfish Trawl (Fall)	SEDAR21-DW-43	Independent	2
Panama City Gillnet (Adult)	SEDAR21-DW-01	Independent	3
Panama City Gillnet (Juvenile)	SEDAR21-DW-01	Independent	3
SCDNR Red Drum Longline (Historical)	SEDAR21-DW-30	Independent	3
Mote Marine Lab Longline	SEDAR21-DW-34	Independent	3
SEFSC Shark Bottom Longline Observer Program	SEDAR21-DW-02	Dependent	4
Drift Gillnet Observer Program	SEDAR21-DW-03	Dependent	4
UNC Longline	SEDAR21-DW-33	Independent	5
Dauphin Island Sea Lab Bottom Longline	SEDAR21-DW-25	Independent	5
GADNR Red Drum Longline	SEDAR21-DW-29	Independent	5
Coastal Fishery Logbook Gillnet	SEDAR21-DW-40	Dependent	5

Table 5.7.9. Fishery independent indices recommended by the Indices Working Group for the combined stock (Atlantic Ocean and Gulf of Mexico) of blacknose sharks (*Carcharhinus acronotus*), including the corresponding SEDAR document number, overall ranking and run type (base or sensitivity). Rankings are the working group's recommendation for index weighting.

	NMFS Southeast Bottom Longline SEDAR21-DW-39 Base (Rank=1)		NMFS SEAMAP Groundfish Trawl (Summer) SEDAR21-DW-43 Base (Rank=2)		NMFS SEAMAP Groundfish Trawl (Fall) SEDAR21-DW-43 Base (Rank=2)	
Year	Index Values	CV	Index Values	CV	Index Values	CV
1972						
1973						
1974						
1975						
1976						
1977						
1978						
1979						
1980						
1981						
1982						
1983						
1984						
1985						
1986						
1987			0.002331	0.784212784	0.003216	0.919465174
1988			0.002418	0.835814723	0.002896	0.887085635
1989			0.005522	0.611915972	0.002526	0.886777514
1990			0.002122	0.817624882	0.004368	0.670787546
1991			0.00359	0.700835655	0.004096	0.692871094
1992			0.002635	0.840986717	0.004641	0.76405947
1993			0.004889	0.659439558	0.002307	0.745557
1994			0.002853	0.688047669	0.003436	0.694412107
1995	0.07097	0.41558	0.002482	0.914585012	0.007061	0.620450361
1996	0.16847	0.40148	0.004021	0.666003482	0.003897	0.771105979
1997	0.12021	0.27351	0.004177	0.727076849	0.003668	0.789803708
1998			0.003396	0.737926973	0.003771	0.726067356
1999	0.14079	0.24833	0.002502	0.847322142	0.005087	0.687831728
2000	0.14297	0.22875	0.004224	0.642282197	0.004348	0.732060718
2001	0.20988	0.24483	0.008831	0.645906466	0.002811	0.804695838
2002	0.2028	0.23353	0.003607	0.725533685	0.003412	0.745896835
2003	0.4046	0.21592	0.006501	0.585140748	0.00457	0.575929978
2004	0.33747	0.21426	0.004821	0.629744866	0.003577	0.805703103
2005	0.09764	0.82136	0.005295	0.743720491	0.004996	0.572658127
2006	0.37326	0.27076	0.004284	0.68487395	0.003208	0.771820449
2007	0.17308	0.32259	0.003567	0.736753574	0.005754	0.740354536
2008	0.30221	0.31518	0.005391	0.596920794	0.007182	0.465329992
2009	0.34907	0.25325	0.01164	0.293041237	0.004807	0.623465779

Table 5.7.9. (continued)

	Panama City Gillnet (Adult)	Panama City Gillnet (Juvenile)	SCDNR Red Drum Longline (Historical)

Year	SEDAR21-DW-01 Base (Rank=3)		SEDAR21-DW-01 Base (Rank=3)		SEDAR21-DW-30 Base (Rank=3)	
	Index Values	CV	Index Values	CV	Index Values	CV
1972						
1973						
1974						
1975						
1976						
1977						
1978						
1979						
1980						
1981						
1982						
1983						
1984						
1985						
1986						
1987						
1988						
1989						
1990						
1991						
1992						
1993						
1994						
1995						
1996	0.023	0.31	0.44	0.32		
1997	0.013	0.43	0.26	0.42		
1998	0.033	0.31	0.12	0.62	0.203788734	0.281162092
1999			0.43	0.50	0.27815916	0.405424048
2000			0.02	4.14	0.177385407	0.242336909
2001	0.020	0.43	0.16	0.68	0.168005468	0.347193623
2002	0.019	0.36	0.21	0.52	0.341851293	0.250009688
2003	0.016	0.36	0.2	0.47	0.357409365	0.20868598
2004	0.038	0.36	0.15	0.61	0.130662017	0.383893531
2005	0.029	0.36	0.11	1.29	0.145767541	0.530906086
2006			0.14	0.93	0.160742768	0.290953067
2007	0.010	0.43	0.19	0.58		
2008	0.048	0.31	0.17	0.68		
2009	0.011	0.58	0.12	1.07		

Table 5.7.9. (continued)

	Mote Marine Lab Longline SEDAR21-DW-34 Base (Rank=3)		UNC Longline SEDAR21-DW-33 Base (Rank=5)		Dauphin Island Sea Lab Bottom Longline SEDAR21-DW-25 Base (Rank=5)	
Year	Index Values	CV	Index Values	CV	Index Values	CV
1972			0.057079647	0.879797		
1973			0.088494355	0.585293		
1974			0.032027555	0.900346		
1975			0.039308515	0.458022		
1976			0.035680408	0.530198		
1977			0.056460396	0.29584		
1978			0.056812849	0.343711		
1979			0.031989155	0.340532		
1980			0.018205313	0.332184		
1981			0.009121157	0.522268		
1982			0.013861563	0.291329		
1983			0.011455218	0.309014		
1984			0.014930413	0.329129		
1985			0.008526004	0.461483		
1986			0.005211507	0.69739		
1987			0.010132829	0.55377		
1988			0.020980523	0.60706		
1989			0.00751782	0.651812		
1990			0.004069541	0.7845		
1991			0.009567187	0.537649		
1992			0.018396819	0.644476		
1993			0.017079747	0.601881		
1994			0.008628579	0.71548		
1995			0.004251396	0.784229		
1996			0.006948694	0.690177		
1997			0.003426	0.769764		
1998			0.001900595	0.850587		
1999			0.002283724	1.012023		
2000			0.002496924	0.795336		
2001			0.004031893	0.838254		
2002			0.001982096	0.854264		
2003	0.09192	0.64933	0.001278037	1.151028		
2004	0.29474	0.3696	0.003478401	0.796945		
2005	0.24632	0.33322	0.003738323	0.860331		
2006	0.17269	0.61566	0.006521078	0.571284	1.92036	0.24655
2007	0.26844	0.32904	0.01517777	0.465167	0.98698	0.30785
2008	0.4925	0.3722	0.004092476	0.795925	0.76021	0.36994
2009	0.05931	0.8667	0.008101659	0.716968	0.33245	0.55653

Table 5.7.9. (continued)

	GADNR Red Drum Longline SEDAR21-DW-29 Base (Rank=5)	
Year	Index Values	CV
1972		
1973		
1974		
1975		
1976		
1977		
1978		
1979		
1980		
1981		
1982		
1983		
1984		
1985		
1986		
1987		
1988		
1989		
1990		
1991		
1992		
1993		
1994		
1995		
1996		
1997		
1998		
1999		
2000		
2001		
2002		
2003		
2004		
2005		
2006		
2007	0.064351199	0.540976092
2008	0.161105846	0.445554107
2009	0.144848049	0.475400056

Table 5.7.10. Fishery dependent indices recommended by the Indices Working Group for the combined stock (Atlantic Ocean and Gulf of Mexico) of blacknose sharks (*Carcharhinus acronotus*), including the corresponding SEDAR document number, overall ranking and run type (base or sensitivity). Rankings are the working group's recommendation for index weighting.

	SEFSC Shark Bottom Longline Observer Program SEDAR21-DW-02 Base (Rank=4)		Drift Gillnet Observer Program SEDAR21-DW-03 Base (Rank=4)		Coastal Fisheries Logbook Gillnet SEDAR21-DW-40 Base (Rank=5)		Sink Gillnet Observer Program SEDAR21-DW-04 Sensitivity (Rank=1)	
Year	Index Values	CV	Index Values	CV	Index Values	CV	Index Values	CV
1993			16.2	1.46				
1994	18.03	0.42	114.67	0.78				
1995	39.39	0.22	48.91	1.16				
1996	41.6	0.23						
1997	12.23	0.43						
1998	35.59	0.31	28.51	0.99	0.001103754	0.6963795		
1999	67.02	0.34	54.21	0.65	0.001144843	0.7030089		
2000	129.07	0.37	108.34	0.67	0.001926084	0.6684202		
2001	24.65	0.56	56.39	0.61	0.000973698	0.6804639		
2002	81.41	0.38	166.1	0.58	0.001183764	0.6926486		
2003	65.83	0.4	59.95	0.69	0.002007794	0.6896288		
2004	56.4	0.39	43.81	0.67	0.000744868	0.7144613		
2005	137.15	0.37	239.03	0.75	0.002375108	0.7085882	241.644	0.43
2006	148.4	0.39	14.49	1.04	0.002753644	0.6715055	86.111	0.46
2007	85.38	0.48	43.78	1.04	0.001467736	0.720916	1665.538	0.3
2008	98.31	0.45			0.012040469	0.6396446	196.587	0.61
2009	23.63	0.49	83.61	1.05	0.003850332	0.6729216	28.285	0.52

Table 5.7.11. Indices recommended by the Indices Working Group for a model base run for sandbar sharks (*Carcharhinus plumbeus*), including the corresponding SEDAR document number, index type (fishery independent or dependent) and overall ranking. Rankings are the working group's recommendation for index weighting.

Index Name	SEDAR Document Number	Index Type	Rank
NMFS Southeast Bottom Longline	SEDAR21-DW-39	Independent	1
NMFS COASTSPAN Longline (Total juveniles)	SEDAR21-DW-27	Independent	2
NMFS COASTSPAN Longline (YOY)	SEDAR21-DW-27	Independent	2
NMFS COASTSPAN Longline (Age 1+)	SEDAR21-DW-27	Independent	2
VIMS Longline	SEDAR21-DW-18	Independent	2
NMFS Northeast Longline	SEDAR21-DW-28	Independent	2
SEFSC Shark Bottom Longline Observer Program	SEDAR21-DW-02	Dependent	2
Southeast Pelagic Longline Observer Program	SEDAR21-DW-08	Dependent	2
SC COASTSPAN Longline	SEDAR21-DW-30	Independent	3
SCDNR Red Drum Longline (Historical)	SEDAR21-DW-30	Independent	3
Panama City Gillnet (Juvenile)	SEDAR21-DW-01	Independent	4
GA COASTSPAN Longline (Juvenile)	SEDAR21-DW-29	Independent	4
Large Pelagic Survey	SEDAR21-DW-44	Dependent	5

Table 5.7.12. Indices recommended by the Indices Working Group for a model sensitivity run for sandbar sharks (*Carcharhinus plumbeus*), including the corresponding SEDAR document number, index type (fishery independent or dependent) and overall ranking. Rankings are the working group's recommendation for index weighting.

Index Name	SEDAR Document Number	Index Type	Rank
NMFS Historical Longline	SEDAR21-DW-31	Independent	1
Coastal Fishery Logbook Bottom Longline	SEDAR21-DW-41	Dependent	1
Southeast Pelagic Longline Logbook	SEDAR21-DW-08	Dependent	2

Table 5.7.13. Fishery independent indices recommended by the Indices Working Group for sandbar sharks (*Carcharhinus plumbeus*), including the corresponding SEDAR document number, overall ranking and run type (base or sensitivity). Rankings are the working group's recommendation for index weighting.

	NMFS Southeast Bottom Longline SEDAR21-DW-39 Base (Rank=1)		NMFS COASTSPAN Longline (Total juveniles) SEDAR21-DW-27 Base (Rank=2)		NMFS COASTSPAN Longline (YOY) SEDAR21-DW-27 Base (Rank=2)	
Year	Index Values	CV	Index Values	CV	Index Values	CV
1961						
1962						
1963						
1964						
1965						
1966						
1967						
1968						
1969						
1970						
1971						
1972						
1973						
1974						
1975						
1976						
1977						
1978						
1979						
1980						
1981						
1982						
1983						
1984						
1985						
1986						
1987						
1988						
1989						
1990						
1991						
1992						
1993						
1994						
1995	0.25813	0.25711				
1996	0.13525	0.33861				
1997	0.20402	0.26883				
1998						
1999	0.06429	0.27042				
2000	0.15083	0.18204				
2001	0.14182	0.24836	5.727756877	0.234450223	3.240047811	0.30335089
2002	0.11112	0.22223	2.45723195	0.357113747	0.927128104	0.356121453
2003	0.13632	0.24629	6.190712501	0.234450223	2.919619495	0.25847576
2004	0.10677	0.25598	5.164320235	0.261739708	2.820840454	0.370029678
2005	0.04851	0.593	5.999475654	0.269013467	3.02841037	0.281635046
2006	0.0621	0.36378	2.923472109	0.304998778	0.955579665	0.335941642
2007	0.13501	0.38803	2.879033515	0.268961459	0.596391106	0.386943254
2008	0.11682	0.31767	0.900887554	0.515733745	0.561841123	0.765763625
2009	0.27767	0.21121	8.268378406	0.188810872	4.524184907	0.331418963

Table 5.7.13. (continued)

	NMFS COASTSPAN Longline (Age 1+) SEDAR21-DW-27 Base (Rank=2)		VIMS Longline SEDAR21-DW-18 Base (Rank=2)		NMFS Northeast Longline SEDAR21-DW-28 Base (Rank=2)	
Year	Index Values	CV	Index Values	CV	Index Values	CV
1961						

1962						
1963						
1964						
1965						
1966						
1967						
1968						
1969						
1970						
1971						
1972						
1973						
1974						
1975			1.825634358	0.360376689		
1976						
1977			1.635891511	0.521582584		
1978						
1979						
1980			2.293265768	0.264063049		
1981			2.397062894	0.226554377		
1982						
1983						
1984						
1985						
1986						
1987						
1988						
1989						
1990			0.39624397	0.597098541		
1991			0.557525783	0.628415491		
1992			0.231593529	0.8980708		
1993			0.748631652	0.593820322		
1994						
1995			0.884558669	0.294047438		
1996			0.881846526	0.371809598	0.000507169	0.3664
1997			0.818355334	0.367133198		
1998			1.334933214	0.309671481	0.003073641	0.266923
1999			1.054182939	0.528779797		
2000			1.000364725	0.368767427		
2001	3.654375104	0.227480649	1.103219254	0.340852048	0.001518167	0.271596
2002	1.264290565	0.410772897	0.596068416	0.518482147		
2003	3.447783328	0.240859446	0.50837524	0.611346116		
2004	3.431556182	0.270194705	0.681558373	0.463981249	0.001175704	0.34505
2005	3.560493317	0.255055925	0.434748645	0.490660292		
2006	1.843585006	0.308243605	1.079308538	0.290307581		
2007	1.924655965	0.286428144	0.311037819	0.645446814	0.005183215	0.303858
2008	0.595852697	0.488298171	0.957679453	0.334759496		
2009	4.77299118	0.187095552	1.267913389	0.362186265	0.010630747	0.206756

Table 5.7.13. (continued)

	SC COASTSPAN Longline SEDAR21-DW-30 Base (Rank=3)		SCDNR Red Drum Longline (Historical) SEDAR21-DW-30 Base (Rank=3)		Panama City Gillnet (Juvenile) SEDAR21-DW-01 Base (Rank=4)	
Year	Index Values	CV	Index Values	CV	Index Values	CV
1961						
1962						
1963						
1964						
1965						
1966						
1967						
1968						

1969						
1970						
1971						
1972						
1973						
1974						
1975						
1976						
1977						
1978						
1979						
1980						
1981						
1982						
1983						
1984						
1985						
1986						
1987						
1988						
1989						
1990						
1991						
1992						
1993						
1994						
1995						
1996					0.023	0.22
1997					0.013	0.31
1998	0.633603818	0.699043	0.140006517	0.464096004	0.033	0.35
1999	0.553232708	0.639898	0.594843139	0.353115019		0.57
2000	0.094719442	0.923998	0.057636573	0.549310345		0.57
2001	0.049259203	0.853746	0.349656526	0.467578459	0.020	0.35
2002	0.200698092	0.864094	0.230689744	0.401777962	0.019	0.35
2003	0.279554105	0.733766	0.15419554	0.364550582	0.016	0.25
2004	1.578117399	0.364751	0.337614502	0.292640367	0.038	0.42
2005	0.960821692	0.256205	0.15485314	0.422599789	0.029	0.42
2006	1.605292136	0.234392	0.279326352	0.260725904		0.00
2007	1.826859614	0.317614			0.010	0.35
2008	1.811278298	0.37738			0.048	0.42
2009	1.238999216	0.374072			0.011	0.28

Table 5.7.13. (continued)

	GA COASTSPAN Longline (Juvenile) SEDAR21-DW-29 Base (Rank=4)		NMFS Historical Longline SEDAR21-DW-31 Sensitivity (Rank=1)	
Year	Index Values	CV	Index Values	CV
1961			0.081714524	0.996300874
1962			0.045755169	1.149192395
1963			0.028279273	1.095417941
1964			0.146209941	1.059074134
1965			0.117610722	0.988735019
1966				
1967			0.000831895	1.024803485
1968			0.000298887	1.581988714
1969			0.00463847	1.261426971
1970			0.00344356	1.326875579
1971				
1972				
1973				
1974				
1975			0.001637877	1.367481706

1976			0.001566827	1.171154763
1977			0.001209011	0.92590786
1978			0.006091362	0.551673207
1979			0.009946878	0.609419993
1980			0.007886367	0.568513798
1981			0.002740715	0.928121842
1982			0.007449143	0.627204215
1983			0.004385455	0.72130479
1984			0.030002386	0.695637776
1985			0.012586565	0.580081473
1986			0.017538785	0.628484207
1987			0.019593653	0.818385386
1988			0.002688709	1.219299112
1989			0.010803036	0.640428234
1990			0.001498913	1.546579765
1991			0.01720694	0.66845261
1992				
1993			0.001703239	1.213149617
1994				
1995				
1996				
1997				
1998				
1999				
2000	0.004332475	2.768798672		
2001				
2002				
2003	0.023791361	0.906034876		
2004	0.026763128	0.889637918		
2005	0.008298468	2.061785767		
2006	0.030708617	0.707337995		
2007	0.049604131	0.516604302		
2008	0.043198235	0.572190066		
2009	0.035675824	0.544905652		

Table 5.7.14. Fishery dependent indices recommended by the Indices Working Group for sandbar sharks (*Carcharhinus plumbeus*), including the corresponding SEDAR document number, overall ranking and run type (base or sensitivity). Rankings are the working group's recommendation for index weighting.

	SEFSC Shark Bottom Longline Observer Program SEDAR21-DW-02 Base (Rank=2)		Southeast Pelagic Longline Observer Program SEDAR21-DW-08 Base (Rank=2)		Large Pelagic Survey SEDAR21-DW-44 Base (Rank=5)	
Year	Index Values	CV	Index Values	CV	Index Values	CV
1986					1.067	0.149
1987					0.314	0.215
1988					0.979	0.203
1989					1.159	0.125
1990					0.381	0.18
1991					0.637	0.174
1992			0.816	0.318	0.498	0.185
1993			0.646	0.209	0.254	0.551
1994	142.35	0.17	0.457	0.231	0.156	0.47
1995	151.62	0.14	0.368	0.289	0.135	0.575
1996	131.02	0.15	0.3	0.382	0.166	0.586
1997	210.17	0.18	0.304	0.336	0.191	0.471
1998	231.34	0.19	0.215	0.516	0.052	0.978
1999	170.87	0.21	0.274	0.407	0.075	0.837
2000	101.08	0.31	0.1	0.455	0.09	0.861
2001	290.99	0.2	0.118	0.482	0.374	0.651
2002	120.76	0.4	0.008	1.969	0.128	0.762
2003	172.03	0.37	0.007	1.97	0.059	0.586
2004	134.29	0.38	0.136	0.355	0.034	0.664
2005	175.96	0.42	0.048	0.477	0.145	0.464
2006	247.3	0.4	0.216	0.43	0.046	0.788
2007	327.74	0.41	0.136	0.368	0.102	0.441
2008	245.22	0.43	0.132	0.281	0.121	0.437
2009	836.28	0.37	0.135	0.279	0.195	0.389

Table 5.7.14. (continued)

	Coastal Fishery Logbook Bottom Longline SEDAR21-DW-41 Sensitivity (Rank=1)		Southeast Pelagic Longline Logbook SEDAR21-DW-08 Sensitivity (Rank=2)	
Year	Index Values	CV	Index Values	CV
1986				
1987				
1988				
1989				
1990				
1991				
1992	1.600533007	0.25382		
1993	0.671012969	0.55134		
1994	0.093402117	0.57802	0.106	0.379
1995	0.229030818	0.46301	2.276	0.294
1996	0.793330522	0.20805	2.23	0.293
1997	0.999969577	0.20944	1.467	0.302
1998	1.210310564	0.20334	1.58	0.307
1999	1.44285449	0.20872	1.884	0.306
2000	1.370908513	0.21004	1.931	0.305
2001	1.234203727	0.20555	1.694	0.312
2002	1.291165135	0.20314	1.714	0.316
2003	1.157322571	0.2053	1.5	0.315
2004	0.968341774	0.20576	1.731	0.306
2005	1.009314056	0.20944	1.338	0.318
2006	0.974719023	0.20386	1.231	0.323
2007	0.953581134	0.24345	0.747	0.334
2008			0.675	0.368
2009			0.817	0.361

Table 5.7.15. Indices recommended by the Indices Working Group for a model base run for dusky sharks (*Carcharhinus obscurus*), including the corresponding SEDAR document number, index type (fishery independent or dependent) and overall ranking. Rankings are the working group's recommendation for index weighting.

Index Name	SEDAR Document Number	Index Type	Rank
NMFS Northeast Longline	SEDAR21-DW-28	Independent	1
SEFSC Shark Bottom Longline Observer Program	SEDAR21-DW-02	Dependent	1
Southeast Pelagic Longline Observer Program	SEDAR21-DW-08	Dependent	2
VIMS Longline	SEDAR21-DW-18	Independent	3
Large Pelagic Survey	SEDAR21-DW-44	Dependent	4

Table 5.7.16. Indices recommended by the Indices Working Group for a model sensitivity run for dusky sharks (*Carcharhinus obscurus*), including the corresponding SEDAR document number, index type (fishery independent or dependent) and overall ranking. Rankings are the working group's recommendation for index weighting.

Index Name	SEDAR Document Number	Index Type	Rank
NMFS Historical Longline	SEDAR21-DW-31	Independent	1
UNC Longline	SEDAR21-DW-33	Independent	1

Table 5.7.17. Fishery independent indices recommended by the Indices Working Group for dusky sharks (*Carcharhinus obscurus*), including the corresponding SEDAR document number, overall ranking and run type (base or sensitivity). Rankings are the working group's recommendation for index weighting.

	NMFS Northeast Longline SEDAR21-DW-28 Base (Rank=1)		VIMS Longline SEDAR21-DW-18 Base (Rank=3)	
Year	Index Values	CV	Index Values	CV
1961				
1962				
1963				
1964				
1965				
1966				
1967				
1968				
1969				
1970				
1971				
1972				
1973				
1974				
1975			0.876395874	0.517967964
1976				
1977			0.040972429	1.921390289
1978				
1979				
1980			0.46599134	0.542346839
1981			0.371418212	0.519144033
1982				
1983				
1984				
1985				
1986				
1987				
1988				
1989				
1990			0.012919467	2.539903017
1991			0.017329432	2.292280987
1992			0.004484919	5.18132773
1993			0.071628634	1.242009261
1994				
1995			0.034627772	1.835483785
1996	5.74201E-05	0.749211298	0.105525947	0.861412327
1997				
1998	0.00024333	0.528330768	0.035586382	1.52575651
1999			0.172382358	0.945595917
2000			0.260634369	0.682447462
2001	0.000262727	0.484182628	0.061790141	1.277351042
2002			0.198408394	0.949115836
2003			0.03609167	2.162337588
2004	0.000759835	0.306838177	0.204993995	0.712542783
2005			0.44053962	0.689898558
2006			0.567362642	0.498442566
2007	0.000705893	0.516586471	0.058196874	1.118394279
2008			0.026219396	2.036706755
2009	0.002179195	0.340328548	0.580124834	0.747135782

Table 5.7.17. (continued)

	NMFS Historical Longline SEDAR21-DW-31 Sensitivity (Rank=1)		UNC Longline SEDAR21-DW-33 Sensitivity (Rank=1)	
Year	Index Values	CV	Index Values	CV
1961	0.017665043	0.416860684		

1962	0.016279032	0.592465814		
1963	0.010996223	0.821645192		
1964	0.009129835	1.133349923		
1965	0.006310728	0.913194		
1966				
1967				
1968	0.002727223	0.876923275		
1969	0.000755281	0.966046598		
1970	0.002096797	1.346978616		
1971				
1972	0.00031645	1.25275257		
1973			0.016761352	0.550741889
1974			0.041512961	0.435528172
1975	0.001927944	1.329733344	0.084545481	0.440250518
1976	0.000254709	1.384728505	0.044496357	0.55071267
1977	0.000170851	1.494346159	0.052945585	0.439450314
1978	0.000659796	0.903750091	0.011340569	0.713363699
1979	0.000301819	1.411759893	0.013160169	0.498066429
1980	0.000415391	1.067623689	0.005373356	0.701492707
1981	2.21393E-05	1.460702543	0.039916309	0.366515482
1982	0.003316036	0.890468545	0.024773218	0.296236862
1983			0.018095379	0.341375976
1984			0.011946973	0.404113468
1985	0.00359412	0.77807369	0.001660538	0.713209207
1986	0.005128761	0.721393759	0.009314688	0.541793849
1987			0.008337932	0.607974697
1988			0.004030574	0.629929169
1989	0.001168427	1.083012134	0.005815753	0.580750795
1990			0.000881785	0.793412816
1991	0.001010549	1.077299515	0.00744207	1.318544735
1992	0.022346905	1.241987846		
1993			0.001721976	0.792824614
1994	0.001319996	1.054513881	0.004546356	0.791325085
1995				
1996			0.00020589	1.313858721
1997			0.000736139	1.310101947
1998				
1999			0.000658745	1.302799145
2000			0.000248552	1.312373229
2001			0.000429914	1.31106475
2002			0.001705053	0.954124492
2003			0.000255702	1.312491369
2004			0.004185083	0.980398546
2005				
2006			0.000232863	1.307764474
2007			0.000862206	0.972474347
2008			0.001045625	1.320666293
2009			0	

Table 5.7.18. Fishery dependent indices recommended by the Indices Working Group for dusky sharks (*Carcharhinus obscurus*), including the corresponding SEDAR document number, overall ranking and run type (base or sensitivity). Rankings are the working group's recommendation for index weighting.

	SEFSC Shark Bottom Longline Observer Program SEDAR21-DW-02 Base (Rank=1)		Southeast Pelagic Longline Observer Program SEDAR21-DW-08 Base (Rank=2)		Large Pelagic Survey SEDAR21-DW-44 Base (Rank=4)	
Year	Index Values	CV	Index Values	CV	Index Values	CV
1986					1.353	0.123
1987					1.355	0.121
1988					1.148	0.298
1989					1.179	0.168
1990					0.89	0.154
1991					0.889	0.16
1992			2.279	0.274	0.284	0.292
1993			1.06	0.218	0.785	0.242
1994	6.64	0.39	1.724	0.217	0.338	0.377
1995	14.05	0.34	0.689	0.258	0.376	0.322
1996	12.01	0.34	0.676	0.29	0.616	0.412
1997	21.86	0.36	0.309	0.353	0.589	0.378
1998	13.11	0.38	0.805	0.296	0.321	0.491
1999	21.46	0.39	0.217	0.392	0.337	0.677
2000	7.16	0.66	0.454	0.307	0.316	0.526
2001	9.02	0.44	0.196	0.373	0.192	0.658
2002	2.73	0.51	0.096	0.889	0.403	0.611
2003	3.62	0.37	0.058	0.632	0.261	0.38
2004	3.98	0.38	0.314	0.311	0.384	0.337
2005	4.42	0.5	0.254	0.297	0.459	0.335
2006	5.54	0.55	0.454	0.284	0.212	0.458
2007	6.62	0.66	0.182	0.32	0.763	0.242
2008	9.29	0.62	0.126	0.425	0.925	0.208
2009	14.26	0.32	0.114	0.294	0.614	0.257

5.8. *FIGURES*

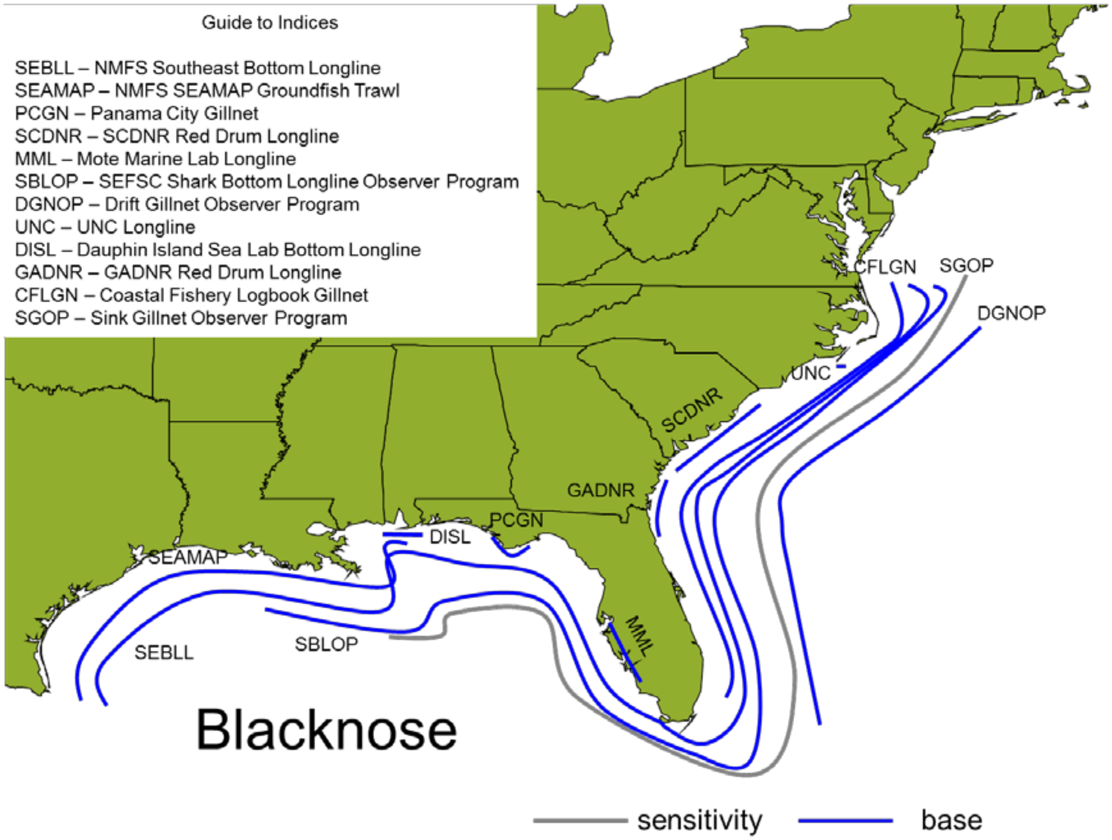

Figure 5.8.1. Approximate linear coverage of specific abundance indices for blacknose sharks (*Carcharhinus acronotus*) along the coast of the Gulf of Mexico and Atlantic Ocean.

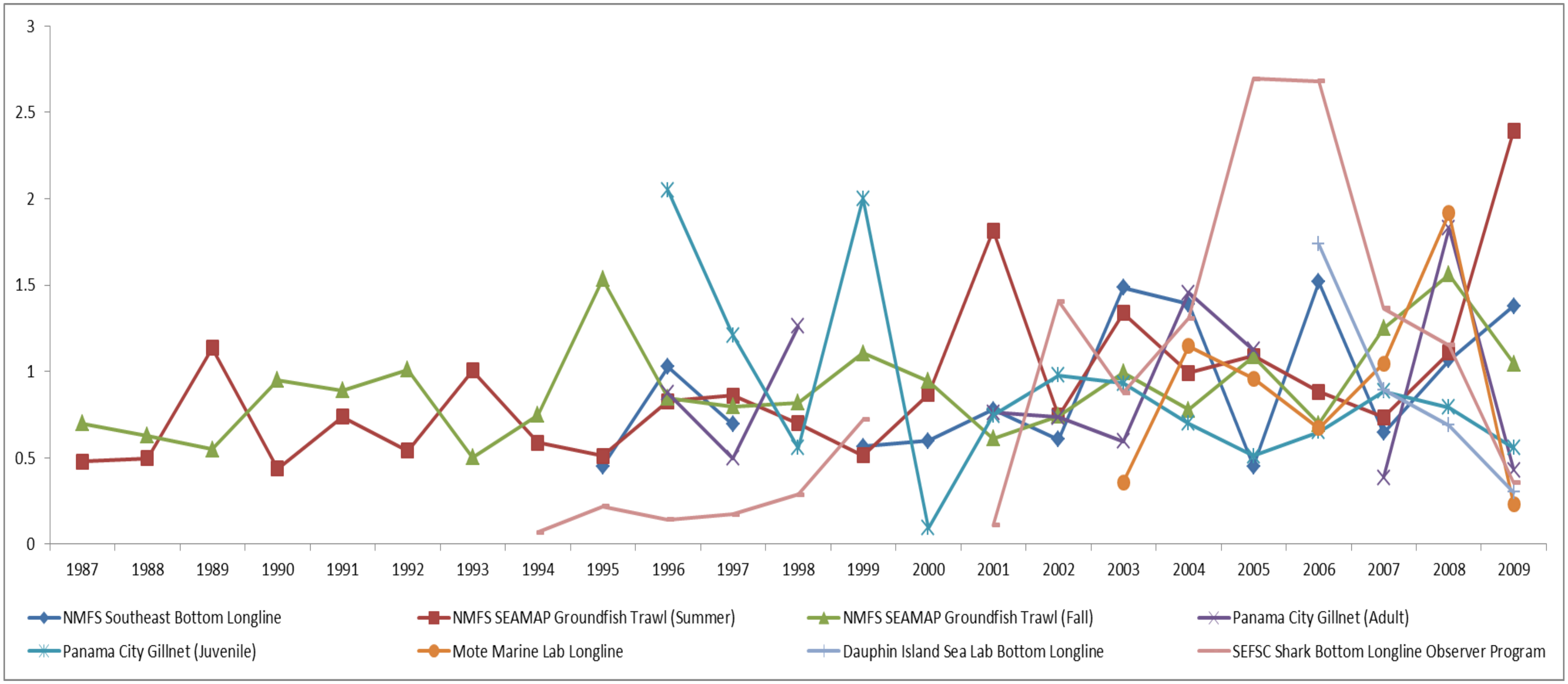

Figure 5.8.2. Plots of mean yearly CPUE for each index recommended for the Gulf of Mexico stock of blacknose sharks (*Carcharhinus acronotus*) by the working group. Values were normalized to a common scale by dividing yearly CPUE of each index by the mean CPUE (across all indices) for those years common to all indices.

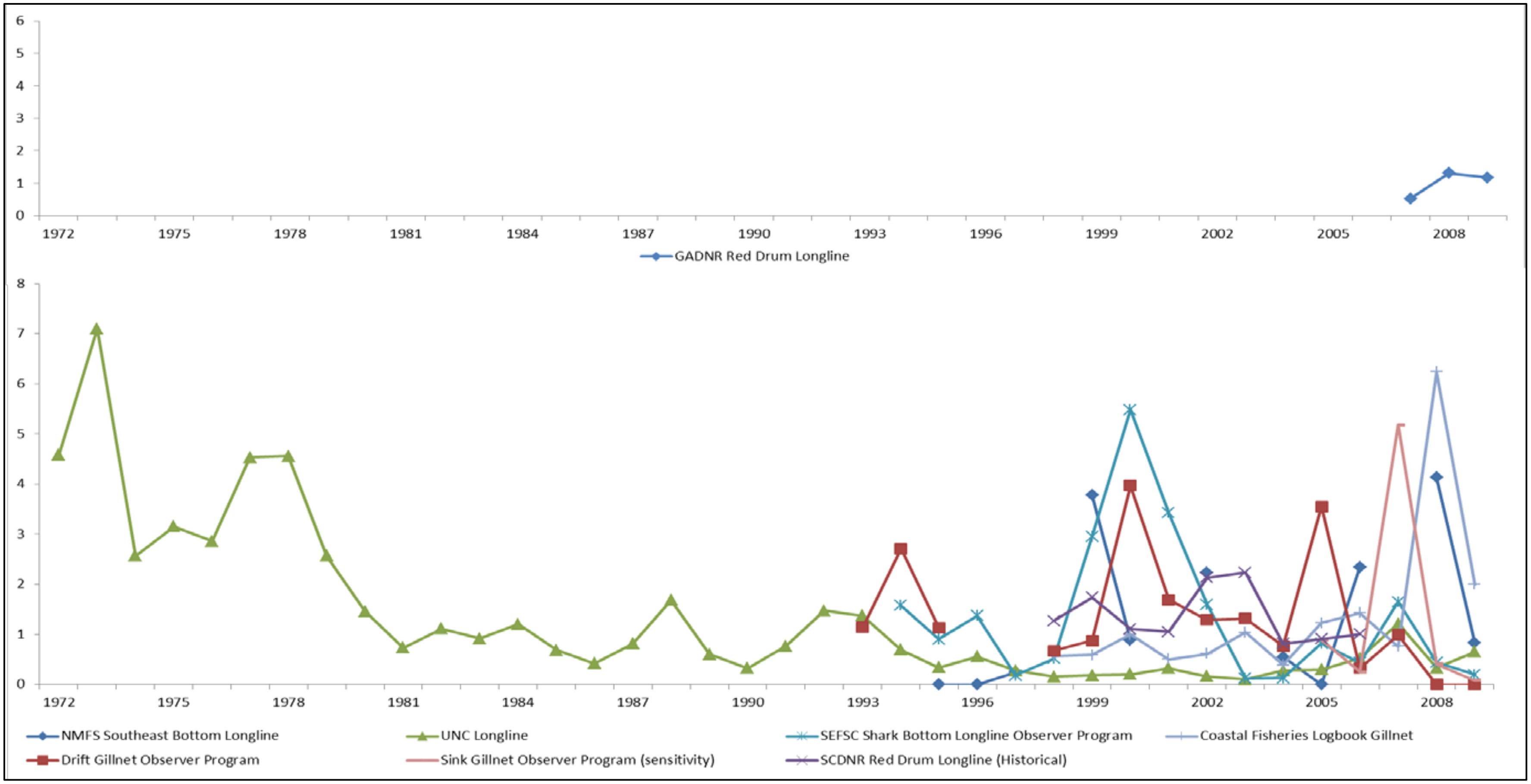

Figure 5.8.3. Plots of mean yearly CPUE for each index recommended for the Atlantic Ocean (ATL) stock of blacknose sharks (*Carcharhinus acronotus*) by the working group. Values were normalized to a common scale by dividing yearly CPUE of each index by the mean CPUE (across all indices) for those years common to all indices. The GADNR Red Drum Longline index was plotted separately (top graph) because several of the other blacknose shark ATL indices had few or no years in common with that index, thereby preventing normalization to a common scale. The GADNR Red Drum Longline index was normalized by dividing the yearly CPUEs by the mean of the series.

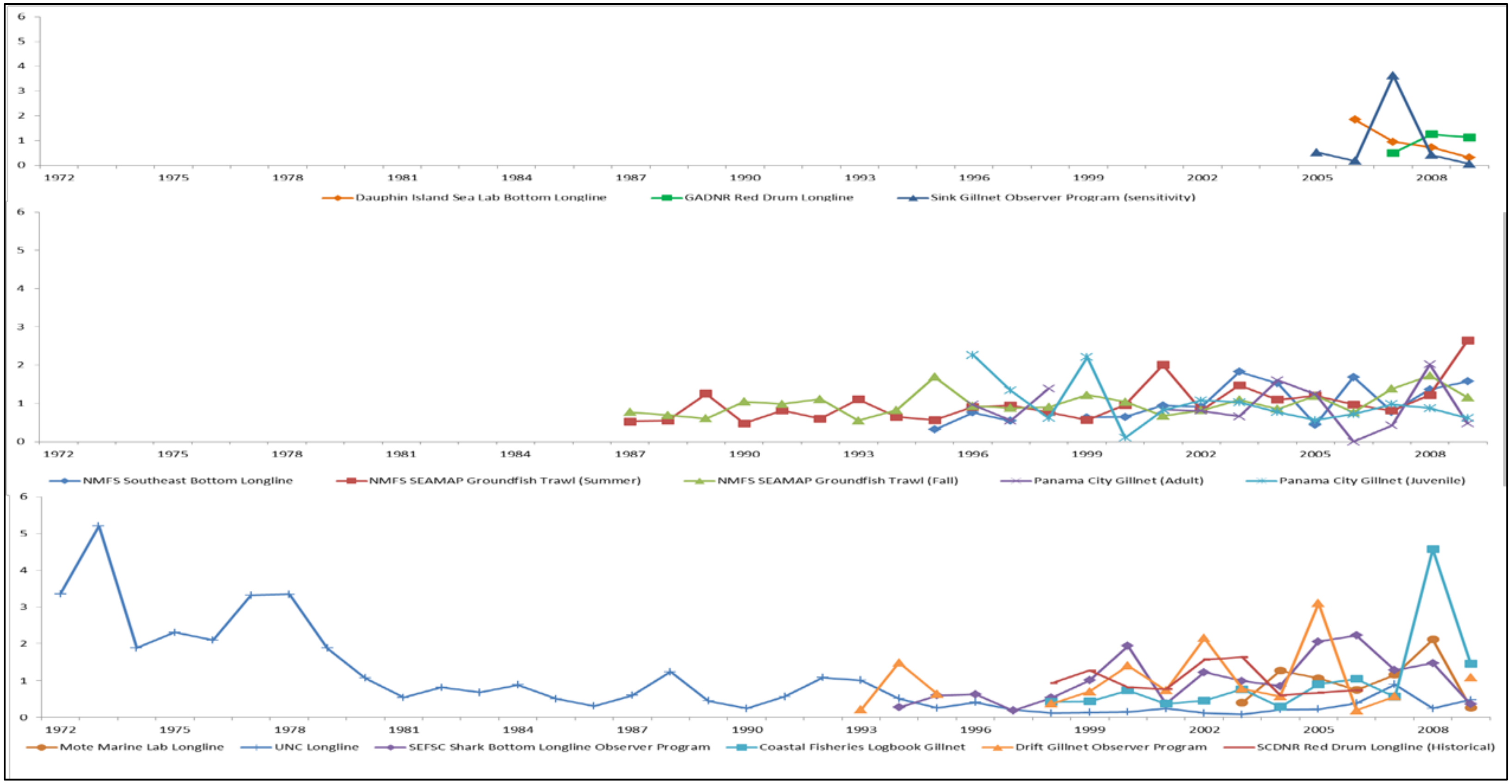

Figure 5.8.4. Plots of mean yearly CPUE (middle and bottom graphs) for each index recommended for the combined stock of blacknose sharks (*Carcharhinus acronotus)* by the working group. Values were normalized to a common scale by dividing yearly CPUE of each index by the mean CPUE (across all indices) for those years common to all indices. The Dauphin Island Sea Lab Bottom Longline, GADNR Red Drum Longline and Sink Gillnet Observer Program indices were plotted separately (top graph) because several of the other blacknose shark indices had few or no years in common with those two indices, thereby preventing normalization to a common scale. The Dauphin Island Sea Lab Bottom Longline, GADNR Red Drum Longline and Sink Gillnet Observer Program indices were normalized by dividing the yearly CPUE of each index by the mean CPUE of the three indices for those years common to both indices.

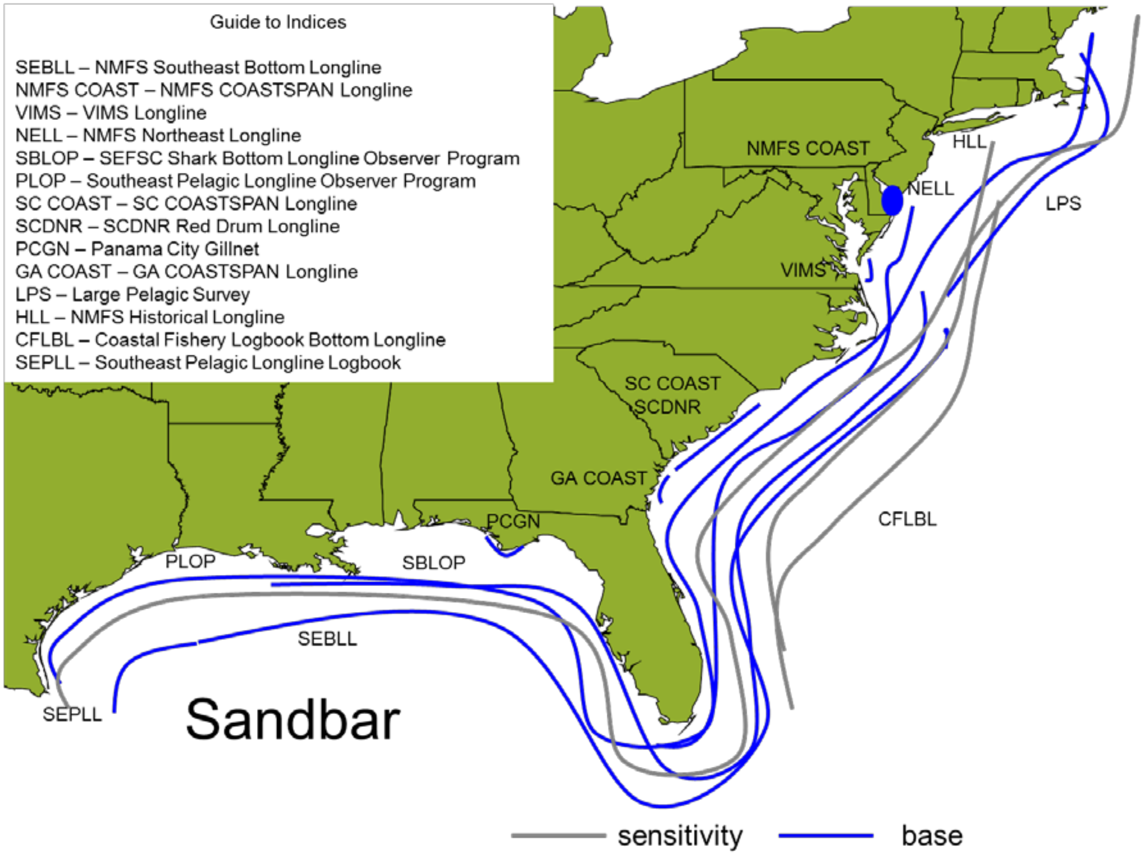

Figure 5.8.5. Approximate linear coverage of specific abundance indices for sandbar sharks (*Carcharhinus plumbeus*) along the coast of the Gulf of Mexico and Atlantic Ocean.

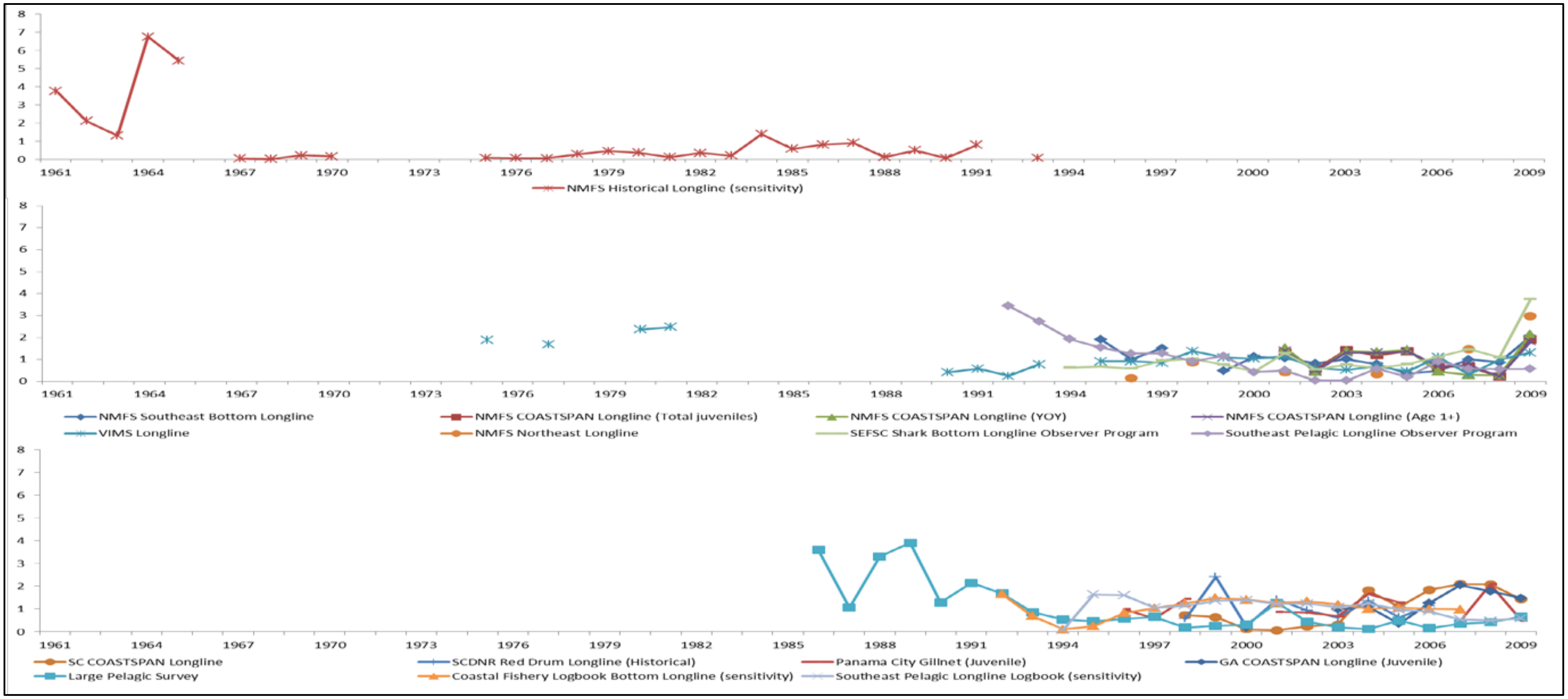

Figure 5.8.6. Plots of mean yearly CPUE (middle and bottom graphs) for each index recommended for sandbar sharks (*Carcharhinus plumbeus*) by the working group. Values were normalized to a common scale by dividing yearly CPUE of each index by the mean CPUE (across all indices) for those years common to all indices. The NMFS Historical Longline index was plotted separately (top graph) because several of the other sandbar shark indices had few or no years in common with the index, thereby preventing normalization to a common scale. The NMFS Historical Longline index was normalized by dividing the yearly CPUEs by the mean of the series.

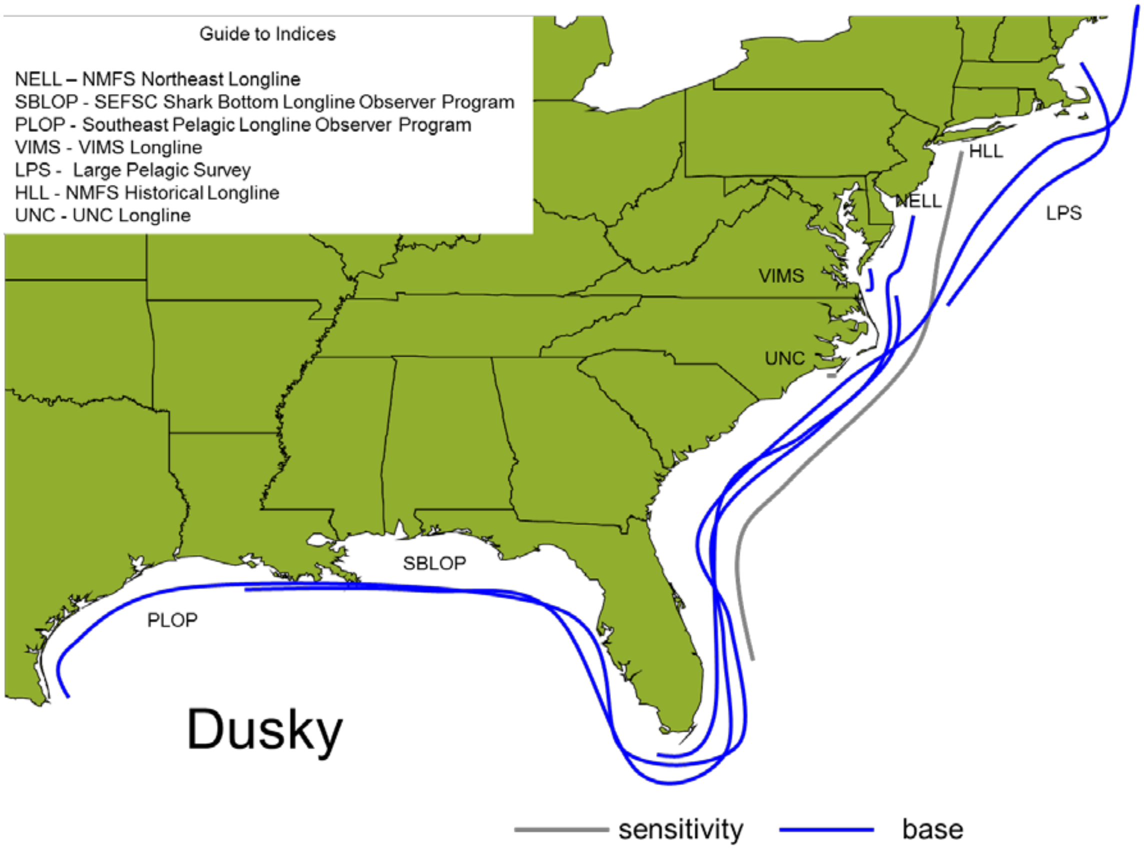

Figure 5.8.7. Approximate linear coverage of specific abundance indices for dusky sharks (*Carcharhinus obscurus*) along the coast of the Gulf of Mexico and Atlantic Ocean.

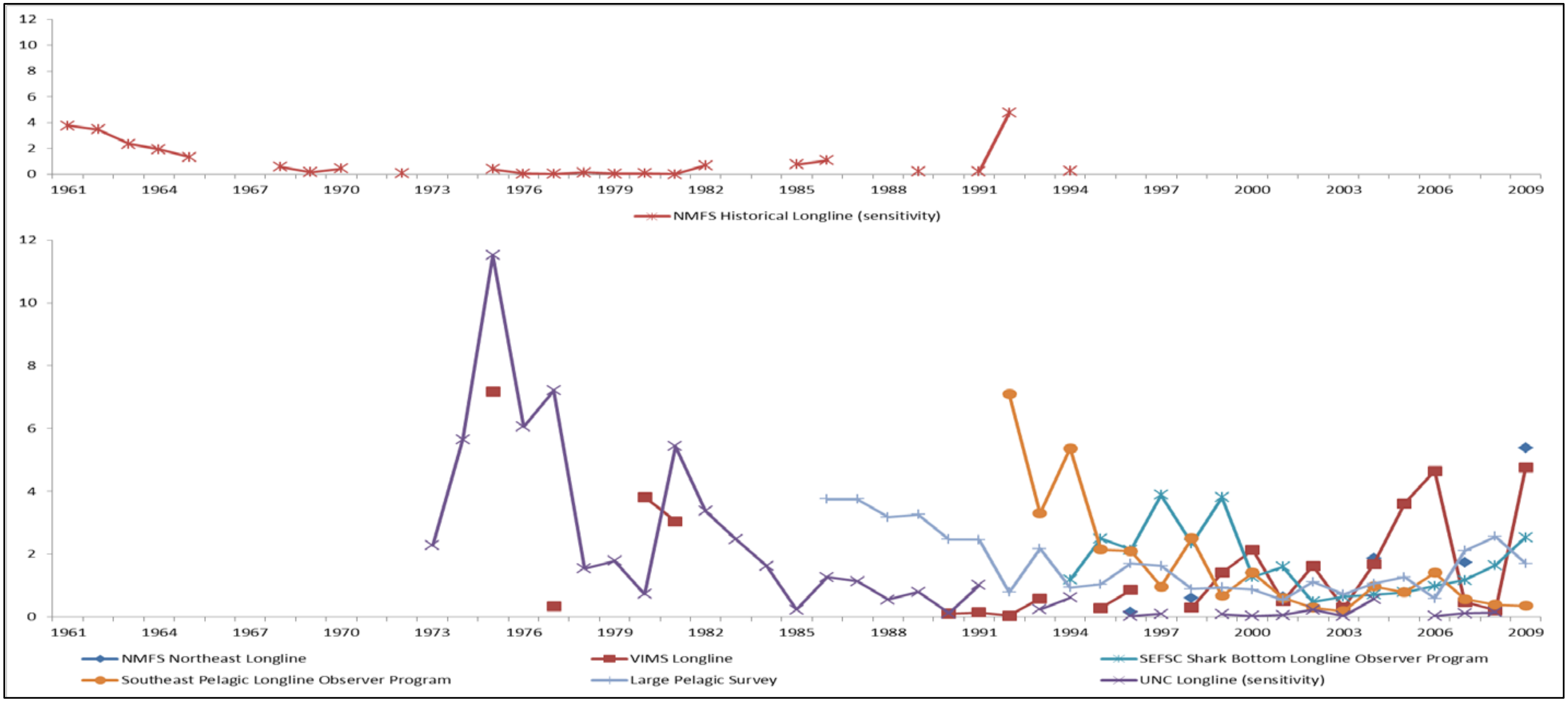

Figure 5.8.8. Plots of mean yearly CPUE for each index recommended for dusky sharks (*Carcharhinus obscurus*) by the working group. Values were normalized to a common scale by dividing yearly CPUE of each index by the mean CPUE (across all indices) for those years common to all indices. The NMFS Historical Longline index was plotted separately (top graph) because several of the other Dusky shark indices had few or no years in common with that index, thereby preventing normalization to a common scale. The NMFS Historical Longline index was normalized by dividing the yearly CPUEs by the mean of the series.

5.9. *Appendix: Evaluation of Abundance Indices for SEDAR 21.*

Evaluation of Abundance Indices for SEDAR 21: Panama City Gillnet (SEDAR21-DW-01)

DESCRIPTION OF THE DATA SOURCE

1. Fishery Independent Indices

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.				✓	
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)				✓	
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)				✓	
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				✓	
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).				✓	
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				✓	

2. Fishery Dependent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).				
B. Describe any changes to reporting requirements, variables reported, etc.				
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				

METHODS

1. Data Reduction and Exclusions

	Not Applicable	Absent	Incomplete	Complete
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.	✓			
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).	✓			
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?	✓			

2. Management Regulations (for FD Indices)

	Not Applicable	Absent	Incomplete	Complete
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).	✓			
B. Describe the effects (if any) of management regulations on CPUE	✓			
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.	✓			

3. Describe Analysis Dataset (after exclusions and other treatments)

	Not Applicable	Absent	Incomplete	Complete
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.				✓
B. Include tables and/or figures of number of positive observations by factors and interaction terms.				✓
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.				✓
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.				✓
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).			✓	
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				✓
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				✓

4. Model Standardization

	Not Applicable	Absent	Incomplete	Complete
A. Describe model structure (e.g. delta-lognormal)				✓
B. Describe construction of GLM components (e.g. forward selection from null etc.)				✓
C. Describe inclusion criteria for factors and interactions terms.				✓
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?	✓			
E. Provide a table summarizing the construction of the GLM components.				✓
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)				✓
G. Report convergence statistics.				✓

Working Group Comments:

3E. AOD

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

Item	Not Applicable	Absent	Incomplete	Complete
1. Binomial Component				
A. Include plots of the chi-square residuals by factor.				✓
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)				✓
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				✓
2. Lognormal/Gamma Component				
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.				✓
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.			✓	
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				✓
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				✓
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	✓			
F. Include plots of the residuals by factor				✓
3. Poisson Component				
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.				
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				
4. Zero-inflated model				
A. Include ROC curve to quantify goodness of fit.				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).				
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.				

Working Group Comments:

2B. AOD

The feasibility of this diagnostic is still under review.

MODEL DIAGNOSTICS (CONT.)

Not Applicable	Absent	Incomplete	Complete

Working Group Comments:

D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				

MODEL RESULTS

A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report				✓
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).				✓

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

1. Plot of resulting indices and estimates of variance				
2. Table of model statistics (e.g. AIC criteria)				

	Date Received	*Workshop Recommendation*	*Revision Deadline* ***	*Author and Rapporteur Signatures*
First Submission	6/21/10	accept as is		
Revision				

The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author ***DOES NOT*** *commit to any* ***LEGAL OBLIGATION*** *by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

Blacknose Gulf of Mexico adult index - recommended for model base run (ranking=3)

Blacknose Gulf of Mexico juvenile index - recommended for model base run (ranking=3)

Sandbar Gulf of Mexico juvenile index - recommended for model base run (ranking=4)

Data used to construct these indices were collected in a fishery independent sampling program. The index covered a relatively small geographic area, however, because it was a fishery independent program the limitations of fishery dependent data were not present. The time series was fairly lengthy, 1996-2009, with three years of missing data in the blacknose adult index. Only a single year of data was missing from the sandbar index. The blacknose juvenile index had no missing years of data.

The working group recommended these indices for use in base runs of the models. The indices' rankings were relatively low due to the limited spatial coverage of the indices and the lesser importance of the northern Gulf of Mexico as juvenile habitat compared to some Atlantic estuaries.

Evaluation of Abundance Indices for SEDAR 21: SEFSC Shark Bottom Longline Observer Program (SEDAR21-DW-02)

Working Group Comments:

DESCRIPTION OF THE DATA SOURCE

1. Fishery Independent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.				
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)				
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)				
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).				
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				

2. Fishery Dependent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).				✓
B. Describe any changes to reporting requirements, variables reported, etc.				✓
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				✓
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				✓

METHODS

1. Data Reduction and Exclusions

	Not Applicable	Absent	Incomplete	Complete
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.				✓
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).	✓			
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?	✓			

2. Management Regulations (for FD Indices)

	Not Applicable	Absent	Incomplete	Complete
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).				✓
B. Describe the effects (if any) of management regulations on CPUE			✓	
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.				✓

3. Describe Analysis Dataset (after exclusions and other treatments)

	Not Applicable	Absent	Incomplete	Complete
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.				✓
B. Include tables and/or figures of number of positive observations by factors and interaction terms.				✓
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.				✓
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.			✓	
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).	✓			
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				✓
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				✓

4. Model Standardization

	Not Applicable	Absent	Incomplete	Complete
A. Describe model structure (e.g. delta-lognormal)				✓
B. Describe construction of GLM components (e.g. forward selection from null etc.)				✓
C. Describe inclusion criteria for factors and interactions terms.				✓
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?				✓
E. Provide a table summarizing the construction of the GLM components.				✓
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)				✓
G. Report convergence statistics.				✓

Working Group Comments:

3E confidential data

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

1. Binomial Component

Item	Not Applicable	Absent	Incomplete	Complete
A. Include plots of the chi-square residuals by factor.				✓
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)			✓	
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				✓

2. Lognormal/Gamma Component

Item	Not Applicable	Absent	Incomplete	Complete
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.				✓
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.				✓
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				✓
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				✓
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.			✓	
F. Include plots of the residuals by factor				✓

3. Poisson Component

Item	Not Applicable	Absent	Incomplete	Complete
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.				
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				

4. Zero-inflated model

Item	Not Applicable	Absent	Incomplete	Complete
A. Include ROC curve to quantify goodness of fit.				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).				
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.				

Working Group Comments:

1B. AOD
2E. AOD

The feasibility of this diagnostic is still under review.

MODEL DIAGNOSTICS (CONT.)

Not Applicable	Absent	Incomplete	Complete

Working Group Comments:

D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				

MODEL RESULTS

A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report				✓
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).				✓

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

1. Plot of resulting indices and estimates of variance				
2. Table of model statistics (e.g. AIC criteria)				

	Date Received	*Workshop Recommendation*	*Revision Deadline* ***	*Author and Rapporteur Signatures*
First Submission	5/21/10	split SA/GOM sandb	6/23/10	
Revision	6/23/10			

The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author ***DOES NOT*** *commit to any* ***LEGAL OBLIGATION*** *by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

Sandbar - recommend for use in base run of model (ranking=2)
Dusky - recommend for use in base run of model (ranking=1)
Blacknose - recommend for use in base run of model (ranking=4)

Data used to construct these indices was fishery dependent, observer reported data. Observed vessels were in the directed shark fishery. For sandbar sharks, those vessels included in the experimental fishery (begun in 2008) had 100% observer coverage. The data time series is long (1994-2009) compared to many of the other data sets. In addition, the index covers the area from Louisiana to North Carolina and is among the more geographically extensive indices.

The working group did have some concern with the large increase in CPUE during 2009 in the sandbar index. There was some discussion that the increase may not be real, but was an artifact of management decisions (i.e. change in catchability with implementation of the experimental fishery). Other indices also had increases in cpue during 2009, however. The working group did not recommend a reanalysis of those data other than splitting the index into Gulf of Mexico and south Atlantic indices.

The working group recommended that the indices constructed for each species be included in base runs of the models. That decision was based upon the long time series, large geographic coverage, and that the data were observer reported from the directed fishery. The blacknose shark index was ranked lower because that species was not targeted by the shark bottom longline fishery.

Evaluation of Abundance Indices for SEDAR 21: Drift Gillnet Observer Program (SEDAR21-DW-03)

DESCRIPTION OF THE DATA SOURCE

1. Fishery Independent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.				
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)				
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)				
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).				
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				

2. Fishery Dependent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).				✓
B. Describe any changes to reporting requirements, variables reported, etc.				✓
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				✓
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				✓

METHODS

1. Data Reduction and Exclusions

	Not Applicable	Absent	Incomplete	Complete
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.	✓			
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).				✓
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?	✓			

Working Group Comments:

Working Group Comments:

3C,D. AOD
3E. confidential data

2. Management Regulations (for FD Indices)

	Not Applicable	Absent	Incomplete	Complete
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).				✓
B. Describe the effects (if any) of management regulations on CPUE				✓
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.				✓

3. Describe Analysis Dataset (after exclusions and other treatments)

	Not Applicable	Absent	Incomplete	Complete
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.				✓
B. Include tables and/or figures of number of positive observations by factors and interaction terms.				✓
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.			✓	
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.			✓	
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).		✓		
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				✓
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				✓

4. Model Standardization

	Not Applicable	Absent	Incomplete	Complete
A. Describe model structure (e.g. delta-lognormal)				✓
B. Describe construction of GLM components (e.g. forward selection from null etc.)				✓
C. Describe inclusion criteria for factors and interactions terms.				✓
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?				✓
E. Provide a table summarizing the construction of the GLM components.				✓
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)				✓
G. Report convergence statistics.				✓

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

1. Binomial Component

	Not Applicable	Absent	Incomplete	Complete
A. Include plots of the chi-square residuals by factor.				✓
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)				✓
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				✓

2. Lognormal/Gamma Component

	Not Applicable	Absent	Incomplete	Complete
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.				✓
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.			✓	
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				✓
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				✓
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				✓
F. Include plots of the residuals by factor				✓

3. Poisson Component

	Not Applicable	Absent	Incomplete	Complete
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.				
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				

4. Zero-inflated model

	Not Applicable	Absent	Incomplete	Complete
A. Include ROC curve to quantify goodness of fit.				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).				
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.				

Working Group Comments:

2B. AOD

The feasibility of this diagnostic is still under review.

MODEL DIAGNOSTICS (CONT.)

Not Applicable	Absent	Incomplete	Complete	Working Group Comments:

D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				

MODEL RESULTS

A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report				✓
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).				✓

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

1. Plot of resulting indices and estimates of variance				
2. Table of model statistics (e.g. AIC criteria)				

	Date Received	*Workshop Recommendation*	*Revision Deadline* ***	*Author and Rapporteur Signatures*
First Submission	6/21/10	accept as is		
Revision				

The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author ***DOES NOT*** *commit to any* ***LEGAL OBLIGATION*** *by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

Blacknose - recommend for use in base model run (ranking=4)

This index was constructed using fishery dependent observer data, was a relatively long time series (1993-2007), and is limited to the south Atlantic. The working group recommended this index for a base model run because of the length of the time series and the spatial scale of the index. Although the data were fishery dependent, they were reported from observers and were believed to be more accurate than self-reported data. The low ranking of the index was due to the data being fishery dependent.

Evaluation of Abundance Indices for SEDAR 21: Sink Gillnet Observer Program (SEDAR21-DW-04)

DESCRIPTION OF THE DATA SOURCE

1. Fishery Independent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.				
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)				
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)				
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).				
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				

Working Group Comments:

2. Fishery Dependent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).				✓
B. Describe any changes to reporting requirements, variables reported, etc.				✓
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				✓
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				✓

METHODS

1. Data Reduction and Exclusions

	Not Applicable	Absent	Incomplete	Complete
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.				✓
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).	✓			
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?	✓			

2. Management Regulations (for FD Indices)

	Not Applicable	Absent	Incomplete	Complete
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).				✓
B. Describe the effects (if any) of management regulations on CPUE				✓
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.				✓

3. Describe Analysis Dataset (after exclusions and other treatments)

	Not Applicable	Absent	Incomplete	Complete
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.				✓
B. Include tables and/or figures of number of positive observations by factors and interaction terms.				✓
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.				✓
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.			✓	
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).				✓
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				✓
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				✓

4. Model Standardization

	Not Applicable	Absent	Incomplete	Complete
A. Describe model structure (e.g. delta-lognormal)				✓
B. Describe construction of GLM components (e.g. forward selection from null etc.)				✓
C. Describe inclusion criteria for factors and interactions terms.				✓
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?				✓
E. Provide a table summarizing the construction of the GLM components.				✓
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)				✓
G. Report convergence statistics.			✓	

Working Group Comments:

3D. AOD

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

Working Group Comments:

2B,D,E. AOD

1. Binomial Component

Item	Not Applicable	Absent	Incomplete	Complete
A. Include plots of the chi-square residuals by factor.				✓
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)				✓
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				✓

2. Lognormal/Gamma Component

Item	Not Applicable	Absent	Incomplete	Complete
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.				✓
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.			✓	
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				✓
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.			✓	
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.			✓	
F. Include plots of the residuals by factor				✓

3. Poisson Component

Item	Not Applicable	Absent	Incomplete	Complete
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.				
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				

The feasibility of this diagnostic is still under review.

4. Zero-inflated model

Item	Not Applicable	Absent	Incomplete	Complete
A. Include ROC curve to quantify goodness of fit.				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).				
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.				

MODEL DIAGNOSTICS (CONT.)

	Not Applicable	Absent	Incomplete	Complete

Working Group Comments:

D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				

MODEL RESULTS

A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report				✓
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).				✓

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

1. Plot of resulting indices and estimates of variance				
2. Table of model statistics (e.g. AIC criteria)				

	Date Received	*Workshop Recommendation*	*Revision Deadline* ***	*Author and Rapporteur Signatures*
First Submission	6/04/10	limit to SA	6/23/10	
Revision	6/23/10			

The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author ***DOES NOT*** *commit to any* ***LEGAL OBLIGATION*** *by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

Blacknose - recommended for model sensitivity run (ranking=1)

The time series of this index is short, therefore the working group recommended that the index be used in a model sensitivity run. The index constructed using coastal logbook data was recommended for the base model run. Those two indices track the same portion of the blacknose population, those animal caught in the south Atlantic fishery. Although the working group recognized that observer data is preferred to self-reported data, the available time series of observer data was considered too short for construction of an informative index of abundance. With additional years of data, however, the sink gill net observer data will useful for index construction.

Evaluation of Abundance Indices for SEDAR 21:
Southeast Pelagic Longline Observer Program (SEDAR21-DW-08)

DESCRIPTION OF THE DATA SOURCE

Working Group Comments:

1. Fishery Independent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.				
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)				
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)				
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).				
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				

2. Fishery Dependent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).				✓
B. Describe any changes to reporting requirements, variables reported, etc.				✓
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				✓
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				✓

METHODS

1. Data Reduction and Exclusions

	Not Applicable	Absent	Incomplete	Complete
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.				✓
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).	✓			
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?	✓			

2. Management Regulations (for FD Indices)

	Not Applicable	Absent	Incomplete	Complete
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).	✓			
B. Describe the effects (if any) of management regulations on CPUE	✓			
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.	✓			

3. Describe Analysis Dataset (after exclusions and other treatments)

	Not Applicable	Absent	Incomplete	Complete
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.			✓	
B. Include tables and/or figures of number of positive observations by factors and interaction terms.			✓	
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.			✓	
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.			✓	
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).				✓
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				✓
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				✓

4. Model Standardization

	Not Applicable	Absent	Incomplete	Complete
A. Describe model structure (e.g. delta-lognormal)				✓
B. Describe construction of GLM components (e.g. forward selection from null etc.)				✓
C. Describe inclusion criteria for factors and interactions terms.				✓
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?				✓
E. Provide a table summarizing the construction of the GLM components.				✓
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)				✓
G. Report convergence statistics.			✓	

Working Group Comments:

3A-D. AOD

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

1. Binomial Component

	Not Applicable	Absent	Incomplete	Complete
A. Include plots of the chi-square residuals by factor.				✓
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)		✓		
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).		✓		

2. Lognormal/Gamma Component

	Not Applicable	Absent	Incomplete	Complete
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.				✓
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.			✓	
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.			✓	
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.			✓	
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.			✓	
F. Include plots of the residuals by factor				✓

3. Poisson Component

	Not Applicable	Absent	Incomplete	Complete
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.				
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				

4. Zero-inflated model

	Not Applicable	Absent	Incomplete	Complete
A. Include ROC curve to quantify goodness of fit.				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).				
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.				

Working Group Comments:

2B-E. AOD

The feasibility of this diagnostic is still under review.

MODEL DIAGNOSTICS (CONT.)

Not Applicable	Absent	Incomplete	Complete	Working Group Comments:

D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				

MODEL RESULTS

A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report				✓
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).				✓

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

1. Plot of resulting indices and estimates of variance				
2. Table of model statistics (e.g. AIC criteria)				

	Date Received	*Workshop Recommendation*	*Revision Deadline ****	*Author and Rapporteur Signatures*
First Submission	5/27/10	use observer series	N/A	
Revision				

The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author ***DOES NOT*** *commit to any* ***LEGAL OBLIGATION*** *by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

Sandbar - recommended for use in base model run (ranking=2)
Dusky - recommended for use in base model run (ranking=2)

The data set used to construct these indices contains fishery dependent (commercial longline) data reported by observers. Species misidentification is therefore minimized, while effort and location are accurately reported. Spatial coverage of this index included the entire Gulf of Mexico and US Atlantic coast (matching the largest geographic range among the indices presented). The observer coverage of the pelagic longline fishery was 4-8%. Given the long time series, large spatial coverage, and accuracy of the data the working group recommended these indices for use in a base run of the models.

Evaluation of Abundance Indices for SEDAR 21: Southeast Pelagic Longline Logbook (SEDAR21-DW-08)

DESCRIPTION OF THE DATA SOURCE

Working Group Comments:

	Not Applicable	Absent	Incomplete	Complete
1. Fishery Independent Indices				
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.				
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)				
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)				
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).				
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				
2. Fishery Dependent Indices				
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).				✓
B. Describe any changes to reporting requirements, variables reported, etc.				✓
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				✓
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				✓

METHODS

	Not Applicable	Absent	Incomplete	Complete
1. Data Reduction and Exclusions				
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.				✓
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).	✓			
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?	✓			

Working Group Comments:

3A-D. AOD

2. Management Regulations (for FD Indices)

Item	Not Applicable	Absent	Incomplete	Complete
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).	✓			
B. Describe the effects (if any) of management regulations on CPUE	✓			
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.	✓			

3. Describe Analysis Dataset (after exclusions and other treatments)

Item	Not Applicable	Absent	Incomplete	Complete
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.			✓	
B. Include tables and/or figures of number of positive observations by factors and interaction terms.			✓	
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.			✓	
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.			✓	
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).				✓
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				✓
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				✓

4. Model Standardization

Item	Not Applicable	Absent	Incomplete	Complete
A. Describe model structure (e.g. delta-lognormal)				✓
B. Describe construction of GLM components (e.g. forward selection from null etc.)				✓
C. Describe inclusion criteria for factors and interactions terms.				✓
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?				✓
E. Provide a table summarizing the construction of the GLM components.				✓
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)				✓
G. Report convergence statistics.			✓	

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

1. Binomial Component

Item	Not Applicable	Absent	Incomplete	Complete
A. Include plots of the chi-square residuals by factor.				✓
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)		✓		
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).		✓		

2. Lognormal/Gamma Component

Item	Not Applicable	Absent	Incomplete	Complete
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.				✓
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.			✓	
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.			✓	
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.			✓	
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.			✓	
F. Include plots of the residuals by factor				✓

3. Poisson Component

Item	Not Applicable	Absent	Incomplete	Complete
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.				
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				

4. Zero-inflated model

Item	Not Applicable	Absent	Incomplete	Complete
A. Include ROC curve to quantify goodness of fit.				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).				
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.				

Working Group Comments:

2B-E. AOD

The feasibility of this diagnostic is still under review.

MODEL DIAGNOSTICS (CONT.)

Not Applicable	Absent	Incomplete	Complete

Working Group Comments:

D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				

MODEL RESULTS

A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report				✓
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).				✓

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

1. Plot of resulting indices and estimates of variance				
2. Table of model statistics (e.g. AIC criteria)				

	Date Received	*Workshop Recommendation*	*Revision Deadline ****	*Author and Rapporteur Signatures*
First Submission	5/27/10	use observer series		
Revision				

The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author ***DOES NOT*** *commit to any* ***LEGAL OBLIGATION*** *by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

Sandbar - recommended for model sensitivity run (ranking=2)

The data set consists of fishery dependent (commercial longline) self-reported data. All self-reported data issues (e.g. species misidentification) are present, Data are set based with set location reported to the minute of latitude and longitude, however, suggesting that effort and fishing location were more accurately reported than in some other self-reported data sets. Spatial coverage of this index included the entire Gulf of Mexico and US Atlantic coast (matching the largest geographic range among the indices presented). The working group recommended this index for a sensitivity run of the model due to the many limitations of self-reported data and because an index constructed using observer data from this fishery was available.

Evaluation of Abundance Indices for SEDAR 21: MRFSS (SEDAR21-DW-11)

Working Group Comments:

DESCRIPTION OF THE DATA SOURCE

1. Fishery Independent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.				✓
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)				✓
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)				✓
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				✓
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).				✓
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.		✓		

2. Fishery Dependent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).				✓
B. Describe any changes to reporting requirements, variables reported, etc.				✓
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				✓
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.		✓		

METHODS

1. Data Reduction and Exclusions

	Not Applicable	Absent	Incomplete	Complete
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.				✓
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).				✓
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?	✓			

2. Management Regulations (for FD Indices)

Item	Not Applicable	Absent	Incomplete	Complete
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).		✓		
B. Describe the effects (if any) of management regulations on CPUE			✓	
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.				✓

3. Describe Analysis Dataset (after exclusions and other treatments)

Item	Not Applicable	Absent	Incomplete	Complete
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.				✓
B. Include tables and/or figures of number of positive observations by factors and interaction terms.			✓	
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.			✓	
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.			✓	
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).			✓	
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				✓
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				✓

4. Model Standardization

Item	Not Applicable	Absent	Incomplete	Complete
A. Describe model structure (e.g. delta-lognormal)				✓
B. Describe construction of GLM components (e.g. forward selection from null etc.)				✓
C. Describe inclusion criteria for factors and interactions terms.				✓
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?				✓
E. Provide a table summarizing the construction of the GLM components.				✓
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)				✓
G. Report convergence statistics.			✓	

Working Group Comments:

2B. AOD

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

Working Group Comments: 2B,D. AOD

1. Binomial Component

Item	Not Applicable	Absent	Incomplete	Complete
A. Include plots of the chi-square residuals by factor.		✓		
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)		✓		
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).		✓		

2. Lognormal/Gamma Component

Item	Not Applicable	Absent	Incomplete	Complete
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.		✓		
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.		✓		
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				✓
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.		✓		
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.		✓		
F. Include plots of the residuals by factor		✓		

3. Poisson Component

Item	Not Applicable	Absent	Incomplete	Complete
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.				
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				

The feasibility of this diagnostic is still under review.

4. Zero-inflated model

Item	Not Applicable	Absent	Incomplete	Complete
A. Include ROC curve to quantify goodness of fit.				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).				
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.				

MODEL DIAGNOSTICS (CONT.)

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:

D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				

MODEL RESULTS

A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report				✓
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).				✓

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

1. Plot of resulting indices and estimates of variance				
2. Table of model statistics (e.g. AIC criteria)				

	Date Received	*Workshop Recommendation*	*Revision Deadline ****	*Author and Rapporteur Signatures*
First Submission	6/21/10	not recommended		
Revision				

*The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author **DOES NOT** commit to any **LEGAL OBLIGATION** by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

The working group did not recommend the use of indices constructed using MRFSS data. The working group did recognized that the indices were produced properly using the available data. The limitations of those self-reported data, acquired during dockside interviews, were believed to be too significant for the indices to be recommended for use, however.

Evaluation of Abundance Indices for SEDAR 21: VIMS Longline (SEDAR21-DW-18)

DESCRIPTION OF THE DATA SOURCE

1. Fishery Independent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.				✓
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)				✓
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)				✓
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				✓
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).				✓
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				✓

2. Fishery Dependent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).				
B. Describe any changes to reporting requirements, variables reported, etc.				
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				

METHODS

1. Data Reduction and Exclusions

	Not Applicable	Absent	Incomplete	Complete
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.				✓
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).	✓			
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?	✓			

Working Group Comments:

Working Group Comments:

2. Management Regulations (for FD Indices)

	Not Applicable	Absent	Incomplete	Complete
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).	✓			
B. Describe the effects (if any) of management regulations on CPUE	✓			
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.	✓			

3. Describe Analysis Dataset (after exclusions and other treatments)

	Not Applicable	Absent	Incomplete	Complete
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.				✓
B. Include tables and/or figures of number of positive observations by factors and interaction terms.				✓
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.				✓
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.			✓	
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).				✓
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				✓
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				✓

4. Model Standardization

	Not Applicable	Absent	Incomplete	Complete
A. Describe model structure (e.g. delta-lognormal)				✓
B. Describe construction of GLM components (e.g. forward selection from null etc.)				✓
C. Describe inclusion criteria for factors and interactions terms.				✓
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?				✓
E. Provide a table summarizing the construction of the GLM components.				✓
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)				✓
G. Report convergence statistics.				✓

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

Item	Not Applicable	Absent	Incomplete	Complete
1. Binomial Component				
A. Include plots of the chi-square residuals by factor.				✓
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)			✓	
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).			✓	
2. Lognormal/Gamma Component				
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.			✓	
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.			✓	
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				✓
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.			✓	
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.			✓	
F. Include plots of the residuals by factor				✓
3. Poisson Component				
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.				
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				
4. Zero-inflated model				
A. Include ROC curve to quantify goodness of fit.				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).				
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.				

Working Group Comments:

1B,C. AOD
2A,B,D,E. AOD

The feasibility of this diagnostic is still under review.

MODEL DIAGNOSTICS (CONT.)

Not Applicable	Absent	Incomplete	Complete

Working Group Comments:

D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				

MODEL RESULTS

A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report				✓
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).				✓

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

1. Plot of resulting indices and estimates of variance				
2. Table of model statistics (e.g. AIC criteria)				

	Date Received	*Workshop Recommendation*	*Revision Deadline* ***	*Author and Rapporteur Signatures*
First Submission	6/21/10	rerun w/100% pos	????	
Revision	???	accept as revised		

The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author ***DOES NOT*** *commit to any* ***LEGAL OBLIGATION*** *by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

Sandbar - recommended for model base run (ranking=2)

Dusky - recommended for model base run (ranking=3)

The working group recommended that these data be reanalyzed with 100% positive years included in the time series. The working group recognized that the Chesapeake Bay includes important juvenile/pupping habitat for sandbar and dusky sharks. These indices were constructed using data collected from fixed stations at the mouth of Chesapeake Bay. Sampling has been ongoing since 1975 using consistent methods. Although the spatial scale of these indices were limited, the working group recommended the indices be used in model base runs because of the length of the time series, the sampling location, and the consistent survey design.

Evaluation of Abundance Indices for SEDAR 21:
Dauphin Island Sea Lab Bottom Longline (SEDAR21-DW-25)

DESCRIPTION OF THE DATA SOURCE

1. Fishery Independent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.				✓
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)				✓
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)				✓
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				✓
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).				✓
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				✓

2. Fishery Dependent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).				
B. Describe any changes to reporting requirements, variables reported, etc.				
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				

METHODS

1. Data Reduction and Exclusions

	Not Applicable	Absent	Incomplete	Complete
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.				✓
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).	✓			
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?	✓			

Working Group Comments:

1C. group recommends excluding stations within Mobile Bay and those beyond 20 meters

Working Group Comments:

3A-D. AOD

2. Management Regulations (for FD Indices)

Item	Not Applicable	Absent	Incomplete	Complete
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).	✓			
B. Describe the effects (if any) of management regulations on CPUE	✓			
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.	✓			

3. Describe Analysis Dataset (after exclusions and other treatments)

Item	Not Applicable	Absent	Incomplete	Complete
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.			✓	
B. Include tables and/or figures of number of positive observations by factors and interaction terms.		✓	✓	
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.			✓	
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.			✓	
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).		✓		
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				✓
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				✓

4. Model Standardization

Item	Not Applicable	Absent	Incomplete	Complete
A. Describe model structure (e.g. delta-lognormal)				✓
B. Describe construction of GLM components (e.g. forward selection from null etc.)				✓
C. Describe inclusion criteria for factors and interactions terms.				✓
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?				✓
E. Provide a table summarizing the construction of the GLM components.				✓
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)				✓
G. Report convergence statistics.				✓

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
1. Binomial Component					
A. Include plots of the chi-square residuals by factor.				✓	
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)				✓	
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				✓	
2. Lognormal/Gamma Component					
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.				✓	
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.		✓			
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				✓	
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.		✓			
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.		✓			
F. Include plots of the residuals by factor				✓	
3. Poisson Component					
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).					
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.					
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.					
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.					
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.					***The feasibility of this diagnostic is still under review.***
4. Zero-inflated model					
A. Include ROC curve to quantify goodness of fit.					
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).					
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.					

MODEL DIAGNOSTICS (CONT.)

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:

D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				

MODEL RESULTS

A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report				✓
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).				✓

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

1. Plot of resulting indices and estimates of variance				
2. Table of model statistics (e.g. AIC criteria)				

	Date Received	*Workshop Recommendation*	*Revision Deadline* ***	*Author and Rapporteur Signatures*
First Submission	6/4/10	revise (see below)	6/23/10	
Revision	6/23/10	base run		

The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author ***DOES NOT*** *commit to any* ***LEGAL OBLIGATION*** *by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

Blacknose - Gulf of Mexico - recommend for base model run (ranking=5)

Spatially limited, temporally limited, but is a fishery independent survey. GOM blacknose indices are few and no reason to exclude this index. Revise by excluding stations within Mobile Bay and those beyond 20 meters depth.

Evaluation of Abundance Indices for SEDAR 21: NMFS COASTSPAN Longline (SEDAR21-DW-27)

DESCRIPTION OF THE DATA SOURCE

Working Group Comments:

1. Fishery Independent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.				✓
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)				✓
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)				✓
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				✓
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).				✓
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				✓

2. Fishery Dependent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).				
B. Describe any changes to reporting requirements, variables reported, etc.				
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				

METHODS

1. Data Reduction and Exclusions

	Not Applicable	Absent	Incomplete	Complete
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.	✓			
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).	✓			
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?	✓			

2. Management Regulations (for FD Indices)

	Not Applicable	Absent	Incomplete	Complete
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).	✓			
B. Describe the effects (if any) of management regulations on CPUE	✓			
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.	✓			

3. Describe Analysis Dataset (after exclusions and other treatments)

	Not Applicable	Absent	Incomplete	Complete
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.				✓
B. Include tables and/or figures of number of positive observations by factors and interaction terms.			✓	
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.			✓	
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.			✓	
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).				✓
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				✓
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				✓

4. Model Standardization

	Not Applicable	Absent	Incomplete	Complete
A. Describe model structure (e.g. delta-lognormal)				✓
B. Describe construction of GLM components (e.g. forward selection from null etc.)				✓
C. Describe inclusion criteria for factors and interactions terms.				✓
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?				✓
E. Provide a table summarizing the construction of the GLM components.				✓
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)				✓
G. Report convergence statistics.				✓

Working Group Comments:

3B,C,D. AOD

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

1. Binomial Component

Item	Not Applicable	Absent	Incomplete	Complete
A. Include plots of the chi-square residuals by factor.				✓
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)				✓
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				✓

2. Lognormal/Gamma Component

Item	Not Applicable	Absent	Incomplete	Complete
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.				✓
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.			✓	
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				✓
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.			✓	
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				✓
F. Include plots of the residuals by factor				✓

3. Poisson Component

Item	Not Applicable	Absent	Incomplete	Complete
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.				
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				

4. Zero-inflated model

Item	Not Applicable	Absent	Incomplete	Complete
A. Include ROC curve to quantify goodness of fit.				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).				
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.				

Working Group Comments:

2B,D. AOD

The feasibility of this diagnostic is still under review.

MODEL DIAGNOSTICS (CONT.)

Not Applicable	Absent	Incomplete	Complete	Working Group Comments:

D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.

E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.

MODEL RESULTS

A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report				✓
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).				✓

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

1. Plot of resulting indices and estimates of variance				
2. Table of model statistics (e.g. AIC criteria)				

	Date Received	*Workshop Recommendation*	*Revision Deadline* ***	*Author and Rapporteur Signatures*
First Submission	6/22/2010	see below		
Revision		base		

The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author ***DOES NOT*** *commit to any* ***LEGAL OBLIGATION*** *by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

DW-27 - Delaware Bay juvenile sandbars

workshop recommendations: run with new code and also split out yoy and age 1+ as done in last assessment.

Time series recommended for base run. This series (all three - yoy, age 1+ and total juvenile sandbar sharks) was used as base in the last stock assessment. Since that time this time series has been updated through 2009 giving it a nine year time span. This is a standardized survey which uses random stratified sampling based on depth within geographic regions and covers the entire Delaware Bay. This bay is one of two principle nursery areas for the sandbar shark in east coast waters of the U.S. The CVs look great and this time series provides a great juvenile sandbar shark index.

Since all three Delaware Bay indices were used in the last stock assessment and the total juvenile index is a combination of the yoy and age 1+ indices, it may be beneficial to use the total juvenile sandbar shark index for continuity and the yoy and age 1+ indices in the base run.

Evaluation of Abundance Indices for SEDAR 21: NMFS Northeast Longline (SEDAR21-DW-28)

DESCRIPTION OF THE DATA SOURCE

1. Fishery Independent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.				✓
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)				✓
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)				✓
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				✓
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).				✓
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				✓

2. Fishery Dependent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).				
B. Describe any changes to reporting requirements, variables reported, etc.				
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				

METHODS

1. Data Reduction and Exclusions

	Not Applicable	Absent	Incomplete	Complete
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.	✓			
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).	✓			
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?	✓			

Working Group Comments:

2. Management Regulations (for FD Indices)

Item	Not Applicable	Absent	Incomplete	Complete
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).	✓			
B. Describe the effects (if any) of management regulations on CPUE	✓			
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.	✓			

3. Describe Analysis Dataset (after exclusions and other treatments)

Item	Not Applicable	Absent	Incomplete	Complete
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.			✓	
B. Include tables and/or figures of number of positive observations by factors and interaction terms.			✓	
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.			✓	
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.			✓	
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).				✓
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				✓
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				✓

4. Model Standardization

Item	Not Applicable	Absent	Incomplete	Complete
A. Describe model structure (e.g. delta-lognormal)				✓
B. Describe construction of GLM components (e.g. forward selection from null etc.)				✓
C. Describe inclusion criteria for factors and interactions terms.				✓
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?				✓
E. Provide a table summarizing the construction of the GLM components.				✓
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)				✓
G. Report convergence statistics.				✓

Working Group Comments:

3A,B,C,D. AOD

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

1. Binomial Component

Item	Not Applicable	Absent	Incomplete	Complete
A. Include plots of the chi-square residuals by factor.				✓
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)				✓
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				✓

2. Lognormal/Gamma Component

Item	Not Applicable	Absent	Incomplete	Complete
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.				✓
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.			✓	
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				✓
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.			✓	
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				✓
F. Include plots of the residuals by factor				✓

3. Poisson Component

Item	Not Applicable	Absent	Incomplete	Complete
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.				
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				

4. Zero-inflated model

Item	Not Applicable	Absent	Incomplete	Complete
A. Include ROC curve to quantify goodness of fit.				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).				
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.				

Working Group Comments:

2B,D. AOD

The feasibility of this diagnostic is still under review.

MODEL DIAGNOSTICS (CONT.)

	Not Applicable	Absent	Incomplete	Complete

Working Group Comments:

D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				

MODEL RESULTS

A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report				✓
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).				✓

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

1. Plot of resulting indices and estimates of variance				
2. Table of model statistics (e.g. AIC criteria)				

	Date Received	*Workshop Recommendation*	*Revision Deadline ****	*Author and Rapporteur Signatures*
First Submission	6/22/10	rerun with new code	6/23/10	
Revision	6/23/10	base		

The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author ***DOES NOT*** *commit to any* ***LEGAL OBLIGATION*** *by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

DW28 - NE LL

Sandbar - include in base run (ranking=2)

Dusky - include in base run (ranking=1)

This time series was recommended for use in base analyses for both sandbar and dusky sharks. Even though this survey is conducted at fixed stations, it is a highly standardized survey and covers a large portion of both the dusky and sandbar shark's geographic range (off the Florida Keys to New Jersey coastal waters). Sandbar and dusky sharks are the primary shark species caught during this coastal shark longline survey due to the timing of the survey with their migration up the coast. During the last stock assessment for these species, this time series was used for sensitivity analyses. Since then, this time series has been updated with data through 2009, and included recovered surface water temperature and depth data.

Evaluation of Abundance Indices for SEDAR 21:
GA COASTSPAN Longline / GADNR Red Drum Longline
(SEDAR21-DW-29)

DESCRIPTION OF THE DATA SOURCE

1. Fishery Independent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.				✓
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)				✓
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)				✓
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				✓
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).				✓
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				✓

2. Fishery Dependent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).				
B. Describe any changes to reporting requirements, variables reported, etc.				
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				

METHODS

1. Data Reduction and Exclusions

	Not Applicable	Absent	Incomplete	Complete
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.	✓			
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).	✓			
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?	✓			

Working Group Comments:

2. Management Regulations (for FD Indices)

	Not Applicable	Absent	Incomplete	Complete
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).	✓			
B. Describe the effects (if any) of management regulations on CPUE	✓			
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.	✓			

3. Describe Analysis Dataset (after exclusions and other treatments)

	Not Applicable	Absent	Incomplete	Complete
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.				✓
B. Include tables and/or figures of number of positive observations by factors and interaction terms.			✓	
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.			✓	
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.			✓	
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).				✓
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				✓
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				✓

4. Model Standardization

	Not Applicable	Absent	Incomplete	Complete
A. Describe model structure (e.g. delta-lognormal)				✓
B. Describe construction of GLM components (e.g. forward selection from null etc.)				✓
C. Describe inclusion criteria for factors and interactions terms.				✓
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?				✓
E. Provide a table summarizing the construction of the GLM components.				✓
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)				✓
G. Report convergence statistics.				✓

Working Group Comments:

3B,C,D. AOD

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

Item	Not Applicable	Absent	Incomplete	Complete
1. Binomial Component				
A. Include plots of the chi-square residuals by factor.				✓
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)				✓
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				✓
2. Lognormal/Gamma Component				
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.				✓
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.			✓	
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				✓
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.			✓	
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				✓
F. Include plots of the residuals by factor				✓
3. Poisson Component				
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.				
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				
4. Zero-inflated model				
A. Include ROC curve to quantify goodness of fit.				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).				
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.				

Working Group Comments:

2B,D. AOD

The feasibility of this diagnostic is still under review.

MODEL DIAGNOSTICS (CONT.)

Item	Not Applicable	Absent	Incomplete	Complete

Working Group Comments:

D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				

MODEL RESULTS

A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report				✓
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).				✓

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

1. Plot of resulting indices and estimates of variance				
2. Table of model statistics (e.g. AIC criteria)				

	Date Received	*Workshop Recommendation*	*Revision Deadline* ***	*Author and Rapporteur Signatures*
First Submission	6/21/2010	run using new code		
Revision		see below		

The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author ***DOES NOT*** *commit to any* ***LEGAL OBLIGATION*** *by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

DW-29 GADNR red drum and GA COASTSPAN surveys

Sandbar (red drum survey) - Not recommended.
The model diagnostic plots reveal that the residual positive catch distribution is not normally distributed. This is a relatively new survey (3 year time series) and as the time series develops it may provide a useful index in future assessments. At this time it is recommended that GADNR continues to collect sandbar shark catch information from their red drum survey and submit it to future SEDAR data workshops for further evaluation.

Blacknose (red drum survey) - Recommended for base.
Even though this is a short time series (3 years), model diagnostics are acceptable, the CVs look good and it covers the majority of the blacknose shark size range from yoy to adult. This time series also samples an area of the blacknose shark distribution not covered by other time series

Sandbar (GA COASTSPAN) - Recommended for base.
This time series was not available during the last sandbar shark assessment. This time series spans nine years and provides a juvenile sandbar shark index for Georgia's coastal waters. This index provides information on a portion of the US Atlantic sandbar population not sampled by other surveys because it is conducted in GA waters during the summer months when many of the sandbar juveniles have migrated north to cooler waters

Evaluation of Abundance Indices for SEDAR 21:
SC COASTSPAN Longline / SCDNR Red Drum Longline
(SEDAR21-DW-30)

DESCRIPTION OF THE DATA SOURCE

Working Group Comments:

1. Fishery Independent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.				✔
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)				✔
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)				✔
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				✔
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).				✔
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				✔

2. Fishery Dependent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).				
B. Describe any changes to reporting requirements, variables reported, etc.				
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				

METHODS

1. Data Reduction and Exclusions

	Not Applicable	Absent	Incomplete	Complete
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.	✔			
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).	✔			
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?	✔			

	Not Applicable	Absent	Incomplete	Complete
2. Management Regulations (for FD Indices)				
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).	✔			
B. Describe the effects (if any) of management regulations on CPUE	✔			
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.	✔			
3. Describe Analysis Dataset (after exclusions and other treatments)				
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.				✔
B. Include tables and/or figures of number of positive observations by factors and interaction terms.			✔	
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.			✔	
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.			✔	
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).				✔
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				✔
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				✔
4. Model Standardization				
A. Describe model structure (e.g. delta-lognormal)				✔
B. Describe construction of GLM components (e.g. forward selection from null etc.)				✔
C. Describe inclusion criteria for factors and interactions terms.				✔
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?				✔
E. Provide a table summarizing the construction of the GLM components.				✔
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)				✔
G. Report convergence statistics.				✔

Working Group Comments:

3B,C,D. AOD

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

Working Group Comments: 2B,D. AOD

1. Binomial Component

Item	Not Applicable	Absent	Incomplete	Complete
A. Include plots of the chi-square residuals by factor.				✔
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)				✔
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				✔

2. Lognormal/Gamma Component

Item	Not Applicable	Absent	Incomplete	Complete
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.				✔
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.			✔	
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				✔
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.			✔	
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				✔
F. Include plots of the residuals by factor				✔

3. Poisson Component

Item	Not Applicable	Absent	Incomplete	Complete
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.				
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				

The feasibility of this diagnostic is still under review.

4. Zero-inflated model

Item	Not Applicable	Absent	Incomplete	Complete
A. Include ROC curve to quantify goodness of fit.				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).				
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.				

MODEL DIAGNOSTICS (CONT.)

	Not Applicable	Absent	Incomplete	Complete

Working Group Comments:

D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				

MODEL RESULTS

A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report				✔
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).				✔

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

1. Plot of resulting indices and estimates of variance				
2. Table of model statistics (e.g. AIC criteria)				

	Date Received	Workshop Recommendation	Revision Deadline ***	Author and Rapporteur Signatures
First Submission	6/21/2010	run with new code		
Revision		see below		

The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author ***DOES NOT*** *commit to any* ***LEGAL OBLIGATION*** *by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

DW-30 - Sandbar (SC COASTSPAN) - Recommended for base. This time series was not available during the last sandbar shark assessment. The model diagnostics and the CVs look good. This index provides information on a portion of the US Atlantic sandbar population not sampled by other surveys. It is conducted in SC waters during summer months when many sandbar juveniles have migrated north to cooler waters.
DW-30 - Sandbar (SCDNR red drum - hist (98-06) - Recommended for base. This time series was not available during the last sandbar shark assessment. The time series spans nine years and covers the majority of the sandbar shark's size range. The model diagnostics and CVs look good. In addition it also provides information on a portion of the US Atlantic sandbar population not sampled by other surveys because it is conducted in SC waters during the summer months when many of the sandbar juveniles have migrated north to cooler waters.
DW-30 - Blacknose (SCDNR red drum - hist (98-06) - Recommended for base. This time series was used as base in the last blacknose assessment. Since last used it has been updated through 2006 (the final year of this time series before gear and sampling design changes) and includes recovered depth data. The model diagnostics and CVs look good. This time series also samples an area of the blacknose shark distribution not covered by other time series.
DW-30 - Sandbar and Blacknose (SCDNR red drum - new (07-09) - Not recommended. The model diagnostic plots reveal the residual positive catch distribution is not normally distributed. This is a relatively new survey (3 year time series) and as it develops it should provide a useful index for future assessments. It is recommended that SCDNR continues to collect sandbar shark catch information from their red drum survey and submit it to future SEDAR data workshops for further evaluation.

Evaluation of Abundance Indices for SEDAR 21: NMFS Historical Longline (SEDAR21-DW-31)

Working Group Comments:

DESCRIPTION OF THE DATA SOURCE

1. Fishery Independent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.				✓
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)				✓
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)				✓
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				✓
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).				✓
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				✓

2. Fishery Dependent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).				
B. Describe any changes to reporting requirements, variables reported, etc.				
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				

METHODS

1. Data Reduction and Exclusions

	Not Applicable	Absent	Incomplete	Complete
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.	✓			
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).	✓			
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?	✓			

	Not Applicable	Absent	Incomplete	Complete
2. Management Regulations (for FD Indices)				
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).	✓			
B. Describe the effects (if any) of management regulations on CPUE	✓			
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.	✓			
3. Describe Analysis Dataset (after exclusions and other treatments)				
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.			✓	
B. Include tables and/or figures of number of positive observations by factors and interaction terms.			✓	
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.			✓	
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.			✓	
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).				✓
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				✓
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				✓
4. Model Standardization				
A. Describe model structure (e.g. delta-lognormal)				✓
B. Describe construction of GLM components (e.g. forward selection from null etc.)				✓
C. Describe inclusion criteria for factors and interactions terms.				✓
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?				✓
E. Provide a table summarizing the construction of the GLM components.				✓
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)				✓
G. Report convergence statistics.				✓

Working Group Comments:

3A,B,C,D. AOD

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

Item	Not Applicable	Absent	Incomplete	Complete
1. Binomial Component				
A. Include plots of the chi-square residuals by factor.				✓
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)				✓
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				✓
2. Lognormal/Gamma Component				
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.				✓
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.			✓	
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				✓
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.			✓	
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				✓
F. Include plots of the residuals by factor				✓
3. Poisson Component				
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.				
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				
4. Zero-inflated model				
A. Include ROC curve to quantify goodness of fit.				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).				
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.				

Working Group Comments:

2B,D. AOD

The feasibility of this diagnostic is still under review.

MODEL DIAGNOSTICS (CONT.)

Not Applicable	Absent	Incomplete	Complete

Working Group Comments:

D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				

MODEL RESULTS

A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report				✓
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).				✓

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

1. Plot of resulting indices and estimates of variance				
2. Table of model statistics (e.g. AIC criteria)				

	Date Received	*Workshop Recommendation*	*Revision Deadline ****	*Author and Rapporteur Signatures*
First Submission	6/22/10	rerun with new code	6/23/10	
Revision	6/23/10	sensitivity		

The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author ***DOES NOT*** *commit to any* ***LEGAL OBLIGATION*** *by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

Sandbar - recommended for sensitivity model run (ranking=1).
Dusky - recommended for sensitivity model run (ranking=1).

These indices were not recommended for base runs of the models due to small sample size and inconsistent sampling effort over the entire US south Atlantic. The proportion of positive dusky shark sets was low, approximately 9% over all years. Although the time series was long (1961-1996), total sets in many years was low. The highest number of sets in any year was 74, however, in most years fewer than 30 sets were completed. The working group was concerned that so few sets per year may not be sufficient to adequately follow the trends in the sandbar and dusky shark populations over the broad geographic range of the survey. In future data workshops for these species, it may be beneficial to restrict the survey data to the waters off the northeast US.

Evaluation of Abundance Indices for SEDAR 21: UNC Longline (SEDAR21-DW-33)

Working Group Comments:

DESCRIPTION OF THE DATA SOURCE

1. Fishery Independent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.				✓
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)				✓
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)				✓
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				✓
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).				✓
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				✓

2. Fishery Dependent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).				
B. Describe any changes to reporting requirements, variables reported, etc.				
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				

METHODS

1. Data Reduction and Exclusions

	Not Applicable	Absent	Incomplete	Complete
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.	✓			
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).	✓			
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?	✓			

2. Management Regulations (for FD Indices)

Item	Not Applicable	Absent	Incomplete	Complete
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).	✓			
B. Describe the effects (if any) of management regulations on CPUE	✓			
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.	✓			

3. Describe Analysis Dataset (after exclusions and other treatments)

Item	Not Applicable	Absent	Incomplete	Complete
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.				✓
B. Include tables and/or figures of number of positive observations by factors and interaction terms.			✓	
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.			✓	
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.			✓	
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).			✓	
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				✓
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				✓

4. Model Standardization

Item	Not Applicable	Absent	Incomplete	Complete
A. Describe model structure (e.g. delta-lognormal)				✓
B. Describe construction of GLM components (e.g. forward selection from null etc.)				✓
C. Describe inclusion criteria for factors and interactions terms.				✓
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?				✓
E. Provide a table summarizing the construction of the GLM components.				✓
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)				✓
G. Report convergence statistics.				✓

Working Group Comments:

3B,C,D. AOD

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

1. Binomial Component

Item	Not Applicable	Absent	Incomplete	Complete
A. Include plots of the chi-square residuals by factor.				✓
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)				✓
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				✓

2. Lognormal/Gamma Component

Item	Not Applicable	Absent	Incomplete	Complete
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.				✓
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.			✓	
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				✓
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.			✓	
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				✓
F. Include plots of the residuals by factor				✓

3. Poisson Component

Item	Not Applicable	Absent	Incomplete	Complete
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.				
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				

4. Zero-inflated model

Item	Not Applicable	Absent	Incomplete	Complete
A. Include ROC curve to quantify goodness of fit.				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).				
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.				

Working Group Comments:

2B,D. AOD

The feasibility of this diagnostic is still under review.

MODEL DIAGNOSTICS (CONT.)

Not Applicable	Absent	Incomplete	Complete	Working Group Comments:

D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				

MODEL RESULTS

A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report				✓
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).				✓

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

1. Plot of resulting indices and estimates of variance				
2. Table of model statistics (e.g. AIC criteria)				

	Date Received	*Workshop Recommendation*	*Revision Deadline ****	*Author and Rapporteur Signatures*
First Submission	6/22/2010	rerun with new code		
Revision	6/24/2010			

*The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author **DOES NOT** commit to any **LEGAL OBLIGATION** by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

DW-33 -UNC LL - Blacknose - base
Even though the UNC LL survey is only two fixed stations at the northern end of the blacknose range, this species was regularly encountered during the survey years. This time series is recommended for base because of the long time series and lack of blacknose data available in the Atlantic. This time series was used as base in the 2007 stock assessment for blacknose sharks. The current time series has been updated with data through 2009, including recovered temperature data and data corrections detailing missing water hauls and missing or incorrect information pertaining to individual animal records, since it was used in the last stock assessment.

DW-33 -UNC LL - Dusky - sensitivity
Dusky sharks are a good portion of the overall UNC catch but they are transient in the area sampled and could easily be missed by the two fixed stations. There are a few years during the time series when there were no dusky catch throughout the entire year Because this is such a long time series, dusky time series are scarce, and dusky sharks are only second to the blacknose in numbers caught throughout the lifetime of the survey, it is recommended that this time series be used in sensitivity analyses.

DW-33 - UNC LL - Sandbar - not recommended
As with dusky sharks, sandbar sharks are transient in this area and many are likely to bypass the sampling area during their migrations. The overall and yearly proportions of positive sets is low and there are numerous years without any sandbar shark catch. Due to the limited sampling area and the abundance of other time series available for this species, it is not recommended to use this time series for sandbar sharks.

Evaluation of Abundance Indices for SEDAR 21: Mote Marine Lab Longline (SEDAR21-DW-34)

DESCRIPTION OF THE DATA SOURCE

1. Fishery Independent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.				✓
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)				✓
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)				✓
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).		✓		
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).				✓
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.		✓		

2. Fishery Dependent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).				
B. Describe any changes to reporting requirements, variables reported, etc.				
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				

METHODS

1. Data Reduction and Exclusions

	Not Applicable	Absent	Incomplete	Complete
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.	✓			
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).	✓			
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?	✓			

Working Group Comments:

Working paper DW34 describes survey design

2. Management Regulations (for FD Indices)

	Not Applicable	Absent	Incomplete	Complete
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).				
B. Describe the effects (if any) of management regulations on CPUE				
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.				

3. Describe Analysis Dataset (after exclusions and other treatments)

	Not Applicable	Absent	Incomplete	Complete
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.		✓		
B. Include tables and/or figures of number of positive observations by factors and interaction terms.		✓		
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.		✓		
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.		✓		
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).		✓		
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.		✓		
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).		✓		

4. Model Standardization

	Not Applicable	Absent	Incomplete	Complete
A. Describe model structure (e.g. delta-lognormal)				✓
B. Describe construction of GLM components (e.g. forward selection from null etc.)				✓
C. Describe inclusion criteria for factors and interactions terms.				✓
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?		✓		
E. Provide a table summarizing the construction of the GLM components.		✓		
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)	✓			
G. Report convergence statistics.		✓		✓

Working Group Comments:

3A-G. AOD, indices from this data set were produced at the data workshop and methodology for constructing those indices was not included in the working paper. Index methods were reported verbally by the analyst.

4E,G. AOD

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

Item	Not Applicable	Absent	Incomplete	Complete
1. Binomial Component				
A. Include plots of the chi-square residuals by factor.		✓		
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)		✓		
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).		✓		
2. Lognormal/Gamma Component				
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.		✓		
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.		✓		
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.		✓		
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.		✓		
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.		✓		
F. Include plots of the residuals by factor		✓		
3. Poisson Component				
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.				
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				
4. Zero-inflated model				
A. Include ROC curve to quantify goodness of fit.				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).				
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.				

Working Group Comments:

1A-C. AOD
2A-F. AOD

The feasibility of this diagnostic is still under review.

MODEL DIAGNOSTICS (CONT.)

	Not Applicable	Absent	Incomplete	Complete

Working Group Comments:

D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				

Model Results A, B. AOD.

MODEL RESULTS

A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report		✓		
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).		✓		

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

1. Plot of resulting indices and estimates of variance				
2. Table of model statistics (e.g. AIC criteria)				

	Date Received	*Workshop Recommendation*	*Revision Deadline* ***	*Author and Rapporteur Signatures*
First Submission	6/25/10	accept as prepared	N/A	
Revision				

The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author ***DOES NOT*** *commit to any* ***LEGAL OBLIGATION*** *by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

Blacknose GOM (longline index) - recommended for use in a base model run (ranking=3)

The data set included longline, drumline, and gillnet data. Only the longline data were useful for constructing an index of abundance. Analyses were conducted during the data workshop due to late arrival of the data.

These data were fisheries independent, collected during a survey using standardized methods. The ranking was based upon the relatively short time series and limited spatial coverage of the survey.

Evaluation of Abundance Indices for SEDAR 21:
NMFS Southeast Bottom Longline (SEDAR21-DW-39)

DESCRIPTION OF THE DATA SOURCE

1. Fishery Independent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.				✓
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)				✓
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)				✓
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				✓
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).				✓
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				✓

2. Fishery Dependent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).				
B. Describe any changes to reporting requirements, variables reported, etc.				
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				

METHODS

1. Data Reduction and Exclusions

	Not Applicable	Absent	Incomplete	Complete
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.	✓			
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).	✓			
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?	✓			

Working Group Comments:

Working Group Comments:

2. Management Regulations (for FD Indices)

	Not Applicable	Absent	Incomplete	Complete
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).	✓			
B. Describe the effects (if any) of management regulations on CPUE	✓			
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.	✓			

3. Describe Analysis Dataset (after exclusions and other treatments)

	Not Applicable	Absent	Incomplete	Complete
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.		✓		
B. Include tables and/or figures of number of positive observations by factors and interaction terms.		✓		
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.		✓		
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.		✓		
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).				✓
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				✓
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				✓

4. Model Standardization

	Not Applicable	Absent	Incomplete	Complete
A. Describe model structure (e.g. delta-lognormal)				✓
B. Describe construction of GLM components (e.g. forward selection from null etc.)				✓
C. Describe inclusion criteria for factors and interactions terms.				✓
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?	✓			
E. Provide a table summarizing the construction of the GLM components.				✓
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)		✓		
G. Report convergence statistics.		✓		

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

Item	Not Applicable	Absent	Incomplete	Complete
1. Binomial Component				
A. Include plots of the chi-square residuals by factor.			✓	
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)		✓		
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).			✓	
2. Lognormal/Gamma Component				
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.			✓	
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.		✓		
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.			✓	
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.		✓		
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.		✓		
F. Include plots of the residuals by factor			✓	
3. Poisson Component				
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.				
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				
4. Zero-inflated model				
A. Include ROC curve to quantify goodness of fit.				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).				
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.				

Working Group Comments:

The feasibility of this diagnostic is still under review.

MODEL DIAGNOSTICS (CONT.)

Not Applicable	Absent	Incomplete	Complete

Working Group Comments:

D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				

MODEL RESULTS

A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report				✓
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).				✓

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

1. Plot of resulting indices and estimates of variance				
2. Table of model statistics (e.g. AIC criteria)				

	Date Received	*Workshop Recommendation*	*Revision Deadline* ***	*Author and Rapporteur Signatures*
First Submission	6/21/10	accept as submitted		
Revision				

The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author ***DOES NOT*** *commit to any* ***LEGAL OBLIGATION*** *by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

This is a fisheries independent data set that includes a long time series of data and large spatial coverage (TX-NC).

Blacknose south Atlantic - recommend for use in base model (ranking=1)

Blacknose Gulf of Mexico - recommend for use in base model (ranking=1)

Blacknose SA & GOM - recommend for use in base model (ranking=1)

Sandbar SA & GOM - recommend for use in base model (ranking=1)

Dusky south Atlantic - do not use due to very small sample size (11 individuals)

Dusky Gulf of Mexico - do not use due to very small sample size (11 individuals)

Dusky SA & GOM - do not use due to very small sample size (11 individuals)

Evaluation of Abundance Indices for SEDAR 21: Coastal Fishery Logbook Gillnet (SEDAR21-DW-40)

Working Group Comments:

2D unknown, data are pounds landed no size data reported

DESCRIPTION OF THE DATA SOURCE

1. Fishery Independent Indices

Item	Not Applicable	Absent	Incomplete	Complete
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.				
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)				
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)				
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).				
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				

2. Fishery Dependent Indices

Item	Not Applicable	Absent	Incomplete	Complete
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).				✓
B. Describe any changes to reporting requirements, variables reported, etc.				✓
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				✓
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				✓

METHODS

1. Data Reduction and Exclusions

Item	Not Applicable	Absent	Incomplete	Complete
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.				✓
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).				✓
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?				✓

2. Management Regulations (for FD Indices)

Item	Not Applicable	Absent	Incomplete	Complete
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).				✓
B. Describe the effects (if any) of management regulations on CPUE	✓			
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.		✓		

3. Describe Analysis Dataset (after exclusions and other treatments)

Item	Not Applicable	Absent	Incomplete	Complete
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.			✓	
B. Include tables and/or figures of number of positive observations by factors and interaction terms.			✓	
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.			✓	
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.			✓	
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).			✓	
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				✓
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				✓

4. Model Standardization

Item	Not Applicable	Absent	Incomplete	Complete
A. Describe model structure (e.g. delta-lognormal)				✓
B. Describe construction of GLM components (e.g. forward selection from null etc.)				✓
C. Describe inclusion criteria for factors and interactions terms.				✓
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?				✓
E. Provide a table summarizing the construction of the GLM components.				✓
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)			✓	
G. Report convergence statistics.			✓	

Working Group Comments:

2B,C No size limit, used open season,No trip limit used as there was no way to account for number of sharks caught (1999-2009 limit of 16 scs/pelagic sharks for combined/trip for incidental permit holders).

3A-E. confidential data

4F,G. AOD

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

Item	Not Applicable	Absent	Incomplete	Complete
1. Binomial Component				
A. Include plots of the chi-square residuals by factor.				✓
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)			✓	
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).			✓	
2. Lognormal/Gamma Component				
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.				✓
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.			✓	
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				✓
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.			✓	
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.			✓	
F. Include plots of the residuals by factor				✓
3. Poisson Component				
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.				
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				
4. Zero-inflated model				
A. Include ROC curve to quantify goodness of fit.				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).				
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.				

Working Group Comments:

1B. Confidential data
1C. AOD
2B,D,E. AOD

The feasibility of this diagnostic is still under review.

MODEL DIAGNOSTICS (CONT.)

Not Applicable	Absent	Incomplete	Complete

Working Group Comments:

D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				

MODEL RESULTS

A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report				✓
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).				✓

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

1. Plot of resulting indices and estimates of variance				
2. Table of model statistics (e.g. AIC criteria)				

	Date Received	*Workshop Recommendation*	*Revision Deadline ****	*Author and Rapporteur Signatures*
First Submission	06/24/10	Accept	NA	
Revision				

The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author ***DOES NOT*** *commit to any* ***LEGAL OBLIGATION*** *by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

Blacknose fisheries dependent gillnet index was recommended for base case due to longer time series data than sink gillnet observer data. Those two indices were constructed using fishery dependent data from the same fishery. (ranking=5)

Evaluation of Abundance Indices for SEDAR 21:
Coastal Fishery Logbook Longline (Sandbar) (SEDAR21-DW-41)

DESCRIPTION OF THE DATA SOURCE

1. Fishery Independent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.				
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)				
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)				
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).				
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				

2. Fishery Dependent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).				✓
B. Describe any changes to reporting requirements, variables reported, etc.				✓
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				✓
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				✓

METHODS

1. Data Reduction and Exclusions

	Not Applicable	Absent	Incomplete	Complete
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.				✓
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).				✓
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?				✓

Working Group Comments:

2D unknown, data are pounds landed no size data reported

2. Management Regulations (for FD Indices)

	Not Applicable	Absent	Incomplete	Complete
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).				✓
B. Describe the effects (if any) of management regulations on CPUE	✓			
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.		✓		

3. Describe Analysis Dataset (after exclusions and other treatments)

	Not Applicable	Absent	Incomplete	Complete
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.			✓	
B. Include tables and/or figures of number of positive observations by factors and interaction terms.			✓	
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.			✓	
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.			✓	
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).			✓	
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				✓
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				✓

4. Model Standardization

	Not Applicable	Absent	Incomplete	Complete
A. Describe model structure (e.g. delta-lognormal)				✓
B. Describe construction of GLM components (e.g. forward selection from null etc.)				✓
C. Describe inclusion criteria for factors and interactions terms.				✓
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?				✓
E. Provide a table summarizing the construction of the GLM components.				✓
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)			✓	
G. Report convergence statistics.			✓	

Working Group Comments:

2B,C add comment
3A-E. confidential data
4F,G. AOD

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

Item	Not Applicable	Absent	Incomplete	Complete
1. Binomial Component				
A. Include plots of the chi-square residuals by factor.				✓
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)			✓	
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).			✓	
2. Lognormal/Gamma Component				
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.				✓
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.			✓	
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				✓
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.			✓	
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.			✓	
F. Include plots of the residuals by factor				✓
3. Poisson Component				
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.				
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				
4. Zero-inflated model				
A. Include ROC curve to quantify goodness of fit.				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).				
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.				

Working Group Comments:

1B. Confidential data
1C. AOD
2B,D,E. AOD

The feasibility of this diagnostic is still under review.

MODEL DIAGNOSTICS (CONT.)

Not Applicable	Absent	Incomplete	Complete

Working Group Comments:

D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				

MODEL RESULTS

A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report				✓
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).				✓

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

1. Plot of resulting indices and estimates of variance				
2. Table of model statistics (e.g. AIC criteria)				

	Date Received	*Workshop Recommendation*	*Revision Deadline* ***	*Author and Rapporteur Signatures*
First Submission	6/21/10	accept as submitted		
Revision				

The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author ***DOES NOT*** *commit to any* ***LEGAL OBLIGATION*** *by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

Sandbar - this index was recommended for use in a sensitivity model run (ranking=1).

This data set includes fishery dependent, self-reported data. The time series of these data is long (1992-2007) and the spatial coverage is broad (TX-NC), however observer data are available for the fishery. The working group recommended the index constructed from those observer data for use in a base run of the model rather than the index constructed using self-reported data. The working group believed that observer data were more accurate than self-reported data.

Evaluation of Abundance Indices for SEDAR 21:
NMFS SEAMAP Groundfish Trawl (SEDAR21-DW-43)

Working Group Comments:

DESCRIPTION OF THE DATA SOURCE

1. Fishery Independent Indices

Item	Not Applicable	Absent	Incomplete	Complete
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.				✓
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)				✓
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)				✓
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				✓
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).				✓
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				✓

2. Fishery Dependent Indices

Item	Not Applicable	Absent	Incomplete	Complete
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).				
B. Describe any changes to reporting requirements, variables reported, etc.				
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				

METHODS

1. Data Reduction and Exclusions

Item	Not Applicable	Absent	Incomplete	Complete
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.	✓			
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).	✓			
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?	✓			

2. Management Regulations (for FD Indices)

Item	Not Applicable	Absent	Incomplete	Complete
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).				
B. Describe the effects (if any) of management regulations on CPUE				
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.				

3. Describe Analysis Dataset (after exclusions and other treatments)

Item	Not Applicable	Absent	Incomplete	Complete
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.		✓		
B. Include tables and/or figures of number of positive observations by factors and interaction terms.		✓		
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.		✓		
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.		✓		
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).				✓
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				✓
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				✓

4. Model Standardization

Item	Not Applicable	Absent	Incomplete	Complete
A. Describe model structure (e.g. delta-lognormal)				✓
B. Describe construction of GLM components (e.g. forward selection from null etc.)	✓			
C. Describe inclusion criteria for factors and interactions terms.				✓
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?				✓
E. Provide a table summarizing the construction of the GLM components.	✓			
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)	✓			
G. Report convergence statistics.		✓		

Working Group Comments:

3A-D. AOD

4A. general Bayesian Lo et al. method

4G. AOD.

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

Item	Not Applicable	Absent	Incomplete	Complete
1. Binomial Component				
A. Include plots of the chi-square residuals by factor.	✓			
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)	✓			
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).	✓			
2. Lognormal/Gamma Component				
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.	✓			
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.	✓			
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.	✓			
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	✓			
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	✓			
F. Include plots of the residuals by factor	✓			
3. Poisson Component				
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).	✓			
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.	✓			
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.	✓			
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	✓			
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	✓			
4. Zero-inflated model				
A. Include ROC curve to quantify goodness of fit.	✓			
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).	✓			
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.	✓			

Working Group Comments:

Frequentist diagnostics were not applicable for this Bayesian analysis.

Diagnostics examined included: posterior probabilities and credible intervals. Also examined, and judged to be sufficient, were mixing of the model and burn-in period.

The feasibility of this diagnostic is still under review.

MODEL DIAGNOSTICS (CONT.)

Not Applicable	Absent	Incomplete	Complete

Working Group Comments:

D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	✓			
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	✓			

MODEL RESULTS

A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report				✓
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).				✓

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

1. Plot of resulting indices and estimates of variance				
2. Table of model statistics (e.g. AIC criteria)				

	Date Received	*Workshop Recommendation*	*Revision Deadline* ***	*Author and Rapporteur Signatures*
First Submission	6/21/2010	accept as prepared	N/A	
Revision				

The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author ***DOES NOT*** *commit to any* ***LEGAL OBLIGATION*** *by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

Blacknose GOM - recommended for use in base model run (ranking=2)

These data were collected from a fishery independent survey. The ranking was based upon the relatively extensive spatial coverage (TX-AL) and long time series (1987-2009) of those data. The survey used standardized methods with all changes in methodology known and accounted for in the analysis.

Evaluation of Abundance Indices for SEDAR 21: Large Pelagic Survey (SEDAR21-DW-44)

Working Group Comments:

DESCRIPTION OF THE DATA SOURCE

1. Fishery Independent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.				
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)				
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)				
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).				
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				

2. Fishery Dependent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).				✓
B. Describe any changes to reporting requirements, variables reported, etc.				✓
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				✓
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				✓

METHODS

1. Data Reduction and Exclusions

	Not Applicable	Absent	Incomplete	Complete
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.				✓
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).				✓
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?	✓			

Working Group Comments:

3E confidential data

2. Management Regulations (for FD Indices)

	Not Applicable	Absent	Incomplete	Complete
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).				✓
B. Describe the effects (if any) of management regulations on CPUE			✓	
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.			✓	

3. Describe Analysis Dataset (after exclusions and other treatments)

	Not Applicable	Absent	Incomplete	Complete
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.				✓
B. Include tables and/or figures of number of positive observations by factors and interaction terms.				✓
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.				✓
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.			✓	
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).	✓			
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				✓
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				✓

4. Model Standardization

	Not Applicable	Absent	Incomplete	Complete
A. Describe model structure (e.g. delta-lognormal)				✓
B. Describe construction of GLM components (e.g. forward selection from null etc.)				✓
C. Describe inclusion criteria for factors and interactions terms.				✓
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?				✓
E. Provide a table summarizing the construction of the GLM components.				✓
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)				✓
G. Report convergence statistics.				✓

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

Item	Not Applicable	Absent	Incomplete	Complete
1. Binomial Component				
A. Include plots of the chi-square residuals by factor.				✓
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)			✓	
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				✓
2. Lognormal/Gamma Component				
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.				✓
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.				✓
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				✓
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				✓
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.			✓	
F. Include plots of the residuals by factor				✓
3. Poisson Component				
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.				
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				
4. Zero-inflated model				
A. Include ROC curve to quantify goodness of fit.				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).				
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.				

Working Group Comments:

1B. AOD
2E. AOD

The feasibility of this diagnostic is still under review.

MODEL DIAGNOSTICS (CONT.)

Not Applicable	Absent	Incomplete	Complete

Working Group Comments:

D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.				

MODEL RESULTS

A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report				✓
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).				✓

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

1. Plot of resulting indices and estimates of variance				
2. Table of model statistics (e.g. AIC criteria)				

	Date Received	*Workshop Recommendation*	*Revision Deadline* ***	*Author and Rapporteur Signatures*
First Submission	6/21/2010	accept as is		
Revision				

The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author ***DOES NOT*** *commit to any* ***LEGAL OBLIGATION*** *by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

Sandbar - recommend for use in base model (ranking=5)
Dusky - recommend for use base model (ranking=4)

These data are fishery dependent, reported by recreational fishers during dockside or telephone interviews. Some of those data were reported from fishing tournaments, therefore size/age composition of reported catch may be affected. The working group recommended that these indices be included in base model runs, but with low weighting due to data concerns (self-reported fishery dependent, collected during tournaments).

SEDAR

Southeast Data, Assessment, and Review

SEDAR 21

HMS Sandbar Shark

SECTION III: Assessment Process Report

April 2011

NOTE: Modifications to the model results reported in this report were made during the Review Workshop held 18-22 April 2011. For complete results reflecting those changes, please see the Addendum of this Stock Assessment Report (Section VI).

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

Table of Contents

1. WORKSHOP PROCEEDINGS

1.1. INTRODUCTION

1.1.1. Workshop time and Place

The SEDAR 21 Assessment Process was held via a series of webinars between September 2010 and March 2011.

1.1.2. Terms of Reference

1. Review data, including any changes since the Data Workshop, and any analyses suggested by the data workshop. Summarize data as used in each assessment model. Provide justification for any deviations from Data Workshop recommendations.
2. Develop population assessment models that are compatible with available data and recommend which model and configuration is deemed most reliable or useful for providing advice. Document all input data, assumptions, and equations.
3. Provide estimates of stock population parameters (fishing mortality, abundance, biomass, selectivity, stock-recruitment relationship, etc); include appropriate and representative measures of precision for parameter estimates.
4. Characterize uncertainty in the assessment and estimated values, considering components such as input data, modeling approach, and model configuration. Provide appropriate measures of model performance, reliability, and ‘goodness of fit’.
5. Provide spawning stock fecundity and stock-recruitment evaluations, including figures and tables of complete parameters.
6. Provide estimates for benchmark and biological reference points, consistent with the Consolidated HMS FMP, proposed FMPs and Amendments, other ongoing or proposed management programs, and National Standards. This may include: evaluating existing reference points, estimating benchmarks or alternative benchmarks, as appropriate, and recommending proxy values.
7. Provide declarations of stock status based on the status determination criteria.
8. Provide stochastic projections of stock status at various harvest or exploitation levels for various timeframes.

9. Project future stock conditions (biomass, abundance, and exploitation) and develop rebuilding schedules, if warranted. Provide the estimated generation time for each unit stock. Stock projections shall be developed in accordance with the following:

   A) If stock is overfished:
   F=0, F=current, F=Fmsy, Ftarget (OY),
   F=Frebuild (max that rebuild in allowed time)
   B) If stock is undergoing overfishing:
   F=0, F=Fcurrent, F=Fmsy, F= Ftarget (OY),
   F=Freduce (different reductions in F that could prevent overfishing, as appropriate)
   C) If stock is neither overfished nor undergoing overfishing:
   F=Fcurrent, F=Fmsy, F=Ftarget (OY)

10. Provide recommendations for future research and data collection (field and assessment); be as specific as practicable in describing sampling design and sampling intensity and emphasize items which will improve future assessment capabilities and reliability.
11. Prepare an accessible, documented, labeled, and formatted spreadsheet containing all model parameter estimates and all relevant population information resulting from model estimates and any projection and simulation exercises. Include all data included in assessment report tables and all data that support assessment workshop figures.
12. Complete the Assessment Workshop Report (Section III of the SEDAR Stock Assessment Report). Provide a list of tasks that were not completed, who is responsible for completing each task, and when each task will be completed.

1.1.3. List of Participants

SEDAR 21: HMS Sandbar, Dusky, and Blacknose Sharks

SEDAR 21 ASSESSMENT WEBINARS ATTENDANCE REPORT

x = present

		Web1	Web2	Web3	Web4	Web5	Web6	Web7	Web8	Web9	Web10	Web11	Web12	Web13	Web14	Web15
First	Last	14-Sep	16-Sep	30-Sep	8-Oct	22-Oct	26-Oct	28-Oct	2-Nov	4-Nov	8-Nov	10-Nov	2-Dec	8-Dec	11-Jan	15-Mar
PANELISTS																
Katie	Andrews	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Enric	Cortes	X	X			X	X	X	X	X	X	X	X	X	X	X
Paul	Conn	X	X	X	X	X	X		X	X	X	X	X	X	X	X
Frank	Hester	X	X	X	X	X	X	X		X	X	X	X	X	X	X
Bill	Gazey	X	X													
Beth	Babcock		X	X	X	X	X	X	X	X	X		X	X		
Yan	Jiao		X					X							X	
Ivy	Baremore	X	X	X	X	X	X	X	X		X	X	X	X	X	X
Lori	Hale	X	X		X	X	X		X	X		X				
Michelle	Passerotti	X	X	X	X		X									X
HMS REPRESENTATION																
Jackie	Wilson	X	X	X			X	X	X	X		X	X	X	X	X
Steve	Durkee	X	X	X	X			X	X	X	X		X	X	X	
Karyl	Brewster-Geisz		X	X	X			X	X	X	X	X	X	X	X	X
STAFF																
Julie	Neer	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
OBSERVERS																
Catherine	Kilduff	X														
Clark	Gray	X		X					X					X	X	
Rusty	Hudson	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Adam	Pollack	X														
John	Carlson	X							X		X	X		X	X	X
Kevin	McCarthy	X														

Melissa	Recks			X					X					
Jason	Adriance	X	X		X		X		X			X		
Mike	Clark					X	X							
Iris	Ho										X			
Claudia	Friess							X		X		X		
David	Stiller												X	X

1.1.4. List of Assessment Process Working and Reference Papers

SEDAR21-AW-01: Hierarchical analysis of blacknose, sandbar, and dusky shark CPUE indices

SEDAR21-AW-02: Computer code for the SEDAR 21 age-structured catch-free model for dusky sharks

1.2. PANEL RECOMMENDATIONS AND COMMENTS

1.2.1. Term of Reference 1

Review data, including any changes since the Data Workshop, and any analyses suggested by the data workshop. Summarize data as used in each assessment model. Provide justification for any deviations from Data Workshop recommendations.

All changes to the data and additional analyses following the Data Workshop (DW) are reviewed in Section 2. The main changes include 1) splitting commercial catches into Gulf of Mexico and Atlantic regions, 2) using separate selectivities for these two newly derived catch streams, 3) develop an approach for calculating total discard mortality for potential use in the SS3 model, and 4) use an approach based on the maximum estimate of survival at age obtained from four life-history invariant methods to generate a vector of natural mortality (M) values. There were also additional analyses undertaken that were not discussed at the DW, including 1) development of age-length keys to transform length-frequency distributions into age-frequency distributions, 2) derivation of selectivity curves from age frequencies, and 3) exploration of the impact of using different methods to estimate M on population parameters derived from a life table.

1.2.2. Term of Reference 2

Develop population assessment models that are compatible with available data and recommend which model and configuration is deemed most reliable or useful for providing advice. Document all input data, assumptions, and equations.

The original intent was to use two stock assessment models for this assessment: 1) stock synthesis (SS3), and 2) an age-structured production model (ASPM). Since this was the first time that implementation of SS3 was attempted for any species of HMS shark and owing to limited progress in that implementation (due in part to the simultaneous assessment of four stocks of sharks under SEDAR-21), it was decided that the ASPM would be the primary model used and that implementation of SS3 would be attempted after completion of this report. Thus, only the ASPM and its configuration are described more fully in Section 3.1.

1.2.3. Term of Reference 3

Provide estimates of stock population parameters (fishing mortality, abundance, biomass, selectivity, stock-recruitment relationship, etc); include appropriate and representative measures of precision for parameter estimates.

Estimates of assessment model parameters and their associated CVs are reported in Section 3.1.2.

1.2.4. Term of Reference 4

Characterize uncertainty in the assessment and estimated values, considering components such as input data, modeling approach, and model configuration. Provide appropriate measures of model performance, reliability, and 'goodness of fit'.

Uncertainty in the assessment and estimated values is characterized in Section 3.2. Fits to observed catches and relative abundance indices are also provided in section 3.2.

1.2.5. Term of Reference 5

Provide spawning stock fecundity and stock-recruitment evaluations, including figures and tables of complete parameters.

Spawning stock fecundity and stock-recruitment evaluations are provided in Section 3.1.2.

1.2.6. Term of Reference 6

Provide estimates for benchmark and biological reference points, consistent with the Consolidated HMS FMP, proposed FMPs and Amendments, other ongoing or proposed management programs, and National Standards. This may include: evaluating existing reference points, estimating benchmarks or alternative benchmarks, as appropriate, and recommending proxy values.

Estimates of benchmark and biological reference points are provided in Section 3.2.

1.2.7. Term of Reference 7

Provide declarations of stock status based on the status determination criteria.

Stock status based on the status determination criteria is reported in Section 3.2.

1.2.8. Term of Reference 8

Provide stochastic projections of stock status at various harvest or exploitation levels for various timeframes.

Stochastic projections of stock status at various exploitation levels are provided in Section 3.2.10.

1.2.9. Term of Reference 9

Project future stock conditions (biomass, abundance, and exploitation) and develop rebuilding schedules, if warranted. Provide the estimated generation time for each unit stock.

Projections of future stock conditions and rebuilding schedules can be found in Section 3.2.10. Estimated generation time is provided in Section 3.2.

1.2.10. Term of Reference 10

Provide recommendations for future research and data collection (field and assessment); be as specific as practicable in describing sampling design and sampling intensity and emphasize items which will improve future assessment capabilities and reliability.

Recommendations by the Assessment Panel (AP) for future research and data collection are provided in Section 3.4.

2. DATA REVIEW AND UPDATE

2.1. CATCHES

No changes were introduced to the catch streams presented and approved at the DW with the exception of splitting the commercial+unreported catch series into Gulf of Mexico and Atlantic components. Following the peer review provided by the CIE reviewer, we also attempted to quantify uncertainty in those landings and catches that were estimated and developed two sensitivity scenarios: a low catch scenario and a high catch scenario, both of which are described in Section 3.1.

2.1.1. Commercial Landings

Commercial landings data used in the assessment are presented in Table 2.1 and Figure 2.1. A full description of the landings and how they were calculated is given in the SEDAR 21 DW Report and SEDAR21-DW-09. Following discussions and recommendations by the AP, it was decided that the single "commercial+unreported" catch series should be split into a Gulf of Mexico (GOM) and an Atlantic (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 1991-2009, commercial landings were split into GOM and ATL using the percentage by region and year from the general canvass data (Table 7 of SEDAR21-DW-09). Second, 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). The unreported commercial catches in 1986-1991 were split into the two regions using the percent composition reported on page 3 of SEDAR21-DW-09.

2.1.2. Recreational and Mexican catches

The recreational catch data used in the assessment are presented in Table 2.1 and Figure 2.1. 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 (fish landed [A] and discarded dead [B1]), Headboat survey (fish landed) and Texas Parks and Wildlife Department survey (fish landed). Catches of sandbar sharks caught in the states of Tamaulipas and Veracruz in Mexico, 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 2001-2009 (see the SEDAR 21 DW Report and SEDAR21-DW-09).

2.1.3. Menhaden Fishery Discards

This was the only series of discards incorporated into the assessment (Table 2.1 and Figure 2.1) and has a very small magnitude (less than 1,000 fish). A full description of the derivation of these estimates is given in the SEDAR 21 DW Report and SEDAR21-DW-09.

2.2. LENGTH COMPOSITIONS, AGE COMPOSITIONS, AND SELECTIVITIES

Length and age composition data were not used directly in the assessment because catch-at-length and catch-at age information is not collected for sharks. However, length-frequency information from animals caught in scientific observer programs, recreational fishery surveys, and various fishery-independent surveys was used to generate age-frequency distributions through age-length keys (Figures 2.2 to 2.6). Although the simplest way to obtain an age-frequency distribution from a length-frequency distribution is to back-transform length into age through a growth curve (von Bertalanffy or other), this approach has multiple biases, among them that 1) any observed length > L_∞ must be eliminated or arbitrarily assigned to older ages and 2) when an observed length approaches L_∞, it is mathematically allocated to ages above those attainable by aged fish within the stock, yielding in some cases unreasonably old ages. The next way to obtain an age-frequency distribution from a length-frequency distribution is an age-length key, an approach that also has biases and whose main assumption is that age can be estimated from length using information contained in a previously aged sample from the population. The method of construction of the age-length key and its application to obtain ages from lengths are presented in Appendix 1. The AP decided that age frequencies be estimated using an age-length key and recommended that other approaches (e.g., age slicing, stochastic age-frequency estimation using the VBGF [Bartoo and Parker 1983] or probabilistic methods

[Goodyear 1997]) be investigated in the future, although some of these methods require more information that may not be available.

The age-frequency distributions produced were then used to estimate selectivity curves externally to the stock assessment model. Although in theory the ASPM can estimate selectivities, there are no age and very few length data available for the model to do so, and so the estimation of selectivities must be done independently of the model. The derivation of selectivities from age-frequency distributions was done under the following assumptions. With only natural mortality (M) operating, one would expect an age-frequency histogram to decline with age. However, with both M and fishing mortality (F) operating, what is observed instead is an increase in the age frequency that reflects the increase in selectivity with age up to a "fully selected" age. Beyond the "fully selected" age, all subsequent ages are expected to consistently decline because they all experience (approximately) the same F and M. The fully selected age is thus determined by looking at the age-frequency distribution and identifying the "fulcrum" or modal age class, where younger ages show an increasing frequency and all subsequent ages decrease in frequency. The specific algorithm for deriving selectivities is in Appendix 2. Based on the above, the following selectivity curves were fitted statistically or by eye (to accommodate AP members beliefs of the selectivity of a particular gear type) to each catch and CPUE series:

2.2.1. Catches

<u>Commercial+unreported GOM</u>—Logistic curve, with age at full selectivity of 17, and with the ascending portion of the curve prior to the inflection point covering the younger age classes.

<u>Commercial+unreported ATL</u>—Logistic curve, with age at full selectivity of 14, and with the ascending portion of the curve prior to the inflection point covering the younger age classes.

<u>Recreational + Mexican</u>—A dome-shaped selectivity curve (double logistic) corresponding to the MRFSS CPUE index was assigned to this series, with age-1 being fully selected and only the descending right limb of the curve being represented.

<u>Menhaden fishery discards</u>—A constant selectivity of 1 was assumed as in the previous stock assessment (but expressed in logistic form).

2.2.2. Indices of relative abundance

BLLOP (bottom longline)—Logistic curve, with age at full selectivity of 12, and with the ascending portion of the curve prior to the inflection point covering the younger age classes.

VIMS (bottom longline)—Since the AP recognized that this was a juvenile shark survey only, a double logistic curve was assumed, with age at full selectivity of 1 followed by a descending right limb.

LPS (hook and line)—The recommendation for this index was a double logistic curve with fully selected age at 9 and with an ascending portion of the curve prior to the inflection point covering the younger age classes. The reason for the dome shape was to reflect the fact that larger, older animals could escape by breaking the monofilament line.

PLLOP (pelagic longline)—The recommendation for this index was a double logistic curve with fully selected age at 13. As above, the reason for the dome shape was to reflect the fact that larger, older animals could escape by breaking the monofilament leader.

NELL (pelagic longline)—Logistic curve with full selectivity age of 19.

NMFS COASTSPAN LL-AGE-1+ (bottom longline)—This was also a juvenile survey, but a logistic curve with age at full selectivity of 3 was assumed.

GA COASTSPAN-LL (bottom longline)—Essentially the same as above, with the same selectivity curve.

SC COASTSPAN-LL (bottom longline)—Essentially the same as above, with the same selectivity curve.

SC DNR HISTORIC RED DRUM-LL (bottom longline)—Logistic curve with age at full selectivity of 5, and with the ascending portion of the curve prior to the inflection point covering the younger age classes.

PC GILLNET (gillnet)—This was also a juvenile survey and a double logistic curve with age at full selectivity of 1 was assumed, followed by a descending right limb that covered the older ages as well.

NMFS SE BLL (bottom longline)—Because the age-frequency distributions from this survey and the BLLOP were very similar, the resulting selectivities were almost identical. The AP thus decided to use the same selectivity curve derived for the BLLOP index (logistic age at full selectivity of 12, and with the ascending portion of the curve prior to the inflection point covering the younger age classes).

Logistic curves fitted to the data were:

$$s = \frac{1}{1 - e^{-\left(\frac{a - a_{50}}{b}\right)}}$$

where a_{50} is the median selectivity age (inflection point) and b is the slope. Double logistic curves were expressed as:

$$s = \frac{\frac{1}{1-e^{-\left(\frac{a-a_{50}}{b}\right)}} \times \left(1 - \frac{1}{1-e^{-\left(\frac{a-c_{50}}{d}\right)}}\right)}{\max\left(\frac{1}{1-e^{-\left(\frac{a-a_{50}}{b}\right)}} \times \left(1 - \frac{1}{1-e^{-\left(\frac{a-c_{50}}{d}\right)}}\right)\right)}$$

where a_{50} and c_{50} are the ascending and descending inflection points, b and d are the ascending and descending slopes, respectively, and max (sel) is the maximum selectivity.

All selectivities used in the assessment are summarized in Table 2.2 and Figure 2.7.

2.3. INDICES OF RELATIVE ABUNDANCE

The standardized indices of relative abundance used in the assessment are presented in Table 2.3 and Figure 2.8. The Index WG of the DW recommended the use of eleven indices: eight fishery-independent series (VIMS LL, NELL, NMFS Coastspan age-1+ LL, GA Coastspan LL, SC Coastspan LL, SCDN Historic red drum LL, PCGN, and NMFS SE LL) and three fishery-dependent series (the commercial BLLOP and PLLOP observer indices and the recreational LPS), all of which were standardized by the respective authors through GLM techniques (see SEDAR 21 DW Report). Since the baseline scenario used equal weighting of the CPUE indices, the coefficients of variation (CV) associated with the standardized indices will be presented in Section 3.1 (Sensitivity Analyses, inverse weighting scenario).

2.4. LIFE HISTORY INPUTS

The life history inputs used in the assessment are presented in Table 2.4. These include age and growth, as well as several parameters associated with reproduction, including sex ratio, reproductive frequency, fecundity at age, maturity and maternity at age, and month of pupping, and natural mortality. The ASPM uses most life history characteristics as constants (inputs) and others are estimated parameters, which are given priors and initial values. The estimated parameters are described in the Parameters Estimated section (3.1.4) of the report.

All biological input values in Table 2.4 are as reported in the DW report, with the exception of natural mortality at age. The values of M recommended by the Life History WG resulted in a negative population growth rate when used in a life table (where fishing mortality was set to zero). The AP agreed that one possible strategy that resulted in a more realistic, positive population growth rate in the absence of fishing was to take the maximum of several estimates at age. These estimates came from the same life history invariant methods that were explored at the DW (Hoenig [1983], Chen and Watanabe [1989], Peterson and Wroblewski [1984], and Lorenzen [1996]), but rather than taking the *average* of the Peterson and Wroblewski, Chen and Watanabe, and Lorenzen methods, the *maximum* of the four methods mentioned was used instead. For fecundity, since the ASPM tracks only females, the number of offspring produced was divided by 2 to account for females only and again by 2.5 to account for a 2.5 year reproductive cycle agreed upon at the DW. The proportion of females in maternal condition, rather than the proportion of mature females, was used because the latter does not account for the time it takes for a female to become pregnant and produce offspring after it reaches maturity (Walker 2005).

2.5. REFERENCES

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2.6. TABLES

Table 2.1. Catches of sandbar shark by fleet in numbers. 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 discards.

Year	Com+Un (GOM)	Com + Un (SA)	REC+MEX	Menhaden discards
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 2.2. Selectivity curves for catches and indices of relative abundance. All were fitted by eye except where otherwise indicated. Parameters are ascending inflection point (a_{50}), ascending slope (b), descending inflection point (c_{50}), descending slope (d), and maximum selectivity (max(sel)).

Series	Selectivity	a_{50}	b	c_{50}	d	max(sel)
CATCHES						
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			
INDICES OF ABUNDANCE						
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			

* Fitted by least squares

Table 2.3. Standardized indices of relative abundance used in the baseline scenario. All indices are scaled (divided by their respective mean).

YEAR	LPS	BLLOP	VA-LL	NMFS LLSE	NMFS Coast age 1+	NMFS-NE	PLLOP	GA-Coastspan	SC-Coastspan	SCDNR-Red dr	PCGN
1960	-	-	-	-	-	-	-	-	-	-	-
1961	-	-	-	-	-	-	-	-	-	-	-
1962	-	-	-	-	-	-	-	-	-	-	-
1963	-	-	-	-	-	-	-	-	-	-	-
1964	-	-	-	-	-	-	-	-	-	-	-
1965	-	-	-	-	-	-	-	-	-	-	-
1966	-	-	-	-	-	-	-	-	-	-	-
1967	-	-	-	-	-	-	-	-	-	-	-
1968	-	-	-	-	-	-	-	-	-	-	-
1969	-	-	-	-	-	-	-	-	-	-	-
1970	-	-	-	-	-	-	-	-	-	-	-
1971	-	-	-	-	-	-	-	-	-	-	-
1972	-	-	-	-	-	-	-	-	-	-	-
1973	-	-	-	-	-	-	-	-	-	-	-
1974	-	-	-	-	-	-	-	-	-	-	-
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 2.4. Life history inputs used in the assessment. All these quantities are treated as constants in the model.

Age	Proportion mature	Proportion maternal	M	Fecundity
1	0.00035	0.0024	0.15431	4.2488
2	0.00068	0.0036	0.15431	4.5079
3	0.00131	0.0054	0.15431	4.7670
4	0.00253	0.0082	0.15431	5.0261
5	0.00487	0.0124	0.15431	5.2852
6	0.00935	0.0186	0.15431	5.5443
7	0.01788	0.0279	0.15431	5.8034
8	0.03393	0.0417	0.15323	6.0625
9	0.06346	0.0618	0.14812	6.3216
10	0.11562	0.0908	0.13116	6.5807
11	0.20141	0.1313	0.13116	6.8398
12	0.32730	0.1863	0.13116	7.0989
13	0.48418	0.2575	0.13116	7.3580
14	0.64424	0.3443	0.13116	7.6171
15	0.77746	0.4430	0.13099	7.8762
16	0.87079	0.5464	0.12942	8.1353
17	0.92858	0.6460	0.12806	8.3944
18	0.96166	0.7343	0.12688	8.6535
19	0.97975	0.8071	0.12586	8.9126
20	0.98940	0.8637	0.12497	9.1717
21	0.99448	0.9057	0.12419	9.4308
22	0.99713	0.9356	0.12351	9.6899
23	0.99851	0.9566	0.12291	9.9490
24	0.99923	0.9709	0.12239	10.2081
25	0.99960	0.9806	0.12193	10.4672
26	0.99979	0.9871	0.12153	10.7263
27	0.99989	0.9914	0.12117	10.9854

Sex ratio at birth:	1:1
Reproductive frequency:	2.5 yr
Pupping month:	June
Age vs litter size relation:	pups = 0.2591*age + 3.9897
L_{inf}	181.15 cm FL
k	0.12
t_0	-2.33
Weight vs length relation:	$W=0.000010885L^{3.0124}$

2.7. FIGURES

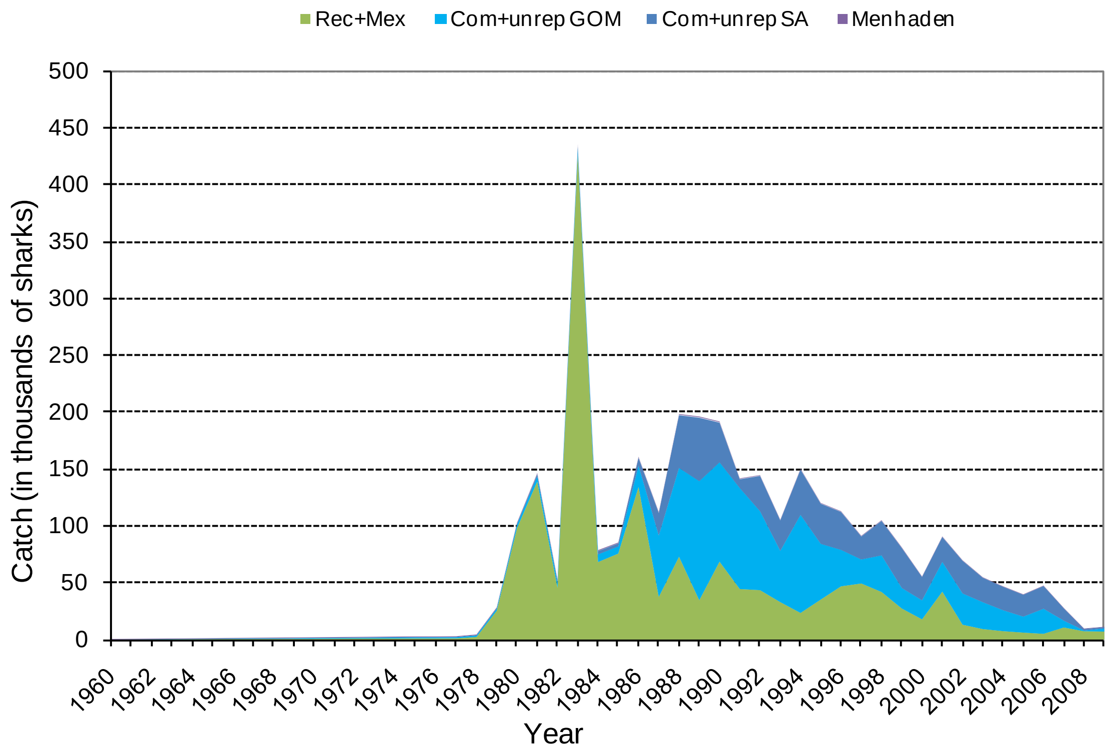


Figure 2.1. Catches of sandbar shark by fleet. Catches are separated into four fisheries: commercial landings + unreported commercial catches in the GOM, commercial landings + unreported commercial catches in the ATL, recreational + Mexican catches, and menhaden fishery discards (this last series does not show up in the figure due to its small magnitude).

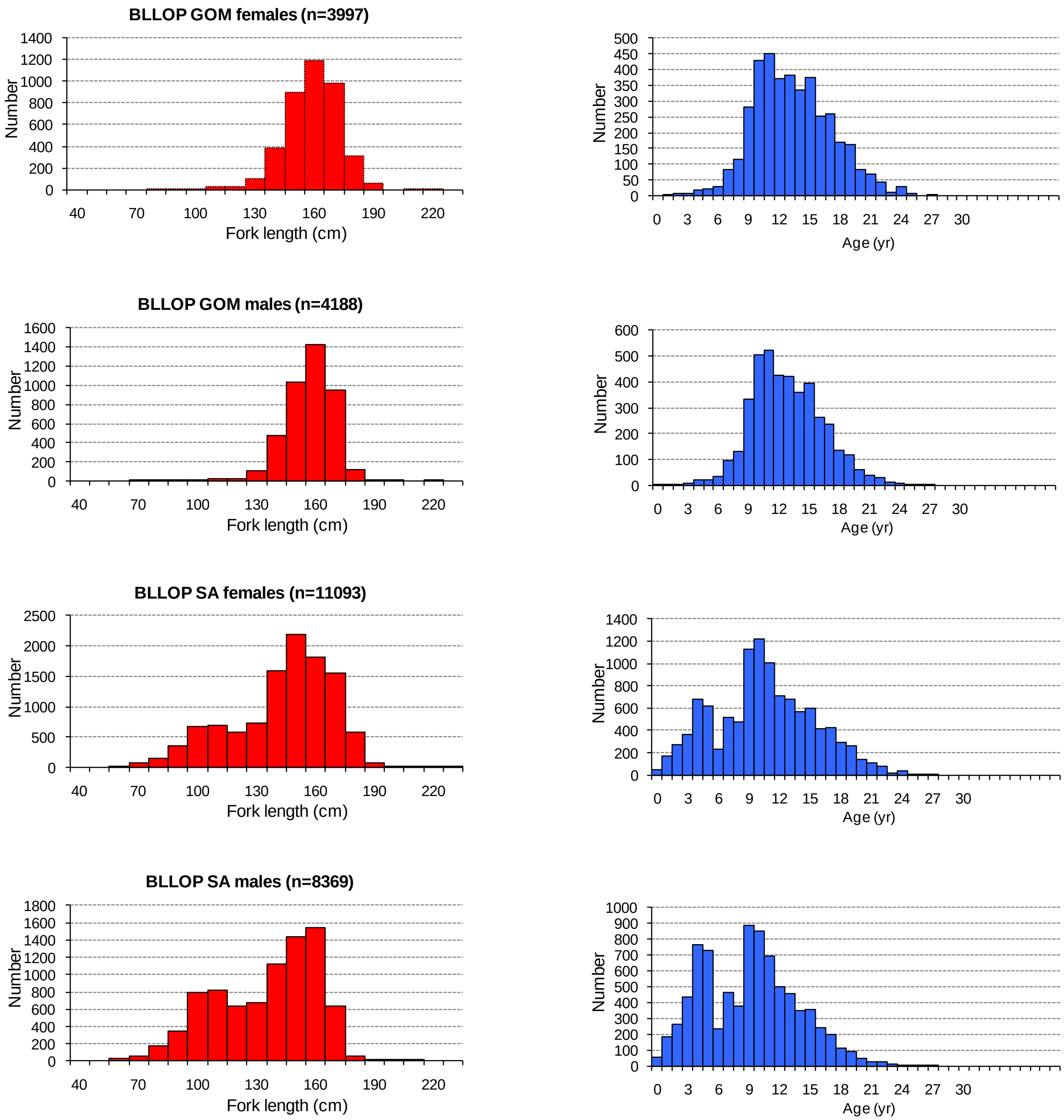


Figure 2.2. Length-frequency (left panels) and age-frequency (right panels) distributions of sandbar shark from the Shark Bottom Longline Observer Program (BLLOP) for the Gulf of Mexico (GOM) and South Atlantic (SA) regions by sex for 1994-2009. Note that the age distributions for males and females within area are very similar. Age distributions for combined sexes for each area were used to estimate selectivities that were assigned to the commercial+unreported GOM and commercial+unreported SA catch series.

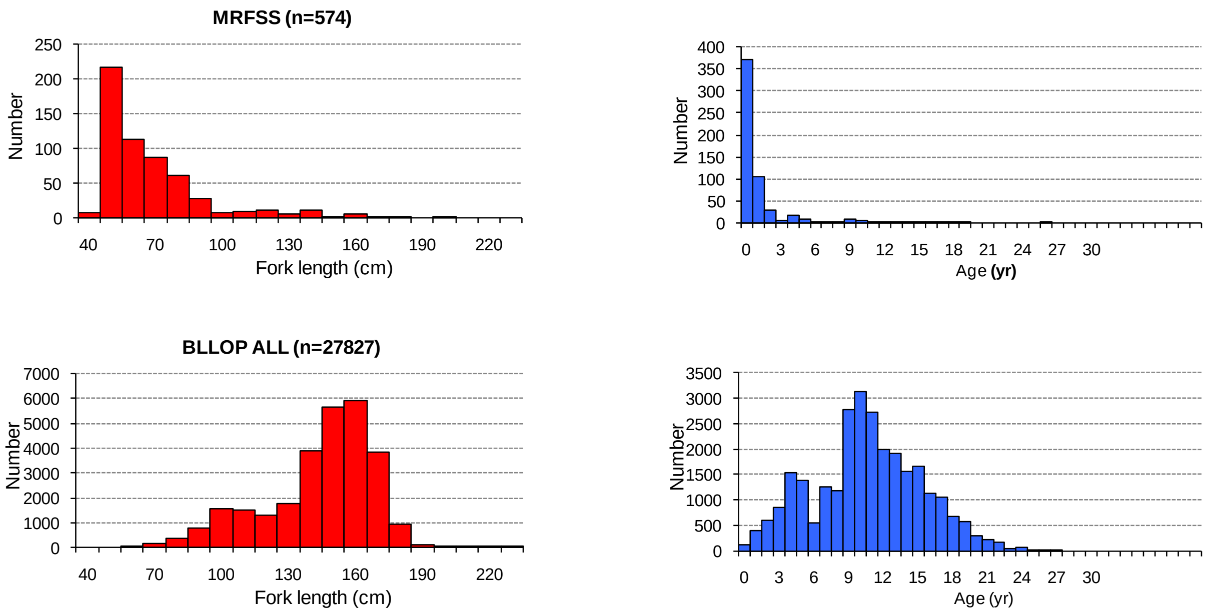


Figure 2.3. Length-frequency (left panels) and age-frequency (right panels) distributions of sandbar shark from the MRFSS for 1981-2009 and the Shark Bottom Longline Observer Program (BLLOP) for areas combined for 1994-2009. Age distributions were used to estimate selectivities that were assigned to the recreational+Mexican catch series and to the BLLOP CPUE series.

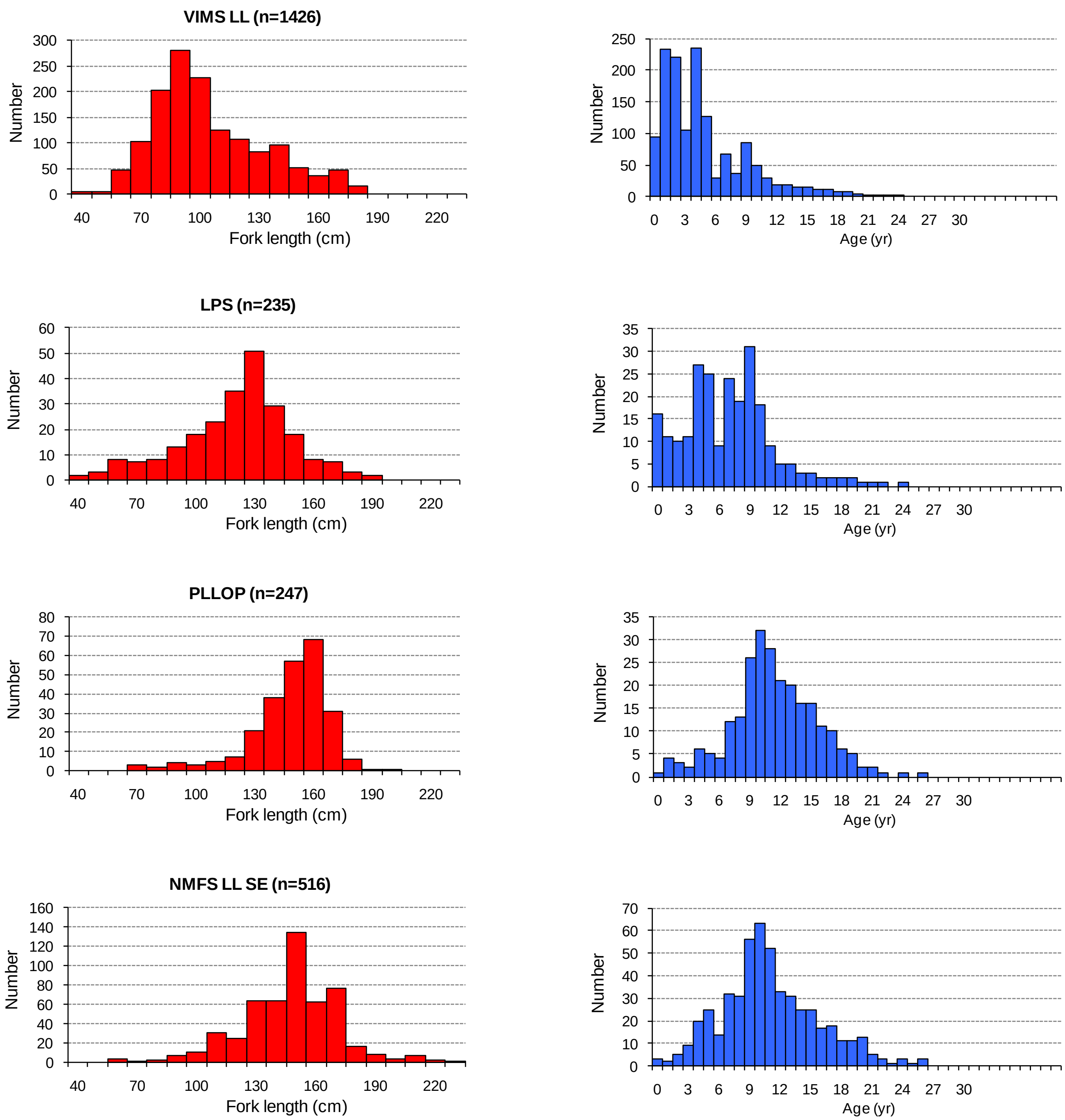


Figure 2.4. Length-frequency (left panels) and age-frequency (right panels) distributions of sandbar shark from the VIMS (1975-2009), LPS (1986-2009), PLLOP (1992-2009), and NMFS LL SE (1994-2009) programs. Age distributions were used to estimate selectivities that were assigned to the VIMS, LPS, PLLOP, and NMFS LL SE CPUE indices, respectively.

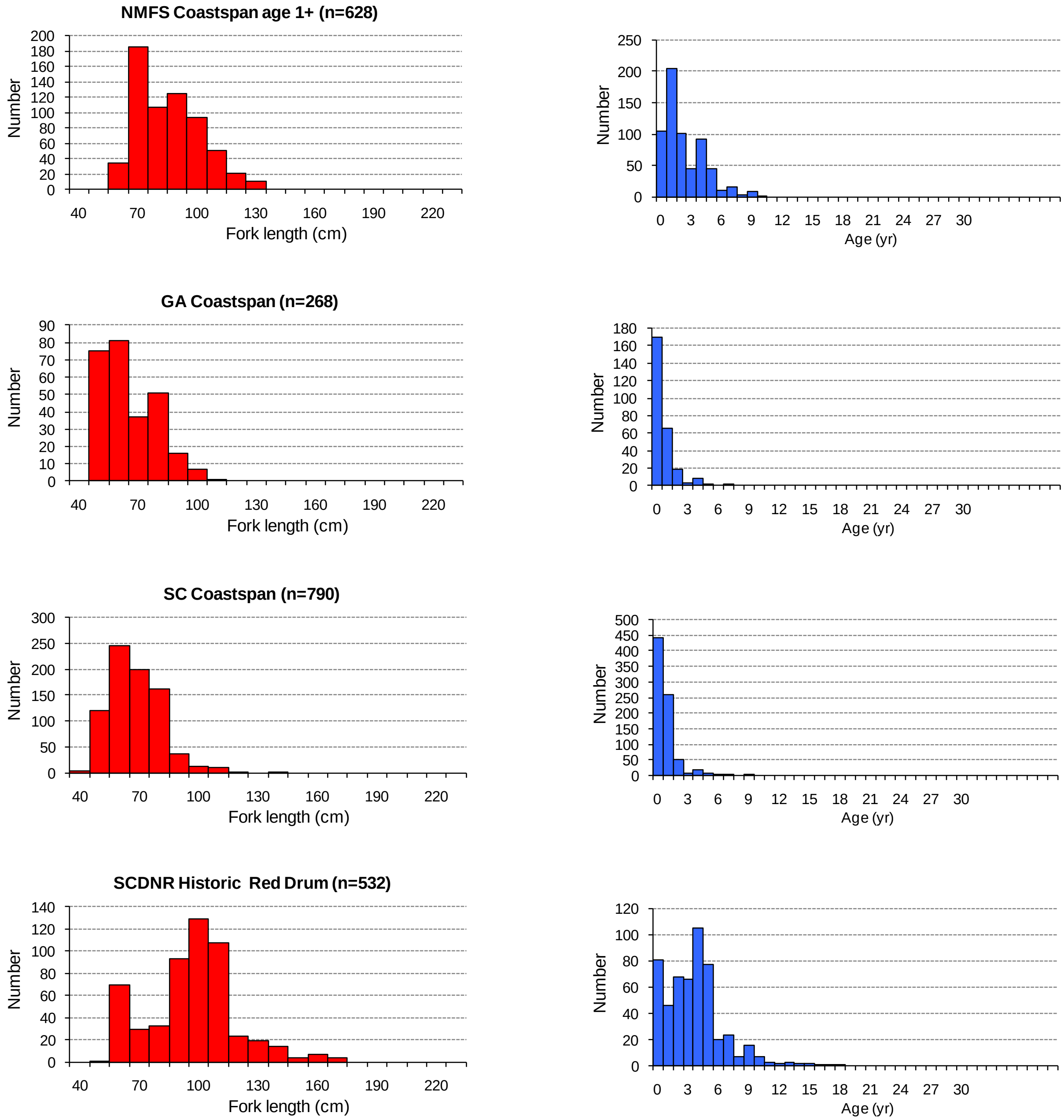


Figure 2.5. Length-frequency (left panels) and age-frequency (right panels) distributions of sandbar shark from the NMFS Coastspan age-1+ (2001-2009), GA Coastspan (2000-2009), SC Coastspan (1998-2009), and SCDNR Historic Red Drum (1998-2006) surveys. Age distributions were used to estimate selectivities that were assigned to the NMFS Coastspan age-1+, GA Coastspan, SC Coastspan, and SCDNR Historic Red Drum CPUE indices, respectively.

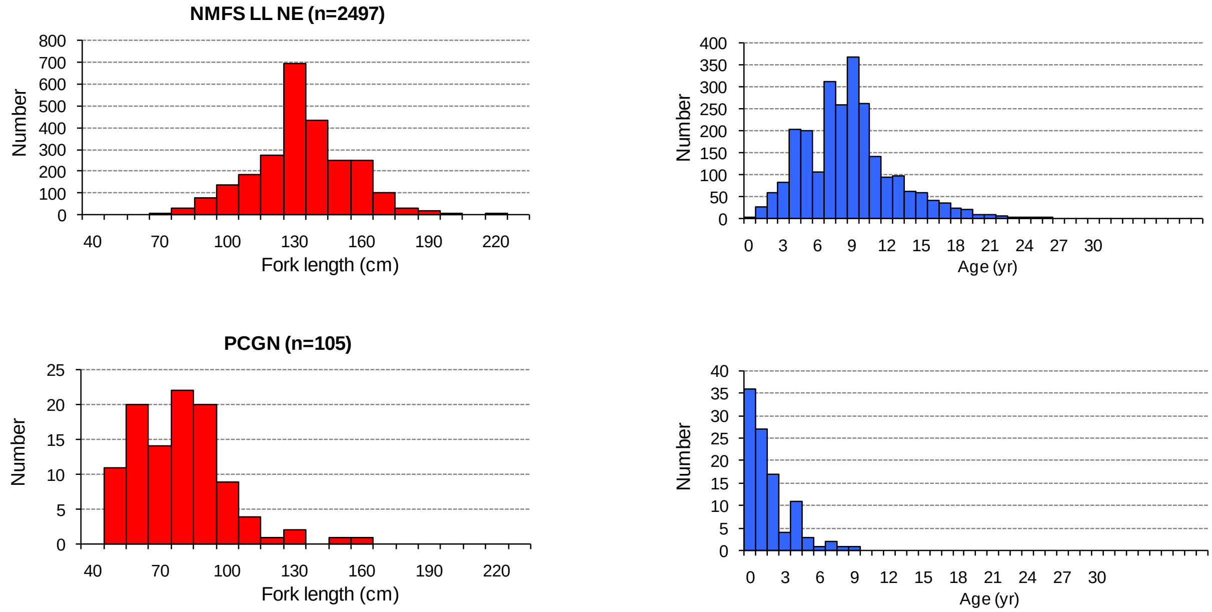
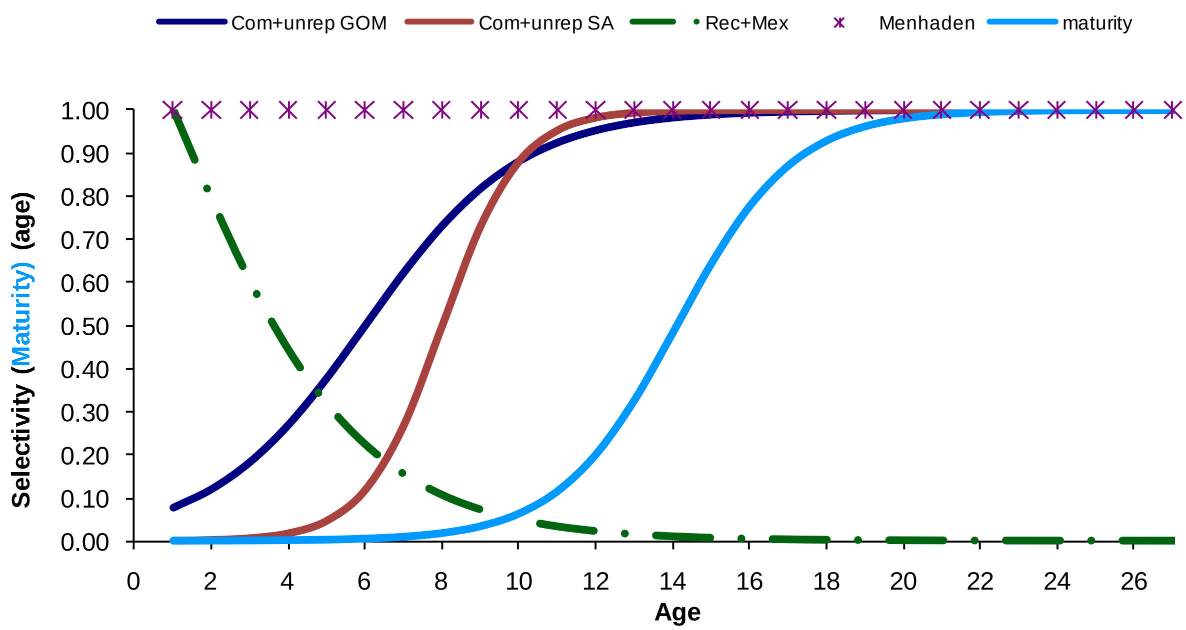


Figure 2.6. Length-frequency (left panels) and age-frequency (right panels) distributions of sandbar shark from the NMFS LL NE (1996-2009) and PCGN (1996-2009) surveys. Age distributions were used to estimate selectivities that were assigned to the NMFS LL NE and PCGN CPUE indices, respectively.



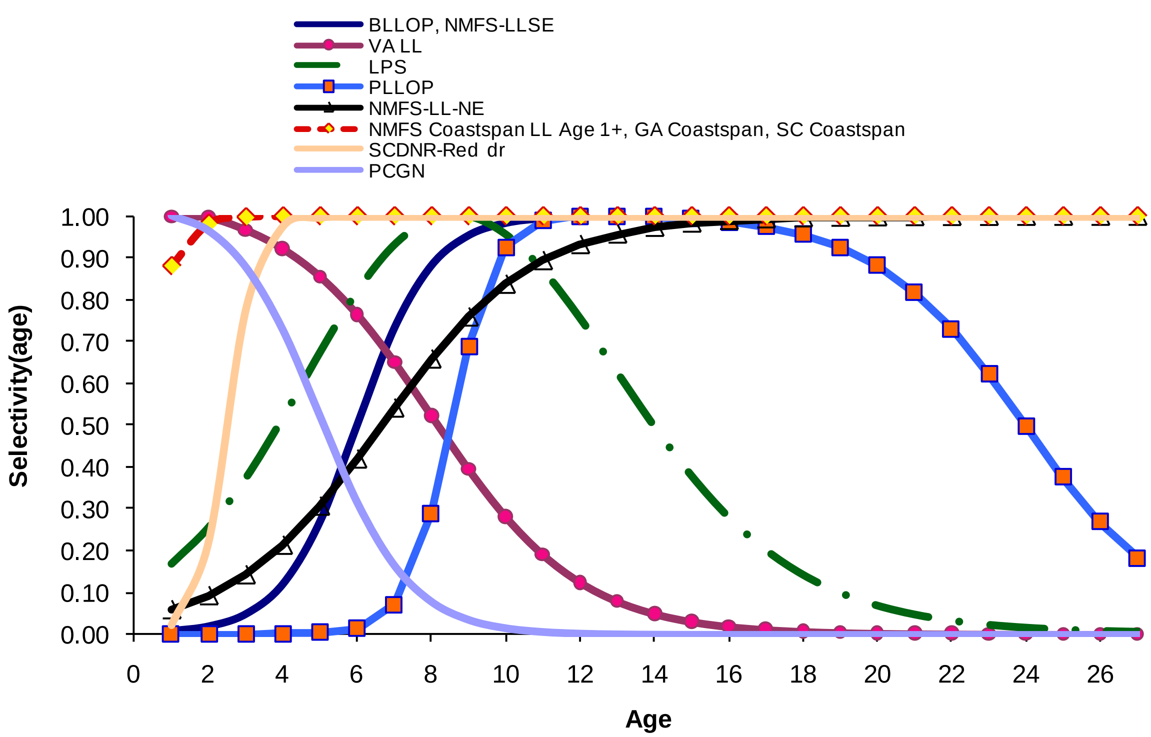


Figure 2.7. Selectivity curves for catches (upper panel) and indices of relative abundance (bottom panel). The maturity ogive for sandbar shark has been added to the upper panel.

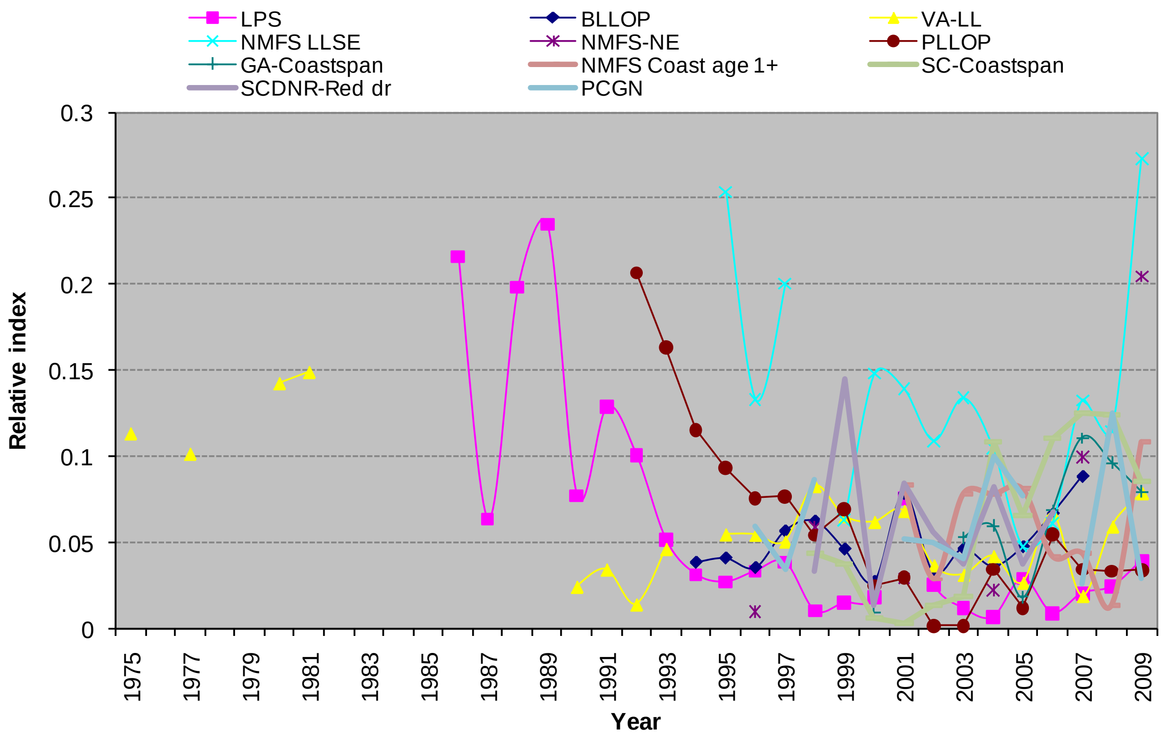


Figure 2.8. Indices of relative abundance used for the baseline scenario. All indices are statistically standardized and scaled (divided by their respective mean and a global mean for overlapping years for plotting purposes).

3. STOCK ASSESSMENT MODEL(S) AND RESULTS

3.1. MODEL 1 METHODS: STATE- SPACE AGE-STRUCTURED PRODUCTION MODEL (ASPM)

3.1.1. Overview

The state-space, age-structured production model (ASPM) was finally used as the primary assessment modeling approach. The ASPM has been used extensively for assessing shark stocks domestically and under the auspices of ICCAT since 2002 (see e.g. ICCAT 2005). The ASPM allows incorporation of many of the important biological (mortality, growth, reproduction) and fishery (selectivity, effort) processes in conjunction with observed catches and CPUE indices (and length and age compositions if available). Similar to the catch-free methodology used for dusky shark (see SEDAR 21 dusky shark assessment report), a first step in applying this method is to identify a year in which the stock can be considered to be at virgin conditions. Assuming that there is some basis for deriving historic removals, one can estimate a population trajectory from virgin conditions through a more data-poor historic period when only catch or effort data are available, until a more recent year ("modern period") when more data (e.g., CPUE indices) become available for model fitting.

3.1.2. Data Sources

Catches, indices of abundance, length and age compositions to derive selectivities, selectivities, and biological inputs used in the ASPM are described in Section 2.

3.1.3. Model Configuration and Equations

To derive numbers at age for the first model year, one must define a year when the stock could be considered to be at virgin conditions. The AP set the year of virgin conditions at 1960 (vs. 1975 in the previous assessment for sandbar shark).

Population Dynamics

The dynamics of the model are described below, and are extracted (and/or modified) from Porch (2003a). The model begins with the population at unexploited conditions, where the age structure is given by

(1) $$N_{a,y=1,m=1} = \begin{cases} R_0 & a = 1 \\ R_0 \exp\left(-\sum_{j=1}^{a-1} M_j\right) & 1 < a < A \\ \dfrac{R_0 \exp\left(-\sum_{j=1}^{A-1} M_j\right)}{1-\exp(-M_A)} & a = A \end{cases} ,$$

where $N_{a,y,1}$ is the number of sharks in each age class in the first model year (y=1), in the first month (m=1), M_a is natural mortality at age, A is the plus-group age, and recruitment (R) is assumed to occur at age 1.

The stock-recruit relationship was assumed to be a Beverton-Holt function, which was parameterized in terms of the maximum lifetime reproductive rate, α:

(2) $$R = \frac{R_0 S\alpha}{S_0 + (\alpha - 1)S} .$$

In (2), R_0 and S_0 are virgin number of recruits (age-1 pups) and spawning production (units are number of mature adult females times pup production at age), respectively. The parameter α is calculated as:

(3) $$\alpha = e^{-M_0}\left[\left(\sum_{a=1}^{A-1} p_a m_a \prod_{j=1}^{a-1} e^{-M_j}\right) + \frac{p_A m_A}{1-e^{-M_A}} \prod_{a=1}^{A-1} e^{-M_a}\right] = e^{-M_0}\varphi_0 ,$$

where p_a is pup-production at age a (divided by 2 to account for a 1:1 male to female sex ratio at birth), m_a is maturity at age a, and M_a is natural mortality at age a. The first term in (3) is pup survival at low population density (Myers et al. 1999). Thus, α is virgin spawners per recruit (φ_0) scaled by the slope at the origin (pup-survival).

The time period from the first model year (y_1) to the last model year (y_T) is divided into a historic and a modern period (mod), where y_i for i<mod are historic years, and modern years are y_i for which mod ≤ i ≤ T. The historic period is characterized by having relatively fewer data compared to the modern period. The manner in which effort is estimated depends on the period modeled. In the historic period, effort is estimated as either a constant (4a) or a linear trend (4b)

(4a) $f_{y,i} = b_0$ (constant effort)

or

(4b) $f_{y,i} = b_0 + \frac{(f_{y=\text{mod},i} - b_0)}{(y_{\text{mod}} - 1)} f_{y=\text{mod},i}$ (linear effort),

where $f_{y,i}$ is annual fleet-specific effort, b_0 is the intercept, and $f_{y=\text{mod},i}$ is a fleet-specific constant. Historic effort for the two commercial and the recreational fleets was estimated as a linear trend interpolated from a constant value equal to zero or close to zero in 1960 to a higher value estimated for the first year of the modern period (eqn. 4b); for the menhaden fleet historic effort was estimated as a constant with a very small value (eqn. 4a). In the modern period, fleet-specific effort is estimated as a constant with annual deviations, which are assumed to follow a first-order lognormal autoregressive process:

(5)
$$\begin{aligned} f_{y=\text{mod},i} &= f_i \exp(\delta_{y,i}) \\ \delta_{y,i} &= \rho_i \delta_{y-1} + \eta_{y,i} \\ \eta_{y,i} &\sim N(0, \sigma_i) \end{aligned} \quad .$$

From the virgin age structure defined in (1), abundance at the beginning of subsequent months is calculated by

(6) $$N_{a,y,m+1} = N_{a,y,m} e^{-M_a \delta} - \sum_i C_{a,y,m,i} \quad ,$$

where δ is the fraction of the year (m/12) and $C_{a,y,m,i}$ is the catch in numbers of fleet i. The monthly catch by fleet is assumed to occur sequentially as a pulse at the end of the month, after natural mortality:

(7) $$C_{a,y,m,i} = F_{a,y,i}\left(N_{a,y,m}e^{-M_a\delta} - \sum_{k=1}^{i-1} C_{a,y,m,k}\right)\frac{\delta}{\tau_i} \quad ,$$

where τ_i is the duration of the fishing season for fleet i. This form of catch equation is useful when the fleets fish simultaneously rather than sequentially, and the monthly time steps cause the error to be negligible. Catch in weight is computed by multiplying (7) by $w_{a,y}$, where weight at age for the plus-group is updated based on the average age of the plus-group.

The fishing mortality rate, F, is separated into fleet-specific components representing age-specific relative-vulnerability, v, annual effort expended, f, and an annual catchability coefficient, q:

(8) $$F_{a,y,i} = q_{y,i} f_{y,i} v_{a,i} \quad .$$

Catchability is the fraction of the most vulnerable age class taken per unit of effort. The relative vulnerability would incorporate such factors as gear selectivity, and the fraction of the stock exposed to the fishery. For this model application to sandbar sharks, both vulnerability and catchability were assumed to be constant over years. Vulnerability was imputed as fleet-specific selectivity as described in sections 2.2 and 3.2.5.

Catch per unit effort (CPUE) or fishery abundance surveys are modeled as though the observations were made just before the catch of the fleet with the corresponding index, i:

(9) $$I_{y,m,i} = q_{y,i}\sum_a v_{a,i}\left(N_{a,y,m}e^{-M_a\delta} - \sum_{k=1}^{i-1} C_{a,y,m,k}\right)\frac{\delta}{\tau_i} \quad .$$

Equation (9) provides an index in numbers; the corresponding CPUE in weight is computed by multiplying $v_{a,i}$ in (9) by $w_{a,y}$.

State space implementation

In general, process errors in the state variables and observation errors in the data variables can be modeled as a first-order autoregressive model:

(10) $$\begin{aligned} g_{t+1} &= E[g_{t+1}]e^{\varepsilon_{t+1}} \\ \varepsilon_{t+1} &= \rho\varepsilon_t + \eta_{t+1} \end{aligned} \quad .$$

In (10), g is a given state or observation variable, η is a normally distributed random error with mean 0 and standard deviation σ_g, and ρ is the correlation coefficient. E[g] is the deterministic expectation. When g refers to data, then g_t is the observed quantity, but when g refers to a state variable, then those g terms are estimated parameters. For example, effort in the modern period is treated in this fashion.

The variances for process and observation errors (σ_g) are parameterized as multiples of an overall model coefficient of variation (CV):

(11a) $$\sigma_g = \ln\left[(\lambda_g CV)^2 + 1\right]$$

(11b) $$\sigma_g = \ln\left[(\omega_{i,y}\lambda_g CV)^2 + 1\right]$$.

The term λ_g is a variable-specific multiplier of the overall model CV. For catch series and indices (eq 11b), the additional term, $\omega_{i,y}$, is the weight applied to individual points within those series. For instance, because the indices are standardized externally to the model, the estimated variance of points within each series is available and could be used to weight the model fit. Given the DW decision to use equal weighting between indices as a baseline, all $\omega_{i,y}$ were fixed to 1.0 and the same λ_g was applied to all indices. To evaluate the sensitivity case where indices were weighted by the inverse of their CV, each $\omega_{i,y}$ was fixed to the estimated CV for point *y* in series *i*; an attempt was also made to estimate a separate λ_g for each series, however those multipliers were not estimable and so a single λ was applied to all indices.

In the present model, these multipliers on catches and indices were fixed after exploring the effects on model outputs for several different values. A fleet-specific effort constant was estimated, but by allowing for large process error it was effectively a free parameter (a log-scale variance of 5 was used); the correlation was fixed at 0.5.

Additional model specifications

Individual points within catch and index series can be assigned different weights, based either on estimated precision or expert opinion. The base case model configuration downweighted the historical catches (1960-1980), giving them ½ of the weight of catches from 1981-2009, on the rationale that they were less well known (as was done in the last assessment in 2006). Also in

2006, several weighting factors were evaluated for the value of the recreational catch in 1983. Recreational catch in 1983 was roughly ten times the value in 1982 and six times the value in 1984; also, it was about nine times the series average without that point. For these reasons, the value for 1983 catch seems anomalously high. Downweighting it by ½ led to the predicted value matching it within 3%; downweighting it by 1/10 led to a predicted value within 25%. In both cases, the relative benchmarks were nearly identical. It was decided to proceed by downweighting that point by 1/10. The same weights were used for the current assessment.

One further model specification was the degree to which the model predicted values matched catches versus indices. An overall model CV is estimated (see equations 11a and 11b), and multiples (λ_g) of this overall CV can be specified separately for catches and indices (see Porch 2003a). All catch series were assigned the same CV multiple, and all indices were assigned a single CV multiple (this forces equal weighting of the indices). Also in 2006, an initial attempt was made to estimate these multipliers. This resulted in boundary solutions for the multipliers. In a second attempt, the multiplier for catch was fixed at 1 and the index multiplier was estimated. Again, this resulted in the index multiplier estimate at the upper bound. An explanation for this behavior was that the interannual variability within indices is substantial in some cases, and additionally, indices with the same selectivity had conflicting trends. To deal with this, two values were evaluated for the CV multiplier of indices: a value that was 5 times the catch CV multiplier, and a value equal to the catch CV multiplier. The former case implies that indices are less certain than catches, while the latter case implies the same relative certainty in catches and indices. Both results indicated an overfished stock with overfishing in the 2006 assessment. The estimate of relative biomass (B_{2004}/B_{MSY}) was nearly identical between these two configurations (0.72 vs. 0.73, respectively), while the degree of overfishing (F_{2004}/F_{MSY}) was about 10% less (3.72 vs. 3.29). Given that the estimated stock status did not vary based on the weighting between catch and indices, it was decided to proceed by placing relatively more confidence in the catch series (notwithstanding the weighting of individual points within the catch series, as described in the paragraph above). The same weights were used for the current assessment.

3.1.4. Parameter Estimation

Parameters were estimated by minimizing an objective function (the negative log joint posterior density function) using AD Model Builder software (Otter Research, Ltd. 2004). The (log) joint posterior distribution was specified up to a proportionality constant and included log likelihood components for observed data (Λ_1), process error components (Λ_2), and prior distribution components (Λ_3). The total objective function was then given by $\Lambda = \Lambda_1 + \Lambda_2 + \Lambda_3$, with each component as described below.

Observed data log likelihood—The observed data log likelihoods were specified as lognormal, but included a number of variance terms that could be estimated or fixed to allow for a wide range of choices for how to fit the data. The objective function takes the sum of the negative log likelihood contributions from indices, catches, and effort. The indices contribution is provided by

(12) $$\Lambda_1 = 0.5\sum_i \sum_y \sum_m \frac{(\log(I_{i,y,m}) - \log(\tilde{I}_{i,y,m}))^2}{\sigma_{i,y}^2} + \log(\sigma_{i,y}^2),$$

where $I_{i,m,y}$ and $\tilde{I}_{i,m,y}$ give observed and predicted indices, respectively, and

(13) $$\sigma_{i,y}^2 = \log(1 + \mathrm{CV}^2{}_{i,y}).$$

The catch and effort contributions have the same form. The term $\mathrm{CV}_{i,y}$ gives the observed CV reported along with index *i* in year *y* (for example, as a byproduct of the CPUE standardization process).

Process errors—Process errors for effort deviations made a contribution to the objective function. The contribution for effort deviations is given by

(14) $$\Lambda_2 = 0.5 \sum_{1961 \le y \le 2009} \frac{(\varepsilon_{ey} - \rho_e \varepsilon_{ey-1})^2}{\sigma_e + (y-1)\log \sigma_e}.$$

Prior distributions—The model started in 1960 and ended in 2009, with the historic period covering 1960-1980, and the modern period spanning 1981-2009. Estimated model parameters were pup (age-0) survival, virgin recruitment (R_0), catchability coefficients associated with catches and indices (q_i), and fleet-specific effort (e_i). Virgin recruitment was given a uniform prior distribution ranging from 1000 to 10 billion individuals, whereas pup survival was given an informative lognormal prior with median=0.81 (mean=0.85, mode=0.77), a CV of 0.3, and bounded between 0.50 and 0.99. The mean value for pup survival matched closely that derived using life-history based methods (see Section 2.4).

The total contribution for prior distributions to the objective function was then

(15) $$\Lambda_3 = \log(p(e^{-M_0})) + \log(p(R_0)) + \sum_i \log(p(q_i)) + \sum_i \log(p(e_i))$$

A list of estimated model parameters is presented in Table 3.1 (other parameters were held constant and thus not estimated, see Section 3.1.2). The table includes predicted parameter values and their associated SDs from ASPM, initial parameter values, minimum and maximum values a parameter could take, and prior densities assigned to parameters.

3.1.5. Uncertainty and Measures of Precision

Numerical integration for this model was done in AD Model Builder (Otter Research Ltd. 2001), which uses the reverse mode of AUTODIF (automatic differentiation). Estimation can be carried out in phases, where convergence for a given phase is determined by comparing the maximum gradient to user-specified convergence criteria. The final phase of estimation used a convergence criterion of 10^{-6}. For models that converge, the variance-covariance matrix is obtained from the inverse Hessian. Uncertainty in parameter estimates was quantified by computing asymptotic standard errors for each parameter (Table 3.1), which are calculated by ADMB by inverting the Hessian matrix (i.e., the matrix of second derivatives) after the model fitting process. Additionally, likelihood profiling was performed to examine posterior distributions for several model parameters and to provide probabilities of the stock being overfished and overfishing occurring. Likelihood profiles are calculated by assuming that the posterior probability distribution is well approximated by a multivariate normal (Otter Research

Ltd. 2001). The relative negative log-likelihood (objective function) and AICc (small sample AIC) values are listed in the tables of model results.

Uncertainty in data inputs and model configuration was examined through the use of sensitivity scenarios. Sixteen alternative runs are included in this report in addition to the baseline run. We also include continuity and retrospective analyses. The *continuity analysis* uses the same model and inputs as in 2006, but includes additional years of catches and indices, to see the effect that additional observations have on model results. *Retrospective analyses* of the baseline run were conducted, in which the model was refit while sequentially dropping the last two years of data to look for systematic bias in key model output quantities over time. As recommended by the CIE assessment reviewer, the analysis was only run back to 2007 because the SCDNR red drum historical index only spanned the period 1998-2006 and thus considering a period that extended beyond 2007 may have introduced artifacts into the trends of the output quantities examined.

We now specifically describe how each of the 16 sensitivity runs was implemented.

Baseline run: the base model configuration assumed virgin conditions in 1960, used the imputed historical catch series, the updated biological parameters, and the 11 base case CPUE indices. In addition, historic catches (1960-1980) were downweighted by ½ and the 1983 recreational catch was downweighted by 1/10; lastly, catches were assumed to be 5 times more certain than the indices.

Scenario 1: Inverse CV weighting—Same as the base run, but using the inverse of the CV to weight each CPUE series (Table 3.2).

Scenario 2: All CPUE series—Same as the base run, but adding three indices identified as "sensitivity" by the Index WG of the DW: Bottom longline logbook, Pelagic longline logbook, and NMFS historical longline (Table 3.3).

Scenario 3: Combined commercial catches—Same as the base run, but without splitting the commercial landings + unreported catch series into GOM and ATL, thus having only 3 catch series (fleets; Table 3.4)

Scenario 4: Combined commercial catches with inverse CV weighting—Same as scenario 3 but with inverse CV weighting of the indices.

Scenario 5: 2-year reproductive cycle—Same as the base run, but using a biennial reproductive periodicity, instead of 2.5 yr as in the baseline run.

Scenario 6: 3-year reproductive cycle—Same as the base run, but using a triennial reproductive periodicity, instead of 2.5 yr as in the baseline run.

Scenario 7: U-shaped M—Same as the base run, but using a U-shaped vector of natural mortality at age to account for increased natural mortality for the older ages. Initially the Chen and Watanabe (1989) method mentioned in Section 2.4 was used to derive a U-shaped curve for M, but given that the curve was not quite U-shaped because it decreased again for the oldest ages, another method (the "bathtub" method; see Siegfried [2006]) was used instead to approximate the M predicted by the Chen and Watanabe equation while maintaining a U shape (Table 3.5 and Figure 3.1). The equation for the "bathtub" method is:

(16) $$U(a) = c\left[e^{-\lambda_d(a-d)} + e^{\lambda_g(a-g)}\right]$$

where c is a scaling factor, d is the age when constant M begins, g is the age where M starts to increase again, λ_d is the descending slope and λ_g is the ascending slope.

Scenario 8: Fishery-independent CPUE series—Same as the base run, but using only the eight fishery-independent indices (VIMS LL, NELL, NMFS Coastspan age-1+, GA Coastspan, SC Coastspan, SCDNR Historic red drum, PCGN, and NMFS SE LL).

Scenario 9: Rank-based weighting—Same as the base run, but using the inverse of the a priori ranks (based on criteria such as spatial coverage, reliability, etc.) provided by the Index WG after the DW to weight each CPUE series (Table 3.6). The ranks ranged from a best of 1 for the NMFS SE LL index to a worst of 5 for the LPS series.

Scenario 10: Hierarchical index—Same as the base run, but using only one hierarchical index of relative abundance weighted by the inverse of the CV (see document SEDAR21-AW-01 and Table 3.7). The selectivity used for the single index was a weighted average of the selectivities associated with the individual indices (Figure 3.2). The inverse variance selectivity weights reported in SEDAR-21-AW-01 (NMFS SE LL: 0.207; NMFS Coastspan age-1+: 0.101; VIMS: 0.140; NELL: 0.033; SC Coastspan: 0.027; SCDNR Historic red drum: 0.087; BLLOP: 0.271; PLLOP: 0.052; LPS: 0.082; GA Coastspan and PCGN=SC Coastspan) were used to weight the individual selectivity curves. Once a weighted selectivity vector was obtained, a functional form (double logistic curve) was developed to approximate the weighted selectivity for input into the model.

<u>Scenario 11:</u> Hierarchical index with equal weighting—Same as scenario 10, but using equal weights for the single index.

<u>Scenarios 12 and 13:</u> Low and high catch scenarios—Same as the base run, but using a low and high catch scenario, respectively. The low and high catch series were constructed in an attempt to incorporate uncertainty in the magnitude of the catches as recommended by the DW CIE reviewer. This was done as follows. Commercial landings are reported in weight (not estimated), but then converted into numbers by using average weights from animals observed in the shark bottom longline observer program. Thus, the only way to incorporate uncertainty in this catch stream is in the average weights used for conversion from weight to numbers. Lower and upper 95% confidence intervals (CIs) of those average weights were thus computed (Figure 3.3a) and used to produced high and low commercial landings scenarios, respectively. For recreational catches, lower and upper CIs of the combined estimates of sharks landed and discarded dead (A+B1 in MRFSS terminology) were also computed (Figure 3.3b) and low and high catch scenarios produced. No measure of uncertainty was available for unreported commercial catches, menhaden fishery discards, or Mexican catches. The low and high catch scenarios varied widely with respect to the baseline catches (Tables 3.8 and 3.9; Figure 3.4).

Following the CIE assessment review we ran several additional sensitivities. Given that model predictions tend to be very sensitive to the assumed natural mortality, we explored the effect of alternative trends in M by proportionally decreasing and increasing the vector of age-specific values by 10%. We also explored the effect of considering different assumptions for the reconstruction of the historical catch series. In the base run, commercial and recreational catches were assumed to increase linearly from 1960 to 1975, and exponentially from 1975 to 1981, the first year with data. In a new sensitivity run, we assumed a single linear increase from zero catches in 1960 to the 1981 value for the two commercial and the recreational+Mexican series. The three additional sensitivities were thus:

<u>Scenarios 14 and 15:</u> low and high M values—Same as the base run, but decreasing and increasing, respectively, age-specific values of M by 10% (Table 3.10).

Scenario 16: alternative historical catches—Same as the base run, but assuming a linear increase from 1960 to 1981 for the commercial and recreational series (Table 3.11).

3.1.6. Benchmark/Reference points methods

Benchmarks included estimates of absolute population levels and fishing mortality for year 2009 (F_{2009}, SSF_{2009}, B_{2009}, N_{2009}, $Nmature_{2009}$), reference points based on MSY (F_{MSY}, SSF_{MSY}, SPR_{MSY}), current status relative to MSY levels, and depletion estimates (current status relative to virgin levels). In addition, trajectories for F_{year}/F_{MSY} and SSF_{year}/SSF_{MSY} were plotted and phase plots provided. Phase plots of stock status, including MSST (Minimum Stock Size Threshold) were also included. Because M<0.5, MSST is computed as $(1\text{-}M)SSF_{MSY}$. The value of M used (0.136) was the arithmetic mean of the age-specific values of M used for the baseline run (Table 2.4).

3.1.7. Projection methods

Projections were carried out using Pro-2Box (Porch 2003b). Projections were bootstrapped ≥500 times by allowing for process error in the spawner-recruit relationship. Lognormal recruitment deviations with SD = 0.4, with no autocorrelation, were assumed. No other variability was introduced into the projections. Under these assumptions, the base model was projected at F = 0 to determine the year when the stock can be declared recovered with a 70% probability ($SSF/SSF_{MSY} > 1$). If that year is >10, 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 is about 20 years, and was calculated as:

(17)

$$GenTime = \frac{\sum_i i f_i \prod_{j=1}^{i-1} s_j}{\sum_i f_i \prod_{j=1}^{i-1} s_j}$$

where *i* is age, f_i is the product of (fecundity at age) x (maturity at age), and s_j is survival at age. Maximum age used in the calculations was 27 years. This generation time corresponds to the mean age of parents of offspring produced by a cohort over its lifetime (ν_1; Caswell 2001); other formulae for calculating generation time gave very similar estimates (T: time required by the population to increase by R_0=19.8; A: mean age of parents of offspring in a stable age distribution=19.5; Caswell 2001).

A fixed F strategy and a fixed TAC strategy were estimated that would attain rebuilding by the designated year with a 50% and a 70% probability. Assumptions for these projections included the above process error in stock-recruitment, the selectivity vector was the geometric mean of the last 3 years (2007-2009), and it was assumed that any modification to F or a TAC will impact each fishery by the same proportion. As per HMS Management Division guidance, the first year that management begins to operate was set to 2013; in the interim years (2010-2012), F-based projections were set equal to F_{2009} and TAC-based projections, to the mean of catches in 2008 and 2009. Because catches are in numbers, we transformed numbers to weight using average weights. For the commercial series, we used average weights from the BLLOP for 2008 and 2009; for the recreational+Mexican series, we used an average weight from MRFSS for the period 2000-2009 (owing to small sample sizes in any given year), and for the menhaden discard series we estimated a value of about 8 kg ww based on a description given in De Silva et al. (2001) that seems to indicate that the size of sandbar sharks caught would be mostly <100 cm total length. The resulting mean of catches in weight for 2008 and 2009 was 234 mt ww.

As requested by the HMS Management Division, we also determined the probability of rebuilding by 2070, which is the current rebuilding timeframe under Amendment 2 to the 2006 Consolidated HMS FMP. These projections were done with the current (for 2009) level of F and current TAC of 220 mt ww (158 mt dw). Additionally, we explored the effect of increasing recruitment deviations by doubling the value of the SD from 0.4 to 0.8.

3.2. MODEL RESULTS

3.2.1. Measures of Overall Model Fit

Catches were fit 5 times better than indices and thus were fit very well, with the exception of some years in the early 1980s for the recreational+Mexican catch series, in particular the estimated recreational 1983 value is below the observed value due to the downweighting of that point (Figure 3.5). The model appeared to have trouble reconciling the conflicting trends and oscillations of some of the indices of abundance. As a result, some of the indices were poorly fit, particularly the model did not fit well the steep decreasing trend in the early years of the LPS and the PLLOP series as well as the 4 first years of the VA LL series, which is the longest time series, beginning in 1975 (Figure 3.6). Several of the indices (BLLOP, VA-LL since 1990, NMFS LL SE, NMFS Coastspan age-1+, NMFS LL NE, SCDNR historic red drum, PCGN) showed no clear trend and two indices (GA Coastspan and SC Coastspan) showed a generally increasing trend. The model interpreted those trends by predicting a stabilization 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 the catch data, which has been greatly reduced in recent years due to management action (Figure 2.1). 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.

3.2.2. Parameter estimates and associated measures of uncertainty

A list of model parameters is presented in Table 3.1. The table includes predicted parameter values with associated SDs, initial parameter values, minimum and maximum allowed values, and prior density functions assigned to parameters. Parameters designated as constant were estimated as such; parameters that were held fixed (not estimated) are not included in this table.

3.2.3. Stock Abundance and Recruitment

Predicted stock abundance at age is presented in Figure 3.7. The first six age classes made up about 50% of the population in any given year and mean age by year varied very little (min=6.80, max=7.73).

The ASPM does not model age 0s and thus no predicted age-0 recruits are produced, only the estimated virgin number of age-1 recruits (see Section 3.1.3). However, one can calculate an “observed” and an “expected” recruitment for different levels of relative SSB using the Beverton-Holt model reparameterized in terms of steepness (Francis 1992) and maximum lifetime reproductive rate, which are quantities estimated by ASPM. Figure 3.8 shows "observed" vs. predicted recruits for different levels of SSB depletion. Predicted recruits are given by equation (2) in Section 3.1.3 and "observed" recruits are given by:

$$(18) \qquad R = \frac{4zS}{SPR_0(1-z) + \frac{S(5z-1)}{\varphi_0}}$$

where z is steepness, S is spawners, SPR_0 is the spawning potential ratio at virgin conditions and φ_0 is virgin spawners per recruit (from equation 3 in section 3.1.3).

3.2.4. Stock Biomass

Predicted abundance, total biomass, and spawning stock fecundity (numbers x proportion mature x fecundity in numbers) are presented in Table 3.12 and Figure 3.9. All trajectories show little depletion from 1960 to 1982 (a few years later for SSF), corresponding to very reduced catches, effort and estimated F in the historic period, and a marked decline until 2007, followed by stabilization until 2009. Decreasing biomass and abundance in 1983-2007 correspond to increased catches 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 tendencies for some of the indices in those years.

3.2.5. Fishery Selectivity

As explained in Section 2.2 and shown in Table 2.2 and Figure 2.7, selectivities are estimated externally to the model and a functional form inputted for each fleet and index. In Figure 2.7 one can see that most fleets fully select for immature animals, and that many of the indices include immature animals too.

3.2.6. Fishing Mortality

Predicted total and fleet-specific instantaneous fishing mortality rates are presented in Table 3.13 and Figure 3.10. Fishing mortality was very low in 1960-1981 in accordance with very reduced catches and effort during that period. Starting in 1982, fishing mortality widely oscillated but always exceeded the estimated F_{MSY} of 0.021. Fishing mortality dropped below F_{MSY} in 2008 and 2009 in accordance with reduced catches imposed by management and increasing trends of some of the indices. During 1982-1987, fishing mortality was strongly influenced by the Recreational+Mexican fleet, after which the importance of this fleet and the two directed commercial fleets alternated (Figure 3.10). The contribution of the menhaden fishery fleet to total F was insignificant.

3.2.7. Stock-Recruitment Parameters

See Section 3.1.2.3 above for additional discussion of the stock-recruitment curve and associated parameters. The predicted virgin recruitment (R_0; number of age 1 pups) was 563,000 animals (Figure 3.8 and see next section for further discussion on R_0). The predicted steepness was 0.29 and the maximum lifetime reproductive rate was 1.64, values in line with the life history of this species (Brooks et al. 2009). The estimated pup (age-0) survival was 0.84 (see next section for further discussion on pup survival).

3.2.8. Evaluation of Uncertainty

Estimates of asymptotic standard errors for all model parameters are presented in Table 3.1. Posterior distributions for several model parameters of interest were obtained through likelihood profiling. Prior and posterior distributions for pup survival and virgin recruitment are shown in Figure 3.11. There appeared to be information in the data since the posteriors for these two parameters were different from the priors. The mode for the posterior of pup survival was estimated at a higher value than the prior mode, whereas the posterior for virgin recruitment of pups was very informative in contrast to its diffuse uniform prior (Figure 3.11).

Posterior distributions were also obtained for several benchmarks. The distributions for total biomass and spawning stock fecundity in 2009 have little overlap with their respective distributions for virgin conditions. The distributions for total biomass depletion and spawning stock fecundity depletion are wide, but most of the density is concentrated between about 0.2 and 0.6, and about 0.1 and 0.6, respectively (Figure 3.12). The estimate of F_{2009} ranges from 0 to about 0.05 and the estimate for mature number of females in 2009 also shows little overlap with the corresponding distribution for virgin conditions (Figure 3.13).

Results of the base and sensitivity analyses are summarized in Table 3.14. Using the inverse CVs to weight the indices (sensitivity scenario 1) led to a somewhat more productive stock that showed higher depletion but experienced the same fishing mortality as the base run. The fits to several indices were improved with respect to the base run (Figure 3.14). Adding the sensitivity indices to those from the base run (scenario 2) resulted in a more optimistic status, with less depletion and less overfishing. However, the initial years of the additional NMFS Historic longline index were not fit well and thus the sharp initial decline indicated by that index was not captured by the model (Figure 3.15). Collapsing the two commercial catch streams into a single one (scenarios 3 and 4) as in the 2006 stock assessment improved and worsened the status, respectively. As expected, decreasing the length of the reproductive cycle to 2 years (scenario 5) or increasing it to 3 years (scenario 6) led to a more productive and less productive stock, respectively. The degree of stock depletion was little affected, but overfishing was substantially reduced in scenario 5 and approached the reference point in scenario 6. The fits to catches and indices of both scenarios were very similar to those of the base run. Using a U-shaped vector for natural mortality (scenario 7) effectively decreased M at age and resulted in a little more depletion but less overfishing, with the fits again being very similar to those of the base run. Using only the eight fishery-independent indices (scenario 8) included in the base run was the most optimistic scenario and led to a change in status. The productivity of the stock was almost identical to that of the base run, but the indices showed no trend or an increasing tendency in recent years. The VIMS LL index was the only series that started before 1995 and the first 4 years of that index covering the period 1975-1981 were very poorly fit (Figure 3.16). Using the inverse ranks derived by the Index WG (scenario 9) had little effect on results. Using only the hierarchical index did not alter status and had a small effect on results when weighting the index by the inverse of the CV (scenario 10). However, when using the index with equal weights (all CVs=1; scenario 11), the overfished status worsened considerably and overfishing was occurring. Although neither model could fit three of the years in the index, scenario 10 (inverse CV weighting) fit the rest of the years better than scenario 11 (equal weighting; Figure 3.17). Considering catches lower (scenario 12) and higher (scenario 13) than those in the base run did not change status; the most noticeable result being that with higher catches, scenario 13 predicted a substantially lower level of overfishing and absolute values of abundance and biomass about one order of magnitude larger than in the base run and the other sensitivity scenarios. Assuming lower values of M resulted in the overfished status worsening by about 10% but a prediction of even less overfishing; assuming higher M values improved the overfished status by about 10% but changed the status with respect to overfishing, with overfishing now occurring. Considering an alternative assumption for reconstructing the historical catches did not affect status, with the overfished criterion improving but the overfishing measure worsening.

3.2.8.1. Continuity analysis

This run consisted of using the same exact model, data inputs and assumptions used in the 2006 assessment, but adding five additional years of catch data (2005-2009; Figure 3.18) and the same indices updated to 2009 (Figure 3.19). Table 3.15 shows the summarized results of the continuity analysis and of the 2006 base run. The base run in 2006 indicated that the stock was overfished with overfishing occurring, whereas the continuity run predicted a somewhat less overfished stock, but that overfishing was no longer occurring (Table 3.15). Although the same eight indices used in 2006 were also used in the continuity run, 7 of the 8 indices were reanalyzed and had five additional years of data. Figure 3.19 shows that 4 of those 7 indices have an increasing trend in the added 2005-2009 time period (very steep for the BLLOP and NMFS LL SE indices), whereas 3 of them (NMFS LL NE, BLL Logs, and PLL Logs) show a decreasing trend in 2005-2009. The model interpreted the upswing in relative abundance shown by several indices in recent years as an indication that abundance had stabilized, predicting that overfishing is no longer occurring, but that the stock is still depleted to levels below MSY, not having had yet enough time to rebuild.

3.2.8.2 Retrospective analysis

Results of the retrospective analysis are presented in Figure 3.20. Three model output quantities were examined in the analysis: 1) spawning stock fecundity, 2) relative spawning stock fecundity, and 3) relative fishing mortality. The SSF trajectories for the 2008 and 2007 retrospective runs overlapped and ran parallel to the base run, estimating lower abundance. The relative spawning fecundity (SSF/SSF_{MSY}) trajectories for the 2008 and 2007 retrospective runs also overlapped and ran parallel to the base run until about 1990, when the three trajectories converged for a few years. The 2008 retrospective run then diverged and ran in parallel below the base and 2007 retrospective runs, which completely overlapped from about 1990 to 1960.

No systematic pattern of over- or under-estimation of relative abundance was thus observable. The relative fishing mortality (F/F_{MSY}) trajectories did not fully converge until about 1983. The base and 2008 retrospective runs ran closely in parallel to each other during stretches of years, and the 2007 retrospective run also ran in parallel to the other two series but with much wider spread. No systematic pattern of over- or under-estimation of fishing mortality was thus observable.

3.2.9. Benchmarks/Reference Points/ABC Values

Benchmarks for the MSY reference points for the base run and all sensitivity scenarios are summarized in Table 3.14 and those for the continuity analysis in Table 3.15. The base model estimated an overfished stock but that overfishing was no longer occurring (Table 3.14; Figure 3.21). The model estimated that the stock had been overfished since 1996 but that overfishing no longer occurred in 2008 and 2009 (Figure 3.21). Probabilities obtained through likelihood profiling indicated that there was a 69 % probability that the stock in 2009 was overfished ($P(SSB_{09}<SSB_{MSY}=0.69)$) and an 86% probability that there was no overfishing in 2009 ($P(F_{09}<F_{MSY}=0.86)$). All sensitivity runs estimated an overfished status, with the exception of run 8 (fishery-independent indices only), and all runs estimated that the stock was not undergoing overfishing, except for runs 11 (hierarchical index with equal weights) and run 15 (high M; Table 3.14). Figure 3.22 is a phase plot showing the outcomes of the base model, the 16 sensitivity scenarios, the continuity analysis, and the results of the base models from the 2006 and 2002 assessments. Figure 3.23 is a phase plot of the outcomes of the base model, the retrospective runs, and the 2006 assessment base model. The results of retrospective analysis support the conclusions from the base run, i.e., that the stock stopped experiencing overfishing in 2008, but not before.

3.2.10. Projections

Projecting the stock at F=0 (with $F=F_{2009}$ for years 2010-2012) estimated that stock recovery ($SSF>SSF_{MSY}$) would occur with a 70% probability by 2038. Given that rebuilding time is greater than 10 years, management action dictates that one generation be added to the rebuilding time. Since generation time was estimated at 20 years (section 3.1.7), the rebuilding target becomes 2058 (2038+20) or 45 years from 2013, when new management measures can first be implemented.

Fixed F strategies that would allow stock rebuilding by 2058 with a 70% and 50% probability, respectively, were F=0.011 and F=0.013 (Figure 3.24). Constant TAC strategies that would allow stock rebuilding by 2058 with a 70% and 50% probability, respectively, were 260 and 300 mt ww (Figure 3.25). We also calculated the probability of stock rebuilding under the present rebuilding target (2070) and current F (F_{2009}=0.013) and TAC (220 mt ww). There was a 78% probability of rebuilding based on current F (Figure 3.24) and a 94% probability of rebuilding based on current TAC (Figure 3.25).

Doubling the value of the SD of recruitment deviations increased the cone of uncertainty around the median, but also altered the projected rebuilding timeframe. With F=0, a 70% probability of stock rebuilding was now reached by 2031, hence the rebuilding target became 2051. Fixed F strategies that would allow stock rebuilding by 2051 with a 70% and 50% probability, respectively, were F=0.022 and F=0.028 (Figure 3.26). Constant TAC strategies that would allow stock rebuilding by 2051 with a 70% and 50% probability, respectively, were 500 and 680 mt ww (Figure 3.27). We also calculated the probability of stock rebuilding under the present rebuilding target (2070) and current F (F_{2009}=0.013) and TAC (220 mt ww). There was a 97% probability of rebuilding based on current F (Figure 3.26) and a 100% probability of rebuilding based on current TAC (Figure 3.27).

3.3. 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 dusky sharks, sandbar sharks are easy to identify, mostly by their high first dorsal fin. 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. The only scenario that included a historical index of relative abundance starting close to 1960, when the stock was considered to be in virgin conditions, poorly fit the early years of that index showing the greatest decline from the early 1960s to the end of that decade, leading actually to more optimistic conclusions. An issue of concern regarding the indices of relative abundance, is that many of them show interannual variability that does not seem to be compatible with the life history of the species, suggesting that the GLMs used to standardize the indices 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 outcome to some extent. Considering higher M values (scenario 15) than in the baseline scenario resulted in a prediction of overfishing and assuming a three-year reproductive cycle (scenario 6) also increased the value of fishing mortality rate in 2009 close to the limit of 1. Despite the significant differences between the inputs used in the 2006 and the current assessment, stock status only changed with regard to overfishing, a result largely attributable to the stabilization and even increase in several of the indices of relative abundance used for the current assessment. Indeed, differences between the 2006 and current assessment include: the model now starts in 1960 (vs. 1975), catches span 1960-2009 (vs. 1975-2004) and commercial catches are split into the Gulf of Mexico and Atlantic (vs. one single commercial series), there are 11 indices, 5 of them new and all of which were reanalyzed (vs. 8 indices), there are 4 selectivities for catches, 3 of which are new (vs. 3), and 8 selectivities for indices (vs. 2), there are new biological parameters, including a new von Bertalanffy growth curve with a more rapid growth coefficient K=0.12 (vs. 0.09), lifespan is now shorter at 27 years (vs. 40), there is a new maturity-at-age ogive that is shifted to younger ages, with a median maturity of 13 years (vs. 19), the DW panel agreed on a longer reproductive cycle of 2.5 years as a compromise between 2 and 3 years (vs. 2), 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 affect 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 are 13 fewer years during which females can produce offspring and at a slower rate of every 2.5 years. Despite the maturity ogive having been shifted to the left, selectivities for all catch series and the vast majority of indices fully select for immature individuals, thus curtailing the reproductive potential of the stock.

As noted by the AW CIE reviewer, we recognize that the estimation of selectivities externally to the model may not have captured the uncertainty associated with the sample size used to fit age-length curves, the computation of the age-length key, and subsequent transformation of lengths into ages to produce age-frequency distributions to which selectivity curves were fitted. As noted in Section 2.2, we did not attempt to estimate selectivities using ASPM owing to the lack of age composition data and the limited amount of length data in most cases, which would have resulted in a substantial number of additional parameters having to be estimated. In the future, if more length data from the different surveys and programs become available, we hope to use a length-based, age-structured model, but note that even then an externally derived age-length key may still be required to transform lengths into ages. In that respect, it is important to obtain more samples to age the smallest and largest segments of the population, as attested by examining the presently available age-length key (Appendix 1).

The 2006 assessment estimated the total biomass in 1981, the first year with non-estimated catches, to be at 93% of virgin levels, and SSF_{1981}/SSF_0 = 0.98. The current base model estimated both B/B_0 and SSF/SSF_0 at 98%. The current base model estimated a somewhat less productive stock than the 2006 assessment, with lower maximum lifetime reproductive rate (1.64 vs. 1.88) and steepness (0.29 vs. 0.32). However, the estimate of virgin recruitment (age-1 pups) was higher (563,000 vs. 461,000) as a result of a substantially higher pup survival (0.84 vs. 0.62). Total biomass in 2009 was very similar to that estimated for 2004 in the 2006 assessment (31,000 mt vs. 30,000 mt) and the estimate of MSY for the current base model (481 mt) was higher than the 2006 assessment estimate (403 mt).

Despite this better outlook compared to the 2006 assessment, the combination of some 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 appears to have ended overfishing.

3.4. RECOMMENDATION FOR DATA COLLECTION AND FUTURE RESEARCH

We list below research recommendations that are more feasible and would allow substantial improvement of future stock assessment of this stock:

- Explore alternative approaches to age-length keys for estimating age from length
- Obtain more vertebral samples to age the smallest and largest segments of the stock. More generally, implement a systematic sampling program that gathers vertebral samples for annual ageing to allow tracking the age distribution of the catch as well as updating of age-length keys
- 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

3.5. REFERENCES

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3.6. TABLES

Table 3.1. List of parameters estimated in ASPM for sandbar shark (base run). The list includes predicted parameter values with associated SDs, initial parameter values, minimum and maximum allowed values, and prior density functions assigned to parameters. Parameters that were held fixed (not estimated) are not included in this table.

	Predicted					Prior pdf			
Parameter/Input name	Value	SD	Initial	Min	Max	Type	Value	SD (CV)	Status
Virgin recuitment	5.63E+05	1.13E+05	5.00E+05	1.00E+03	1.00E+10	uniform	-	-	estimated
Pup (age-0) survival	8.43E-01	2.45E-01	8.10E-01	5.00E-01	9.90E-01	lognormal	0.81	(0.3)	estimated
Catchability coefficient LPS index	5.83E-07	2.38E-07	2.46E-03	1.00E-12	1.00E-02	constant	-	-	estimated
Catchability coefficient BLLOP index	9.47E-07	4.84E-07	6.33E-03	1.00E-12	1.00E-02	constant	-	-	estimated
Catchability coefficient VA-LL index	6.04E-07	2.44E-07	1.68E-03	1.00E-12	1.00E-02	constant	-	-	estimated
Catchability coefficient NMFS LL SE index	1.18E-06	6.23E-07	3.55E-03	1.00E-12	1.00E-02	constant	-	-	estimated
Catchability coefficient NMFS Coastspan age-1+ index	5.70E-07	3.35E-07	1.46E-03	1.00E-12	1.00E-02	constant	-	-	estimated
Catchability coefficient NMFS LL NE index	9.82E-07	6.28E-07	8.33E-03	1.00E-12	1.00E-02	constant	-	-	estimated
Catchability coefficient PLLOP index	1.27E-06	6.41E-07	7.68E-03	1.00E-12	1.00E-02	constant	-	-	estimated
Catchability coefficient GA Coastspan index	5.30E-07	3.21E-07	4.55E-03	1.00E-12	1.00E-02	constant	-	-	estimated
Catchability coefficient SC Coastspan index	3.93E-07	2.13E-07	4.55E-03	1.00E-12	1.00E-02	constant	-	-	estimated
Catchability coefficient SCDNR Hist red drum index	6.47E-07	3.64E-07	4.55E-03	1.00E-12	1.00E-02	constant	-	-	estimated
Catchability coefficient PCGN index	1.10E-06	5.81E-07	4.55E-03	1.00E-12	1.00E-02	constant	-	-	estimated
Catchability coefficient Com+unrep GOM catch series	0.0018	9.74E-04	4.68E-02	1.00E-06	1.00E-01	constant	-	-	estimated
Catchability coefficient Com+unrep ATL catch series	0.0012	6.63E-04	4.68E-02	1.00E-06	1.00E-01	constant	-	-	estimated
Catchability coefficient Rec+Mex catch series	0.0015	1.36E-03	5.70E-02	1.00E-06	1.00E+00	constant	-	-	estimated
Catchability coefficient menhaden disc catch series	0.0021	7.77E-04	3.44E-03	1.00E-06	1.00E-01	constant	-	-	estimated
Historic effort Com+unrep GOM fleet	0.011	3.05E-03	0.01	0	9.90E-01	lognormal	0.01	(0.3)	estimated
Historic effort Com+unrep ATL fleet	0.010	2.95E-03	0.01	0	9.90E-01	lognormal	0.01	(0.3)	estimated
Historic effort Rec+Mex fleet	0.019	1.90E-02	0	0	9.90E-01	lognormal	0	(0.3)	estimated
Historic effort menhaden discard fleet	0.060	1.68E-02	0.05	0	9.90E-01	lognormal	0.05	(0.3)	estimated
Modern effort Com+unrep GOM fleet	13.8590	3.91E+00	15	0	9.90E-01	lognormal	15	(0.3)	estimated
Modern effort Com+unrep ATL fleet	14.3550	4.05E+00	15	0	9.90E-01	lognormal	15	(0.3)	estimated
Modern effort Rec+Mex fleet	16.2180	4.75E+00	16.2	0	9.90E-01	lognormal	16.2	(0.3)	estimated
Modern effort menhaden discard fleet	0.4149	1.16E-01	0.5	0	9.90E-01	lognormal	0.5	(0.3)	estimated
Overall variance	-3.22E-01	1.55E-02	-2.00E-01	-4.00E+00	-4.00E-02	constant			estimated
Effort deviation for Com+unrep GOM fleet in 1981	-3.28E+00	5.42E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep GOM fleet in 1982	-2.30E+00	6.02E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep GOM fleet in 1983	-2.20E+00	6.02E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep GOM fleet in 1984	-1.88E+00	6.02E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep GOM fleet in 1985	-1.92E+00	6.02E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep GOM fleet in 1986	-8.25E-01	6.02E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep GOM fleet in 1987	2.58E-01	6.02E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep GOM fleet in 1988	6.89E-01	6.02E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep GOM fleet in 1989	1.06E+00	6.03E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep GOM fleet in 1990	9.53E-01	6.02E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep GOM fleet in 1991	1.02E+00	6.02E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep GOM fleet in 1992	8.17E-01	6.02E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep GOM fleet in 1993	4.43E-01	6.03E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep GOM fleet in 1994	1.12E+00	6.04E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep GOM fleet in 1995	6.27E-01	6.06E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep GOM fleet in 1996	2.47E-01	6.08E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated

Effort deviation for Com+unrep GOM fleet in 1997	-1.26E-01	6.09E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep GOM fleet in 1998	3.16E-01	6.11E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep GOM fleet in 1999	-2.03E-01	6.15E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep GOM fleet in 2000	-2.42E-01	6.18E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep GOM fleet in 2001	2.27E-01	6.20E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep GOM fleet in 2002	3.25E-01	6.25E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep GOM fleet in 2003	2.12E-01	6.29E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep GOM fleet in 2004	1.88E-03	6.35E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep GOM fleet in 2005	-2.28E-01	6.41E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep GOM fleet in 2006	2.20E-01	6.45E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep GOM fleet in 2007	-1.03E+00	6.53E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep GOM fleet in 2008	-3.18E+00	6.55E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep GOM fleet in 2009	-1.83E+00	6.53E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep ATL fleet in 1981	-3.46E+00	5.40E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep ATL fleet in 1982	-2.47E+00	6.00E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep ATL fleet in 1983	-2.38E+00	5.99E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep ATL fleet in 1984	-2.06E+00	5.99E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep ATL fleet in 1985	-2.11E+00	5.99E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep ATL fleet in 1986	-1.18E+00	5.99E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep ATL fleet in 1987	-8.67E-02	5.99E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep ATL fleet in 1988	8.32E-01	6.00E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep ATL fleet in 1989	1.12E+00	6.00E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep ATL fleet in 1990	7.43E-01	6.00E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep ATL fleet in 1991	-6.49E-01	6.00E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep ATL fleet in 1992	7.49E-01	6.02E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep ATL fleet in 1993	6.67E-01	6.03E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep ATL fleet in 1994	1.11E+00	6.06E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep ATL fleet in 1995	1.06E+00	6.08E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep ATL fleet in 1996	1.03E+00	6.10E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep ATL fleet in 1997	5.67E-01	6.11E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep ATL fleet in 1998	9.85E-01	6.13E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep ATL fleet in 1999	1.17E+00	6.16E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep ATL fleet in 2000	6.67E-01	6.18E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep ATL fleet in 2001	7.60E-01	6.20E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep ATL fleet in 2002	1.06E+00	6.25E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep ATL fleet in 2003	8.30E-01	6.31E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep ATL fleet in 2004	8.24E-01	6.36E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep ATL fleet in 2005	7.91E-01	6.43E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep ATL fleet in 2006	8.58E-01	6.50E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep ATL fleet in 2007	2.75E-01	6.58E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep ATL fleet in 2008	-1.67E+00	6.58E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep ATL fleet in 2009	-1.84E+00	6.54E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec+Mex fleet in 1981	-2.12E+00	8.18E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec+Mex fleet in 1982	2.42E-01	8.64E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec+Mex fleet in 1983	1.51E+00	1.37E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec+Mex fleet in 1984	7.28E-01	8.62E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec+Mex fleet in 1985	8.30E-01	8.62E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec+Mex fleet in 1986	1.40E+00	8.62E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec+Mex fleet in 1987	1.78E-01	8.62E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec+Mex fleet in 1988	8.17E-01	8.62E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec+Mex fleet in 1989	1.23E-01	8.61E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec+Mex fleet in 1990	8.27E-01	8.61E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec+Mex fleet in 1991	4.64E-01	8.60E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated

Effort deviation for Rec+Mex fleet in 1992	4.90E-01	8.59E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec+Mex fleet in 1993	2.65E-01	8.58E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec+Mex fleet in 1994	-1.59E-02	8.57E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec+Mex fleet in 1995	4.45E-01	8.57E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec+Mex fleet in 1996	8.02E-01	8.57E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec+Mex fleet in 1997	9.24E-01	8.57E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec+Mex fleet in 1998	8.18E-01	8.58E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec+Mex fleet in 1999	4.39E-01	8.58E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec+Mex fleet in 2000	5.44E-02	8.59E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec+Mex fleet in 2001	9.20E-01	8.61E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec+Mex fleet in 2002	-1.87E-01	8.62E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec+Mex fleet in 2003	-5.17E-01	8.63E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec+Mex fleet in 2004	-7.19E-01	8.65E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec+Mex fleet in 2005	-8.85E-01	8.67E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec+Mex fleet in 2006	-1.04E+00	8.70E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec+Mex fleet in 2007	-3.02E-01	8.73E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec+Mex fleet in 2008	-6.39E-01	8.76E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec+Mex fleet in 2009	-6.70E-01	8.75E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden disc fleet in 1981	-1.54E+00	4.89E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden disc fleet in 1982	-1.52E+00	4.92E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden disc fleet in 1983	-1.50E+00	4.92E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden disc fleet in 1984	-1.48E+00	4.93E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden disc fleet in 1985	-1.57E+00	4.93E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden disc fleet in 1986	-1.56E+00	4.92E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden disc fleet in 1987	-1.50E+00	4.92E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden disc fleet in 1988	-1.49E+00	4.92E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden disc fleet in 1989	-1.39E+00	4.92E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden disc fleet in 1990	-1.36E+00	4.92E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden disc fleet in 1991	-1.57E+00	4.93E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden disc fleet in 1992	-1.65E+00	4.94E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden disc fleet in 1993	-1.59E+00	4.95E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden disc fleet in 1994	-1.47E+00	4.97E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden disc fleet in 1995	-1.49E+00	4.99E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden disc fleet in 1996	-1.44E+00	5.02E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden disc fleet in 1997	-1.37E+00	5.06E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden disc fleet in 1998	-1.36E+00	5.11E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden disc fleet in 1999	-1.22E+00	5.16E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden disc fleet in 2000	-1.33E+00	5.20E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden disc fleet in 2001	-1.36E+00	5.26E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden disc fleet in 2002	-1.34E+00	5.32E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden disc fleet in 2003	-1.33E+00	5.38E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden disc fleet in 2004	-1.28E+00	5.44E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden disc fleet in 2005	-1.25E+00	5.50E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden disc fleet in 2006	-1.23E+00	5.57E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden disc fleet in 2007	-1.21E+00	5.63E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden disc fleet in 2008	-1.20E+00	5.67E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden disc fleet in 2009	-1.19E+00	5.68E-01	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated

Table 3.2. Coefficients of variation used for weighting the indices of relative abundance in sensitivity scenario 1.

YEAR	LPS	BLLOP	VA-LL	NMFS LLSE	NMFS Coast age 1+	NMFS-NE	PLLOP	GA-Coastspan	SC-Coastspan	SCDNR-Red dr	PCGN
1960	1	1	1	1	1	1	1	1	1	1	1
1961	1	1	1	1	1	1	1	1	1	1	1
1962	1	1	1	1	1	1	1	1	1	1	1
1963	1	1	1	1	1	1	1	1	1	1	1
1964	1	1	1	1	1	1	1	1	1	1	1
1965	1	1	1	1	1	1	1	1	1	1	1
1966	1	1	1	1	1	1	1	1	1	1	1
1967	1	1	1	1	1	1	1	1	1	1	1
1968	1	1	1	1	1	1	1	1	1	1	1
1969	1	1	1	1	1	1	1	1	1	1	1
1970	1	1	1	1	1	1	1	1	1	1	1
1971	1	1	1	1	1	1	1	1	1	1	1
1972	1	1	1	1	1	1	1	1	1	1	1
1973	1	1	1	1	1	1	1	1	1	1	1
1974	1	1	1	1	1	1	1	1	1	1	1
1975	1	1	0.360	1	1	1	1	1	1	1	1
1976	1	1	1	1	1	1	1	1	1	1	1
1977	1	1	0.522	1	1	1	1	1	1	1	1
1978	1	1	1	1	1	1	1	1	1	1	1
1979	1	1	1	1	1	1	1	1	1	1	1
1980	1	1	0.264	1	1	1	1	1	1	1	1
1981	1	1	0.227	1	1	1	1	1	1	1	1
1982	1	1	1	1	1	1	1	1	1	1	1
1983	1	1	1	1	1	1	1	1	1	1	1
1984	1	1	1	1	1	1	1	1	1	1	1
1985	1	1	1	1	1	1	1	1	1	1	1
1986	0.149	1	1	1	1	1	1	1	1	1	1
1987	0.215	1	1	1	1	1	1	1	1	1	1
1988	0.203	1	1	1	1	1	1	1	1	1	1
1989	0.125	1	1	1	1	1	1	1	1	1	1
1990	0.180	1	0.597	1	1	1	1	1	1	1	1

1991	0.174	1	0.628	1	1	1	1	1	1	1	1
1992	0.185	1	0.898	1	1	1	0.318	1	1	1	1
1993	0.551	1	0.594	1	1	1	0.209	1	1	1	1
1994	0.470	0.170	1	1	1	1	0.231	1	1	1	1
1995	0.575	0.140	0.294	0.257	1	1	0.289	1	1	1	1
1996	0.586	0.150	0.372	0.339	1	0.366	0.382	1	1	1	0.222
1997	0.471	0.180	0.367	0.269	1	1	0.336	1	1	1	0.307
1998	0.978	0.190	0.310	1	1	0.267	0.516	1	0.699	0.464	0.351
1999	0.837	0.210	0.529	0.270	1	1	0.407	1	0.640	0.353	1
2000	0.861	0.310	0.369	0.182	1	1	0.455	2.769	0.924	0.549	1
2001	0.651	0.200	0.341	0.248	0.227	0.272	0.482	1	0.854	0.468	0.351
2002	0.762	0.400	0.518	0.222	0.411	1	1.969	1	0.864	0.402	0.351
2003	0.586	0.370	0.611	0.246	0.241	1	1.970	0.906	0.734	0.365	0.254
2004	0.664	0.380	0.464	0.256	0.270	0.345	0.355	0.890	0.365	0.293	0.423
2005	0.464	0.420	0.491	0.593	0.255	1	0.477	2.062	0.256	0.423	0.423
2006	0.788	0.400	0.290	0.364	0.308	1	0.430	0.707	0.234	0.261	1
2007	0.441	0.410	0.645	0.388	0.286	0.304	0.368	0.517	0.318	1	0.351
2008	0.437	0.430	0.335	0.318	0.488	1	0.281	0.572	0.377	1	0.423
2009	0.389	0.370	0.362	0.211	0.187	0.207	0.279	0.545	0.374	1	0.276

Table 3.3. Additional standardized indices of relative abundance used in sensitivity scenario 2. All indices are scaled (divided by their respective mean). The three indices are bottom longline logbooks (BLL Logs), pelagic longline logbooks (Pel Logs), and the NMFS historical longline survey (NMFS Hist LL).

YEAR	BLL Logs	Pel Logs	NMFS Hist LL
1960	-	-	-
1961	-	-	3.769
1962	-	-	2.111
1963	-	-	1.304
1964	-	-	6.744
1965	-	-	5.425
1966	-	-	-
1967	-	-	0.038
1968	-	-	0.014
1969	-	-	0.214
1970	-	-	0.159
1971	-	-	-
1972	-	-	-
1973	-	-	-
1974	-	-	-
1975	-	-	0.076
1976	-	-	0.072
1977	-	-	0.056
1978	-	-	0.281
1979	-	-	0.459
1980	-	-	0.364
1981	-	-	0.126
1982	-	-	0.344
1983	-	-	0.202
1984	-	-	1.384
1985	-	-	0.581
1986	-	-	0.809
1987	-	-	0.904
1988	-	-	0.124
1989	-	-	0.498
1990	-	-	0.069
1991	-	-	0.794
1992	1.601	-	-
1993	0.671	-	0.079
1994	0.093	0.074	-
1995	0.229	1.589	-
1996	0.793	1.557	-
1997	1.000	1.024	-
1998	1.210	1.103	-
1999	1.443	1.315	-
2000	1.371	1.348	-
2001	1.234	1.182	-
2002	1.291	1.196	-
2003	1.157	1.047	-
2004	0.968	1.208	-
2005	1.009	0.934	-
2006	0.975	0.859	-
2007	0.954	0.521	-
2008	-	0.471	-
2009	-	0.570	-

Table 3.4. Catches of sandbar shark by fleet in numbers used in sensitivity scenario 3. Catches are separated into three fisheries: a single commercial landings + unreported commercial catches, recreational + Mexican catches, and menhaden fishery discards.

Year	Com + Un	REC+MEX	Menhaden disc
1960	85	65	504
1961	169	129	504
1962	254	194	504
1963	339	259	504
1964	424	323	504
1965	508	388	504
1966	593	453	504
1967	678	517	504
1968	763	582	504
1969	847	647	504
1970	932	711	504
1971	1017	776	504
1972	1101	841	504
1973	1186	905	504
1974	1271	970	504
1975	1356	1035	504
1976	1383	1036	504
1977	1474	1079	504
1978	1764	2310	504
1979	2581	25366	504
1980	4309	97983	504
1981	6640	138933	696
1982	6640	45401	713
1983	7173	426979	705
1984	9797	68135	705
1985	9100	75593	635
1986	25826	134151	626
1987	73984	37438	653
1988	124681	72789	635
1989	160713	34532	670
1990	122440	68479	653
1991	96681	44428	505
1992	100593	43450	444
1993	71978	32922	452
1994	126274	23411	486
1995	84398	35206	445
1996	65545	46817	444
1997	41465	49315	452
1998	62655	41846	435
1999	53299	27329	479
2000	37324	17794	409
2001	48182	42127	383
2002	56360	13062	374
2003	45229	9252	365
2004	39139	7395	374
2005	33374	6126	374
2006	42117	5059	374
2007	16913	10638	374
2008	2153	7324	374
2009	3986	7026	374

Table 3.5. Values of natural mortality (M, instantaneous natural mortality rate) at age obtained by applying a U-shaped equation in sensitivity scenario 7.

Age	U-shaped M
1	0.2809
2	0.2338
3	0.1956
4	0.1647
5	0.1398
6	0.1200
7	0.1042
8	0.0918
9	0.0824
10	0.0753
11	0.0702
12	0.0668
13	0.0650
14	0.0644
15	0.0650
16	0.0667
17	0.0693
18	0.0728
19	0.0772
20	0.0825
21	0.0886
22	0.0956
23	0.1035
24	0.1124
25	0.1222
26	0.1331
27	0.1451

Table 3.6. Ranks used for weighting the indices of relative abundance in sensitivity scenario 9.

YEAR	LPS	BLLOP	VA-LL	NMFS LLSE	NMFS Coast age 1+	NMFS-NE	PLLOP	GA-Coastspan	SC-Coastspan	SCDNR-Red dr	PCGN
1960	5	2	2	1	2	2	2	4	3	3	4
1961	5	2	2	1	2	2	2	4	3	3	4
1962	5	2	2	1	2	2	2	4	3	3	4
1963	5	2	2	1	2	2	2	4	3	3	4
1964	5	2	2	1	2	2	2	4	3	3	4
1965	5	2	2	1	2	2	2	4	3	3	4
1966	5	2	2	1	2	2	2	4	3	3	4
1967	5	2	2	1	2	2	2	4	3	3	4
1968	5	2	2	1	2	2	2	4	3	3	4
1969	5	2	2	1	2	2	2	4	3	3	4
1970	5	2	2	1	2	2	2	4	3	3	4
1971	5	2	2	1	2	2	2	4	3	3	4
1972	5	2	2	1	2	2	2	4	3	3	4
1973	5	2	2	1	2	2	2	4	3	3	4
1974	5	2	2	1	2	2	2	4	3	3	4
1975	5	2	2	1	2	2	2	4	3	3	4
1976	5	2	2	1	2	2	2	4	3	3	4
1977	5	2	2	1	2	2	2	4	3	3	4
1978	5	2	2	1	2	2	2	4	3	3	4
1979	5	2	2	1	2	2	2	4	3	3	4
1980	5	2	2	1	2	2	2	4	3	3	4
1981	5	2	2	1	2	2	2	4	3	3	4
1982	5	2	2	1	2	2	2	4	3	3	4
1983	5	2	2	1	2	2	2	4	3	3	4
1984	5	2	2	1	2	2	2	4	3	3	4
1985	5	2	2	1	2	2	2	4	3	3	4
1986	5	2	2	1	2	2	2	4	3	3	4
1987	5	2	2	1	2	2	2	4	3	3	4
1988	5	2	2	1	2	2	2	4	3	3	4
1989	5	2	2	1	2	2	2	4	3	3	4
1990	5	2	2	1	2	2	2	4	3	3	4

1991	5	2	2	1	2	2	2	4	3	3	4
1992	5	2	2	1	2	2	2	4	3	3	4
1993	5	2	2	1	2	2	2	4	3	3	4
1994	5	2	2	1	2	2	2	4	3	3	4
1995	5	2	2	1	2	2	2	4	3	3	4
1996	5	2	2	1	2	2	2	4	3	3	4
1997	5	2	2	1	2	2	2	4	3	3	4
1998	5	2	2	1	2	2	2	4	3	3	4
1999	5	2	2	1	2	2	2	4	3	3	4
2000	5	2	2	1	2	2	2	4	3	3	4
2001	5	2	2	1	2	2	2	4	3	3	4
2002	5	2	2	1	2	2	2	4	3	3	4
2003	5	2	2	1	2	2	2	4	3	3	4
2004	5	2	2	1	2	2	2	4	3	3	4
2005	5	2	2	1	2	2	2	4	3	3	4
2006	5	2	2	1	2	2	2	4	3	3	4
2007	5	2	2	1	2	2	2	4	3	3	4
2008	5	2	2	1	2	2	2	4	3	3	4
2009	5	2	2	1	2	2	2	4	3	3	4

Table 3.7. Standardized hierarchical index of relative abundance used in sensitivity scenario 10 with associated CVs. The index is scaled (divided by the mean).

YEAR	Hierarchical index	CV
1960	-	-
1961	-	-
1962	-	-
1963	-	-
1964	-	-
1965	-	-
1966	-	-
1967	-	-
1968	-	-
1969	-	-
1970	-	-
1971	-	-
1972	-	-
1973	-	-
1974	-	-
1975	-	-
1976	-	-
1977	-	-
1978	-	-
1979	-	-
1980	-	-
1981	-	-
1982	-	-
1983	-	-
1984	-	-
1985	-	-
1986	2.90	0.56
1987	1.14	0.58
1988	2.66	0.57
1989	3.10	0.56
1990	0.81	0.49
1991	1.22	0.51
1992	1.22	0.44
1993	1.03	0.44
1994	0.59	0.37
1995	0.69	0.29
1996	0.52	0.28
1997	0.75	0.26
1998	0.71	0.28
1999	0.56	0.29
2000	0.46	0.29
2001	0.76	0.25
2002	0.42	0.27
2003	0.49	0.28
2004	0.52	0.27
2005	0.46	0.29
2006	0.59	0.28
2007	0.61	0.29
2008	0.57	0.29
2009	1.23	0.28

Table 3.8. Low catch scenario of sandbar shark used in sensitivity scenario 12. Catches are by fleet in numbers.

Year	Com+Un (GOM)	Com + Un (SA)	REC+MEX	Menhaden disc
1960	59	25	27	504
1961	119	51	29	504
1962	178	76	31	504
1963	237	102	33	504
1964	297	127	35	504
1965	356	152	38	504
1966	415	178	40	504
1967	475	203	43	504
1968	534	228	46	504
1969	593	254	50	504
1970	653	279	53	504
1971	712	305	57	504
1972	771	330	61	504
1973	831	355	65	504
1974	890	381	70	504
1975	949	406	75	504
1976	969	414	75	504
1977	1033	442	78	504
1978	1236	529	167	504
1979	1807	773	1838	504
1980	3018	1291	7098	504
1981	4650	1990	10065	696
1982	4650	1990	11822	713
1983	5024	2149	11649	705
1984	6861	2936	11708	705
1985	6373	2727	8612	635
1986	11486	821	12174	626
1987	32833	2317	6962	653
1988	52727	36240	10314	635
1989	65555	30802	8480	670
1990	49948	1717	18455	653
1991	48662	4209	12153	505
1992	37590	16827	10678	444
1993	24452	14485	13117	452
1994	51442	23818	10636	486
1995	25911	18684	12808	445
1996	15991	16634	11519	444
1997	10271	9827	18065	452
1998	13944	13134	7893	435
1999	8236	16034	7976	479
2000	10716	13119	7133	409
2001	14199	11928	6900	383
2002	16474	17200	5071	374
2003	14134	12882	4338	365
2004	10868	12160	4258	374
2005	9243	12621	4420	374
2006	14213	12879	4692	374
2007	3990	7132	4244	374
2008	458	1020	2570	374
2009	1904	902	2696	374

Table 3.9. High catch scenario of sandbar shark used in sensitivity scenario 13. Catches are by fleet in numbers.

Year	Com+Un (GOM)	Com + Un (SA)	REC+MEX	Menhaden discards
1960	59	25	1000	504
1961	119	51	1071	504
1962	178	76	1148	504
1963	237	102	1230	504
1964	297	127	1318	504
1965	356	152	1412	504
1966	415	178	1513	504
1967	475	203	1621	504
1968	534	228	1737	504
1969	593	254	1861	504
1970	653	279	1994	504
1971	712	305	2136	504
1972	771	330	2288	504
1973	831	355	2452	504
1974	890	381	2627	504
1975	949	406	2815	504
1976	969	414	2819	504
1977	1033	442	2936	504
1978	1236	529	6282	504
1979	1807	773	68999	504
1980	3018	1291	266524	504
1981	4650	1990	377914	696
1982	4650	1990	96519	713
1983	5024	2149	974681	705
1984	6861	2936	151169	705
1985	6373	2727	174849	635
1986	87941	36453	303420	626
1987	252228	104605	90040	653
1988	315537	147965	158186	635
1989	470208	212194	74671	670
1990	436442	184276	134740	653
1991	463139	41001	87011	505
1992	366158	163904	88165	444
1993	238181	141098	58110	452
1994	267907	124046	41199	486
1995	456216	328966	70361	445
1996	256149	266450	99651	444
1997	171033	163646	91865	452
1998	200559	188916	99555	435
1999	265109	516107	56976	479
2000	38660	47329	33210	409
2001	167980	141118	85714	383
2002	84495	88219	27360	374
2003	72617	66185	18612	365
2004	61501	68807	13372	374
2005	29797	40687	9491	374
2006	49614	44957	5557	374
2007	12659	22626	22139	374
2008	1228	2731	15773	374
2009	4669	2212	13526	374

Table 3.10. Low and high values of age-specific natural mortality of sandbar shark used in sensitivity scenarios 14 and 15.

Age	Low M	High M
1	0.1389	0.1697
2	0.1389	0.1697
3	0.1389	0.1697
4	0.1389	0.1697
5	0.1389	0.1697
6	0.1389	0.1697
7	0.1389	0.1697
8	0.1379	0.1686
9	0.1333	0.1629
10	0.1180	0.1443
11	0.1180	0.1443
12	0.1180	0.1443
13	0.1180	0.1443
14	0.1180	0.1443
15	0.1179	0.1441
16	0.1165	0.1424
17	0.1153	0.1409
18	0.1142	0.1396
19	0.1133	0.1384
20	0.1125	0.1375
21	0.1118	0.1366
22	0.1112	0.1359
23	0.1106	0.1352
24	0.1102	0.1346
25	0.1097	0.1341
26	0.1094	0.1337
27	0.1091	0.1333

Table 3.11. Alternative historic catches of sandbar shark used in sensitivity scenario 16. Catches are by fleet in numbers.

Year	Com+Un (GOM)	Com + Un (SA)	REC+MEX	Menhaden discards
1960	0	0	0	504
1961	221	95	6616	504
1962	443	189	13232	504
1963	664	284	19848	504
1964	886	379	26463	504
1965	1107	474	33079	504
1966	1329	568	39695	504
1967	1550	663	46311	504
1968	1772	758	52927	504
1969	1993	853	59543	504
1970	2214	947	66159	504
1971	2436	1042	72774	504
1972	2657	1137	79390	504
1973	2879	1232	86006	504
1974	3100	1326	92622	504
1975	3322	1421	99238	504
1976	3543	1516	105854	504
1977	3765	1611	112470	504
1978	3986	1705	119085	504
1979	4207	1800	125701	504
1980	4429	1895	132317	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 3.12. Predicted abundance (numbers), total biomass (kg), and spawning stock fecundity (numbers) of sandbar shark for the base run.

Year	N	B	SSF
1960	4,136,052	88,307,548	1,157,184
1961	4,135,480	88,294,090	1,157,010
1962	4,134,619	88,274,185	1,156,732
1963	4,133,523	88,249,192	1,156,395
1964	4,132,124	88,217,597	1,155,981
1965	4,130,510	88,180,897	1,155,490
1966	4,128,645	88,138,044	1,154,922
1967	4,126,575	88,089,966	1,154,274
1968	4,124,267	88,035,502	1,153,528
1969	4,121,738	87,975,820	1,152,724
1970	4,119,018	87,911,547	1,151,850
1971	4,116,115	87,842,350	1,150,900
1972	4,113,000	87,767,679	1,149,871
1973	4,109,733	87,689,191	1,148,772
1974	4,106,229	87,604,799	1,147,593
1975	4,102,552	87,516,177	1,146,338
1976	4,098,701	87,423,467	1,145,037
1977	4,094,689	87,326,255	1,143,642
1978	4,090,482	87,224,521	1,142,178
1979	4,086,122	87,119,246	1,140,667
1980	4,081,608	87,010,124	1,139,070
1981	4,076,893	86,896,459	1,137,423
1982	4,071,819	86,773,595	1,135,623
1983	4,025,192	86,137,310	1,130,645
1984	3,882,774	84,458,374	1,123,653
1985	3,834,516	83,300,472	1,115,474
1986	3,784,642	82,110,607	1,107,222
1987	3,671,804	79,837,404	1,086,772
1988	3,603,422	76,582,667	1,034,921
1989	3,442,693	71,293,576	946,597
1990	3,269,287	65,311,505	837,586
1991	3,088,063	60,884,602	758,891
1992	2,949,985	57,897,374	704,227
1993	2,805,026	54,684,577	644,964
1994	2,692,431	52,540,571	603,754
1995	2,530,868	48,700,128	536,991
1996	2,391,551	46,166,875	494,628
1997	2,259,984	44,116,196	464,346
1998	2,154,324	42,800,641	449,447
1999	2,041,650	40,720,368	425,258
2000	1,954,665	38,982,212	405,796
2001	1,894,891	37,912,155	397,026
2002	1,806,557	36,256,021	383,467
2003	1,740,611	34,525,532	365,366
2004	1,688,826	33,268,064	353,121

2005	1,645,191	32,247,512	343,206
2006	1,608,720	31,436,577	335,358
2007	1,565,308	30,383,263	323,068
2008	1,541,327	30,139,700	322,934
2009	1,539,102	30,431,026	330,902

Table 3.13. Estimated total and fleet-specific instantaneous fishing mortality rates by year.

Year	Total F	Fleet-specific F Com+Un (GOM)	Com + Un (SA)	REC+MEX	Menhaden disc
1960	0.00016	0.00002	0.00001	0.00003	0.00013
1961	0.00030	0.00006	0.00004	0.00017	0.00013
1962	0.00044	0.00011	0.00006	0.00031	0.00013
1963	0.00058	0.00015	0.00009	0.00045	0.00013
1964	0.00072	0.00019	0.00011	0.00059	0.00013
1965	0.00086	0.00023	0.00014	0.00072	0.00013
1966	0.00101	0.00028	0.00017	0.00086	0.00013
1967	0.00115	0.00032	0.00019	0.00100	0.00013
1968	0.00129	0.00036	0.00022	0.00114	0.00013
1969	0.00143	0.00041	0.00024	0.00128	0.00013
1970	0.00157	0.00045	0.00027	0.00142	0.00013
1971	0.00171	0.00049	0.00029	0.00156	0.00013
1972	0.00185	0.00053	0.00032	0.00170	0.00013
1973	0.00200	0.00058	0.00034	0.00184	0.00013
1974	0.00214	0.00062	0.00037	0.00198	0.00013
1975	0.00228	0.00066	0.00039	0.00212	0.00013
1976	0.00242	0.00071	0.00042	0.00226	0.00013
1977	0.00256	0.00075	0.00045	0.00239	0.00013
1978	0.00270	0.00079	0.00047	0.00253	0.00013
1979	0.00284	0.00084	0.00050	0.00267	0.00013
1980	0.00299	0.00088	0.00052	0.00281	0.00013
1981	0.00319	0.00092	0.00055	0.00295	0.00019
1982	0.03147	0.00247	0.00147	0.03128	0.00019
1983	0.11148	0.00273	0.00161	0.11141	0.00019
1984	0.05108	0.00377	0.00221	0.05086	0.00020
1985	0.05654	0.00360	0.00210	0.05636	0.00018
1986	0.09998	0.01079	0.00537	0.09931	0.00018
1987	0.04807	0.03186	0.01597	0.02936	0.00020
1988	0.08935	0.04901	0.04001	0.05560	0.00020
1989	0.12463	0.07083	0.05332	0.02778	0.00022
1990	0.10083	0.06380	0.03662	0.05619	0.00022
1991	0.07743	0.06798	0.00910	0.03907	0.00018
1992	0.09286	0.05572	0.03682	0.04012	0.00017
1993	0.07254	0.03834	0.03394	0.03203	0.00018
1994	0.12910	0.07559	0.05302	0.02418	0.00020
1995	0.09653	0.04609	0.05009	0.03834	0.00020
1996	0.08070	0.03150	0.04885	0.05478	0.00021
1997	0.06348	0.02169	0.03068	0.06188	0.00022
1998	0.08074	0.03375	0.04663	0.05568	0.00023
1999	0.07637	0.02010	0.05586	0.03810	0.00026
2000	0.05355	0.01932	0.03394	0.02594	0.00023
2001	0.06846	0.03087	0.03723	0.06163	0.00022
2002	0.08490	0.03405	0.05049	0.02038	0.00023
2003	0.07068	0.03043	0.03993	0.01465	0.00023
2004	0.06467	0.02466	0.03970	0.01197	0.00024
2005	0.05830	0.01959	0.03840	0.01014	0.00025
2006	0.07207	0.03065	0.04107	0.00864	0.00026
2007	0.03205	0.00883	0.02293	0.01817	0.00026
2008	0.01323	0.00103	0.00326	0.01297	0.00026
2009	0.01305	0.00395	0.00275	0.01257	0.00027

Table 3.14. Summary of results for base and sensitivity runs for sandbar shark. R_0 is the number of age-1 pups at virgin conditions. SSF is spawning stock fecundity (sum of number at age times pup production at age). All biomass metrics are in kg, except for MSY (numbers). AICc is the Akaike Information Criterion for small sample sizes, which converges to the AIC statistic as the number of data points gets large. Sensitivity runs are: S1 (inverse CV weighting), S2 (all indices), S3 (combined catches), S4 (combined catches and inverse CV weighting), S5 (2-yr cycle), S6 (3-yr cycle), S7 (U-shaped M), S8 (fishery-independent indices only), S9 (ranked indices), S10 (hierarchical index), S11 (hierarchical index, no weighting), S12 (low catch), S13 (high catch), S14 (low M), S15 (high M), and S16 (alternative historic catch).

	Base		S1		S2		S3		S4		S5		S6	
	Est	CV	Est	CV	Est	CV	Est	CV	Est	CV	Est	CV	Est	CV
AICc	718.01		652.84		767.34		617.71		538.54		717.81		718.71	
Objective function	117.95		85.37		158.18		133.56		93.98		117.85		118.30	
SSF_{2009}/SSF_{MSY}	**0.66**	0.83	**0.56**	0.70	**0.81**	0.52	**0.78**	0.73	**0.58**	0.73	**0.64**	0.71	**0.66**	1.09
F_{2009}/F_{MSY}	**0.62**	0.57	**0.62**	0.44	**0.46**	0.52	**0.53**	0.30	**0.61**	0.30	**0.46**	0.55	**0.93**	0.61
N_{2009}/N_{MSY}	0.74	---	0.38	---	0.49	---	0.48	---	0.38	---	0.43	---	0.43	---
MSY	160643	---	264367	---	313002	---	299543	---	252875	---	264927	---	313581	---
SPR_{MSY}	0.78	0.06	0.74	0.09	0.77	0.11	0.79	0.01	0.74	0.01	0.69	0.09	0.86	0.04
F_{MSY}	0.021	---	0.025	---	0.022	---	0.020	---	0.026	---	0.030	---	0.030	---
SSF_{MSY}	477590	---	430320	---	507410	---	509800	---	402450	---	503420	---	503420	---
N_{MSY}	1928165	---	3120188	---	3741763	---	3608844	---	2971324	---	3063451	---	3639906	---
F_{2009}	0.01	0.57	0.02	0.44	0.01	---	0.01	0.30	0.02	0.30	0.01	0.55	0.01	0.61
SSF_{2009}	312890	0.60	240950	0.40	410450	0.38	397980	0.37	234890	0.37	319760	0.59	313510	0.63
N_{2009}	1539102	---	1277408	---	1966818	---	1857216	---	1219683	---	1408804	---	1688767	---
SSF_{2009}/SSF_0	0.28	0.41	0.24	0.27	0.34	0.33	0.35	0.25	0.24	0.25	0.25	0.42	0.32	0.41
B_{2009}/B_0	0.34	0.33	0.30	0.18	0.40	0.27	0.40	0.18	0.30	0.18	0.33	0.33	0.35	0.34
R_0	563490	0.20	516900	0.14	612910	0.08	587230	0.16	494350	0.16	516810	0.18	612140	0.23
Pup-survival	0.84	0.29	0.94	0.30	0.86	0.00	0.82	0.29	0.94	0.29	0.84	0.29	0.84	0.29
alpha	1.64	---	1.84	---	1.67	---	1.59	---	1.82	---	2.05	---	1.37	---
steepness	0.29	---	0.31	---	0.29	---	0.28	---	0.31	---	0.34	---	0.25	---

Table 3.14 (continued)

	S7		S8		S9		S10		S11		S12		S13	
	Est	CV	Est	CV	Est	CV	Est	CV	Est	CV	Est	CV	Est	CV
AICc	717.40		721.25		791.27		753.73		781.79		712.71		716.79	
Objective function	117.644		93.60		154.58		51.94		65.97		115.30		117.34	
SSF_{2009}/SSF_{MSY}	**0.57**	0.59	**1.17**	0.83	**0.66**	0.85	**0.61**	0.82	**0.41**	1.07	**0.66**	0.79	**0.77**	0.81
F_{2009}/F_{MSY}	**0.41**	0.51	**0.26**	0.95	**0.63**	1.02	**0.67**	0.57	**1.14**	0.83	**0.70**	0.57	**0.21**	0.58
N_{2009}/N_{MSY}	0.43	---	0.67	---	0.42	---	0.39	---	0.27	---	0.43	---	0.46	---
MSY	225930	---	427070	---	292289	---	282174	---	252619	---	145726	---	1350123	---
SPR_{MSY}	0.62	0.11	0.78	0.06	0.79	0.05	0.78	0.07	0.79	0.06	0.78	0.07	0.78	0.06
F_{MSY}	0.044	---	0.021	---	0.020	---	0.021	---	0.020	---	0.014	---	0.023	---
SSF_{MSY}	543750	---	721400	---	491570	---	471350	---	418530	---	249020	---	2233800	---
N_{MSY}	2501535	---	5128279	---	3522572	---	3386675	---	3046233	---	1770890	---	16150499	---
F_{2009}	0.02	0.51	0.01	0.95	0.01	1.02	0.01	0.57	0.02	0.83	0.01	0.57	0.00	0.58
SSF_{2009}	312140	0.56	841940	1.04	326150	1.07	288810	0.59	172330	0.89	163310	0.62	1722400	0.59
N_{2009}	1163572	---	3720384	---	1583756	---	1436508	---	900438	---	823421	---	7932433	---
SSF_{2009}/SSF_0	0.22	0.43	0.52	0.50	0.29	0.48	0.27	0.41	0.18	0.71	0.29	0.41	0.33	0.37
B_{2009}/B_0	0.30	0.33	0.56	0.41	0.35	0.42	0.32	0.33	0.23	0.59	0.36	0.32	0.38	0.31
R_0	439030	0.15	836730	0.55	572880	0.59	552790	0.19	495180	0.19	285570	0.21	2644800	0.22
Pup-survival	0.85	0.29	0.85	0.29	0.83	0.29	0.85	0.29	0.81	0.29	0.86	0.29	0.84	0.29
alpha	2.69	---	1.65	---	1.61	---	1.65	---	1.59	---	1.68	---	1.63	---
steepness	0.40	---	0.29	---	0.29	---	0.29	---	0.28	---	0.30	---	0.29	---

Table 3.14 (continued)

	S14		S15		S16	
	Est	CV	Est	CV	Est	CV
AICc	717.87		718.21		134.36	
Objective function	117.88		118.05		-173.87	
SSF_{2009}/SSF_{MSY}	**0.59**	0.65	**0.75**	1.65	**0.83**	1.25
F_{2009}/F_{MSY}	**0.48**	0.54	**1.15**	0.59	**0.75**	0.36
N_{2009}/N_{MSY}	0.77	---	0.74	---	0.88	---
MSY	136654	---	188038	---	227970	---
SPR_{MSY}	0.68	0.09	0.90	0.03	0.89	0.01
F_{MSY}	0.033	---	0.009	---	0.010	---
SSF_{MSY}	479160	---	481340	---	779320	---
N_{MSY}	1569644	---	2366861	---	2862847	---
F_{2009}	0.02	0.54	0.01	0.59	0.01	0.36
SSF_{2009}	282080	0.59	361100	0.59	644450	0.44
N_{2009}	1309279	---	1889311	---	2714925	---
SSF_{2009}/SSF_0	0.24	0.43	0.33	0.37	0.39	0.24
B_{2009}/B_0	0.32	0.34	0.36	0.32	0.42	0.19
R_0	436380	0.17	744630	0.23	849350	0.20
Pup-survival	0.84	0.29	0.85	0.28	0.65	0.27
alpha	2.23	---	1.23	---	1.26	---
steepness	0.36	---	0.23	---	0.24	---

Table 3.15. Summary of results for continuity run and 2006 base run for sandbar shark. R_0 is the number of age-1 pups at virgin conditions. SSF is spawning stock fecundity (sum of number at age times pup production at age). All biomass metrics are in kg, except for MSY (numbers). AICc is the Akaike Information Criterion for small sample sizes, which converges to the AIC statistic as the number of data points gets large.

	Continuity		2006 Base	
	Est	CV	Est	CV
AICc	253.02		145.13	
Objective function	-80.11		-118.92	
SSF_{cur}/SSF_{MSY}	**0.80**	0.70	**0.72**	0.46
F_{cu}/F_{MSY}	**0.37**	1.50	**3.72**	0.15
N_{cur}/N_{MSY}	0.90	---	0.79	---
MSY	147058	---	138304	---
SPR_{MSY}	0.65	0.39	0.73	0.02
F_{MSY}	0.06	---	0.02	---
SSF_{MSY}	556810	---	594300	---
N_{MSY}	1737724	---	1769980	---
F_{cur}	0.02	1.50	0.06	0.15
SSF_{cur}	444130	0.59	428340	0.19
N_{cur}	1685467	---	1520555	---
SSF_{cur}/SSF_0	0.32	0.53	0.31	0.13
B_{cur}/B_0	0.39	0.54	0.35	0.10
R_0	467100	0.25	461100	0.07
Pup-survival	0.79	0.23	0.62	0.27
alpha	2.38	---	1.88	---
steepness	0.37	---	0.32	---

cur = 2009 for continuity, 2004 for Base 2006 assessment

3.7. FIGURES

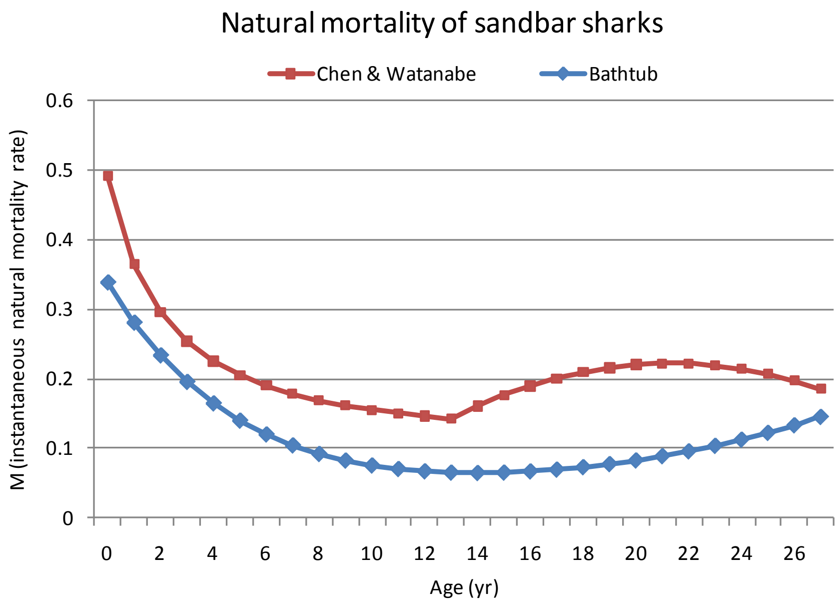


Figure 3.1. Natural mortality at age derived from the Chen and Watanabe (1989) and “bathtub” methods. The “bathtub” method was used to approximate the values of the Chen and Watanabe method while providing a better U shape.

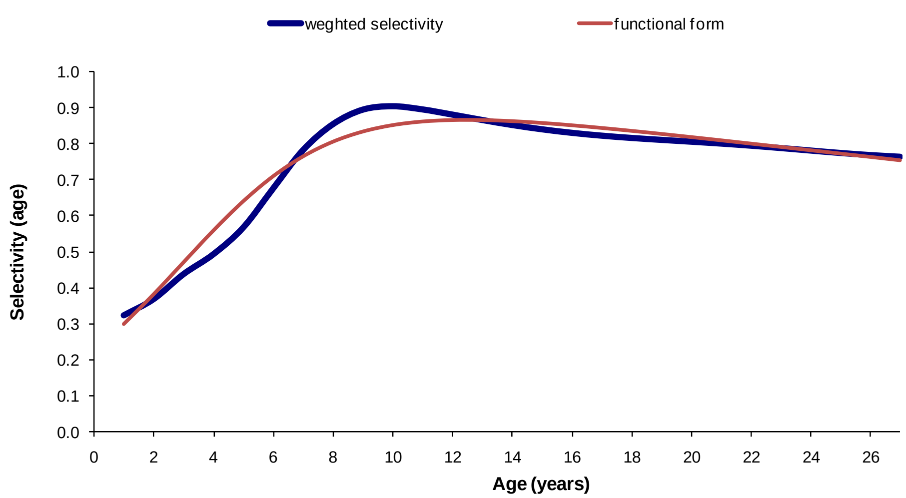
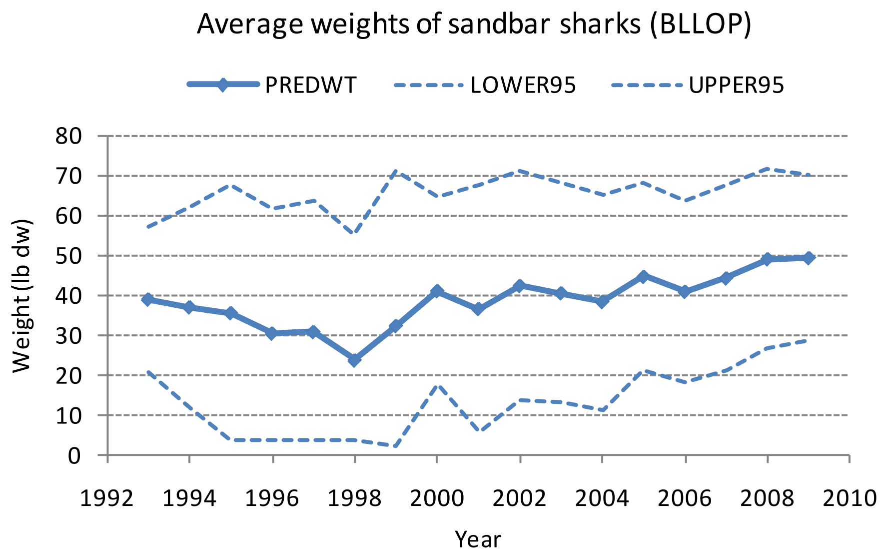


Figure 3.2. Selectivity for the hierarchical index. “Weighted selectivity” is the selectivity obtained by weighting the base run selectivities by the inverse variance selectivity weights reported in SEDAR-21-AW-01; “functional form” is an approximation of the weighted selectivity for input into sensitivity scenarios 10 and 11.

A



B

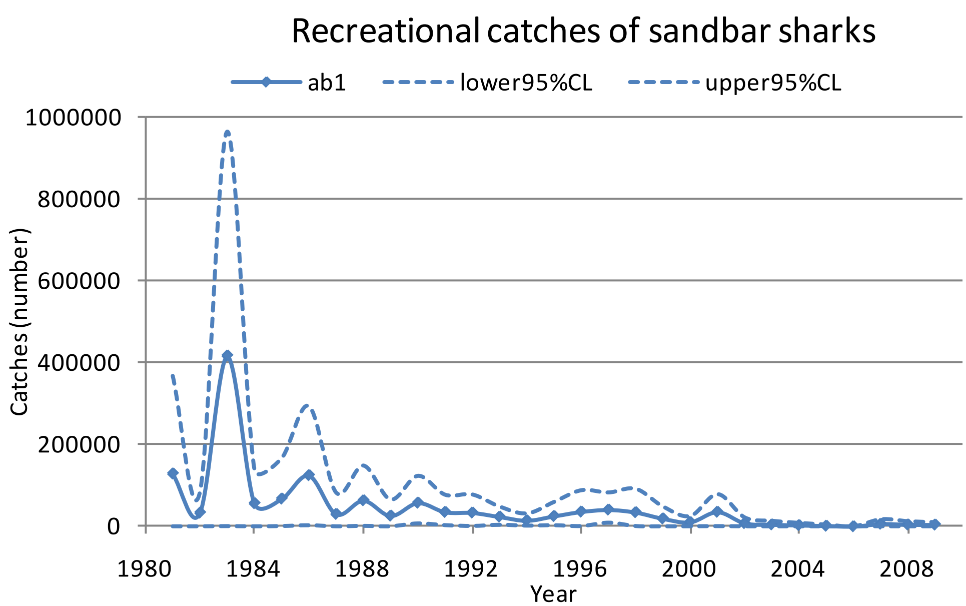


Figure 3.3. A) Average weights of sandbar shark from the bottom longline observer program showing mean and upper and lower 95% CIs; B) Recreational catches of sandbar shark (sum of animals landed and discard dead) showing mean and upper and lower 95% CIs.

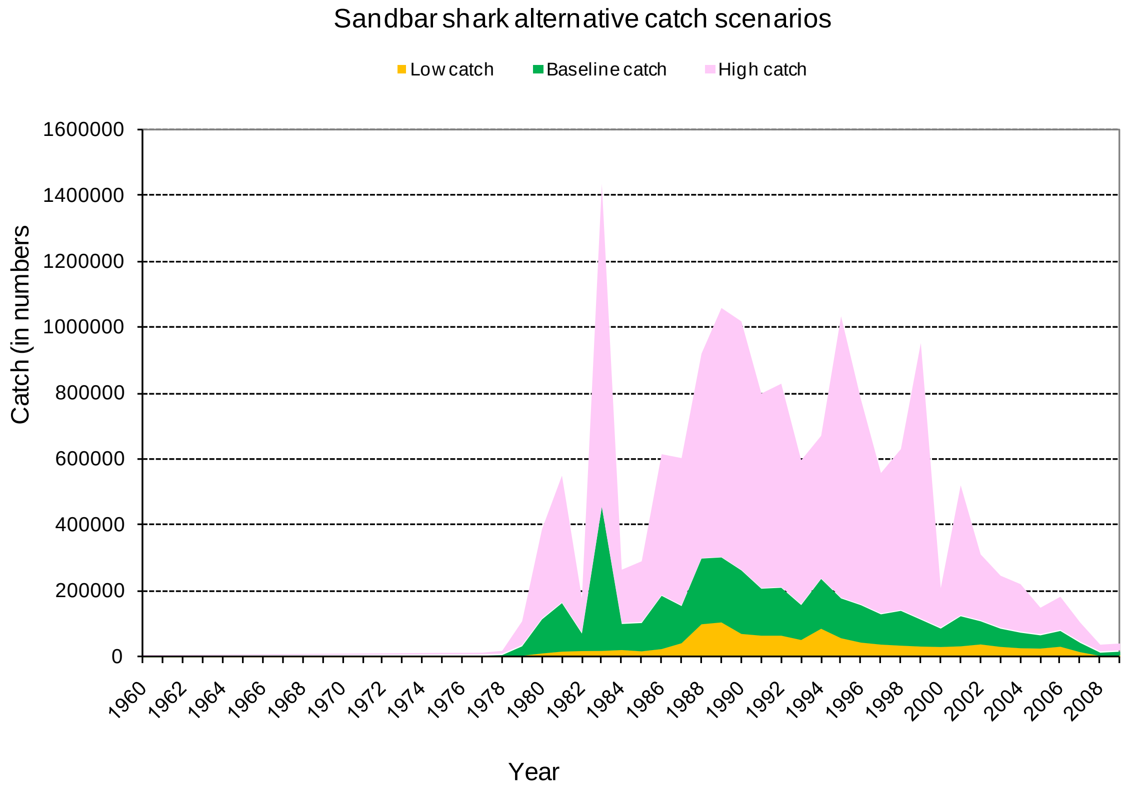


Figure 3.4. Low and high catch estimates for sandbar shark used in sensitivity scenarios 12 and 13. Catch series are stacked.

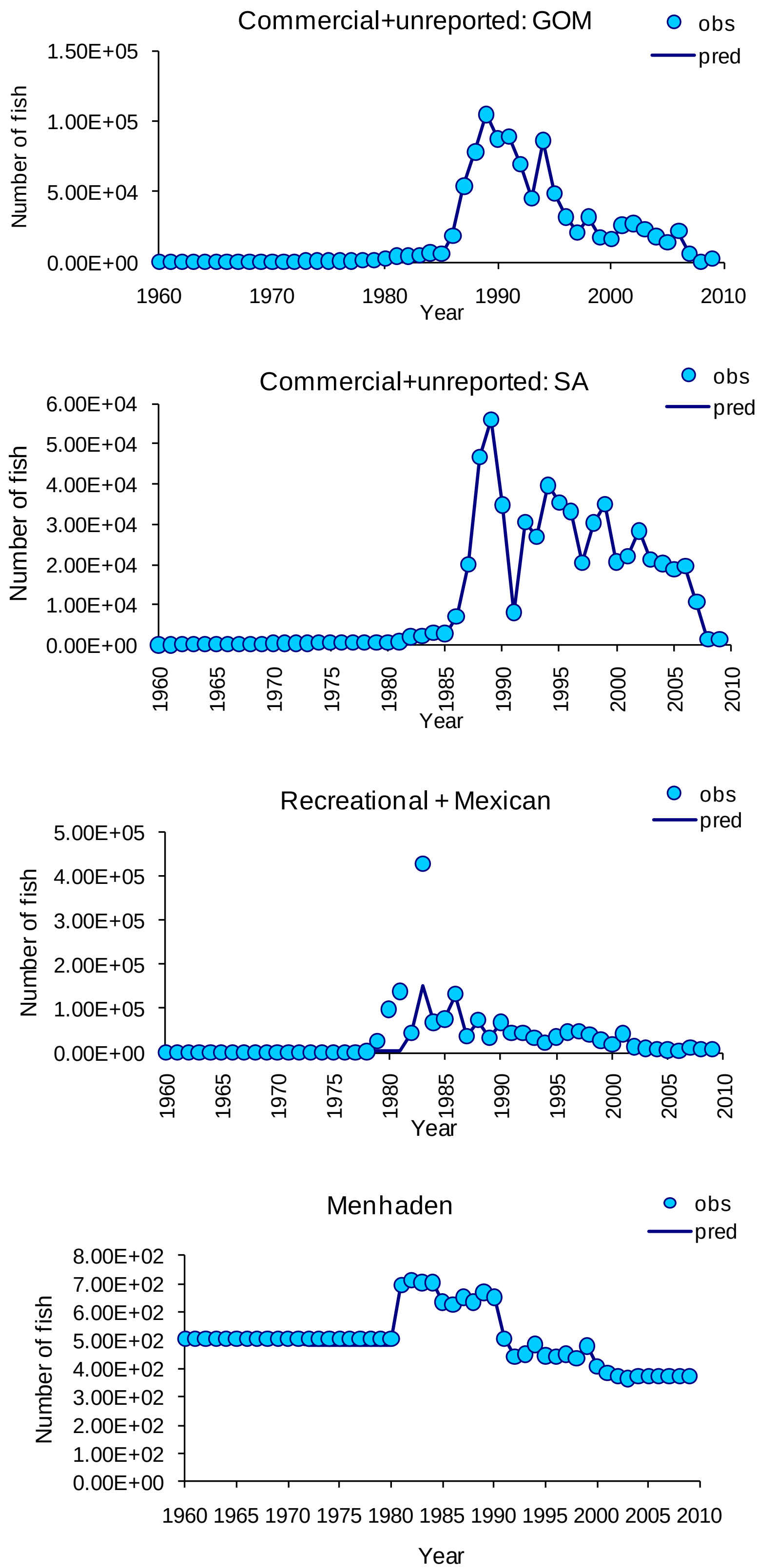


Figure 3.5. Predicted fits to catch data for the base run.

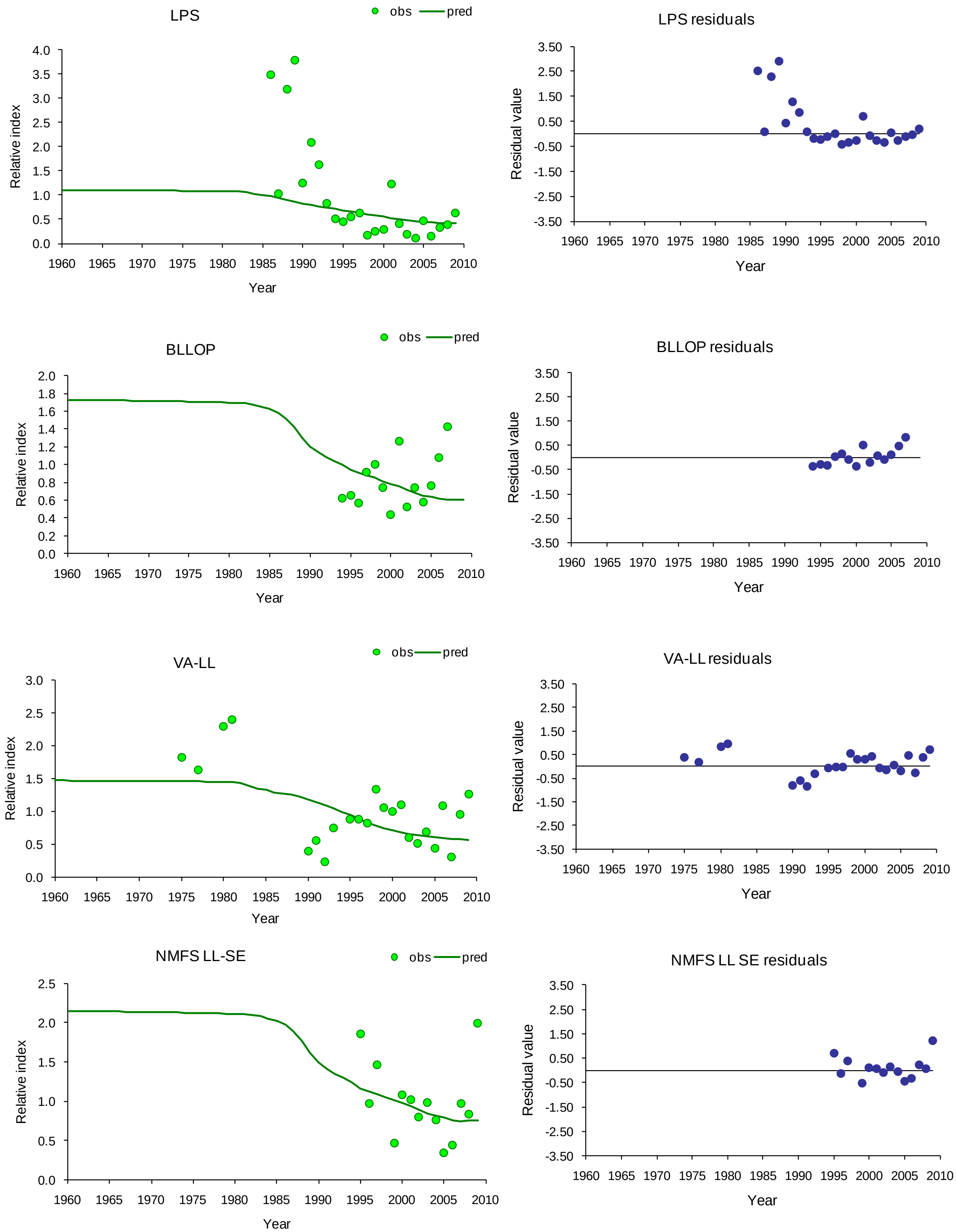


Figure 3.6. Predicted fits to indices (left) and residual plots (right) for the base run.

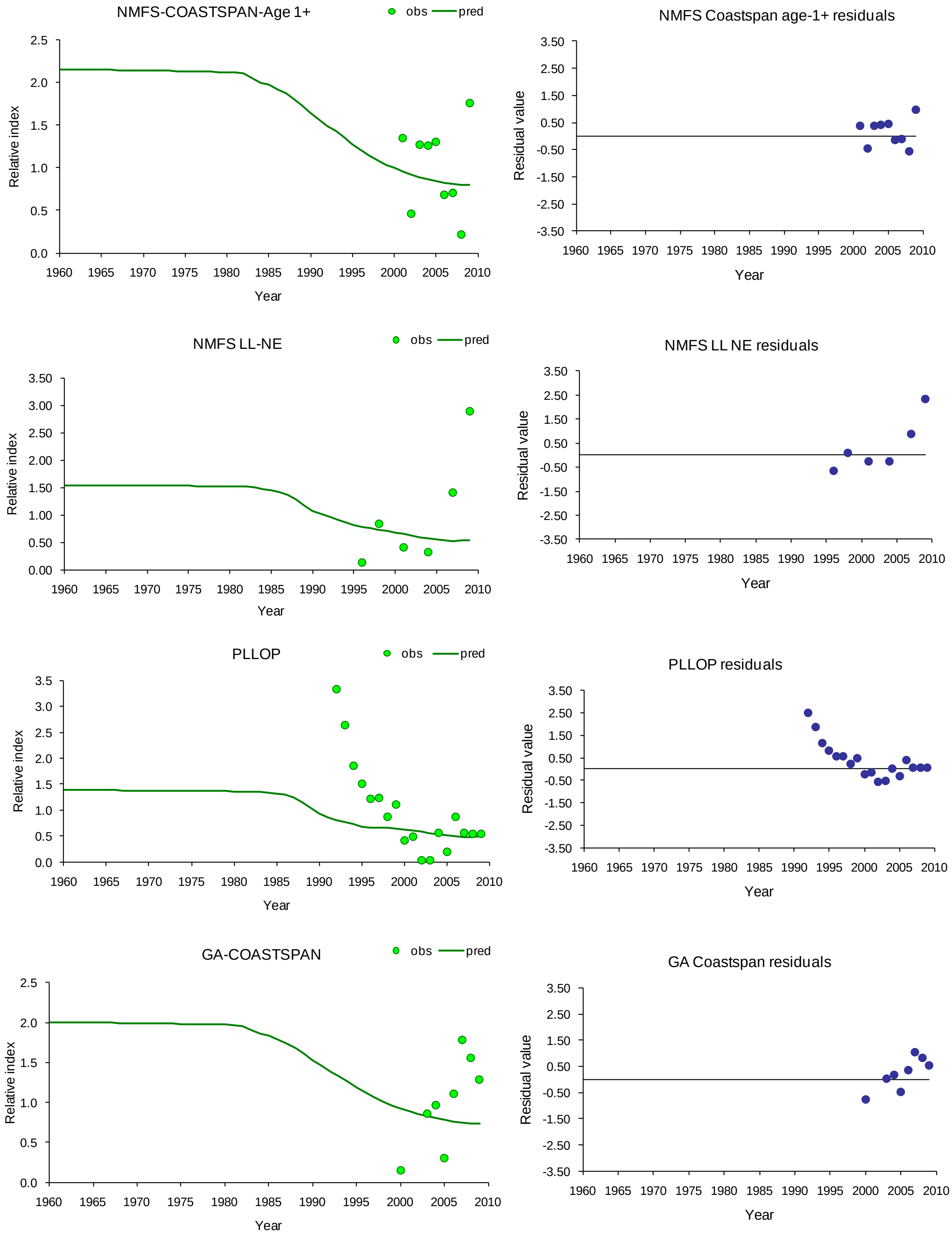


Figure 3.6 (continued). Predicted fits to indices (left) and residual plots (right) for the base run.

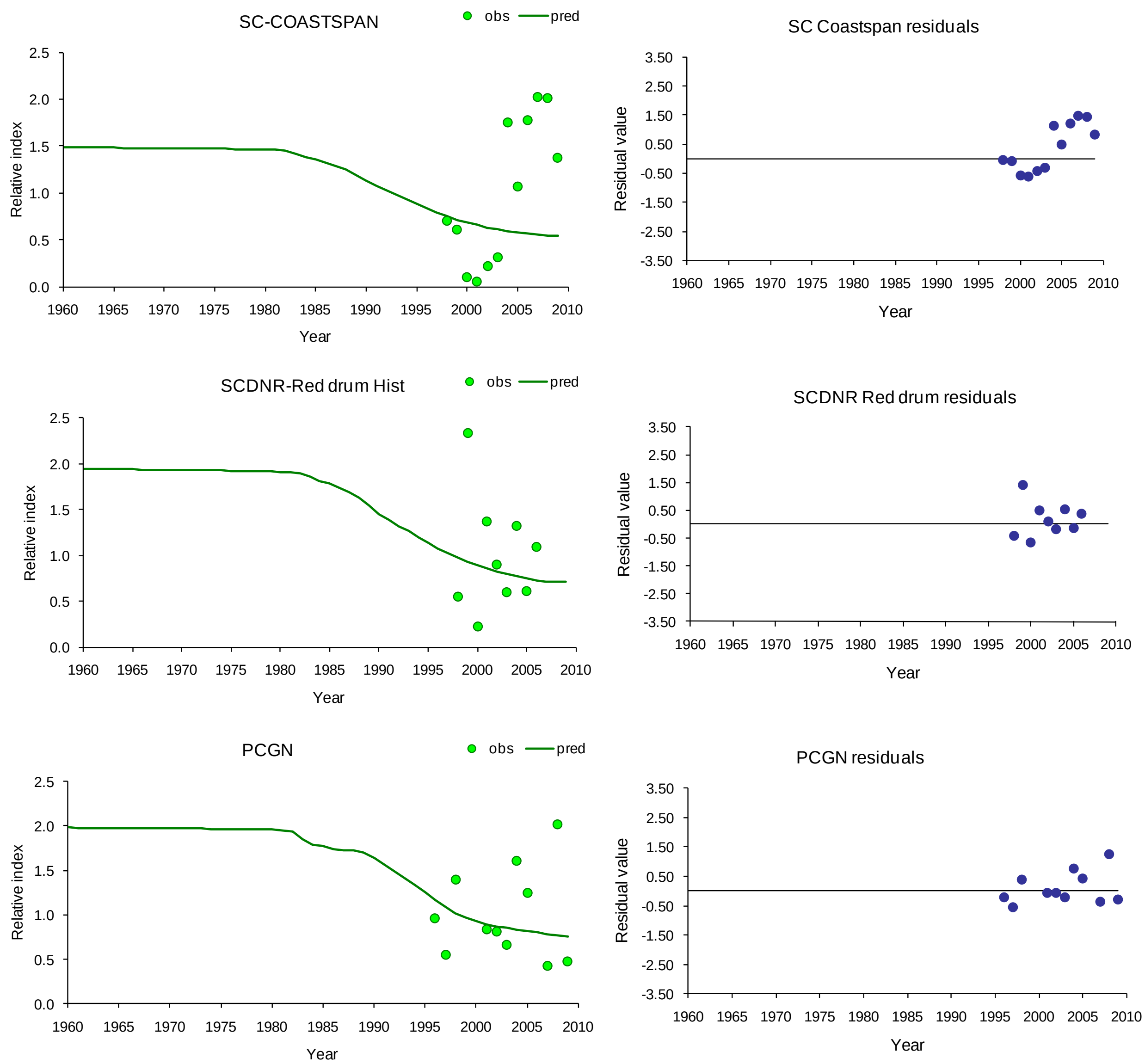


Figure 3.6 (continued). Predicted fits to indices (left) and residual plots (right) for the base run.

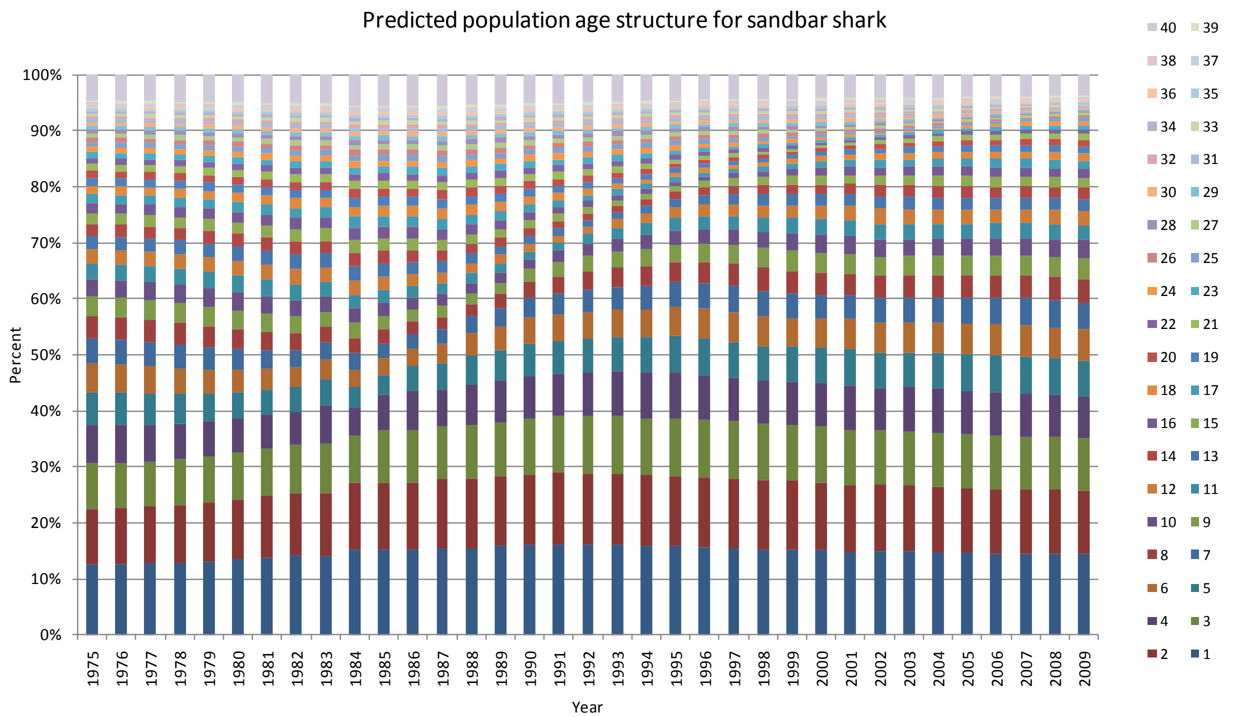


Figure 3.7. Predicted abundance at age for sandbar shark.

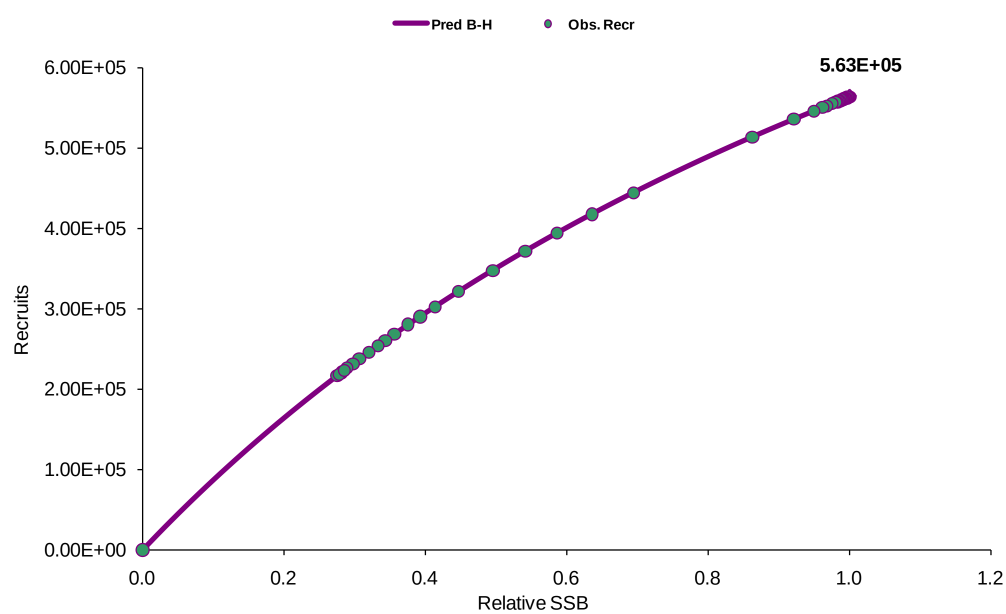


Figure 3.8. Predicted and "observed" Beverton-Holt recruitment (number of age-1 pups) for sandbar sharks at different levels of SSB depletion. The label shows the estimated virgin number of (age-1) recruits.

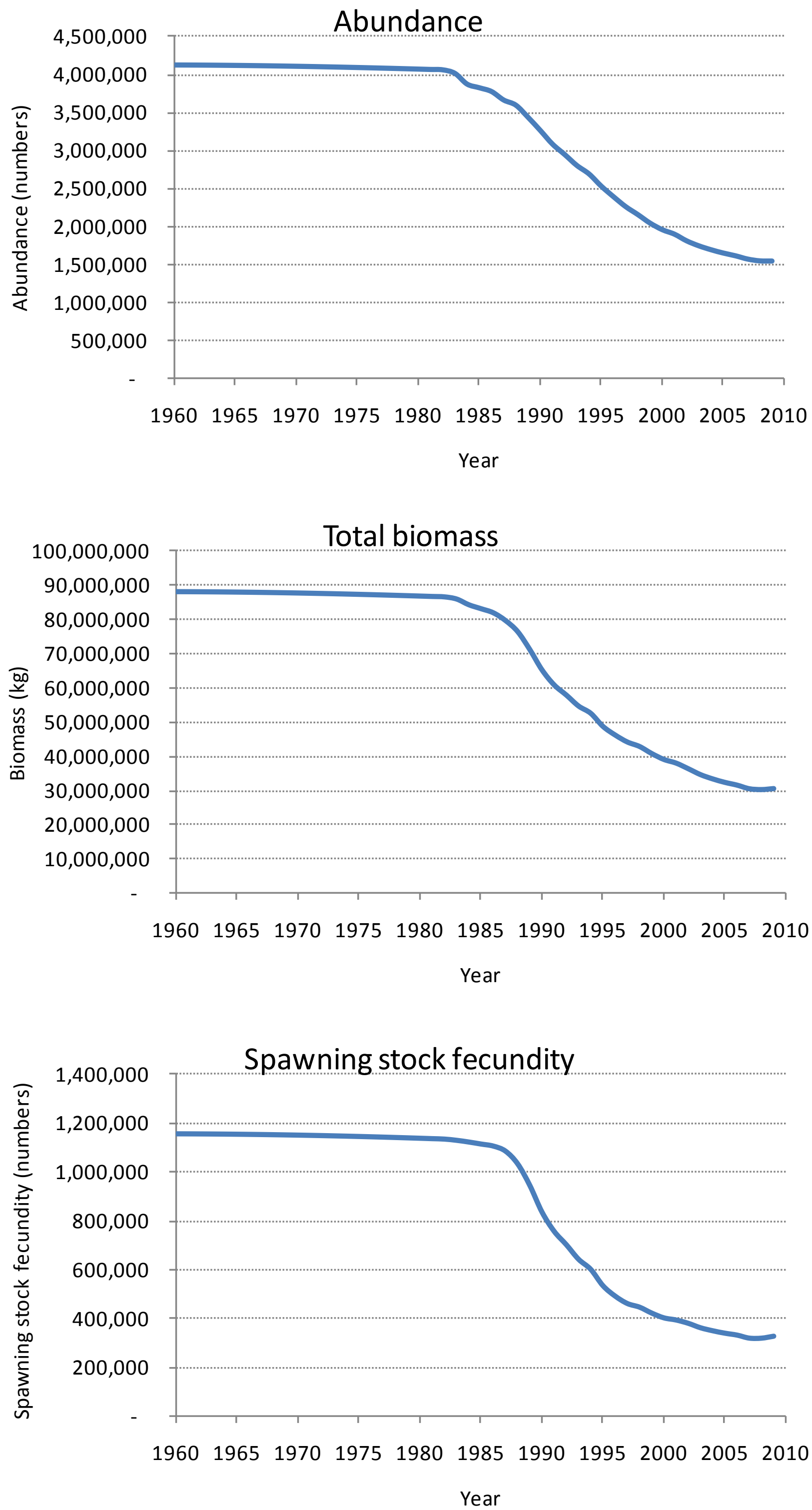


Figure 3.9. Predicted abundance, total biomass, and spawning stock fecundity trajectories for sandbar sharks.

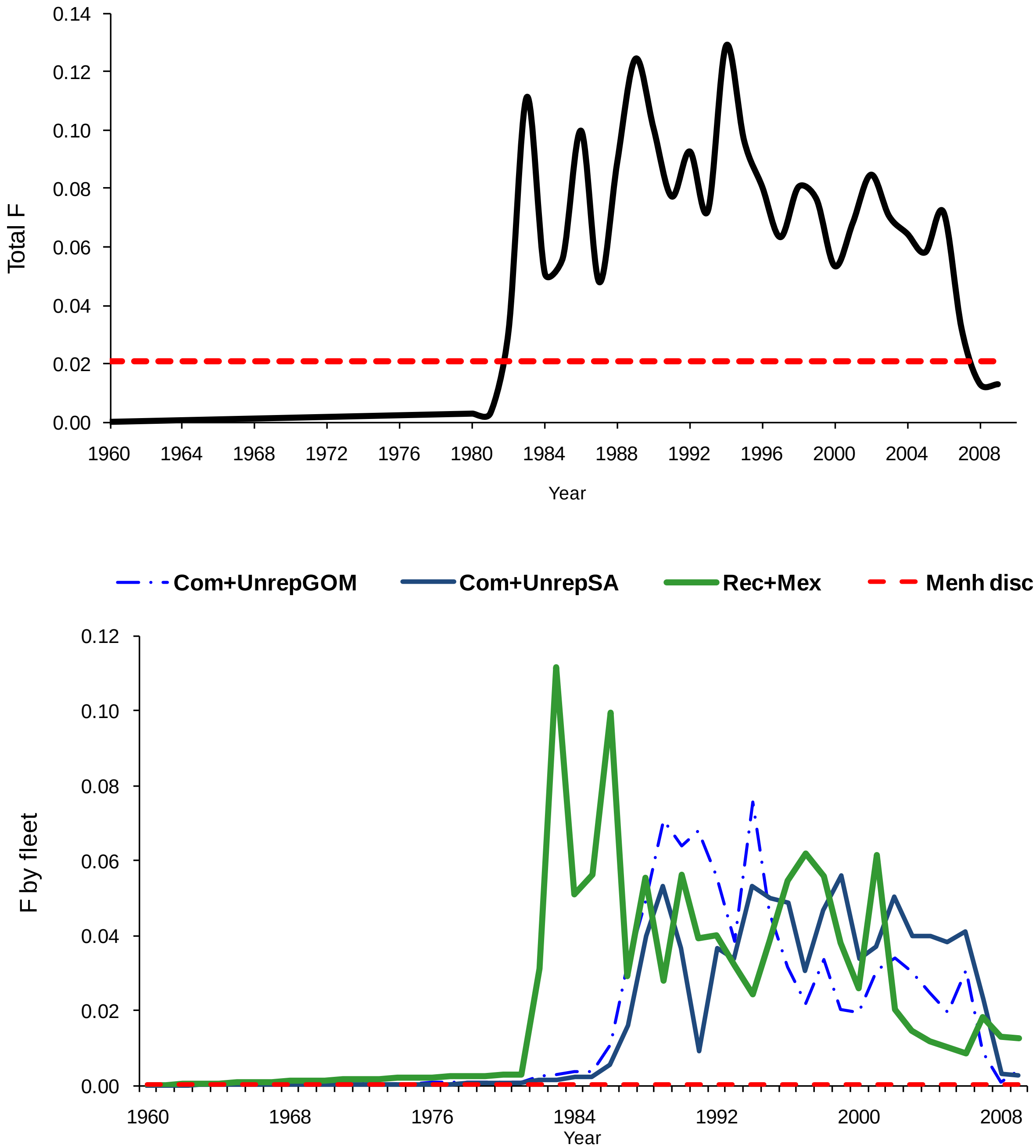
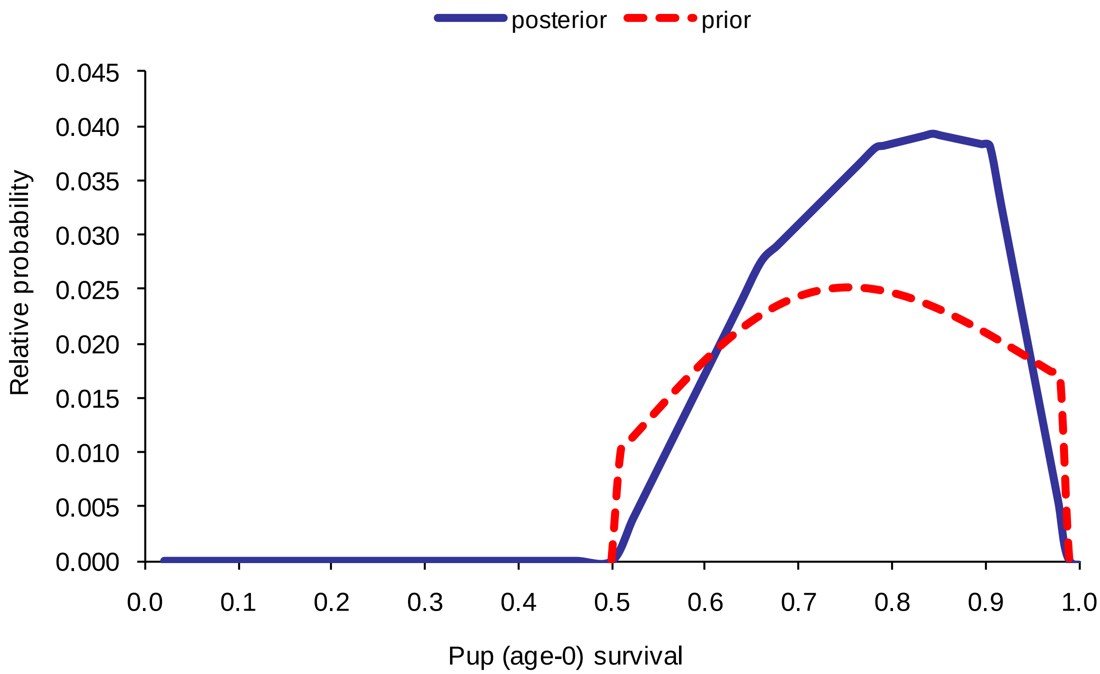


Figure 3.10. Estimated total fishing mortality (top) and fleet-specific F (bottom) for sandbar shark. The dashed line in the middle panel indicates F_{MSY} (0.021).



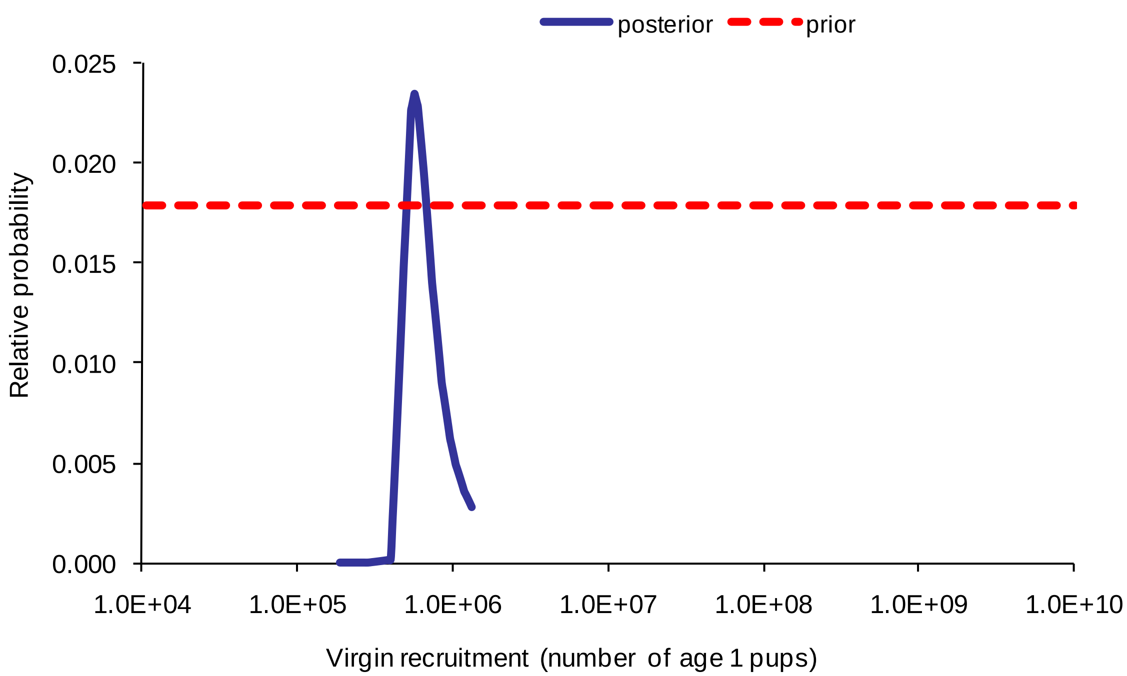


Figure 3.11. Profile likelihoods for pup survival and virgin recruitment. Both prior and posterior distributions are shown.

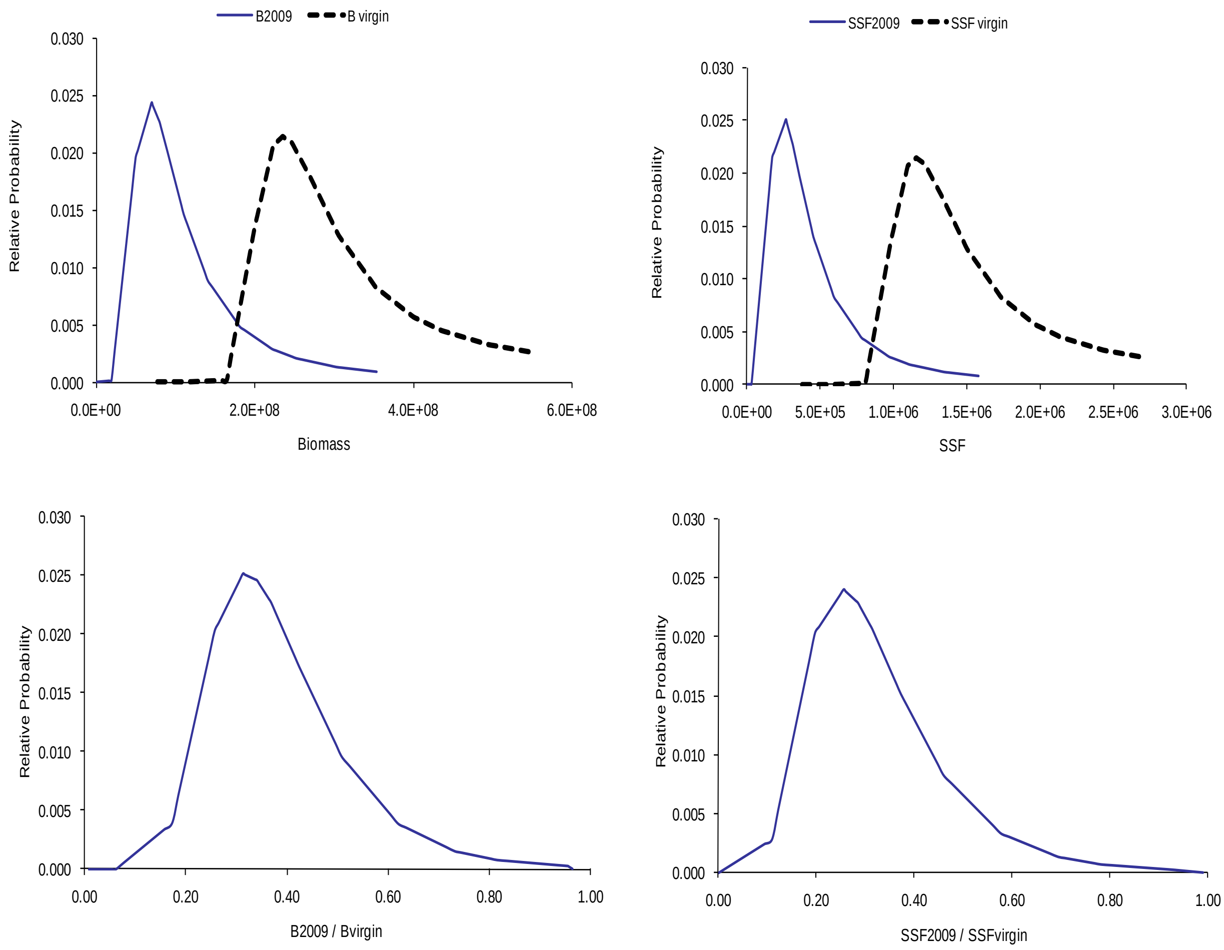


Figure 3.12. Profile likelihoods for total biomass and spawning stock fecundity in virgin conditions and in 2009 (top) as well as depletion estimates of these parameters (bottom).

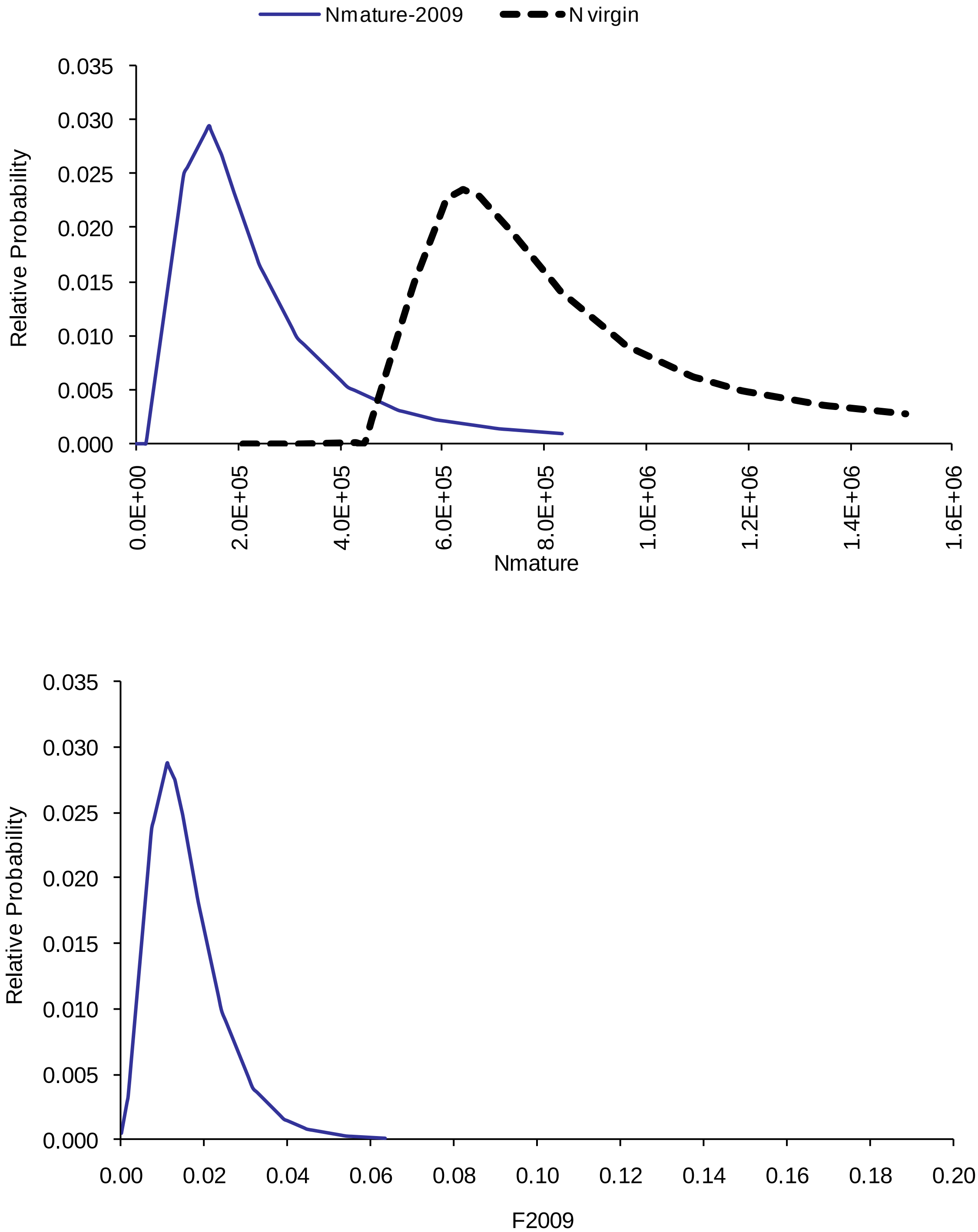


Figure 3.13. Profile likelihoods for number of mature females in virgin conditions and in 2009 (top) and for fishing mortality in 2009 (bottom).

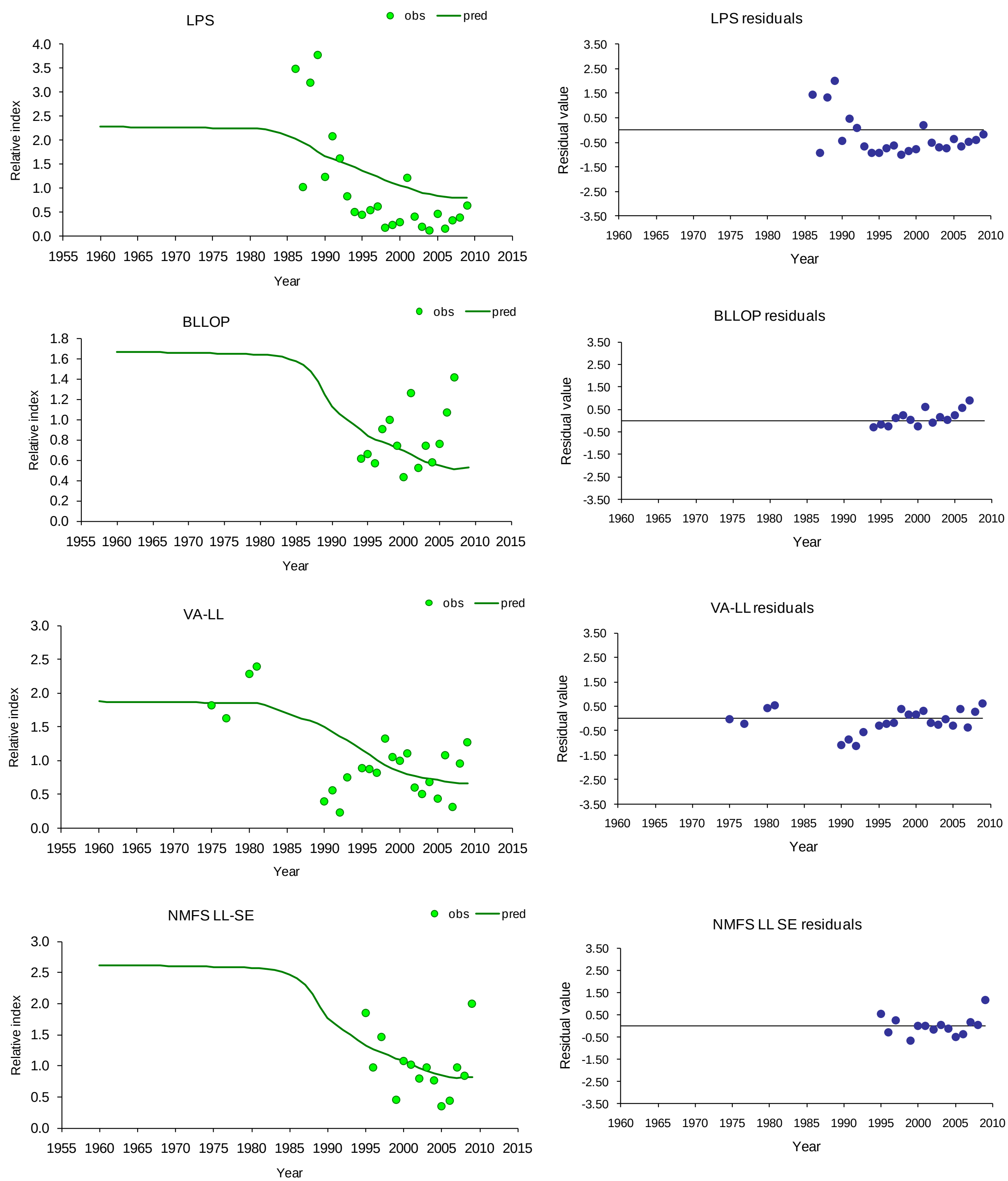


Figure 3.14. Predicted fits to indices (left) and residual plots (right) for sensitivity scenario 1 (inverse CV weighting).

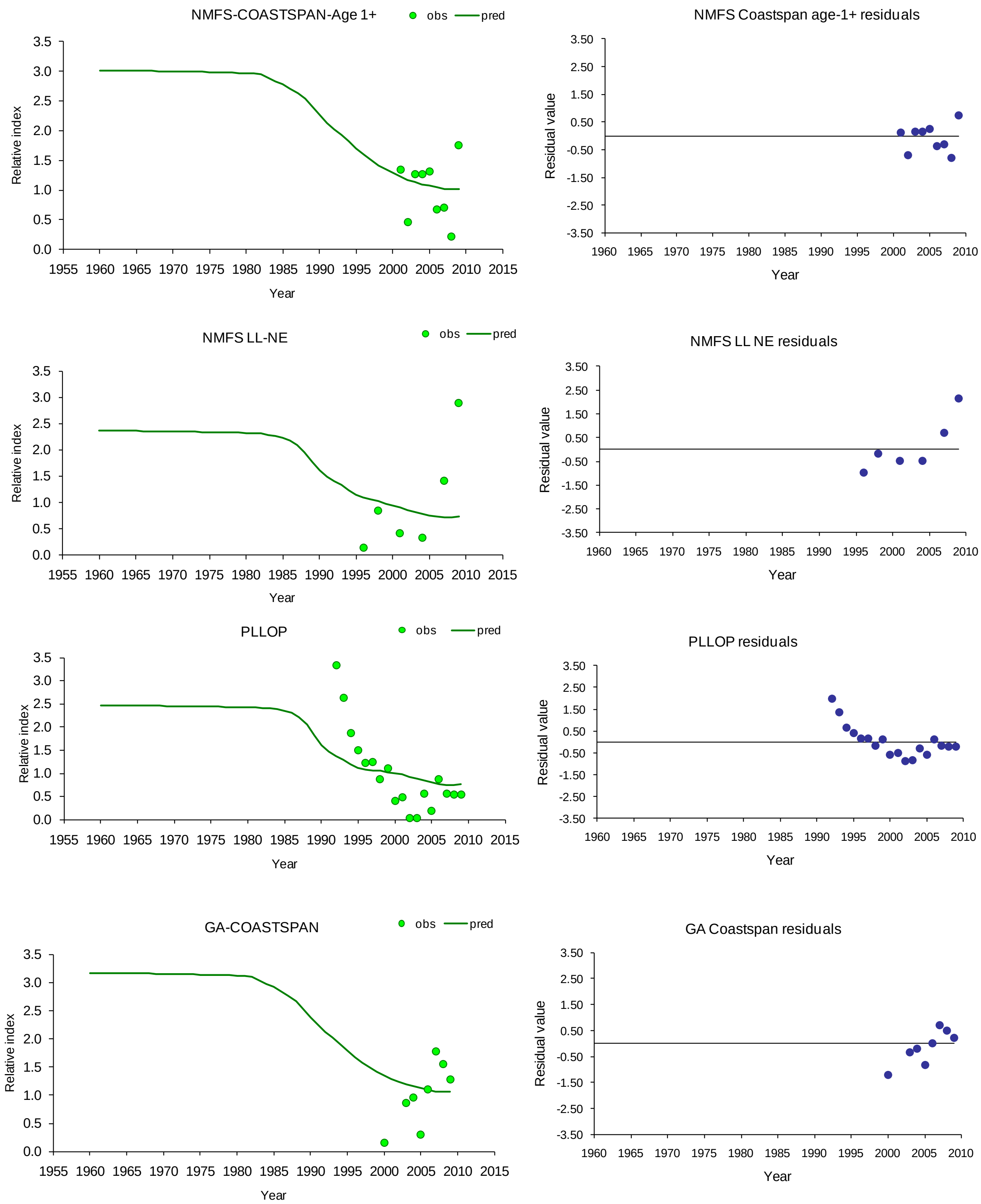


Figure 3.14 (continued). Predicted fits to indices (left) and residual plots (right) for sensitivity scenario 1 (inverse CV weighting).

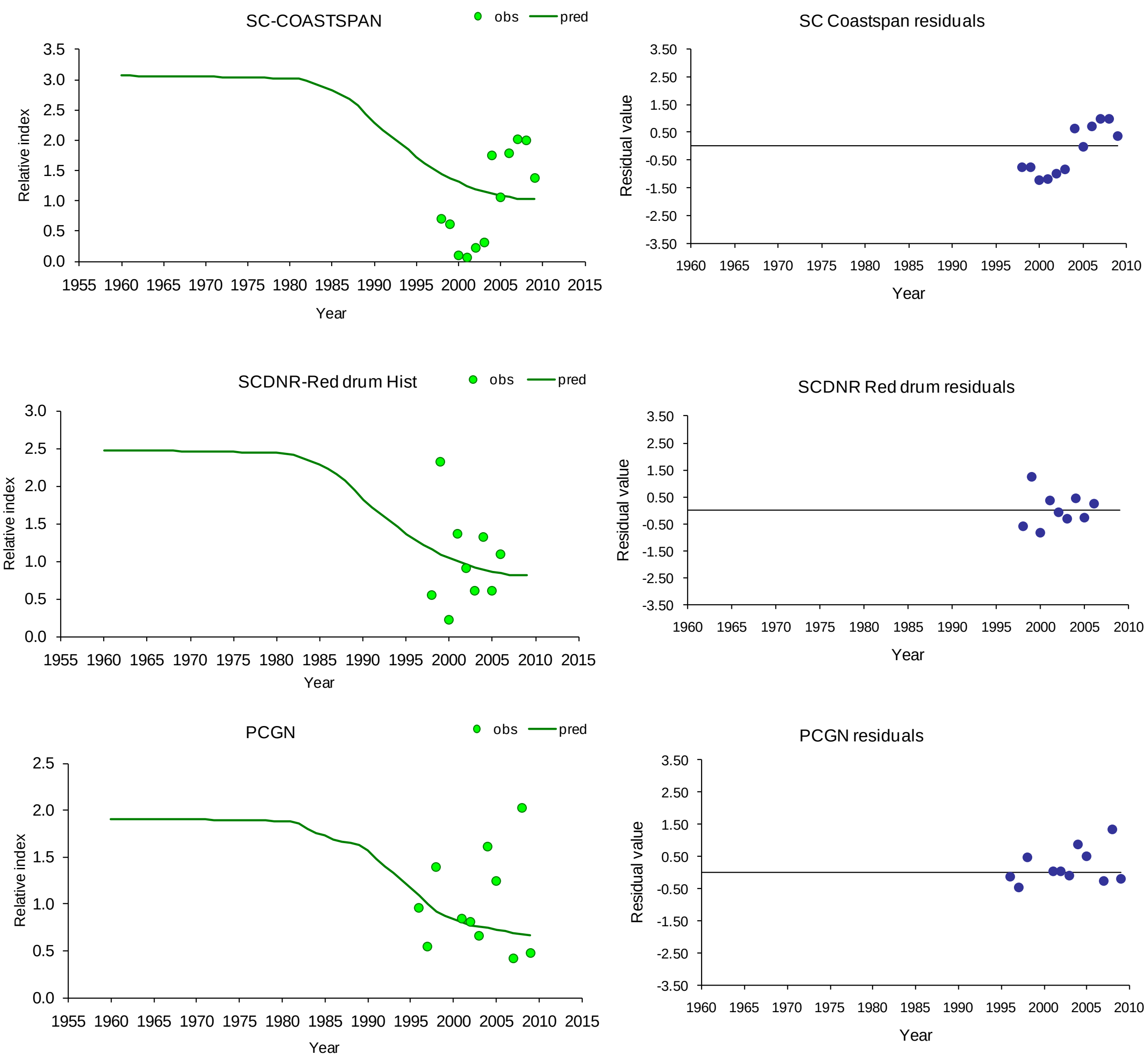


Figure 3.14 (continued). Predicted fits to indices (left) and residual plots (right) for sensitivity scenario 1 (inverse CV weighting).

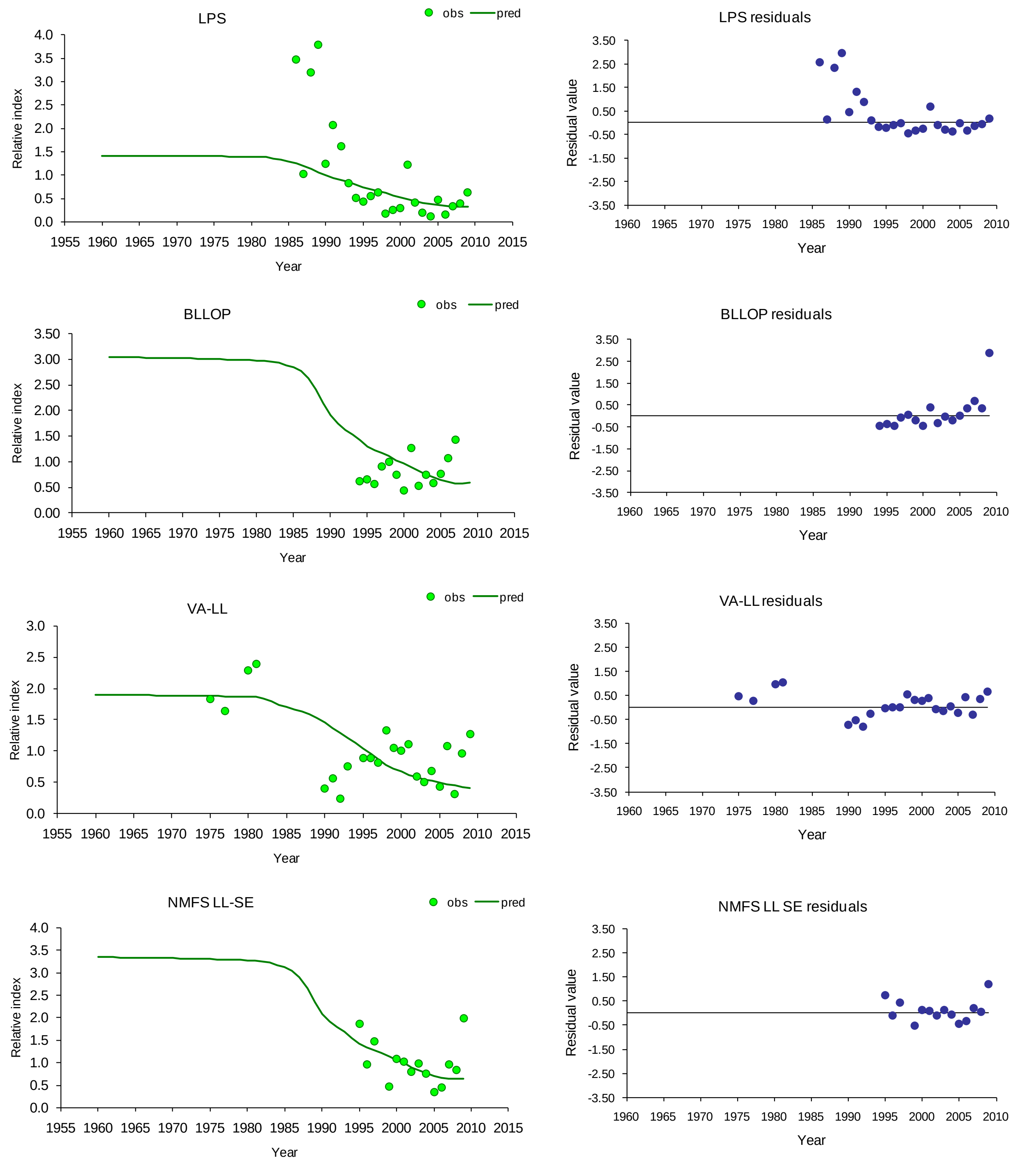


Figure 3.15. Predicted fits to indices (left) and residual plots (right) for sensitivity scenario 2 (all indices).

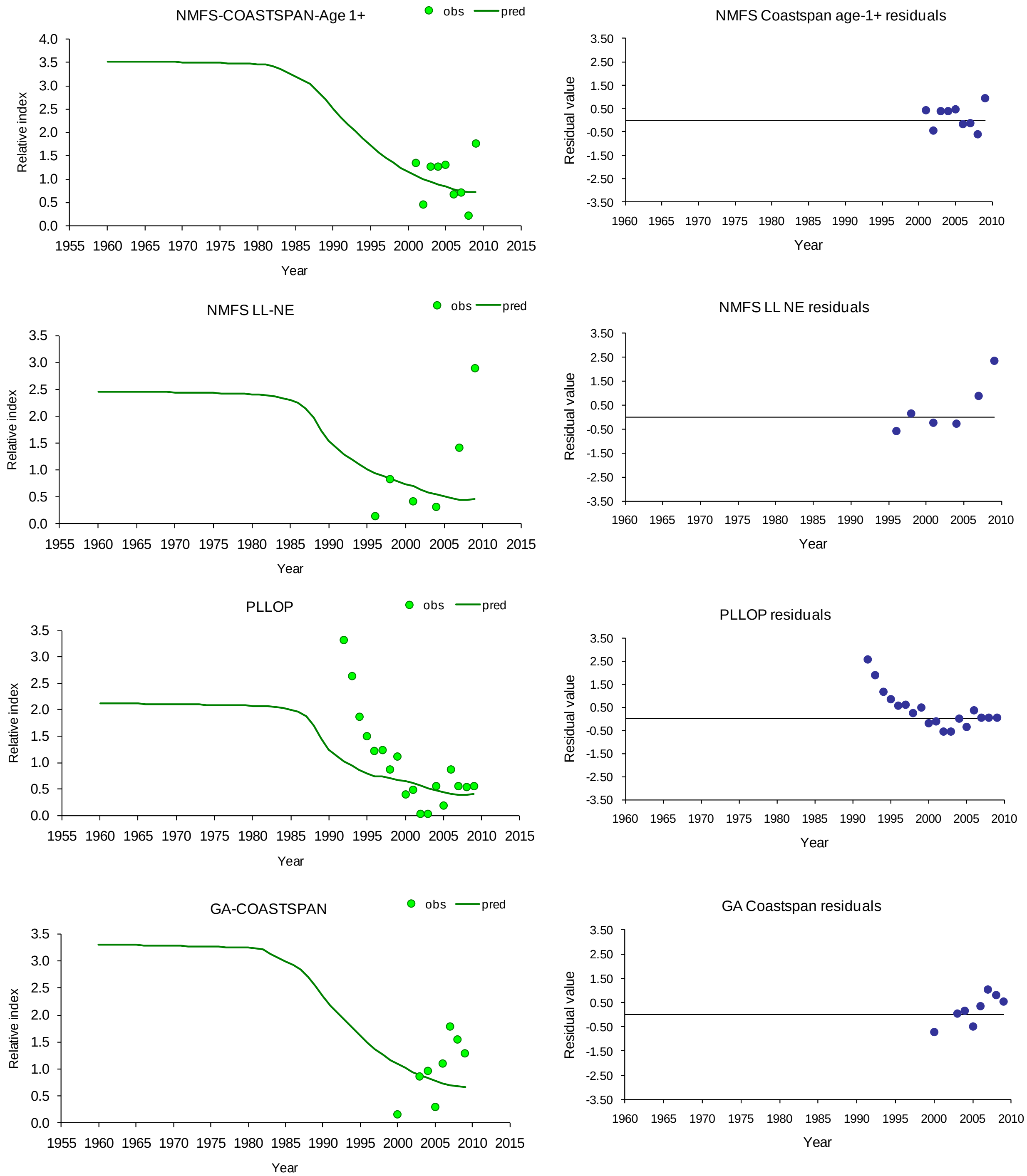


Figure 3.15 (continued). Predicted fits to indices (left) and residual plots (right) for sensitivity scenario 2 (all indices).

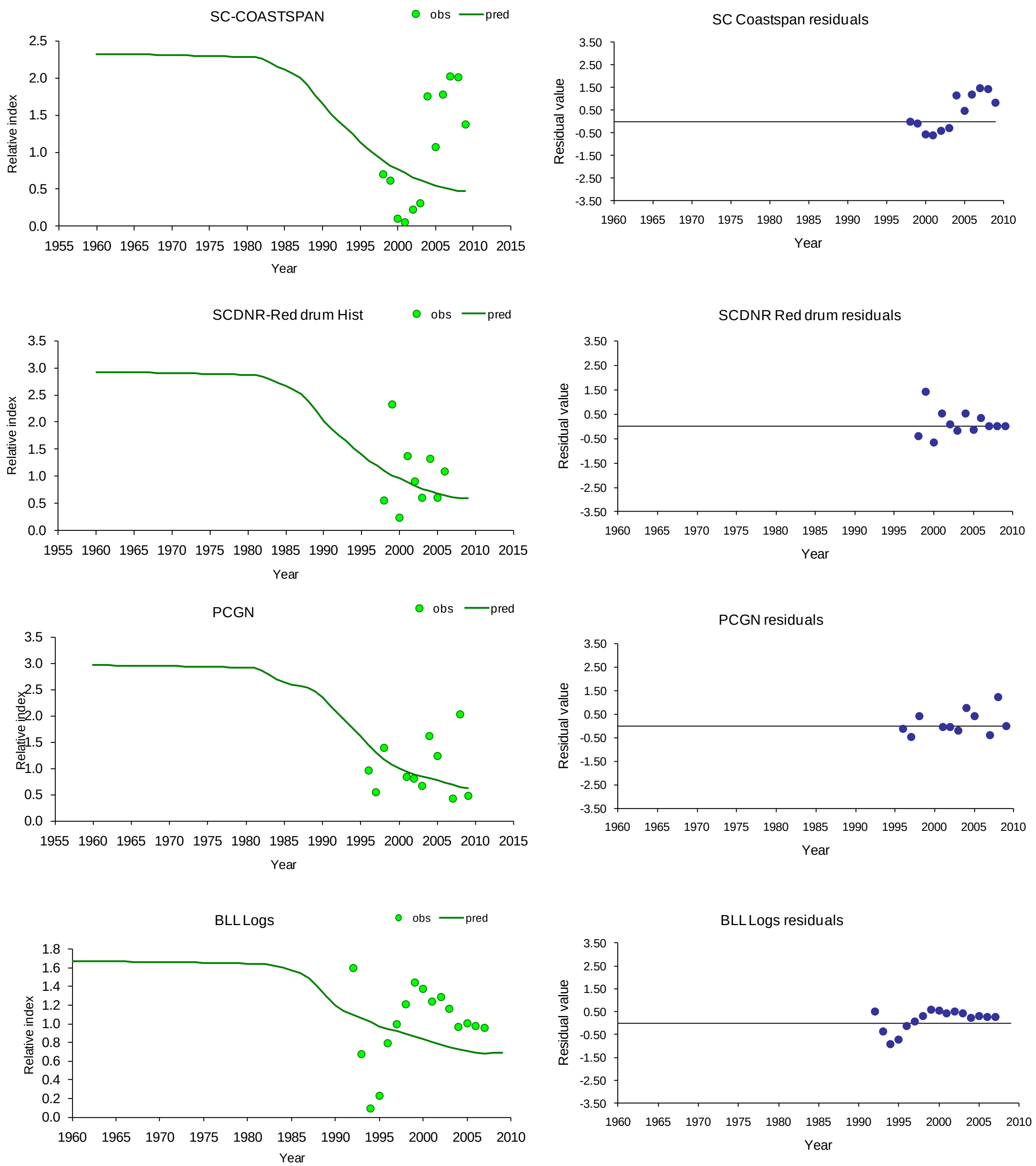


Figure 3.15 (continued). Predicted fits to indices (left) and residual plots (right) for sensitivity scenario 2 (all indices).

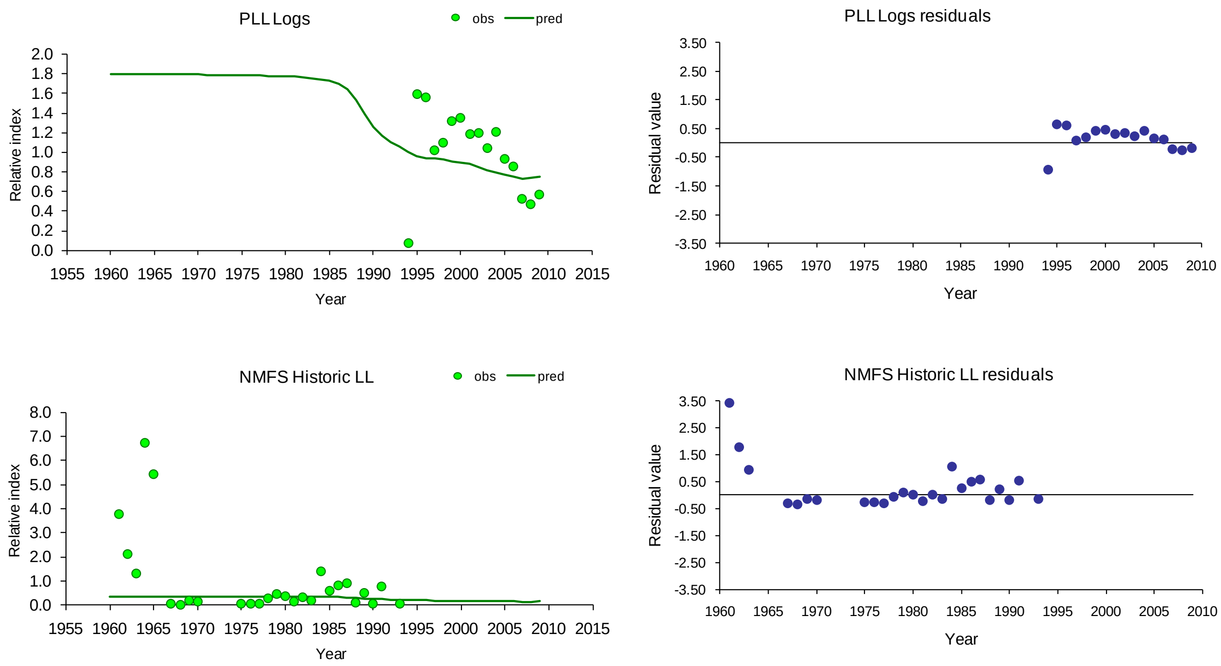


Figure 3.15 (continued). Predicted fits to indices (left) and residual plots (right) for sensitivity scenario 2 (all indices).

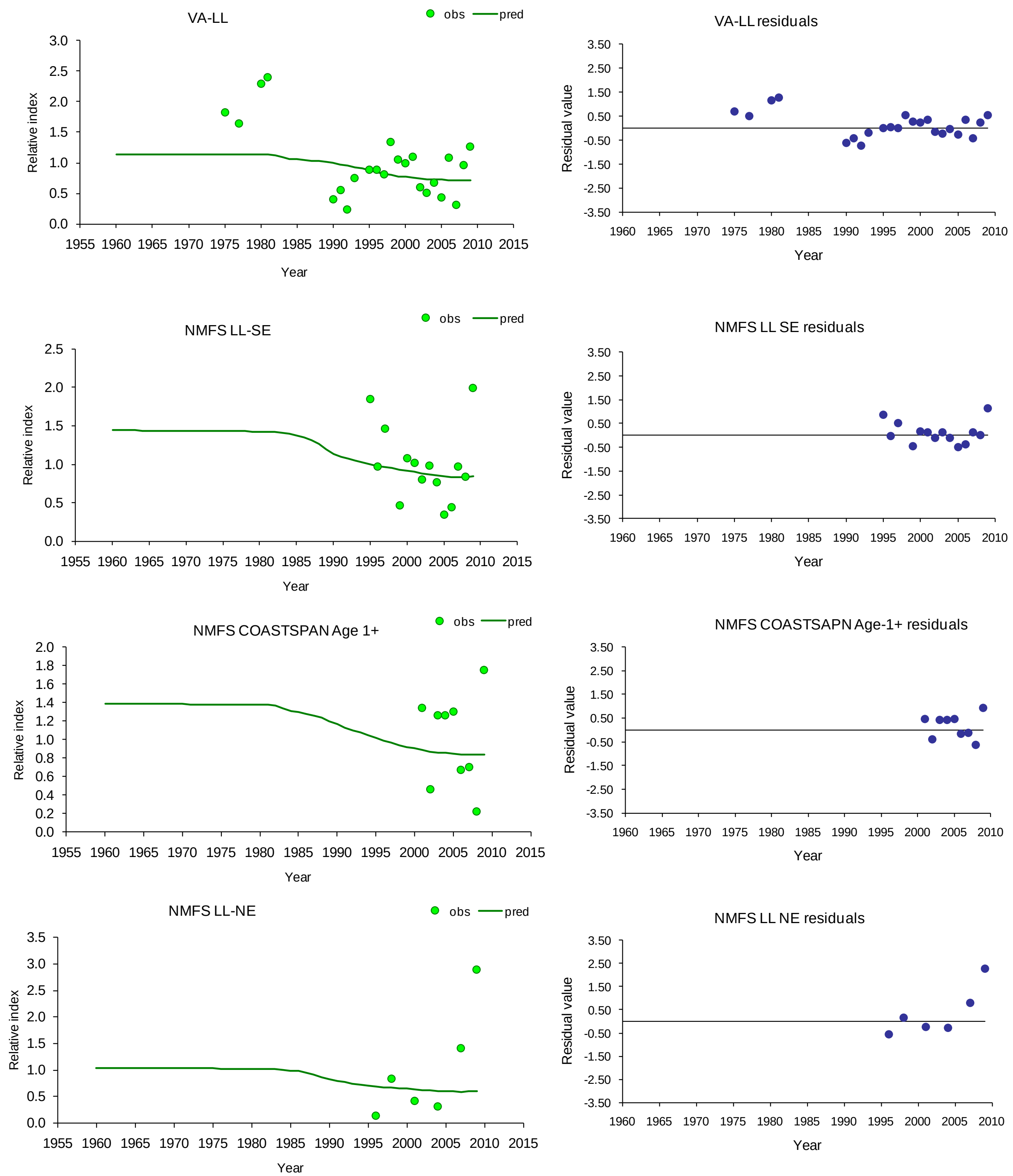


Figure 3.16. Predicted fits to indices (left) and residual plots (right) for sensitivity scenario 8 (fishery-independent indices only).

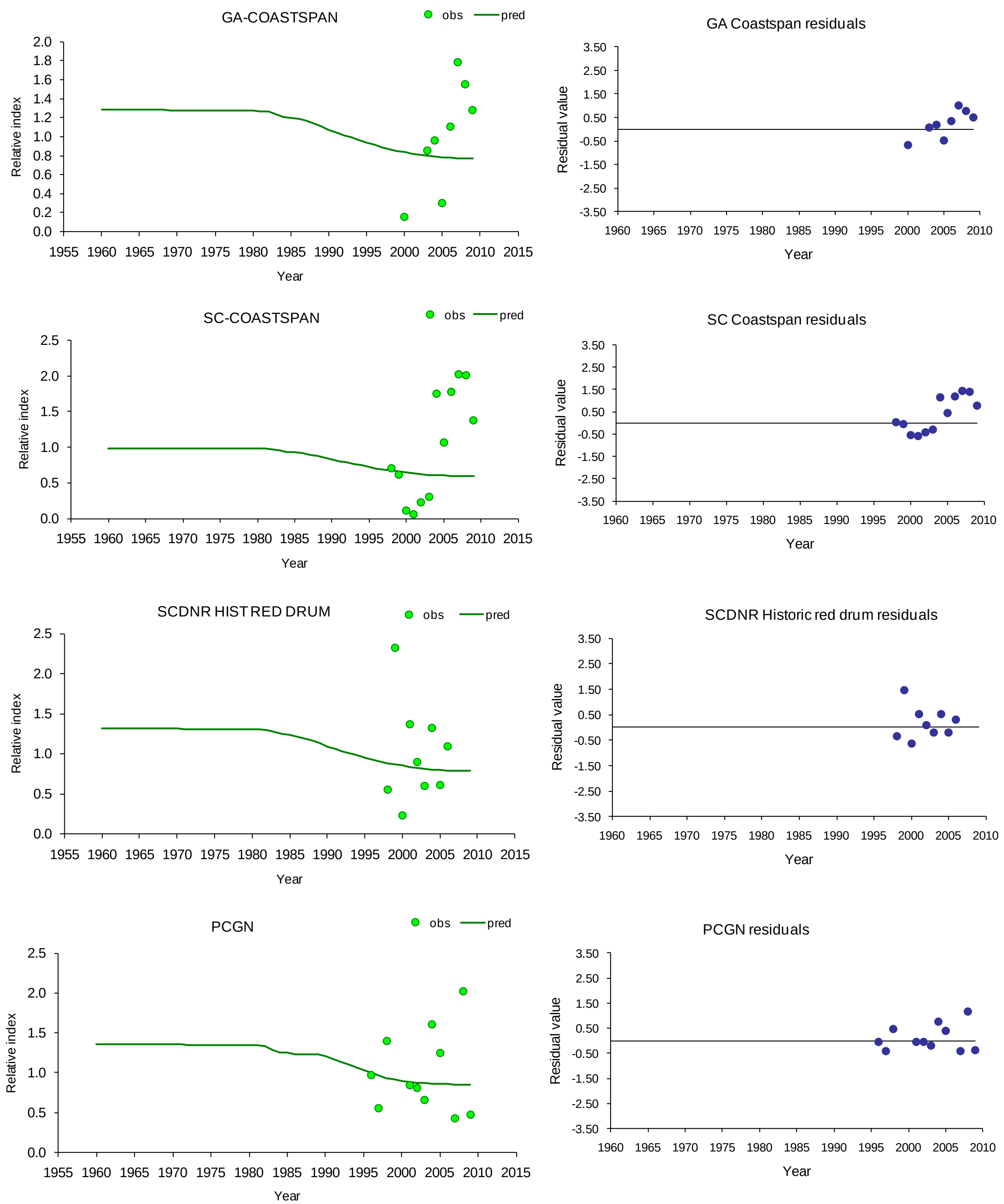


Figure 3.16 (continued). Predicted fits to indices (left) and residual plots (right) for sensitivity scenario 8 (fishery-independent indices only).

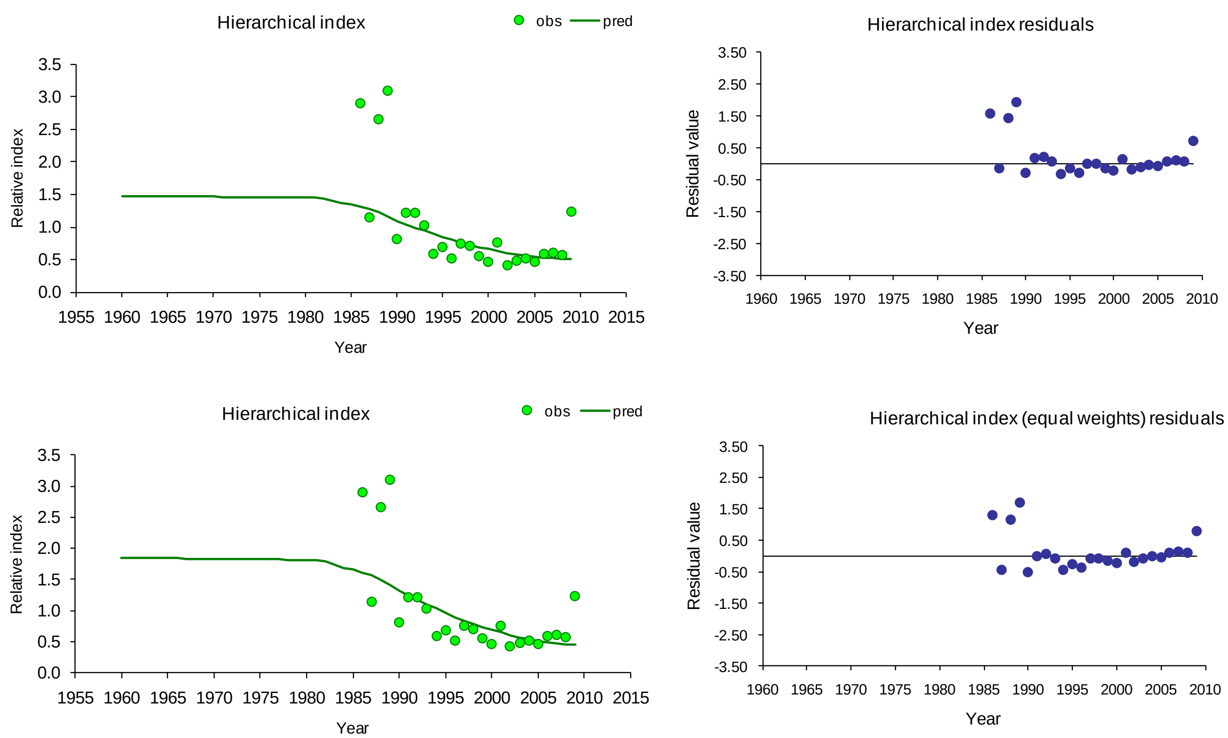


Figure 3.17. Predicted fits to indices (left) and residual plots (right) for sensitivity scenarios 10 and 11 (hierarchical index with inverse CV and equal weighting, respectively).

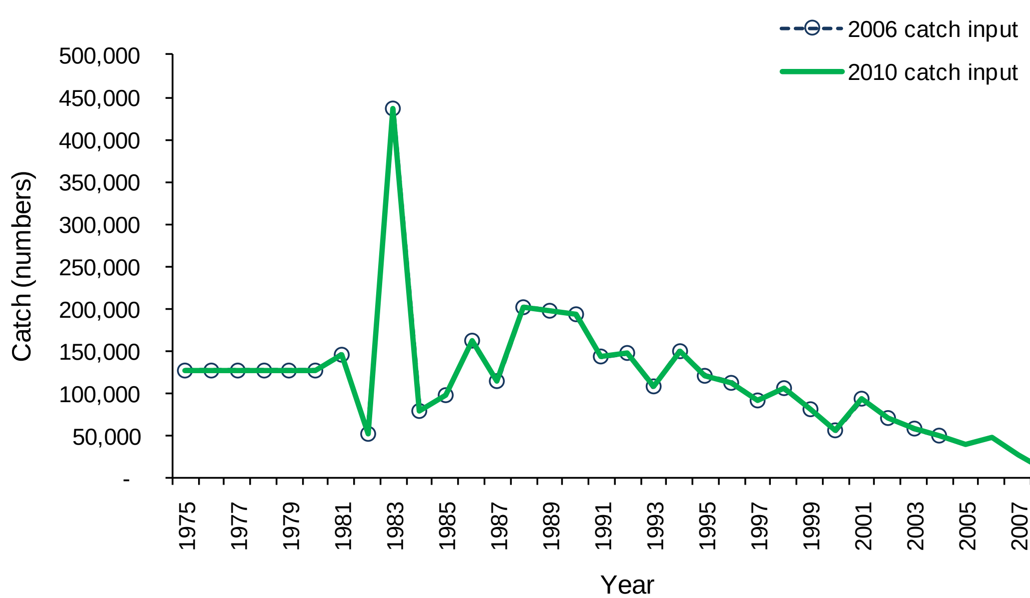


Figure 3.18. Comparison of catch streams used in the 2006 assessment and in the current continuity analysis.

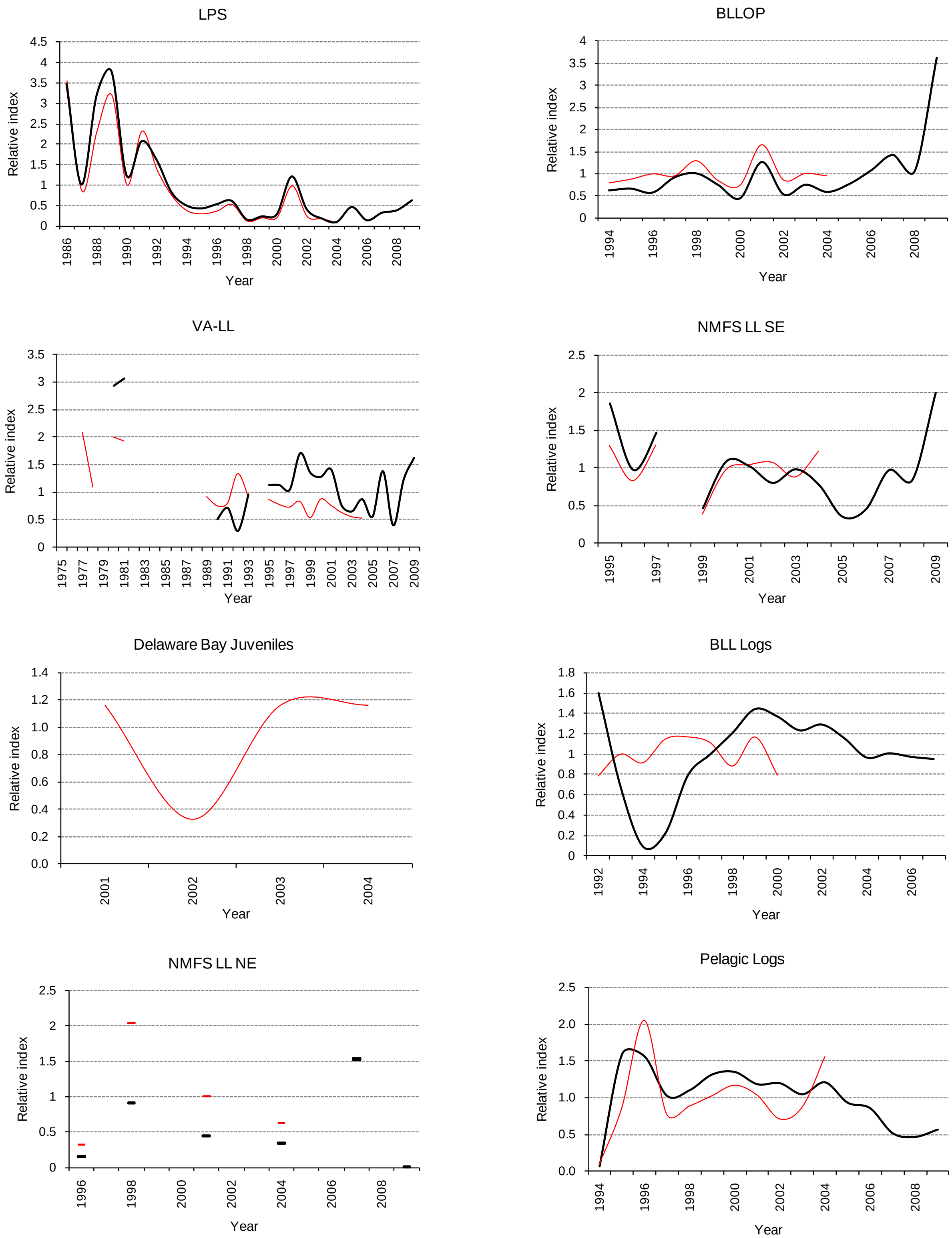


Figure 3.19. Indices used in the 2006 assessment (thin red line) vs. current continuity analysis (thick black line). The Delaware Bay Juvenile index was as used in 2006; the other seven indices were re-analyzed. All indices are scaled (divided by their respective mean).

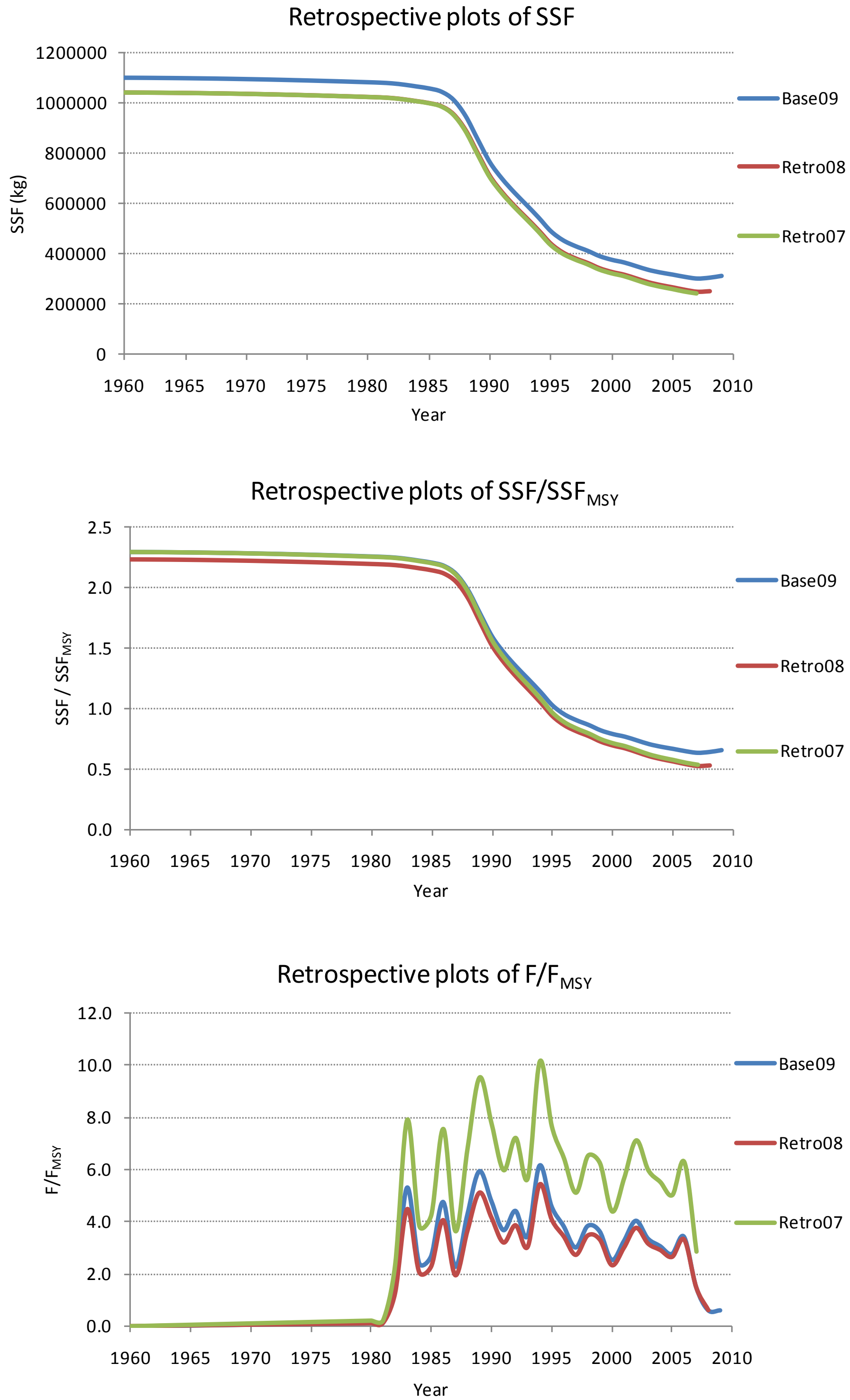
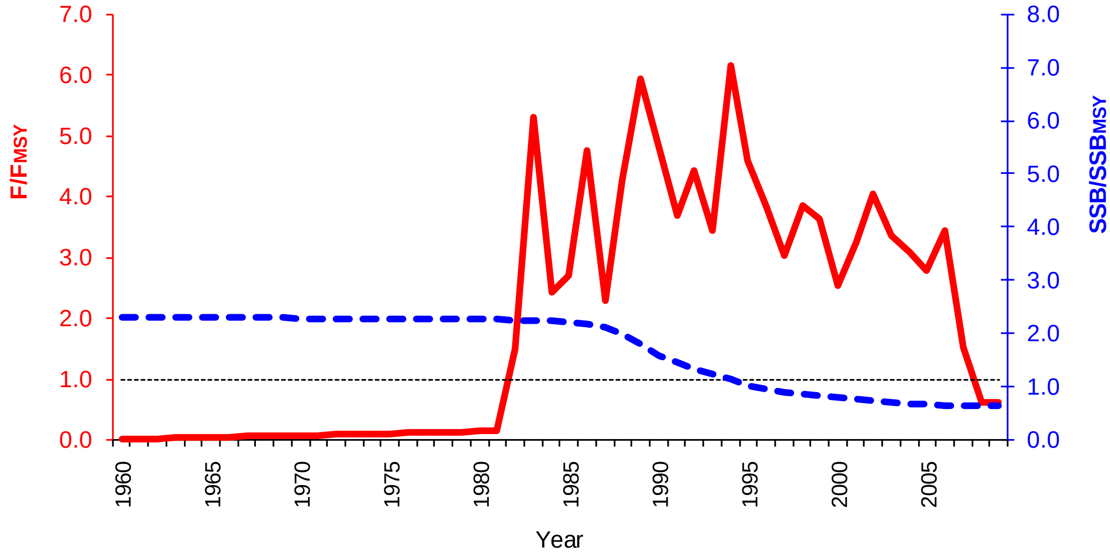


Figure 3.20. Retrospective analysis for sandbar shark with last two years of data sequentially removed from the model. Model quantities examined include spawning stock fecundity (top), relative spawning stock fecundity (middle), and relative fishing mortality rate (bottom).

A



B

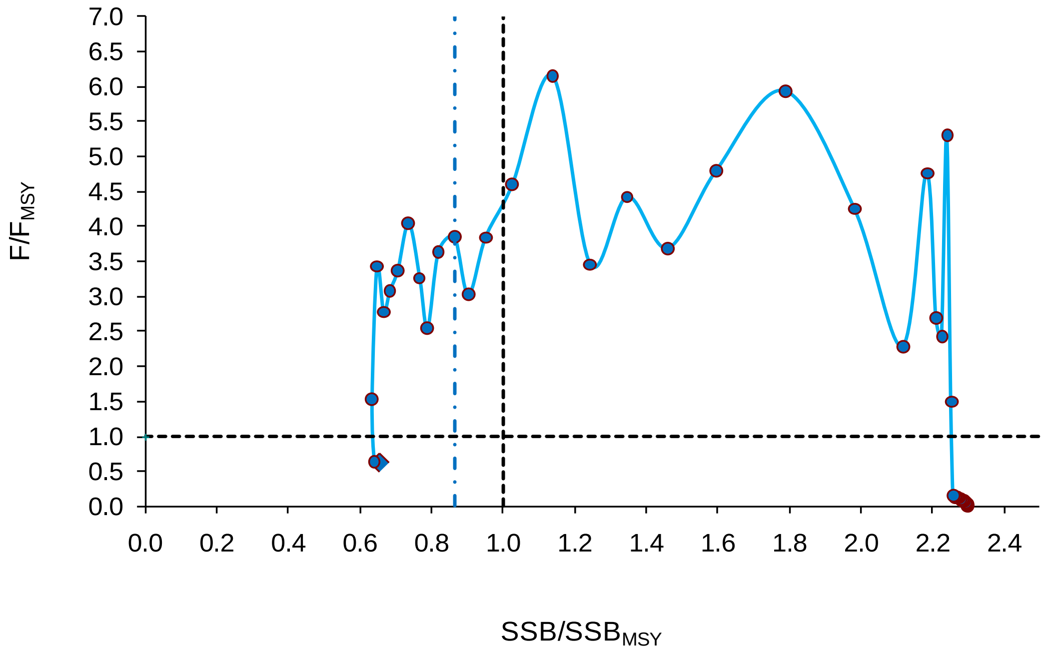


Figure 3.21. (A) Estimated relative biomass and fishing mortality rate trajectories for sandbar shark in the base run. The dashed line indicates F_{MSY}. (B) Phase plot of relative biomass and fishing mortality rate by year. The diamond indicates current (for 2009) conditions. The dashed vertical blue line indicates MSST ((1-M)*B_{MSY}).

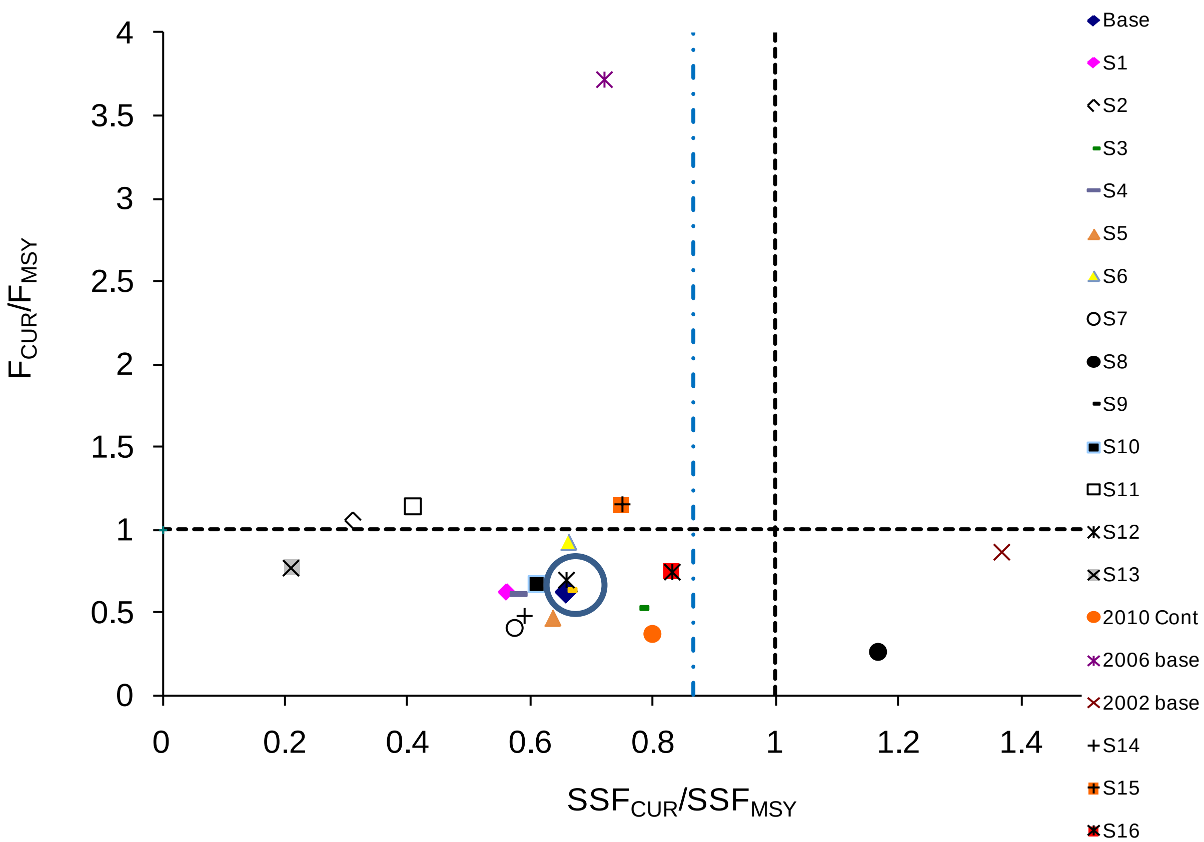


Figure 3.22. Phase plot of sandbar shark stock status. Results are shown for the base model (base), 16 sensitivity scenarios (S1: inverse CV weighting; S2: all indices; S3: combined catches; S4: combined catches and inverse CV weighting; S5: 2-yr cycle; S6: 3-yr cycle; S7: U-shaped M; S8: fishery-independent indices only; S9: ranked indices; S10: hierarchical index; S11: hierarchical index, no weighting; S12: low catch; S13: high catch; S14: low M; S15: high M; S16: alternative historic catch), continuity analysis (2010 Cont), and 2006 and 2002 assessment base models (2006 base, 2002 base). The circle indicates the position of the base run, which overlaps with that of sensitivity runs 9 and 12. The vertical dashed line denotes MSST ((1-M)*SSF_{MSY}). Points to the left of the vertical dashed line indicate runs in which the stock is estimated to be overfished; points above the horizontal black line (MFMT=F_{MSY}) indicate runs in which overfishing is estimated to be occurring.

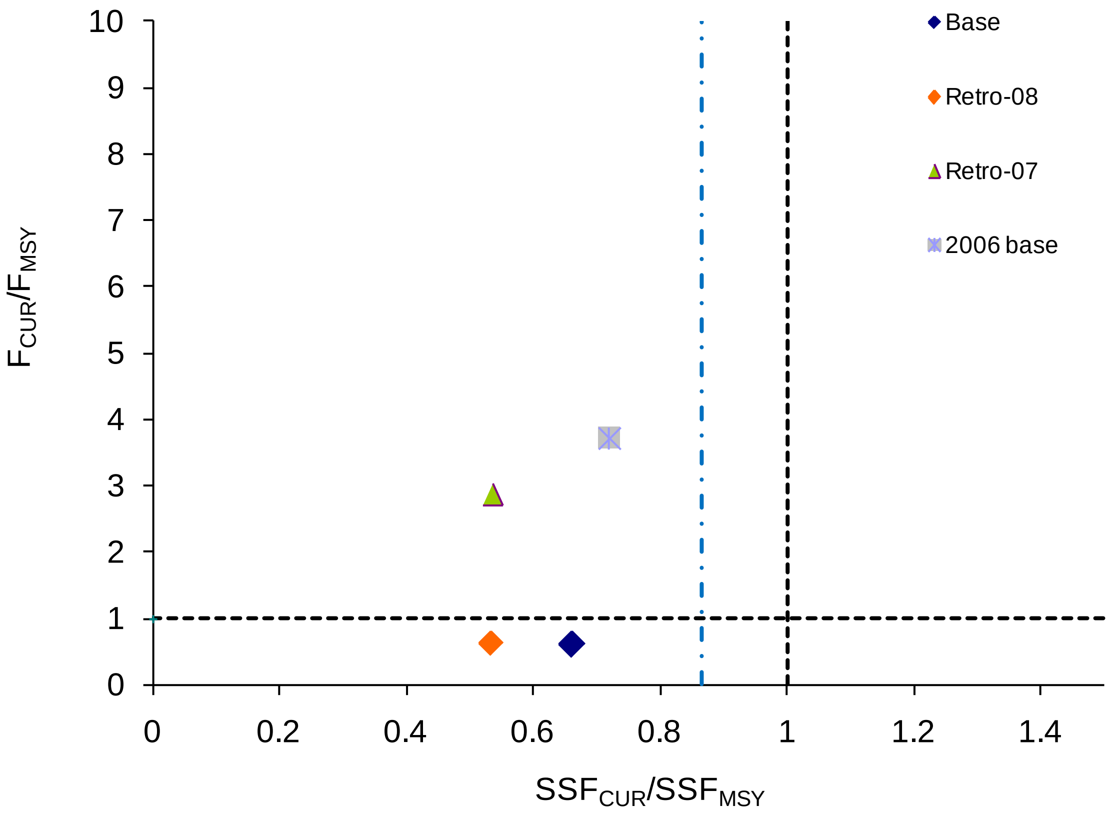


Figure 3.23. Phase plot of sandbar shark stock status for the base model (base), retrospective analysis (sequentially dropping one year from the model: retro08, retro07), and 2006 assessment base model (2006 base). The vertical dashed line denotes MSST ((1-M)*SSF_{MSY}). Points to the left of the vertical dashed line indicate runs in which the stock is estimated to be overfished; points above the horizontal black line (MFMT=F_{MSY}) indicate runs in which overfishing is estimated to have occurred.

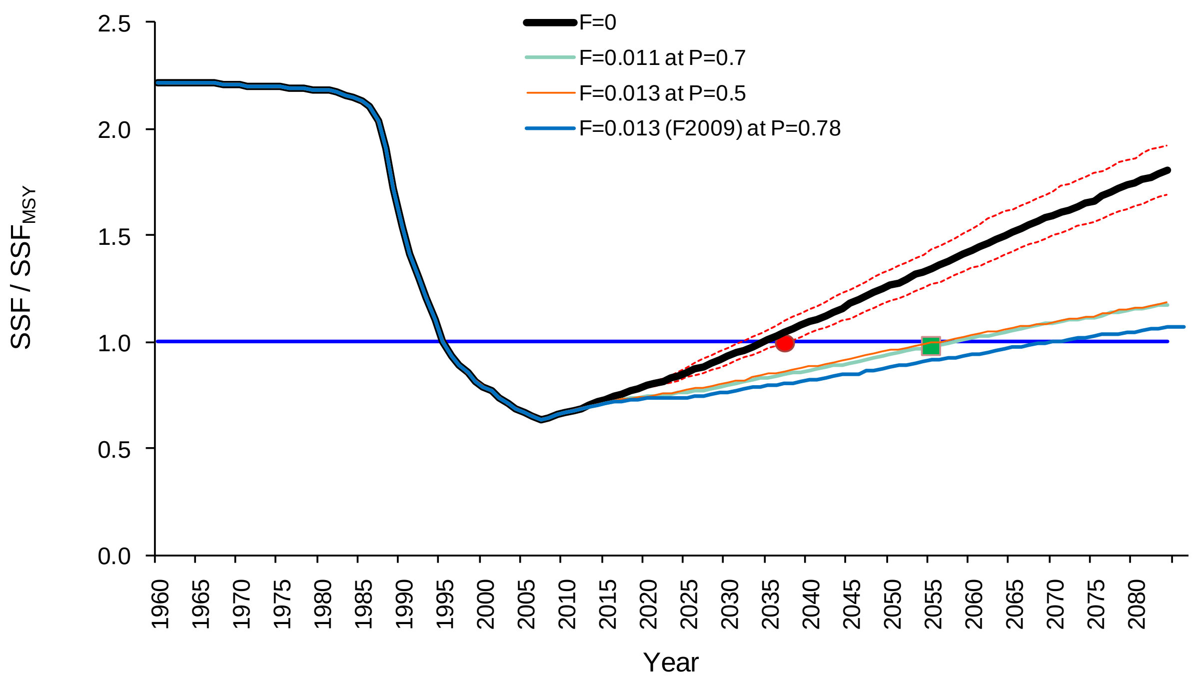


Figure 3.24. Projections with constant F (solid black, orange, green, and blue lines). The dashed red lines represent the 30th (lower) and 70th (upper) percentile. Rebuilding under F=0 with 70% probability is achieved in 2038 (solid red circle). F=0.011 (green) rebuilds by 2058 with 70% probability (indicated by solid green box); F=0.013 (orange) rebuilds by 2058 with 50% probability. Rebuilding under the old target of 2070 with current F (=F_{2009}) could be achieved with a 78% probability.

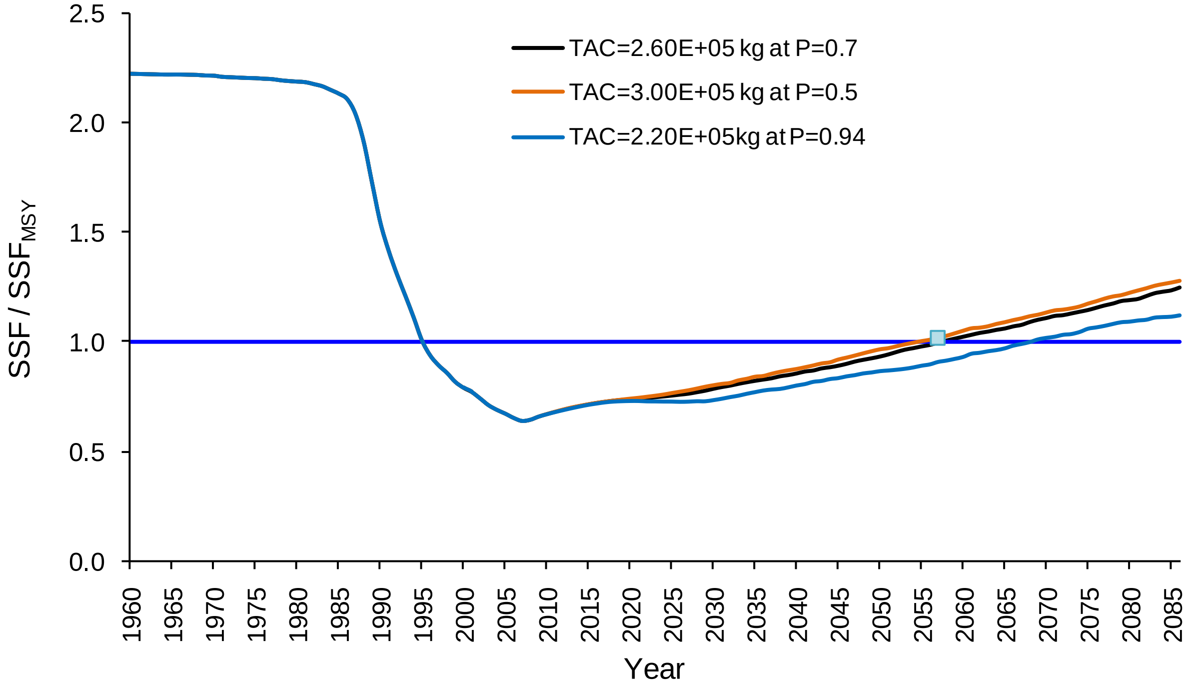


Figure 3.25. Projections with constant TAC (solid black, orange, and blue lines). A TAC of 260 mt ww (black line) yields a 70% probability of rebuilding by 2058 (solid blue square), whereas a TAC of 300 mt ww yields only a 50% probability of rebuilding by 2058. There is a 94% probability of rebuilding under the old target of 2070 with the current TAC (220 mt ww).

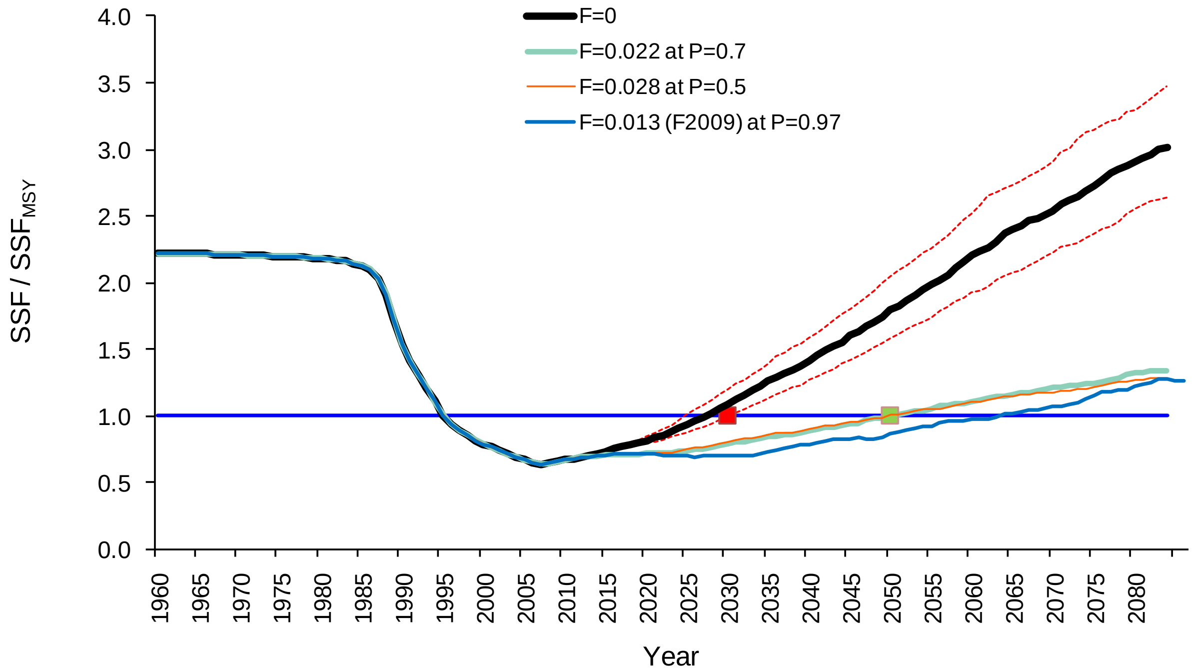


Figure 3.26. Projections with constant F (solid black, orange, green, and blue lines) with the SD of recruitment deviations doubled to 0.8. The dashed red lines represent the 30th (lower) and 70th (upper) percentile. Rebuilding under F=0 with 70% probability is achieved in 2031 (solid red circle). F=0.022 (green) rebuilds by 2051 with 70% probability (indicated by solid green box); F=0.028 (orange) rebuilds by 2051 with 50% probability. Rebuilding under the old target of 2070 with current F (=F_{2009}) could be achieved with a 97% probability.

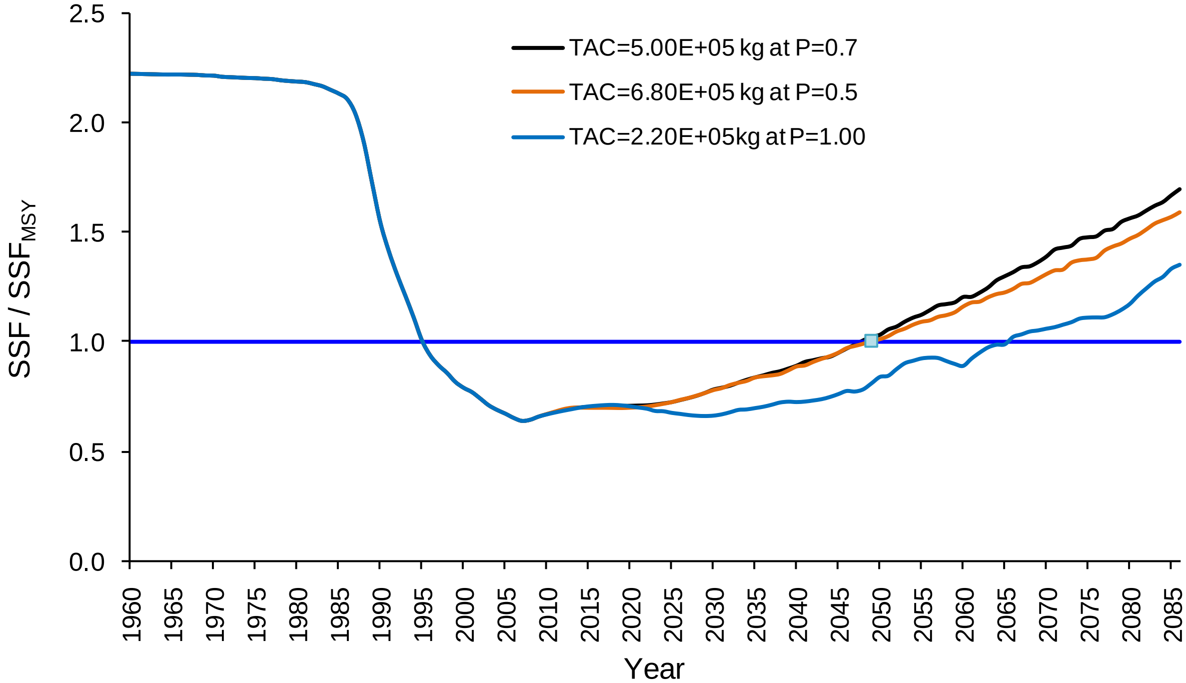


Figure 3.27. Projections with constant TAC (solid black, orange, and blue lines) with the SD of recruitment deviations doubled to 0.8. A TAC of 500 mt ww (black line) yields a 70% probability of rebuilding by 2051 (solid blue square), whereas a TAC of 680 mt ww yields a 50% probability of rebuilding by 2051. There is a 100% probability of rebuilding under the old target of 2070 with the current TAC (220 mt ww).

3.8. Appendices.

Appendix 1:

Computation of an age-length key and subsequent transformation of lengths into ages for length sample of interest (implemented in MS Excel)

1. From the original age and growth study (SEDAR21-DW-21), determine the number of sharks at each age within a series of arbitrary length-classes (10 cm for sandbar shark) to cover the full range of lengths of sharks aged
2. Express those numbers as proportions
3. Divide the sample for which we have lengths and want ages into the same length classes and divide the number of sharks within each length class into ages on the basis of the proportion of each age in that length class in the age-length key
4. The final step is to add up across the length classes the number of sharks of each age.

   Following is a table of the age-length key, showing the proportions of sharks at each age within each length class (step 2 above):

	Age (years)																											
FL (cm)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
30-40	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40-50	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50-60	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60-70	37.5	62.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70-80	0.0	83.3	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80-90	0.0	0.0	66.7	0.0	33.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90-100	0.0	0.0	0.0	37.5	37.5	12.5	0.0	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100-110	0.0	0.0	0.0	16.7	16.7	50.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
110-120	0.0	0.0	0.0	0.0	33.3	33.3	0.0	0.0	0.0	33.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
120-130	0.0	0.0	0.0	0.0	0.0	0.0	10.0	36.7	30.0	13.3	6.7	0.0	0.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
130-140	0.0	0.0	0.0	0.0	0.0	0.0	0.8	8.5	8.5	34.6	30.8	9.2	3.8	0.8	1.5	0.0	0.8	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
140-150	0.0	0.0	0.0	0.0	0.0	0.0	1.1	1.5	5.0	12.2	26.3	27.5	11.8	7.3	3.4	1.1	0.8	0.8	0.4	0.0	0.0	0.0	0.4	0.4	0.0	0.0	0.0	0.0
150-160	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.6	1.2	5.3	11.5	16.1	16.7	12.7	14.6	9.0	5.9	2.8	1.9	0.9	0.0	0.6	0.0	0.0	0.0	0.0	0.0
160-170	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	3.2	5.4	10.1	13.7	17.7	11.9	13.4	7.2	7.2	4.0	3.2	1.1	0.7	0.4	0.0	0.0	0.4
170-180	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	3.8	3.8	5.8	6.7	15.4	18.3	18.3	8.7	7.7	5.8	0.0	3.8	1.0	0.0	0.0
180-190	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.7	0.0	6.7	0.0	0.0	0.0	0.0	6.7	0.0	20.0	6.7	20.0	6.7	0.0	20.0	6.7	0.0	0.0
190-200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
200-210	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Appendix 2:

Algorithm used to estimate selectivities (implemented in MS Excel).

1. Obtain age-frequencies
2. Identify age of full selectivity. You should expect to see the age frequency bar chart increase with age to a modal age (*age_full*), after which it begins to decline again. One can assume that *age_full* is the age which is fully selected
3. Calculate the observed proportion at age: Obs[prop.CAA] = freq(age)/Total_samples
4. Take the natural log of observed proportion at age, plot age against it, and fit a trend line
5. Use the fitted trend line to predict expected proportion at age, E[prop.CAA]=exp(trend line)
6. Use the ratio of Obs[prop.CAA]/E[prop.CAA] to estimate the non-fully selected ages (i.e. selectivity of ages < *age_full*)
7. Normalize the column of Obs/Exp by dividing by the ratio value for *age_full* (this will scale ages so that the maximum selectivity will be 1 for *age_full*)
8. The age frequency for ages > *age_full* should decline as a result of natural mortality alone. If natural mortality is relatively constant for those ages, this should be a linear decline when you look at the log(Obs[prop.CAA]). If that decline departs severely from a linear trend, it may be that true selectivity is dome-shaped. Also, you may know because of gear characteristics that selectivity is lower for older animals. In this instance, a double logistic could be estimated to capture the decline in selectivity for the older animals
9. Fit a logistic curve (or alternatively a double logistic curve) by least squares by minimizing the sum of squared residuals of the expected value and the normalized Obs/Exp value
10. If the resulting fitted curve does not cover the ages as expected according to “expert” knowledge, manipulate parameter values to satisfaction (“fit by eye”)

SEDAR

Southeast Data, Assessment, and Review

SEDAR 21

HMS Sandbar Shark

SECTION IV: Research Recommendations

SEDAR
4055 Faber Place Drive, Suite 201
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1. DATA WORKSHOP RESEARCH RECOMMENDATIONS

1.1 LIFE HISTORY WORKING GROUP

- Increase research on post-release survivorship of all shark species by gear type
- Continue to investigate reproductive periodicity for sandbar sharks
- Continue to collect vertebral samples from the sandbar shark research fishery to develop an ageing material archive and to keep track of the age distribution of the catch, and continue monitoring juvenile sandbar shark ages through the collection of fishery-independent samples
- Develop empirically based estimates of natural mortality
- Continue tagging efforts

1.2 COMMERCIAL STATISTICS WORKING GROUP

- Expand observer coverage to obtain 5% coverage of total trips or 20 to 30% PSE (percent standard error).
- Conduct more studies to better estimate post-release mortality
- Review bycatch estimation models
- Discard rates of sandbar sharks in the current directed and non-directed bottom longline fishery should be calculated and extrapolated using BLLOP data.
- Continue to develop better methods to quantify discards and effort from logbook programs and observer programs

1.3 RECREATIONAL STATISTICS WORKING GROUP

No recommendations were provided.

1.4 INDICES OF ABUNDANCE WORKING GROUP

No general research recommendations were provided. Recommendations specific to each index can be found in the workshop text and on the appropriate index scorecard.

2. CIE REVIEW RECOMMENDATIONS - DATA WORKSHOP

Conclusions and Recommendations

The Data Workshop provides a productive environment in which stakeholders and scientists can share knowledge to optimize the information available for assessment. It also serves as a mechanism where differences of opinion can be resolved before assessments are completed. The quality of science was high and appropriate for the purpose of stock assessment.

Compared with many stocks the availability of data are comparatively limited, especially in relation to catches, whether landings or discards. Although there is a large quantity of abundance index information the quality of these data is limited by the amount of fishery independent information or spatial coverage of the survey. Preliminary inspection of the indices at the meeting suggested that there was very little similarity of trends suggesting they have high uncertainty. There is a danger that the assessment might be driven arbitrarily by one of the time series if it happened to have low estimated CVs. I would **recommend that more exploratory analyses are done with the CPUE indices to try to identify those which contribute the most information on stock trends over the area of the assessment.** One possible line of analysis would be to use factor analysis to see if a common annual signal could be extracted from the suite of indices.

During the meeting some time was devoted to filling out a ‘report card’ for each series. In order to save time I **would recommend that the report card is completed by the author and that more time at the meeting is devoted to assessing the value of each time series for the assessment.** The latter should include participation by assessment analysts.

The catch data suffer from a high degree of uncertainty. As much of the uncertainty relates to historical records there is not much that can be done to improve them. However, I would **recommend that an analysis is performed to try to quantify the uncertainty in the time series of catch data.** This would help in characterizing the overall uncertainty in the assessment.

The frequency of spawning by female sharks may be an important factor in estimating the spawning potential of the stock. Biological examination of female sharks appears to be able to determine that some species spawn less often that annually but the actual frequency cannot yet be established. In the absence of definitive information on spawning frequency I would **recommend that female sharks are examined in the spawning period to determine the proportion of spawning females**. While this will not provide an estimate of spawning frequency, it may provide sufficient information to estimate annual spawning biomass.

Estimates of discard survival proved an area of disagreement between scientists and fishing industry representatives. This was in part a result of differing perceptions of the meaning of discard survival. It is important that such disagreements don't lead to negotiated values that have no scientific basis. It might be worth investing in further discussion with the industry to reach a common understanding of the parameter in question. It might also help if **a desk study was undertaken to examine whether the choice of discard survival has a significant bearing on the estimated status of the stock in relation to MSY reference points.** If the sensitivity of the assessments to this quantity is low, it might defuse some of the polarization over the chosen values.

There may be a case for assessment analysts at the workshop to be more active in commenting whether certain biological effects can usefully be incorporated into assessments. This might be because some biological phenomena that are statically significant in their own right have little importance in determining the assessment outcome or where added biological realism in an assessment model is negated by the added uncertainty in input parameter values.

3. ASSESSMENT WORKSHOP RESEARCH RECOMMENDATIONS

- Investigate alternative approaches to age-length keys for estimating age from length

4. REVIEW PANEL RESEARCH RECOMMENDATIONS

The Assessment Team provided several research recommendations in the data workshop and AW reports, and these are endorsed by the Review Panel (RP) to the extent that they will improve the assessment. The RP considers research leading to an improved understanding of landings and removals, that improves consistency among indices, that reduces variability within the individual indices, and that leads to development or application of a model that more fully takes advantage of the length and age data including integration of the selectivity estimation into the assessment to be priorities.

With respect to further life history research, the RP considers the following to be priorities:

- Research on post-release survival by fishing sector and gear type should lead to improved landings and removals time series

- Research on fecundity and reproductive frequency should lead to an improved understanding of population productivity. As shown in assessment, status with respect to benchmarks is relatively robust to assumptions about overall productivity; however abundance and fishing mortality rate estimates are sensitive to this information. Research about natural mortality would also lead to a better understanding of productivity but traditionally has been difficult for most species.

- As noted throughout this report, the lack of age data was a limiting factor in this assessment and collection of sex-specific age and length data would aid the assessment. Regular collection of age data will help in the construction of improved age-length keys, in the interpretation of indices particularly in cases where populations have spatially structured with respect to age, and significantly aid in fitting the selectivity within the models. Additionally, if the abundance indices are age-structured, population responses to management actions should be detectable earlier than if the indices only provide information on total abundance.

- Although information about stock structure is important, as noted under ToR 1, genetic studies may not necessarily be informative about structure. Tagging studies to determine stock structure need to take into account that populations may be discrete during reproduction, but otherwise mixed most of the time. Increased international collaboration (e.g. Mexico) could help ensure wider distribution and returns of tags.

With respect to the abundance indices, the RP recommends:

- Evaluation of the individual indices via power analyses to determine whether they are informative about abundance trends. The majority of indices used in these assessments exhibited greater inter-annual variability than would be expected given the life history of these species, and given this variability, may only be able to detect large changes in abundance which are not expected to occur rapidly. A power analysis would help to determine how much abundance would have to change in order for the change to be detected with the survey, and additionally, if the survey effort needs to be increased or re-distributed in order to be able to evaluate the effectiveness of rebuilding strategies given the relatively low population grow rates for these species.

- A small study on how to make the best use of the knowledge of the data workshop participants for developing index rankings.

- Ensuring that, to the extent possible, information about sex, length and age is collected for the reasons provided above.

With respect to the landings and removals, the RP recommends:

- Research that improves the understanding of historical landings, both in the modern and historical period and to support the assumptions about when stocks are at virgin biomass if this assumption is carried forward in future assessments. This is particularly important for GoM blacknose sharks given the difficulties reconciling the abundance indices, landings and life history information.

- As recommended by the AT, improved observer coverage particularly during periods of regulatory or gear changes (e.g. TEDs).

- Ensuring that, to the extent possible, information about sex, length and age is collected for each fishery in order that selectivity can be estimated in the model.

With respect to the assessment models, the RP recommends further model development using both simpler and more complex models taking the following into consideration:

- The RP noted that the models used in this assessment were reasonably suited to shark life history. However, other models (e.g. SS3) could also be adapted. If reproduction is modeled as a function of the number of mature females, uncertainty in the reproductive frequency, fecundity and pup-survival can be integrated into a single parameter (the slope at the origin of the SR function), and information about these traits can be incorporated via priors on the parameter. The RP recommends consideration of this approach if information on reproduction remains uncertain.

- Estimating the fishery and survey 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.

- If external age-length keys are used in future assessments, development of a key based on a growth model to better assign proportions-at-age in each length class.
- Simulation tests (management strategy evaluation) can be used to test the performance of alternative assessment methods (including the catch-free model, ASPM, ASPIC, SS3, or stock specific models), recruitment parameterizations, harvest control rules, assessment frequency and data collection. Simulation studies may have a particular use in these assessments because of the particular biology of sharks and the data poor nature of these stocks.

SEDAR

Southeast Data, Assessment, and Review

SEDAR 21

HMS Sandbar Shark

SECTION V: Review Workshop Report

May 2011

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Table of Contents

1. INTRODUCTION

1.1 WORKSHOP TIME AND PLACE

The SEDAR 21 Review Workshop was held April 18-22, 2011 in Annapolis, MD.

1.2 TERMS OF REFERENCE

1. Evaluate the adequacy, appropriateness, and application of data used in the assessment.
2. Evaluate the adequacy, appropriateness, and application of methods used to assess the stock.
3. Recommend appropriate estimates of stock abundance, biomass, and exploitation.
4. Evaluate the methods used to estimate population benchmarks and stock status(*e.g., MSY, Fmsy, Bmsy, MSST, MFMT, or their proxies*); recommend appropriate management benchmarks, provide estimated values for management benchmarks, and declare stock status, consistent with the stock status determination criteria, benchmark, and biological reference points in the Consolidated HMS FMP, proposed FMPs and Amendments, other ongoing or proposed management programs, and National Standards.
5. Evaluate the adequacy, appropriateness, and application of the methods used to project future population status, rebuilding timeframe, and generation time; recommend appropriate estimates of future stock condition (e.g., exploitation, abundance, biomass).
6. Evaluate the adequacy, appropriateness, and application of methods used to characterize the uncertainty in estimated parameters. Provide measures of uncertainty for estimated parameters. Ensure that the implications of uncertainty in technical conclusions are clearly stated.
7. Ensure that stock assessment results are clearly and accurately presented in the Stock Assessment Report and that reported results are consistent with Review Panel recommendations. If there are differences between the AW and RW due to reviewer's requests for changes and/or additional model runs, etc., describe those reasons and results.

8. Evaluate the SEDAR Process as applied to the reviewed assessments and identify any Terms of Reference that were inadequately addressed by the Data or Assessment Workshops.
9. Consider the research recommendations provided by the Data and Assessment workshops and make any additional recommendations or prioritizations warranted. Clearly denote research and monitoring needs that could improve the reliability of future assessments. Recommend an appropriate interval for the next assessment, and whether a benchmark or update assessment is warranted.
10. Prepare a Peer Review Summary summarizing the Panel's evaluation of the stock assessment and addressing each Term of Reference. Provide a list of tasks that were not completed, who is responsible for completing each task, and when each task will be completed. Complete and submit the Final Summary Report within 3 weeks of workshop conclusion.

The review panel may request additional sensitivity analyses, evaluation of alternative assumptions, and correction of errors identified in the assessments provided by the assessment workshop panel; the review panel may not request a new assessment. Additional details regarding the latitude given the review panel to deviate from assessments provided by the assessment workshop panel are provided in the *SEDAR Guidelines* and the *SEDAR Review Panel Overview and Instructions*.

** The panel shall ensure that corrected estimates are provided by addenda to the assessment report in the event corrections are made in the assessment, alternative model configurations are recommended, or additional analyses are prepared as a result of review panel findings regarding the TORs above.**

1.3 LIST OF PARTICIPANTS

Workshop Panel

Larry Massey, Chair..NMFS SEFSC
Jamie Gibson..CIE Reviewer
Neil Klaer..CIE Reviewer
Shelton Harley ....CIE Reviewer

Analytic Representation

Enric Cortés .... NMFS SEFSC Panama City
Kate Andrews..NMFS SEFSC Beaufort
Paul Conn..NMFS AFSC

Rapporteur

Ivy Baremore .... NMFS SEFSC Panama City

HMS Representation

Karyl Brewster-Geisz..NMFS HMS

Observers

Peter Cooper..NMFS HMS
Chris Vonderweidt...ASMFC

Staff

Julie Neer .... SEDAR
Tyree Davis..NMFS Miami

2. REVIEW PANEL REPORT

Executive Summary

An independent peer-review panel workshop (RW) convened in Annapolis, Maryland, April 18-22, 2011, in a public meeting to review draft stock assessments for four SEDAR 21 stocks of Highly Migratory Species: U.S. South Atlantic blacknose, U.S. Gulf of Mexico (GoM) blacknose, sandbar, and dusky sharks. Data and assessment reports were presented that had been developed since June 2010 in a data workshop (DW) and a series of assessment webinars (AW). After examining the documents, the review panel (RP) questioned and asked for additional information from the chief stock-assessment analysts to determine whether the decisions, assumptions, assessment models, and outputs were adequate, complete, and scientifically sound. The RP's findings are:

ToR 1: Evaluate the adequacy, appropriateness, and application of data used in the assessment:

Data: The RP examined all input parameters and data used in the four assessments. Uncertainties associated with some of the sources of information were addressed by the assessment team (AT) via sensitivity analysis.

Stock Units: The AT used genetic studies, life history characteristics and tagging information to develop one stock unit for sandbar, one for dusky, and two for blacknose (GoM stock and Atlantic stock). The RP accepted these, but noted that if the sampling for the genetic and tagging studies occurred at a time when discrete populations were mixed, finer scale stock structure would not be detected. Additionally, if low rates of straying exist between populations or if genetic divergence is recent, genetic studies may not detect population structure even if populations are demographically uncoupled.

Life History Parameters: The RP examined the biological characteristics for the four stocks and generally accepted that the information was used appropriately, but expressed reservations about how the limited age and length data were used to derive selectivities for the various fisheries and surveys. Some selectivity-related sensitivity analyses were undertaken.

Abundance Indices: The RP generally accepted the selection of indices, agreed with the AT that many of the indices were short relative to the life span of the stocks under assessment, that most exhibited annual variability that exceeds what might be expected for these stocks, and that several did not span the full geographic distribution of the stocks. Assessment results were sensitive to these changes, and the RP appreciated that these variations were carried forward as sensitivity analyses.

Landings and Removals: Data issues identified by the data workshop panel include: under-reporting, species identification, spatial coverage, landings being aggregated for more than one species and whether data were included in more than one database creating the potential for double counting. The AW evaluated the effects of under- or overestimating landings and removals with model runs using higher and lower landings. The RP agreed that this approach was a reasonable way to evaluate how model output is scaled to overall abundance, but noted that the approach would only work if over- or under-reporting, or other issues with landings and removals data were similar over the entire time series. Regarding the historical period—defined as the period from a year in which the population could be considered to be at virgin levels, to the time at which landings data become available—the AT assumed that fishing effort increased during this period, and explored the effects of the assumed nature of this increase (e.g. linear versus exponential) on the assessment results using additional model runs with different assumptions. The RP accepted this as a reasonable approach, but also agreed with the AT that there was considerable uncertainty about the removals during the historical period and therefore the status of the populations at the time when landings data became available.

ToR 2: Evaluate the adequacy, appropriateness, and application of methods used to assess the stock:

Assessment Models: Two assessment methods were used across the four stock assessments, both being variants on the basic Age-Structured Production Model. For sandbar and the two blacknose stocks, a state-space variant was used: the state-space age-structured production model (referred to here as ASPM); while for the dusky assessment the catch-free variant was used: Age-Structured Catch-Free Production Model (ASCFM).

Overall it is the conclusion of the RP that these approaches are appropriate to the assessment of these stocks given some of the particular issues that relate to shark assessments, e.g., uncertain catch histories, and low productivity.

ASPM – Sandbar and Blacknose Assessments: The RP concludes that the general population dynamics assumed in the assessment model are appropriate for the assessments, but it is not clear that the added complexity of the state-space age-structured production model variant of ASPM was useful. The RP believes that using a model that did not include added complexity would not change the conclusions of the assessments or this review but would have made the models and model results easier to interpret, in particular allowing for easier analysis of the impacts of alternative data weighting scenarios.

ASCFM – Dusky Shark: The underlying population dynamics for ASCFM are essentially the same as those for ASPM – the major difference in the approaches being that absolute estimates fishery removals are not used within ASCFM. This is the same modeling platform used for the previous dusky assessment and is necessary due to the difficulties in obtaining any sort of catch history. A concern of the RP was the lack of simulation studies to determine the performance of the ASCFM under known conditions, particularly the response of the model to alternative scenarios about productivity when catches are known. This is further discussed under ToR 9.

GoM Blacknose Shark: Sensitivity runs requested by the RP demonstrated that the blacknose GoM assessment model was unable to fit apparent trends in the abundance indices at all, unless implausible additional historical catches were also estimated. This fundamental lack of fit of the model to the input data caused the RP to reject the blacknose GoM assessment model.

ToR 3: Recommend appropriate estimates of stock abundance, biomass, and exploitation:

The RP accepted the model results for Atlantic blacknose, sandbar and dusky sharks although there was considerable uncertainty in those results that is conveyed as part of the RW recommendations.

ToR 4: Evaluate the methods used to estimate population benchmarks and stock status (e.g., MSY, FMSY, BMSY, MSST, MFMT, or their proxies); recommend appropriate management benchmarks, provide estimated values for management benchmarks, and declare stock status, consistent with the stock status determination criteria, benchmark, and biological reference points in the Consolidated HMS FMP, proposed FMPs and Amendments, other ongoing or proposed management programs, and National Standards.

Atlantic Blacknose Shark: Results showed that the stock was overfished (SSF_{2009}/SSF_{MSY} of 0.43 to 0.64, all below MSST) and therefore subject to rebuilding. Current F values over all sensitivities also indicated that the stock was subject to overfishing (F_{2009}/F_{MSY} of 3.26 to 22.53).

Sandbar Shark: Results showed that the stock was overfished and therefore subject to rebuilding. Current F values over most sensitivities indicated that the stock was not currently subject to overfishing (F_{2009}/F_{MSY} 0.29 to 0.93). However, the low productivity scenario did indicate overfishing (F_{2009}/F_{MSY} of 2.62).

Dusky Shark: Results showed that the stock was overfished (SSB_{2009}/SSB_{MSY} of 0.41 to 0.50) and therefore subject to rebuilding. Current F values over all sensitivities also indicated that the stock was subject to overfishing (F_{2009}/F_{MSY} of 1.39 to 4.35).

ToR 5: Evaluate the adequacy, appropriateness, and application of the methods used to project future population status, rebuilding timeframe, and generation time; recommend appropriate estimates of future stock condition (e.g., exploitation, abundance, biomass).

Given the critical importance of incorporating uncertainty in the projections, the RP did not accept the projections or projection method applied to the sandbar and Atlantic blacknose stocks. However, it is the opinion of the RP that the methodology applied to the dusky assessment is sufficient and those projection results valid.

ToR 6: Evaluate the adequacy, appropriateness, and application of methods used to characterize the uncertainty in estimated parameters. Provide measures of uncertainty for estimated parameters. Ensure that the implications of uncertainty in technical conclusions are clearly stated.

The RP concluded that the AT has used and applied appropriate methods to characterize uncertainty in the four stock assessments.

Future assessments could consider additional approaches to characterize uncertainty.

The approaches used by the AT are appropriate and the RP has used the information provided by the AT to characterize the bounds of uncertainty in current and projected stock status under ToRs 3-5.

ToR 7: Ensure that stock assessment results are clearly and accurately presented in the Stock Assessment Report and that reported results are consistent with RP recommendations. If there are differences between the assessment workshop and review workshop due to reviewer's requests for changes and/or additional model runs, etc., describe those reasons and results.

Assessment documentation prepared by the AT was comprehensive for use of input data, model description, results and sensitivity analysis selection.

Considerable improvement is needed in the provision of model diagnostics. Evidence of convergence should be included particularly for the base case, minimally in the form of convergence statistics and preferably as MCMC diagnostic plots. Sensitivity results should include for the base case and all sensitivities, as columns, the individual objective function components. Developing national standards in stock assessment documentation should be implemented.

ToR 8. Evaluate the SEDAR Process as applied to the reviewed assessments and identify any Terms of Reference that were inadequately addressed by the data or assessment workshops.

The RP believes this SEDAR process has, overall, led to a comprehensive assessment of these stocks.

An independent reviewer participated in the data workshop and the AW report was also reviewed prior to being finalized for the RW. It remained unclear to the RP whether placing greater emphasis on reviews earlier in assessment processes will automatically lead to better assessments.

The RP believes that the ToRs of the data and AW were generally met.

There is a recommendation in the AW report that more time should be available for the data vetting process, while at the RW, the time available for the assessment modeling appeared to be one of the factors limiting further model development.

The review of four stocks in four days at the RW was only possible because three of the stocks used the same model and limited time was placed on the review of the data inputs.

The RP endorses the AT recommendation that no more than probably two stocks be assessed at one time with the same number of participants. The RP notes that the time required for a RW depends not only on the number of stocks, but also on the complexity of the individual assessments.

ToR 9. Consider the research recommendations provided by the data and assessment workshops and make any additional recommendations or prioritizations warranted. Clearly denote research and monitoring needs that could improve the reliability of future assessments. Recommend an appropriate interval for the next assessment, and whether a benchmark or update assessment is warranted.

The RP considers the following to be priorities:

- Research on post-release survival by fishing sector and gear type.
- Research on fecundity and reproductive frequency.
- Regular collection of age-specific data.
- Tagging studies conducted in collaboration with international entities (e.g. Mexico).
- Evaluation of the individual indices of abundance via power analyses.
- A small study on how to make the best use of the knowledge of the data workshop participants for developing index rankings.
- Ensuring information about sex, length and age is collected.
- Research that improves the understanding of historical landings, both in the modern and historical period and to support the assumptions about when stocks are at virgin biomass if this assumption is carried forward in future assessments.
- Improved observer coverage particularly during periods of regulatory or gear changes (e.g. TEDs).
- Further model development using simpler and more complex models.
- Estimating fishery and survey selectivities within the assessment model.
- Development of a two sex model.
- Fitting the model to either length or age data.
- Exploration of models that do not require an assumption that the population is at virgin levels at some point in time.
- If external age-length keys are used in future assessments, development of a key based on a growth model to better assign proportions-at-age in each length class.
- Simulation tests (management strategy evaluation) to test the performance of alternative assessment methods (including the catch-free model, ASPM, ASPIC, SS3, or stock specific models), recruitment parameterizations, harvest control rules, assessment frequency and data collection.
- For GoM blacknose shark, the appropriate interval of the next assessment depends on progress made towards reconciling the issues raised during this assessment process. For Atlantic blacknose shark, dusky shark and sandbar shark, the RP recognizes that population growth is expected to be relatively slow, but that modifications to the model may result in a different assessment of status. Benchmark assessments are recommended once the

modifications are made. Additionally, for dusky shark, given the retrospective patterns in the present analysis and the resulting uncertainties in the assessment, updates using the existing model in the shorter term are also recommended. In the longer-term, development of a set of indicators (age-structure, total mortality estimates from catch curves, changes in abundance indices values) that could be used to determine whether status has changed sufficiently to warrant a full assessment, is recommended.

ToR 10. Prepare a Peer Review Summary summarizing the Panel's evaluation of the stock assessment and addressing each Term of Reference. Provide a list of tasks that were not completed, who is responsible for completing each task, and when each task will be completed. Complete and submit the Final Summary Report within 3 weeks of workshop conclusion.

This report is the peer-review panel's summary of its evaluation of the stock assessments based on the given terms of reference.

SEDAR 21 Stock Assessment Review

A panel of three independent peer reviewers met in a workshop open to the public in Annapolis, Maryland, April 18-22, to critically examine population assessments for four shark stocks of Highly Migratory Species (HMS) (see list of participants in Appendix I). The workshop (SEDAR 21) was hosted by the office of the Southeast Data Assessment and Review (SEDAR)—an independent, cooperative fishery management council process for the southeastern United States. SEDAR was instituted in 2002 to improve the quality and reliability of fishery stock assessments in the U.S. South Atlantic, Gulf of Mexico (GoM), and U.S. Caribbean Sea by using a transparent and participatory process that typically includes federal, state, university and non-governmental scientists.

The stocks assessed in SEDAR 21 were dusky shark, sandbar shark, U.S. South Atlantic blacknose shark, and U.S. GoM blacknose shark. Starting in June 2010, scientists met in a data workshop and in a series of webinars to conduct a rigorous process of gathering and collating associated data, analyzing pertinent data and information, and conducting population model building and testing. Those efforts produced a stock assessment report for each fishery stock.

The objective of the independent review panel (RP) was to critically examine in a workshop the data, assumptions, decisions, analyses, models, and outputs for each stock. At the review workshop (RW), the panel studied the assessment documents and interviewed the chief stock assessment scientists to revisit each aspect of the assessment. The panel also requested and received additional sensitivity model runs and outputs.

The RP followed ten Terms of Reference (ToR). Since the four stocks were similar in nature, the same modeling software was applied to data and information for each stock, and the assessments were somewhat parallel in structure, the panel decided to provide one summary document that provides their consensus set of findings for all four stock assessments. Those findings are listed below.

ToR 1: Evaluate the adequacy, appropriateness, and application of data used in the assessment.

The RP examined all input parameters and data used in these four assessments and commends the assessment team (AT) for providing thorough reviews of the multiple data sources available for these shark stocks. Data included abundance indices based on both fisheriey-dependent as well as fishery-independent surveys, commercial landings and removals including discards and by-catch, recreational fisheries landings and removals including discard mortality, length and age data, life history information such as age-at-maturation and fecundity, as well as the results of genetic studies and tagging information used to determine stock structure. As described below, there are uncertainties associated with some of these sources of information which the AT carried through the assessment via sensitivity analyses.

Stock Units

The AT used genetic studies, life history characteristics and tagging information, to develop the stock units used in these assessments. As appropriately described by the AT, there is relatively little information for delineating population structure within each of the assessed species. For sandbar and dusky sharks the AT determined that one stock would be appropriate because genetic data indicate no significant differentiation between the GoM and U.S. South Atlantic tag-recapture data showed a high frequency of movement between basins. For blacknose sharks, the AT determined two stocks would be appropriate because tagging studies showed very little movement between the GoM and the Atlantic Ocean, and because the life history information indicated that the reproductive cycle differed between these regions. The RP accepted these determinations, but noted that if the sampling for the genetic and tagging studies occurred at a time when discrete populations were mixed, finer scale stock structure would not be detected. Additionally, if low rates of straying exist between populations or if genetic divergence is recent, genetic studies may not detect population structure even if populations are demographically uncoupled. A potential consequence of defining a larger stock is that exploitation at levels appropriate for the overall stocks could lead to overfishing of lower-productivity populations if they exist.

Life History Parameters

Although many aspects of shark life history are not well studied, others such as fecundity for some species are better known and can be informative in assessment models. The AT provided information on natural mortality, discard mortality, age and growth, as well as reproduction (maturity schedules, fecundity and reproductive cycles) for each of the four stocks. The RP examined the biological characteristics for the four stocks and generally accepted that the information was used appropriately. In particular, the RP appreciated that the uncertainties in the biological data was carried through the assessment via sensitivity analyses to evaluate how assumptions about natural mortality and reproductive frequency affected the assessment results. A discard mortality rate of 6% was used in the assessment. It was suggested during the review that as an alternative to a constant value, this value could be scaled up or down as a proportion of those landed dead, the idea being that the greater this proportion, the greater the stress on the animals landed alive and the lower the probability that they would live after being released.

Although the RP accepted the biological inputs as used in the assessment, the RP did express reservations about how the limited age and length data were used to derive selectivities for the various fisheries and surveys, an analysis that was carried out externally to the assessment model. Exploration at the RW showed that length measurements were not always the same (e.g. pre-caudal, total) requiring some standardization before it could be used. Because relatively small amounts of length data were available, data were at times aggregated over years prior to being converted to ages. Although this approach may be more appropriate for some sharks than some teleost species due to their lower reproductive rates, it does require the assumption that size-at-age and numbers-at-age have not changed during these years. Numbers-at-age particularly, could change rapidly if fishing mortality rates increase during the period over which these data are aggregated. The length frequencies were then converted to age frequencies using an age-length key. This key was developed using proportions at age in each length category. Because age data are sparse, this approach led to some anomalies in age-length keys. As an example, for dusky shark, sharks in the 180-190 cm category were assigned to age classes 5, 7, 8 and 10 with 25% of the sharks in each age class. The RP believed that the use of a growth model to assign an age distribution to sharks in a given length category would have led to a distribution that was more plausible biologically. Selectivity curves were then derived for the various fisheries and surveys using either algorithm or in many cases by fitting the selectivity by eye. This approach requires estimating the selectivity with knowledge of the true underlying age structure. An assumption is made that the fully selected age class is the one that is most abundant in the sample, an assumption that may not be valid if total mortality is high. The RP expressed a strong preference for including the length data and a growth model or age-length key in the assessment model in order that both abundance-at-age and selectivity can be estimated simultaneously overcoming this problem. However, the RP acknowledged that the only limited length data were available and that the assessment models being used were not set up to fit to these data. The AT did correctly acknowledge the subjectivities introduced by the method that was used to derive these curves. The RP accepted that, given the limited data and the models being used, the selectivity curves were sufficient for this assessment.

Abundance Indices

The AT considered a total of fifty-eight indices of abundance, based on both fishery dependent and fishery independent data, at the data workshop. Factors considered when selecting the indices to be used in the assessments included sample size, the length of the time series and whether the survey was conducted in appropriate habitat. The indices that were used are summarized in Table 1. The RP generally accepted the selection of indices, and agreed with the AT that many of the indices were short relative to the life span of the stocks under assessment, that most exhibited annual variability that exceeds what might be expected for these stocks and that several did not span the full geographic distribution of the stocks. The AT also correctly pointed out that some indices had different trends, indicating, together with their variability, that they were likely responding to factors other than stock-level abundance. Additionally, the AT ranked the indices based on factors such as geographic coverage as a way of giving different weightings to the indices in the assessment model. The RP accepted the rankings, believing the data workshop participants understood best the indices and their strengths and weaknesses.

Table 1. Abundance indices fitted by the shark assessment models with rankings assigned by the data workshop.

Abundance Index	Blacknose GoM	Blacknose Atlantic	Dusky	Sandbar
Fishery independent				
Panama city gillnet	3(2)			4
VIMS longline			3	2
Dauphin Is sea lab BLL	5			
NMFS coastspan LL				2(3)
NMFS NE LL			1	2
GA coastspan LL/GADNR		4		4
SC coastspan/SCDNR		2		3(2)
NMFS historical LL			1s	
UNC LL		4	1s	
MOTE ML LL	3			
NMFS SE BLL	1	1		1
NMFS SEAMAP trawl	2(2)			
Fishery dependent				
SEFC shark BLL OB	4	3	1	2
Drift gillnet OB		3		
Sink gillnet OB		1s		
SE pelagic LL OB/log			2	2
MRFSS				
NE gillnet OB				
Coastal fishery gillnet log		4		
Coastal fishery BLL log				
Large pelagic survey			4	5

Note: values shown in brackets indicate multiple indices from the same source (e.g. adult/juvenile), s indicates that the index was used for a sensitivity run only.

The AT examined the influence of the indices on the assessment results in several ways: by a variety of weighting schemes such as weighting all data points equally, weighting individual data by the inverse of their CV, and weighting individual indices by their rank, by fitting the model using subsets of the indices (e.g. fishery independent indices only) and by deriving a single index using a hierarchical model. Assessment results were sensitive to these changes, and the RP appreciated that these variations were carried forward as sensitivity analyses.

Landings and Removals

Landings and removals for sandbar, dusky and blacknose sharks, including commercial landings, recreational landings, discards and discard mortality and bycatch, are difficult to estimate. Issues were well described in the data workshop reports, including: under-reporting, species identification, spatial coverage, landings being aggregated for more than one species and whether data were included in more than one database creating the potential for double counting.

For sandbar shark, catches were included in the model as: the commercial and unreported catch series split into the GoM and Atlantic components, a recreational and Mexican catch series, and menhaden fishery discards. In the case of Atlantic blacknose shark, catches were included in the model as: commercial landings (bottom longlines, nets and lines) recreational catches, shrimp bycatch and bottom longline discards. For GoM blacknose shark, catches were included in the model as: commercial landings (bottom longlines, nets and lines) recreational catches, shrimp bycatch and bottom longline discards. Of these data, the shrimp bycatch in the GoM, which comprises most of the catches for this stock, is a key source of uncertainty particularly during and before the historical period defined for the model. For dusky shark, catches were considered to be too uncertain to be useful, leading to the use of a catch-free model. Instead, relative effort series were developed for the directed bottom longline, pelagic longline fishery and the recreational fishery.

The AW evaluated the effect of under- or over-estimating landings and removals using model runs with both higher and lower landings. The RP agreed that this approach was a reasonable way to evaluate how model output is scaled to overall abundance, but noted that the approach would only work if over- or under-reporting, or other issues with landings and removals data were similar over the entire time series.

In addition to the issues of estimating landings and removals for more recent years, the AT also needed a method to estimate landings during the historical period, defined as the period from a year in which the population could be considered to be at virgin levels, to the time at which landings data become available. The AT addressed this issue by assuming that fishing effort increased during the historical period, and explored the effects of the assumed nature of this increase (e.g. linear versus exponential) on the assessment results using additional model runs with different assumptions. The RP accepted that this was a reasonable approach, but also agreed with the AT that there was considerable uncertainty about the removals during the historical period and therefore the status of the populations at the time when landings data became available.

ToR 2: Evaluate the adequacy, appropriateness, and application of methods used to assess the stock.

Two assessment methods were used across the four stock assessments, both being variants on the basic Age-Structured Production Model. For sandbar and the two blacknose stocks a state-space variant was used: the State-Space Age-Structured Production Model (referred to here as ASPM); while for the dusky assessment the catch-free variant was used: Age-Structured Catch-Free Production Model (ASCFM).

Overall, it is the conclusion of the RP that these approaches are appropriate to the assessment of these stocks given some of the particular issues that relate to shark assessments, e.g., uncertain catch histories, and low productivity. Nevertheless there is improvement that could be made to the assessment platforms. Specific comments on each method and the applications in the individual assessments are provided in the sections below.

The RP notes that the AT had hoped to use Stock Synthesis (SS) instead of the variant on the age-structured production model for the three stocks assessed with ASPM. It is the understanding of the RP that at this time SS does not include the specific parameterization of some of the key biological processes used in these shark assessments, which are available within ASPM. Further we note that given the resources and time available to the AT—in particular that four assessments were to be completed—it would have been difficult for them to develop SS models for these stocks. While SS would have allowed the separation of the sexes, and estimation of length-specific selectivity, it is not presently known if setting up the model in this way, as would have been preferred by the RP, would have markedly changed the assessment results.

ASPM – Sandbar and Blacknose Assessments

The state-space age-structured production variant of the ASPM model was applied to the assessments of sandbar sharks and the two blacknose shark stocks. It has previously been applied to shark stocks, including some of the stocks being assessed here.

The basic model is quite simple – a combined or unisex age-structured model with recruitment modeled via a Beverton-Holt spawner recruitment curve and selectivity and other biological processes (e.g. natural mortality and maturity) modeled as age-specific processes. In particular ASPM incorporates pup survival and density-dependence, important biological characteristics of shark populations, which makes it easy to explicitly incorporate information on the productivity of the stocks which is a key constraining factor in shark stock assessment. ASPM requires the assumption that at the start of the model period the population was in a virgin state, and in the implementations for the three stocks recruitment was estimated as deterministic and selectivity at age was fixed.

Whilst ASPM was considered appropriate for the assessments undertaken, the RP had some questions as to the additional benefit that came from the additional complexity allowed through the state-space implementation. Briefly, in the three assessments the state-space component was implemented as a random walk on deviates on the fishery-specific effort trajectories. Effort was then used to predict catch through other model quantities, e.g. abundance and catchability. So catches are not assumed to be known without error and therefore the model trades off the penalties on the effort deviates with the CVs on the catch estimates. This is essentially a random walk in fishery-specific fishing mortality. This approach requires the estimation of a large number of additional parameters, although they are constrained deviates so that the effective number of estimated parameters is less than the absolute number.

A second issue of the ASPM relates to the weighting of different data sources – a very well-known important issue in stock assessments. ASPM has incredible flexibility in the weighting of catch and CPUE data – through time specific CV's on individual catch and CPUE series ($w_{i,j}$); lambda scaling factors on individual series, and overall model CVs. When you add to this the process error variances on the effort deviates it made it difficult for both the AT and the RP to determine the actual weightings that were being applied/estimated for the various data sources. This was particularly important in determining the weightings provided to the different abundance indices when trying to understand the fit to some of these series. The use of lambdas may also have theoretical implications for estimates of parameter uncertainty.

In the sandbar assessment, where an assumption was made to fit the catch data five times better than the CPUE indices, it essentially resulted in the assumption that catches were known without error and all the complexity with the state-space implementation and various lambdas just made things more difficult to understand. However, in the case of the GoM blacknose assessment where the catch and CPUE were given equal weight – the lack of fit to the shrimp trawl catches actually provided some insights into the tensions that were going on in the model between the catch series, key CPUE series, and productivity.

With the sandbar assessment, the RP identified problems in fits to early catch data due to a mismatch between catch series and the different assumptions of the 'historic' and 'modern' periods. This was another example of where the added complexity of the modeling made the implementation of the assessment harder as there were more model options that are needed to be set.

With the GoM blacknose assessment problems in the implementation of the state-space component meant that they were unable to get a satisfactory model with different selectivities for the shrimp bycatch fishery pre- and post- TED implementation. So the post-TED selectivity was assumed for the entire model period. The RP requested a model run with a selectivity curve that might better approximate the pre-TED situation and the results were broadly similar, so the problem encountered in the assessment probably did not have a qualitative impact on the results. Nevertheless it is another example where the additional complexity did not necessarily help in the assessment process.

Principal data inputs for the blacknose GoM assessment were historical catches and the abundance indices. Evidence of the acceptability of the assessment depends in particular on how well the model was able to fit to the input data. The abundance indices generally either showed no trend or an increasing trend over recent years – particularly for those indices given a high ranking by the DW (NFMS SE LL, SEAMAP summer and fall and SEFC shark BLL OB indices). Sensitivity runs requested by the RP demonstrated that the blacknose GoM assessment model was unable to fit apparent trends in the abundance indices at all, unless implausible additional historical catches were also estimated. This fundamental lack of fit of the model to the input data caused the RP to reject the blacknose GoM assessment model. A remedy for the situation would involve the development and application of a model with additional but plausible flexibility (e.g. in perhaps annual recruitment variation) to provide improved fits to observation data.

Some other secondary comments on the use of ASPM for the three assessments which should be considered in either the interpretation of the results and/or the consideration of modeling approaches for future assessments:

- Assuming fixed values or tight priors on pup survival, with other biological parameters fixed (e.g. fecundity and natural mortality) implies very tight, or exact estimates for key population productivity parameters such as the annual number of replacement spawners per spawner at low population size (α), which translates into steepness and F_{MSY} . This is not necessarily a bad thing – we know that the productivity of sharks is low, but people should be aware that the assumptions that go into the model tightly constrain some key reference points. The population trends were typically a 'one-way trip' so the data are unlikely to be that informative with respect to population productivity. This is discussed further under ToR 4.

- Both ASPM and the ASCFM removes catches starting from age 1 (depending on the selectivity), but there were several instances where size data suggested major catches of age-zero individuals. The problem with extending the catches back to age zeros relates to the assumption that it is at this stage where density dependence occurs, e.g. pup survival increases at lower stock sizes. Both the assumption that pup survival is the source of density dependence and the assumption that age zero catches are zero should be addressed in future assessments. In the current implementation, the use of catch in numbers meant that instead removing these fish at age 1 probably did not have a significant impact on the assessment results – but this might not hold if the fishing of age zeros was prior to density dependence.

- For all assessments the selectivity curves were estimated/guesstimated external to the modeling process – this is clearly not ideal and discussed under ToR 1. Under this ToR the RP also discussed the problem of the age-length key and the use of a single age-length key to convert length to age over the entire period for which length samples are available. All of these factors suggest that converting length data to age data and estimating age-based selectivity is not ideal. The RP recommends that future modeling approaches fit to catch-at-length data and, if possible, estimate length-specific rather than age-specific selectivity curves.

- The assumption of initial virgin conditions was unlikely to be met, but the absence of early age composition data makes it difficult to try and estimate the initial levels of depletion. The RP requested various runs for the ASPM assessments in order to investigate this assumption.

- Based on discussions during the review it was determined that the AT experienced problems obtaining convergence (as measured by obtaining a positive definite Hessian matrix) with several of the models for some of the species. With these models that did not converge they also found instances where alternative starting values led to different results and that this commonly occurred with the effort deviates. In order to assist in future assessment reviews tables of parameter values and likelihood components by estimation phase should be provided and specific sensitivity analyses to alternative starting values should be undertaken for key model runs. This is covered in more detail under ToR 7.

In order to address the various issues described in this section, numerous sensitivity analyses were undertaken by the AT, including several at the request of the RP.

So on balance, the RP concludes that the general population dynamics assumed in the assessment model are appropriate for the assessments, but it is not clear to the RP that the added complexity of the state space implementation of ASPM was useful in these assessments. This complexity includes the use of so-called 'historic' and 'modern' periods where different assumptions are made about the reliability of catch data and the relationship between catch and effort. Importantly, the RP believes that using a model that did not include this added complexity would not change the conclusions of the assessments or this review, but would only have made the models and model results easier to interpret, in particular allowed for easier analysis of the impacts of alternative data weighting scenarios.

ASCFM – Dusky Shark

The underlying population dynamics for ASCFM are essentially the same as those for ASPM – the major difference in the approaches being that absolute estimates fishery removals are not used within ASCFM. This is the same modeling platform used for the previous dusky assessment and is necessary due to the difficulties in obtaining any sort of catch history.

In the current implementation of ASCFM, effort series for the various fleets were used as input to the model and fishing mortality modeled as a function of effort. A random walk in fishing mortality is estimated through time, and specific to this assessment, a break point in F at the year 2000 was incorporated into the model to allow for significant change in management that occurred at that time (the ban on retention of dusky sharks).

In the case of a single fleet the relationship between effort and overall fishing mortality is relatively simple, but in this implementation multiple fleets were exploiting the stock. Estimates of relative effort for the fleets were determined. The actual quantity that is of interest would be the 'effective effort' of each fleet and this requires the incorporation of the catchability of each fleet, e.g. how many dusky sharks are caught per unit of effort for each fleet. One improvement to future dusky assessments will be the incorporation of information on the relative catchability of the different fleets and this could be done by comparing the ratios of CPUE for the different methods, with the same units of effort. Preferably this is done over a period when the fleets overlap and it is important to consider any differences in selectivity of the fleets when making such comparisons.

One concern of the RP was the lack of simulation studies to determine the performance of the ASCFM under known conditions, particularly the response of the model to alternative scenarios about productivity when catches are known. This is further discussed under ToR 9.

ToR 3: Recommend appropriate estimates of stock abundance, biomass, and exploitation.

The RP accepted the model results for Atlantic blacknose, sandbar and dusky sharks, but not GoM blacknose sharks. There was considerable uncertainty in the accepted results that the RP considers should be conveyed as part of the RW recommendations. The AT had assigned a base case model in each assessment as a suitable basis for conducting sensitivity analyses, but not with the interpretation that it provided a central best case for the provision of management advice. Dimensions explored by the AT in sensitivity analyses were not necessarily as upper and lower dimensions from the base case, and often only as a plausible alternative to the base, with unknown relative probability. Given the general uncertainty in these shark assessment inputs and results, the RP was unable to recommend central best estimates for stock abundance, biomass and exploitation values.

The RP considered that major dimensions in shark assessment uncertainty were in the overall biomass scale and the stock productivity. A data input that affects biomass scale is the estimated level of historical catch, and productivity is particularly affected by pup survival, reproduction periodicity, and natural mortality. Plausible sensitivity scenarios were developed by the RP in consultation with the AT to bracket the uncertainty in biomass scale, productivity, and other important dimensions particular to each shark species (Table 2). Sensitivities can be considered as plausible alternative states of nature of the stock for the interpretation of population benchmarks, stock status and management recommendations. For Atlantic blacknose the RW-base case differed from the base case in the assessment report in that the UNC series was down-weighted to better account for higher uncertainty in that index relative to others (rank 4 by the data workshop), and poor model fit to the UNC index.

Blacknose Shark: GoM Stock

For the GoM blacknose shark stock, there were two main issues that were not sufficiently reconciled at the RW, and as a result, the RP in unwilling to accept that stock status can be determined based on the RW analyses. The first of these is the uncertainty in the status of the population at the start of the historical period, when the population is assumed to be at a virgin size. In the case of GoM blacknose shark, the shrimp bycatch comprises most of the catches, and this fishery existed before the start of the historical period (1950). Although it is not known whether bycatch levels would have been similar in the past, this assumption is difficult to justify, but statements about the status of relative to a biomass benchmark are based on this assumption. The second issue pertains to difficulties fitting to both the catches and the survey indices simultaneously. The catch series shows relatively stable catches until about 2005 followed by gradual decline. Given the low productivity of the stock, when these catches are reasonably fit, the model estimates a general downward trend in abundance from 1950 to about 2008. In contrast, the BLLOP, NMFS SE LL, SEAMAP summer and SEAMAP fall indices appear to indicate stable or increasing abundance trends and the marked residual patterns indicate how poorly the model results fits these indices. At the RW, the AT did a model run with a very low weight on the catch data in order to see what the predicted catch series would look like if the indices were fit well. Both the magnitude and trend of the predicted catches were sufficiently different from the observed catches, that it was not possible to reconcile the catch and abundance index time series at the RW.

Blacknose Shark: Atlantic Stock

The unit used for spawning biomass was spawning stock fecundity (SSF: the female numbers multiplied by the age-specific fecundity). Current spawning biomass depletion was estimated to be between 0.17 and 0.26 across the range of sensitivities (SSF_{2009}/SSF_0, Table 3). Current fishing mortality on the stock was estimated to be between 0.29 and 0.48 per year in 2009 (F_{2009}, Table 3). Trajectories of SSF/SSF_{MSY} and F/F_{MSY} through time show a fairly consistent pattern across all sensitivities (Figure 1). Spawning biomass generally declined from about 1986 to 2004, and flattened off in recent years. Fishing mortality generally increased in the period from about 1990 to 2000, then reduced to a low level by 2006, and again increased to levels comparable to previous maximums by 2009. Abundance estimates in 2009 range from about 107,000 to about 439,000 sharks (Table 3), and fishing mortality estimates in 2009 range from 0.29 to 0.48.

Sandbar Shark

Current spawning biomass depletion was estimated to be between 0.18 and 0.34 across the range of sensitivities (SSF_{2009}/SSF_0, Table 4). Current fishing mortality on the stock was estimated to be between 0.01 and 0.02 per year in 2009 (F2009, Table 4). Trajectories of SSF/SSF_{MSY} and F/F_{MSY} through time show a fairly consistent pattern across all sensitivities (Figure 3). An exception was the RW-4 low productivity scenario that showed considerably increased F/F_{MSY} values in comparison with the other sensitivities. Spawning biomass generally declined from about 1986 to 2007, and then showed a slight increase to 2009. Fishing mortality varied about a constant level of about 0.08 (apical F) from 1983 to 2003, and then declined to below 0.03 by 2009. Abundance estimates in 2009 range from just less than 1 million to about 4.6 million sharks.

Dusky Shark

Current spawning biomass depletion was estimated to be between 0.13 and 0.24 across the range of sensitivities (SSB2009/SSB0, Table 5). Current fishing mortality on the stock was estimated to be between 0.026 and 0.080 per year in 2009 (F2009, Table 5). Trajectories of SSB/SSBMSY and F/FMSY through time show a fairly consistent pattern across all sensitivities (Figure 5). An exception was the S18 low productivity scenario that showed considerably increased F/FMSY values in comparison with the other sensitivities. Spawning biomass generally declined from about 1980 to 2009. Fishing mortality increased during the period 1982 to 1999, declined to a comparably low level by 2008, and then either flattened off or increased slightly in 2009.

Table 2. Sensitivity analyses selected for the RW.

Run	**Code**	**Description**
Blacknose Atlantic		
Base	RW-Base	Base case as provided by the AT with down-weighted UNC index
Inverse CV	RW-S1	Inverse CV abundance index weighting
1 year cycle	RW-S2	One year reproduction cycle
High catch	RW-S3	Catch increased one standard deviation
Low catch	RW-S4	Catch decreased one standard deviation
High productivity	RW-S5	Fecundity fixed at 6 pups for all ages, pup survival increased to 0.90
Low productivity	RW-S6	Pups per female reduced to 1, pup survival reduced to 0.75, M for ages 1-max increased to 0.25
Sandbar		
Base	Base	Base case as provided by the AT
Inverse CV	S1	Inverse CV abundance index weighting by the AT
2 year cycle	S5	Two year reproduction cycle by the AT
3 year cycle	S6	Three year reproduction cycle by the AT
High catch	RW-S1	Midpoint of base and high catch scenario of S13 by the AT
Low catch	RW-S2	Midpoint of base and low catch scenario of S12 by the AT
High productivity	RW-S3	Fecundity fixed at 9.5 pups for all ages, pup survival increased to 0.90, *M* for ages 1-max set to 0.105
Low productivity	RW-S4	Pup survival reduced to 0.80, *M* for ages 1-max increased by 10%
Dusky		
Base	Base	Base case as provided by the AT
High *M*	S3	Base *M* multiplied by 1.342
U-shaped *M*	S4	Elevated *M* for older age classes
High productivity	S17	Pups per female 10, two year reproductive cycle, pup survival 0.97
Low productivity	S18	Pups per female 4, pup survival 0.51

Table 3. Results of scenarios selected to explore the range of model outputs for Atlantic blacknose shark.

	RW-Base		**RW-S1 (Inv-CV)**		**RW-S2 (1-yr cycle)**		**RW-S3 (high catch)**		**RW-S4 (low catch)**		**RW-S5 (high productivity)**		**RW-S6 (low productivity)**	
	Estimate	**CV**	**Estimate**	**CV**	**Estimate**	**CV**	**Estimate**	**CV**	**Estimate**	**CV**	**Estimate**	**CV**	**Estimate**	**CV**
SSF_{2009}/SSF_{MSY}	**0.60**	0.16	**0.43**	0.16	**0.61**	0.18	**0.58**	0.16	**0.64**	0.16	**0.61**	0.18	**0.55**	0.15
F_{2009}/F_{MSY}	**5.02**	0.32	**4.77**	0.36	**3.37**	0.32	**5.51**	0.33	**4.67**	0.32	**3.26**	0.32	**22.53**	0.32
SSF_{MSY}/SSF_0	0.41		0.41		0.33		0.41		0.41		0.33		0.47	
MSY	24495		22978		20810		66625		17910		20429		36996	
SPR_{MSY}	0.67	0.03	0.67	0.04	0.48	0.04	0.67	0.03	0.67	0.03	0.46	0.04	0.94	0.034
F_{MSY}	0.08		0.07		0.14		0.08		0.08		0.15		0.01	
SSF_{MSY}	96809		90814		123900		288360		77577		116650		104620	
N_{MSY}	153709		144550		122172		576722		155385		118788		247916	
F_{2009}	0.38	0.32	0.34	0.36	0.46	0.32	0.41	0.33	0.35	0.32	0.48	0.32	0.29	0.32
SSF_{2009}	58049	0.19	38816	0.17	76066	0.20	168300	0.19	49395	0.19	71346	0.20	57920	0.19
N_{2009}	155000		107418		120381		439136		131490		116155		222969	
SSF_{2009}/SSF_0	0.24	0.08	0.17	0.11	0.21	0.19	0.24	0.08	0.26	0.07	0.20	0.17	0.26	0.14
B_{2009}/B_0	0.22	0.17	0.16	0.14	0.20	0.18	0.21	0.15	0.24	0.15	0.20	0.19	0.22	0.16
R0	85148	0.06	79571	0.08	66366	0.06	252780	0.07	68012	0.06	64308	0.06	145330	0.06
Pup-survival	0.81		0.81		0.81		0.81		0.81		0.90		0.75	
alpha	2.26		2.26		4.52		2.26		2.26		5.02		1.14	
steepness	0.36		0.36		0.53		0.36		0.36		0.56		0.22	

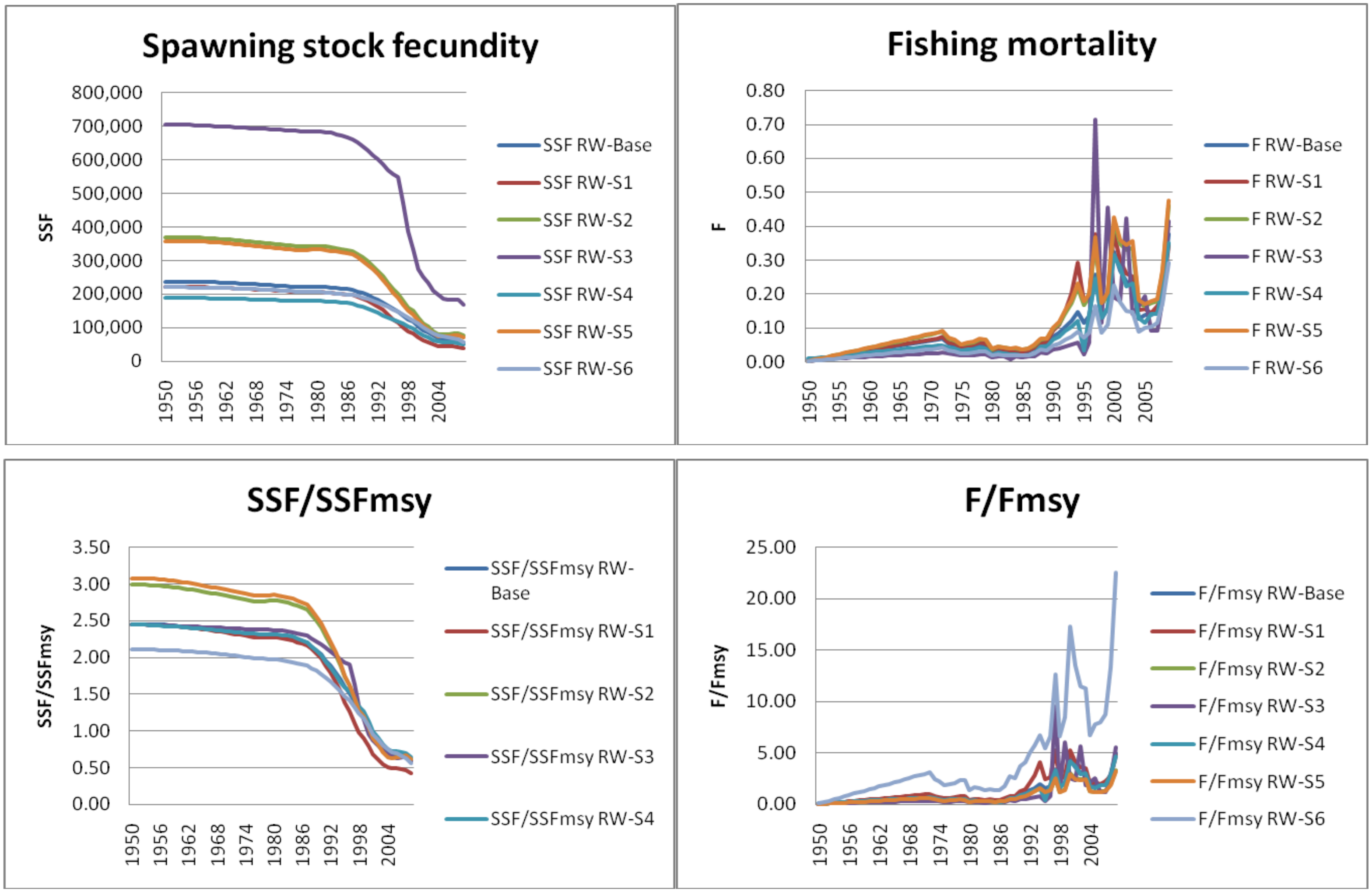

Figure 1. Time trajectories of key stock status indicators for Atlantic blacknose shark. Four trajectories are shown: SSF (spawning stock fecundity; top left panel), total apical F (top right panel), relative biomass (bottom left panel), and relative fishing mortality (bottom right panel). Each line within a panel is a different sensitivity analysis.

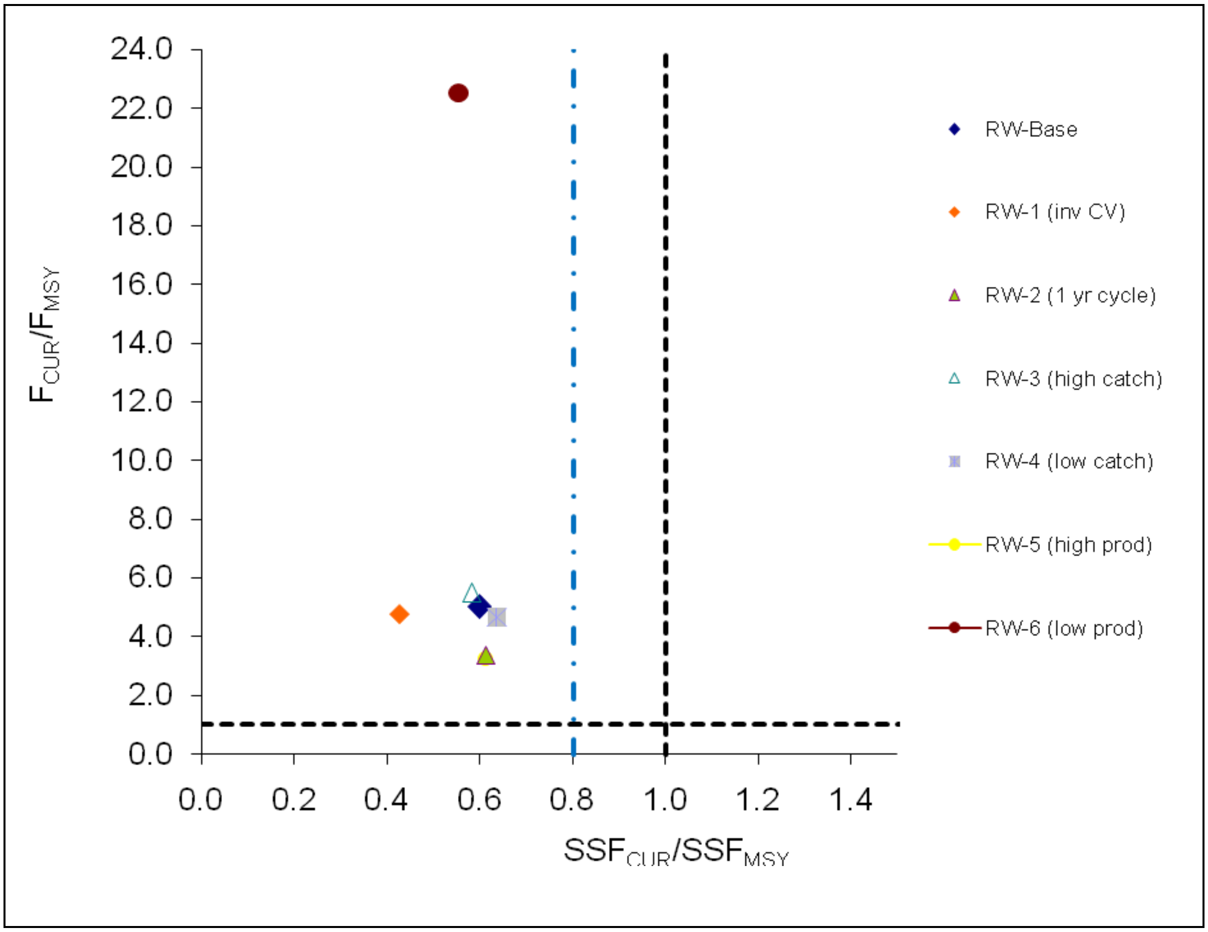

Figure 2. Phase plot of stock status for Atlantic blacknose shark, MSST shown as blue vertical dashed line.

Table 4. Results of scenarios selected to explore the range of model outputs sandbar shark.

	BASE		S5 (2 yr rep cycle)		S6 (3 yr rep cycle)		S1 (Inv CV)		RW-1 (high catch)		RW-2 (low catch)		RW-3 (high prod)		RW-4 (low prod)	
Parameter	**Estimate**	**CV**	**Estimate**	**CV**	**Estimate**	**CV**	**Estimate**	**CV**	**Estimate**	**CV**	**Estimate**	**CV**	**Estimate**	**CV**	**Estimate**	**CV**
AICc	718.01		717.81		718.71		652.84		715.02		716.89		716.91		716.16	
Objective function	117.95		117.85		118.30		85.37		116.46		117.39		117.40		117.02	
SSF_{2009}/SSF_{MSY}	**0.66**	0.83	**0.64**	0.71	**0.66**	1.09	**0.56**	0.70	**0.71**	0.78	**0.67**	0.85	**0.51**	0.55	**0.72**	3.49
F_{2009}/F_{MSY}	**0.62**	0.57	**0.46**	0.55	**0.93**	0.61	**0.62**	0.44	**0.29**	0.57	**0.64**	0.57	**0.36**	0.48	**2.62**	0.61
N_{2009}/N_{MSY}	0.74		0.74		0.78		0.65		0.77		0.76		0.87		0.70	
MSY	160643		152940		173414		152907		461238		118699		98928		194389	
SPR_{MSY}	0.78	0.06	0.69	0.09	0.86	0.04	0.74	0.09	0.78	0.06	0.77	0.07	0.53	0.14	0.95	0.01
F_{MSY}	0.021		0.030		0.030		0.025		0.022		0.019		0.059		0.004	
SSF_{MSY}	477590		503420		503420		430320		1377800		349330		425530		530410	
N_{MSY}	1928165		1768504		2012907		1804687		5530573		1427463		1037329		2500141	
F_{2009}	0.01	0.57	0.01	0.55	0.01	0.61	0.02	0.44	0.01	0.57	0.01	0.57	0.02	0.48	0.01	0.61
SSF_{2009}	312890	0.60	319760	0.59	313510	0.63	240950	0.40	984770	0.58	234320	0.60	215900	0.55	381620	0.61
N_{2009}	1539102		1408804		1688767		1277408		4605900		1165723		975580		1899533	
SSF_{2009}/SSF_0	0.28	0.41	0.25	0.42	0.32	0.41	0.24	0.27	0.32	0.38	0.28	0.41	0.18	0.44	0.34	0.38
B_{2009}/B_0	0.34	0.33	0.33	0.33	0.35	0.34	0.30	0.18	0.37	0.31	0.34	0.33	0.27	0.33	0.36	0.33
R0	563490	0.20	516810	0.18	612140	0.23	516900	0.14	1587000	0.21	423250	0.20	281740	0.12	774030	0.24
Pup-survival	0.84	0.29	0.84	0.29	0.84	0.29	0.94	0.30	0.84	0.29	0.85	0.29	0.90	0.29	0.76	0.29
alpha	1.64		2.05		1.37		1.84		1.65		1.66		3.80		1.10	
steepness	0.29		0.34		0.25		0.31		0.29		0.29		0.49		0.22	
SSF_0	1097900	0.20	1258700	0.18	993980	0.23	1007200	0.14	3092300	0.21	824700	0.20	1192200	0.12	1121000	0.24
SSF_{MSY}/SSF_0	0.43		0.40		0.48		0.43		0.45		0.42		0.36		0.47	

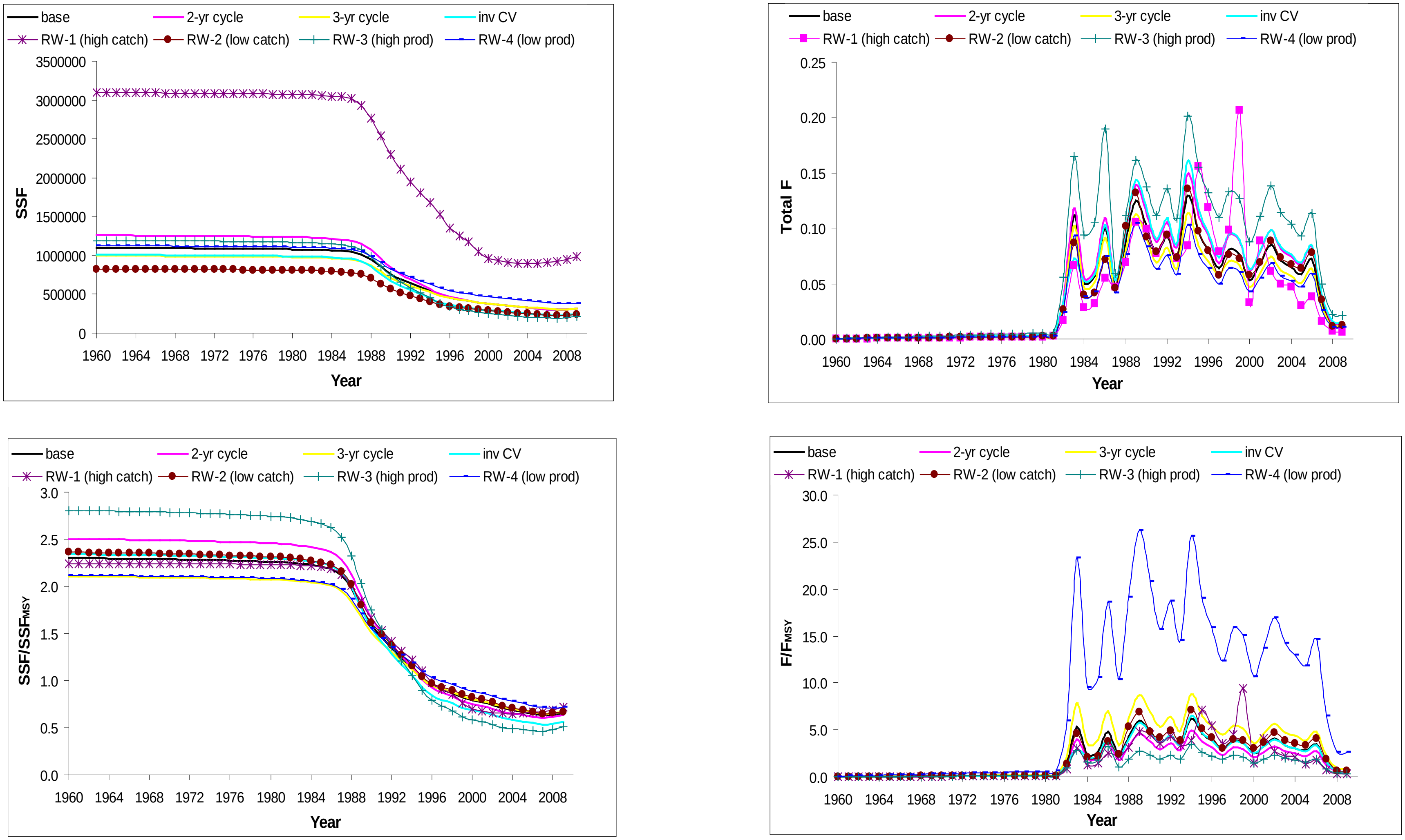

Figure 3. Time trajectories of key stock status indicators for sandbar shark. Four trajectories are shown: SSF (spawning stock fecundity; top left panel), total apical F (top right panel), relative biomass (bottom left panel), and relative fishing mortality (bottom right panel). Each line within a panel is a different sensitivity analysis.

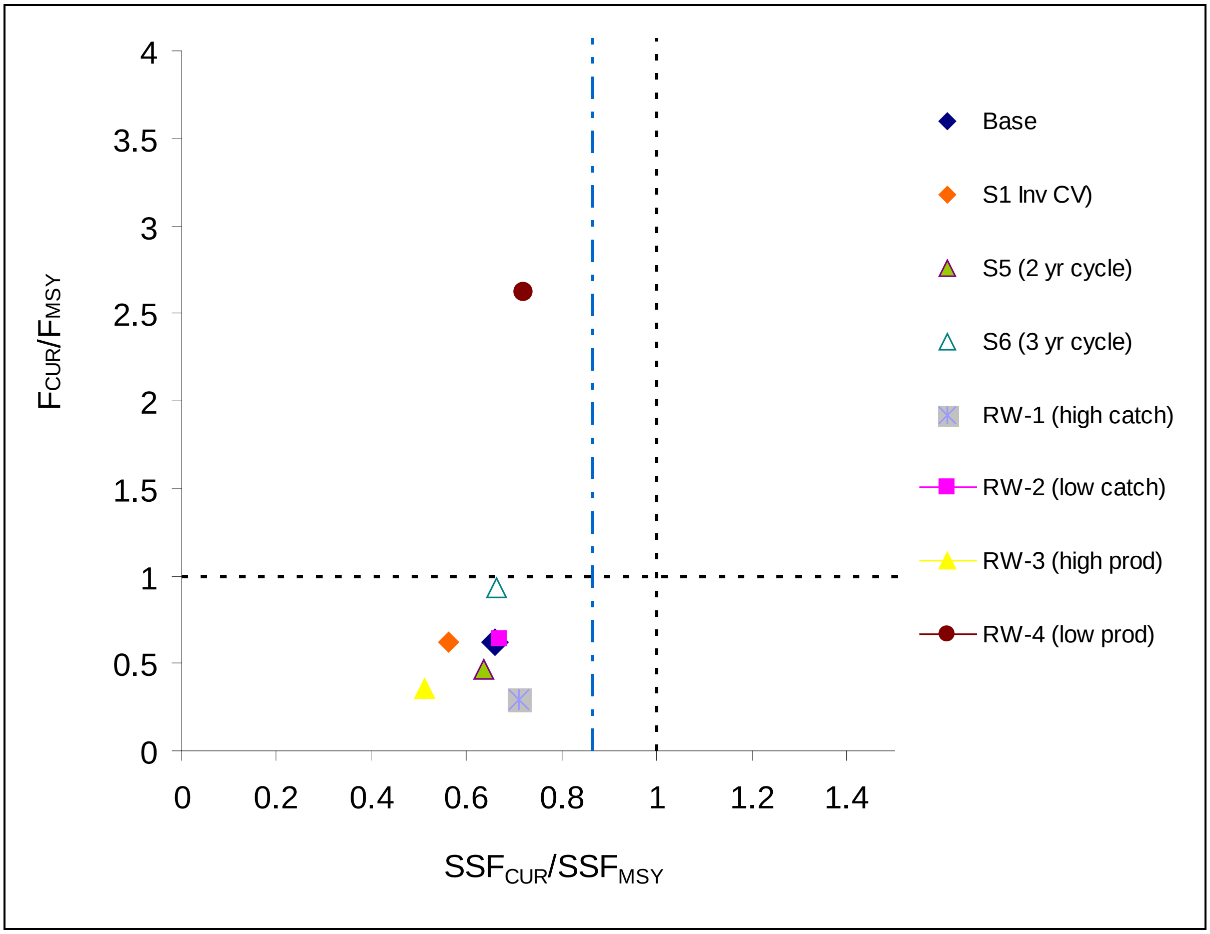

Figure 4. Phase plot of stock status for sandbar shark, MSST shown as blue vertical dashed line.

Table 5. Results of scenarios selected to explore the range of model outputs for dusky shark.

Run	**Base**	**S3**	**S4**	**S17**	**S18**
Description	--	High M	U shaped M	High productivity	Low productivity
F_{2009}	0.054	0.034	0.026	0.080	0.030
F_{MSY}	0.035	0.017	0.019	0.054	0.007
SSB_{2009}/SSB_0	0.15	0.18	0.18	0.13	0.24
SSB_{MSY}/SSB_0	0.35	0.43	0.43	0.28	0.47
SSB_{2009}/SSB_{MSST}	**0.46**	**0.45**	**0.44**	**0.49**	**0.53**
SSB_{2009}/SSB_{MSY}	**0.44**	**0.42**	**0.41**	**0.45**	**0.5**
F_{2009}/F_{MSY}	**1.55**	**2.01**	**1.39**	**1.49**	**4.35**
Pup survival	0.89	0.95	0.96	0.97	0.51
Steepness	0.51	0.32	0.32	0.71	0.25

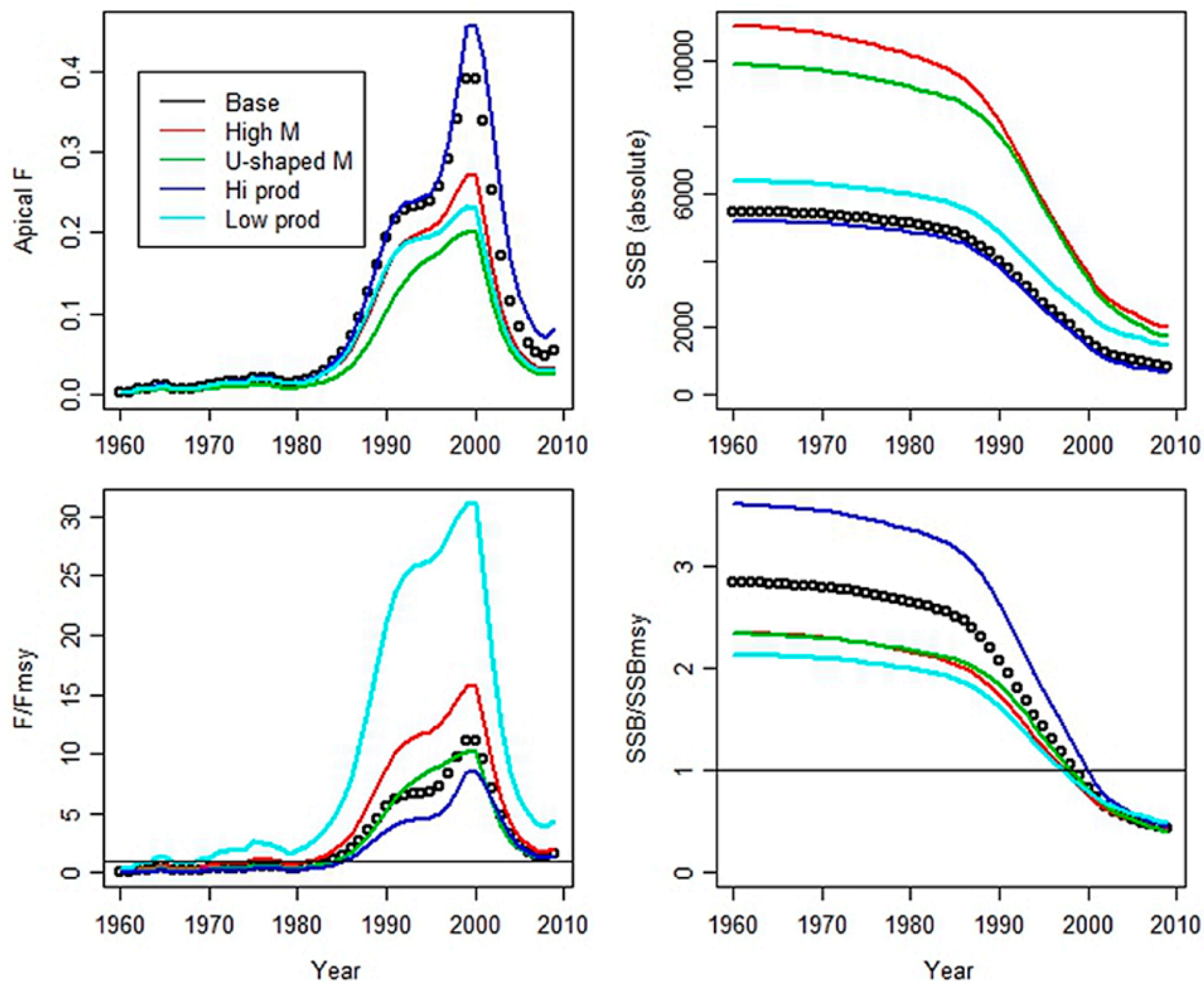

Figure 5. Time trajectories of key stock status indicators for dusky shark. Four trajectories are shown: total apical F (top left panel), SSB (spawning stock biomass; top right panel), relative fishing mortality (bottom left panel) and relative biomass (bottom right panel). Each line within a panel is a different sensitivity analysis.

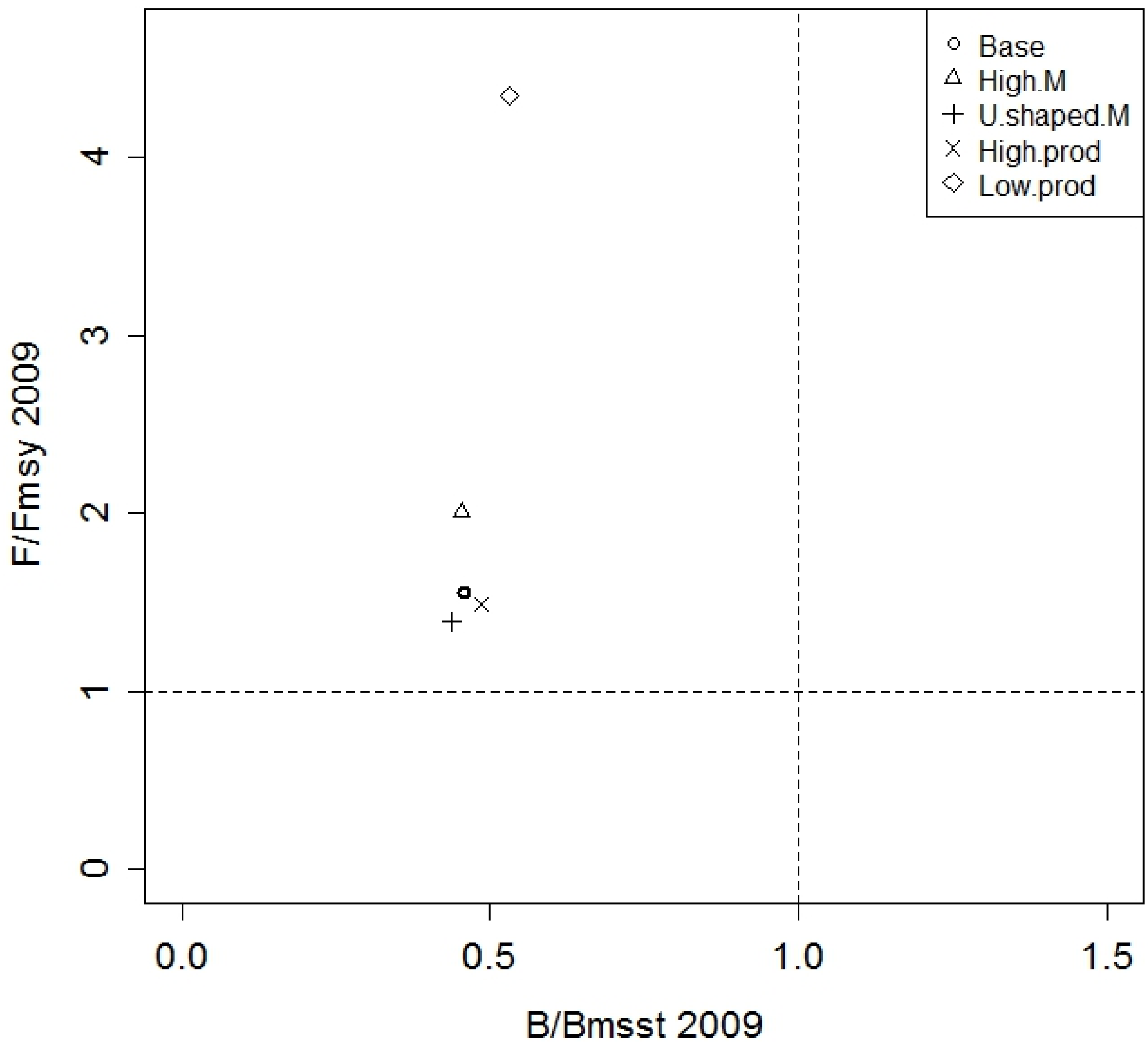

Figure 6. Phase plot of stock status for dusky shark (note that BMSST is used as a denominator for the X axis and not B_{MSY} as for the other species).

ToR 4: Evaluate the methods used to estimate population benchmarks and stock status (e.g., MSY, FMSY, BMSY, MSST, MFMT, or their proxies); recommend appropriate management benchmarks, provide estimated values for management benchmarks, and declare stock status, consistent with the stock status determination criteria, benchmark, and biological reference points in the Consolidated HMS FMP, proposed FMPs and Amendments, other ongoing or proposed management programs, and National Standards.

Methods used to calculate population and management benchmarks were appropriate and followed guidelines provided by Restrepo et al. 1998 and procedures developed for the 2006 assessments (Brooks et al. 2010). Values of MSY, FMSY and SSFMSY were estimated by the assessment models (special case for dusky shark). The minimum spawning stock size threshold (MSST) was defined as [(1-M) or 0.5 whichever is greater]*SSFMSY, the default for data-moderate situations in the guidelines. The maximum fishing mortality threshold (MFMT) was defined as FMSY.

The method for the calculation of MSST was made more complicated because of the age-specific M used for these shark species. An age-independent average M value that results in the same survivorship of fish to the plus group was used for MSST calculations.

Table 6. Principal stock indicator ranges over the RW sensitivities per shark species.

	Blacknose Atlantic	**Sandbar**	**Dusky**
SSF_{2009}/SSF_{MSY}*	0.43 - 0.64	0.51 - 0.72	0.41 - 0.50
F_{2009}/F_{MSY}	3.26 - 22.53	0.29 - 2.62	1.39 - 4.35

* Dusky shark used spawning stock biomass (SSB) rather than spawning stock fecundity (SSF).

Atlantic Blacknose Shark

Results over the alternative sensitivity analyses all showed that the stock was overfished (SSF_{2009}/SSF_{MSY} of 0.43 to 0.64, all below MSST) (Figure 2, Table 6) and therefore subject to rebuilding. Current F values over all sensitivities also indicated that the stock was subject to overfishing (F_{2009}/F_{MSY} 3.26 to 22.53).

Sandbar Shark

Results over the alternative sensitivity analyses all showed that the stock was overfished (SSF_{2009}/SSF_{MSY} of 0.51 to 0.72, all below MSST) (Figure 4, Table 6) and therefore subject to rebuilding. Current *F* values over most sensitivities indicated that the stock was not currently subject to overfishing (F_{2009}/F_{MSY} 0.29 to 0.93). However, the low productivity scenario did indicate overfishing (F_{2009}/F_{MSY} 2.62)

Dusky Shark

Results over the alternative sensitivity analyses all showed that the stock was overfished (SSB_{2009}/SSB_{MSY} of 0.41 to 0.50) (Table 6, Figure 6) and therefore subject to rebuilding. Current *F* values over all sensitivities also indicated that the stock was subject to overfishing (F_{2009}/F_{MSY} 1.39 to 4.35).

ToR 5: Evaluate the adequacy, appropriateness, and application of the methods used to project future population status, rebuilding timeframe, and generation time; recommend appropriate estimates of future stock condition (e.g., exploitation, abundance, biomass).

For the four stocks being assessed projection analyses are very important, in particular the propagation of uncertainty in the projections. This is for two reasons 1) these stocks are currently all subject to rebuilding plans; and 2) some of the projection benchmarks rely not on the median of the projections, rather some percentile of the distribution.

Two approaches were used for undertaking projections and the split was the same as that for the assessment methods. For the stocks assessed using ASPM (sandbar, and the two blacknose stocks) projections were carried out using Pro-2Box. The sandbar shark assessment report describes the procedure as it was applied in that assessment and we have repeated the important elements below:

"Projections were bootstrapped ≥500 times by allowing for process error in the spawner-recruit relationship. Lognormal recruitment deviations with SD = 0.4, with no autocorrelation, were assumed. No other variability was introduced into the projections. Under these assumptions, the base model was projected at F = 0 to determine the year when the stock can be declared recovered with a 70% probability (SSF/SSFMSY > 1). If that year is >10, then management action should be implemented to rebuild the stock within the estimated rebuilding time+1 generation time."

An alternative approach was used for projections for the dusky shark assessment and is detailed below:

"Projections were governed with the same set of population dynamics equations as the original assessment model, but allowed for uncertainty in initial conditions at the beginning of the time series (that is, in 2009) as well as in underlying productivity. Projections were run using Monte Carlo bootstrap simulation, where initial biomass (B_{2009}^{boot}), fishing mortality (F_{2009}^{boot}), and pup survival at low biomass ($\exp(-M0)_{2009}^{boot}$) were sampled from a multivariate normal distribution with expectations equivalent to posterior modes from the base run, and standard deviations set to the posterior standard deviation (obtained numerically by rejection sampling of the "profile likelihood" posterior approximation). Covariance values were obtained from the Hessian approximation of the variance-covariance matrix at the posterior mode. The multivariate normal approximation was chosen because it reduces the probability of selecting values of the different parameters that are unlikely to have generated the data (for instance, high fishing mortality and low pup survival)."

The key difference between the two approaches is that the latter method considers uncertainty in two key additional model quantities, the abundance of the stock in the terminal year and the level of productivity. Further it incorporates the correlation that exists between these estimated quantities.

Given the critical importance of incorporating uncertainty in the projections, the RP did not accept the projections or projection method applied to the sandbar and south Atlantic blacknose stocks. However, although not all sources of variability are included in the projections, it is the opinion of the RP that the method applied to the dusky assessment is sufficient given the greater uncertainties in different scenarios.

The RP recommends that projections be undertaken for sandbar and south Atlantic blacknose stocks using a method similar to that applied to dusky shark. The projection methodology should at least:

- Incorporate uncertainty in the overall abundance estimate in the terminal year;
- Incorporate uncertainty in the key productivity parameters, if estimated;
- Incorporate any correlation in the estimation of the above quantities; and
- Incorporate low levels of stochasticity in future recruitment – consistent with the tightly constraining biology of the species.

In making this recommendation, the RP was not aware of a generic package available to do the projections and that it was not possible to complete these projections within the RW.

Even with a more accurate reflection of the within model uncertainty being propagated through the projections, the RP was of the opinion that it was necessary to carry through the structural uncertainty considered in bracketing the current stock conditions (ToRs 3 and 4) through into the projections.

The RP prepared the following set of tables to contain the projection results. The key aspects of this table are:

- That multiple scenarios or possible ‘states of nature’ are included;

- Current terminal F’s are included to allow comparisons across runs and to allow examination in the relative change in F necessary to achieve the particular rebuild strategies;

- It includes projection scenarios requested by HMS that relate to the current management arrangements;

- It includes most of the results for dusky shark requested by the RP – the others will be done after the meeting; and

- It has no results for sandbar and south Atlantic blacknose because as noted above a satisfactory package to undertake the projections was not available to the AT during the RW.

When considering results similar to those presented in the tables below and developing a management response it is often useful to look not only at the results for particular scenarios, but also to examine the results in the context of a decision table. A management decision is made in the absence of knowing the true state of nature (i.e. which scenario is most correct), subsequently an important part of the process of making a management decision is having some indication of the consequences of making a decision if the true state of nature is different from that used to make the decision. Often a decision is made that performs ‘best’ (perhaps in terms of future stock sizes and removals) over the different states of nature without necessarily being the ideal management response for any single state of nature.

Table 7: Template for the projections results for three assessments (blacknose shark, dusky shark, and sandbar shark).

Blacknose Shark (Atlantic)

	Terminal conditions					$F_{Y\ rebuild}$		$TAC_{Y\ rebuild}$		P(rebuild by 2027)		
Scenario	F_{2009}	F_{2009}/F_{MSY}	S_{2009}/S_{MSY}	$Y_{F=0(P=0.7)}$	$Y_{rebuild}$	P=0.5	P=0.7	P=0.5	P=0.7	F_{2009}	TAC_{2009}	$Y_{rebuild(P=0.7)}$ TAC_{2009}
RW1												
..												
..												
..												
RWx												

Dusky Shark

	Terminal conditions					$F_{Y\ rebuild}$		$TAC_{Y\ rebuild}$		P(rebuild by 2408)	
Scenario	F_{2009}	F_{2009}/F_{MSY}	S_{2009}/S_{MSY}	$Y_{F=0(P=0.7)}$	$Y_{rebuild}$	P=0.5	P=0.7	P=0.5	P=0.7	F_{2009}	TAC_{2009}
RW1:Base	0.056	1.59	0.44	2059	2099	0.026	0.021				
RW2:High M	0.034	2.01	0.42	2150	2190	0.010	0.005				
RW3: U-shape M	0.026	1.39	0.41	2107	2147	0.009	0.005				
RW4:Hi Prod	0.080	1.49	0.45	2041	2081	0.046	0.042				
RW5:Low Prod	0.030	4.35	0.50	2217	2257	0.003	0.001				

Sandbar Shark

	Terminal conditions					$F_{Y\ rebuild}$		$TAC_{Y\ rebuild}$		P(rebuild by 2070)	
Scenario	F_{2009}	F_{2009}/F_{MSY}	S_{2009}/S_{MSY}	$Y_{F=0(P=0.7)}$	$Y_{rebuild}$	P=0.5	P=0.7	P=0.5	P=0.7	F_{2009}	TAC_{2009}
RW1											
..											
..											
..											
RWx											

ToR 6: Evaluate the adequacy, appropriateness, and application of methods used to characterize the uncertainty in estimated parameters. Provide measures of uncertainty for estimated parameters. Ensure that the implications of uncertainty in technical conclusions are clearly stated.

There are many types of uncertainty that can be considered when undertaking a stock assessment. The first is the uncertainty within a single model which is typically estimated with some statistical procedure; a second is the uncertainty across different structural models (e.g. models with either different model structure or alternative assumptions about data inputs or biological assumptions); and a third is the impact of new data on parameter estimates, an approach known as 'retrospective analysis' which can be useful for determining the potential for bias in parameter estimates. Often it is found that the structural uncertainty is greater than the within model uncertainty for a range of plausible structural models. All three approaches were applied to these assessments.

The RP concluded that the AT has used and applied appropriate methods to characterize uncertainty in the four stock assessments. Approximated normal standard errors and likelihood profiles were used to characterize the uncertainty in both model parameters and other model outputs of interest, e.g. stock status in relation to benchmarks. Extensive sensitivity analyses were used to characterize structural uncertainty and retrospective analysis was used to assess the change in parameter estimates as new data was added.

The importance of structural uncertainty was recognized by both the AT and RP. Because it was not considered appropriate to describe stock status with a single model, estimates of uncertainty in model parameters and key model outputs are provided under ToRs 3 - 5 where multiple model runs are used to characterize the status of the stock and the expected response to future management through projections.

Future assessments could consider additional approaches to characterize uncertainty. Within model uncertainty could be characterized using full Bayesian integration and this could also provide insights into model fit / convergence. Most of the sensitivity analyses were a single change from the reference model in either some model assumption or data input. Some of these changes represented plausible alternative states of nature and some changes were independent of others. In such circumstances it can be useful to evaluate all possible combinations of the sensitivity analyses, e.g. make several changes at the same time. Through the automation of model running procedures such extensive sensitivity analyses can easily be implemented.

Notwithstanding this, the RP reiterates that the approaches used by the AT are appropriate and the RP have used the information provided by the AT to characterize the bounds of uncertainty in stock status under ToRs 3-5.

ToR 7: Ensure that stock assessment results are clearly and accurately presented in the Stock Assessment Report and that reported results are consistent with RP recommendations. If there are differences between the assessment workshop and review workshop due to reviewer's requests for changes and/or additional model runs, etc., describe those reasons and results.

Assessment documentation prepared by the AT was comprehensive for use of input data, model description, results and sensitivity analysis selection. An area that requires considerable improvement is in the provision of model diagnostics. Evidence of convergence should be included particularly for the base case, minimally in the form of convergence statistics (such as Geweke convergence diagnostic, Gelman and Rubin diagnostic and the Heidelberger and Welch stationarity and half-width tests for key model parameters) and preferably as MCMC diagnostic plots. Sensitivity results should include for the base case and all sensitivities, as columns, the individual objective function components (in this case, each abundance index, catch or effort series, parameter priors). Developing national standards in stock assessment documentation (e.g. Crab Plan Team 2009) should be implemented.

ToR 8. Evaluate the SEDAR Process as applied to the reviewed assessments and identify any Terms of Reference that were inadequately addressed by the data or assessment workshops.

In spite of some of the uncertainties in the conclusions, the RP believes this SEDAR process has, overall, led to a comprehensive assessment of these stocks. The DW and AW reports summarize a considerable amount of information, and providing the background documentation affords the opportunity for a thorough review. In this assessment, an independent reviewer participated in the data workshop and the AW report was also reviewed prior to being finalized for the RW. After discussion, it remained unclear to the RP whether placing greater emphasis on reviews earlier in assessment processes will automatically lead to better assessments. The utility of this approach is likely case specific depending on issues encountered during the process.

Notwithstanding the findings of this review, as well as the comments and recommendations in this report, the RP believes that the ToRs of the data and AW were generally met. For example, although the AT did not provide maps showing the geographic distributions of the individual stocks, but the descriptions in the text delineated the stocks sufficiently. The data workshop and AW reports provide detailed summaries of the information available for these species.

There is recommendation in the AW report that more time should be available for the data vetting process, while at the RW, the time available for the assessment modeling appeared to be one of the factors limiting further model development. The review of four stocks in four days at the RW was only possible because three of the stocks used the same model and limited time was placed on the review of the data inputs. The RP endorses the AT recommendation that no more than probably two stocks be assessed at one time with the same number of participants. The RP notes that the time required for a RW depends not only on the number of stocks, but also on the complexity of the individual assessments.

ToR 9. Consider the research recommendations provided by the data and assessment workshops and make any additional recommendations or prioritizations warranted. Clearly denote research and monitoring needs that could improve the reliability of future assessments. Recommend an appropriate interval for the next assessment, and whether a benchmark or update assessment is warranted.

The AT provided several research recommendations in the data workshop and AW reports, and these are endorsed by the RP to the extent that they will improve the assessment. The RP considers research leading to an improved understanding of landings and removals, that improves consistency among indices, that reduces variability within the individual indices, and that leads to development or application of a model that more fully takes advantage of the length and age data including integration of the selectivity estimation into the assessment to be priorities.

With respect to further life history research, the RP considers the following to be priorities:

- Research on post-release survival by fishing sector and gear type should lead to improved landings and removals time series

- Research on fecundity and reproductive frequency should lead to an improved understanding of population productivity. As shown in assessment, status with respect to benchmarks is relatively robust to assumptions about overall productivity; however abundance and fishing mortality rate estimates are sensitive to this information. Research about natural mortality would also lead to a better understanding of productivity but traditionally has been difficult for most species.

- As noted throughout this report, the lack of age data was a limiting factor in this assessment and collection of sex-specific age and length data would aid the assessment. Regular collection of age data will help in the construction of improved age-length keys, in the interpretation of indices particularly in cases where populations have spatially structured with respect to age, and significantly aid in fitting the selectivity within the models. Additionally, if the abundance indices are age-structured, population responses to management actions should be detectable earlier than if the indices only provide information on total abundance.

- Although information about stock structure is important, as noted under ToR 1, genetic studies may not necessarily be informative about structure. Tagging studies to determine stock structure need to take into account that populations may be discrete during reproduction, but otherwise mixed most of the time. Increased international collaboration (e.g. Mexico) could help ensure wider distribution and returns of tags.

With respect to the abundance indices, the RP recommends:

- Evaluation of the individual indices via power analyses to determine whether they are informative about abundance trends. The majority of indices used in these assessments exhibited greater inter-annual variability than would be expected given the life history of these species, and given this variability, may only be able to detect large changes in abundance which are not expected to occur rapidly. A power analysis would help to determine how much abundance would have to change in order for the change to be detected with the survey, and additionally, if the survey effort needs to be increased or re-distributed in order to be able to evaluate the effectiveness of rebuilding strategies given the relatively low population grow rates for these species.
- A small study on how to make the best use of the knowledge of the data workshop participants for developing index rankings.
- Ensuring that, to the extent possible, information about sex, length and age is collected for the reasons provided above.

With respect to the landings and removals, the RP recommends:

- Research that improves the understanding of historical landings, both in the modern and historical period and to support the assumptions about when stocks are at virgin biomass if this assumption is carried forward in future assessments. This is particularly important for GoM blacknose sharks given the difficulties reconciling the abundance indices, landings and life history information.
- As recommended by the AT, improved observer coverage particularly during periods of regulatory or gear changes (e.g. TEDs).
- Ensuring that, to the extent possible, information about sex, length and age is collected for each fishery in order that selectivity can be estimated in the model.

With respect to the assessment models, the RP recommends further model development using both simpler and more complex models taking the following into consideration:

- The RP noted that the models used in this assessment were reasonably suited to shark life history. However, other models (e.g. SS3) could also be adapted. If reproduction is modeled as a function of the number of mature females, uncertainty in the reproductive frequency, fecundity and pup-survival can be integrated into a single parameter (the slope at the origin of the SR function), and information about these traits can be incorporated via priors on the parameter. The RP recommends consideration of this approach if information on reproduction remains uncertain.
- Estimating the fishery and survey 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.

- If external age-length keys are used in future assessments, development of a key based on a growth model to better assign proportions-at-age in each length class.

- Simulation tests (management strategy evaluation) can be used to test the performance of alternative assessment methods (including the catch-free model, ASPM, ASPIC, SS3, or stock specific models), recruitment parameterizations, harvest control rules, assessment frequency and data collection. Simulation studies may have a particular use in these assessments because of the particular biology of sharks and the data poor nature of these stocks.

In the case of GoM blacknose shark, the appropriate interval of the next assessment depends on progress made towards reconciling the issues raised during this assessment process. For Atlantic blacknose shark, dusky shark and sandbar shark, the RP recognizes that population growth is expected to be relatively slow, but that modifications to the model may result in a different assessment of status. Benchmark assessments are recommended once the modifications are made. Additionally, for dusky shark, given the retrospective patterns in the present analysis and the resulting uncertainties in the assessment, updates using the existing model in the shorter term are also recommended. In the longer-term, development of a set of indicators (age-structure, total mortality estimates from catch curves, changes in abundance indices values) that could be used to determine whether status has changed sufficiently to warrant a full assessment, is recommended.

ToR10. Prepare a Peer Review Summary summarizing the Panel's evaluation of the stock assessment and addressing each Term of Reference. Provide a list of tasks that were not completed, who is responsible for completing each task, and when each task will be completed. Complete and submit the Final Summary Report within 3 weeks of workshop conclusion.

This report documents the Panel's findings with respect to each Term of Reference. Each section of the RP's report was assigned to a panelist for drafting, and was discussed during the RW. The plan developed for completion of the report is as follows: the reviewers provide draft sections of the report to the Chair by April 28th, the Chair compiles the sections and produces a complete draft of the RW report and returns it to the Reviewers by May 3rd, the reviewers provide edits, additions, clarification and other comments back to the Chair by May 6th, the Chair compiles incorporates these changes into the report and returns it to the Reviewers for final review by May 10th, and the reviewers approve the final report by May 12th.

References

Brooks, E.N., Powers, J.E. and Cortés, E. 2010. Analytical reference points for age-structured models: application to data-poor fisheries. ICES Journal of Marine Science, 67: 165-175.

Crab Plan Team 2009. Stock Assessment and Fishery Evaluation Report for the King and Tanner Crab Fisheries of the Bering Sea and Ateutian Regions. North Pacific Fishery Management Council, Anchorage, AK.

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Appendix I

SEDAR 21 HMS Sharks
Review Workshop Participants

Workshop Panel
Larry Massey, Chair..NMFS SEFSC
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SEDAR

Southeast Data, Assessment, and Review

SEDAR 21

HMS Sandbar Shark

Section VI: Addenda and Post-Review Updates

July 2011

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6 Revisions

This addendum documents the results of several additional runs requested by the CIE reviewers at the SEDAR 21 Review Workshop (RW) for sandbar sharks. In addition to the baseline and three sensitivity scenarios previously run, the reviewers identified four additional sensitivity analyses to run to provide verification that the results of the assessment were robust to assumptions about underlying stock productivity and assumed level of removals. Reviewers also requested that projections be run for several of the sensitivity runs, noting that the uncertainty will be underestimated if only one of several equally plausible "states of nature" is used for projection purposes.

6.1.1 Corrections

Several discrepancies relating to metrics of MSY in numbers were noticed in Table 3.14 of the Assessment Report. These have been corrected in Table 6.1. The table also shows two additional benchmarks (SSF_0) and SSF_{MSY}/SSF_0 requested by the reviewers. We also added the baseline run results to Table 3.15 (Table 6.2 herein) and added a table showing the results of the retrospective analyses (Table 6.3 herein).

6.1.2 Sensitivity analyses

Reviewers identified seven sensitivity runs, in addition to the baseline run, to better understand how assessment outputs were related to key model assumptions. Three of those sensitivity scenarios had already been run and four were new. The seven runs were:

- S1: Inverse CV weighting of CPUEs.
- S5: Two-year reproductive cycle.
- S6: Three-year reproductive cycle.
- RW-1: High catch scenario. This scenario consisted of taking the midpoint between the baseline catch and the high catch scenario (S13 of the AP).
- RW-2: Low catch scenario. This scenario consisted of taking the midpoint between the baseline catch and the low catch scenario (S12 of the AP).
- RW-3: High productivity scenario. The aim of scenario RW-3 was to produce high values of the maximum lifetime reproductive rate (alpha hat). To that end, fecundity was fixed at 9.5 pups for all ages, the prior for first-year survival (S_0) was increased to 0.90 (mean; median=0.86), and M for ages 1-max was fixed at a value of 0.105.
- RW-4: Low productivity scenario. The aim of scenario RW-4 was to produce low values of the maximum lifetime reproductive rate (alpha hat). To that end, the prior for S_0 was decreased to 0.80 (mean; median=0.77) and M for ages 1-max was increased by 10% with respect to the values in the baseline run

Other than these changes, assessment methods were identical to those presented in section 3.

6.1.3 Projection scenarios

Reviewers requested projections be run for several sensitivity runs to characterize uncertainty as to underlying “states of nature.” Reviewers also requested that an alternate projection methodology from Pro2box be used in order to better characterize uncertainty in parameters other than recruitment.

New projections methodology was developed as follows: Projections were governed with the same set of population dynamics equations as the original assessment model, but allowed for uncertainty in initial conditions at the beginning of the time series (that is, in 2009) as well as in underlying productivity. Projections were run using Monte Carlo bootstrap simulation, where initial biomass (B_{2009}^{boot}), fishing mortality (F_{2009}^{boot}), and pup survival at low biomass ($\exp(-M0)_{2009}^{boot}$) were sampled from a multivariate normal distribution with expectations equivalent to posterior modes from the base run, and standard deviations set to the posterior standard deviation (obtained numerically by rejection sampling of the “profile likelihood” posterior approximation). Covariance values were obtained from the Hessian approximation of the variance-covariance matrix at the posterior mode. The multivariate normal approximation was chosen because it reduces the probability of selecting values of the different parameters that are unlikely to have generated the data (for instance, high fishing mortality and low pup survival).

Projections were started in 2009 and run until the year 2108. All projections used 10,000 Monte Carlo bootstrap simulations with initial values pulled from a multivariate normal distribution (described above). Moments of the bootstrap runs were summarized using quantiles, with median used for the central tendency, and 30th percentile used as the criterion for whether a projection had a 70% chance of rebuilding by 2108. Each projection was summarized with respect to landings, recruitment, and mature spawning stock biomass.

All projections assumed the selectivity function for 2009; projections thus assume that the current allocation of effort within the fishery (between fleets) stays the same. They also assumed that any change in management would not take into effect until 2013 (estimated 2009 fishing levels were thus assumed for 2009-2012).

Projections were run for sensitivity runs thought to incorporate the range of possible underlying productivity, mortality, and states of nature in the terminal year of the assessment. These runs included the original “Base” run, as well as scenarios S1 (inverse CV), S5 (2-year reproductive cycle), S6 (3-year reproductive cycle), RW-1 (high catch), RW-2 (low catch), RW-3 (high productivity), and RW-4 (low productivity). For each scenario, we attempted to estimate (1) the year in which F=0 would result in a 70% probability of rebuilding (Year $F=0_{p70}$), (2) the target rebuilding year, which was calculated as

$$Year_{rebuild}=(YearF=0_{p70})+20 \text{ (one generation time)},$$

(3) the F that would result in a 50% probability of rebuilding by $Year_{rebuild}$, (4) the F that would result in a 70% probability of rebuilding by $Year_{rebuild}$, (5) the fixed level of removals (TAC) that would allow rebuilding of the stock with a 50% probability by $Year_{rebuild}$, (6) the fixed level of removals (TAC) that would allow rebuilding of the stock with a 70% probability by $Year_{rebuild}$, (7) the probability of rebuilding with the estimated fishing mortality in 2009 by 2070 (the current rebuilding target), and (8) the probability of rebuilding if applying the current TAC (220 mt ww) by 2070. Each scenario assumed that

management measures would be implemented in 2013; in the interim, the fishing mortality estimated in 2009 was applied for F-based projections, and the mean of catches in 2008 and 2009 was applied for the TAC-based projections.

6.1.4 Implied steepness

Reviewers also asked for calculations of the implied steepness distribution that was associated with the prior distribution of pup survival at low biomass. We calculated this distribution for the original base run, and for sensitivity run S7 (U-shaped M). The implied prior distribution of steepness is a function of both pup survival and low biomass and spawners-per-recruit at 0 (), which differed between sensitivity runs. In general,

$$h = \frac{\varphi_0 \exp(-M0)}{4 + \varphi_0 \exp(-M0)} .$$

We approximated the implied prior for *h* by parametric boostrapping on $\exp^{(-M0)}$ and applying the above relationship.

6.2.1 Sensitivity results

Key parameter estimates and benchmarks are provided in Table 6.4. With the exception of run RW-4 (low productivity) which predicted overfishing was occurring in 2009, none of the other runs altered the results of the baseline run, predicting that the stock was overfished but that overfishing was not occurring. A phase plot depicting results from all sensitivity runs considered at the Review Workshop is provided in Figure 6.1. Time series trajectories for four quantities of interest (SSF, total F, SSF/SSF_{MSY}, and F/F_{MSY}) were produced for the baseline and seven sensitivity scenarios considered by reviewers to have incorporated uncertainty in assessment results (Figure 6.2).

6.2.2 Projection results

Results of projections are summarized in Table 6.5. The target year for rebuilding ranged between 2047 and 2360 depending on the state of nature of the stock. When excluding the low productivity scenario (RW-4), which seems unrealistic, the rebuilding year ranged between 2047 and 2083, thus it was lower than for the previous assessment (2070), except for S6 (3-yr cycle). All scenarios suggested that fishing mortality needed to be reduced with respect to the 2009 level to meet rebuilding targets with a 70% probability, except for scenarios RW-1(high catch) and RW-3(high productivity), likely due to the fact that these two scenarios modeled the stock as more productive. The TAC-based projections to meet rebuilding targets with 70% probability mirrored the general trends of the F-based projections. The three scenarios with higher inferred productivity (S5, RW-1, and RW-3) resulted in higher estimates than the current TAC. The results over all scenarios ranged from 168 to 522 mt whole weight (using a dressed to whole weight conversion ratio of 2.0) or 84 to 261 mt dressed weight. The low and high productivity scenarios were meant to encapsulate all the other scenarios by pushing the lower and upper bounds on the life history parameters. For projection purposes, both scenarios are unlikely to represent a true state of nature.

6.2.3 Implied distributions of steepness

Implied priors on steepness for the base run and sensitivity scenario S7 are plotted in Figure 6.3.

6.3 Tables

Table 6.1. Summary of results for base and sensitivity runs for sandbar shark. R_0 is the number of age-1 pups at virgin conditions. SSF is spawning stock fecundity (sum of number at age times pup production at age). All biomass metrics are in kg, except for MSY (numbers). AICc is the Akaike Information Criterion for small sample sizes, which converges to the AIC statistic as the number of data points gets large. Sensitivity runs are: S1 (inverse CV weighting), S2 (all indices), S3 (combined catches), S4 (combined catches and inverse CV weighting), S5 (2-yr cycle), S6 (3-yr cycle), S7 (U-shaped M), S8 (fishery-independent indices only), S9 (ranked indices), S10 (hierarchical index), S11 (hierarchical index, no weighting), S12 (low catch), S13 (high catch), S14 (low M), S15 (high M), and S16 (alternative historic catch). Highlighted fields indicate fields in which errors have been corrected.

	Base		S1		S2		S3		S4		S5		S6	
	Est	CV	Est	CV	Est	CV	Est	CV	Est	CV	Est	CV	Est	CV
AICc	718.01		652.84		1120.71		617.71		538.54		717.81		718.71	
Objective function	117.95		85.37		334.86		133.56		93.98		117.85		118.30	
SSF_{2009}/SSF_{MSY}	**0.66**	0.83	**0.56**	0.70	**0.31**	0.52	**0.78**	0.73	**0.58**	0.73	**0.64**	0.71	**0.66**	1.09
F_{2009}/F_{MSY}	**0.62**	0.57	**0.62**	0.44	**1.06**	0.52	**0.53**	0.30	**0.61**	0.30	**0.46**	0.55	**0.93**	0.61
N_{2009}/N_{MSY}	0.74	---	0.65	---	0.40	---	0.85	---	0.67	---	0.74	---	0.78	---
MSY	160643	---	152907	---	124373	---	168071	---	143387	---	152940	---	173414	---
SPR_{MSY}	0.78	0.06	0.74	0.09	0.72	0.11	0.79	0.01	0.74	0.01	0.69	0.09	0.86	0.04
F_{MSY}	0.021	---	0.025	---	0.027	---	0.020	---	0.026	---	0.030	---	0.030	---
SSF_{MSY}	477590	---	430320	---	340170	---	509800	---	402450	---	503420	---	503420	---
N_{MSY}	1928165	---	1804687	---	1455460	---	2024893	---	1684822	---	1768504	---	2012907	---
F_{2009}	0.01	0.57	0.02	0.44	0.03	0.52	0.01	0.30	0.02	0.30	0.01	0.55	0.01	0.61
SSF_{2009}	312890	0.60	240950	0.40	103850	0.38	397980	0.37	234890	0.37	319760	0.59	313510	0.63
N_{2009}	1539102	---	1277408	---	634848	---	1857216	---	1219683	---	1408804	---	1688767	---
SSF_{2009}/SSF_0	0.28	0.41	0.24	0.27	0.13	0.33	0.35	0.25	0.24	0.25	0.25	0.42	0.32	0.41
B_{2009}/B_0	0.34	0.33	0.30	0.18	0.18	0.27	0.40	0.18	0.30	0.18	0.33	0.33	0.35	0.34
R_0	563490	0.20	516900	0.14	419940	0.08	587230	0.16	494350	0.16	516810	0.18	612140	0.23
Pup-survival	0.84	0.29	0.94	0.30	0.99	0.00	0.82	0.29	0.94	0.29	0.84	0.29	0.84	0.29
alpha	1.64	---	1.84	---	1.93	---	1.59	---	1.82	---	2.05	---	1.37	---
steepness	0.29	---	0.31	---	0.33	---	0.28	---	0.31	---	0.34	---	0.25	---
SSF_0	1097900	0.20	1007200	0.14	818230	0.08	1144200	0.16	963230	0.16	1258700	0.18	993980	0.23
SSF_{MSY}/SSF_0	0.43	---	0.43	---	0.42	---	0.45	---	0.42	---	0.40	---	0.48	---

Table 6.1 (continued)

	S7		S8		S9		S10		S11		S12		S13	
	Est	CV	Est	CV	Est	CV	Est	CV	Est	CV	Est	CV	Est	CV
AICc	717.40		721.25		791.27		753.78		781.79		712.71		716.79	
Objective function	117.64		93.60		154.58		51.97		65.97		115.30		117.34	
SSF_{2009}/SSF_{MSY}	**0.57**	0.59	**1.17**	0.83	**0.66**	0.85	**0.60**	0.82	**0.41**	1.07	**0.66**	0.79	**0.77**	0.81
F_{2009}/F_{MSY}	**0.41**	0.51	**0.26**	0.95	**0.63**	1.02	**0.67**	0.57	**1.14**	0.83	**0.70**	0.57	**0.21**	0.58
N_{2009}/N_{MSY}	0.68	---	1.19	---	0.74	---	0.69	---	0.50	---	0.75	---	0.82	---
MSY	143016	---	242003	---	163252	---	160320	---	138548	---	84031	---	750154	---
SPR_{MSY}	0.62	0.11	0.78	0.06	0.79	0.05	0.78	0.07	0.79	0.06	0.78	0.07	0.78	0.06
F_{MSY}	0.044	---	0.021	---	0.020	---	0.021	---	0.020	---	0.014	---	0.023	---
SSF_{MSY}	543750	---	721400	---	491570	---	476320	---	418530	---	249020	---	2233800	---
N_{MSY}	1583494	---	2905982	---	1967458	---	1924085	---	1670697	---	1021159	---	8973517	---
F_{2009}	0.02	0.51	0.01	0.95	0.01	1.02	0.01	0.57	0.02	0.83	0.01	0.57	0.00	0.58
SSF_{2009}	312140	0.56	841940	1.04	326150	1.07	286000	0.59	172330	0.89	163310	0.62	1722400	0.59
N_{2009}	1163572	---	3720384	---	1583756	---	1429211	---	900438	---	823421	---	7932433	---
SSF_{2009}/SSF_0	0.22	0.43	0.52	0.50	0.29	0.48	0.27	0.41	0.18	0.71	0.29	0.41	0.33	0.37
B_{2009}/B_0	0.30	0.33	0.56	0.41	0.35	0.42	0.32	0.33	0.23	0.59	0.36	0.32	0.38	0.31
R_0	439030	0.15	836730	0.55	572880	0.59	550210	0.19	495180	0.19	285570	0.21	2644800	0.22
Pup-survival	0.85	0.29	0.85	0.29	0.83	0.29	0.85	0.29	0.81	0.29	0.86	0.29	0.84	0.29
alpha	2.69	---	1.65	---	1.61	---	1.66	---	1.59	---	1.68	---	1.63	---
steepness	0.40	---	0.29	---	0.29	---	0.29	---	0.28	---	0.30	---	0.29	---
SSF_0	1392700	0.15	1630300	0.55	1116200	0.59	1072100	0.19	964850	0.19	556410	0.21	5153300	0.22
SSF_{MSY}/SSF_0	0.39	---	0.44	---	0.44	---	0.44	---	0.43	---	0.45	---	0.43	---

Table 6.1 (continued)

	S14		S15		S16	
	Est	CV	Est	CV	Est	CV
AICc	717.87		718.21		615.40	
Objective function	117.88		118.05		66.65	
SSF_{2009}/SSF_{MSY}	**0.59**	0.65	**0.75**	1.65	**0.77**	1.00
F_{2009}/F_{MSY}	**0.48**	0.54	**1.15**	0.59	**0.61**	0.51
N_{2009}/N_{MSY}	0.77	---	0.74	---	0.83	---
MSY	136654	---	188038	---	216759	---
SPR_{MSY}	0.68	0.09	0.90	0.03	0.85	0.04
F_{MSY}	0.033	---	0.009	---	0.014	---
SSF_{MSY}	479160	---	481340	---	705930	---
N_{MSY}	1569644	---	2366861	---	2678391	---
F_{2009}	0.02	0.54	0.01	0.59	0.01	0.51
SSF_{2009}	282080	0.59	361100	0.59	541360	0.51
N_{2009}	1309279	---	1889311	---	2389563	---
SSF_{2009}/SSF_0	0.24	0.43	0.33	0.37	0.36	0.30
B_{2009}/B_0	0.32	0.34	0.36	0.32	0.40	0.24
R_0	436380	0.17	744630	0.23	772050	0.22
Pup-survival	0.84	0.29	0.85	0.28	0.71	0.29
alpha	2.23	---	1.23	---	1.39	---
steepness	0.36	---	0.23	---	0.26	---
SSF_0	1160500	0.17	1078400	0.23	1504300	0.22
SSF_{MSY}/SSF_0	0.41	---	0.45	---	0.47	---

Table 6.2. Summary of results for baseline run, continuity run, and 2006 base run for sandbar shark. R_0 is the number of age-1 pups at virgin conditions. SSF is spawning stock fecundity (sum of number at age times pup production at age). All biomass metrics are in kg, except for MSY (numbers). AICc is the Akaike Information Criterion for small sample sizes, which converges to the AIC statistic as the number of data points gets large.

	Base		Continuity		2006 Base	
	Est	CV	Est	CV	Est	CV
AICc	718.01		253.02		145.13	
Objective function	117.95		-80.11		-118.92	
SSF_{cur}/SSF_{MSY}	**0.66**	0.83	**0.80**	0.70	**0.72**	0.46
F_{cu}/F_{MSY}	**0.62**	0.57	**0.37**	1.50	**3.72**	0.15
N_{cur}/N_{MSY}	0.74	---	0.90	---	0.79	---
MSY	160643	---	147058	---	138304	---
SPR_{MSY}	0.78	0.06	0.65	0.39	0.73	0.02
F_{MSY}	0.021	---	0.06	---	0.02	---
SSF_{MSY}	477590	---	556810	---	594300	---
N_{MSY}	1928165	---	1737724	---	1769980	---
F_{cur}	0.01	0.57	0.02	1.50	0.06	0.15
SSF_{cur}	312890	0.60	444130	0.59	428340	0.19
N_{cur}	1539102	---	1685467	---	1520555	---
SSF_{cur}/SSF_0	0.28	0.41	0.32	0.53	0.31	0.13
B_{cur}/B_0	0.34	0.33	0.39	0.54	0.35	0.10
R_0	563490	0.20	467100	0.25	461100	0.07
Pup-survival	0.84	0.29	0.79	0.23	0.62	0.27
alpha	1.64	---	2.38	---	1.88	---
steepness	0.29	---	0.37	---	0.32	---
SSF_0	1097900	0.20	1404800	0.20	1386700	0.07
SSF_{MSY}/SSF_0	0.43	---	0.40	---	0.43	---

cur = 2009 for base and continuity, 2004 for Base 2006 assessment

Table 6.3. Summary of results for baseline run and retrospective analyses for sandbar shark. R_0 is the number of age-1 pups at virgin conditions. SSF is spawning stock fecundity (sum of number at age times pup production at age). All biomass metrics are in kg, except for MSY (numbers). AICc is the Akaike Information Criterion for small sample sizes, which converges to the AIC statistic as the number of data points gets large.

	Base		Retrospective 2008		Retrospective 2007	
	Est	CV	Est	CV	Est	CV
AICc	718.01		701.70		684.32	
Objective function	117.95		114.98		111.93	
SSF_{cur}/SSF_{MSY}	**0.66**	0.83	**0.53**	0.85	**0.50**	0.96
F_{cu}/F_{MSY}	**0.62**	0.57	**0.62**	0.57	**3.04**	0.61
N_{cur}/N_{MSY}	0.74	---	0.64	---	0.60	---
MSY	160643	---	154063	---	150530	---
SPR_{MSY}	0.78	0.06	0.79	0.05	0.79	0.01
F_{MSY}	0.021	---	0.03	---	0.01	---
SSF_{MSY}	477590	---	466860	---	455710	---
N_{MSY}	1928165	---	1840318	---	1861126	---
F_{cur}	0.01	0.57	0.02	0.57	0.04	0.61
SSF_{cur}	312890	0.60	249100	0.61	226920	0.67
N_{cur}	1539102	---	0	---	0	---
SSF_{cur}/SSF_0	0.28	0.41	0.24	0.45	0.22	0.50
B_{cur}/B_0	0.34	0.33	0.30	0.35	0.28	0.39
R_0	563490	0.20	535910	0.18	524080	0.19
Pup-survival	0.84	0.29	0.82	0.29	0.82	0.31
alpha	1.64	---	1.60	---	1.60	---
steepness	0.29	---	0.29	---	0.29	---
SSF_0	1097900	0.20	1044200	0.18	1021100	0.19
SSF_{MSY}/SSF_0	0.43	---	0.45	---	0.45	---

cur = 2009 for base, 2008 for retrospective 2008, and 2007 for retrospective 2007 assessment

Table 6.4. Summary of results for base and sensitivity runs (S1, S5, S6) together with sensitivity runs requested by the review panel (RW-1 to RW-4). R_0 is the number of age-1 pups at virgin conditions. SSF is spawning stock fecundity (sum of number at age times pup production at age). All biomass metrics are in kg, except for MSY (numbers). AICc is the Akaike Information Criterion for small sample sizes, which converges to the AIC statistic as the number of data points gets large. Sensitivity runs are: S1 (inverse CV weighting), S5 (2-yr cycle), S6 (3-yr cycle), RW-1 (high catch), RW-2 (low catch), RW-3 (high productivity), and RW-4 (low productivity)

	Base		S1		S5		S6		RW-1		RW-2		RW-3		RW-4	
	Est	CV	Est	CV	Est	CV	Est	CV	Est	CV	Est	CV	Est	CV	Est	CV
AICc	718.01		652.84		717.81		718.71		715.02		716.89		716.91		716.16	
Objective function	117.95		85.37		117.85		118.30		116.46		117.39		117.40		117.02	
SSF_{2009}/SSF_{MSY}	**0.66**	0.83	**0.56**	0.70	**0.64**	0.71	**0.66**	1.09	**0.71**	0.78	**0.67**	0.85	**0.51**	0.55	**0.72**	3.49
F_{2009}/F_{MSY}	**0.62**	0.57	**0.62**	0.44	**0.46**	0.55	**0.93**	0.61	**0.29**	0.57	**0.64**	0.57	**0.36**	0.48	**2.62**	0.61
N_{2009}/N_{MSY}	0.74	---	0.65	---	0.74	---	0.78	---	0.77	---	0.76	---	0.87	---	0.70	---
MSY	160643	---	152907	---	152940	---	173414	---	461238	---	118699	---	98928	---	194389	---
SPR_{MSY}	0.78	0.06	0.74	0.09	0.69	0.09	0.86	0.04	0.78	0.06	0.77	0.07	0.53	0.14	0.95	0.01
F_{MSY}	0.021	---	0.025	---	0.030	---	0.030	---	0.022	---	0.019	---	0.059	---	0.004	---
SSF_{MSY}	477590	---	430320	---	503420	---	503420	---	1377800	---	349330	---	425530	---	530410	---
N_{MSY}	1928165	---	1804687	---	1768504	---	2012907	---	5530573	---	1427463	---	1037329	---	2500141	---
F_{2009}	0.01	0.57	0.02	0.44	0.01	0.55	0.01	0.61	0.01	0.57	0.01	0.57	0.02	0.48	0.01	0.61
SSF_{2009}	312890	0.60	240950	0.40	319760	0.59	313510	0.63	984770	0.58	234320	0.60	215900	0.55	381620	0.61
N_{2009}	1539102	---	1277408	---	1408804	---	1688767	---	4605900	---	1165723	---	975580	---	1899533	---
SSF_{2009}/SSF_0	0.28	0.41	0.24	0.27	0.25	0.42	0.32	0.41	0.32	0.38	0.28	0.41	0.18	0.44	0.34	0.38
B_{2009}/B_0	0.34	0.33	0.30	0.18	0.33	0.33	0.35	0.34	0.37	0.31	0.34	0.33	0.27	0.33	0.36	0.33
R_0	563490	0.20	516900	0.14	516810	0.18	612140	0.23	1587000	0.21	423250	0.20	281740	0.12	774030	0.24
Pup-survival	0.84	0.29	0.94	0.30	0.84	0.29	0.84	0.29	0.84	0.29	0.85	0.29	0.90	0.29	0.76	0.29
alpha	1.64	---	1.84	---	2.05	---	1.37	---	1.65	---	1.66	---	3.80	---	1.10	---
steepness	0.29	---	0.31	---	0.34	---	0.25	---	0.29	---	0.29	---	0.49	---	0.22	---
SSF_0	1097900	0.20	1007200	0.14	1258700	0.18	993980	0.23	3092300	0.21	824700	0.20	1192200	0.12	1121000	0.24
SSF_{MSY}/SSF_0	0.43	---	0.43	---	0.40	---	0.48	---	0.45	---	0.42	---	0.36	---	0.47	---

Table 6.5. Summary of projection results for sandbar shark, in form requested by SEDAR 21 reviewers. *The probabilities for S6 are illustrated in Figure 6.4. The uncertainty is so high for the scenario that the probability never reaches 70% in the TAC-based projections.

	Terminal conditions					$F_{Year\_rebuild}$		TAC $_{Year\_rebuild}$ (mt ww)			
Scenario	F_{2009}	F_{2009}/F_{MSY}	S_{2009}/S_{MSY}	YearF=0$_{p70}$	Year$_{rebuild}$	p50	p70	P50	P70	P(rebuild with F2009) by 2070	P(rebuild with 2009 TAC) by 2070
Base	0.013	0.62	0.65	2046	2066	0.010	0.006	286	178	<30%	>70%
S1	0.016	0.62	0.56	2047	2067	0.012	0.006	200	178	<30%	>70%
S5	0.012	0.43	0.70	2030	2050	0.015	0.010	395	304	>70%	>70%
S6	0.012	0.88	0.70	2063	2083	0.007	0.003	222	*	<30%	>50%, <70%
RW-1	0.006	0.29	0.71	2037	2057	0.010	0.007	820	413	>70%	>70%
RW-2	0.012	0.64	0.67	2041	2061	0.011	0.007	230	168	<50%	>50%, <70%
RW-3	0.021	0.36	0.51	2027	2047	0.026	0.026	590	522	>70%	>70%
RW-4	0.011	2.62	0.72	2340	2360	---	---	---	---	---	---

6.4 Figures

Figure 6.1. Phase plot summarizing stock status in 2009 for original base run and scenarios selected to explore the range of model outputs for sandbar shark at the Review Workshop. Base is baseline scenario; S1 is inverse CV weighting; S5 is 2-year reproductive cycle; S6 is 3-year reproductive cycle; RW-1 (high catch) is modified high catch; RW-2 (low catch) is modified low catch; RW-3 (high prod) is high productivity; RW-4 (low prod) is low productivity.

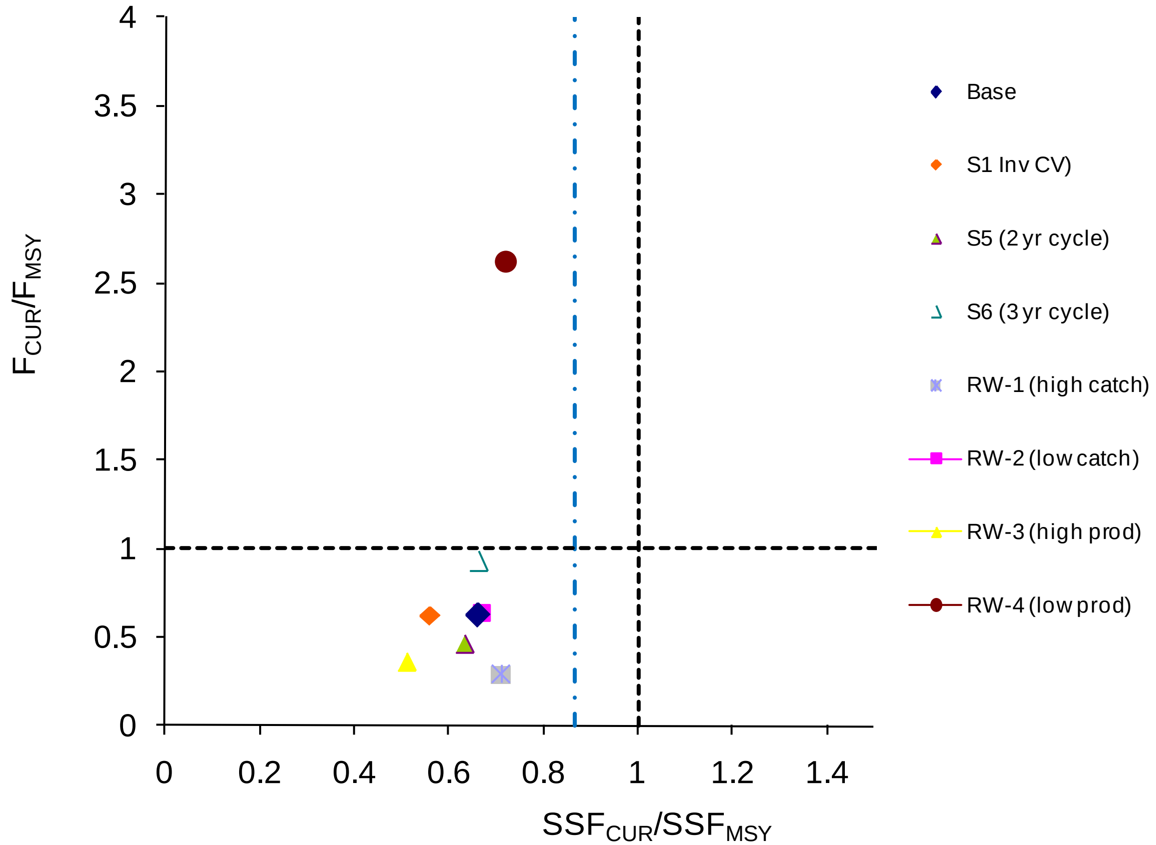


Figure 6.2. Scenarios selected to explore the range of model outputs for sandbar shark at the Review Workshop. Base is baseline scenario; S1 is inverse CV weighting; S5 is 2-year reproductive cycle; S6 is 3-year reproductive cycle; RW-1 (high catch) is modified high catch; RW-2 (low

catch) is modified low catch; RW-3 (high prod) is high productivity; RW-4 (low prod) is low productivity. Four time series trajectories are shown: SSF (spawning stock fecundity; top left panel), total apical F (top right panel), relative biomass (bottom left panel), and relative fishing mortality (bottom right panel).

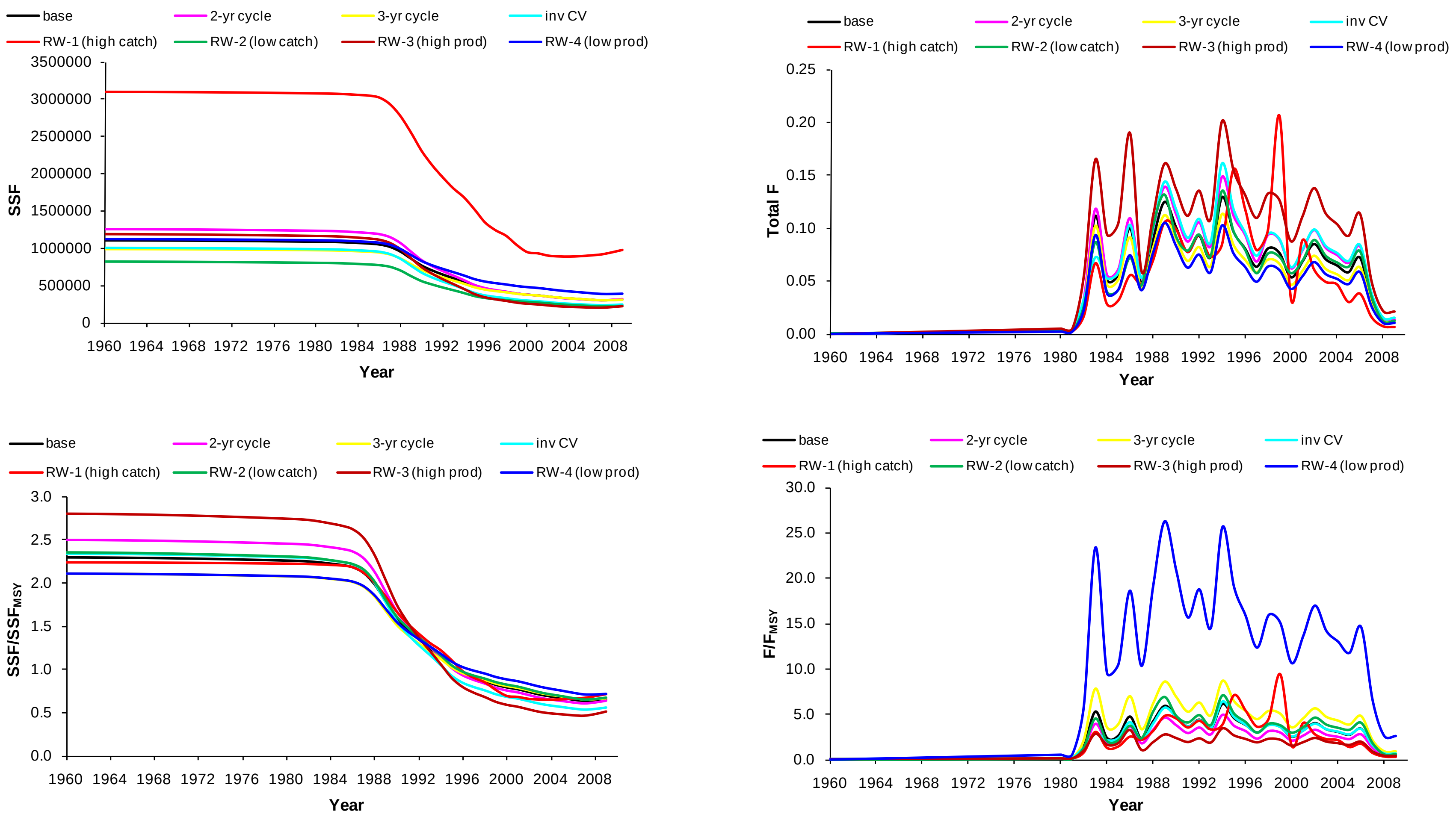


Figure 6.3. Implied steepness prior distribution for the base run (top) and sensitivity run S7 (U-shaped M).

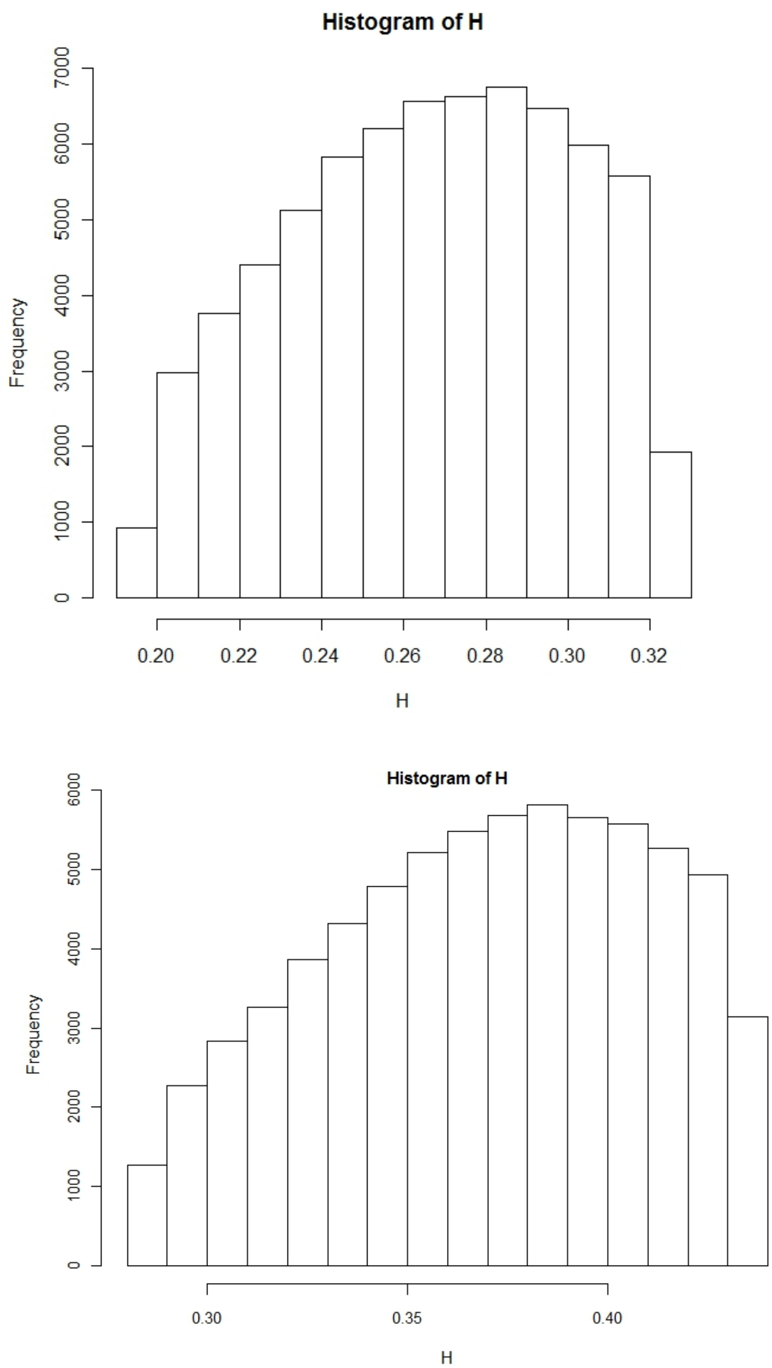
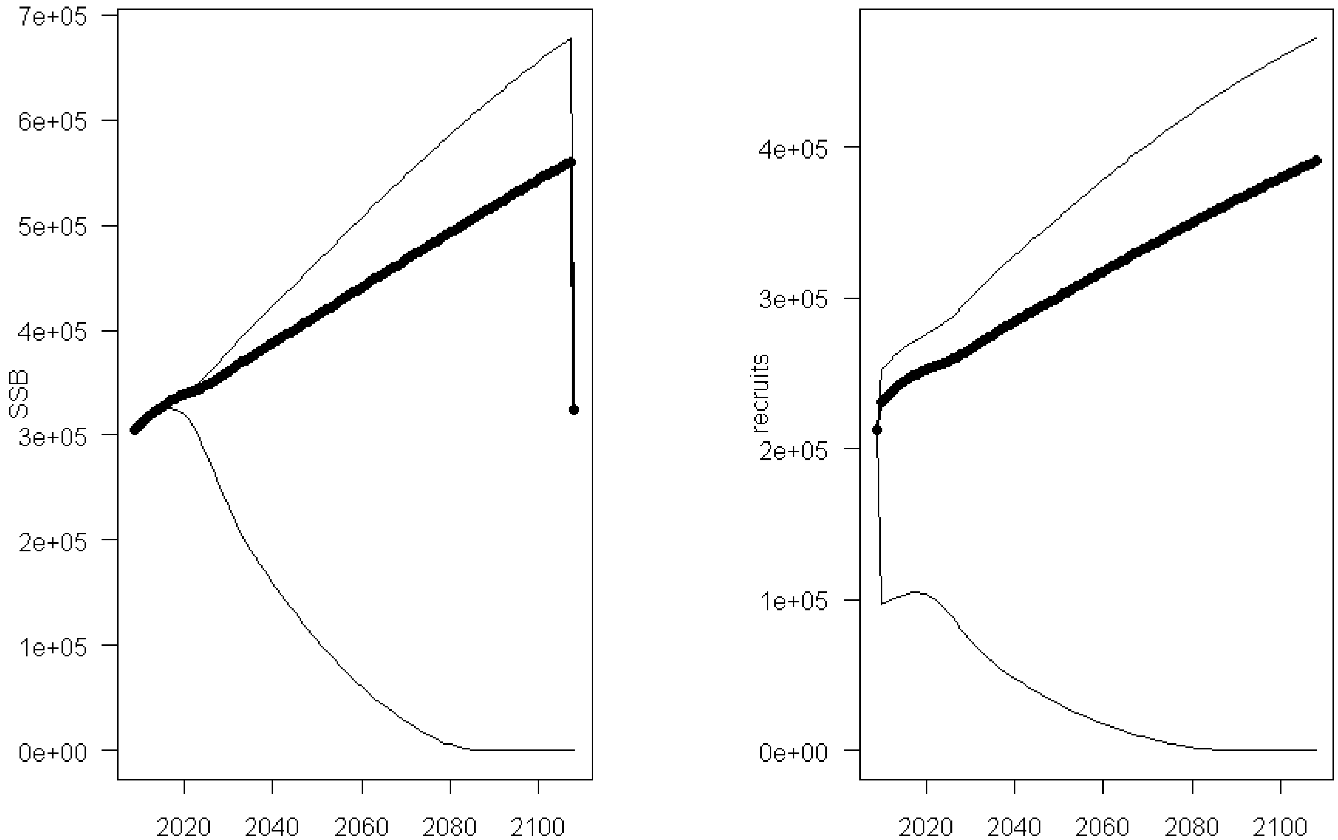
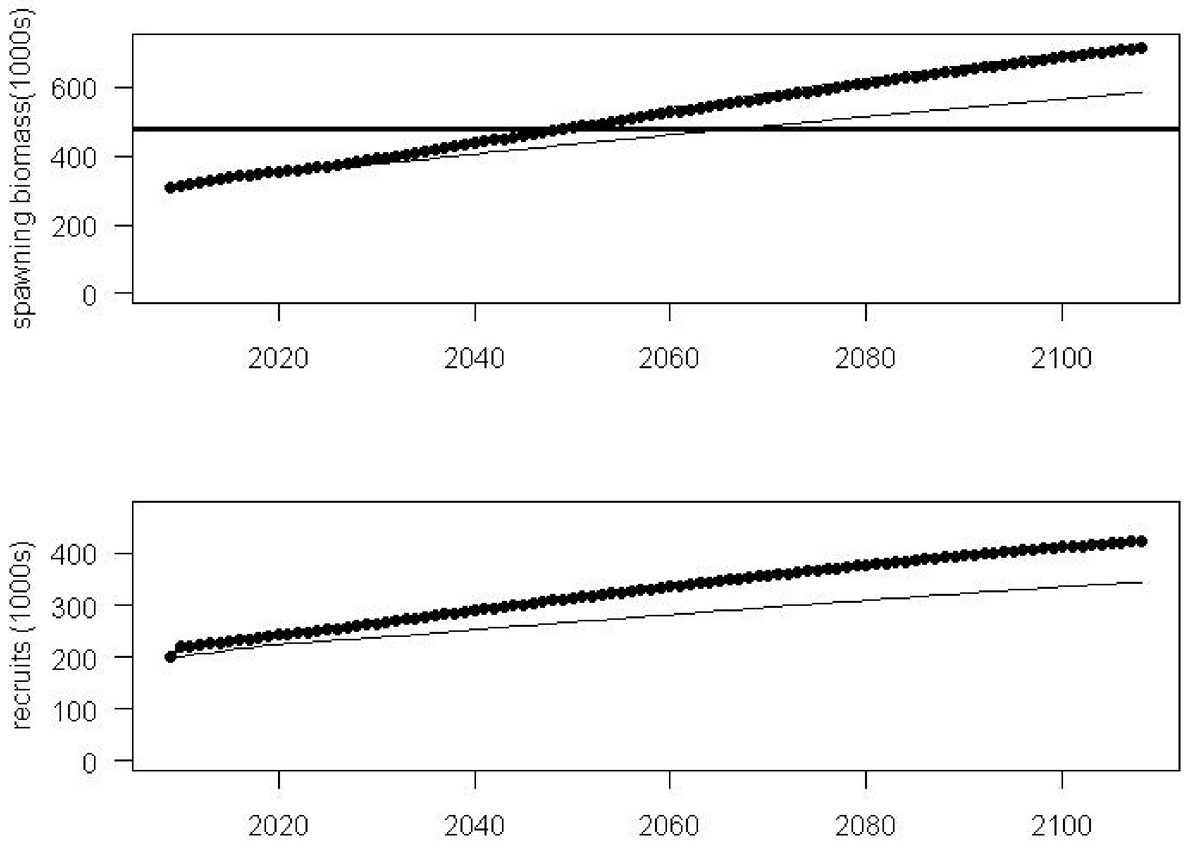
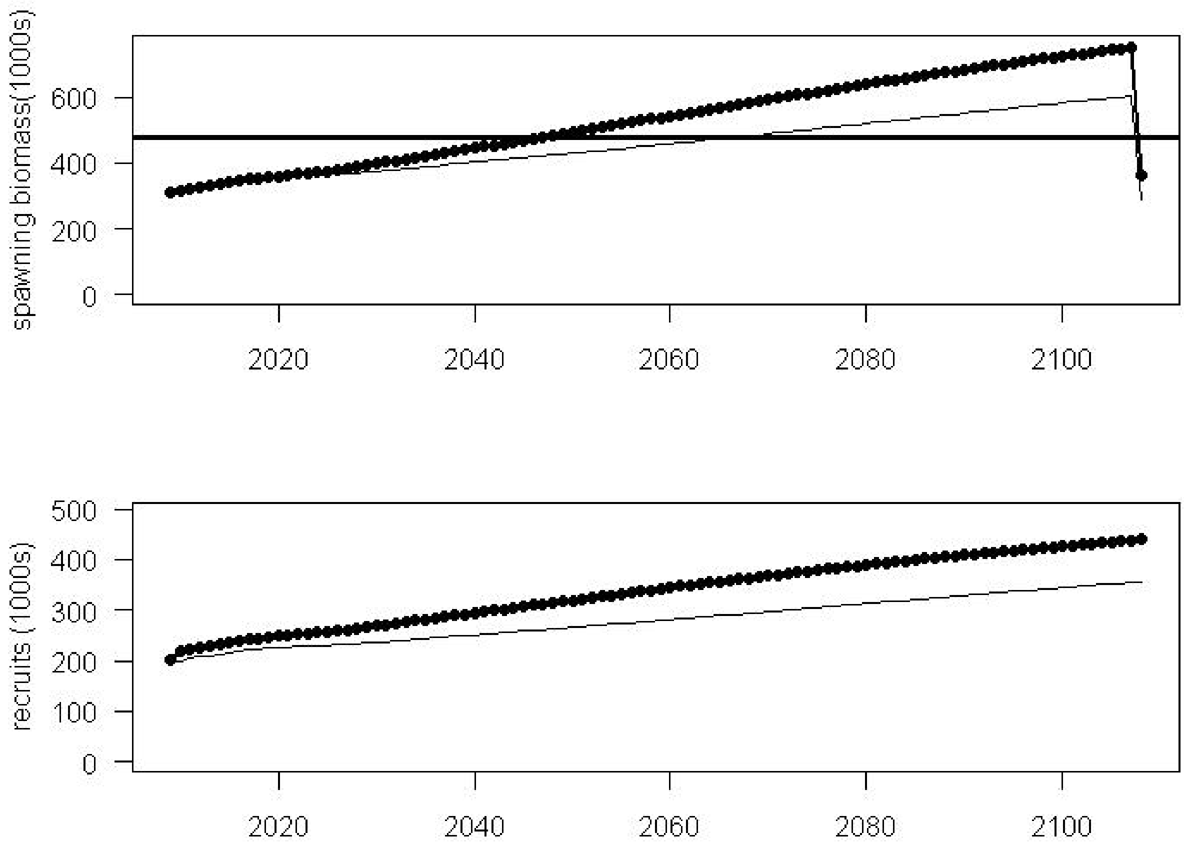


Figure 6.4 The projection quantile plots for SSB and recruits over the projection time period from sensitivity scenario S6. The heavy dotted line gives the median projection, while thin solid lines give 95% uncertainty bounds. The lower 95% confidence limit never tracks with the median. The uncertainty is too high in this scenario to be more than 50% probable that recovery will occur within the rebuilding time frame.





F ure : Base model projections. The top panel is the spawning stock fecundity and recruitment estimates for the Frebuild 70 scenario. Frebuild70 is the fishing mortality permitted in order to attain a 70% probability of recovery by the rebuilding year. The bottom panel is the spawning stock fecundity and recruitment estimates for the TACrebuild70 scenario under the base case model assumptions. The TACrebuild 70 is the total allowable catch permitted to attain recovery by the rebuilding year. The heavy dotted line is the median and the thin lines are the 70% and 30% uantiles. In this case the median and 70% uantiles overlap. The solid horizontal line is the SSFmsy or the Rmsy. Where the horizontal lines are absent for recruitment, the projection does not reach the Rmsy during the projection time period.



F ure (Continued)