SEDAR
Southeast Data, Assessment, and Review

SEDAR 21
Stock Assessment Report

HMS Dusky Shark

August 2011

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

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Table of Contents

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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	15.1
	S. Atl: Jan 1 – April 30	308.4
	N. Atl: Jan 1 – April 30	18.8
	GOM: May 1 – Aug. 31	72.6
	S. Atl: May 1 – Aug. 31	291.6
	N. Atl: May 1 – Aug. 31	36.2
	GOM: September 1 – Dec. 31	80.4
	S. Atl: September 1 – Dec. 31	297.5
	N. Atl: September 1 – Dec. 31	29.4
2008	GOM: Jan 1 – April 30, 2008	73.2
	S. Atl: Jan 1 – April 30, 2008	354.9
	N. Atl: Jan 1 – April 30, 2008	19.3
	GOM: May 1 – July 24, 2008	72.6
	S. Atl: May 1 – July 24, 2008	74.1
	N. Atl: May 1 – July 24, 2008	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

Requirement for Specific Fishery	Retention Limits	Quotas	Other Requirements
Inside the Commercial Shark Research Fishery	**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	**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	- 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.
Outside the Commercial Shark Research Fishery	**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	**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	-Vessels subject to observer coverage, if selected - Adjusted quotas (established through Dec. 31, 2012) may be further adjusted based on future overharvests, if any.
All Commercial Shark Fisheries	**Gears Allowed:** Gillnet; Bottom/Pelagic Longline; Rod and Reel; Handline; Bandit Gear		
	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)		
	Landings condition: All sharks (sandbar, non-sandbar LCS, SCS, and pelagic sharks) must have *fins naturally attached* through offloading; fins can be cut slightly for storage but must remain attached to the carcass via at least a small amount of uncut skin; shark carcasses must remain in whole or log form through offloading. Sharks can have the heads removed but the tails must remain naturally attached.		
	Permits Required: Commercial Directed or Incidental Shark Permit		
	Reporting Requirements: All commercial fishermen must submit commercial logbooks; all dealers must report bi-weekly		
All Recreational Shark Fisheries	**Gears Allowed:** Rod and Reel; Handline		
	Authorized Species: Non-ridgeback LCS (blacktip, spinner, bull, lemon, nurse, great hammerhead, scalloped hammerhead, smooth hammerhead); tiger sharks; pelagic sharks (porbeagle, common thresher, shortfin mako, oceanic whitetip, and blue sharks); and SCS (bonnethead, finetooth, blacknose, and Atlantic sharpnose sharks)		
	Landing condition: Sharks must be landed with head, fins, and tail naturally attached		
	Retention limits: 1 shark > 54" FL vessel/trip, plus 1 Atlantic sharpnose and 1 bonnethead per person/trip (no minimum size)		
	Permits Required: HMS Angling; HMS Charter/Headboat; and, General Category Permit Holders (fishing in a shark tournament)		
	Reporting Requirements: Participate in MRIP and LPS if contacted		

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.

<u>Blacknose Sharks</u>

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 posses 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

<u>Puerto Rico</u> *(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.

<u>Rhode Island</u> *(not confirmed by state):*

No shark regulations

<u>South Carolina</u> *(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 dusky shark was first assessed in 2006, but not under the auspices of the SEDAR process. The 2006 stock assessment (Cortés et al. 2006) examined trends in average size and CPUE tendencies, included stochastic demographic modeling, and used a variety of stock assessment methodologies. Genetic and other evidence supported the existence of a single stock of dusky sharks off the U.S. Atlantic and Gulf of Mexico. The majority of average size and CPUE series examined exhibited declining trends and the demographic analysis confirmed previously published results (e.g., Cortés 2002a) that this species and particular stock has very low productivity. The formal stock assessments undertaken all predicted depletions (for 2004) ranging from 64 to 92% of virgin levels. Specifically, three forms of Bayesian surplus production models estimated depletions of over 80%, an age-structured production model estimated depletions of 62-80%, and a catch-free age-structured production model estimated decreases in spawning stock biomass on the order of 92-93%. The main conclusion from that report was that the multiple indicators used coincided in providing a consistent picture of heavy fishing impact and high vulnerability to exploitation of dusky sharks in the western North Atlantic Ocean and Gulf of Mexico. The report was peer-reviewed by two anonymous referees from NMFS's NEFSC. In a subsequent document prepared for NMFS's HMS Division, results from the assessment were summarized in a phase plot showing that the vast majority of model types and formulations predicted that the stock was overfished ($B<B_{MSY}$) with overfishing occurring ($F>F_{MSY}$). Projections undertaken with the three modeling approaches predicted rebuilding times on the order of 100-400 years.

References

Cortés, E. 2002a. Incorporating uncertainty into demographic modeling: application to shark populations and their conservation. Conservation Biology 16:1048-1062.

Cortés, E., E. Brooks, P. Apostolaki, and C. A. Brown. 2006. Stock assessment of dusky shark in the U.S. Atlantic and Gulf of Mexico. National Marine Fisheries Service Panama City Laboratory Contribution 06-05 and Sustainable Fisheries Division Contribution SFD-2006-014.

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 indicated that the dusky shark stock was overfished (SSB2009/SSBMSY 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).

Table 1. Summary of stock status determination criteria.

Criteria	Recommended Values* from SEDAR 21	
	Definition	Value*
M (Instantaneous natural mortality; per year)	Value used for MSST calculations	0.0666
F_{2009} (per year)	Apical Fishing mortality in 2009	0.055
F_{MSY} (per year)	F_{MSY}	0.035
SSB_{2009}/SSB_0	Relative Spawning stock biomass	0.15
SSB_{MSY} (relative to virgin)	Relative SSB_{MSY}	0.35
SSB_{MSST} (relative to virgin biomass)	$(1-M)*SSB_{MSY}$	0.33
MFMT (per year)	F_{MSY}	0.035
F_{OY} (per year)	F_{OY} = 75% F_{MSY}	0.026
Biomass Status	SSB_{2009}/MSST	0.47
Exploitation Status	F_{2009}/F_{MSY}	1.59

* 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

Stock Identification and Management Unit

After considering the available data, the Data Workshop Life History working group concluded that dusky sharks in the U.S. waters of the western North Atlantic Ocean (including the Gulf of Mexico) should be considered a single stock. Genetic data indicate no significant differentiation between the Gulf of Mexico and western North Atlantic Ocean and tag-recapture data showed a high frequency of movements between basins.

Species Distribution:

The dusky shark, Carcharhinus obscurus, is a common coastal and pelagic shark that inhabits warm temperate and tropical coastal waters of the western North Atlantic, ranging from southern New England to the Caribbean and Gulf of Mexico to southern Brazil. It avoids areas of lower salinity and is rarely found in estuarine environments.

Stock Life History

- As there are currently no natural mortality estimates for dusky shark available based on direct empirical data, the Data Workshop Life History Working Group was concluded that the range of survivorship estimates by age to be used for priors would 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.
- 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 Assessment Panel agreed that rather than taking the *average* of the Hoenig, Peterson and Wroblewski, Chen and Watanabe, and Lorenzen methods, the *maximum* of the four methods mentioned was used instead.
- The most recent information on the age and growth of dusky shark is a 1995 publication in the journal Fishery Bulletin and was recommended for use in the assessment. However, maximum observed age for females in that study was 33 years. Current data from through a single tag recapture indicates a maximum age of approximately 39 years.
- Data on reproduction suggested a 3-year reproductive cycle consisting of a 2-year gestation period and a 1-year resting period. Litter sizes ranged from 3–12 embryos.

Assessment Methods

- Without accurate knowledge of the magnitude of total catches and discards, it is not possible to estimate absolute abundance levels for the population. An alternative modeling methodology appropriate to these situations is to re-scale the model population dynamics as proportional to virgin (unexploited) conditions. This approach is known as an Age-structured Catch Free Model (ASCFM).
- The model started in 1960 and ended in 2009, with the historic period covering 1960-1974, the first modern period spanning 1975-1999, and the second modern period spanning 2000-2009.
- Estimated model parameters were pup (age-0) survival, catchability coefficients associated with indices, a parameter representing the slope of the relationship between PLL effort and fishing mortality for the period 1960-1979, additional variance parameters for each index, relative depletion in 1975, and fishing mortality in the modern periods.

- Fishing mortality starting in 1980 was modeled using a correlated random walk and so are not 'full' parameters. Pup survival was given an informative lognormal prior with median=0.81 (mean=0.85, mode=0.77), a CV of 0.3, and was bounded between 0.50 and 0.99.
- The minimum spawning stock threshold (MSST) is typically calculated as (1-M)*SSB_{MSY} when absolute biomass is estimable. Although only relative estimates are possible here (i.e., SSB_{2009}/SSB_{MSY}), it is still possible to calculate SSB_{2009}/SSB_{MSST} as $SSB_{2009}/((1\text{-}M)*SSB_{MSY})$.

Assessment Data

- Length-frequency information from animals caught in scientific observer programs, recreational fishery surveys, and various fishery-independent surveys were used to generate age-frequency distributions through age-length keys and generate selectivity curves for different gear types.
- Five indices were used in the base model run: two fishery-independent series (VIMS LL, NELL) and three fishery-dependent series (the commercial BLLOP and PLLOP observer indices and the recreational LPS). Two additional fishery- independent indices were recommended for use in sensitivity runs: UNC LL and NMFS Historical LL.
- Life history inputs used in the assessment include age and growth, several parameters associated with reproduction, including sex ratio, reproductive frequency, fecundity at age, maturity at age, month of pupping, and natural mortality. The ASCFM uses most life history characteristics as constants (inputs) and others are estimated parameters, which are given priors and initial values.
- Relative effort series for the three fleets (bottom longline, pelagic longline, and recreational) are used to determine a single, annual weighted selectivity vector for modeling fishing mortality

Catch Trends

Commercial and recreational dusky shark catch information was compiled by the Data Workshop (see Data Workshop Report) but was deemed highly uncertain, primarily due to misreporting and misidentification, and not used in the assessment.

Fishing Mortality Trends

Fishing mortality was low from 1960 through the early 1980s, and then is estimated to have ramped up to unsustainably high levels in the l990s, and to have declined following prohibition of dusky landing in 2000. The moratorium on dusky catch appears to have been an effective management tool in this regard, although terminal estimates of fishing mortality still indicate the stock is undergoing overfishing.

Stock Abundance and Biomass Trends

- Recruitment is predicted to have remained at roughly virgin levels until 1990, after which it declined slightly.
- Declines in spawning stock biomass are estimated to be partially compensated for by increases in pup survival (i.e., density dependent recruitment).
- All abundance trajectories show relatively little depletion until the late 1980s; by 2009 depletion in spawning stock biomass is estimated to be around 85%. The ASCFM predicted an increasing abundance (in numbers) from 2004-present, but a continued decrease in biomass. This apparent contradiction is attributable to decreasing number of older (and heavier) sharks even while the numbers of younger fish are increasing.

Projections

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. 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 (dressed weight and numbers), recruitment, and mature spawning stock biomass.

- The $F_{current}$ projection scenario used a modal apical F of 0.055, and indicated a low probability of stock recovery by 2108.
- The F_0 scenario resulted in recovery from overfished status near the year 2050.
- The F_{msy} scenario utilized a modal F of 0.035, and indicated that the probability of the stock rebuilding to MSY levels was less than 50% .
- The F_{target} scenario, which reduced F to 0.028 in an effort to ensure that the probability of overfishing in any given year (p*) was less than 30%, still did not provide a large enough reduction in F to recover the stock by 2108.
- Reducing F to 0.027 (as in the $F_{rebuild50}$ scenario) was enough result in a 50% chance of rebuilding the stock; however, F had to be reduced to 0.023 (as in the $F_{rebuild70}$ scenario) to achieve a 70% probability of rebuilding the stock by 2108. In practice, the F_{max} scenario yielded identical results to the Frebuild70 scenario.
- While the Fixed Removals scenario suggested reducing annual removals to a preset level of 21,200 lbs. (gutted weight) per year would be sufficient to rebuild the stock with 70% probability by 2108, several of the runs resulted stock collapse (e.g., when terminal biomass and productivity were sampled from the lower tails of their distributions).

Scientific Uncertainty

- Likelihood profiling was used to quantify uncertainty in terminal stock status, terminal fishing mortality, and productivity parameters for the base run and for several sensitivity runs. This procedure could also be used to estimate the probability that the stock was overfished or that overfishing was occurring given a specific model configuration.

- Uncertainty in data inputs and model configuration was examined through the use of sensitivity scenarios and retrospective runs. Eleven alternative runs were conducted in addition to the baseline run. Retrospective analyses, in which the model was refit while sequentially dropping the last three years of data to look for systematic bias in key model output quantities over time, were also conducted.
- A total of seven additional sensitivity analyses were run during the Review Workshop to provide verification that the results of the assessment were robust to assumptions about underlying stock productivity, choice of selectivity curves, choice of indices, and index weighting. Time series plots were produced for runs considered by reviewers to have encapsulated uncertainty in assessment results (High M, U-shaped M, High productivity, and Low Productivity).
- The greatest source of uncertainty about dusky sharks is clearly the amount of human induced removals (e.g., discards) that are occurring. Improving the reliability of removal data would help assessment modeling immensely.
- Estimates of stock status seemed to be quite robust to changes in life history parameters such as productivity and natural mortality.
- Estimates of stock status seemed most sensitive to including different groups of indices or to different ways of weighting indices.

Significant Assessment Modifications

The Review Panel requested seven additional sensitivity runs but no significant changes to the base model configuration were required.

Sources of Information

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

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

Age	Proportion mature	M
1	0.00	0.104
2	0.00	0.104
3	0.00	0.104
4	0.00	0.104
5	0.00	0.104
6	0.00	0.098
7	0.00	0.092
8	0.00	0.088
9	0.00	0.084
10	0.00	0.080
11	0.00	0.077
12	0.00	0.074
13	0.00	0.072
14	0.00	0.070
15	0.01	0.068
16	0.02	0.066
17	0.05	0.064
18	0.13	0.063
19	0.28	0.061
20	0.51	0.060
21	0.74	0.059
22	0.88	0.058
23	0.95	0.057
24	0.98	0.056
25	0.99	0.055
26	1.00	0.054
27	1.00	0.053
28	1.00	0.052
29	1.00	0.052
30	1.00	0.051
31	1.00	0.048
32	1.00	0.048
33	1.00	0.048
34	1.00	0.048
35	1.00	0.048
36	1.00	0.048
37	1.00	0.048
38	1.00	0.048
39	1.00	0.048
40	1.00	0.048

Sex ratio at birth:	1:1
Reproductive frequency:	3 yr
Pupping month:	June
Gestation period:	12 months
Fecundity:	7.13 pups
L_{inf}	350.3 cm FL
k	0.039
t_0	-7.04
Weight vs length relation:	$W=0.000032415L2^{.7862}$
maturity ogive:	a=-19.76, b=0.99

Table 3: Apical instantaneous fishing mortality rates by year. (*Table 3.5 from the Assessment Workshop Report*)

Year	Total F
1960	0.003
1961	0.003
1962	0.006
1963	0.007
1964	0.010
1965	0.010
1966	0.007
1967	0.006
1968	0.007
1969	0.009
1970	0.010
1971	0.014
1972	0.014
1973	0.014
1974	0.014
1975	0.020
1976	0.019
1977	0.019
1978	0.016
1979	0.012
1980	0.014
1981	0.017
1982	0.022
1983	0.029
1984	0.038
1985	0.051
1986	0.068
1987	0.092
1988	0.121
1989	0.156
1990	0.188
1991	0.212
1992	0.225
1993	0.229
1994	0.232
1995	0.237
1996	0.254
1997	0.287
1998	0.335
1999	0.385
2000	0.385
2001	0.333
2002	0.249
2003	0.171
2004	0.116
2005	0.083
2006	0.064
2007	0.054
2008	0.049
2009	0.056

Table 4: Predicted relative recruitment (numbers), abundance (numbers), total biomass (kg), and spawning stock biomass (kg). All estimates are presented relative to virgin levels. (*Table 3.4 in Assessment Workshop Report*)

Year	Rec	N	B	SSB
1960	1	1	1	1
1961	0.999951	0.998682	0.99921	0.999533
1962	0.99984	0.99731	0.998315	0.998757
1963	0.999654	0.994484	0.996476	0.997603
1964	0.999377	0.991575	0.994436	0.996036
1965	0.999	0.987221	0.991381	0.994032
1966	0.998517	0.983065	0.988229	0.992083
1967	0.998045	0.980735	0.985988	0.990335
1968	0.997621	0.97913	0.984104	0.988484
1969	0.997171	0.977176	0.981979	0.986243
1970	0.996625	0.974156	0.979173	0.983564
1971	0.995969	0.970786	0.976056	0.980355
1972	0.995179	0.965986	0.971978	0.976593
1973	0.994249	0.961134	0.967683	0.972518
1974	0.993235	0.956628	0.963417	0.968183
1975	0.992149	0.952375	0.959156	0.96317
1976	0.990884	0.945623	0.953303	0.957519
1977	0.989446	0.939929	0.947826	0.951703
1978	0.987953	0.934718	0.942461	0.945862
1979	0.98644	0.931074	0.937885	0.940277
1980	0.98498	0.929087	0.934242	0.934502
1981	0.983456	0.926132	0.929824	0.927964
1982	0.981714	0.921662	0.924322	0.920448
1983	0.979689	0.915072	0.917222	0.911471
1984	0.977237	0.9056	0.90777	0.900485
1985	0.974188	0.892397	0.895292	0.886936
1986	0.97035	0.87438	0.878923	0.869936
1987	0.96541	0.85013	0.857326	0.847257
1988	0.958596	0.817544	0.827446	0.817789
1989	0.949334	0.776492	0.789928	0.781932
1990	0.937392	0.727994	0.74518	0.739792
1991	0.922319	0.675232	0.694753	0.693271
1992	0.904215	0.623427	0.643046	0.645458
1993	0.883781	0.576536	0.593565	0.598539
1994	0.861648	0.535644	0.547865	0.553494
1995	0.838149	0.499891	0.505969	0.51039
1996	0.813259	0.467576	0.467093	0.468497
1997	0.786442	0.435832	0.429433	0.426537
1998	0.756545	0.401737	0.390986	0.383609
1999	0.722238	0.364273	0.350945	0.340164
2000	0.682937	0.325586	0.310673	0.299319
2001	0.640916	0.293626	0.275734	0.264761
2002	0.600735	0.272261	0.249197	0.237908
2003	0.566043	0.261757	0.231432	0.2179
2004	0.537919	0.259197	0.220403	0.202705
2005	0.515107	0.261073	0.213653	0.190506
2006	0.495799	0.264839	0.209418	0.180153
2007	0.478666	0.269008	0.206642	0.171011
2008	0.462931	0.272728	0.204682	0.162742
2009	0.448179	0.275546	0.20314	0.155

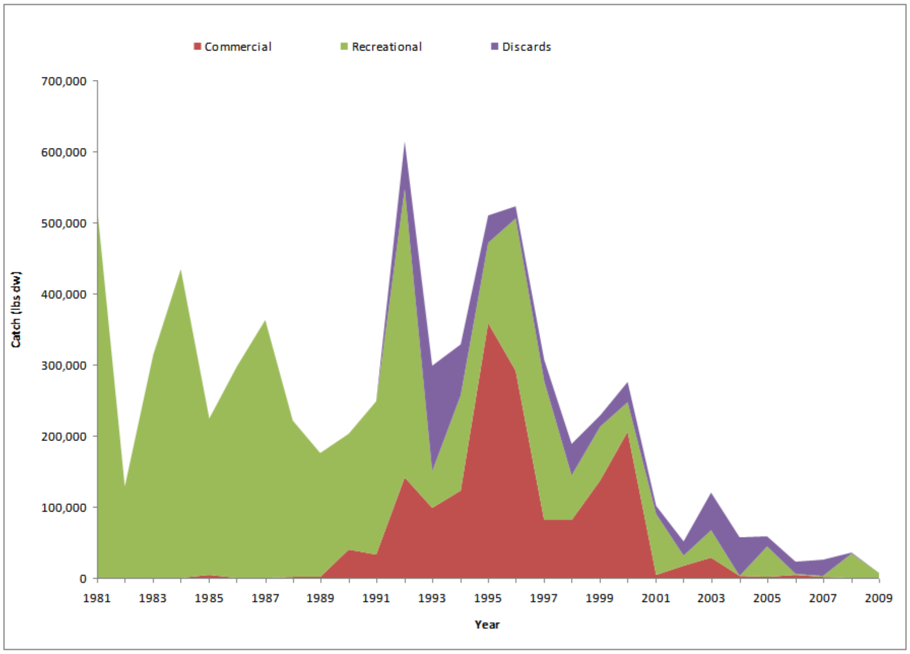

Figure 1: Total catches of dusky shark (in pounds dressed weight), 1981-2009. (*Figure 1 of the Data Workshop Report*)

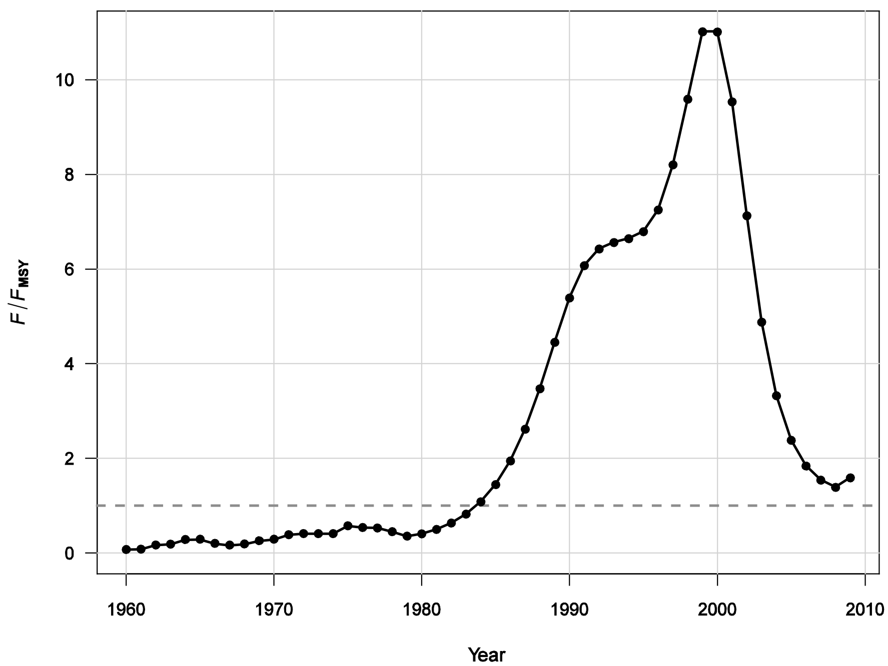

Figure 2: Apical fishing mortality relative to MSY levels for dusky sharks, 1960-2009. The base ASCFM indicated that overfishing has been occurring since 1984 (although there is considerable uncertainty about whether overfishing occurred during the last several years of the time series). (*Figure 3.14 in the Assessment Workshop Report*)

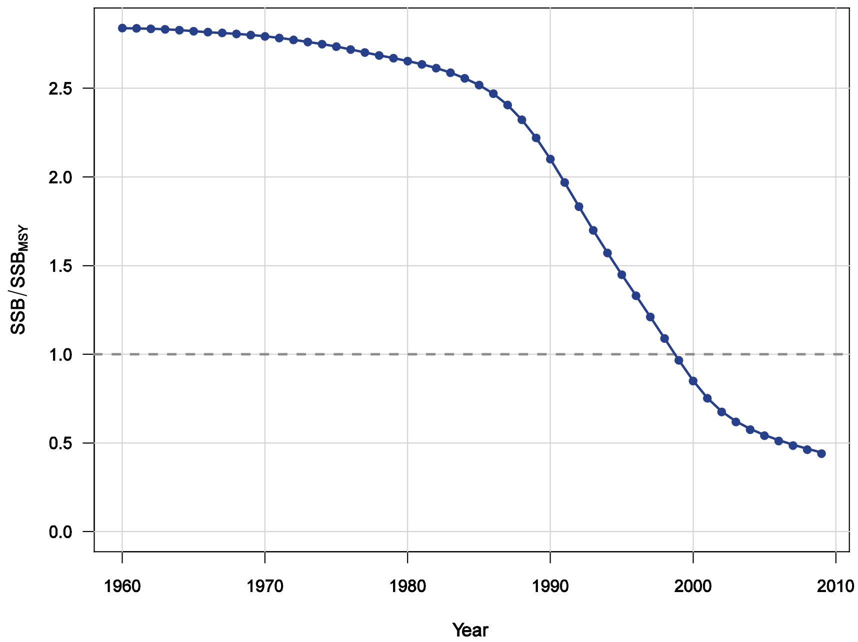

Figure 3: Spawning biomass relative to MSY levels over time from the base ASCFM model for dusky sharks. (*Figure 3.13 from the Assessment Workshop Report*)

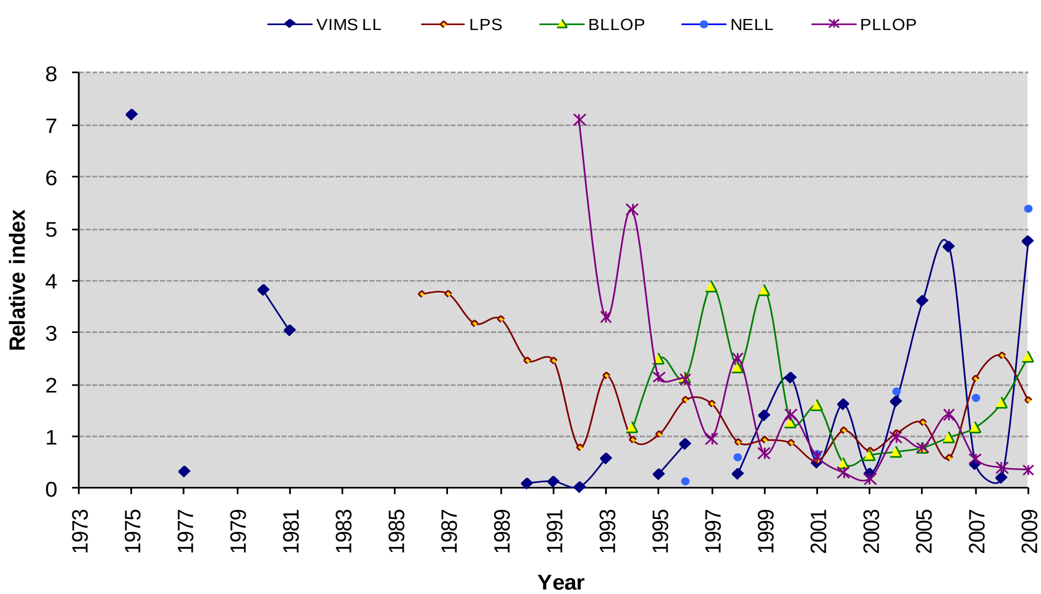

Figure 4: Baseline indices of relative abundance used for dusky shark. All indices are statistically standardized and scaled (divided by their respective mean and a global mean for overlapping years; except NMFS Historic LL). (*Figure 2.3 from the Assessment Workshop Report*)

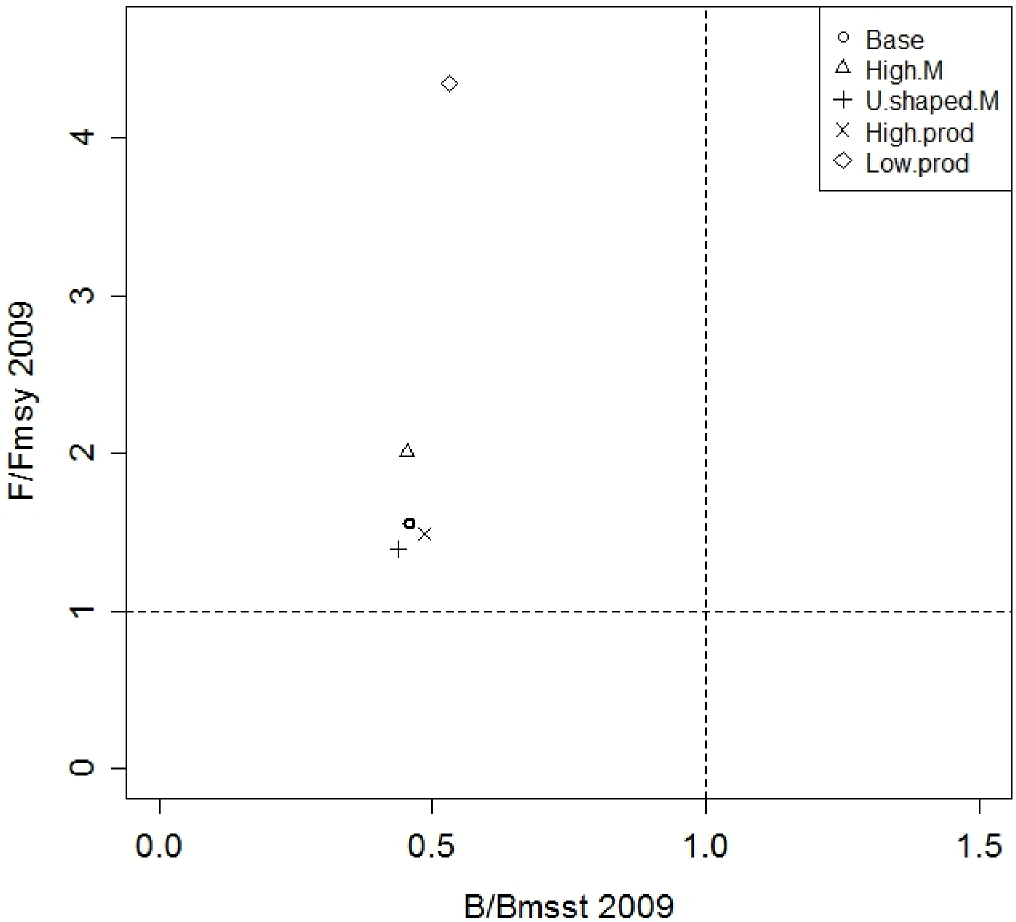

Figure 5: A phase plot summarizing stock status of dusky sharks in the terminal year of the assessment model according to various base and sensitivity runs selected by the Review Panel. Points to the left of the vertical dashed line indicate runs in which the stock is estimated to be overfished; points above the horizontal black line indicate runs in which overfishing is estimated to have occurred. (*Figure 6 from the Review Workshop Report*)

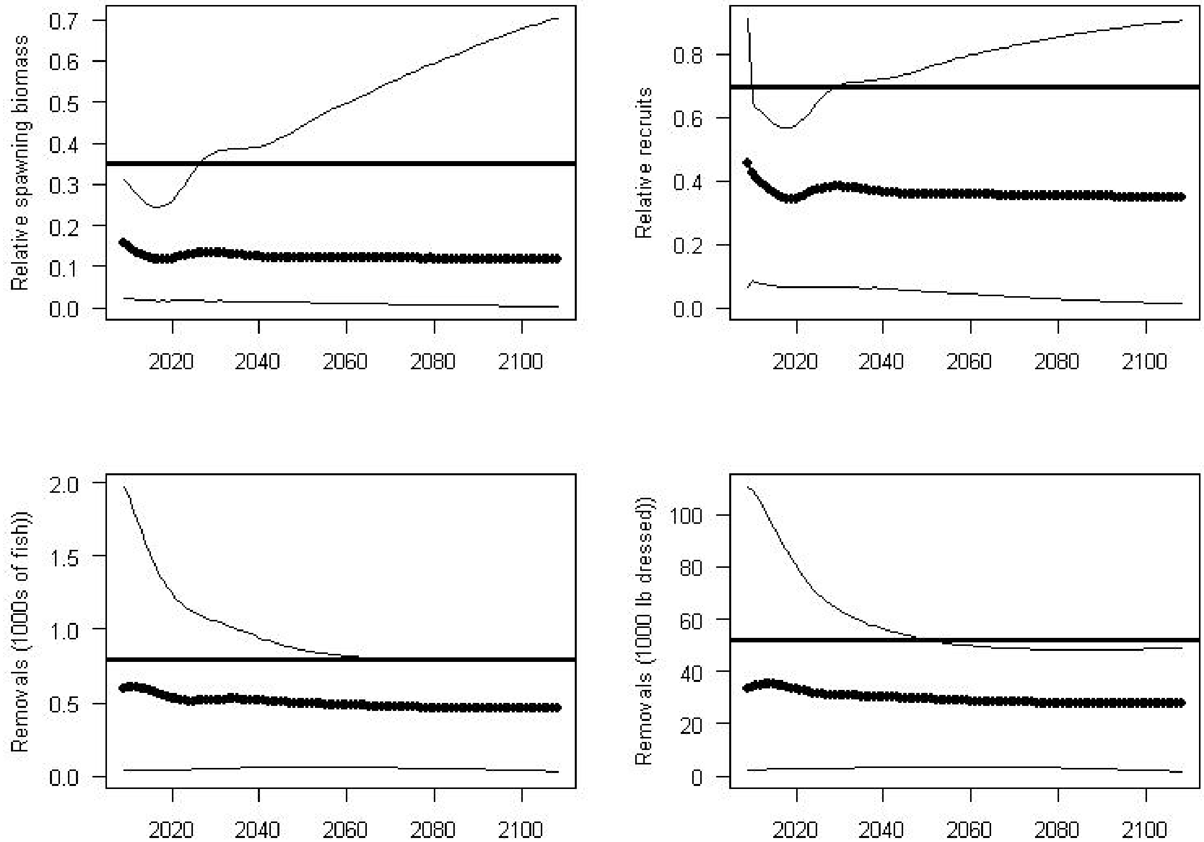

Figure 6: Results for the $F_{current}$ projection scenario, 2009-2108. The heavy dotted line gives the median projection, while thin solid lines give 95% uncertainty bounds. The horizontal line represents the corresponding value that would be anticipated at MSY. (*Figure 3.16 from the Assessment Workshop Report*)

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

Dusky Shark

SECTION II: Data Workshop Report

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 dusky shark life history working group was led by Dr. John Carlson, NOAA Fisheries Panama City, and rappeteured 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-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 1999-2009 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-37 - Movements and environmental preferences of dusky sharks, *Carcharhinus obscurus*, in the northern Gulf of Mexico – E. Hoffmayer, J. Franks, W. Driggers, and M. Grace

This document examines movement pattern and environmental preference data collected from dusky sharks in the northern Gulf of Mexico (GOM) using pop-up satellite archival tag technology. Prior to this study, few data existed on essential fish habitat (EFH) of dusky sharks in the GOM. During summer 2008-2009, pop-up satellite archival tags (PSAT) were attached to 10 (8 adult, 2 sub-adult) dusky sharks in the northern GOM. All tags reported data, with deployment durations ranging from 7 to 124 days. A total of 426 total days of movement and habitat preference data were acquired. Dusky sharks traveled distances >200 km, primarily utilizing GOM waters along the continental shelf edge from the Desoto Canyon to the Texas/Mexican border. They spent 75% of their time between 10 - 125m, and 70% of their time between 23 – 30 C. One dusky shark moved into the southern GOM (Mexican waters), which demonstrates the need for shared stock management of this species. This study represents the first use of PSAT technology to address critical gaps in information on habitat and behavior of dusky sharks in the GOM. Such information is imperative to the development of effective management strategies for population recovery of dusky sharks in the GOM and wider U.S. South Atlantic Ocean.

SEDAR21-DW-38 - 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 DESCRIPTIONS*

After considering the available data, the working group concluded that dusky sharks in the U.S. waters of the western North Atlantic Ocean (including the Gulf of Mexico) should be considered a single stock. Genetic data indicate no significant differentiation between the Gulf of Mexico and western North Atlantic Ocean and tag-recapture data showed a high frequency of movements between basins (SEDAR21-DW-37, SEDAR 21-DW-38, Demian Chapman, pers. comm.).

2.4. *NATURAL MORTALITY*

There are currently no natural mortality estimates for dusky 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 utilized 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. In addition, the group decided that the method of Chen and Watanabe was not appropriate for dusky shark because there is no evidence of senescence. It was concluded that the range of survivorship estimates by age to be used for priors would 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, we chose to provide the following estimates of discard mortality. One paper examining blue shark mortality (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 the two mortality rates is applicable to other species, we applied this 6% increase in mortality to the at-vessel mortality estimates for sandbar and blacknose sharks from observer data collected 1994-

2009 in the longline fishery. At-vessel mortality estimates for dusky sharks were limited to 2005-2009 due to the North Carolina closed area. This resulted in an estimate of discard mortality for longline captured dusky sharks of 65.17%.

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.

2.6. *AGE AND GROWTH*

There have been no recent updates to the age and growth of dusky shark since a 1995 publication in the journal Fishery Bulletin (SEDAR21-RD09). As there are no updates for the northwest Atlantic Ocean population the group adopted that model as the most appropriate. However, maximum observed age for females in that study was 33 years. Current data from through a single tag recapture (SEDAR21-RD09) indicates a maximum age of approximately 39 years. Life history parameters are summarized in section 2.8.

2.7. *REPRODUCTION*

Reproductive information and based on and agreed to from information from SEDAR 21-RD06 and SEDAR 21-RD07. In the previous stock assessment conducted on dusky shark (Cortés et al. 2006), maturity ogives were developed for females and males using data from the shark bottom longline observer program from 1994-2002. An updated schedule was developed based on data collected by Romine et al. (2009) and agreed to at SEDAR21 (see sections 2.8 and 2.10).

2.8. SUMMARY OF LIFE HISTORY CHARACTERISTICS RECOMMENDED FOR DUSKY SHARKS

Life history Workgroup	Summary of Dusky -- Biological Inputs for 2010 Assessment	
1st year survivorship	male = 0.79, female = 0.765	Section 2.4
Juvenile survivorship	Male = 0.81-0.90 , female = 0.78 – 0.885	Section 2.4
Adult survivorship	male = 0.90-0.92, female = 0.89-0.91	Section 2.4
S-R function	Beverton Holt	Cortés et al. (2006)
S-R parameters, priors		
steepness or alpha	0.2-0.3	Cortés et al. (2006), SEDAR21-RD03
Pupping month	May-June	SEDAR21-RD06,
Growth parameters	Male | Female | Combined sexes	
L_∞ (cm FL)	373 | 349 | 352	Natanson et al. (1995)
k	0.038 | 0.039 | 0.040	Natanson et al. (1995)
t_o	-6.28 | -7.04 | -6.43	Natanson et al. (1995)
Maximum observed age	33, 39	Natanson et al. (1995), Pat Turner (pers comm..)
Sample size	120 total (47 male, 67 female)	Natanson et al. (1995)
Length-weight relationships		
FL in cm	FL = 0.8352 (TL) -2.2973	Natanson et al. (1995)
WT in kg	WT = (3.241510^-5)FL^2.7862	Kohler et al. (1996)
Maturity ogive (sexes combined)	tmat = 20, a= −19.76, b = 0.99	Romine et al. (2009), Natanson et al. (1995)
Reproductive cycle	triennial	Romine et al. (2009), Castro (2009)
Fecundity	7.13 pups (S.D. = 2.06, range 3-12)	Romine et al. (2009)
Gestation	18 months	Castro (2009)
Sex-ratio	1:1	Romine et al. (2009), Castro (2009)
Stock structure	high exchange between Atlantic and Gulf based on tagging data, genetic information suggests one stock	SEDAR21-DW-38, Demian Chapman (pers comm..)

Survivorship by age for male dusky sharks

Age	Mortality	Survival StDev	Survivorship	M w/o C&W	Surv st dev w/o Chen and Watanabe	Surv w/o Chen and Watanabe
0.0	0.194	0.031	0.806	0.210	0.023	0.790
1.0	0.176	0.030	0.824	0.192	0.018	0.808
2.0	0.162	0.029	0.838	0.177	0.015	0.823
3.0	0.151	0.028	0.849	0.166	0.013	0.834
4.0	0.141	0.027	0.859	0.156	0.011	0.844
5.0	0.133	0.027	0.867	0.148	0.009	0.852
6.0	0.126	0.026	0.874	0.141	0.008	0.859
7.0	0.120	0.026	0.880	0.135	0.007	0.865
8.0	0.115	0.025	0.885	0.130	0.006	0.870
9.0	0.111	0.025	0.889	0.125	0.005	0.875
10.0	0.107	0.024	0.893	0.121	0.004	0.879
11.0	0.103	0.024	0.897	0.117	0.004	0.883
12.0	0.100	0.024	0.900	0.114	0.003	0.886
13.0	0.097	0.023	0.903	0.111	0.003	0.889
14.0	0.095	0.023	0.905	0.108	0.002	0.892
15.0	0.093	0.023	0.907	0.106	0.002	0.894
16.0	0.090	0.023	0.910	0.103	0.001	0.897
17.0	0.088	0.022	0.912	0.101	0.001	0.899
18.0	0.087	0.022	0.913	0.099	0.001	0.901
19.0	0.085	0.022	0.915	0.098	0.001	0.902
20.0	0.084	0.022	0.916	0.096	0.000	0.904
21.0	0.082	0.022	0.918	0.095	0.000	0.905
22.0	0.081	0.021	0.919	0.093	0.000	0.907
23.0	0.080	0.021	0.920	0.092	0.000	0.908
24.0	0.078	0.021	0.922	0.091	0.000	0.909
25.0	0.077	0.021	0.923	0.090	0.001	0.910
26.0	0.076	0.021	0.924	0.088	0.001	0.912
27.0	0.075	0.021	0.925	0.087	0.001	0.913
28.0	0.075	0.021	0.925	0.087	0.001	0.913
29.0	0.074	0.020	0.926	0.086	0.001	0.914
30.0	0.073	0.020	0.927	0.085	0.001	0.915
31.0	0.072	0.021	0.928	0.084	0.001	0.916
32.0	0.071	0.021	0.929	0.083	0.001	0.917
33.0	0.071	0.021	0.929	0.083	0.001	0.917
34.0	0.070	0.020	0.930	0.082	0.002	0.918
35.0	0.070	0.020	0.930	0.081	0.002	0.919
36.0	0.069	0.020	0.931	0.081	0.002	0.919
37.0	0.069	0.019	0.931	0.080	0.002	0.920
38.0	0.069	0.019	0.931	0.080	0.002	0.920
39.0	0.068	0.019	0.932	0.079	0.002	0.921

Survivorship by age for female dusky sharks

Age	Mortality	Survival StDev	Survivorship	M w/o C&W	Surv st dev w/o Chen and Watanabe	Surv w/o Chen and Watanabe
0.0	0.206	0.053	0.794	0.235	0.028	0.765
1.0	0.189	0.050	0.811	0.216	0.024	0.784
2.0	0.175	0.048	0.825	0.202	0.021	0.798
3.0	0.164	0.046	0.836	0.189	0.018	0.811
4.0	0.155	0.044	0.845	0.179	0.016	0.821
5.0	0.147	0.042	0.853	0.170	0.014	0.830
6.0	0.140	0.041	0.860	0.163	0.012	0.837
7.0	0.134	0.040	0.866	0.156	0.011	0.844
8.0	0.128	0.039	0.872	0.151	0.010	0.849
9.0	0.124	0.038	0.876	0.145	0.009	0.855
10.0	0.120	0.037	0.880	0.141	0.008	0.859
11.0	0.116	0.036	0.884	0.137	0.007	0.863
12.0	0.113	0.036	0.887	0.133	0.006	0.867
13.0	0.110	0.035	0.890	0.130	0.006	0.870
14.0	0.107	0.035	0.893	0.127	0.005	0.873
15.0	0.105	0.034	0.895	0.124	0.005	0.876
16.0	0.102	0.034	0.898	0.122	0.004	0.878
17.0	0.100	0.033	0.900	0.119	0.004	0.881
18.0	0.098	0.033	0.902	0.117	0.004	0.883
19.0	0.097	0.032	0.903	0.115	0.003	0.885
20.0	0.095	0.032	0.905	0.113	0.003	0.887
21.0	0.093	0.032	0.907	0.112	0.003	0.888
22.0	0.092	0.031	0.908	0.110	0.002	0.890
23.0	0.091	0.031	0.909	0.109	0.002	0.891
24.0	0.090	0.031	0.910	0.107	0.002	0.893
25.0	0.088	0.031	0.912	0.106	0.002	0.894
26.0	0.087	0.030	0.913	0.105	0.002	0.895
27.0	0.086	0.030	0.914	0.104	0.001	0.896
28.0	0.085	0.030	0.915	0.103	0.001	0.897
29.0	0.085	0.030	0.915	0.102	0.001	0.898
30.0	0.084	0.029	0.916	0.101	0.001	0.899
31.0	0.082	0.030	0.918	0.100	0.001	0.900
32.0	0.082	0.030	0.918	0.099	0.001	0.901
33.0	0.081	0.029	0.919	0.098	0.001	0.902
34.0	0.081	0.029	0.919	0.098	0.001	0.902
35.0	0.080	0.029	0.920	0.097	0.000	0.903
36.0	0.080	0.028	0.920	0.096	0.000	0.904
37.0	0.079	0.028	0.921	0.096	0.000	0.904
38.0	0.079	0.028	0.921	0.095	0.000	0.905
39.0	0.079	0.027	0.921	0.094	0.000	0.906

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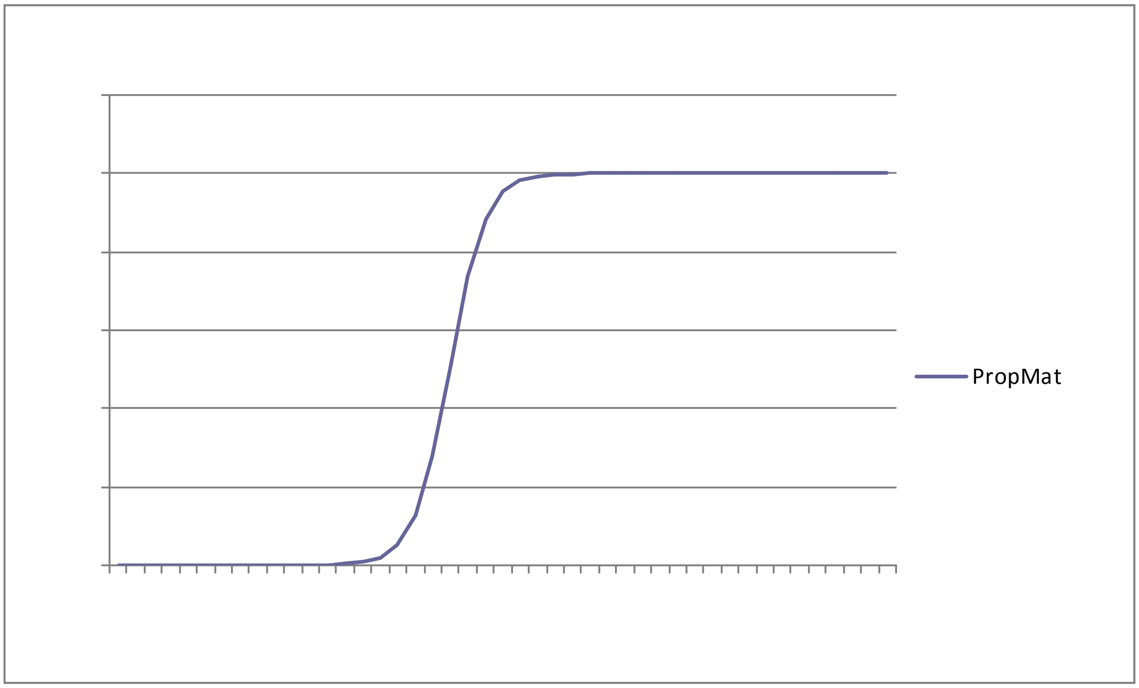
2.10. *TABLES*

Table 1. Maturity schedule for dusky shark (combined sexes) from Natanson et al. (1995), Romine et al. (2009) and Romine (pers comm.).

Age	PropMat
1	0.00
2	0.00
3	0.00
4	0.00
5	0.00
6	0.00
7	0.00
8	0.00
9	0.00
10	0.00
11	0.00
12	0.00
13	0.00
14	0.00
15	0.01
16	0.02
17	0.05
18	0.13
19	0.28
20	0.51
21	0.74
22	0.88
23	0.95
24	0.98
25	0.99
26	1.00
27	1.00
28	1.00
29	1.00
30	1.00
31	1.00
32	1.00
33	1.00
34	1.00
35	1.00
36	1.00
37	1.00
38	1.00
39	1.00
40	1.00
41	1.00
42	1.00
43	1.00
44	1.00
45	1.00

2.11. *FIGURES*

Figure 1. Ogive schedule developed from data in Natanson et al. (1995), Romine et al. (2009) and Romine (pers comm.).



3. COMMERCIAL 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

Historical commercial landings data for dusky sharks were explored to address several issues. These issues included: 1) duration of data for the stock assessment; 2) lack of confidence in the catch data due to misreporting and misidentification; 3) commercial discards; 4) using dressed weight versus numbers; 5) live discard post-release mortality; 6) year of virgin biomass.

3.2. *REVIEW OF WORKING PAPERS*

SEDAR21-DW-02 - Standardized catch rates of sandbar, dusky and blacknose sharks from the Shark Fishery Bottom Longline Observer Program, 1994-2009

J.K. Carlson, L.F. Hale, A. Morgan, and G. Burgess

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. For dusky shark, the abundance trend declined over the length of the series but an increase in abundance was observer in latter years.

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, and E. Cortés

This document provides the background on the data sources that are currently available for providing catch information for dusky sharks. For those data sources that require some form of expansion, that methodology is outlined in this document.

SEDAR21-DW-08 - Standardized catch rates for dusky and sandbar sharks from the US pelagic longline logbook and observer programs using generalized linear models

E. Cortés

This report provides updated indices of abundance that 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.

SEDAR21-DW-09 - Updated catches of sandbar, dusky, and blacknose sharks

E. Cortés and I.E. Baremore

The document presented updated commercial and recreational landings and discard estimates for blacknose sharks through 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.

SEDAR21-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.

SEDAR21-DW-22 - Shark bottom longline observer program: Catch and bycatch 2005-2009
L.H. 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.

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)
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*

U.S. commercial landings of dusky sharks were compiled from multiple data sources, presented in SEDAR21-DW-09. Southeast general canvass landings data were available for 1985-2009 and Quota Monitoring System (QMS) data for 1992-2009. Both pelagic dealer weigh-out reports of dealers holding swordfish and tuna permits (1982-2009) and logbook information from the Coastal Fishery Logbook program (1991-2009) were considered as well. The largest annual value reported in these four sources was taken as the annual value of dusky shark landings for the southeast region. Landings from the northeast general canvass data (1993-2009) were then added to the southeast landings to produce total U.S. commercial estimates.

Averaged over the period 1988-2009, dusky sharks were landed mostly in the Mid Atlantic (Virginia to New Jersey) (49%) and South Atlantic (east coast of Florida to North Carolina) (28%) and Gulf of Mexico (west coast of Florida to Texas) (23%) in similar proportions (SEDAR21-DW-09). In the Mid Atlantic (Virginia to New Jersey), longlines (41%) and gillnets (35%) contributed similar proportions to the landings, but longlines were the dominant gear in both the Gulf of Mexico and South Atlantic (88% and 72%, respectively, SEDAR21-DW-09).

Decision 1. Virgin conditions were assumed in 1960 (Cortés et al. 2006). Prior to 1940, there was a substantial shark fishery for extraction of vitamin A, but it is assumed that 1940 to 1960 was a period of relatively no exploitation.

Decision 2. There was no evidence to separate northwestern Atlantic dusky sharks into multiple stocks, thus all landings were treated as coming from a single stock.

Decision 3. Because the last assessment was conducted in weight, not in numbers as for other shark species, all landings and catches are reported in landed (dressed) weight.

Decision 4. The data provided by the Atlantic Coastal Cooperative Statistics Program (ACCSP) were compared, but these data lacked Gulf landings and were therefore deemed incomplete.

3.4. *COMMERCIAL DISCARDS*

3.4.1. Fishery Discards

Dead discards of some pelagic shark species are estimated based on mandatory logbooks from pelagic longline and other fishing vessels that land swordfish and pelagic longline observer reports when sufficient sample sizes are available (Cramer 2000). Dead discard estimates (SEDAR21-DW-09) were available for dusky sharks since 1992 (the year of inception of the pelagic longline observer program – PLLOP). Estimates are produced in both numbers and mt whole weight (ww); the latter were transformed into lb dw using a whole to dressed weight conversion ratio of 1.96.

Dead discards of dusky sharks in the directed shark bottom longline fishery for 1994-2009 were estimated by using the annual discard rates observed in the Bottom Longline Observer Program (BLLOP) and multiplying that proportion by the annual commercial landings (SEDAR21-DW-09). Dead discard rates were low during 1994-1999 (between 0% and 8%), prior to the species being placed on the prohibited list, and fluctuated between 0% and 100% thereafter.

3.4.2. Post-Release Mortality

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 for shark species. The catch WG 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 released shark would die after being released alive. Gear-specific recommendations are as follows

Gillnet: 50%
Bottom longline: 35%
Pelagic longline: 5%

Justifications:

Industry representatives said that dusky sharks were sometimes lethargic on longline gear, with a fairly large proportion boated dead. The fate of dusky sharks released alive from bottom longline gear was uncertain, but all agreed that a fewer than half would die. Gillnet data were not available at the time, and dusky sharks are not encountered by gillnets often, so the percentage was set at 50%. All representatives agreed that mortality on pelagic longlines was likely to be much lower than that for bottom longlines due to several factors, including the length of the leaders and water temperature.

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 WG applied a '6% rule' to the boated dead portion of the catch. 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 WG 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 WGmostly deferred to the catch group discard mortality estimates for gillnet gear.

A range between the pelagic longline rate of 44.2% and the highest estimate by the LH WG of 65% was selected as the post-release discard mortality for dusky sharks caught by bottom longline gear.

Bottom longline

The LH WG estimated discard mortality to be 65% (59% at-vessel plus 6% post-release) for dusky sharks caught by bottom longline, and the catch group suggested a rate of 35% post-release discard mortality. At-vessel mortality for pelagic longline gear from the PLLOP was calculated at plenary. 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 at-vessel mortality rate of the PLLOP and the discard mortality estimate estimated by the LH WG was chosen. A range of 44.2 - 65% was selected as the discard mortality for dusky sharks caught by bottom longline gear.

Pelagic longline

The LH WG estimated discard mortality for dusky sharks on bottom longline to be 65% (59% at-vessel plus 6%), but did not present any gear-specific estimates. The catch group suggested a post-release discard mortality (percentage of sharks that would die after released alive) of 5% for dusky sharks on pelagic longline. At-vessel mortality for pelagic longline gear was calculated at plenary from PLLOP data. It was noted that discard mortality would be lower for pelagic longline than for bottom longline. Therefore the difference between at-vessel mortality rates (sharks boated dead) for pelagic and bottom longlines was applied to the overall discard mortality estimated by the LH WG. Pelagic longline at-vessel mortality was 40%, leaving a difference of 32%. Therefore the LH group's estimate of 65% was multiplied by 0.68 to get a point estimate of 44.2% discard mortality for dusky sharks caught on pelagic longlines.

Gillnet

The catch WG's recommendation of 50% post-release mortality was chosen as the final estimate for dusky sharks caught in gillnet gear. The Jensen and Hopkins (2001) paper, which estimated at-vessel mortality of 11% for dusky sharks caught by gillnets, was brought up but not discussed.

Decision 5: Post-release mortality for dusky shark in the commercial bottom longline fishery was estimated to be in a range of 44.2% to 65%.

Decision 6: Post-release mortality for dusky shark in the commercial pelagic longline fishery was estimated to be 44.2%.

Decision 7: The catch WG's recommendation of 50% post-release mortality was chosen as the final estimate for the commercial gillnet fishery.

3.5. *COMMERCIAL EFFORT*

Uncertainty associated with dusky shark catch data is primarily due to under reporting and misidentification, along with the fact that dusky sharks have been listed as Prohibited since 1993. Because of this, the previous assessment used a catch-free model for the dusky shark (Cortés et al. 2006). With this model, effort estimates can be used to guide model estimates of annual fishing mortality, and catches are not included. This model also requires an estimated year of virgin conditions.

A substantial shark fishery developed in the Gulf of Mexico and northwest Atlantic Ocean in the mid-1930s to extract vitamin A from shark livers, but was largely abandoned by 1950 due to the synthesis of vitamin A (Wagner 1966). Since negligible exploitation was thought to have occurred from the late 1940s to 1960, virgin conditions were assumed in 1960.

To estimate annual commercial and recreational effort, the same rationale as in Cortés et al. (2006) was used. First, the annual numbers of hooks from all pelagic longline fleets operating in the northwest Atlantic Ocean were obtained from the International Commission for the Conservation of Atlantic Tunas (ICCAT) Task II database up to 2006. A series of relative effort for 1960-2006 was then created by standardizing the annual effort to the 2006 value. An average of 2001-2005 relative effort was used to produce estimates for the years 2007-2009. Second, for both the recreational (REC) and bottom longline (BLL) fleets, it was thought that there was not much effort before 1980. The directed shark bottom longline fleet is known to have developed in the 1970s, while the recreational fishery did not develop until about the late 1970s, Therefore, from 1960 to 1980, effort for both the recreational and the bottom longline fishery was set to very low levels to reflect the fact these fisheries had not really developed yet. For the remaining years, relative effort trends for these two fisheries were derived by comparing total removals (landings + dead discards) to removals from the pelagic longline (PLL) fleet (assuming that removals would be proportional to effort). Removals form the recreational sector were first available in 1981 (from MRFSS), in 1982 from the bottom longline fishery, and 1992 from the pelagic longline fishery. For the years where removals were available there were often large fluctuations, on the order of several orders of magnitude, among the removals from the three sources. This was not believed to be a reflection of drastic changes in effort, but rather be due possibly to misidentification, misreporting or expansion factors based on very small sample sizes. An exploratory exercise was thus undertaken to identify the period when the magnitude of the removal ratios REC:PLL and BLL:PLL was lowest, resulting in the years 2002-2007. Those years were thus used to derive an average ratio of REC:PLL and BLL:PLL. Third, these estimated ratios were then used to obtain relative effort in 1990-2009 for REC and BLL by multiplying the annual PLL relative effort by each corresponding ratio (0.89 for REC and 0.46 for BLL). Fourth, these estimated annual relative effort series were then projected back from 1990 to 1980 by assuming a linear decrease with a slope equal to the value in 1990 divided by 11 (number of years from 1970 to 1980). Although dusky sharks have been a prohibited species since 2000, there is incidental catch and discard and thus we did not eliminate effort after 2000. Additional work on the influence of the assumptions described to derive these relative effort series could be undertaken during the assessment phase.

3.6. *BIOLOGICAL SAMPLING*

3.6.1. Sampling Intensity Length/Age/Weight

The BLLOP provides dusky shark lengths between 1994 and 2009 (SEDAR21-DW-02). Observer coverage varies annually between 1 and 4%, and approximately 29% and 14% of sets encountered at least one dusky shark from 1994-2001 and 2002-2009, respectively. The 1994-2001 time series had optional observer coverage while the latter time series had mandatory coverage. The observers provided fork length and sex for the animals encountered. There were between 61 and 162 sets observed annually.

3.6.2. Length/Age distributions

The commercial fishery observer programs – BLLOP and PLLOP – provide length distributions of a sample of the bottom longline and pelagic longline catches, respectively. The predicted average weight and observed fork length of dusky shark from the BLLOP showed a declining trend initially in 1994-1998, followed by a generally increasing trend thereafter. With the exception of a very high peak in 2002 (n=1 for 2002 and 2003); there was no trend in size from the PLLOP (n=534; SEDAR21-DW-09). Data from the dealer weighout (for animals weighed individually) also revealed a fairly stable trend for the period with more observations (1994-2000).

Length-frequency distributions of dusky sharks in the BLLOP show that more mature individuals (ca. > 231-235 cm FL) were observed at the beginning of the program, and that there has been a progressive decline in mature individuals observed. In contrast, immature animals have always been predominantly observed in the PLLOP.

3.6.3. Adequacy for characterizing catch

The observer (BLLOP and PLLOP) programs provide the only length distributions of the commercial shark fisheries. Though a larger sample size would increase precision of length composition of the catch, the catch WG reached consensus that they are adequate and represent the best available data for characterizing the catch.

3.6.4. Alternatives for characterizing discard length/age

The catch WG suggested that fishermen report discard information in trip reports. That may improve characterization of discards.

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

Length-frequency information of the catch from the observer programs 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*

Dusky catch data are particularly data poor due to misreporting and misidentification. Additionally, because Dusky sharks are prohibited, fishery- dependent data are sparse. Therefore, the catch WG of the SEDAR 21 Data Workshop recommends utilizing the catch-free model used in the previous assessment.

3.9. *LITERATURE CITED*

Cortés, E., E. Brooks, P. Apostolaki, and C. A. Brown. 2006. Stock assessment of dusky shark in the U.S. Atlantic and Gulf of Mexico. National Marine Fisheries Service Panama City Laboratory Contribution 06-05 and Sustainable Fisheries Division Contribution SFD-2006-014.

Cramer, J. 2000. Pelagic longline bycatch. Col. Vol. Sci. Pap. ICCAT 51(6): 1895-1929.

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Wagner, M.H. 1966. Shark fishing gear: a historical review. Circular 238, U.S. Dept. of Interior, Fish and Wildlife Service, Washington, D.C.

3.10. *TABLES*

Table 1. Total catches of dusky shark (in pounds dressed weight), 1981-2009.

Year	Commercial	Recreational	Discards	Total
1981		518,858		518,858
1982	40	128,571		128,612
1983	11	313,662		313,673
1984	0	434,626		434,626
1985	4,963	219,271		224,234
1986	0	296,907		296,907
1987	83	362,765		362,848
1988	1,691	220,273		221,964
1989	994	174,117		175,111
1990	39,951	162,857		202,808
1991	33,138	215,404		248,542
1992	141,730	405,806	66,338	613,874
1993	98,273	51,473	148,807	298,553
1994	122,404	134,110	72,738	329,253
1995	357,920	113,547	38,731	510,198
1996	290,820	215,416	16,047	522,283
1997	80,930	195,928	29,650	306,508
1998	81,124	63,332	44,786	189,241
1999	137,650	75,825	15,382	228,856
2000	205,746	40,923	29,751	276,419
2001	4,463	85,226	11,980	101,669
2002	16,905	14,516	20,689	52,110
2003	27,907	38,793	53,552	120,251
2004	2,997	343	53,439	56,779
2005	874	43,064	15,334	59,272
2006	4,209	1,891	16,127	22,227
2007	2,064	879	23,116	26,059
2008	0	33,750	2,039	35,789
2009	486	6,090	0	6,576

3.11. *FIGURES*

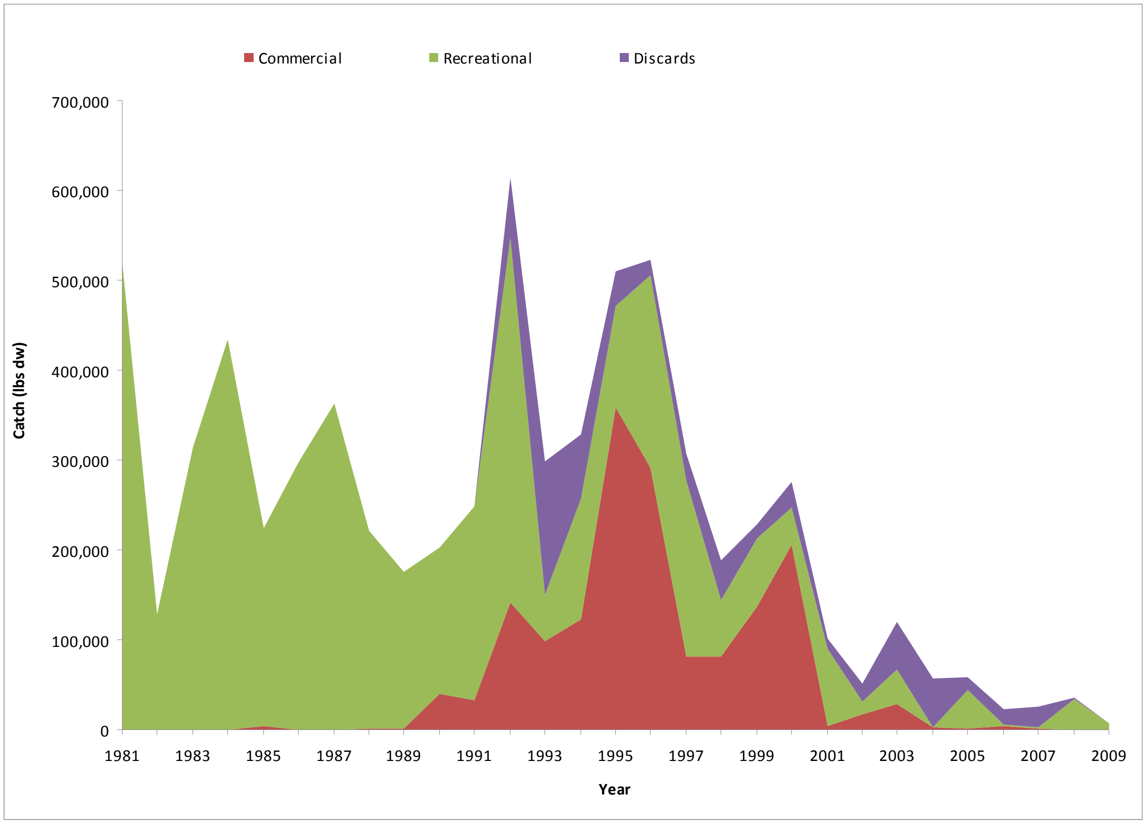

Figure 1. Total catches of dusky shark (in pounds dressed weight), 1981-2009.

4. RECREATIONAL STATISTICS

4.1. *OVERVIEW*

4.1.1. Group Membership

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

Historical recreational landings data for dusky sharks were explored to address several issues. These issues included: (1) duration of data for the stock assessment, (2) lack of confidence in the catch data due to misreporting and misidentification, (3) recreational discards, (4) recreational catch estimates, (5) using dressed weight versus numbers, (6) live discard post-release mortality.

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, and E. Cortés
This document provides the background on the data sources that are currently available for providing catch information for dusky sharks. For those data sources that require some form of expansion, that methodology is outlined in this document.

SEDAR21-DW-09 - Updated catches of sandbar, dusky, and blacknose sharks
E. Cortés and I.E. Baremore
This document presented updated commercial and recreational landings and discard estimates for blacknose sharks through 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 CATCHES*

Recreational catches of dusky sharks were compiled from the three data collection programs described in SEDAR21-DW-09 (MRFSS, HBOAT, and TXPWD). The MRFSS estimates correspond to those incorporating the "new' methodology. Total, annual recreational catch estimates of dusky sharks are the sum of the MRFSS (A+B1=fish landed or killed; 1981-2009), HBOAT (fish landed; 1986-2009), and TXPWD (fish landed; 1983-2009) survey estimates (Table 1, Fig. 1).

Decision 1: Catch statistics were not recommended for a dusky assessment (catch-free model) due to species identification issues.

4.4. *RECREATIONAL DISCARDS*

Recreational live discards are also estimated through the MRFSS survey (referred to as B2) and available for the period 1981 to 2009 (Table 2, Fig. 2). The proportion release alive that will suffer post-release mortality due to handling and other factors was assumed to be zero for previous assessments

The life history group presented their findings on hook and line post-release mortality based on the findings of Cliff and Thurman (1984). Based on this paper, they recommended a 6% post-release mortality for recreationally caught dusky sharks.

Decision 2: Post-release mortality estimates from Cliff and Thurman (1984) of 6% for recommended the recreational dusky shark fishery.

4.5. *BIOLOGICAL SAMPLING*

4.5.1. Sampling Intensity Length/Age/Weight

There were few observations for dusky shark from the three recreational surveys. Due to the limited number of length observations available, a constant weighted (by sample size) average weight for the whole period was used for each survey (MRFSS: 14.2 lb dw, n=157, 1981-2009; HBOAT: 9.5 lb dw, n=88, 1986-2009; TXPWD: 7.5 lb dw, n=38, 1983-2009).

Decision 3: The MRFSS average weight estimates should be weighted by sample size.

4.5.2. Length – Age distributions

All three sources of recreational data provide length-frequency distributions of the catches, but the Headboat and TXPWD surveys have very small sample sizes.

4.5.3. Adequacy for characterizing catch

The recreational surveys provide the length distributions of samples of the recreational shark fisheries. Though a larger sample size would increase precision of length composition of the catch, the group reached consensus that they represent the best available data for characterizing the catch.

4.5.4. Alternatives for characterizing discards

Live release estimates from HBOAT and TXPWD are not available for the current assessment, but could improve estimates of recreational discards of dusky sharks. The current methodology utilizes the best available data.

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

Length-frequency information of the recreational catch from the three surveys 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).

4.7. *RECREATIONAL EFFORT*

To estimate annual commercial and recreational effort, the same rationale as in Cortés et al. (2006) was used. First, the annual numbers of hooks from all pelagic longline fleets operating in the northwest Atlantic Ocean were obtained from the International Commission for the Conservation of Atlantic Tunas (ICCAT) Task II database up to 2006. A series of relative effort for 1960-2006 was then created by standardizing the annual effort to the 2006 value. An average of 2001-2005 relative effort was used to produce estimates for the years 2007-2009. Second, for both the recreational (REC) and bottom longline (BLL) fleets, it was thought that there was not much effort before 1980. The directed shark bottom longline fleet is known to have developed in the 1970s, while the recreational fishery did not develop until about the late 1970s, Therefore, from 1960 to 1980, effort for both the recreational and the bottom longline fishery was set to very low levels to reflect the fact these fisheries had not really developed yet. For the remaining years, relative effort trends for these two fisheries were derived by comparing total removals (landings + dead discards) to removals from the pelagic longline (PLL) fleet (assuming that removals would be proportional to effort). Removals form the recreational sector were first available in 1981 (from MRFSS), in 1982 from the bottom longline fishery, and 1992 from the pelagic longline fishery. For the years where removals were available there were often large fluctuations, on the order of several orders of magnitude, among the removals from the three sources. This was not believed to be a reflection of drastic changes in effort, but rather be due possibly to misidentification, misreporting or expansion factors based on very small sample sizes. An exploratory exercise was thus undertaken to identify the period when the magnitude of the removal ratios REC:PLL and BLL:PLL was lowest, resulting in the years 2002-2007. Those years were thus used to derive an average ratio of REC:PLL and BLL:PLL. Third, these estimated ratios were then used to obtain relative effort in 1990-2009 for REC and BLL by multiplying the annual PLL relative effort by each corresponding ratio (0.89 for REC and 0.46 for BLL). Fourth, these estimated annual relative effort series were then projected back from 1990 to 1980 by assuming a linear decrease with a slope equal to the value in 1990 divided by 11 (number of years from 1970 to 1980). Although dusky sharks have been a prohibited species since 2000, there is incidental catch and discard and thus we did not eliminate effort after 2000. Additional work on the influence of the assumptions described to derive these relative effort series could be undertaken during the assessment phase.

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. The data to be used in the assessment represent the best available recreational data for blacknose sharks. Greater confidence in discards could be achieved through improved species identification, therefore, identification workshops for recreational fishermen would help improve future assessments.

4.9. *LITERATURE CITED*

Cortés, E., E. Brooks, P. Apostolaki, and C. A. Brown. 2006. Stock assessment of dusky shark in the U.S. Atlantic and Gulf of Mexico. National Marine Fisheries Service Panama City Laboratory Contribution 06-05 and Sustainable Fisheries Division Contribution SFD-2006-014.

Cliff, G. and Thurman, G.D. (1984) Pathological and physiological effects of stress during capture and transport in juvenile dusky sharks, Carcharhinus obscures. Comparative Biochemistry and Physiology Part A: Physiology 78:1, 167-173.

Kohler, N.E., Casey, J.G. and Turner, P.A. (1995) Length-weight relationships for 13 species of sharks form the western North Atlantic. Fishery Bulletin 93, 412-418.

4.10. *TABLES*

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2007	2,064	879	23,116	26,059
2008	0	33,750	2,039	35,789
2009	486	6,090	0	6,576

Table 2. Estimated number of discarded alive (B2) dusky sharks from MRFSS, with 6% post-release discard mortality (DM) applied by year.

Year	B2	DM
1981	3729	224
1982	14892	894
1983	23429	1406
1984	9653	579
1985	78581	4715
1986	106175	6371
1987	5577	335
1988	29059	1744
1989	26431	1586
1990	8522	511
1991	33828	2030
1992	28725	1724
1993	2005	120
1994	21155	1269
1995	5546	333
1996	23103	1386
1997	27336	1640
1998	12579	755
1999	12391	743
2000	61692	3702
2001	15576	935
2002	3867	232
2003	6633	398
2004	11115	667
2005	3449	207
2006	7917	475
2007	8498	510
2008	18174	1090
2009	12886	773

4.11. *FIGURES*

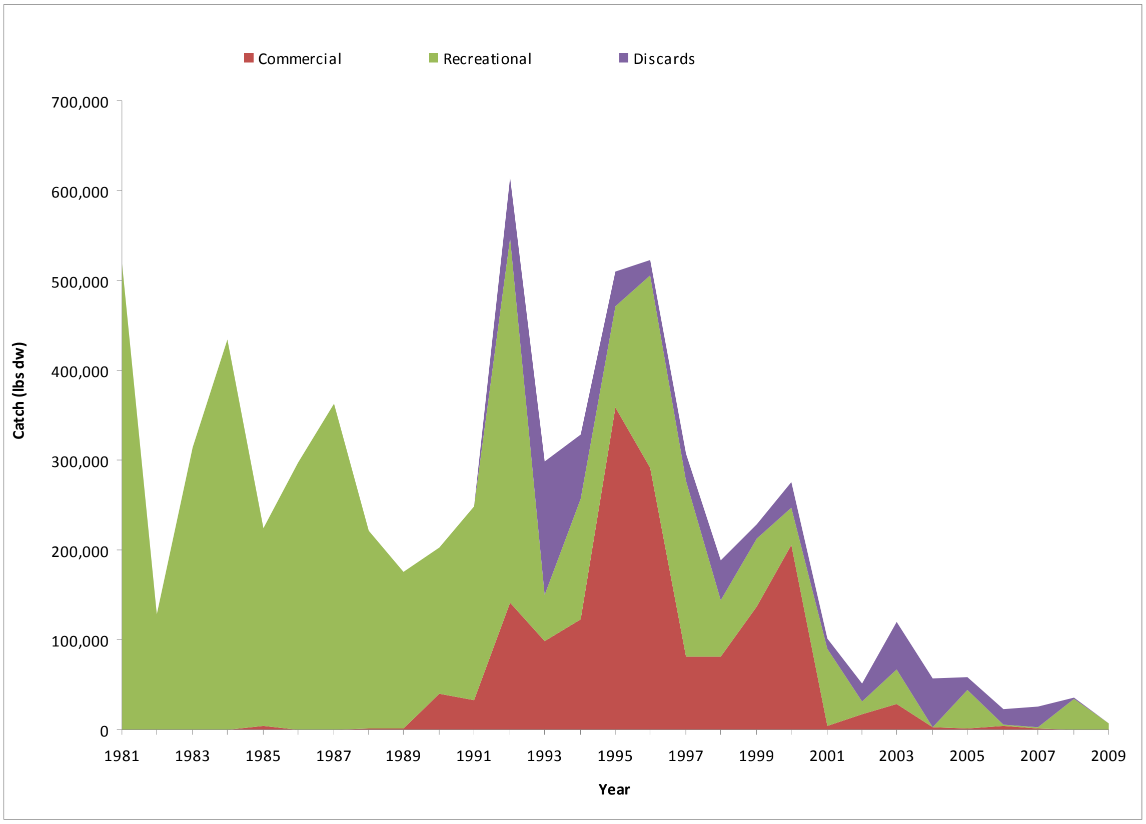

Figure 1. Total catches of dusky shark (in pounds dressed weight), 1981-2009.

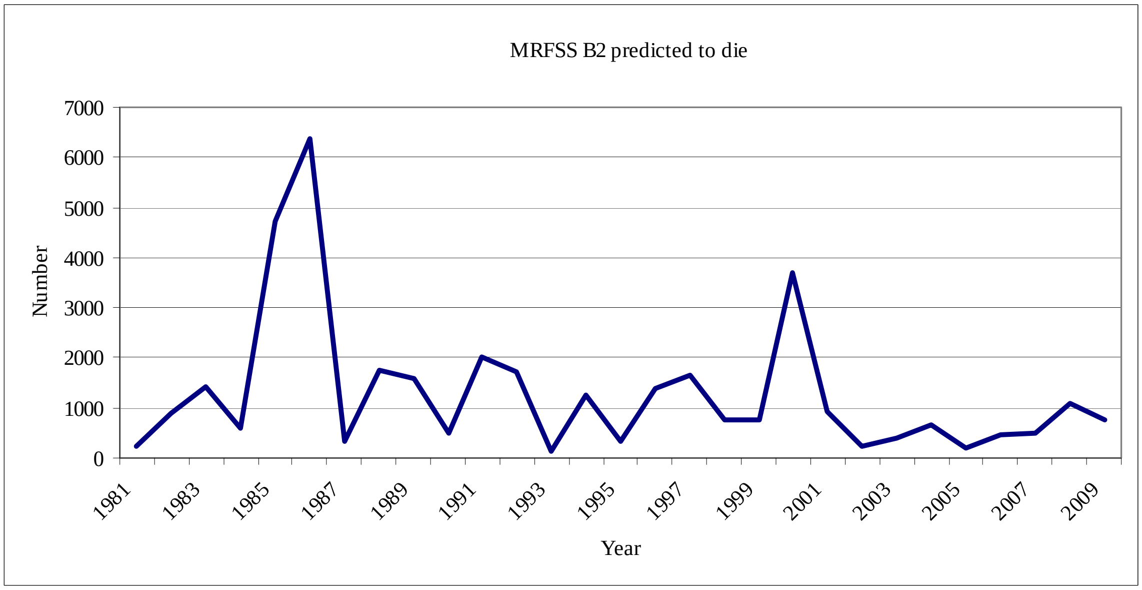

Figure 2. Number of MRFSS discarded alive (B2) dusky sharks predicted to die by year.

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		NMFS SEAMAP Groundfish Trawl (Summer)		NMFS SEAMAP Groundfish Trawl (Fall)	
	SEDAR21-DW-39		SEDAR21-DW-43		SEDAR21-DW-43	
	Base (Rank=1)		Base (Rank=2)		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*

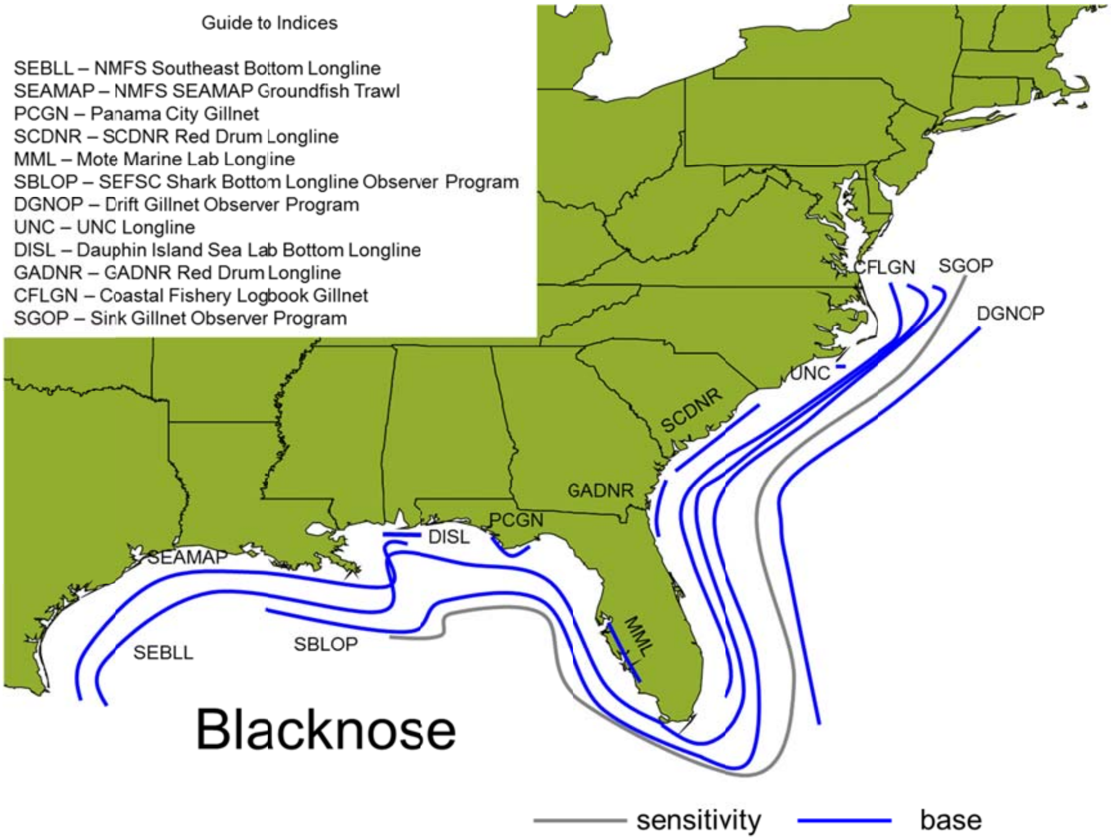

Figure 5.8.1. Approximate linear coverage of specific abundance indices for blacknose sharks (*Carcharhinus acronotus*) along the coast of the Gulf of Mexico and Atlantic Ocean.

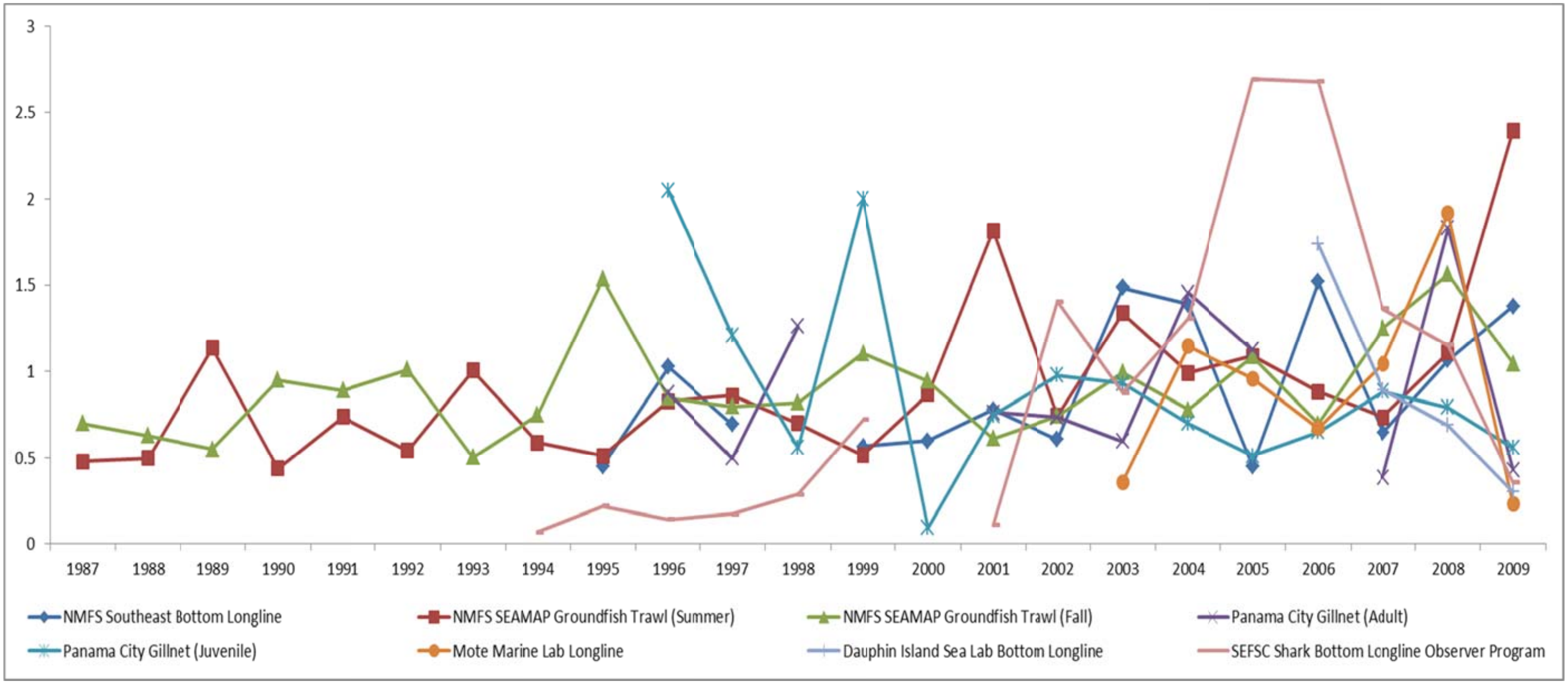

Figure 5.8.2. Plots of mean yearly CPUE for each index recommended for the Gulf of Mexico stock of blacknose sharks (*Carcharhinus acronotus*) by the working group. Values were normalized to a common scale by dividing yearly CPUE of each index by the mean CPUE (across all indices) for those years common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

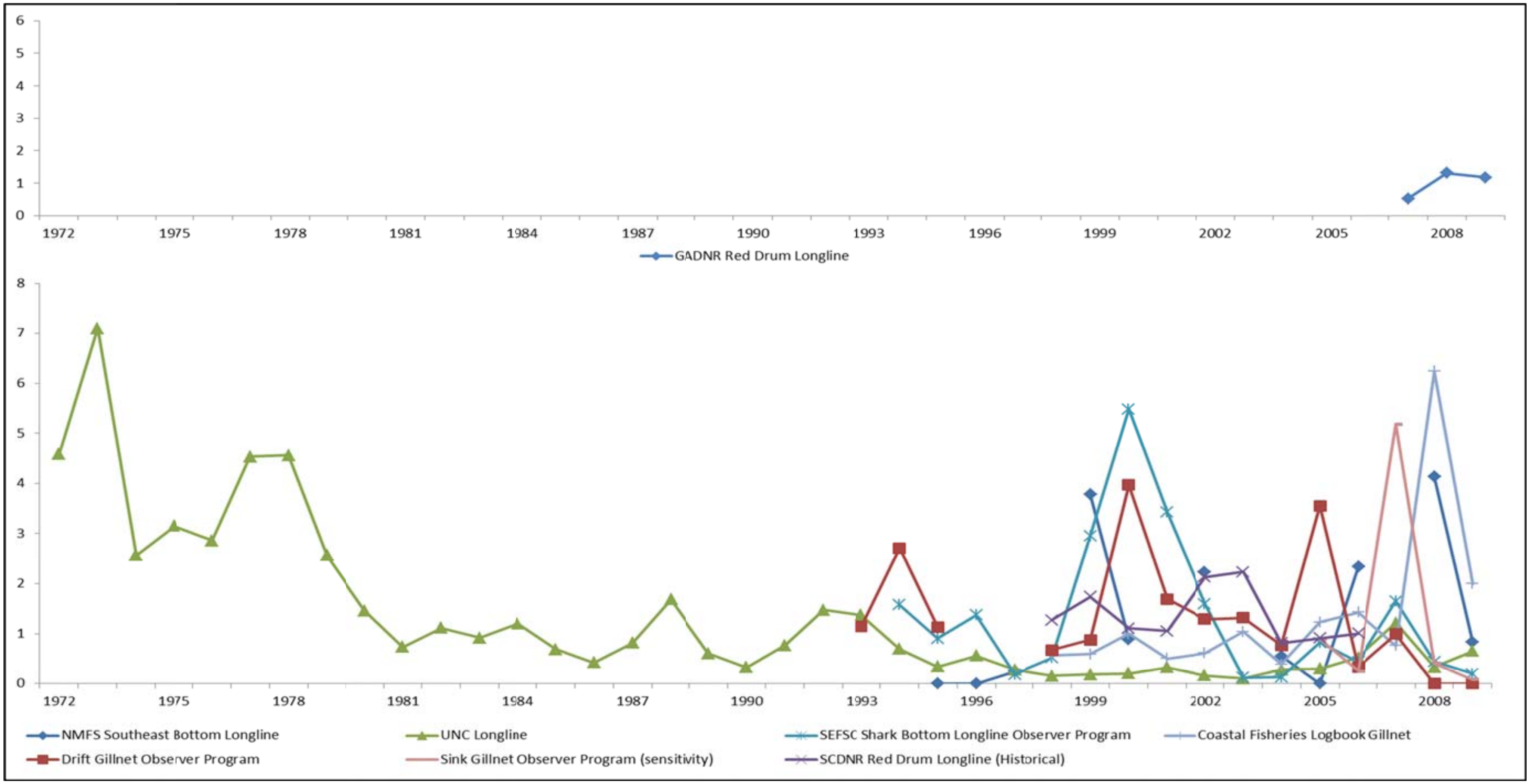

Figure 5.8.3. Plots of mean yearly CPUE for each index recommended for the Atlantic Ocean (ATL) stock of blacknose sharks (*Carcharhinus acronotus*) by the working group. Values were normalized to a common scale by dividing yearly CPUE of each index by the mean CPUE (across all indices) for those years 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.

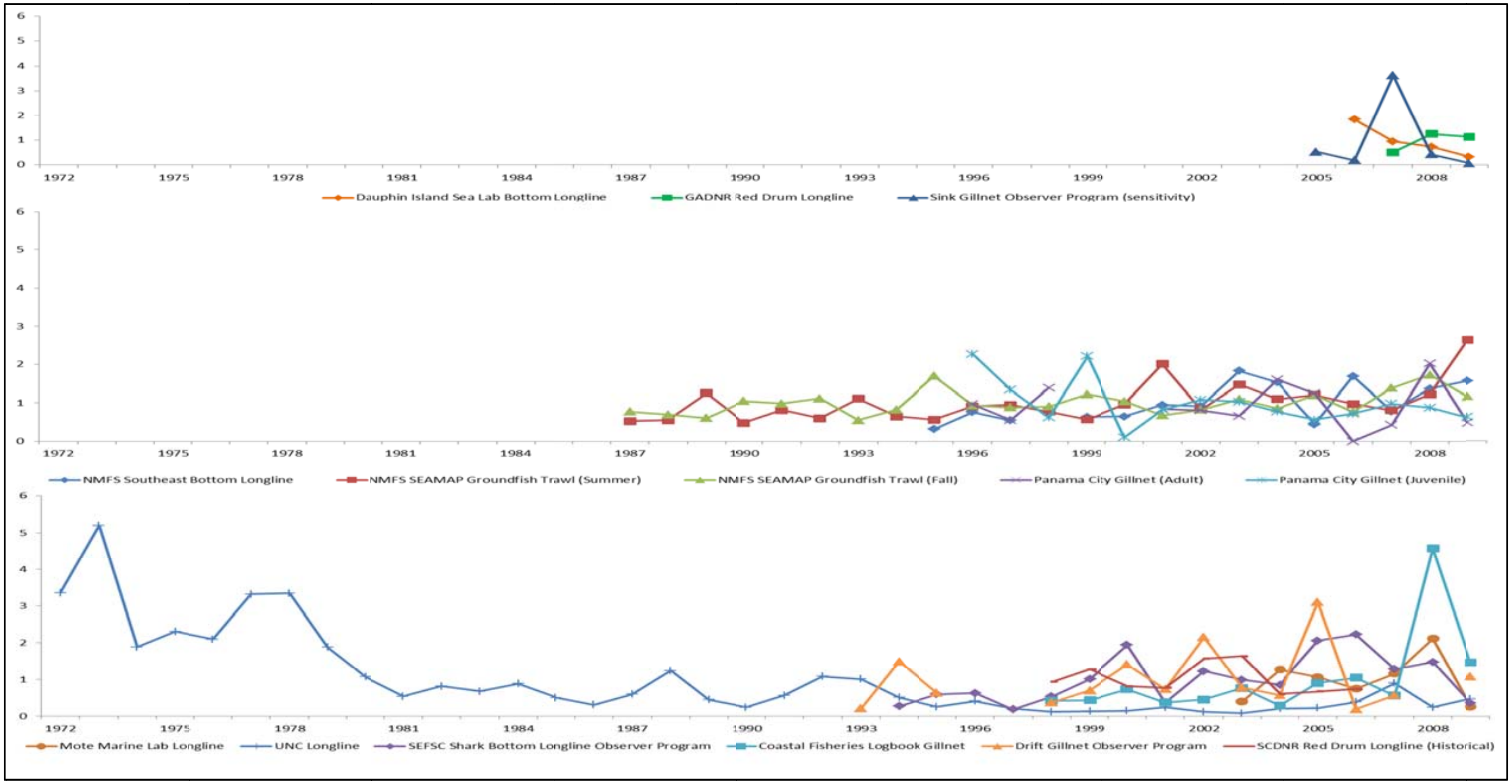

Figure 5.8.4. Plots of mean yearly CPUE (middle and bottom graphs) for each index recommended for the combined stock of blacknose sharks (*Carcharhinus acronotus)* by the working group. Values were normalized to a common scale by dividing yearly CPUE of each index by the mean CPUE (across all indices) 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.

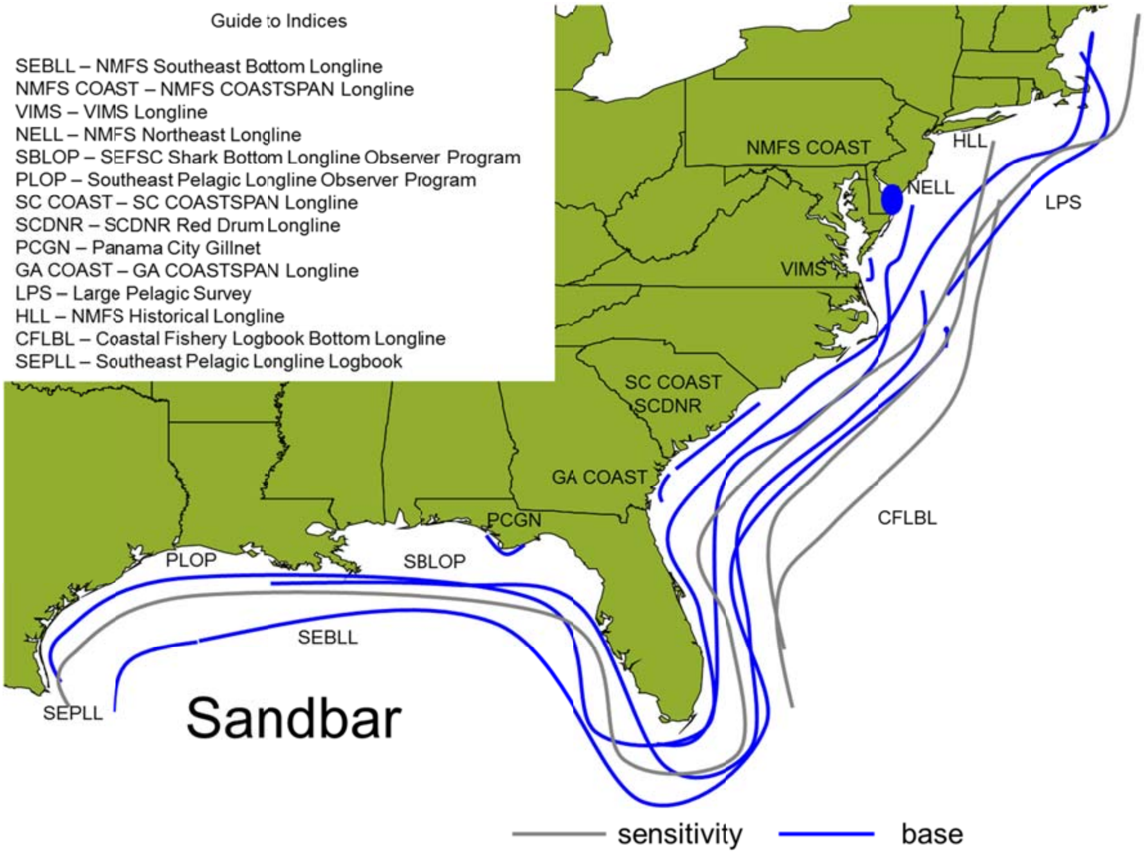

Figure 5.8.5. Approximate linear coverage of specific abundance indices for sandbar sharks (*Carcharhinus plumbeus*) along the coast of the Gulf of Mexico and Atlantic Ocean.

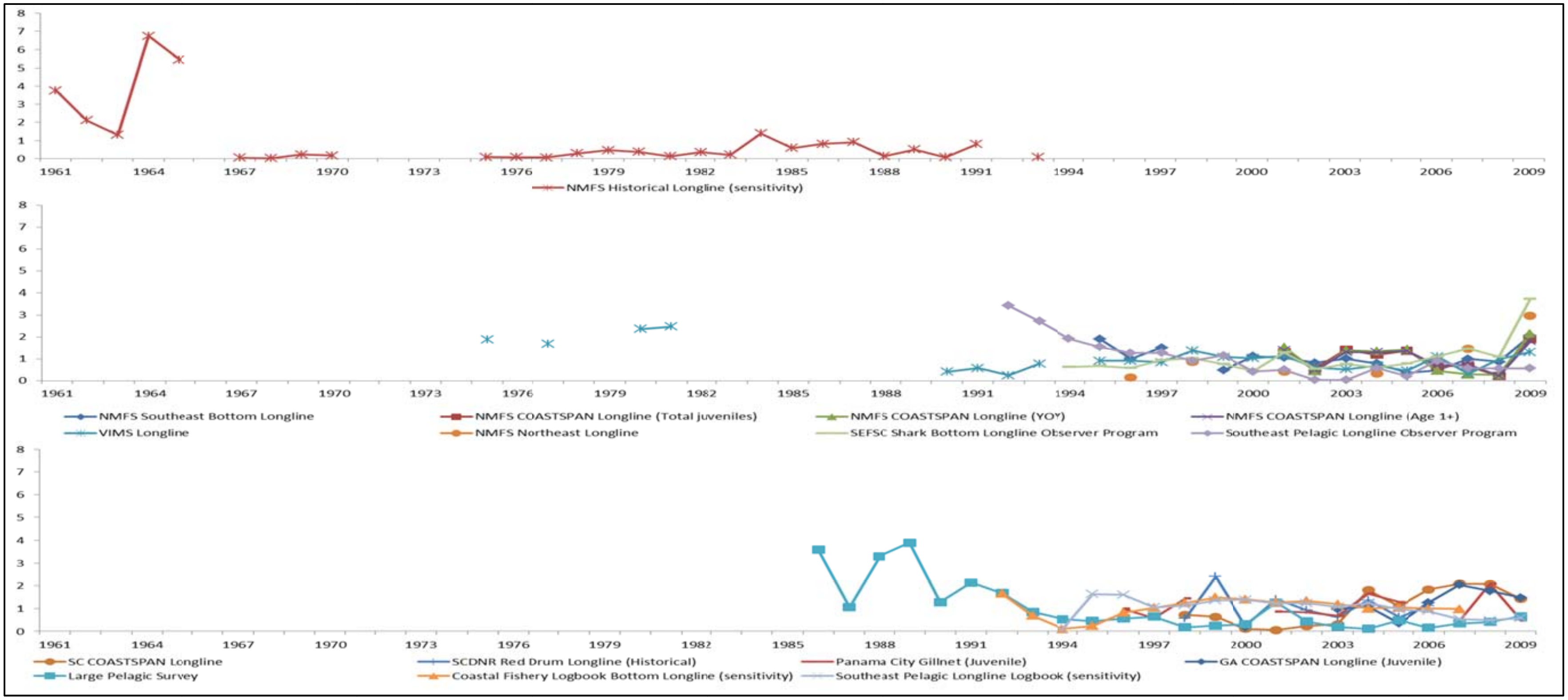

Figure 5.8.6. Plots of mean yearly CPUE (middle and bottom graphs) for each index recommended for sandbar sharks (*Carcharhinus plumbeus*) by the working group. Values were normalized to a common scale by dividing yearly CPUE of each index by the mean CPUE (across all indices) for those years common 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.

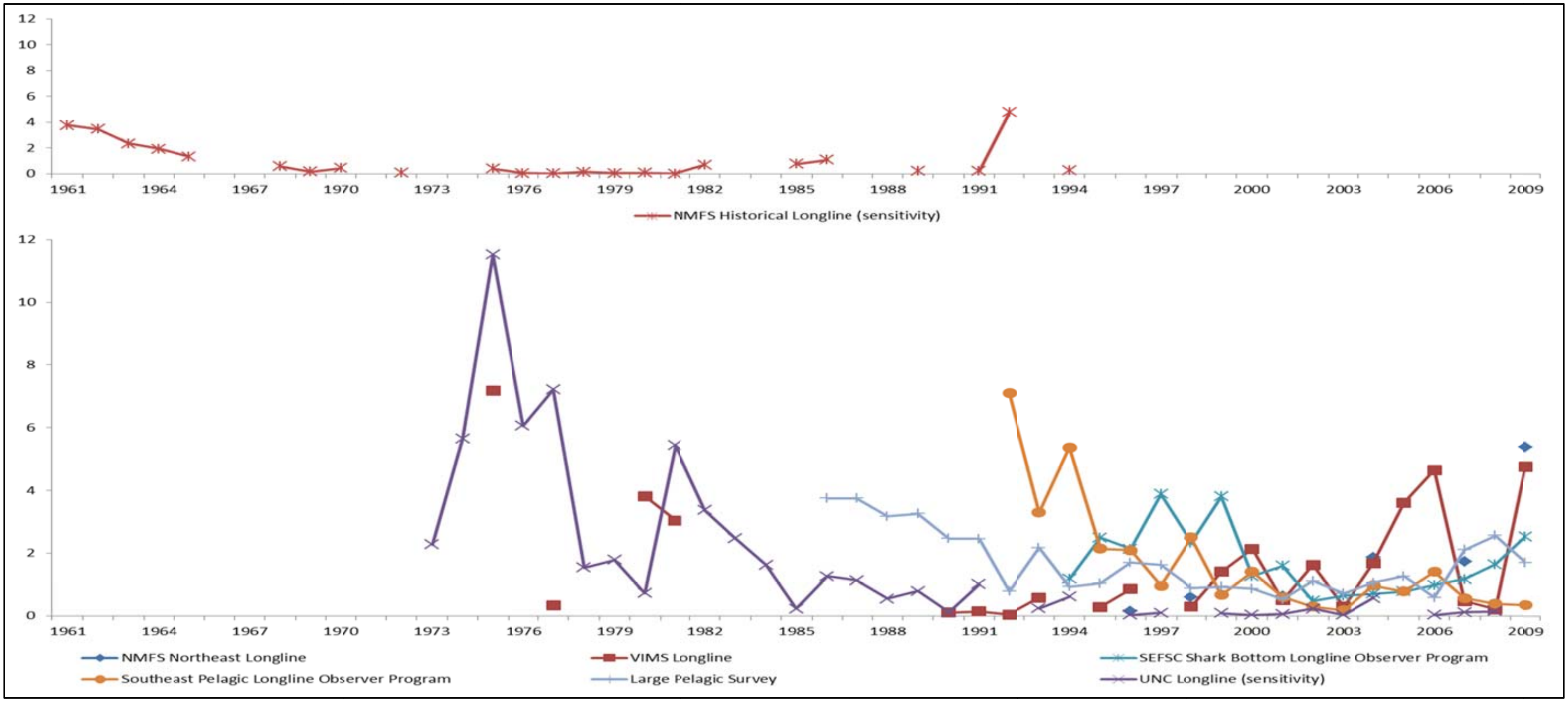

Figure 5.8.8. Plots of mean yearly CPUE for each index recommended for dusky sharks (*Carcharhinus obscurus*) by the working group. Values were normalized to a common scale by dividing yearly CPUE of each index by the mean CPUE (across all indices) for those years common to all indices. The NMFS Historical 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)

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. 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)

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
DESCRIPTION OF THE DATA SOURCE					
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					
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?	✓				

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.

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.

D. Include diagnostic plot for variance function				
E. Include diagnostic plot for link function				

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)

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:

3C,D. AOD
3E. confidential data

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
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 - 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)

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)	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.

Item	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
1. Binomial Component					
A. Include plots of the chi-square residuals by factor.				✓	2B,D,E. AOD
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	6/04/10	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:

	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?	✓			

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.

	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-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

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-D. AOD

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
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-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)

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.				✓

Working Group Comments:

2B. AOD

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:

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	6/21/10	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)

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:

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

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:

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	6/4/10	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

	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:

Working Group Comments:

3A,B,C,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.

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	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

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	6/21/2010	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

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:

	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.

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,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	6/21/2010	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?	✓			

Working Group Comments:

3A,B,C,D. AOD

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	Working Group Comments:
1. Binomial Component					2B,D. AOD
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	6/22/10	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?	✓			

	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.

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
1. Binomial Component					
A. Include plots of the chi-square residuals by factor.				✓	2B,D. AOD
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	6/22/2010	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)

Working Group Comments:

Working paper DW34 describes survey design

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:

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.

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:

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)

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:

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

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
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	Working Group Comments:
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	Working Group Comments:
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

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
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	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)

DESCRIPTION OF THE DATA SOURCE

Working Group Comments:

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

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:

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

Working Group Comments:

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

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. 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)

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.				

	Not Applicable	Absent	Incomplete	Complete
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).				✓

	Not Applicable	Absent	Incomplete	Complete
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-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?	✓			

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.

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 Dusky Shark

SECTION III: Assessment Process Report

April 2011

NOTE: Corrections 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. Additional analyses undertaken that were not discussed at the DW, include 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.

An age-structured, catch-free model (ASCFM) was recommended as most appropriate for assessment of dusky sharks since the magnitude of removals from the population is highly uncertain. Initially developed by Porch et al. (2006) for use in a goliath grouper assessment, this model was used in the previous 2005 assessment of dusky sharks. The model and its configurations are described more fully in Section 3.1.1.

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 3.2.2.

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 relative abundance indices are 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 3.2.

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. Note that since no absolute estimate of biomass is available in the ASCFM, inferences about overfished status are only relative (i.e., one can estimate $SSB_{current}/SSB_{MSY}$ but not $SSB_{current}$ or SSB_{MSY}). A procedure to scale up estimated relative biomass to absolute biomass is developed in conjunction with projections in Section 3.1.7.

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 reported in Section 3.2.

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.

Future stock conditions, rebuilding schedules, and generation time are 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 for future research and data collection are provided in Section 3. 4.

2. DATA REVIEW AND UPDATE

2.1. 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 were used to generate age-frequency distributions through age-length keys (Figure 2.1). 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 may 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. The derivation of selectivities from age-frequency distributions was done under the following assumptions. With only M operating, one would expect an age-frequency histogram to decline with age. However, with both M and 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 the same F and M (approximately). The fully selected age is thus determined by looking at the age-frequency distribution and identifying the "fulcrum" 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 CPUE series:

BLLOP (bottom longline)—All ages were assumed to be fully selected by bottom long line gear.

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 quickly descending right limb.

LPS (hook and line)—The recommendation for this index was a double logistic curve with fully selected age at 4 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 5. 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 6.

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 slope. Double logistic curves were expressed as:

$$s = \frac{\frac{1}{1 - e^{-\left(\frac{a - a_{50}}{b}\right)}} \times \left(1 - \frac{1}{1 - e^{-\left(\frac{a - c_{50}}{d}\right)}}\right)}{e}$$

where a_{50} and c_{50} are the ascending and descending inflection points and b and are the ascending and descending slopes, respectively, and e is the maximum selectivity.

All selectivities used in the assessment are summarized in Table 2.1 and Figure 2.2.

2.2. INDICES OF RELATIVE ABUNDANCE

The standardized indices of relative abundance used in the assessment are presented in Table 2.2 and Figure 2.3. The Index WG of the DW recommended the use of five of these indices in the base model run: two fishery-independent series (VIMS LL, NELL) 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 Data Workshop Report). Two additional fishery- independent indices were recommended for use in sensitivity runs: UNC LL and NMFS Historical LL. The CVs associated with these indices are provided in Table 2.3); these values were used to specify observation error in the base model run ("additional" variance terms were also estimated for each index).

2.3. LIFE HISTORY INPUTS

The life history inputs used in the assessment are presented in Table 2.4. These include age and growth, several parameters associated with reproduction, including sex ratio, reproductive frequency, fecundity at age, maturity at age, month of pupping, and natural mortality. The

ASCFM 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 reproductive 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 each 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 ASCFM tracks only females, we multiply the number of pups per female (7.13) by 0.5 to account for a 50/50 sex ratio, and multiply this number by 0.33 to account for the triennial reproductive cycle) agreed upon by the DW. Since the proportion of females in maternal condition—a quantity that accounts for the time it takes for a female to become pregnant and produce offspring after it reaches maturity and which is more appropriate than using the proportion of mature females (Walker 2005) —was not available, we offset the maturity ogive by one year (the gestation period) as a proxy to using the maternity ogive.

2.4. RELATIVE EFFORT SERIES

As described subsequently, relative effort series for the three fleets are used to determine a single, annual weighted selectivity vector for modeling fishing mortality. The derivation of relative effort for the three fleets considered for 1960-2009 is described in section 3.5 of the SEDAR21 Data Workshop report. Table 2.5 lists the values and Figure 2.4 displays them graphically.

2.5. REFERENCES

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2.6. TABLES

Table 2.1. Selectivity curves for indices of relative abundance. Two indices were fitted by eye and three by least squares. 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)
BLLOP	Logistic	8.65	0.47			
VIMS	Double logistic	0	0.25	2	4.50	0.55
LPS	Double logistic*	3.03	0.06	14.05	4.33	0.91
PLLOP	Double logistic*	2.19	0.82	13.56	7.77	0.73
NELL	Logistic*	3.10	0.28			

* Fitted by least squares

Table 2.2. Standardized indices of relative abundance used in the baseline scenario (five first indices) and two sensitivity indices (in italics). All indices are scaled (divided by their respective mean).

YEAR	VIMS LL	LPS	BLLOP	NELL	PLLOP	*UNC LL*	*NMFS Hist LL*
1961	-	-	-	-	-	-	3.765
1962	-	-	-	-	-	-	3.470
1963	-	-	-	-	-	-	2.344
1964	-	-	-	-	-	-	1.946
1965	-	-	-	-	-	-	1.345
1966	-	-	-	-	-	-	-
1967	-	-	-	-	-	-	-
1968	-	-	-	-	-	-	0.581
1969	-	-	-	-	-	-	0.161
1970	-	-	-	-	-	-	0.447
1971	-	-	-	-	-	-	-
1972	-	-	-	-	-	-	0.067
1973	-	-	-	-	-	1.320	-
1974	-	-	-	-	-	3.268	-
1975	4.152	-	-	-	-	6.656	0.411
1976	-	-	-	-	-	3.503	0.054
1977	0.194	-	-	-	-	4.168	0.036
1978	-	-	-	-	-	0.893	0.141
1979	-	-	-	-	-	1.036	0.064
1980	2.208	-	-	-	-	0.423	0.089
1981	1.760	-	-	-	-	3.142	0.005
1982	-	-	-	-	-	1.950	0.707
1983	-	-	-	-	-	1.425	-
1984	-	-	-	-	-	0.941	-
1985	-	-	-	-	-	0.131	0.766
1986	-	2.166	-	-	-	0.733	1.093
1987	-	2.170	-	-	-	0.656	-
1988	-	1.838	-	-	-	0.317	-
1989	-	1.888	-	-	-	0.458	0.249
1990	0.061	1.425	-	-	-	0.069	-
1991	0.082	1.423	-	-	-	0.586	0.215
1992	0.021	0.455	-	-	4.099	-	4.763
1993	0.339	1.257	-	-	1.907	0.136	-
1994	-	0.541	0.682	-	3.101	0.358	0.281
1995	0.164	0.602	1.443	-	1.239	-	-
1996	0.500	0.986	1.234	0.0819	1.216	0.016	-
1997	-	0.943	2.245	-	0.556	0.058	-
1998	0.169	0.514	1.347	0.3469	1.448	-	-
1999	0.817	0.540	2.204	-	0.390	0.052	-
2000	1.235	0.506	0.735	-	0.817	0.020	-
2001	0.293	0.307	0.926	0.3746	0.353	0.034	-
2002	0.940	0.645	0.280	-	0.173	0.134	-
2003	0.171	0.418	0.372	-	0.104	0.020	-
2004	0.971	0.615	0.409	1.0833	0.565	0.329	-
2005	2.087	0.735	0.454	-	0.457	-	-
2006	2.688	0.339	0.569	-	0.817	0.018	-
2007	0.276	1.222	0.680	1.0064	0.327	0.068	-
2008	0.124	1.481	0.954	-	0.227	0.082	-
2009	2.748	0.983	1.465	3.1069	0.205	0	-

Table 2.3. Coefficients of variation used for weighting the indices of relative abundance.

YEAR	VIMS LL	LPS	BLLOP	NELL	PLLOP	*UNC LL*	*NMFS Hist LL*
1961	1	1	1	1	1	1	1
1962	1	1	1	1	1	1	0.417
1963	1	1	1	1	1	1	0.592
1964	1	1	1	1	1	1	0.822
1965	1	1	1	1	1	1	1.133
1966	1	1	1	1	1	1	0.913
1967	1	1	1	1	1	1	1
1968	1	1	1	1	1	1	1
1969	1	1	1	1	1	1	0.877
1970	1	1	1	1	1	1	0.966
1971	1	1	1	1	1	1	1.347
1972	1	1	1	1	1	1	1
1973	1	1	1	1	1	1	1.253
1974	1	1	1	1	1	0.551	1
1975	1	1	1	1	1	0.436	1
1976	0.518	1	1	1	1	0.440	1.330
1977	1	1	1	1	1	0.551	1.385
1978	1.921	1	1	1	1	0.439	1.494
1979	1	1	1	1	1	0.713	0.904
1980	1	1	1	1	1	0.498	1.412
1981	0.542	1	1	1	1	0.701	1.068
1982	0.519	1	1	1	1	0.367	1.461
1983	1	1	1	1	1	0.296	0.890
1984	1	1	1	1	1	0.341	1
1985	1	1	1	1	1	0.404	1
1986	1	1	1	1	1	0.713	0.778
1987	1	0.123	1	1	1	0.542	0.721
1988	1	0.121	1	1	1	0.608	1
1989	1	0.298	1	1	1	0.630	1
1990	1	0.168	1	1	1	0.581	1.083
1991	2.540	0.154	1	1	1	0.793	1
1992	2.292	0.16	1	1	1	1.319	1.077
1993	5.181	0.292	1	1	0.274	1	1.242
1994	1.242	0.242	1	1	0.218	0.793	1
1995	1.000	0.377	0.390	1	0.217	0.791	1.055
1996	1.835	0.322	0.340	1	0.258	1	1
1997	0.861	0.412	0.340	0.749	0.29	1.314	1
1998	1.000	0.378	0.360	1	0.353	1.310	1
1999	1.526	0.491	0.380	0.528	0.296	1	1
2000	0.946	0.677	0.390	1	0.392	1.303	1
2001	0.682	0.526	0.660	1	0.307	1.312	1
2002	1.277	0.658	0.440	0.484	0.373	1.311	1
2003	0.949	0.611	0.510	1	0.889	0.954	1
2004	2.162	0.380	0.370	1	0.632	1.312	1
2005	0.713	0.337	0.380	0.307	0.311	0.980	1
2006	0.690	0.335	0.500	1	0.297	1	1
2007	0.498	0.458	0.550	1	0.284	1.308	1
2008	1.118	0.242	0.660	0.517	0.320	0.972	1
2009	2.037	0.208	0.620	1	0.425	1.321	1

Table 2.4. Life history inputs used in the assessment. All these quantities are treated as constants in the model.

Age	Proportion mature	M
1	0.00	0.104
2	0.00	0.104
3	0.00	0.104
4	0.00	0.104
5	0.00	0.104
6	0.00	0.098
7	0.00	0.092
8	0.00	0.088
9	0.00	0.084
10	0.00	0.080
11	0.00	0.077
12	0.00	0.074
13	0.00	0.072
14	0.00	0.070
15	0.01	0.068
16	0.02	0.066
17	0.05	0.064
18	0.13	0.063
19	0.28	0.061
20	0.51	0.060
21	0.74	0.059
22	0.88	0.058
23	0.95	0.057
24	0.98	0.056
25	0.99	0.055
26	1.00	0.054
27	1.00	0.053
28	1.00	0.052
29	1.00	0.052
30	1.00	0.051
31	1.00	0.048
32	1.00	0.048
33	1.00	0.048
34	1.00	0.048
35	1.00	0.048
36	1.00	0.048
37	1.00	0.048
38	1.00	0.048
39	1.00	0.048
40	1.00	0.048

Sex ratio at birth:	1:1
Reproductive frequency:	3 yr
Pupping month:	June
Gestation period:	12 months
Fecundity:	7.13 pups
L_{inf}	350.3 cm FL
k	0.039
t_0	-7.04
Weight vs length relation:	$W=0.000032415L^{2.7862}$
maturity ogive:	a=-19.76, b=0.99

Table 2.5. Relative effort for fleets considered in the ASCFM model (BLL=directed bottom-longline shark fishery; REC=recreational fishery; PLL=pelagic longline fishery).

Year	PLL	REC	BLL
1960	0.136	0.001	0.001
1961	0.152	0.001	0.001
1962	0.314	0.002	0.002
1963	0.345	0.002	0.002
1964	0.519	0.003	0.003
1965	0.532	0.003	0.003
1966	0.370	0.001	0.001
1967	0.307	0.001	0.001
1968	0.351	0.002	0.002
1969	0.475	0.002	0.002
1970	0.531	0.002	0.002
1971	0.708	0.002	0.002
1972	0.749	0.002	0.002
1973	0.745	0.002	0.002
1974	0.746	0.002	0.002
1975	1.050	0.002	0.002
1976	0.983	0.002	0.002
1977	0.967	0.002	0.002
1978	0.822	0.002	0.002
1979	0.648	0.002	0.002
1980	0.685	0.080	0.042
1981	0.861	0.161	0.083
1982	0.923	0.241	0.125
1983	0.854	0.322	0.166
1984	0.906	0.402	0.208
1985	1.036	0.482	0.249
1986	1.116	0.563	0.291
1987	0.749	0.643	0.332
1988	0.859	0.724	0.374
1989	0.988	0.804	0.416
1990	0.994	0.884	0.457
1991	1.095	0.974	0.504
1992	1.092	0.972	0.503
1993	1.063	0.946	0.489
1994	1.134	1.009	0.522
1995	1.225	1.090	0.564
1996	1.414	1.258	0.650
1997	1.421	1.264	0.653
1998	1.265	1.126	0.582
1999	1.269	1.129	0.584
2000	1.213	1.079	0.558
2001	1.132	1.008	0.521
2002	0.938	0.835	0.432
2003	1.004	0.893	0.462
2004	1.133	1.008	0.521
2005	1.037	0.923	0.477
2006	1.000	0.890	0.460
2007	1.049	0.933	0.482
2008	1.049	0.933	0.482
2009	1.049	0.933	0.482

2.7. FIGURES

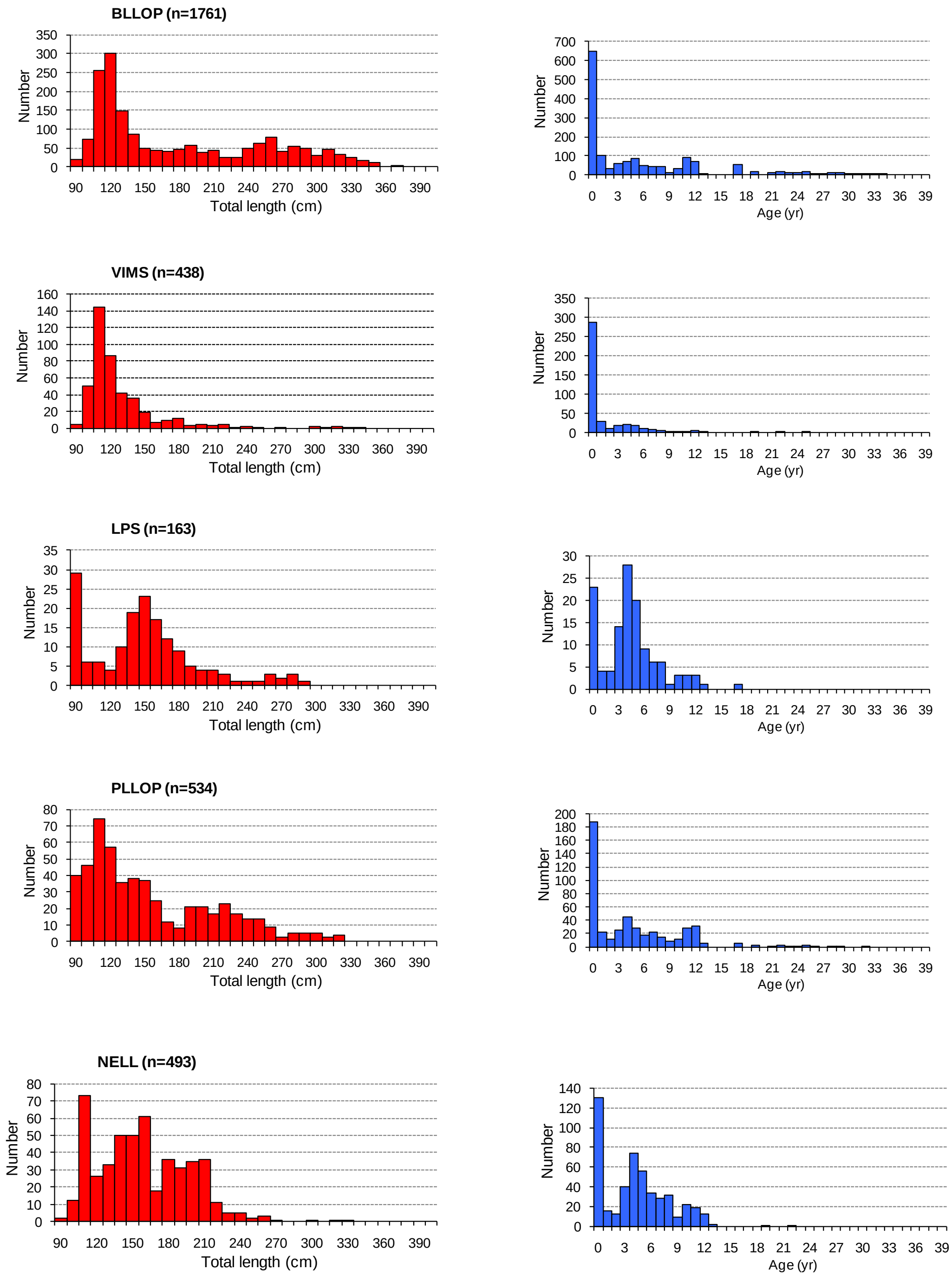

Figure 2.1. Length-frequency (left panels) and age-frequency (right panels) distributions of dusky shark from the Shark Bottom Longline Observer Program (BLLOP; 1994-2009), VIMS (1975-2009), LPS (1986-2009), PLLOP (1992-2009), and NELL (1996-2009). The age distributions were used to estimate selectivities that were assigned to the corresponding indices of relative abundance (BLLOP, VIMS, LPS, PLLOP, NMFS NELL).

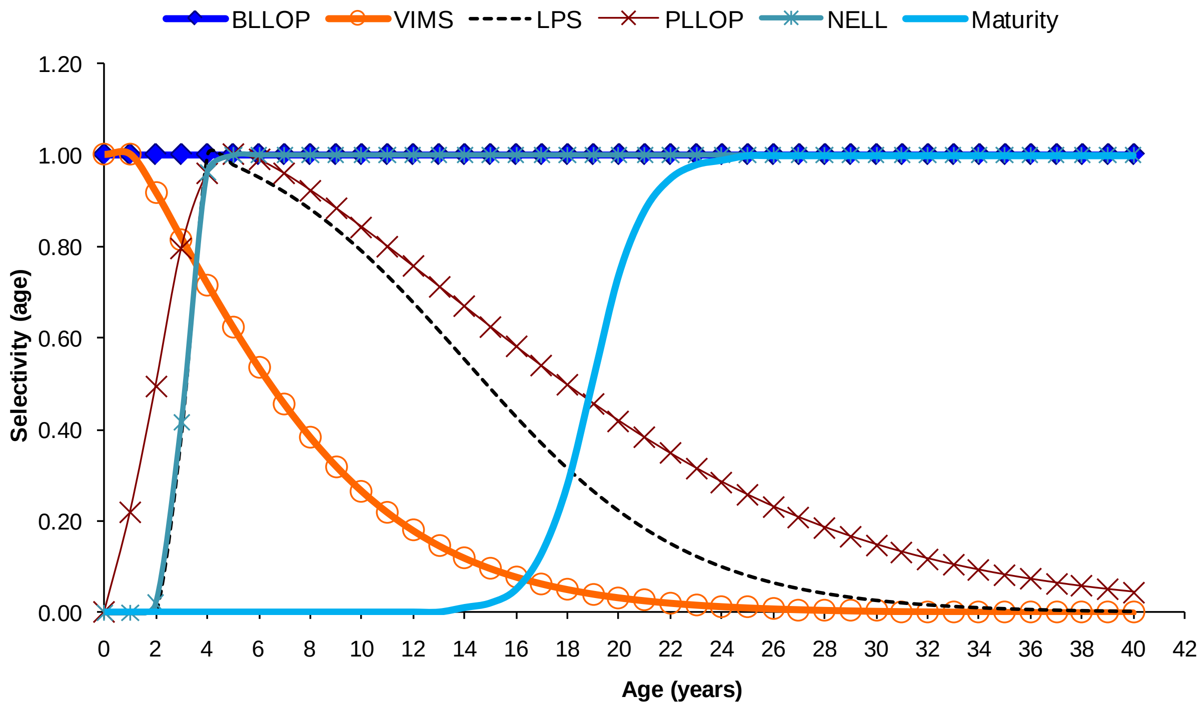

Figure 2.2. Selectivity curves for indices of relative abundance. The maturity ogive for dusky shark has been added for reference.

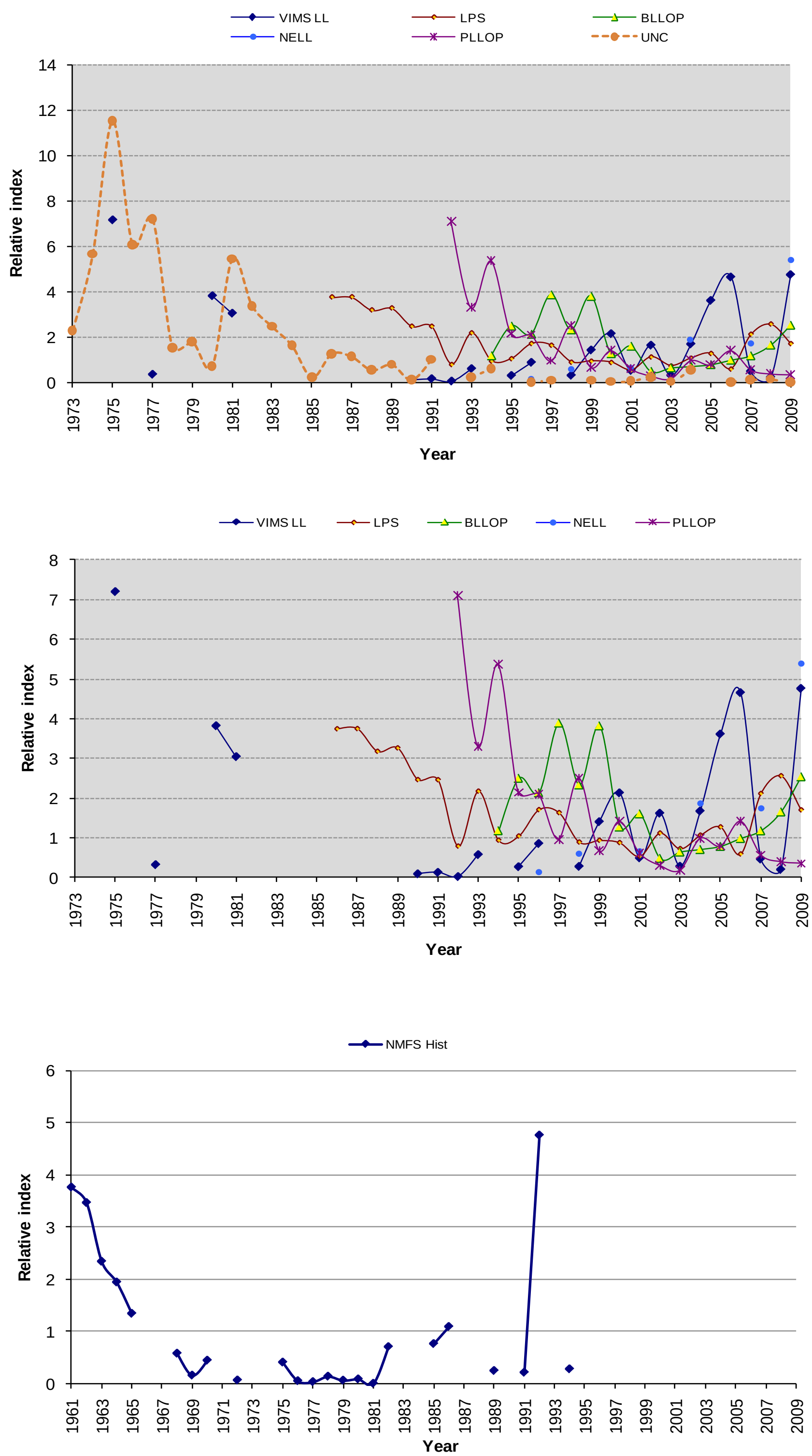

Figure 2.3. Indices of relative abundance used for dusky shark. Top panel: five baseline indices and UNC sensitivity index; middle panel: baseline indices only; bottom panel: NMFS Historic LL sensitivity index. All indices are statistically standardized and scaled (divided by their respective mean and a global mean for overlapping years; except NMFS Historic LL).

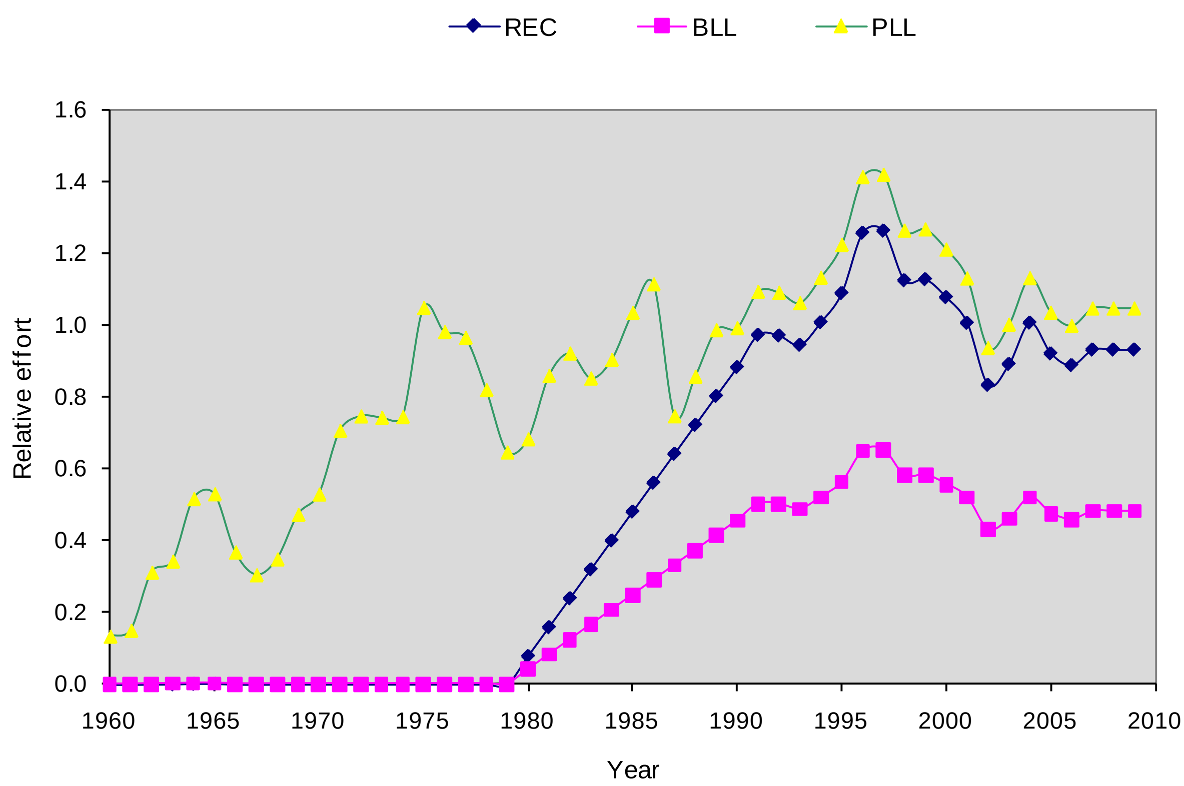

Figure 2.4. Relative effort for fleets considered in the ASCFM model (BLL=directed bottom-longline shark fishery; REC=recreational fishery; PLL=pelagic longline fishery).

3. STOCK ASSESSMENT MODEL AND RESULTS

3.1. ASSESSMENT METHODS

3.1.1 Age-Structured Catch Free Model (ASCFM) description

In fisheries where there is a high degree of uncertainty in reported catches, or catches are not reported at all, stock assessment models that rely on catch data may not be appropriate. For numerous shark species there is uncertainty about the magnitude of commercial and recreational catches, in part due to identification problems. The level of reported discards is especially uncertain and may be underestimated because sharks are often not brought aboard for positive identification and may therefore go unreported. Without accurate knowledge of the magnitude of total catches and discards, it is not possible to estimate absolute abundance levels for the population. An alternative modeling methodology appropriate to these situations is to re-scale the model population dynamics as proportional to virgin (unexploited) conditions. If estimates of effort are available for the time series of exploitation, this information can be incorporated to guide model estimates of annual fishing mortality. Information about population declines relative to virgin can also be incorporated if there is expert opinion or data to suggest possible estimates of depletion. If catch and effort information are available from sampled trips or observer programs, then standardized catch rates can be developed and incorporated into the model.

In the present application, dusky shark landings are first available in the early 1980s at very low levels. Commercial landings during this time period are 2 to 3 orders of magnitude lower than those from the recreational fishery. It is not believed that this is a real trend in landings, but rather that it reflects underreporting and poor species identification. Indeed, dusky sharks—especially immature individuals—are easy to confuse with some other similar-looking species, in particular silky sharks. This has likely led to identification problems in the past in the commercial fisheries, but is most problematic in the recreational fisheries, where anglers unfamiliar with shark identification may incorrectly identify dusky sharks, leading to over- or under-representation of the expanded recreational catches. Underreporting (or mis-reporting as other species) is also likely to have occurred in the commercial fisheries because take of the species was prohibited in 1999. Dead discard estimates of dusky shark from the pelagic longline fishery are first available in 1992 as a result of the observer program that placed observers on a fraction of the vessels to estimate both discards and landings. With such high uncertainty in the series of reported catch and discard, the catch-free methodology was selected as an appropriate application.

Due to the uncertainty and inconsistencies in reported catches, DW participants agreed early on that the ASCFM would be most appropriate for assessing the stock because it does not require total catches. This model was initially developed by Porch et al. (2006) for use in a goliath grouper assessment for which only life history information and relative abundance (CPUE) indices were available.

3.1.2. Data Sources

The ASCFM was fit to life history data and relative abundance indices recommended by the DW. See section 2 for description of these data sources.

3.1.3. Model Configuration and Equations

The ASCFM used in this assessment builds upon the methodology first described by Porch et al. (2006), and as used by Cortés et al. (2006) in a previous assessment of dusky sharks. A first step in applying the catch-free methodology is to determine a year in which the population can be considered to be at virgin conditions. From that year forward, information on fishing effort and/or prior information about possible levels of depletion allow the model to estimate the relative number at age for the year that data (e.g., catch rates) are first available. The period from virgin conditions just prior to availability of fishery data is referred to as the *historic* period. In the present incarnation of the ASCFM, the time period spanning the first year with fishery data through the end of 1999 is referred to as the *first modern* period. The time period from 2000 to the end of the assessment period (2009) is referred to as the *second modern* period (landings for dusky shark were prohibited during the second modern period).

The underlying equations are simply a re-scaled age-structured production model. The stock-recruitment relationship is defined in terms of the spawning stock in year y and the resultant recruits in year y+r, and the first model age is a_r. Assuming that all survival beyond recruitment is density independent, then at virgin conditions the population age structure beyond a_r can be calculated from the expected survival at age from natural mortality:

$$N_{a,1} = \begin{cases} 1 & a = a_r \\ N_{a-1,1}\exp(-M_{a-1}) & a_r < a < A \\ N_{a-1,1}\dfrac{\exp(-M_{A-1})}{1-\exp(-M_{A-1})} & a = A \end{cases} \tag{3.1}$$

where A is the age of the plus-group (assumed 40 years in the present assessment).

Subsequent annual relative recruitment, r_y, is modeled as following a Beverton-Holt function (with recruitment deviations set to zero). This function can be parameterized in terms of α, the maximum number of recruits produced by each spawner over its lifetime (Myers et al. 1999). The parameter α is equivalent to the slope of the spawner-recruit curve at the origin times φ_0 (unexploited number of pups per recruit). The slope of the stock-recruit curve at the origin is equivalent to density-independent survival of pups (e^{-M_0} ; see section 3.1.4). The Beverton-Holt function is given by:

$$r_y = \frac{e^{-M_0}\varphi_0 S_{y-a_r}}{1+(e^{-M_0}\varphi_0 - 1)S_{y-a_r}} \tag{3.2}$$

In (3.2), S_{y-a_r} is a measure of relative spawning stock biomass, which is calculated as:

$$S_y = \frac{\sum_{a=a_r}^{A} E_a N_{a,y}\exp(-(F_{a,y}+M_a)t_j)}{\sum_{a=a_r}^{A} E_a N_{a,1}\exp(-M_a t_j)} \tag{3.3}$$

In (3.3), E_a is per-capita eggs by age class (the product of fecundity and maturity at age was used as a proxy for eggs in the present application), $F_{a,y}$ is total fishing mortality on age a in year y, and t_s is the fraction of the year elapsed at the time of spawning. Since this assessment employs a constant fec_{age} value (i.e., fecundity does not vary by age), fecundity cancels out of (3.3); in fact (3.3) may be interpreted as either relative mature spawning stock biomass, or relative spawning stock fecundity.

The parameter φ_0 in (eq. 3.2) is calculated as:

$$\varphi_0 = \sum_{a=1}^{A-1} fec_a \times mat_a \prod_{j=1}^{a-1} \exp(-M_j) + fec_A \times mat_A \frac{\exp(-M_{A-1})}{1-\exp(-M_{A-1})} \prod_{j=1}^{A-2} \exp(-M_j) \qquad (3.4)$$

where fec_a is fecundity at age and mat_a is maturity at age (Goodyear 1993).

This implementation of the catch-free model can incorporate multiple fleets that may be exploiting the resource. Annual, fleet-specific apical fishing mortality can potentially be estimated from fleet-specific effort series, if available (“apical” in this context refers to the fishing mortality that would be experienced by an age class that is fully vulnerable). However, effort series for several of the fleets (e.g., bottom long line, recreational) were missing, and initial efforts to incorporate effort series derived using proportionality constants resulted in collinearity when attempting to estimate fleet-specific parameters. As such, total age-specific fishing mortality was modeled as follows:

$$F_{a,y} = Fapical_y \bar{v}_{a,y}, \qquad (3.5)$$

where $\bar{v}_{a,y}$ gives mean vulnerability (selectivity) at age in year y across all fleets:

$$\bar{v}_{a,y} = \frac{\sum_{fleet} v_{fleet,a} Effort_{fleet,y}}{\sum_{fleet} Effort_{fleet,y}} \qquad (3.6)$$

(see sections 2.1 and 2.5 for fleet specific vulnerability schedules and derivation of effort series). Since the pelagic long line (PLL) fleet dominated the fishery early in the time series, we modeled apical fishing mortality as proportional to PLL effort the first 20 years of the assessment model, and as a correlated random walk thereafter:

$$Fapical_y = \begin{cases} \beta_1 \times Effort_{PLL,y} & y < 1980 \\ Fapical_{y-1} \exp(\delta_y) & 1980 \le y \le 2009 \end{cases}. \qquad (3.7)$$

An advantage of estimating total fishing mortality in this manner is that it implicitly includes both discard mortality as well as mortality of those retained in the catch. The correlated random walk structure was induced by setting

$$\delta_y = \begin{cases} \varepsilon_y & y = 1980 \\ \rho\delta_{y-1} + \varepsilon_y & 1981 \le y \le 1999 \\ \tau & y = 2000 \\ \rho\delta_{y-1} + \varepsilon_y & 2001 \le y \le 2009 \end{cases} , \quad (3.8)$$

where ρ is a correlation coefficient and ε_y sampling error (assumed to be normally distributed).

A break in the correlated walk series was implemented in 2000 to allow for the possibility of reduced fishing mortality following prohibition of dusky landings in late 1999. The correlation coefficient ρ was fixed to 0.5 in all runs; see section 3.1.4 for description of prior distributions on ε_y and τ.

Given recruitment (i.e., it is assumed that $N_{1,y} = r_y$ from Eq. 3.2, with a_r=1), and fishing and natural morality at age, abundance is propagated forward in the usual fashion:

$$N_{a,y} = \begin{cases} N_{a-1,y-1} \exp(-(M_{a-1} + F_{a-1,y-1})) & 2 < a < A \\ N_{A-1,y-1} \exp(-(M_{a-1} + F_{a-1,y-1})) + N_{A,y-1} \exp(-(M_A + F_{A,y-1})) & a = A \end{cases} \quad (3.9)$$

When fitting to indices of abundance and catch rates, the model predicts values for index j in year y as:

$$\tilde{U}_{j,y} = \frac{q_j v_{j,0} N_{1,y+1}}{\theta_y^{1-t_j}} + q_j \sum_{a=1}^{A} v_{j,a} N_{a,y} \exp(-(M_a + F_{a,y}) t_j) \quad (3.10)$$

(all indices were measured in numbers). Here, q_j is the catchability coefficient, $v_{j,a}$ is age-specific vulnerability for index j, and t_j is the fraction of the year that has elapsed prior to the timing of index j (assumed to be 0.5 for all indices). The first term in the expression is an attempt to account for indices that catch pups; since recruitment is assumed to occur at age 1, the number of pups alive when the index was collected in the previous year is back predicted using the year-specific value of pup survival, computed as

$$\theta_y = \frac{N_{1,y+1}}{\sum_a N_{a,y}\, fec_a mat_a} \quad (3.11)$$

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), prior distribution components (Λ_3), and several penalties intended to keep parameter values within plausible ranges during estimation (Λ_4). The total objective function was then given by $\Lambda = \Lambda_1 + \Lambda_2 + \Lambda_3 + \Lambda_4$, with each component as described below.

Observed data log likelihood—The observed data log likelihood was 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 overall contribution is provided by

$$\Lambda_1 = 0.5 \sum_i \sum_y \frac{(\log(U_{i,y}) - \log(\tilde{U}_{i,y}))^2}{\sigma^2_{i,y}} + \log(\sigma^2_{i,y}), \quad (3.12)$$

where $U_{i,y}$ and $\tilde{U}_{i,y}$ give observed and predicted indices, respectively, and

$$\sigma^2_{i,y} = \log(1 + \mathrm{CV}^2_{\mathrm{i,y}}) + \sigma^2_i + \sigma^2_{\mathrm{overall}}. \quad (3.13)$$

Here, $\sigma^2_{\mathrm{overall}}$ gives an (estimated) baseline level of variance which is applied to all indices, $\mathrm{CV}_{i,y}$ gives the observed CV reported along with index *i* in year *y* (for example, as a byproduct of the CPUE standardization process), and σ^2_i gives an estimated "additional" level of process variance for index *i* that is unaccounted for in observed CVs. Typically, it will not be possible to estimate $\sigma^2_{\mathrm{overall}}$ and σ^2_i in the same model run.

Process errors—Process errors for F were included as part of the random walk model for F (described in section 3.7). The objective function contribution for these deviations was given by

$$\Lambda_2 = 0.5 \sum_{1976 \le y \le 1999,\, 2001 \le y \le 2009} \frac{(\varepsilon_y - \rho\varepsilon_{y-1})^2}{0.1} + \log(0.1) \qquad (3.14)$$

Prior distributions—The following set of prior distributions was implemented:

- Historical F-effort relationship (see eqn 3.7): $p(\beta_1)$: Uniform(0,0.7)
- Pup survival at low biomass: $p(\exp(-M_0))$: Lognormal(median = 0.814, CV = 0.3)
- Catchability: $p(q_i)$: Uniform(0.0001, 100)
- Additional variance: $p(\sigma^2)$: Uniform(0, 2.0)
- Depletion in 1975: $p(B_{1975})$: Lognormal(median = 0.83, CV = 0.2) .

The total contribution for prior distributions to the objective function was then

$$\Lambda_3 = \log(p(\beta_1)) + \log(p(\exp(-M_0))) + \sum_i \log(p(q_i)) + \sum_i \log(p(\sigma_i^2)) + \log(p(\beta_{1975}))$$

(3.15)

Penalties and constraints—The following set of penalties was implemented:

- Penalty for $F_{2000} > F_{1999}$. A penalty was implemented to mirror the a priori notion that fishing mortality rates should decrease following prohibition of dusky landings: $P_1 = I_{F_{2000} > F_{1999}} (F_{2000} - F_{1999})^2 \times 1000$

- Penalty for apical F exceeding 1.0: $P_2 = \sum_y I_{Fapical_y > 1.0} (Fapical_y - 1.0)^2 \times 1000$

The total contribution for penalties was then $\Lambda_4 = P_1 + P_2$. The additional constraint $F_{2009} = (F_{2008} + F_{2007} + F_{2006})/3$ was also made, since preliminary retrospective runs suggested the terminal fishing morality estimate was subject to substantial negative bias.

The model started in 1960 and ended in 2009, with the historic period covering 1960-1974, the first modern period spanning 1975-1999, and the third modern period spanning 2000-2009. Estimated model parameters were pup (age-0) survival, catchability coefficients associated with indices, a parameter representing the slope of the relationship between PLL effort and fishing mortality for the period 1960-1979, additional variance parameters for each index, relative depletion in 1975, and fishing mortality in the modern periods. Fishing mortality starting in 1980 was modeled using a correlated random walk and so are not 'full' parameters. Pup survival was given an informative lognormal prior with median=0.81 (mean=0.85, mode=0.77), a CV of 0.3, and was bounded between 0.50 and 0.99.

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 ASCFM, 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

Initial model runs were made by maximizing the joint posterior (minimizing the negative of the objective function) using AD Model Builder software (Otter Research Ltd. 2004). Subsequent runs attempted to better quantify uncertainty by estimating marginal posterior distributions for key assessment parameters. Initial attempts at integration using Markov chain Monte Carlo resulted in Markov chains with extremely high levels of autocorrelation for several of the desired parameters, with standard convergence diagnostics (e.g., Gelman-Rubin plots) indicating that Markov chains still had not converged after extremely long simulation times (e.g., 500,000 iterations). These indicators suggested that estimates obtained using MCMC would be unreliable in this case. As an alternative, we thus used the “likelihood profiling” procedure in AD Model Builder, which attempts to directly integrate the joint likelihood function. This procedure was used to quantify uncertainty in terminal stock status, terminal fishing mortality, and productivity parameters for the base run and for several sensitivity runs. This procedure could also be used to estimate the probability that the stock was overfished or that overfishing was occurring given a specific model configuration. In the assessment panel’s view, these latter probabilities are more appropriate for informing management decisions than are simple point estimates.

Uncertainty in data inputs and model configuration was examined through the use of sensitivity scenarios and retrospective runs. Eleven alternative runs are included in this report in addition to the baseline run. We also conducted retrospective analyses, in which the model was refit while sequentially dropping the last three years of data to look for systematic bias in key model output quantities over time. Sensitivity runs included:

- S1: Use of a single, hierarchical index in place of the five indices used in the base run
- S2: Decrease in catchability starting in 2000 for the bottom long line sector
- S3: A high natural mortality scenario
- S4: A U-shaped natural mortality curve allowing senescence
- S5: A run using index input CV’s only (no “additional” or estimated variance)
- S6: A run using only VIMS, NELL indices
- S7: A run using all fishery independent indices, including UNC, NMFS historical
- S8: A run using all indices (“base” + “sensitivity” indices)
- S9: Logistic selectivity specified for the pelagic long line sector
- S10: Equal index weighting
- S11: Utilize a priori rankings from data workshop to weight indices
- S12: Fishing mortality from 1960-1979 modeled with a power curve

We now specifically describe how each of these sensitivities was implemented.

S1: Hierarchical index—As the indices exhibited somewhat different trends, several panelists were interested in whether a single, hierarchical index estimated externally from the stock assessment model would yield similar results to the base run. This sensitivity thus employed the hierarchical index and associated CV developed in SEDAR21-AW-01 (Table 3.2, Fig 3.1). A potential issue with using this model is that it represents an averaging over a number of index-specific selectivity patterns. To address this issue, the hierarchical index was fitted using year-specific selectivity curves, which were themselves weighted averages of individual index selectivities. In particular, the inverse variance selectivity weights reported in SEDAR-21-AW-01 (VIMS: 0.043; NELL: 0.043; BLLOP: 0.322; PLLOP: 0.071; LPS: 0.520) were used to weight individual selectivity curves. If an index was not observed in a given year, it did not contribute to the average selectivity curve for that year.

S2: Decrease in BLL catchability—Several panelists and observers knowledgeable in the behavior of fishers following the prohibition of dusky landings in late 1999 surmised that catchability would likely have decreased in 2000 because fishers would likely avoid areas where dusky sharks were more prevalent. To quantify this hypothesis, we examined three running averages (1997-1999 and 2000-2002) of the BLLOP index. Assuming that abundance was roughly constant over this period, this comparison suggested a 66% decrease in catchability following the regulation change. The 2000-2009 BLLOP index values were thus divided by 0.34 for purposes of this sensitivity run.

S3: High natural mortality scenario—The "maximum survival" approach used to derive natural mortality estimates was successful in producing a positive population growth rate in absence of fishing. However, model runs using this natural mortality vector tended to result in estimates of productivity that were higher than expected for typical log-lived shark species (steepness estimates were typically in the 0.45-0.55 range in contrast to expected levels in the 0.25-0.35 range; see e.g. Brooks et al. 2010). It thus seemed plausible that the assumed natural mortality values were too low. As an alternative, we solved for a constant c such that cM_a resulted in a virgin spawners-per-recruit value of 2.0 (which would impose a lower bound on $\exp(-M_0)$ of 0.5). For this sensitivity run, the base natural mortality vector was multiplied by the resulting estimate of c = 1.342.

S4: U-shaped natural mortality scenario—Plots of abundance by age revealed a relatively large proportion of sharks that were forty years old or larger. Several panelists expressed concern that the results of the assessment might be unduly influenced by the presence of such a large cryptic biomass of mature, older individuals. As such individuals are rarely encountered (likely due to a number of processes such as dome-shaped selectivity), it is difficult to assess the validity of the presence of such a cryptic biomass via standard survey methods. As one way of examining the importance of older classes in estimates of stock status, we conducted a sensitivity run with elevated rates of natural mortality for older age classes (representing senescence; Table 3.3).

S5: No additional variance (input CV's only)—Several sensitivities were conducted to examine the influence of estimated "additional variance" parameters on base run estimates. In the first of such runs, additional variance was fixed to zero for all indices.

S6: VIMS, NELL indices only—As fishery dependent indices are sometimes subject to changing catchability over time, several runs were made with fishery independent indices only. In this particular run, only the two fishery independent indices recommended by the DW for use in the base run were utilized. There were too few data to estimate "additional variance" for the two indices, so additional variance was set to 0.1 for both indices in this run.

S7: All fishery independent indices—This sensitivity used the two fishery independent indices recommended by the DW for use in the base fun (VIMS, NELL), as well as two fishery independent indices recommended for use in sensitivity runs (NMFS Historical, UNC). Additional variance was estimated for each index. The two sensitivity indices were assigned the same selectivity function as the PLL index because they were thought to sample similar-sized animals.

S8: All indices (Base + Sensitivity)—This sensitivity used all indices recommended by the DW for use in the base run (VIMS, BLLOP, LPS, NELL, PLLOP), as well as the two indices recommended for use in sensitivity analyses (UNC, NMFS Historical). Additional variance was estimated for each index.

S9: Logistic selectivity for PLLOP—An additional sensitivity was run to examine the assumption that selectivity for the PLL fishery was dome shaped. In this run, a logistic selectivity curve was fit to the ascending limb of the double logistic form assumed in the base assessment run, and assumed to apply to the PLL fishery.

S10: Equal index weighting—In this run, a single parameter for index variance was estimated, and applied equally to all base run indices.

S11: DW index rankings used to specify relative CVs—The DW index working group provided a priori rankings of the indices used in the base run based on criteria such as spatial coverage, reliability, etc. Two indices (BLLOP, NELL received a ranking of one (the highest ranking), while PLLOP received a rank of 2, VIMS received a rank of 3, and LPS received a rank of 4. In this run, we attempted to use these qualitative rankings to determine how well the model fit to each index; in particular, we estimated a single level of process variance for the highest ranked indices, and used rankings as multipliers on this base level of variance (i.e., $\sigma_i^2 = ranking_i \sigma_{overall}^2$).

S12: Fishing mortality from 1960-1979 modeled with a power curve—One of the comments by the initial CIE reviewer (Dr. N. Hall), was that there needed to be a sensitivity run examining the importance of effort series. Effort series affected the dusky model in two ways: (1) by determining the contribution of each sector's selectivity curve to the total, weighted selectivity function for the entire fishery, and (2) by determining the relative fishing mortality in the early years of the fishery (1960-1979). The AW panel did not expect that different effort series would change the fishery-wide selectivity curve very much, but did suggest that it would be good to examine the sensitivity of model results to the historical effort series used to represent the pelagic longline fishery. In place of the historical effort series, we thus developed a version of the ASCFM that used the power function

$$F = \alpha(year_i - 1959)^{\beta}$$

to model fishing mortality from 1960-1979. In practice, the ASCFM became unstable when the upper bound for β was high; an upper bound of β=1.6 was enforced to ensure model convergence (even then, β was estimated at its upper bound).

3.1.6. Benchmark calculations

Since reliable catch data are not available, the model is unable to scale to absolute levels of population biomass, and therefore cannot calculate an absolute level of MSY or SSB_{MSY}. Rather, it is possible to estimate MSY and SSB_{MSY} relative to the unexploited level of recruitment (R_0). This is done as follows.

First, the vector of vulnerability used for equilibrium calculations is derived from the vector of total age-specific fishing mortality in the final year of the model:

$$\dot{v}_a = \frac{F_{a,y}}{\max\{F_{a,y}\}} \tag{3.16}$$

Next, the value of fishing mortality ($\tilde{F}_{MSY}$) that generates the maximum sustainable relative yield (MSY/R_0) is found by solving

$$\frac{MSY}{R_0} = \max_F \left\{ \frac{\dot{R}_F}{R_0} \sum_a w_a F v_a \frac{1 - e^{(-M_a - Fv_a)}}{M_a + Fv_a} e^{(-\sum_{i=0}^{a-1}(M_i + Fv_i))} \right\} \tag{3.17}$$

In the above expression, the term to the right of the summation is simply the calculation of yield per recruit for a given fishing mortality, F; this then gets scaled by the relative equilibrium recruitment that results from that F, R_F. Relative equilibrium recruitment can be calculated from

$$\frac{\dot{R}_F}{R_0} = \tilde{r}_F = \frac{\tilde{s}_F}{SPR_F} \tag{3.18}$$

where SPR_F is simply the ratio of pups per recruit with fishing mortality F to pups per recruit with F = 0 (eq. 3.4), i.e.

$$SPR_F = \frac{\sum_{age} fec_{age} \cdot mat_{age} \prod_{j=1}^{age-1} \mathrm{e}^{(-M_j - Fv_j)}}{\sum_{age} fec_{age} \cdot mat_{age} \prod_{j=1}^{age-1} \mathrm{e}^{(-M_j)}} = \frac{\varphi_F}{\varphi_0} \tag{3.19}$$

Finally, in (3.18), the equilibrium number of relative spawners at fishing mortality F ($\tilde{s}_F$) can be calculated by dividing eq. (3.2) by *r* and then solving for *s*:

$$\tilde{s}_F = \frac{e^{-M_0} \varphi_0 SPR_F - 1}{e^{-M_0} \varphi_0 - 1} \tag{3.20}$$

Replacing the term for relative recruitment in (3.17) with $\tilde{s}_F$ /SPR_F and solving for the F that maximizes the expression, results in the equilibrium estimate of relative MSY.

The minimum spawning stock threshold (MSST) is typically calculated as (1-M)*SSB_{MSY} when absolute biomass is estimable. Although only relative estimates are possible here (i.e., SSB_{2009}/SSB_{MSY}), it is still possible to calculate SSB_{2009}/SSB_{MSST} by dividing by M. Since natural mortality was assumed to be age-specific in this assessment, we calculated an age-independent M as $\overline{M}_a$ for ages 1-40. This procedure results in the same cumulative survivorship up to the plus group (age A=40) for the two approaches (age specific vs. age independent). Specifically, we used a value of M=0.0666 for all MSST calculations.

3.1.7. Projection methods

A number of projection scenarios were run to examine the utility of different rebuilding strategies. 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).

Since the ASCFM is on an arbitrary scale, it at first appears difficult to provide any advice on landings, annual biological catch, or catch limits. However, managers often need such information to set quotas. We thus attempted to scale the ASCFM estimates of abundance to levels that would best explain observed removals in years where managers had the most faith in reported catch. In particular, we attempted to estimate a scaling parameter ψ to match observed removal data from 1993 to 1998. These years were chosen because they were after catch reporting was mandatory, but before landings of dusky sharks were prohibited (after which, removals were purportedly negatively biased). To do this, total removals in dressed weight (including both landings and discards) were input into the ASCFM, and a value of ψ was estimated that minimized

$$\Lambda_5 = 0.5\sum_i \sum_y \frac{(\log(L_{i,y}) - \log(\tilde{L}_{i,y}))^2}{\sigma_L^2} + \log(\sigma_L^2) \ , \tag{3.21}$$

where $L_{i,y}$ and $\tilde{L}_{i,y}$ were observed and predicted landings, respectively. The variance term σ_L^2 was set to a large value (2,000,000) so that the landings data did not effect estimation of any parameter but ψ. Landings were predicted using the Baranov catch equation:

$$\tilde{L}_{i,y} = \psi \sum_a N_{a,y} \frac{F_{a,y}}{Z_{a,y}}(1 - \exp(-Z_{a,y}))w_a \, , \tag{3.22}$$

where w_a gives dressed weight at age. A comparison of observed to predicted landings data (Fig 3.2) shows that the ASCFM actually does a reasonable job at predicting landings (unreliable as they may be) throughout the entire time series when scaled in this manner. Using this formulation, ψ was estimated at 5472.8, and was used in all subsequent projection calculations.

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 (dressed weight and numbers), recruitment, and mature spawning stock biomass.

A number of projection scenarios were considered, including

- Fcurrent: Fishing mortality constant at 2009 levels
- F0: No fishing mortality
- Fmsy: Fishing mortality constant at MSY levels
- Ftarget: Fishing mortality set with P*=0.3
- Frebuild50: The maximum fishing mortality that would allow a 50% chance of

rebuilding by 2108

- Frebuild70: The maximum fishing mortality that would allow a 70% chance of rebuilding by 2108
- Fmax F that would allow largest cumulative harvest over time frame, while still allowing a 70% chance of rebuilding by 2108; in practice, results for this scenario were the same as the *Frebuild70*, so only results for the *Frebuild70* projection are reported.
- Fixed Removals Assumes the maximum fixed removals allowing a 70% chance of rebuilding by 2108

Most of these projection scenarios are self-explanatory, but some require more elaboration:

Fmsy projection—To implement the Fmsy projection, fishing mortality after 2012 was modeled as

$$F_{MSY}^{boot} = F_{2009}^{boot} \times \frac{\hat{F}_{MSY}}{\hat{F}_{2009}},$$

where uncertainty was included in the estimate of fishing mortality in 2009; fishing mortality is then lowered from the 2009 effort levels to try to achieve Fmsy.

Ftarget projection—In this projection, fishing mortality is lowered to try to achieve a probability of overfishing in any given year of 0.3. To determine the highest fishing mortality rate that achieves this goal, we first obtained profile likelihood approximations to the posterior distribution for $\hat{F}_{2009}$ (call this $\hat{P}(F_{2009})$) and a Hessian-based normal approximation to the posterior distribution for $\hat{F}_{MSY}$ (call this $\hat{P}(F_{MSY})$) [a normal approximation was used in the latter case because the profile likelihood method failed for $\hat{F}_{MSY}$]. To generate samples from candidate $F = c\hat{F}_{2009}$ distributions for projections, we sampled from $\hat{P}(F_{2009})$ and then multiplied by the fixed constant *c*; in this manner, candidate *F* values would be drawn from a distribution with the same shape as $\hat{P}(F_{2009})$, but with reduced variance (owing to the well known identity $\text{Var}(aX) = a^2\text{Var}(X)$). We will term this resulting distribution $\hat{P}(F_{trial})$. We then iteratively solved for the highest F_{trial} value that results in

$$\Pr(F_{trial} \geq F_{MSY}) = \int_0^\infty \left[\int_{F_{trial}}^\infty \hat{P}(F_{trial}) dF_{trial} \right] \hat{P}(F_{MSY}) dF_{MSY} \geq 0.3 \text{ (cf., Prager et al. 2003).} \quad (3.23)$$

Using this approach, an estimate of 0.0275 was obtained for *Ftarget* and was used in this projection. This value is equivalent to a reduction in effort of 49.6%.

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).

Generation time is often needed for certain calculations regarding possible rebuilding times, and was calculated using the well known formula

$$\frac{\sum_x l(x)b(x)x}{\sum_x l(x)b(x)},$$

where *l(x)* gives cumulative survival to age *x*, and *b(x)* gives expected female pup production per female by age (cf., Gotelli 2001). Generation time was calculated as 40.47, which is considerably larger than the value obtained from the 2006 assessment (for which generation time was computed as 30 years). This difference is largely a result of accounting for a large number of age classes in the present calculation. If generation time is instead calculated with a maximum age of 40, generation time is 29, and more along the lines of the 2006 assessment.

3.2. RESULTS

3.2.1. Measures of Overall Model Fit

Estimates of additional variance were negligible for the LPS and BLLOP indices (Table 3.1), and relatively small for the PLLOP survey, indicating lower levels of process error. As a result, the assessment model tended to 'key in' on these indices and fit them better (Figure 3.3). In contrast, additional variance was estimated to be large for the VIMS and NELL indices, indicating substantial process error not accounted for in input CVs. As such, fits to these indices are quite poor (Figure 3.3).

In general, the ASCFM was unable to fit any of the indices perfectly. The reproductive constraints of the species (i.e., low fecundity) limits the stock's capability to dramatically increase in abundance from year to year, making it difficult to match some of the observed index patterns (e.g., large increases in the final years of the time series).

3.2.2. Parameter estimates & associated measures of uncertainty

A list of model parameters is presented in Table 3.1. The table includes predicted parameters values with associated SDs, initial parameter values, minimum and maximum allowed values, and prior density functions assigned to parameters. Priors 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 3.4. Recruitment is assumed to occur at age 1, and is also presented in Table 3.4. Recruitment is predicted to have remained at roughly virgin levels until 1990, after which it declined slightly. Declines in spawning stock biomass are estimated to be partially compensated for by increases in pup survival (i.e., density dependent recruitment; Figure 3.5).

3.2.4. Stock Biomass

Predicted abundance, total biomass, and spawning stock biomass (S_y in Equation 3.3) are presented in Table 3.4. All trajectories show relatively little depletion until the late 1980s; by 2009 depletion in spawning stock biomass is estimated to be around 85%. The ASCFM predicted an increasing abundance (in numbers) from 2004-present, but a continued decrease in biomass. This apparent contradiction is attributable to decreasing number of older (and heavier) sharks even while the numbers of younger fish are increasing.

3.2.5. Fishery Selectivity

As explained in Section 2.1 and shown in Table 2.1 and Figure 2.2, selectivities are estimated externally to the model and a functional form inputted for each fleet and index. In Figure 2.2 one can see that most indices fully select for immature animals.

3.2.6. Fishing Mortality

Predicted apical fishing mortality rates are presented in Table 3.5 and Figure 3.6. Fishing mortality was low from 1960 through the early 1980s, and then is estimated to have ramped up to unsustainably high levels in the l990s, and to have declined following prohibition of dusky landing in 2000. The moratorium on dusky catch appears to have been an effective management tool in this regard, although terminal estimates of fishing mortality still indicate the stock is undergoing overfishing (see section 3.2.9).

3.2.7. Stock-Recruitment Parameters

See Section 3.2.3 above for additional discussion of the stock-recruitment curve and associated parameters. The estimated maximum theoretical pup (age-0) survival (i.e., that would occur as biomass approaches zero) was 0.89 (see next section for further discussion on pup survival). The corresponding Beverton-Holt steepness value was 0.51, which is substantially higher than the 0.25-0.35 range often assumed for long-lived elasmobranches (see, e.g., Brooks et al. 2009).

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 as implemented in AD Model Builder. Prior and posterior distributions for pup survival are shown in Figure 3.7. There appeared to be information in the data since the posteriors is different from the prior. The mode for the posterior of pup survival was estimated at a higher value than the prior mode.

Posterior distributions were also obtained for several benchmarks (Figure 3.8). The distribution for spawning biomass is fairly wide, but most of the density is concentrated between 0.05 and 0.30, indicating substantial depletion (i.e. 70-95%) for such a long lived species. In contrast, posterior distributions for SSB_{2009}/SSB_{msy} and SSB_{2009}/SSB_{msst} were much tighter, and indicated that spawning biomass in 2009 was between 40 and 50% of MSY levels. The posterior for

F_{2009}/F_{msy} indicated considerable uncertainty in terminal estimates of fishing mortality relative to MSY levels. In particular, the posterior appeared to be bimodal, with approximately 51% of the posterior mass above 1.0 (Figure 3.8).

Results of the base and sensitivity analyses and retrospective runs are summarized in Table 3.6. Most sensitivity runs resulted in similar estimates of biomass benchmarks, depletion, and stock productivity as the base run, but there were some exceptions. For instance, the two runs where natural mortality was increased (S3: High M; S4: U shaped M) resulted in lower estimates of productivity, with steepness values of 0.32. This level of productivity is more typical of levels expected a priori given the life history of the species. However, estimates of stock status were similar to the base run, providing evidence that stock determination and biomass-related point estimates are robust to changes in natural mortality and productivity. Second, the sensitivity run that employed all fishery independent indices only (S7) indicated the stock was severely depleted (with SSB_{2009}/ SSB_{MSY}=0.05 in comparison to 0.44 for the base run). However, in this case, estimates of "additional variance" was 0.38 for the UNC index, but >1.5 for the other 3 indices (VIMS, NELL, NMFS Historical). As such, the ASCFM keyed in on the UNC index, which if taken by itself indicates a precipitous decline of the dusky stock (Figure 3.9). The AW panel discussed this run, noting that it did not make sense to base inference on a single index that was not initially recommended for use by the DW.

Two sensitivity runs resulted in biomass values greater than MSY levels. In particular, the "equal weighting" scenario (S10) and the "A priori rankings" scenario (S11) both resulted in SSB_{2009}/ SSB_{MSY}>1.0. However, both of these runs resulted in degraded fits to the index time series, essentially fitting a straight line through each index (e.g., Figure 3.10).

As suggested by the AW, several of the sensitivity scenarios were rerun employing the "likelihood profiling" option in ADMB, with the goal of estimating the probability that the stock was overfished and that overfishing was occurring. In particular, the AW suggested that these probabilities be estimated for S4 (U-shaped M), and S11 (DW index rankings). For S4, the posterior probability that the stock was overfished was once again 1.00; the posterior distribution for F_{2009}/ F_{MSY} was unimodal with mass all above 1.0, indicating that the probability of overfishing occurring also approached 1.0. For S11, there was an 89% probability that the stock was overgoing overfishing in 2009, and a 0% probability that the stock was overfished.

Examination of retrospective plots (Figures 3.11 and 3.12) suggested that there was little retrospective pattern in estimates of biomass trajectories. However, there did appear to be a retrospective pattern in estimates of fishing mortality. This is likely due to an upward trend at the end of the time series that appears in several of the indices.

3.2.9. Benchmarks/Reference Points/ABC Values

Benchmarks and MSY reference points for the base run and sensitivity scenarios are summarized in Tables 3.6 and 3.7 and presented visually in Figures 3.13 and 3.14. The base model clearly indicated an overfished stock (the posterior probability of the stock being overfished approached 1.0). In contrast, there was considerable uncertainty about whether fishing mortality exceeded

F_{msy} in 2009; in particular, the posterior prediction was that there is only a 51% probability that overfishing is still occurring.

The base model estimated that overfishing started occurring in 1984, and has occurred ever since (Table 3.8) (although uncertainty in this statement is certainly high for the last few years of the time series). The base ASCFM run also indicated that the stock first became overfished in 1999. Probabilities obtained through likelihood profiling indicated that there is a 51% chance that the stock in 2009 was experiencing overfishing, and a near 100% chance that the stock was overfished. As indicated in section 3.2.8, most runs indicated that the stock was overfished and that overfishing was occurring in 2009. A phase plot showing the outcomes of the base model and the 11 sensitivity scenarios is presented in Figure 3.15. The results of retrospective analysis support the conclusions from the base run, i.e., that the stock was overfished starting in 2000. These results are similar to the conclusions of a preliminary 2006 assessment (stock overfished with overfishing; Cortés et al. 2006).

3.2.10. Projections

Projection results are summarized in Figures 3.16-3.22, and Tables 3.9-3.15. The Fcurrent projection scenario used a modal apical F of 0.055, and indicated a low probability of stock recovery by 2108 (Figure 3.16, Table 3.9). The F0 scenario resulted in recovery from overfished status near the year 2050 (Figure 3.17, Table 3.10). The Fmsy scenario utilized a modal F of 0.035, and indicated that the probability of the stock rebuilding to MSY levels was less than 50% (Figure 3.18, Table 3.11). The Ftarget scenario, which reduced F to 0.028 in an effort to ensure that the probability of overfishing in any given year (p*) was less than 30%, still did not provide a large enough reduction in F to recover the stock by 2108 (Figure 3.19, Table 3.12). Reducing F to 0.027 (as in the Frebuild50 scenario) was enough result in a 50% chance of rebuilding the stock (Figure 3.20, Table 3.13); however, F had to be reduced to 0.023 (as in the Frebuild70 scenario) to achieve a 70% probability of rebuilding the stock by 2108 (Figure 3.21, Table 3.14). In practice, the Fmax scenario yielded identical results to the Frebuild70 scenario. Finally, while the Fixed Removals scenario suggested reducing annual removals to a preset level of 21,200 lbs. (gutted weight) per year would be sufficient to rebuild the stock with 70% probability by 2108 (Figure 3.22, Table 3.15). However, several of the runs resulted stock collapse (e.g., when terminal biomass and productivity were sampled from the lower tails of their distributions).

3.3. DISSCUSSION

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 yield precise inference about stock-wide trends). The poor fit to some of the indices is likely the result of the model attempting to reconcile different signals provided by different indices and fitting a more central tendency. The decision of the AW to proceed with a base model that estimated additional variance for each index helped alleviate, but did not solve, this problem.

The base assessment model and most sensitivity analyses indicated that dusky sharks are currently overfished, and that overfishing has been occurring since the mid-1980s. These conclusions largely mirror results from a previous assessment of dusky sharks occurring outside the auspices of SEDAR (Cortés et al. 2006). However, fishing mortality is estimated to have declined dramatically since the 1990s, and the probability of overfishing having occurred in the terminal year of the assessment is estimated to be just 0.51.

Estimates of stock status seemed to be quite robust to changes in life history parameters such as productivity and natural mortality. This is notable because the estimate of steepness coming from the base assessment model (0.51) was much higher than one would usually expect for a long lived shark species (0.25-0.35 is more typical). Several assessment panelists were initially concerned with this estimate, but were later satisfied when sensitivities including increased natural mortality (S3) or a U-shaped natural mortality curve (S4) produced steepnesses in the 0.3-0.35 range and similar results with regards to stock status.

Estimates of stock status seemed most sensitive to including different groups of indices or to different ways of weighting indices. For instance, if only fishery independent indices were used (including those only recommended for sensitivity runs; S7), the ASCFM keyed in on an index not originally intended for use in the base run, and estimated depletion was extreme. On the other hand, if each index was given an equal weighting (essentially, ignoring any of the reported CVs or possibly different levels of process and sampling error; S10), or if DW supplied rankings were used in place of estimated observation and process error (S11), the stock was estimated to not be overfished. In the latter cases, fits to indices were quite poor. As such, these sensitivity runs (S7, S10, S11) may be of limited utility in describing the true range of uncertainty in estimated outcomes.

The combination of some life-history parameters and the vulnerability of dusky sharks to the various gears long before they are mature suggests a population that cannot support much exploitation. However, the prohibition on catches in recent years appears to have reduced, but perhaps not ended, overfishing. With the present allocation of effort among fishing sectors, projection results indicate that the stock appears to be capable of rebuilding by the end of the current rebuilding time period (2108), and that it could sustain a small amount of fishing-related mortality during this period. However, current estimates are that fishing mortality would have to be reduced to 0.023, which would take about a 58% reduction in total effort. How this could be achieved is not entirely clear, as most of the mortality now comes from discards. We have provided an estimate of the total number of removals that is associated with different reductions in total F, but caution that these are estimates only, and subject to considerable uncertainty because the data used to scale up to absolute abundance are themselves uncertain. An iterative process of adaptive management (e.g., experimenting with new regulations and relying on periodic stock assessments to determine the efficacy of these programs in reducing F) may be a reasonable way to proceed for this stock.

3.4. RECOMMENDATIONS FOR DATA COLLECTION AND FUTURE RESEARCH

The greatest source of uncertainty about dusky sharks is clearly the amount of human induced removals (e.g., discards) that are occurring. However, it is difficult to recommend a single course of action to improve this situation, as uncertainty in removals stems from a number of sources (species misidentification, non-reporting, etc.). Nevertheless, improving the reliability of removal data would help assessment modeling immensely.

Another suggestion for improving the reliability of assessment advice is the development of a stock-wide fishery independent monitoring program. The present assessment is based on a combination of spatially-restricted fishery independent surveys and several fishery dependent surveys. The former are not ideal in that observed trends may better represent localized dynamics than stock wide trends; the latter are deficient in that observed trends may often reflect changes in catchability (for instance, due to differences among vessels, captains, and changes in targeting) rather than absolute abundance.

Finally, further assessment work would benefit from a consistent life history sampling program that gathers annual samples of length and age-frequencies. The current hodgepodge of length-at-age samples is not sufficient to implement catch-age or catch-length models, and is only marginally useful for constructing selectivity curves because temporal changes in age-frequencies are confounded with selectivity. Although an attempt was made to use existing age-length data to produce selectivity curves for the present assessment, this approach is clearly not ideal.

3.5. REFERENCES

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3.6. TABLES

Table 3.1. List of parameters estimated in ASCFM for dusky shark (base run). The list includes predicted parameters values with associated SDs, initial parameter values, minimum and maximum allowed values, and prior density functions assigned to parameters. Priors designated as constant were estimated as such; parameters that were held fixed (not estimated) are not included in this table. Fishing mortality was modeled as an autocorrelated random walk so are not 'full' parameters and thus not presented here. All SD estimates are based on a Hessian approximation to the numerically maximized posterior surface.

	Predicted					Prior pdf		
Parameter/Input name	Value	SD	Initial	Min	Max	Type	Value	SD (CV)
Pup (age-0) survival	8.93E-01	2.54E-01	8.14E-01	5.00E-01	9.90E-01	lognormal	0.814	(0.3)
Catchability coefficient LPS index	4.7822e-01	1.5363e-01	2.46E-03	1.00E-04	1.00E+02	constant		1
Catchability coefficient BLLOP index	2.1935e-01	7.9660e-02	6.33E-03	1.00E-04	1.00E+02	constant		1
Catchability coefficient VIMS	1.6381e-01	6.0541e-02	1.68E-03	1.00E-04	1.00E+02	constant		1
Catchability coefficient NELL index	1.8861e-01	1.2622e-01	8.33E-03	1.00E-04	1.00E+02	constant		1
Catchability coefficient PLLOP index	3.1378e-01	1.1726e-01	7.68E-03	1.00E-04	1.00E+02	constant		1
Historic effort /F relationship	1.98E-02	2.07E-02	0.01	0	2	constant		1
Additional variance LPS index	1.9306e-08	2.7303e-05	4.00E-01	0	2	constant		1
Additional variance BLLOP index	1.3069e-07	1.8482e-04	4.00E-01	0	2	constant		1
Additional variance VIMS index	1.1670e+00	6.1695e-01	4.00E-01	0	2	constant		1
Additional variance NELL index	1.4655e+00	1.1082e+00	4.00E-01	0	2	constant		1
Additional variance PLLOP index	2.9924e-01	2.1872e-01	4.00E-01	0	2	constant		1
Depletion in 1975	9.5747e-01	4.2650e-02	0.83	0	∞	lognormal	0.83	(0.202)

Table 3.2. Standardized hierarchical index of relative abundance used in dusky shark sensitivity scenario S1 with associated CVs.

YEAR	Hierarchical index	CV
1975	2.13	0.87
1976	1.27	1.3
1977	0.74	1.06
1978	1.27	1.34
1979	1.27	1.32
1980	1.58	0.86
1981	1.43	0.88
1982	1.27	1.31
1983	1.26	1.29
1984	1.27	1.32
1985	1.26	1.27
1986	1.69	0.36
1987	1.69	0.36
1988	1.44	0.43
1989	1.48	0.38
1990	1.05	0.36
1991	1.05	0.36
1992	0.51	0.48
1993	1.01	0.38
1994	0.57	0.38
1995	0.69	0.35
1996	0.74	0.34
1997	1.01	0.37
1998	0.65	0.37
1999	0.88	0.4
2000	0.58	0.41
2001	0.45	0.39
2002	0.38	0.43
2003	0.3	0.36
2004	0.47	0.34
2005	0.56	0.36
2006	0.49	0.41
2007	0.76	0.34
2008	0.9	0.34
2009	0.9	0.32

Table 3.3. Values of natural mortality (M, instantaneous natural mortality rate) at age used in sensitivity scenario S4 (senescence).

Age	U-shaped M
1	0.137
2	0.124
3	0.114
4	0.106
5	0.099
6	0.093
7	0.088
8	0.083
9	0.079
10	0.076
11	0.073
12	0.070
13	0.068
14	0.066
15	0.064
16	0.062
17	0.061
18	0.059
19	0.058
20	0.057
21	0.069
22	0.081
23	0.093
24	0.104
25	0.115
26	0.125
27	0.134
28	0.144
29	0.152
30	0.160
31	0.168
32	0.175
33	0.182
34	0.188
35	0.193
36	0.198
37	0.203
38	0.207
39	0.211
40	0.214

Table 3.4. Predicted relative recruitment (numbers), abundance (numbers), total biomass (kg), and spawning stock biomass (kg). The latter is computed as in equation 3.3. All estimates are presented relative to virgin levels.

Year	Rec	N	B	SSB
1960	1	1	1	1
1961	0.999951	0.998682	0.99921	0.999533
1962	0.99984	0.99731	0.998315	0.998757
1963	0.999654	0.994484	0.996476	0.997603
1964	0.999377	0.991575	0.994436	0.996036
1965	0.999	0.987221	0.991381	0.994032
1966	0.998517	0.983065	0.988229	0.992083
1967	0.998045	0.980735	0.985988	0.990335
1968	0.997621	0.97913	0.984104	0.988484
1969	0.997171	0.977176	0.981979	0.986243
1970	0.996625	0.974156	0.979173	0.983564
1971	0.995969	0.970786	0.976056	0.980355
1972	0.995179	0.965986	0.971978	0.976593
1973	0.994249	0.961134	0.967683	0.972518
1974	0.993235	0.956628	0.963417	0.968183
1975	0.992149	0.952375	0.959156	0.96317
1976	0.990884	0.945623	0.953303	0.957519
1977	0.989446	0.939929	0.947826	0.951703
1978	0.987953	0.934718	0.942461	0.945862
1979	0.98644	0.931074	0.937885	0.940277
1980	0.98498	0.929087	0.934242	0.934502
1981	0.983456	0.926132	0.929824	0.927964
1982	0.981714	0.921662	0.924322	0.920448
1983	0.979689	0.915072	0.917222	0.911471
1984	0.977237	0.9056	0.90777	0.900485
1985	0.974188	0.892397	0.895292	0.886936
1986	0.97035	0.87438	0.878923	0.869936
1987	0.96541	0.85013	0.857326	0.847257
1988	0.958596	0.817544	0.827446	0.817789
1989	0.949334	0.776492	0.789928	0.781932
1990	0.937392	0.727994	0.74518	0.739792
1991	0.922319	0.675232	0.694753	0.693271
1992	0.904215	0.623427	0.643046	0.645458
1993	0.883781	0.576536	0.593565	0.598539
1994	0.861648	0.535644	0.547865	0.553494
1995	0.838149	0.499891	0.505969	0.51039
1996	0.813259	0.467576	0.467093	0.468497
1997	0.786442	0.435832	0.429433	0.426537
1998	0.756545	0.401737	0.390986	0.383609
1999	0.722238	0.364273	0.350945	0.340164
2000	0.682937	0.325586	0.310673	0.299319
2001	0.640916	0.293626	0.275734	0.264761
2002	0.600735	0.272261	0.249197	0.237908
2003	0.566043	0.261757	0.231432	0.2179
2004	0.537919	0.259197	0.220403	0.202705
2005	0.515107	0.261073	0.213653	0.190506
2006	0.495799	0.264839	0.209418	0.180153
2007	0.478666	0.269008	0.206642	0.171011
2008	0.462931	0.272728	0.204682	0.162742
2009	0.448179	0.275546	0.20314	0.155

Table 3.5. Apical instantaneous fishing mortality rates by year.

Year	Total F
1960	0.003
1961	0.003
1962	0.006
1963	0.007
1964	0.010
1965	0.010
1966	0.007
1967	0.006
1968	0.007
1969	0.009
1970	0.010
1971	0.014
1972	0.014
1973	0.014
1974	0.014
1975	0.020
1976	0.019
1977	0.019
1978	0.016
1979	0.012
1980	0.014
1981	0.017
1982	0.022
1983	0.029
1984	0.038
1985	0.051
1986	0.068
1987	0.092
1988	0.121
1989	0.156
1990	0.188
1991	0.212
1992	0.225
1993	0.229
1994	0.232
1995	0.237
1996	0.254
1997	0.287
1998	0.335
1999	0.385
2000	0.385
2001	0.333
2002	0.249
2003	0.171
2004	0.116
2005	0.083
2006	0.064
2007	0.054
2008	0.049
2009	0.056

Table 3.6. Summary of results for base and sensitivity runs for dusky shark. Relative spawning stock biomass is defined as in Equation 3.3.

Run	Description	F_{MSY}	SSB_{MSY}/ SSB_0	SSB_{2009}/ SSB_{MSST}	SSB_{2009}/ SSB_{MSY}	F_{2009}/ F_{MSY}	Pup survival	Steepness
Base	--	0.035	0.35	0.46	0.44	1.55	0.89	0.51
R2008	Retrospective to 2008	0.034	0.36	--	--	--	0.84	0.50
R2007	Retrospective to 2007	0.034	0.35	--	--	--	0.86	0.50
R2006	Retrospective to 2006	0.034	0.36	--	--	--	0.84	0.50
S1	Hierarchical index	0.033	0.36	0.44	0.41	6.50	0.82	0.49
S2	Decreased BLL q	0.035	0.35	0.57	0.53	1.18	0.90	0.51
S3	High M	0.017	0.43	0.45	0.42	2.01	0.95	0.32
S4	U shaped M	0.019	0.43	0.44	0.41	1.39	0.96	0.32
S5	No additional variance	0.035	0.35	0.57	0.53	1.28	0.89	0.51
S6	VIMS, NELL only	0.036	0.35	0.70	0.66	0.40	0.93	0.52
S7	All fishery indep	0.032	0.36	0.06	0.05	4.95	0.80	0.48
S8	All indices	0.034	0.36	0.17	0.16	2.12	0.86	0.50
S9	Logistic sel for PLL	0.025	0.36	0.70	0.65	1.16	0.95	0.53
S10	Equal weighting	0.034	0.36	1.11	1.03	1.50	0.85	0.50
S11	A priori rankings	0.033	0.36	1.11	1.29	0.77	0.88	0.51
S12	Power curve for historical F	0.035	0.35	0.42	0.39	1.61	0.89	0.51

Table 3.7. Summary of MSY quantities and management benchmarks for the dusky ASCFM base run. All estimates of CV are based on the numerical Hessian evaluated at the posterior mode.

Quantity	Est	CV
SSB_{2009}/SSB_{MSY}	**0.44**	0.56
SSB_{2009}/SSB_{MSST}	**0.47**	0.56
F_{2009}/F_{MSY}	**1.59**	0.72
SPR_{MSY}	0.51	0.04
F_{MSY}	0.035	0.06
SSB_{MSY}/SSB_0	0.35	0.18
SSB_{MSST}/SSB_0	0.33	0.18
F_{2009}	0.055	0.73
N_{2009}	0.28	0.34
SSB_{2009}	0.15	0.51
B_{2009}	0.20	0.40
Pup-survival	0.89	0.28
Alpha	4.18	0.29
$F_{20\%}$	0.085	0.07
$F_{30\%}$	0.063	0.06
$F_{40\%}$	0.048	0.06
$F_{50\%}$	0.036	0.06
$F_{60\%}$	0.026	0.06
spr0	4.70	NA

Table 3.8. Estimated temporal trends in stock status from the base run ASCFM for dusky sharks.

Year	F/F_{MSY}	SSB/SSB_{MSY}	SSB/SSB_{MSST}
1960	0.08	2.84	3.05
1961	0.09	2.84	3.04
1962	0.18	2.84	3.04
1963	0.20	2.84	3.04
1964	0.29	2.83	3.03
1965	0.30	2.83	3.03
1966	0.21	2.82	3.02
1967	0.17	2.81	3.02
1968	0.20	2.81	3.01
1969	0.27	2.80	3.00
1970	0.30	2.79	2.99
1971	0.40	2.78	2.98
1972	0.42	2.77	2.97
1973	0.42	2.76	2.96
1974	0.42	2.75	2.95
1975	0.60	2.73	2.93
1976	0.56	2.72	2.91
1977	0.55	2.70	2.89
1978	0.47	2.68	2.88
1979	0.37	2.67	2.86
1980	0.42	2.65	2.84
1981	0.52	2.63	2.82
1982	0.66	2.61	2.80
1983	0.86	2.58	2.77
1984	1.13	2.55	2.73
1985	1.51	2.51	2.69
1986	2.02	2.46	2.64
1987	2.72	2.39	2.56
1988	3.59	2.31	2.47
1989	4.59	2.20	2.36
1990	5.53	2.08	2.23
1991	6.20	1.95	2.08
1992	6.53	1.81	1.94
1993	6.65	1.67	1.79
1994	6.71	1.55	1.66
1995	6.85	1.42	1.53
1996	7.32	1.31	1.40
1997	8.28	1.19	1.27
1998	9.70	1.07	1.14
1999	11.15	0.94	1.01
2000	11.15	0.83	0.89
2001	9.64	0.73	0.78
2002	7.18	0.66	0.70
2003	4.89	0.60	0.64
2004	3.31	0.56	0.60
2005	2.36	0.53	0.56
2006	1.81	0.50	0.53
2007	1.51	0.47	0.51
2008	1.35	0.45	0.48
2009	1.56	0.43	0.46

Table 3.9. Projections of median apical fishing mortality, probability of SSB recovery to MSY levels, SSB, number of recruits, removals (lb dressed wgt), and removals (numbers), for the Fcurrent scenario.

Year	F	Pr(SSB>SSB_{MSY})	SSB	Recruits	Removals (wgt)	Removals (#'s)
2009	0.055	0.01	0.16	0.45	597	33357
2010	0.055	0.00	0.15	0.42	604	33948
2011	0.055	0.00	0.14	0.41	606	34439
2012	0.055	0.00	0.13	0.39	604	34781
2013	0.055	0.00	0.13	0.38	600	34973
2014	0.055	0.00	0.12	0.37	591	34980
2015	0.055	0.00	0.12	0.36	581	34931
2016	0.055	0.00	0.12	0.35	571	34709
2017	0.055	0.00	0.12	0.35	561	34410
2018	0.055	0.00	0.12	0.34	551	34056
2019	0.055	0.00	0.12	0.34	540	33673
2020	0.055	0.00	0.12	0.34	531	33273
2021	0.055	0.00	0.12	0.35	523	32842
2022	0.055	0.00	0.12	0.35	518	32435
2023	0.055	0.01	0.13	0.36	515	32077
2024	0.055	0.01	0.13	0.37	512	31733
2025	0.055	0.02	0.13	0.37	510	31433
2026	0.055	0.02	0.13	0.37	512	31210
2027	0.055	0.03	0.13	0.38	513	31040
2028	0.055	0.03	0.13	0.38	515	30921
2029	0.055	0.04	0.13	0.38	518	30785
2030	0.055	0.04	0.13	0.38	519	30761
2031	0.055	0.04	0.13	0.38	522	30668
2032	0.055	0.04	0.13	0.38	522	30630
2033	0.055	0.04	0.13	0.38	523	30601
2034	0.055	0.04	0.13	0.38	524	30586
2035	0.055	0.04	0.13	0.37	524	30520
2036	0.055	0.04	0.13	0.37	523	30440
2037	0.055	0.04	0.13	0.37	521	30391
2038	0.055	0.04	0.13	0.37	520	30321
2039	0.055	0.04	0.12	0.37	518	30256
2040	0.055	0.04	0.12	0.36	515	30232
2041	0.055	0.04	0.12	0.36	513	30103
2042	0.055	0.05	0.12	0.36	511	29989
2043	0.055	0.05	0.12	0.36	508	29971
2044	0.055	0.05	0.12	0.36	505	29926
2045	0.055	0.05	0.12	0.36	504	29881
2046	0.055	0.06	0.12	0.36	502	29828
2047	0.055	0.06	0.12	0.36	500	29729
2048	0.055	0.06	0.12	0.36	499	29633
2049	0.055	0.07	0.12	0.36	497	29510
2050	0.055	0.07	0.12	0.36	496	29421
2051	0.055	0.07	0.12	0.36	494	29338
2052	0.055	0.08	0.12	0.36	492	29237
2053	0.055	0.08	0.12	0.36	491	29159
2054	0.055	0.09	0.12	0.36	490	29050
2055	0.055	0.09	0.12	0.36	488	28978
2056	0.055	0.09	0.12	0.36	487	28922
2057	0.055	0.09	0.12	0.36	486	28848
2058	0.055	0.10	0.12	0.36	485	28780
2059	0.055	0.10	0.12	0.36	484	28738
2060	0.055	0.10	0.12	0.36	483	28668
2061	0.055	0.11	0.12	0.36	482	28620
2062	0.055	0.11	0.12	0.36	481	28551
2063	0.055	0.11	0.12	0.36	480	28558
2064	0.055	0.11	0.12	0.36	479	28481
2065	0.055	0.12	0.12	0.36	478	28464
2066	0.055	0.12	0.12	0.35	477	28439
2067	0.055	0.12	0.12	0.35	476	28419
2068	0.055	0.13	0.12	0.35	475	28322
2069	0.055	0.13	0.12	0.35	475	28265
2070	0.055	0.13	0.12	0.35	474	28245
2071	0.055	0.13	0.12	0.35	473	28206

2072	0.055	0.13	0.12	0.35	473	28138
2073	0.055	0.14	0.12	0.35	471	28088
2074	0.055	0.14	0.12	0.35	470	28091
2075	0.055	0.14	0.12	0.35	469	28021
2076	0.055	0.14	0.12	0.35	468	28018
2077	0.055	0.14	0.12	0.35	467	27981
2078	0.055	0.15	0.12	0.35	466	27942
2079	0.055	0.15	0.12	0.35	466	27908
2080	0.055	0.15	0.12	0.35	466	27888
2081	0.055	0.15	0.12	0.35	465	27895
2082	0.055	0.15	0.12	0.35	464	27879
2083	0.055	0.16	0.12	0.35	463	27885
2084	0.055	0.16	0.12	0.35	462	27890
2085	0.055	0.16	0.12	0.35	461	27840
2086	0.055	0.16	0.12	0.35	461	27816
2087	0.055	0.16	0.12	0.35	461	27839
2088	0.055	0.16	0.12	0.35	461	27800
2089	0.055	0.17	0.12	0.35	460	27817
2090	0.055	0.17	0.12	0.35	460	27766
2091	0.055	0.17	0.12	0.35	460	27732
2092	0.055	0.17	0.12	0.35	459	27751
2093	0.055	0.17	0.12	0.35	459	27737
2094	0.055	0.17	0.12	0.35	458	27737
2095	0.055	0.18	0.12	0.35	458	27719
2096	0.055	0.18	0.12	0.35	458	27716
2097	0.055	0.18	0.12	0.35	458	27715
2098	0.055	0.18	0.12	0.35	458	27700
2099	0.055	0.18	0.12	0.35	457	27727
2100	0.055	0.18	0.12	0.35	457	27726
2101	0.055	0.18	0.12	0.35	457	27725
2102	0.055	0.19	0.12	0.35	457	27732
2103	0.055	0.19	0.12	0.35	457	27765
2104	0.055	0.19	0.12	0.35	457	27751
2105	0.055	0.19	0.12	0.35	457	27739
2106	0.055	0.19	0.12	0.35	457	27734
2107	0.055	0.19	0.12	0.35	457	27700
2108	0.055	0.19	0.12	0.35	457	27674

Table 3.10. Projections of median apical fishing mortality, probability of SSB recovery to MSY levels, SSB, number of recruits, removals (lb dressed wgt), and removals (numbers), for the F0 scenario.

Year	F	$Pr(SSB>SSB_{MSY})$	SSB	Recruits	Removals (wgt)	Removals (#'s)
2009	0.055	0.01	0.16	0.45	600	33514
2010	0.055	0.01	0.15	0.42	604	33977
2011	0.055	0.00	0.14	0.41	606	34444
2012	0.055	0.00	0.13	0.39	604	34723
2013	0	0.00	0.13	0.38	0	0
2014	0	0.00	0.13	0.37	0	0
2015	0	0.00	0.12	0.37	0	0
2016	0	0.00	0.12	0.36	0	0
2017	0	0.00	0.12	0.36	0	0
2018	0	0.00	0.13	0.36	0	0
2019	0	0.00	0.13	0.37	0	0
2020	0	0.00	0.14	0.38	0	0
2021	0	0.01	0.14	0.39	0	0
2022	0	0.01	0.15	0.40	0	0
2023	0	0.02	0.16	0.42	0	0
2024	0	0.03	0.17	0.43	0	0
2025	0	0.05	0.18	0.45	0	0
2026	0	0.07	0.19	0.47	0	0
2027	0	0.08	0.20	0.48	0	0
2028	0	0.10	0.21	0.50	0	0
2029	0	0.12	0.22	0.51	0	0
2030	0	0.13	0.22	0.52	0	0
2031	0	0.15	0.23	0.54	0	0
2032	0	0.17	0.24	0.55	0	0
2033	0	0.18	0.25	0.56	0	0
2034	0	0.20	0.25	0.57	0	0
2035	0	0.21	0.26	0.57	0	0
2036	0	0.23	0.26	0.58	0	0
2037	0	0.24	0.27	0.59	0	0
2038	0	0.25	0.27	0.59	0	0
2039	0	0.27	0.28	0.60	0	0
2040	0	0.29	0.28	0.60	0	0
2041	0	0.30	0.29	0.61	0	0
2042	0	0.32	0.29	0.62	0	0
2043	0	0.34	0.30	0.62	0	0
2044	0	0.36	0.31	0.63	0	0
2045	0	0.39	0.32	0.64	0	0
2046	0	0.41	0.32	0.65	0	0
2047	0	0.44	0.33	0.66	0	0
2048	0	0.46	0.34	0.66	0	0
2049	0	0.49	0.35	0.67	0	0
2050	0	0.51	0.36	0.68	0	0
2051	0	0.54	0.37	0.69	0	0
2052	0	0.56	0.37	0.70	0	0
2053	0	0.59	0.38	0.70	0	0
2054	0	0.61	0.39	0.71	0	0
2055	0	0.63	0.40	0.72	0	0
2056	0	0.64	0.41	0.73	0	0
2057	0	0.67	0.42	0.73	0	0
2058	0	0.69	0.43	0.74	0	0
2059	0	0.70	0.43	0.75	0	0
2060	0	0.72	0.44	0.75	0	0
2061	0	0.74	0.45	0.76	0	0
2062	0	0.75	0.46	0.77	0	0
2063	0	0.77	0.47	0.77	0	0
2064	0	0.78	0.48	0.78	0	0
2065	0	0.79	0.48	0.78	0	0
2066	0	0.80	0.49	0.79	0	0
2067	0	0.81	0.50	0.79	0	0
2068	0	0.82	0.51	0.80	0	0
2069	0	0.83	0.52	0.80	0	0
2070	0	0.84	0.52	0.81	0	0
2071	0	0.85	0.53	0.81	0	0

2072	0	0.86	0.54	0.82	0	0
2073	0	0.87	0.55	0.82	0	0
2074	0	0.88	0.56	0.83	0	0
2075	0	0.88	0.56	0.83	0	0
2076	0	0.89	0.57	0.84	0	0
2077	0	0.89	0.58	0.84	0	0
2078	0	0.90	0.59	0.85	0	0
2079	0	0.91	0.60	0.85	0	0
2080	0	0.91	0.60	0.85	0	0
2081	0	0.92	0.61	0.86	0	0
2082	0	0.92	0.62	0.86	0	0
2083	0	0.92	0.63	0.87	0	0
2084	0	0.93	0.63	0.87	0	0
2085	0	0.93	0.64	0.87	0	0
2086	0	0.94	0.65	0.88	0	0
2087	0	0.94	0.65	0.88	0	0
2088	0	0.94	0.66	0.88	0	0
2089	0	0.95	0.67	0.89	0	0
2090	0	0.95	0.68	0.89	0	0
2091	0	0.95	0.68	0.89	0	0
2092	0	0.95	0.69	0.90	0	0
2093	0	0.96	0.69	0.90	0	0
2094	0	0.96	0.70	0.90	0	0
2095	0	0.96	0.71	0.90	0	0
2096	0	0.96	0.71	0.91	0	0
2097	0	0.96	0.72	0.91	0	0
2098	0	0.97	0.73	0.91	0	0
2099	0	0.97	0.73	0.91	0	0
2100	0	0.97	0.74	0.92	0	0
2101	0	0.97	0.74	0.92	0	0
2102	0	0.97	0.75	0.92	0	0
2103	0	0.97	0.75	0.92	0	0
2104	0	0.97	0.76	0.92	0	0
2105	0	0.98	0.77	0.93	0	0
2106	0	0.98	0.77	0.93	0	0
2107	0	0.98	0.78	0.93	0	0
2108	0	0.98	0.78	0.93	0	0

Table 3.11. Projections of median apical fishing mortality, probability of SSB recovery to MSY levels, SSB, number of recruits, removals (lb dressed wgt), and removals (numbers), for the Fmsy scenario.

Year	F	$Pr(SSB>SSB_{MSY})$	SSB	Recruits	Removals (wgt)	Removals (#'s)
2009	0.055	0.01	0.15	0.45	604	33702
2010	0.055	0.00	0.15	0.42	610	34265
2011	0.055	0.00	0.14	0.41	612	34798
2012	0.055	0.00	0.13	0.39	609	35014
2013	0.035	0.00	0.13	0.38	391	22731
2014	0.035	0.00	0.13	0.37	391	23037
2015	0.035	0.00	0.12	0.36	390	23279
2016	0.035	0.00	0.12	0.36	388	23440
2017	0.035	0.00	0.12	0.35	385	23511
2018	0.035	0.00	0.12	0.35	381	23564
2019	0.035	0.00	0.12	0.35	378	23538
2020	0.035	0.00	0.12	0.35	375	23493
2021	0.035	0.00	0.13	0.36	373	23452
2022	0.035	0.00	0.13	0.37	371	23408
2023	0.035	0.01	0.14	0.38	371	23352
2024	0.035	0.01	0.14	0.39	372	23339
2025	0.035	0.02	0.15	0.40	375	23381
2026	0.035	0.03	0.15	0.41	378	23414
2027	0.035	0.03	0.15	0.41	381	23483
2028	0.035	0.04	0.16	0.42	386	23563
2029	0.035	0.04	0.16	0.42	391	23667
2030	0.035	0.05	0.16	0.43	396	23865
2031	0.035	0.05	0.16	0.43	401	23995
2032	0.035	0.05	0.16	0.43	406	24161
2033	0.035	0.05	0.16	0.44	410	24337
2034	0.035	0.05	0.16	0.44	414	24545
2035	0.035	0.05	0.16	0.44	418	24764
2036	0.035	0.06	0.16	0.44	422	25002
2037	0.035	0.06	0.16	0.44	425	25185
2038	0.035	0.06	0.16	0.44	427	25365
2039	0.035	0.06	0.16	0.44	430	25587
2040	0.035	0.06	0.16	0.44	432	25803
2041	0.035	0.07	0.16	0.44	435	26004
2042	0.035	0.07	0.16	0.44	437	26212
2043	0.035	0.07	0.17	0.44	438	26399
2044	0.035	0.08	0.17	0.44	439	26583
2045	0.035	0.08	0.17	0.45	441	26750
2046	0.035	0.09	0.17	0.45	442	26915
2047	0.035	0.09	0.17	0.45	444	27061
2048	0.035	0.10	0.17	0.45	445	27217
2049	0.035	0.10	0.17	0.46	447	27359
2050	0.035	0.11	0.18	0.46	449	27485
2051	0.035	0.11	0.18	0.46	451	27608
2052	0.035	0.12	0.18	0.47	453	27713
2053	0.035	0.12	0.18	0.47	456	27838
2054	0.035	0.13	0.18	0.47	458	27982
2055	0.035	0.14	0.18	0.47	460	28110
2056	0.035	0.14	0.18	0.48	462	28240
2057	0.035	0.14	0.19	0.48	464	28349
2058	0.035	0.15	0.19	0.48	466	28471
2059	0.035	0.15	0.19	0.48	469	28607
2060	0.035	0.16	0.19	0.48	470	28785
2061	0.035	0.16	0.19	0.49	472	28919
2062	0.035	0.17	0.19	0.49	474	28991
2063	0.035	0.17	0.19	0.49	476	29103
2064	0.035	0.18	0.19	0.49	477	29236
2065	0.035	0.18	0.19	0.49	479	29371
2066	0.035	0.18	0.20	0.49	481	29485
2067	0.035	0.19	0.20	0.50	482	29633
2068	0.035	0.19	0.20	0.50	484	29769
2069	0.035	0.20	0.20	0.50	485	29863
2070	0.035	0.20	0.20	0.50	487	29988
2071	0.035	0.21	0.20	0.50	489	30127

2072	0.035	0.21	0.20	0.51	490	30244
2073	0.035	0.22	0.20	0.51	492	30375
2074	0.035	0.22	0.21	0.51	494	30488
2075	0.035	0.22	0.21	0.51	496	30609
2076	0.035	0.23	0.21	0.51	497	30699
2077	0.035	0.23	0.21	0.51	499	30783
2078	0.035	0.23	0.21	0.51	501	30866
2079	0.035	0.24	0.21	0.52	502	30975
2080	0.035	0.24	0.21	0.52	504	31066
2081	0.035	0.25	0.21	0.52	505	31179
2082	0.035	0.25	0.21	0.52	507	31278
2083	0.035	0.25	0.22	0.52	508	31413
2084	0.035	0.25	0.22	0.52	509	31510
2085	0.035	0.26	0.22	0.53	510	31574
2086	0.035	0.26	0.22	0.53	511	31663
2087	0.035	0.26	0.22	0.53	512	31786
2088	0.035	0.27	0.22	0.53	513	31897
2089	0.035	0.27	0.22	0.53	515	31983
2090	0.035	0.27	0.22	0.53	516	32072
2091	0.035	0.27	0.22	0.54	517	32168
2092	0.035	0.28	0.23	0.54	519	32271
2093	0.035	0.28	0.23	0.54	520	32385
2094	0.035	0.28	0.23	0.54	521	32488
2095	0.035	0.29	0.23	0.54	522	32607
2096	0.035	0.29	0.23	0.54	523	32722
2097	0.035	0.29	0.23	0.55	525	32831
2098	0.035	0.30	0.23	0.55	526	32943
2099	0.035	0.30	0.23	0.55	527	33034
2100	0.035	0.30	0.23	0.55	528	33116
2101	0.035	0.30	0.24	0.55	529	33219
2102	0.035	0.31	0.24	0.55	531	33306
2103	0.035	0.31	0.24	0.56	532	33409
2104	0.035	0.31	0.24	0.56	533	33474
2105	0.035	0.31	0.24	0.56	534	33564
2106	0.035	0.32	0.24	0.56	535	33641
2107	0.035	0.32	0.24	0.56	536	33725
2108	0.035	0.32	0.24	0.56	537	33810

Table 3.12. Projections of median apical fishing mortality, probability of SSB recovery to MSY levels, SSB, number of recruits, removals (lb dressed wgt), and removals (numbers), for the Ftarget scenario.

Year	F	Pr(SSB>SSB$_{MSY}$)	SSB	Recruits	Removals (wgt)	Removals (#'s)
2009	0.055	0.01	0.15	0.45	591	32992
2010	0.055	0.00	0.15	0.42	598	33640
2011	0.055	0.00	0.14	0.41	599	34085
2012	0.055	0.00	0.13	0.40	597	34310
2013	0.028	0.00	0.13	0.38	299	17403
2014	0.028	0.00	0.12	0.37	301	17746
2015	0.028	0.00	0.12	0.36	303	18044
2016	0.028	0.00	0.12	0.36	303	18284
2017	0.028	0.00	0.12	0.35	302	18457
2018	0.028	0.00	0.12	0.35	301	18582
2019	0.028	0.00	0.12	0.35	299	18664
2020	0.028	0.00	0.13	0.36	297	18739
2021	0.028	0.00	0.13	0.37	296	18781
2022	0.028	0.01	0.14	0.38	296	18815
2023	0.028	0.01	0.14	0.39	297	18870
2024	0.028	0.02	0.15	0.40	299	18931
2025	0.028	0.03	0.15	0.41	302	19011
2026	0.028	0.03	0.16	0.42	306	19124
2027	0.028	0.04	0.16	0.43	310	19255
2028	0.028	0.05	0.16	0.43	315	19414
2029	0.028	0.05	0.17	0.44	320	19585
2030	0.028	0.06	0.17	0.45	325	19790
2031	0.028	0.06	0.17	0.45	331	19987
2032	0.028	0.07	0.17	0.46	336	20238
2033	0.028	0.07	0.18	0.46	341	20472
2034	0.028	0.07	0.18	0.46	346	20727
2035	0.028	0.07	0.18	0.47	350	20967
2036	0.028	0.07	0.18	0.47	355	21226
2037	0.028	0.08	0.18	0.47	359	21465
2038	0.028	0.08	0.18	0.47	363	21711
2039	0.028	0.08	0.18	0.47	367	22006
2040	0.028	0.09	0.18	0.47	370	22278
2041	0.028	0.09	0.18	0.48	373	22524
2042	0.028	0.09	0.19	0.48	375	22782
2043	0.028	0.10	0.19	0.48	378	23005
2044	0.028	0.10	0.19	0.48	380	23243
2045	0.028	0.11	0.19	0.49	383	23463
2046	0.028	0.12	0.19	0.49	385	23714
2047	0.028	0.12	0.20	0.49	388	23925
2048	0.028	0.13	0.20	0.50	391	24138
2049	0.028	0.14	0.20	0.50	393	24349
2050	0.028	0.14	0.20	0.50	396	24547
2051	0.028	0.15	0.21	0.51	399	24740
2052	0.028	0.16	0.21	0.51	402	24941
2053	0.028	0.17	0.21	0.52	406	25149
2054	0.028	0.17	0.21	0.52	409	25325
2055	0.028	0.18	0.22	0.52	412	25521
2056	0.028	0.19	0.22	0.53	415	25726
2057	0.028	0.20	0.22	0.53	418	25939
2058	0.028	0.20	0.22	0.53	421	26122
2059	0.028	0.21	0.23	0.54	424	26308
2060	0.028	0.22	0.23	0.54	427	26504
2061	0.028	0.22	0.23	0.54	429	26704
2062	0.028	0.23	0.23	0.54	432	26891
2063	0.028	0.24	0.23	0.55	435	27082
2064	0.028	0.24	0.24	0.55	438	27283
2065	0.028	0.25	0.24	0.55	440	27479
2066	0.028	0.26	0.24	0.56	443	27670
2067	0.028	0.26	0.24	0.56	446	27870
2068	0.028	0.27	0.24	0.56	448	28076
2069	0.028	0.27	0.25	0.56	451	28253
2070	0.028	0.28	0.25	0.57	453	28422
2071	0.028	0.28	0.25	0.57	456	28601

2072	0.028	0.29	0.25	0.57	458	28792
2073	0.028	0.30	0.25	0.58	460	28972
2074	0.028	0.30	0.26	0.58	463	29155
2075	0.028	0.31	0.26	0.58	465	29324
2076	0.028	0.31	0.26	0.58	467	29500
2077	0.028	0.32	0.26	0.59	470	29639
2078	0.028	0.32	0.27	0.59	472	29808
2079	0.028	0.33	0.27	0.59	474	29962
2080	0.028	0.33	0.27	0.60	477	30124
2081	0.028	0.34	0.27	0.60	479	30292
2082	0.028	0.34	0.27	0.60	481	30435
2083	0.028	0.34	0.28	0.60	484	30600
2084	0.028	0.35	0.28	0.61	486	30786
2085	0.028	0.35	0.28	0.61	488	30952
2086	0.028	0.36	0.28	0.61	490	31106
2087	0.028	0.36	0.28	0.61	493	31249
2088	0.028	0.37	0.29	0.61	495	31408
2089	0.028	0.37	0.29	0.62	497	31547
2090	0.028	0.38	0.29	0.62	499	31711
2091	0.028	0.38	0.29	0.62	500	31892
2092	0.028	0.39	0.29	0.62	502	32050
2093	0.028	0.39	0.30	0.63	504	32197
2094	0.028	0.39	0.30	0.63	506	32339
2095	0.028	0.40	0.30	0.63	508	32493
2096	0.028	0.40	0.30	0.63	511	32632
2097	0.028	0.41	0.30	0.63	512	32771
2098	0.028	0.41	0.30	0.64	514	32906
2099	0.028	0.41	0.31	0.64	516	33050
2100	0.028	0.42	0.31	0.64	518	33192
2101	0.028	0.42	0.31	0.64	520	33319
2102	0.028	0.42	0.31	0.64	521	33449
2103	0.028	0.43	0.31	0.65	523	33599
2104	0.028	0.43	0.32	0.65	525	33745
2105	0.028	0.43	0.32	0.65	527	33872
2106	0.028	0.44	0.32	0.65	528	34007
2107	0.028	0.44	0.32	0.65	530	34139
2108	0.028	0.44	0.32	0.66	532	34270

Table 3.13. Projections of median apical fishing mortality, probability of SSB recovery to MSY levels, SSB, number of recruits, removals (lb dressed wgt), and removals (numbers), for the Frebuild50 scenario.

Year	F	Pr(SSB>SSB_{MSY})	SSB	Recruits	Removals (wgt)	Removals (#'s)
2009	0.055	0.01	0.15	0.45	602	33585
2010	0.055	0.00	0.15	0.42	608	34205
2011	0.055	0.00	0.14	0.41	609	34627
2012	0.055	0.00	0.13	0.40	608	34906
2013	0.027	0.00	0.13	0.38	330	19233
2014	0.027	0.00	0.13	0.37	333	19620
2015	0.027	0.00	0.12	0.36	334	19941
2016	0.027	0.00	0.12	0.36	334	20216
2017	0.027	0.00	0.12	0.35	334	20414
2018	0.027	0.00	0.12	0.35	332	20590
2019	0.027	0.00	0.12	0.36	331	20709
2020	0.027	0.00	0.13	0.36	330	20809
2021	0.027	0.00	0.13	0.37	329	20889
2022	0.027	0.00	0.14	0.38	330	20974
2023	0.027	0.01	0.14	0.39	331	21051
2024	0.027	0.01	0.15	0.40	334	21131
2025	0.027	0.01	0.16	0.41	337	21239
2026	0.027	0.02	0.16	0.42	342	21373
2027	0.027	0.02	0.16	0.43	347	21524
2028	0.027	0.03	0.17	0.44	352	21721
2029	0.027	0.03	0.17	0.45	358	21929
2030	0.027	0.03	0.18	0.46	364	22165
2031	0.027	0.03	0.18	0.46	370	22434
2032	0.027	0.03	0.18	0.47	377	22705
2033	0.027	0.03	0.18	0.47	382	22999
2034	0.027	0.03	0.19	0.48	388	23293
2035	0.027	0.03	0.19	0.48	394	23599
2036	0.027	0.03	0.19	0.48	399	23904
2037	0.027	0.03	0.19	0.48	403	24216
2038	0.027	0.03	0.19	0.48	407	24517
2039	0.027	0.03	0.19	0.49	412	24835
2040	0.027	0.03	0.19	0.49	416	25155
2041	0.027	0.03	0.20	0.49	419	25464
2042	0.027	0.03	0.20	0.49	423	25771
2043	0.027	0.03	0.20	0.50	426	26067
2044	0.027	0.03	0.20	0.50	429	26354
2045	0.027	0.03	0.21	0.50	432	26619
2046	0.027	0.04	0.21	0.51	435	26864
2047	0.027	0.04	0.21	0.51	438	27107
2048	0.027	0.04	0.21	0.52	442	27361
2049	0.027	0.05	0.22	0.52	445	27624
2050	0.027	0.05	0.22	0.53	448	27882
2051	0.027	0.05	0.22	0.53	452	28136
2052	0.027	0.06	0.23	0.53	456	28383
2053	0.027	0.06	0.23	0.54	460	28622
2054	0.027	0.06	0.23	0.54	463	28858
2055	0.027	0.07	0.23	0.55	467	29105
2056	0.027	0.07	0.24	0.55	471	29343
2057	0.027	0.08	0.24	0.55	474	29599
2058	0.027	0.08	0.24	0.56	478	29854
2059	0.027	0.08	0.25	0.56	482	30110
2060	0.027	0.09	0.25	0.57	485	30365
2061	0.027	0.09	0.25	0.57	489	30616
2062	0.027	0.10	0.25	0.57	492	30869
2063	0.027	0.10	0.26	0.58	496	31118
2064	0.027	0.10	0.26	0.58	499	31364
2065	0.027	0.11	0.26	0.58	502	31628
2066	0.027	0.11	0.26	0.58	505	31873
2067	0.027	0.12	0.26	0.59	509	32107
2068	0.027	0.12	0.27	0.59	512	32341
2069	0.027	0.13	0.27	0.59	515	32581
2070	0.027	0.14	0.27	0.60	518	32810
2071	0.027	0.14	0.27	0.60	521	33029

2072	0.027	0.15	0.28	0.60	524	33249
2073	0.027	0.16	0.28	0.61	527	33483
2074	0.027	0.16	0.28	0.61	530	33711
2075	0.027	0.17	0.28	0.61	533	33929
2076	0.027	0.18	0.29	0.61	536	34146
2077	0.027	0.18	0.29	0.62	539	34351
2078	0.027	0.19	0.29	0.62	542	34575
2079	0.027	0.20	0.29	0.62	545	34793
2080	0.027	0.21	0.30	0.62	547	34997
2081	0.027	0.22	0.30	0.63	550	35206
2082	0.027	0.23	0.30	0.63	553	35420
2083	0.027	0.24	0.30	0.63	555	35626
2084	0.027	0.25	0.31	0.63	558	35823
2085	0.027	0.26	0.31	0.64	560	36034
2086	0.027	0.27	0.31	0.64	563	36241
2087	0.027	0.28	0.31	0.64	566	36425
2088	0.027	0.29	0.31	0.64	568	36625
2089	0.027	0.30	0.32	0.65	570	36814
2090	0.027	0.31	0.32	0.65	573	37004
2091	0.027	0.32	0.32	0.65	575	37198
2092	0.027	0.33	0.32	0.65	577	37385
2093	0.027	0.34	0.32	0.66	580	37568
2094	0.027	0.35	0.33	0.66	582	37756
2095	0.027	0.36	0.33	0.66	584	37939
2096	0.027	0.37	0.33	0.66	586	38117
2097	0.027	0.38	0.33	0.66	588	38274
2098	0.027	0.40	0.33	0.67	591	38438
2099	0.027	0.41	0.34	0.67	593	38602
2100	0.027	0.42	0.34	0.67	595	38776
2101	0.027	0.43	0.34	0.67	597	38925
2102	0.027	0.44	0.34	0.67	599	39085
2103	0.027	0.45	0.34	0.68	601	39245
2104	0.027	0.46	0.35	0.68	603	39396
2105	0.027	0.48	0.35	0.68	605	39550
2106	0.027	0.49	0.35	0.68	607	39707
2107	0.027	0.50	0.35	0.68	609	39855
2108	0.027	0.51	0.35	0.68	611	40003

Table 3.14. Projections of median apical fishing mortality, probability of SSB recovery to MSY levels, SSB, number of recruits, removals (lb dressed wgt), and removals (numbers), for the Frebuild70 scenario.

Year	F	Pr(SSB>SSB$_{MSY}$)	SSB	Recruits	Removals (wgt)	Removals (#'s)
2009	0.055	0.01	0.15	0.45	598	33335
2010	0.055	0.00	0.15	0.42	602	33890
2011	0.055	0.00	0.14	0.41	604	34313
2012	0.055	0.00	0.13	0.39	602	34526
2013	0.023	0.00	0.13	0.38	284	16610
2014	0.023	0.00	0.12	0.37	288	17012
2015	0.023	0.00	0.12	0.36	290	17349
2016	0.023	0.00	0.12	0.36	291	17597
2017	0.023	0.00	0.12	0.36	291	17806
2018	0.023	0.00	0.12	0.35	291	17990
2019	0.023	0.00	0.12	0.36	290	18120
2020	0.023	0.00	0.13	0.36	290	18231
2021	0.023	0.00	0.13	0.37	290	18345
2022	0.023	0.00	0.14	0.38	291	18438
2023	0.023	0.01	0.15	0.40	292	18538
2024	0.023	0.01	0.15	0.41	294	18670
2025	0.023	0.01	0.16	0.42	298	18805
2026	0.023	0.02	0.16	0.43	302	18964
2027	0.023	0.03	0.17	0.44	307	19144
2028	0.023	0.03	0.17	0.45	313	19353
2029	0.023	0.04	0.18	0.46	318	19566
2030	0.023	0.04	0.18	0.46	324	19793
2031	0.023	0.04	0.19	0.47	330	20050
2032	0.023	0.04	0.19	0.48	336	20329
2033	0.023	0.04	0.19	0.48	342	20616
2034	0.023	0.04	0.19	0.49	347	20902
2035	0.023	0.04	0.19	0.49	352	21207
2036	0.023	0.04	0.20	0.49	358	21503
2037	0.023	0.04	0.20	0.50	362	21810
2038	0.023	0.04	0.20	0.50	367	22124
2039	0.023	0.04	0.20	0.50	371	22435
2040	0.023	0.04	0.20	0.50	375	22756
2041	0.023	0.04	0.21	0.51	379	23070
2042	0.023	0.05	0.21	0.51	382	23386
2043	0.023	0.05	0.21	0.51	385	23689
2044	0.023	0.05	0.21	0.52	388	23965
2045	0.023	0.06	0.22	0.52	392	24243
2046	0.023	0.06	0.22	0.53	395	24517
2047	0.023	0.07	0.22	0.53	398	24798
2048	0.023	0.07	0.23	0.54	401	25060
2049	0.023	0.08	0.23	0.54	405	25322
2050	0.023	0.08	0.23	0.54	408	25581
2051	0.023	0.09	0.24	0.55	412	25829
2052	0.023	0.10	0.24	0.56	415	26079
2053	0.023	0.11	0.25	0.56	419	26337
2054	0.023	0.11	0.25	0.56	423	26572
2055	0.023	0.12	0.25	0.57	427	26837
2056	0.023	0.13	0.26	0.57	430	27098
2057	0.023	0.13	0.26	0.58	434	27356
2058	0.023	0.14	0.26	0.58	438	27606
2059	0.023	0.15	0.27	0.59	441	27851
2060	0.023	0.16	0.27	0.59	445	28089
2061	0.023	0.17	0.27	0.59	449	28336
2062	0.023	0.17	0.27	0.60	452	28609
2063	0.023	0.18	0.28	0.60	456	28870
2064	0.023	0.19	0.28	0.60	459	29118
2065	0.023	0.20	0.28	0.61	462	29371
2066	0.023	0.21	0.29	0.61	466	29613
2067	0.023	0.22	0.29	0.61	469	29877
2068	0.023	0.23	0.29	0.62	472	30120
2069	0.023	0.24	0.29	0.62	475	30353
2070	0.023	0.25	0.30	0.63	478	30579
2071	0.023	0.26	0.30	0.63	481	30812

2072	0.023	0.27	0.30	0.63	484	31053
2073	0.023	0.29	0.31	0.63	487	31292
2074	0.023	0.30	0.31	0.64	490	31536
2075	0.023	0.31	0.31	0.64	493	31766
2076	0.023	0.33	0.32	0.64	496	31986
2077	0.023	0.34	0.32	0.65	499	32199
2078	0.023	0.35	0.32	0.65	501	32414
2079	0.023	0.36	0.32	0.65	504	32631
2080	0.023	0.38	0.33	0.66	507	32861
2081	0.023	0.39	0.33	0.66	510	33078
2082	0.023	0.41	0.33	0.66	512	33290
2083	0.023	0.42	0.34	0.67	515	33491
2084	0.023	0.43	0.34	0.67	517	33700
2085	0.023	0.45	0.34	0.67	520	33909
2086	0.023	0.46	0.34	0.67	522	34090
2087	0.023	0.47	0.35	0.68	525	34288
2088	0.023	0.49	0.35	0.68	527	34485
2089	0.023	0.50	0.35	0.68	530	34685
2090	0.023	0.51	0.35	0.68	532	34871
2091	0.023	0.52	0.36	0.69	534	35059
2092	0.023	0.53	0.36	0.69	537	35251
2093	0.023	0.54	0.36	0.69	539	35441
2094	0.023	0.56	0.36	0.69	541	35619
2095	0.023	0.57	0.37	0.69	543	35793
2096	0.023	0.58	0.37	0.70	545	35971
2097	0.023	0.59	0.37	0.70	547	36145
2098	0.023	0.60	0.37	0.70	549	36314
2099	0.023	0.61	0.38	0.70	551	36478
2100	0.023	0.63	0.38	0.71	553	36647
2101	0.023	0.64	0.38	0.71	555	36808
2102	0.023	0.65	0.38	0.71	557	36970
2103	0.023	0.66	0.39	0.71	559	37131
2104	0.023	0.67	0.39	0.71	561	37291
2105	0.023	0.68	0.39	0.72	563	37451
2106	0.023	0.69	0.39	0.72	565	37595
2107	0.023	0.70	0.39	0.72	566	37748
2108	0.023	0.71	0.40	0.72	568	37896

Table 3.15. Projections of median apical fishing mortality, probability of SSB recovery to MSY levels, SSB (defined as in Eqn. 3.3), number of recruits, removals (lb dressed wgt), and removals (numbers), for the Fixed Removals scenario.

Year	F	Pr(SSB>SSB_{MSY})	SSB	Recruits	Removals (wgt)	Removals (#'s)
2009	0.055	0.01	0.16	0.45	687	38349
2010	0.055	0.00	0.15	0.43	695	39068
2011	0.055	0.00	0.14	0.41	696	39629
2012	0.029	0.00	0.14	0.40	368	21200
2013	0.028	0.00	0.13	0.39	363	21200
2014	0.028	0.00	0.13	0.38	358	21200
2015	0.027	0.00	0.12	0.37	353	21200
2016	0.027	0.00	0.12	0.36	348	21200
2017	0.027	0.00	0.12	0.36	343	21200
2018	0.027	0.00	0.12	0.36	339	21200
2019	0.027	0.00	0.13	0.36	336	21200
2020	0.026	0.00	0.13	0.37	333	21200
2021	0.026	0.00	0.14	0.38	332	21200
2022	0.026	0.01	0.14	0.39	331	21200
2023	0.026	0.01	0.15	0.40	331	21200
2024	0.026	0.02	0.15	0.41	333	21200
2025	0.026	0.02	0.16	0.42	334	21200
2026	0.026	0.03	0.17	0.43	337	21200
2027	0.026	0.04	0.17	0.44	339	21200
2028	0.025	0.05	0.18	0.45	341	21200
2029	0.025	0.06	0.18	0.46	344	21200
2030	0.025	0.07	0.18	0.47	346	21200
2031	0.024	0.07	0.19	0.47	348	21200
2032	0.024	0.08	0.19	0.48	349	21200
2033	0.024	0.08	0.19	0.48	350	21200
2034	0.023	0.08	0.19	0.49	351	21200
2035	0.023	0.09	0.19	0.49	351	21200
2036	0.023	0.09	0.20	0.49	350	21200
2037	0.022	0.09	0.20	0.49	350	21200
2038	0.022	0.10	0.20	0.50	349	21200
2039	0.022	0.10	0.20	0.50	348	21200
2040	0.021	0.11	0.20	0.50	346	21200
2041	0.021	0.11	0.20	0.50	345	21200
2042	0.021	0.12	0.21	0.51	343	21200
2043	0.021	0.12	0.21	0.51	341	21200
2044	0.020	0.13	0.21	0.52	340	21200
2045	0.020	0.14	0.22	0.52	339	21200
2046	0.020	0.15	0.22	0.53	338	21200
2047	0.019	0.16	0.22	0.53	336	21200
2048	0.019	0.17	0.23	0.54	336	21200
2049	0.019	0.18	0.23	0.54	335	21200
2050	0.019	0.20	0.24	0.55	334	21200
2051	0.019	0.21	0.24	0.55	333	21200
2052	0.018	0.22	0.24	0.56	333	21200
2053	0.018	0.23	0.25	0.56	332	21200
2054	0.018	0.24	0.25	0.57	332	21200
2055	0.018	0.26	0.26	0.58	332	21200
2056	0.017	0.27	0.26	0.58	331	21200
2057	0.017	0.28	0.27	0.59	331	21200
2058	0.017	0.29	0.27	0.59	330	21200
2059	0.017	0.30	0.27	0.60	330	21200
2060	0.017	0.31	0.28	0.60	329	21200
2061	0.016	0.32	0.28	0.61	329	21200
2062	0.016	0.33	0.29	0.61	328	21200
2063	0.016	0.34	0.29	0.61	327	21200
2064	0.016	0.36	0.29	0.62	327	21200
2065	0.016	0.37	0.30	0.62	326	21200
2066	0.016	0.38	0.30	0.63	325	21200
2067	0.015	0.39	0.31	0.63	325	21200
2068	0.015	0.40	0.31	0.64	324	21200
2069	0.015	0.41	0.32	0.64	323	21200
2070	0.015	0.42	0.32	0.65	323	21200
2071	0.015	0.43	0.32	0.65	322	21200

2072	0.015	0.45	0.33	0.66	321	21200
2073	0.014	0.45	0.33	0.66	321	21200
2074	0.014	0.47	0.34	0.67	320	21200
2075	0.014	0.48	0.34	0.67	319	21200
2076	0.014	0.49	0.35	0.67	319	21200
2077	0.014	0.50	0.35	0.68	318	21200
2078	0.014	0.51	0.36	0.68	318	21200
2079	0.014	0.52	0.36	0.69	317	21200
2080	0.013	0.53	0.37	0.69	316	21200
2081	0.013	0.54	0.37	0.70	316	21200
2082	0.013	0.55	0.37	0.70	315	21200
2083	0.013	0.55	0.38	0.70	315	21200
2084	0.013	0.56	0.38	0.71	314	21200
2085	0.013	0.57	0.39	0.71	314	21200
2086	0.013	0.58	0.39	0.72	313	21200
2087	0.013	0.59	0.40	0.72	312	21200
2088	0.012	0.59	0.40	0.72	312	21200
2089	0.012	0.60	0.41	0.73	311	21200
2090	0.012	0.61	0.41	0.73	311	21200
2091	0.012	0.61	0.42	0.74	310	21200
2092	0.012	0.62	0.42	0.74	310	21200
2093	0.012	0.63	0.43	0.74	309	21200
2094	0.012	0.63	0.43	0.75	309	21200
2095	0.012	0.64	0.44	0.75	308	21200
2096	0.012	0.64	0.44	0.75	308	21200
2097	0.012	0.65	0.45	0.76	307	21200
2098	0.011	0.66	0.45	0.76	307	21200
2099	0.011	0.66	0.46	0.77	306	21200
2100	0.011	0.67	0.46	0.77	306	21200
2101	0.011	0.67	0.46	0.77	305	21200
2102	0.011	0.68	0.47	0.78	305	21200
2103	0.011	0.68	0.47	0.78	304	21200
2104	0.011	0.69	0.48	0.78	304	21200
2105	0.011	0.70	0.48	0.78	303	21200
2106	0.011	0.70	0.49	0.79	303	21200
2107	0.011	0.70	0.49	0.79	302	21200
2108	0.011	0.71	0.50	0.79	302	21200

3.7. FIGURES

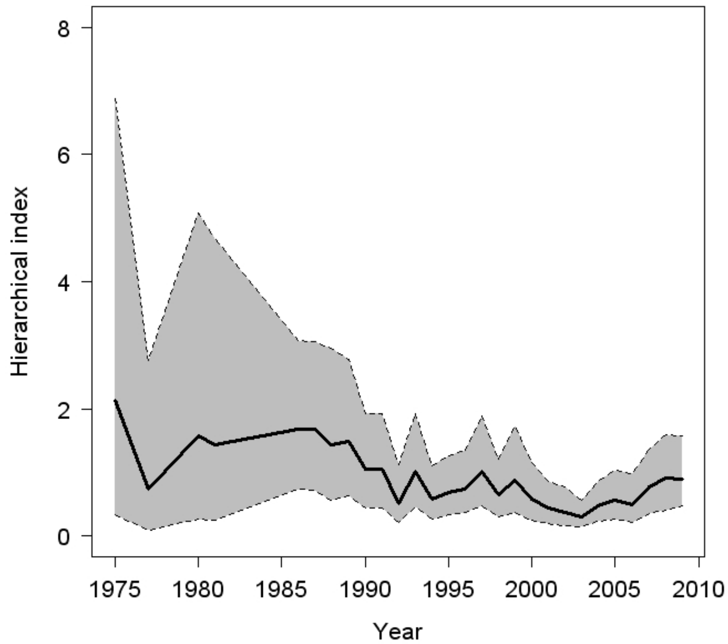


Figure 3.1. Standardized hierarchical index of relative abundance used in dusky shark sensitivity scenario S1. The black line represents the posterior mean, while the dashed lines represent 95% credible intervals.

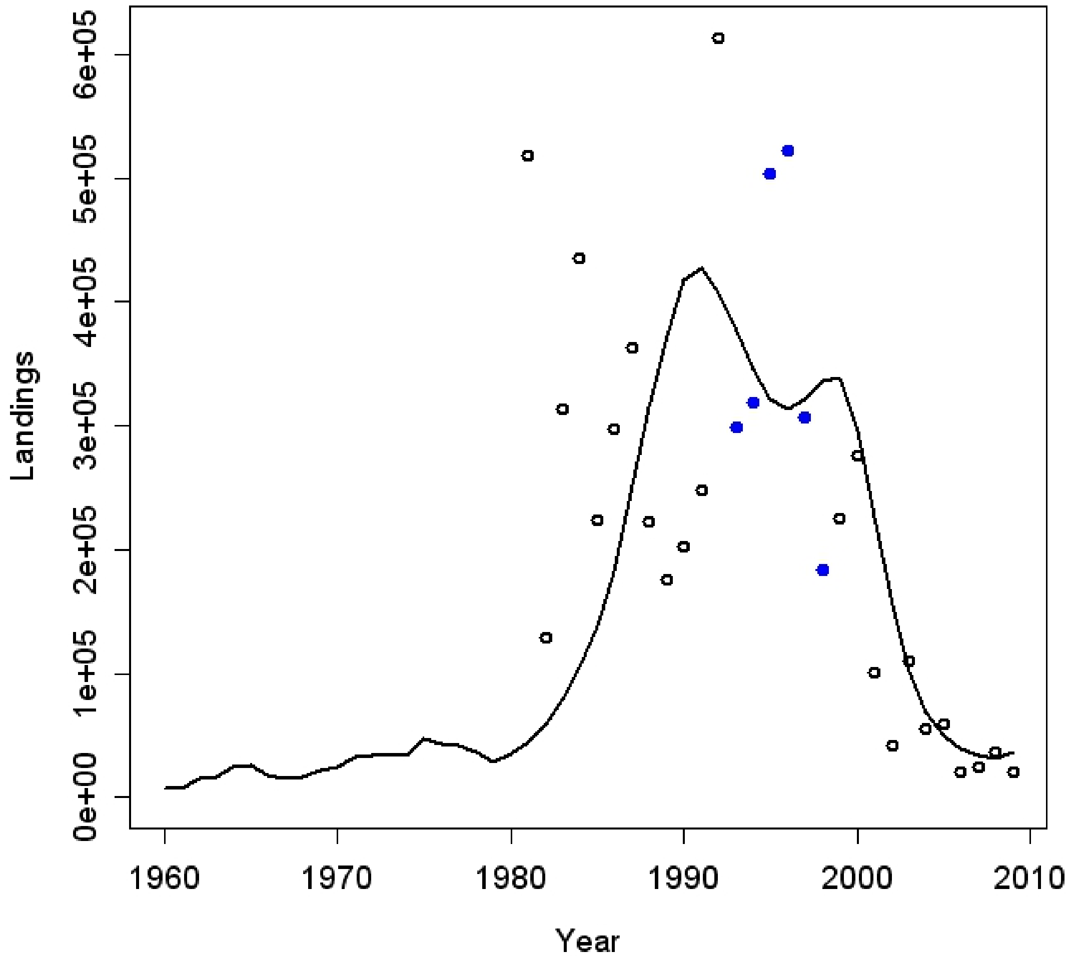
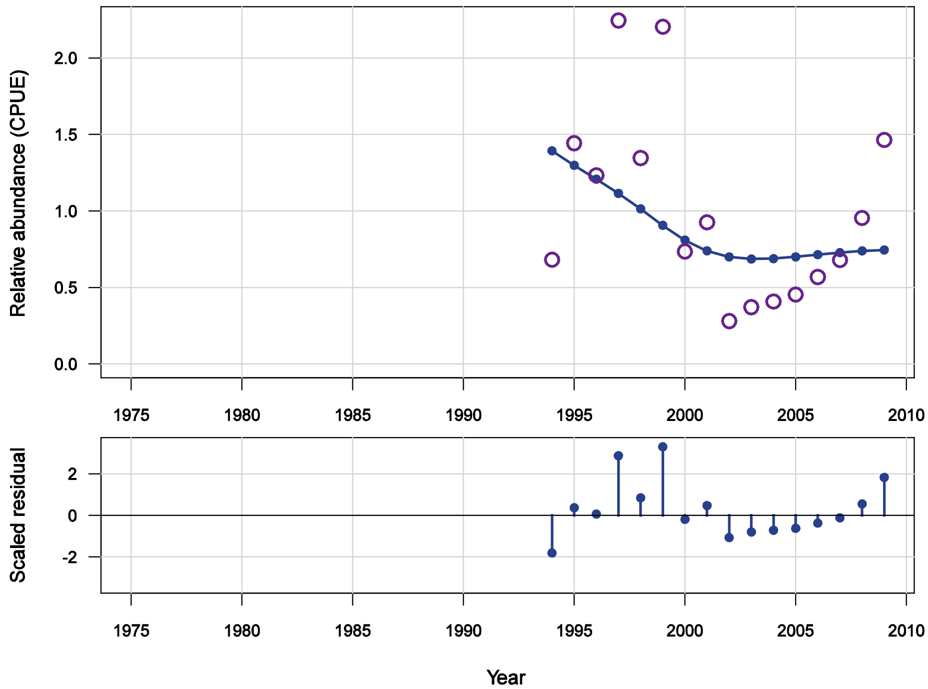


Figure 3.2. Predicted landings/removals (black line) from the ASCFM when observed removals during 1993-1997 (solid points) are used to scale abundance levels up to the absolute scale. Open circles represent observed landings/removals in other years. The estimated scaling factor is used to generate predicted removals for stock projections. Note that observed removals were thought to be unreliable by the DW, and thus not recommended for use in fitting stock assessment models. All values are in dressed weight (lb).

A. BLLOP



B. PLLOP

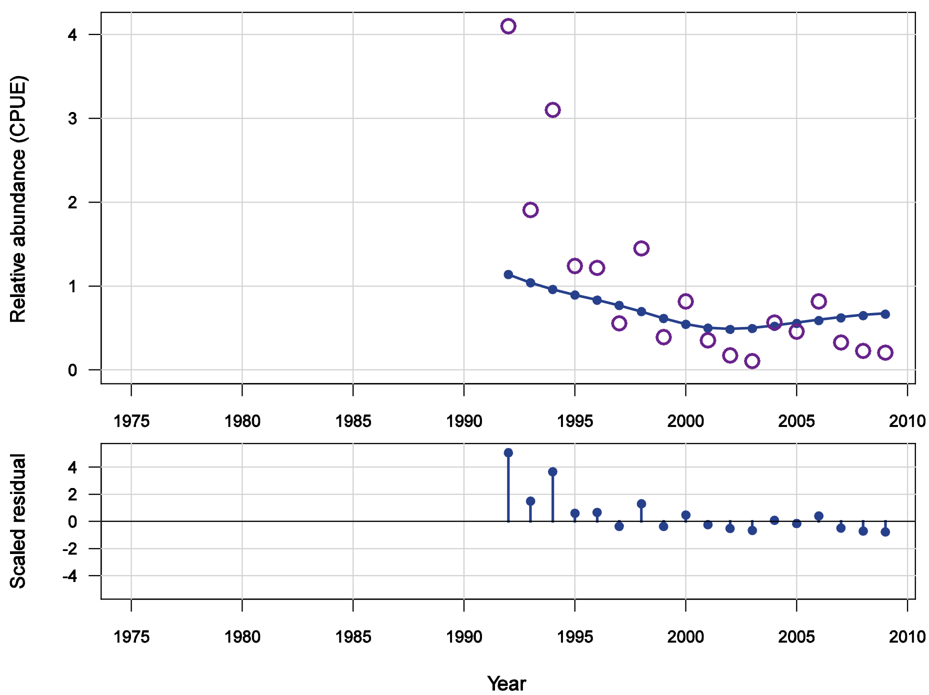
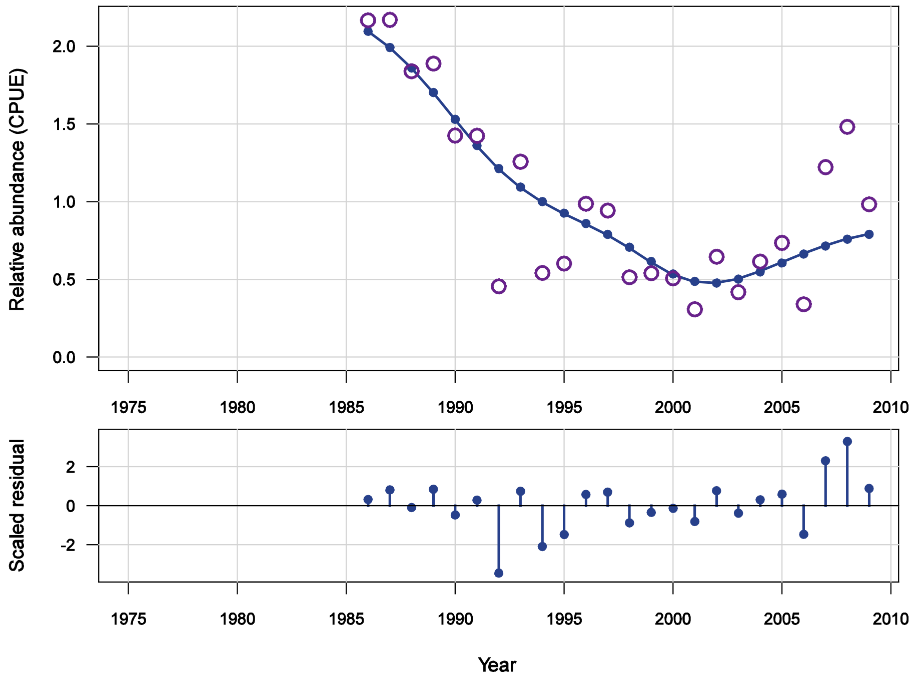


Figure 3.3. Fits to indices for the base run. Solid circles denote ASCFM predictions, while open circles denote observed values. Bottom panels give scaled residuals.

C. LPS



D. VIMS

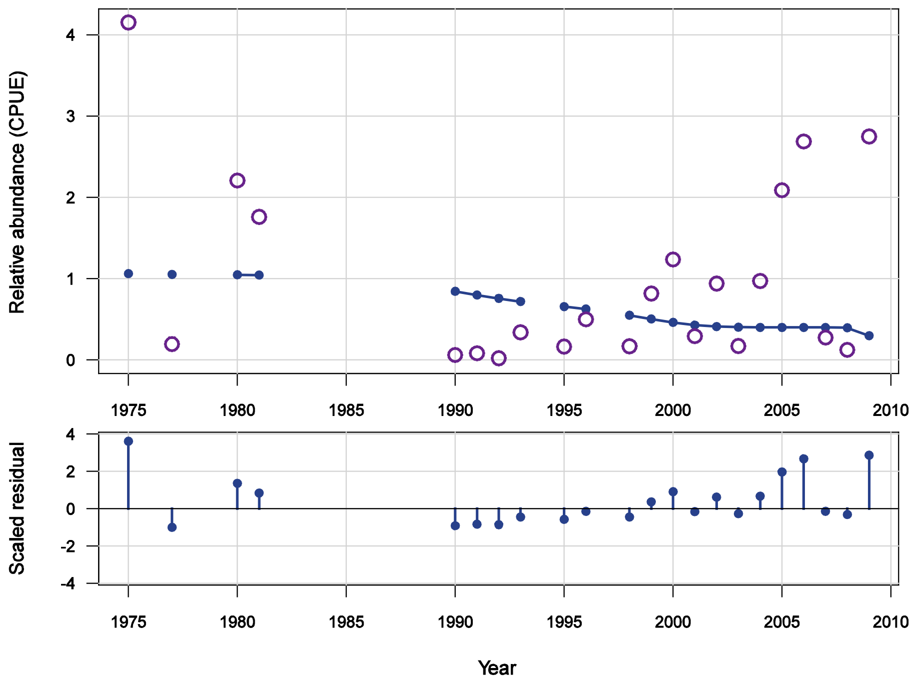


Figure 3.3. Fits to indices for the base run (continued).

E. NELL

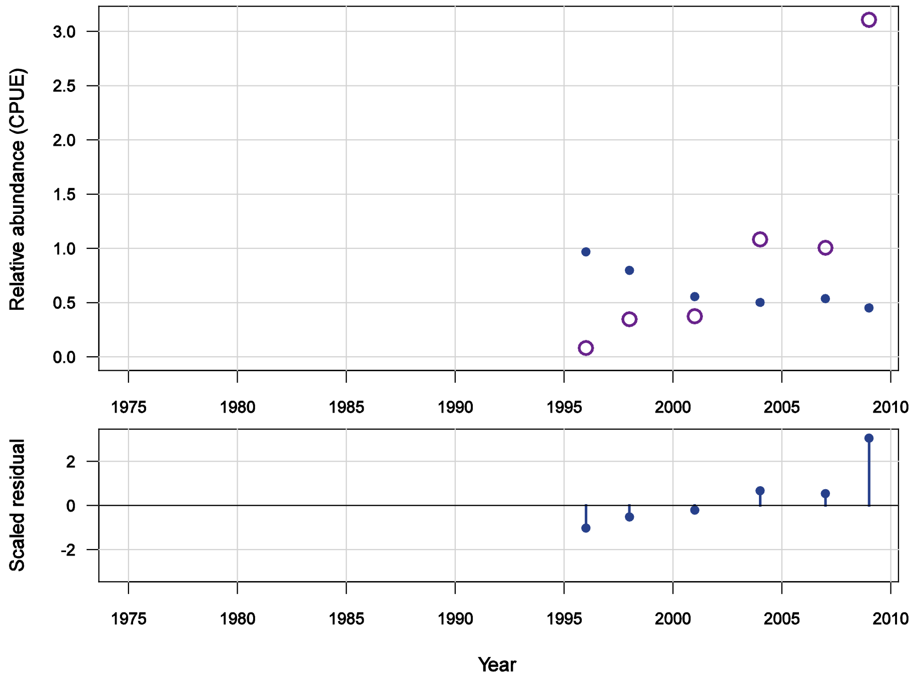


Figure 3.3. Fits to indices for the base run (continued).

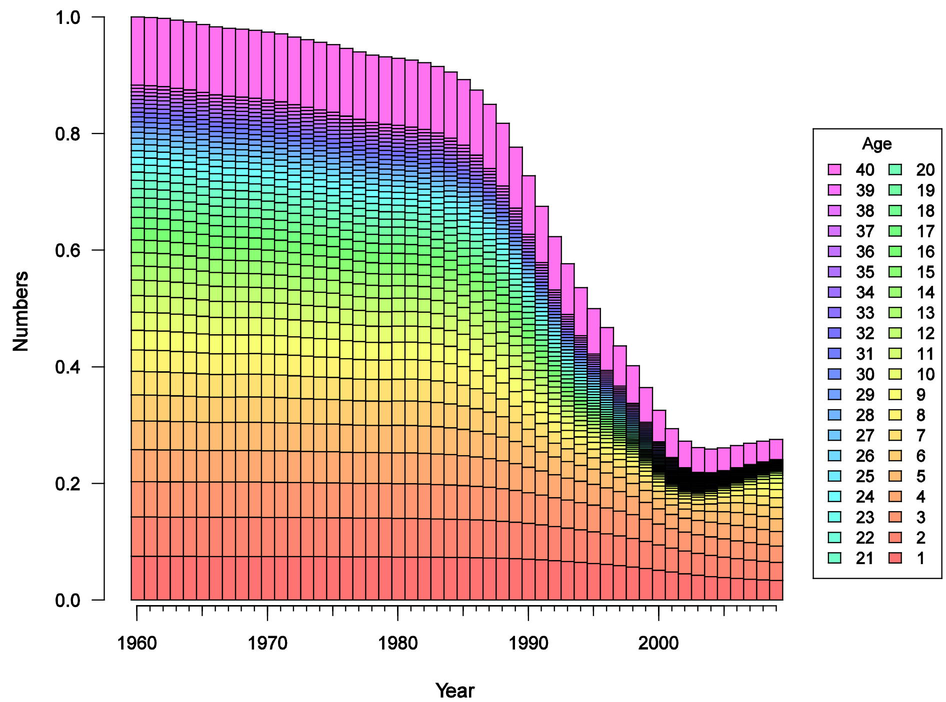


Figure 3.4. Predicted abundance at age for dusky shark, 1960-2009, as estimated by the base assessment model.

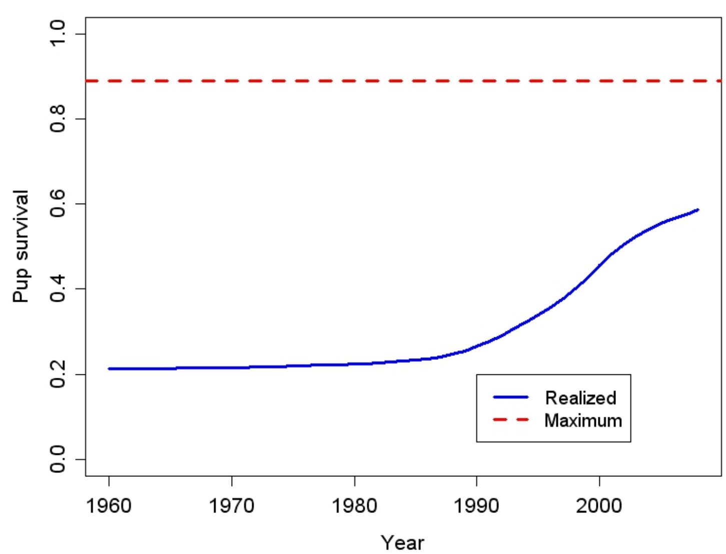


Figure 3.5. Realized pup survival from 1960-2009 as predicted by the base run ASCFM model for dusky sharks. Pup survival is assumed to be density dependent, with an estimated maximum theoretical value of 0.89.

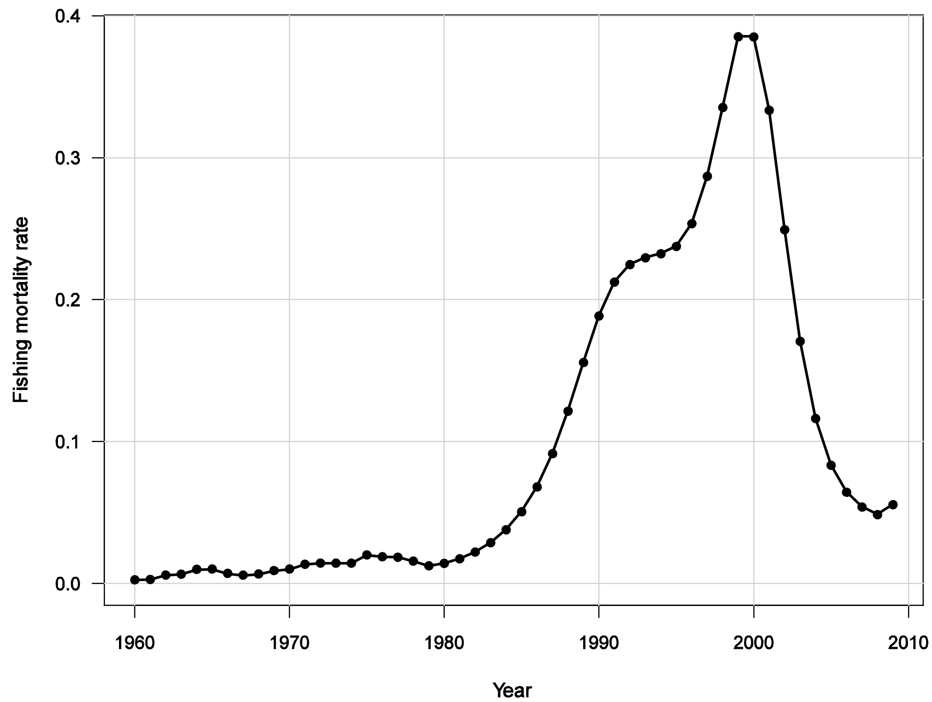


Figure 3.6. Apical instantaneous fishing mortality by year as estimated by the ASCFM for dusky sharks.

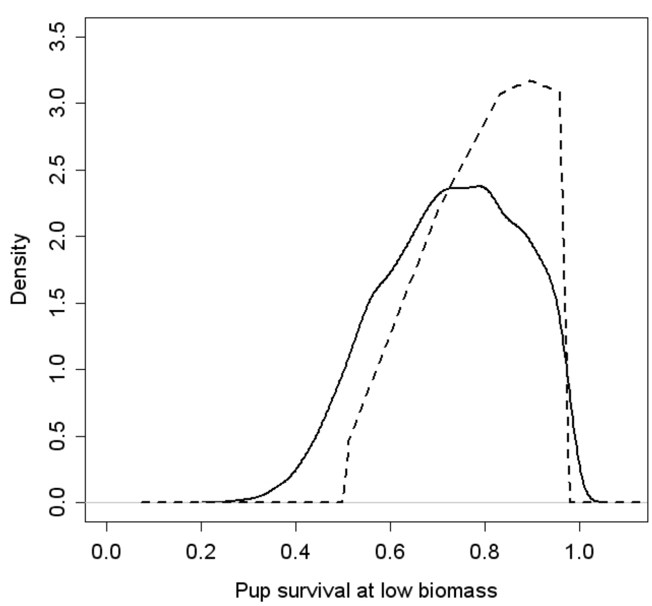


Figure 3.7. Prior (solid line) and estimated posterior distribution (dashed line) for pup survival at low stock size. Pup survival at low stock size was constrained to be between 0.5 and 0.98.

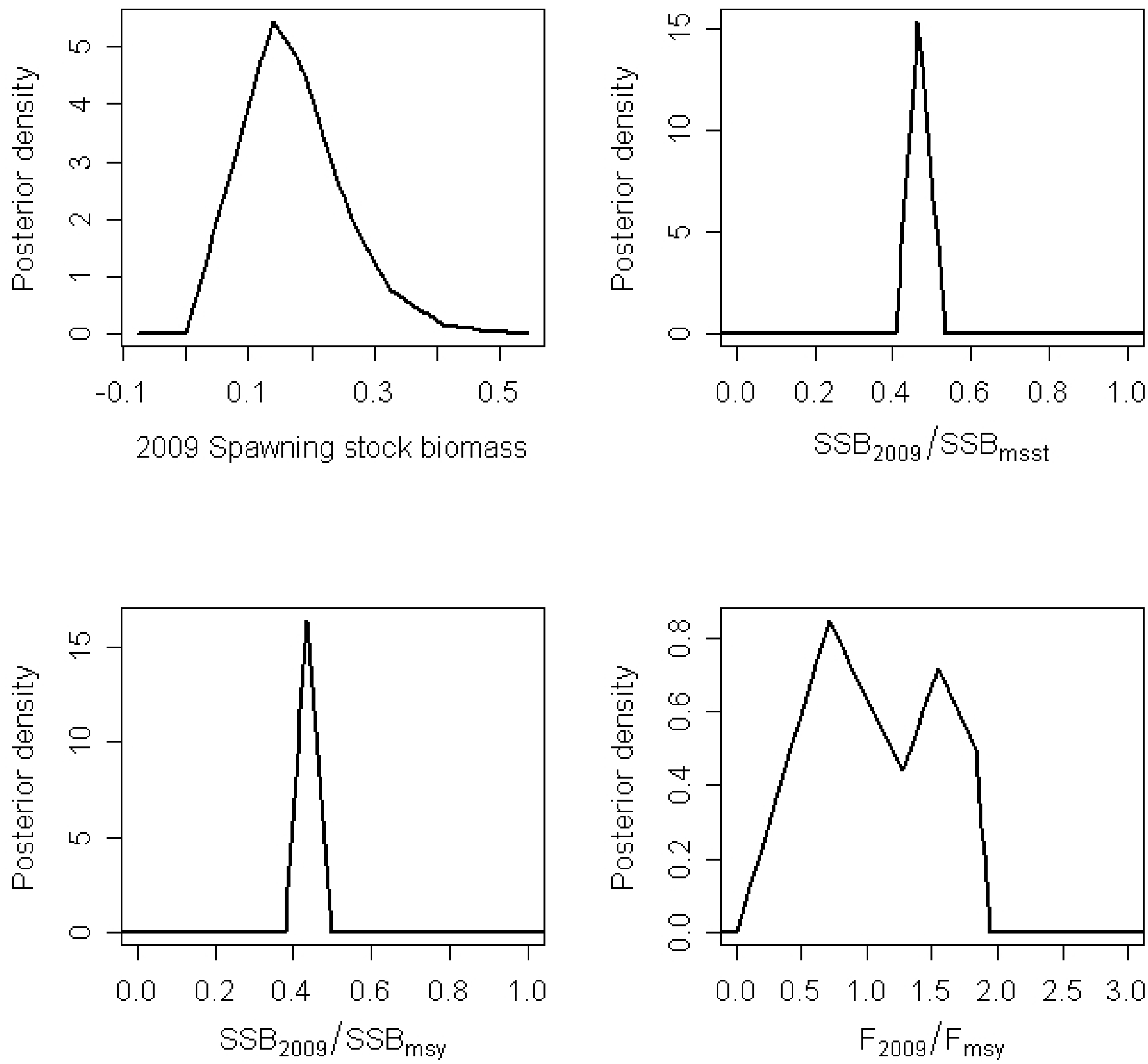
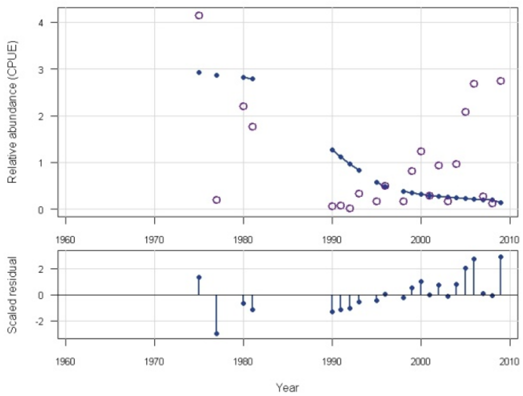
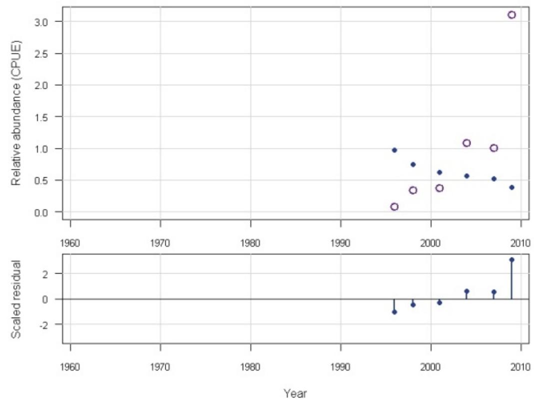


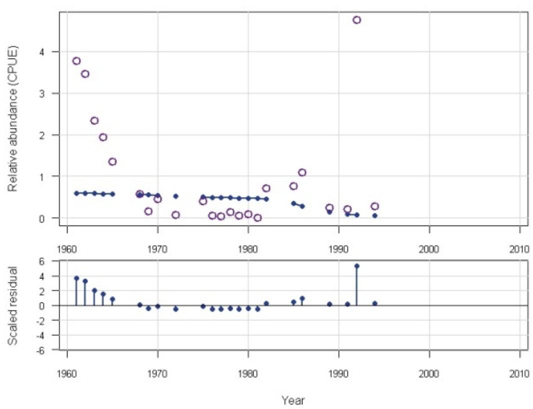
Figure 3.8. Estimated posterior distributions for stock status relative to management benchmarks from the ASCFM for dusky sharks. Relative spawning stock biomass is calculated as in Equation 3.3.



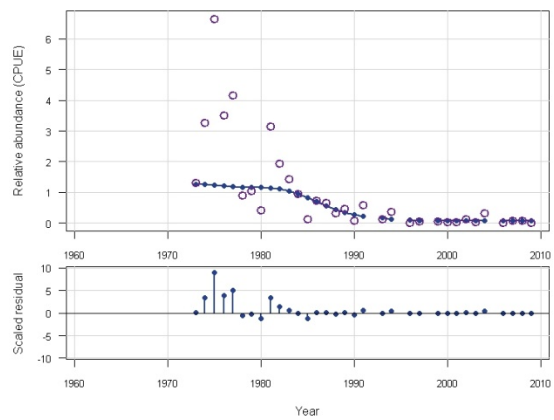
A. VIMS fit



B. NELL fit



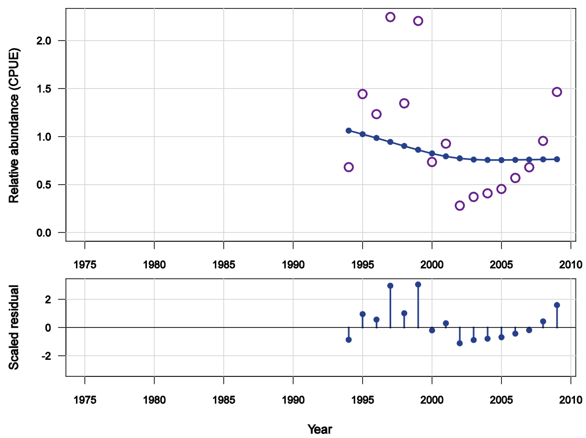
C. NMFS Historical Index



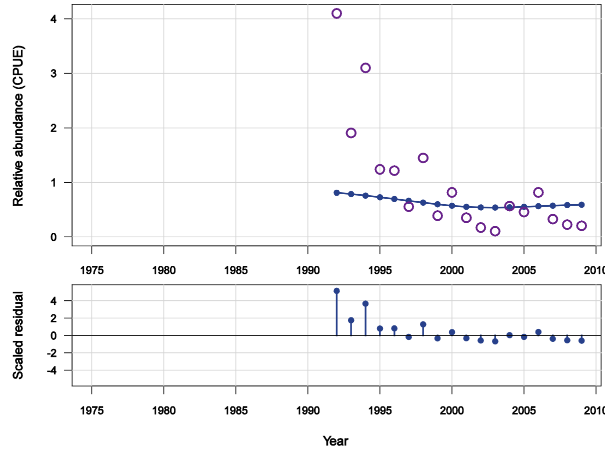
D. UNC Index

Figure 3.9. Fits to indices for sensitivity run S7 (All fishery independent indices). The ASCFM keyed in on the UNC index, resulting in estimates of extreme depletion.

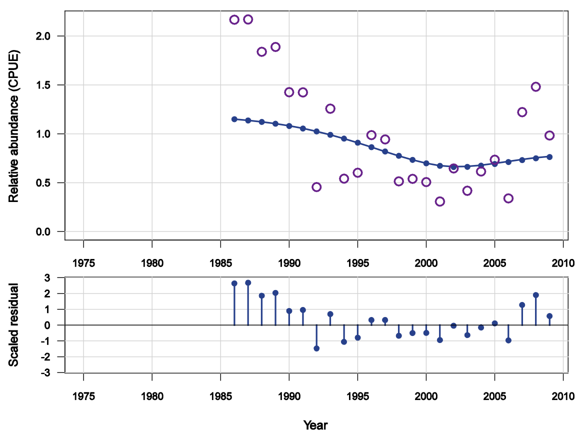
A. BLLOP



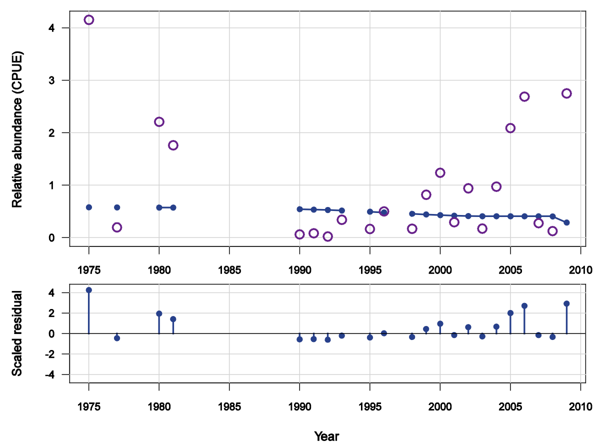
B. PLLOP



C. LPS



D. VIMS



E. NELL

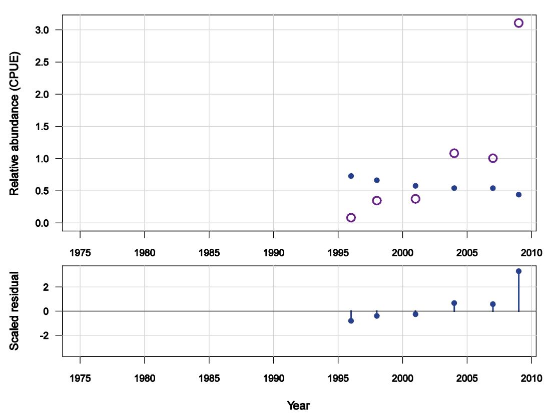


Figure 3.10. Fits to indices for sensitivity run S11(DW index rankings). Application of the ASCFM resulted in a "compromise fit" in this case, essentially resulting in a straight line through each of the indices

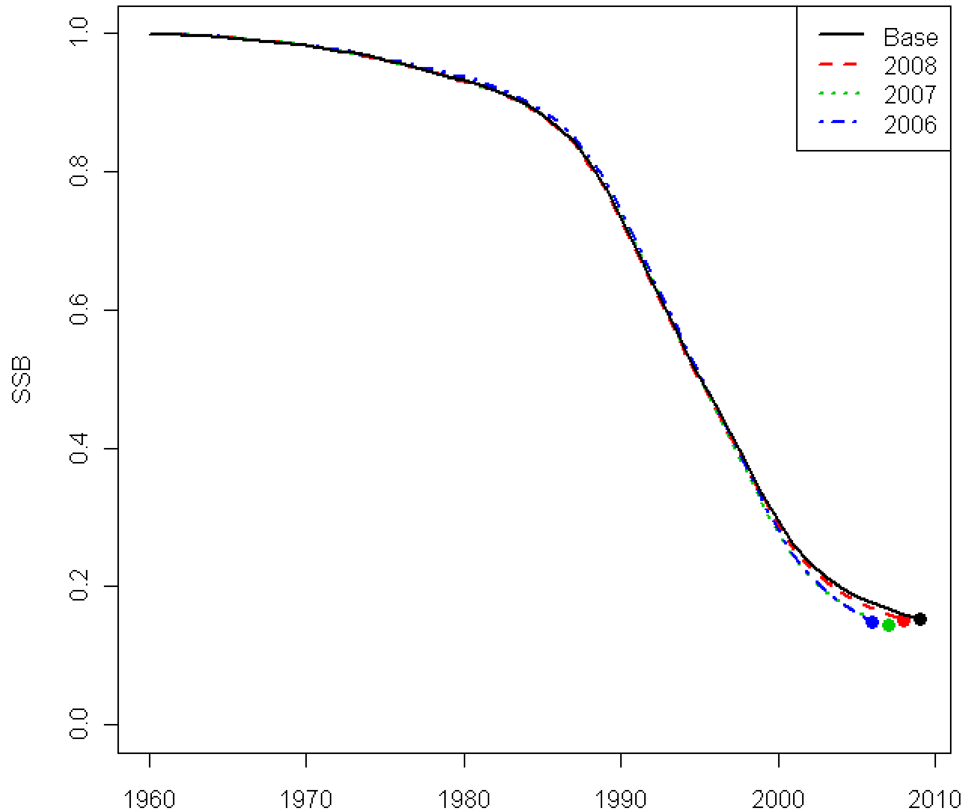


Figure 3.11. Retrospective pattern in spawning stock biomass as a function of the last year included in the ASCFM. The base model ended in 2009.

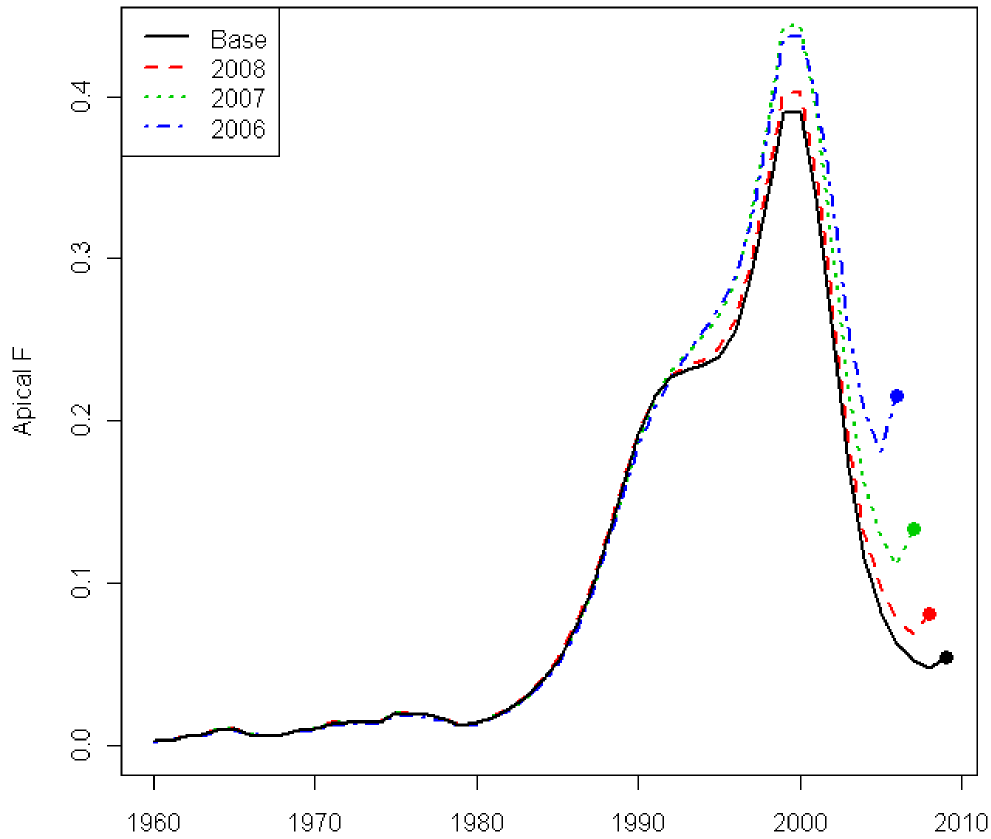


Figure 3.12. Retrospective pattern in estimated fishing mortality as a function of the last year included in the ASCFM. The base model ended in 2009.

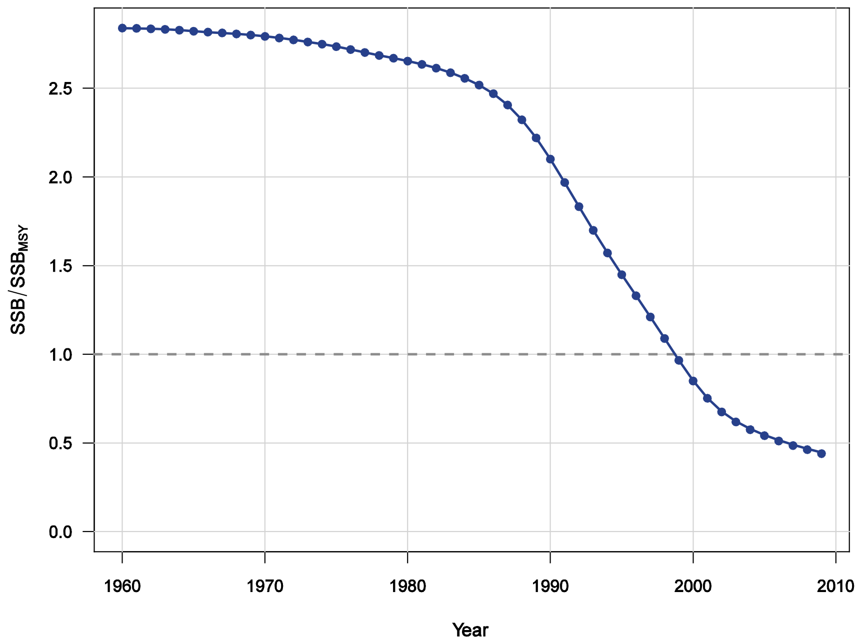


Figure 3.13 Spawning biomass relative to MSY levels over time from the base ASCFM model for dusky sharks.

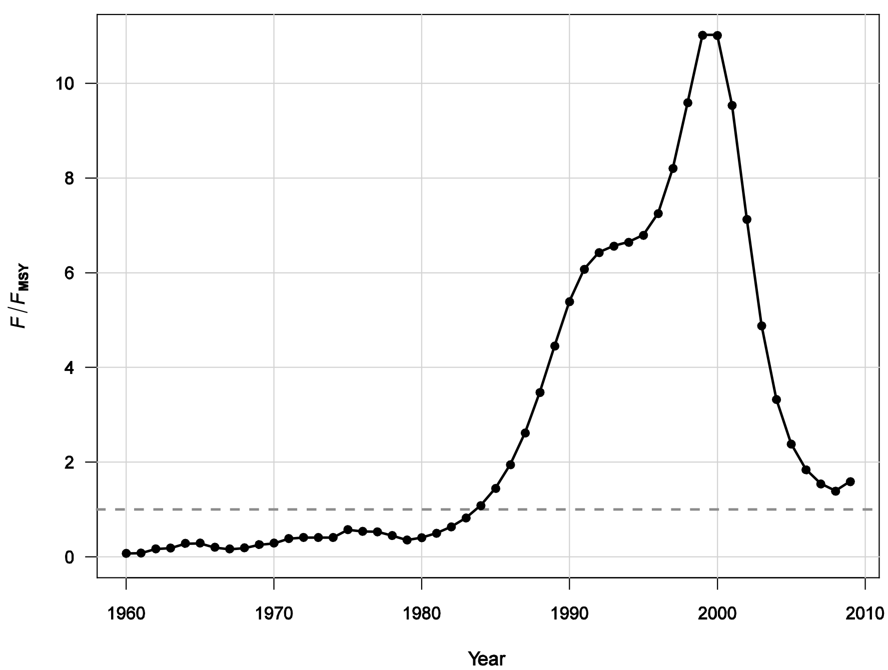


Figure 3.14. Apical fishing mortality relative to MSY levels for dusky sharks, 1960-2009. The base ASCFM indicated that overfishing has been occurring since 1984 (although there is considerable uncertainty about whether overfishing occurred during the last several years of the time series).

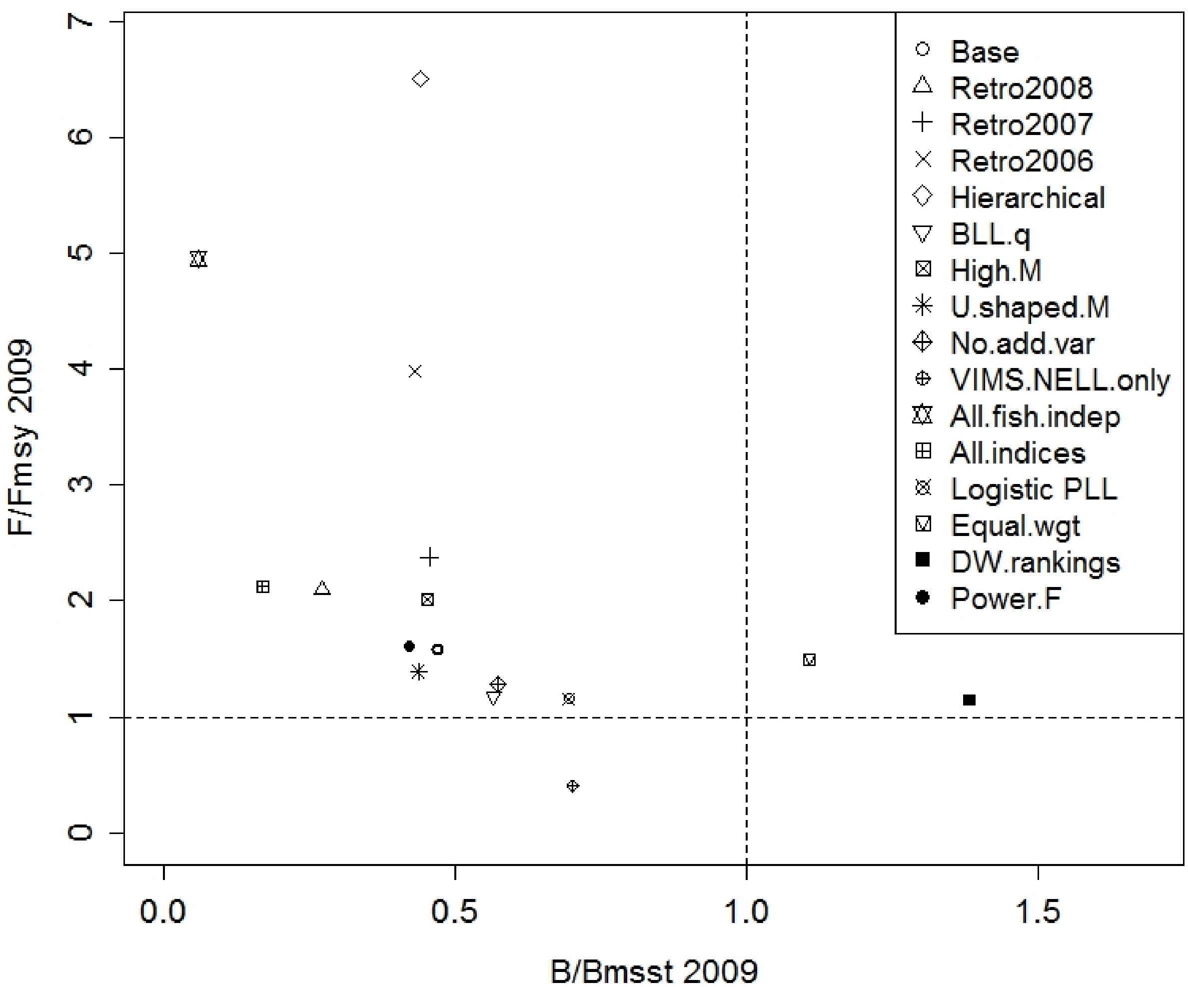


Figure 3.15. A phase plot summarizing stock status of dusky sharks in the terminal year of the assessment model according to various base, retrospective, and sensitivity runs. Points to the left of the vertical dashed line indicate runs in which the stock is estimated to be overfished; points above the horizontal black line indicate runs in which overfishing is estimated to have occurred.

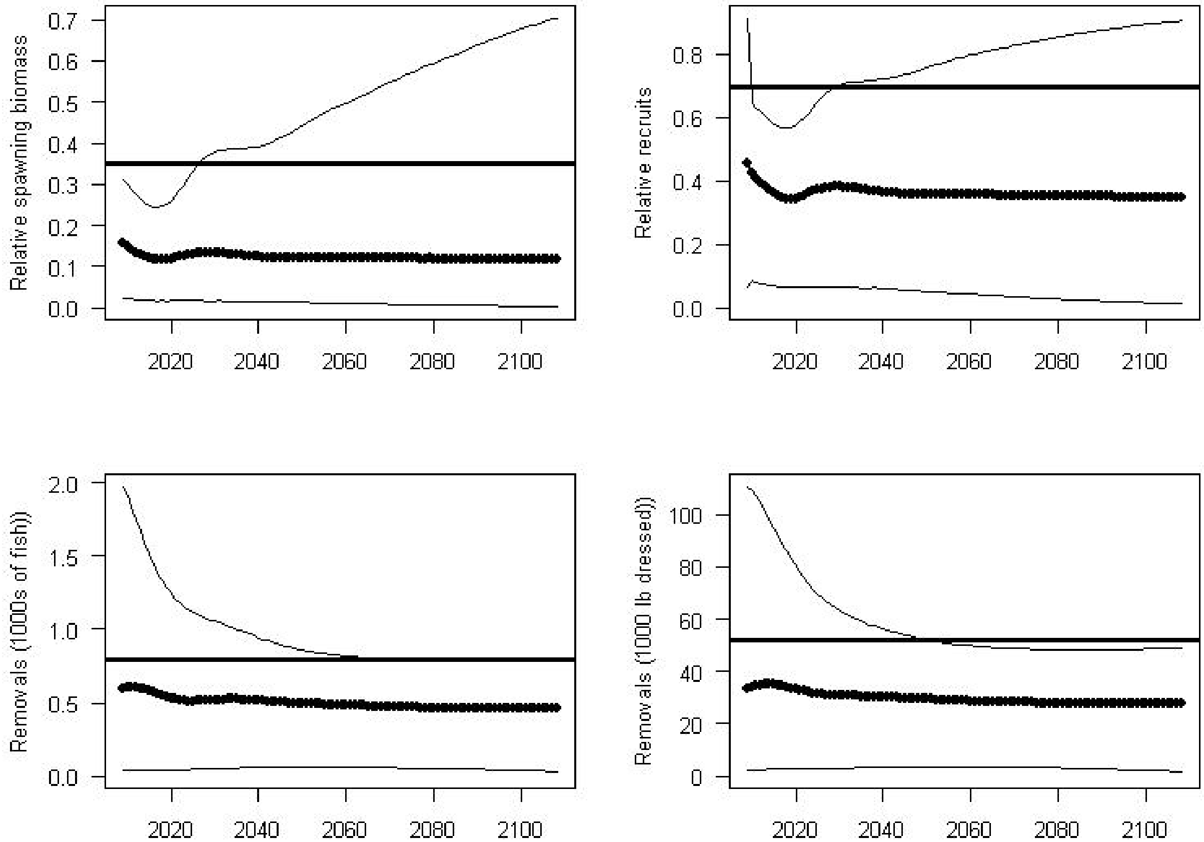


Figure 3.16. Results for the Fcurrent projection scenario, 2009-2108. The heavy dotted line gives the median projection, while thin solid lines give 95% uncertainty bounds. The horizontal line represents the corresponding value that would be anticipated at MSY.

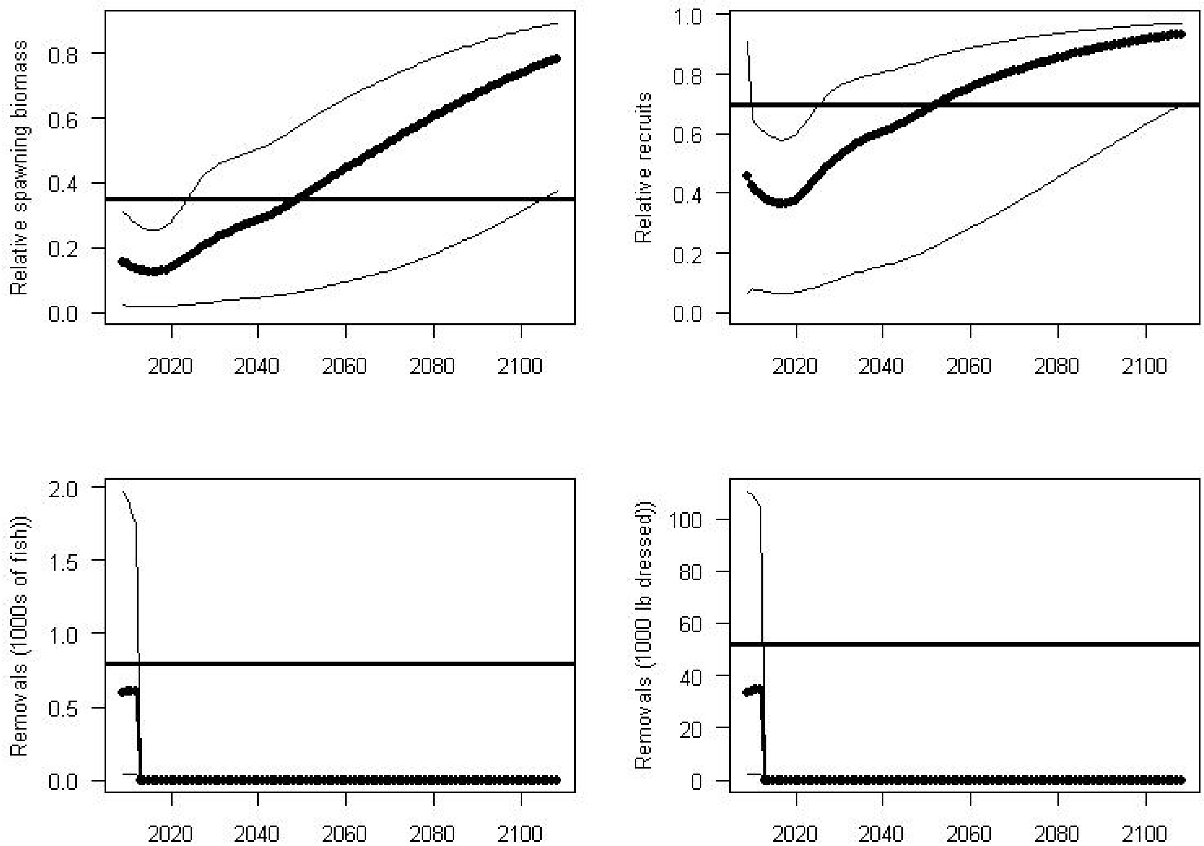


Figure 3.17. Results for the F0 projection scenario, 2009-2108. The heavy dotted line gives the median projection, while thin solid lines give 95% uncertainty bounds. The horizontal line represents the corresponding value that would be anticipated at MSY.

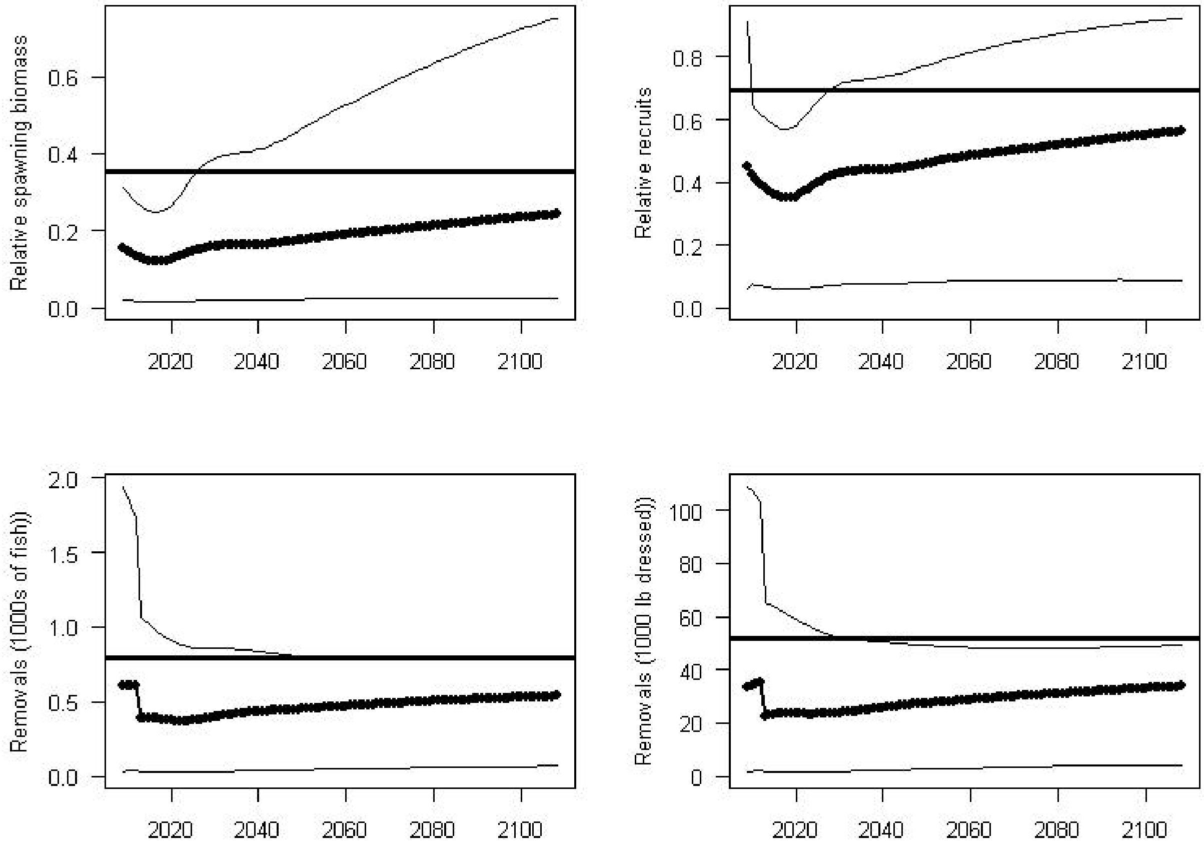


Figure 3.18. Results for the Fmsy projection scenario, 2009-2108. The heavy dotted line gives the median projection, while thin solid lines give 95% uncertainty bounds. The horizontal line represents the corresponding value that would be anticipated at MSY.

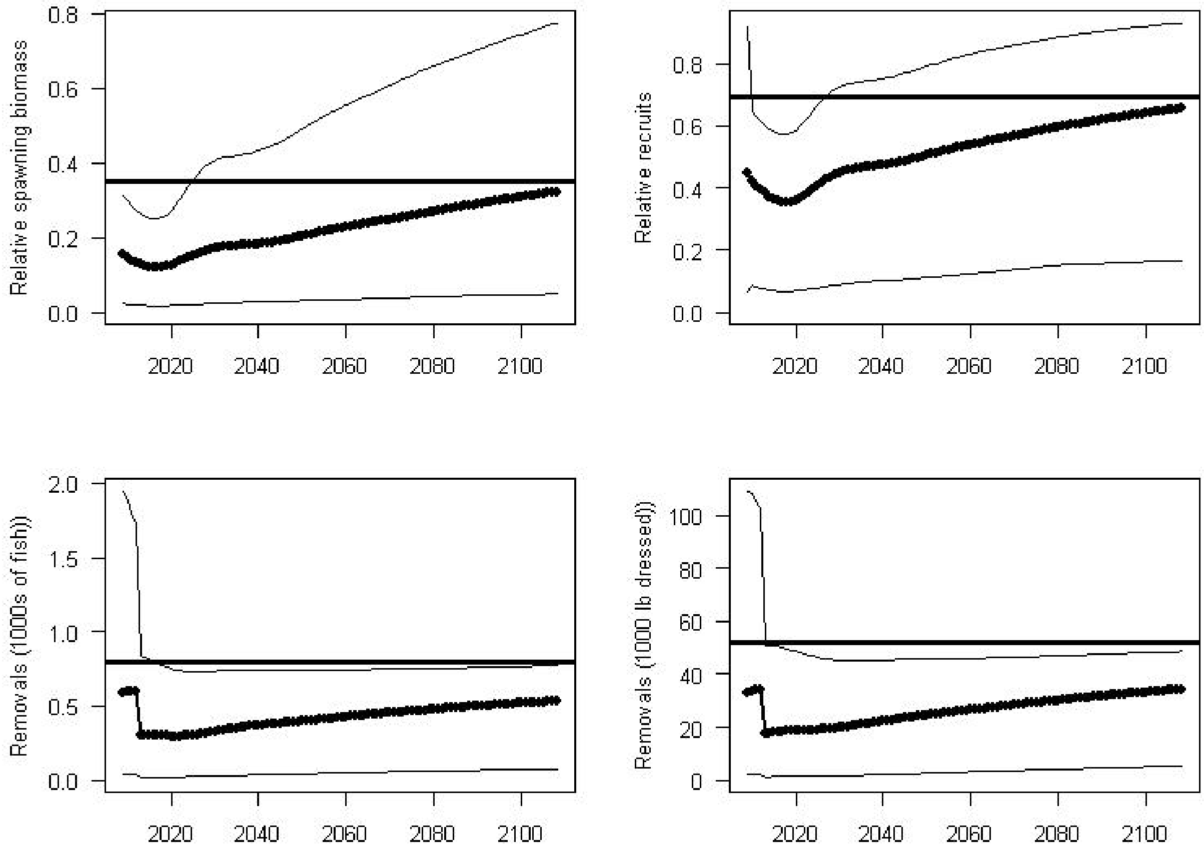


Figure 3.19. Results for the Ftarget projection scenario, 2009-2108. The heavy dotted line gives the median projection, while thin solid lines give 95% uncertainty bounds. The horizontal line represents the corresponding value that would be anticipated at MSY.

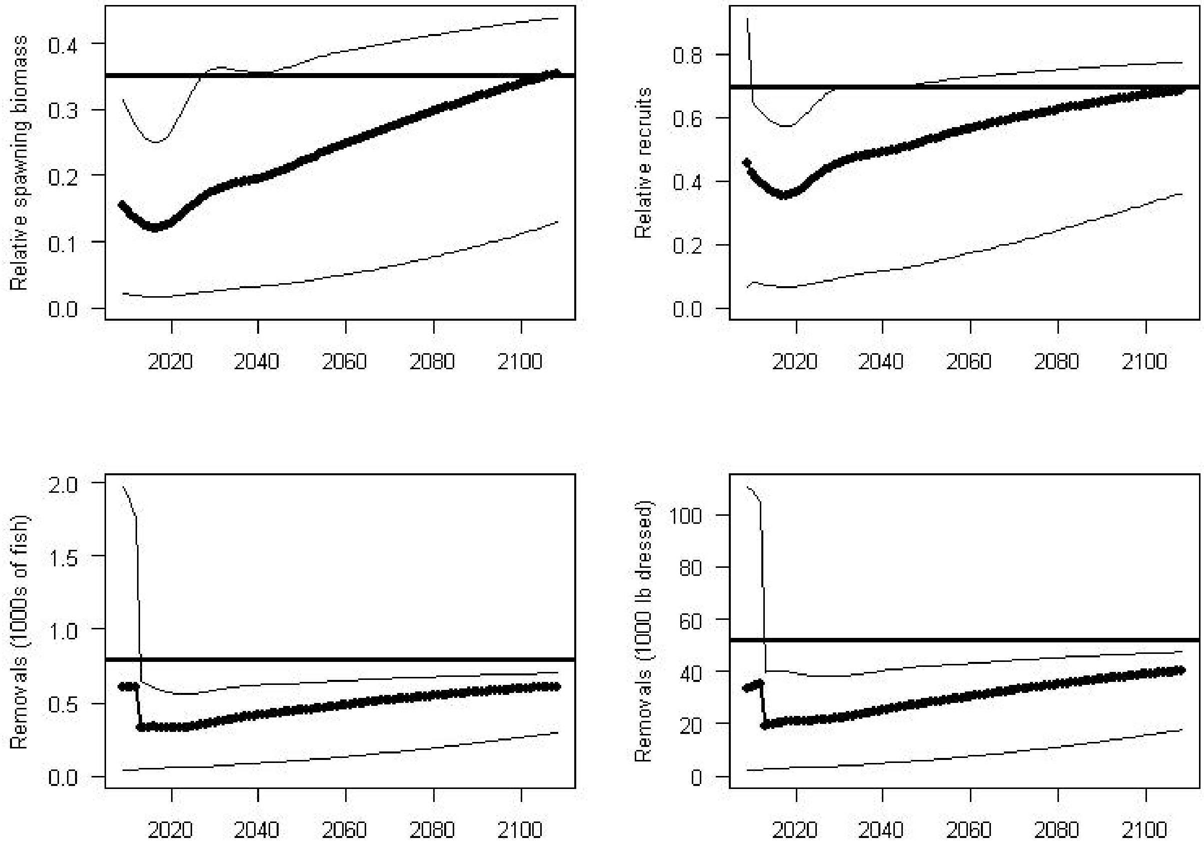


Figure 3.20. Results for the Frebuild50 projection scenario, 2009-2108. The heavy dotted line gives the median projection, while thin solid lines give 95% uncertainty bounds. The horizontal line represents the corresponding value that would be anticipated at MSY.

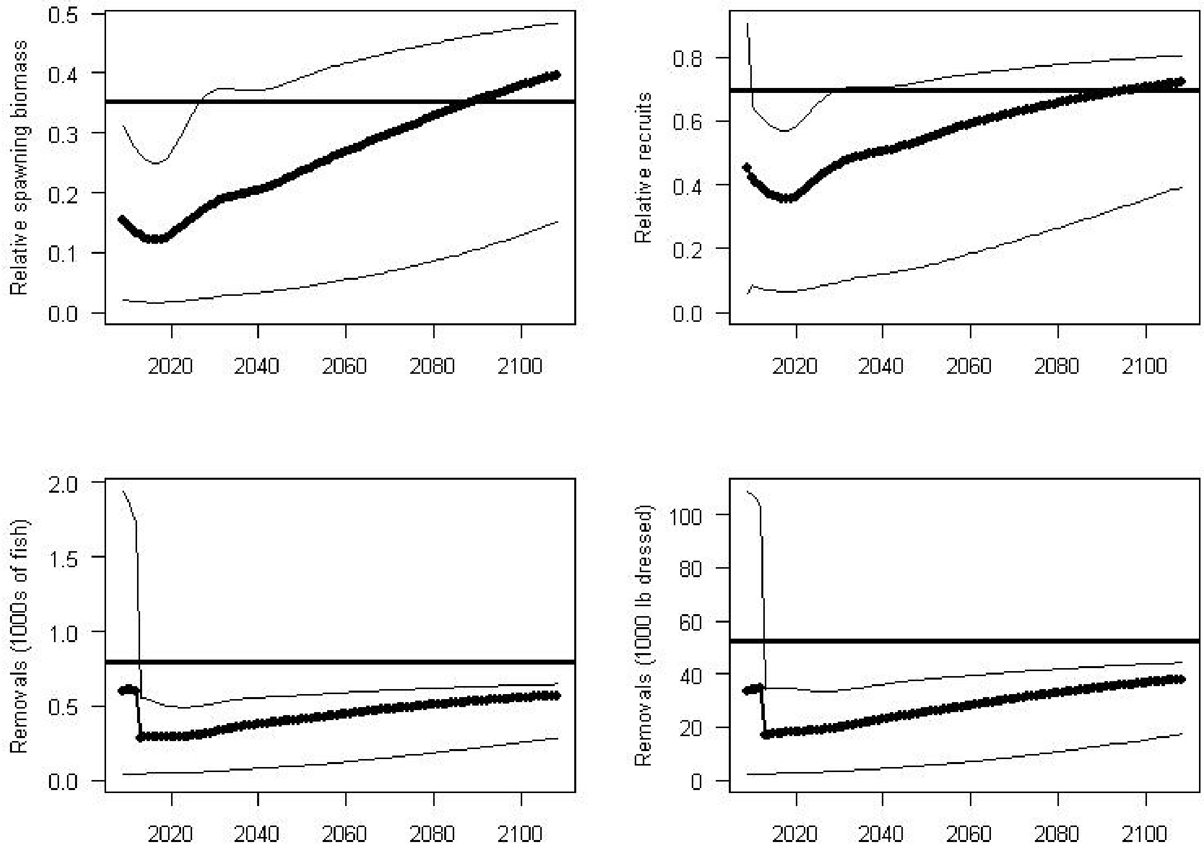


Figure 3.21. Results for the Frebuild70 projection scenario, 2009-2108. The heavy dotted line gives the median projection, while thin solid lines give 95% uncertainty bounds. The horizontal line represents the corresponding value that would be anticipated at MSY.

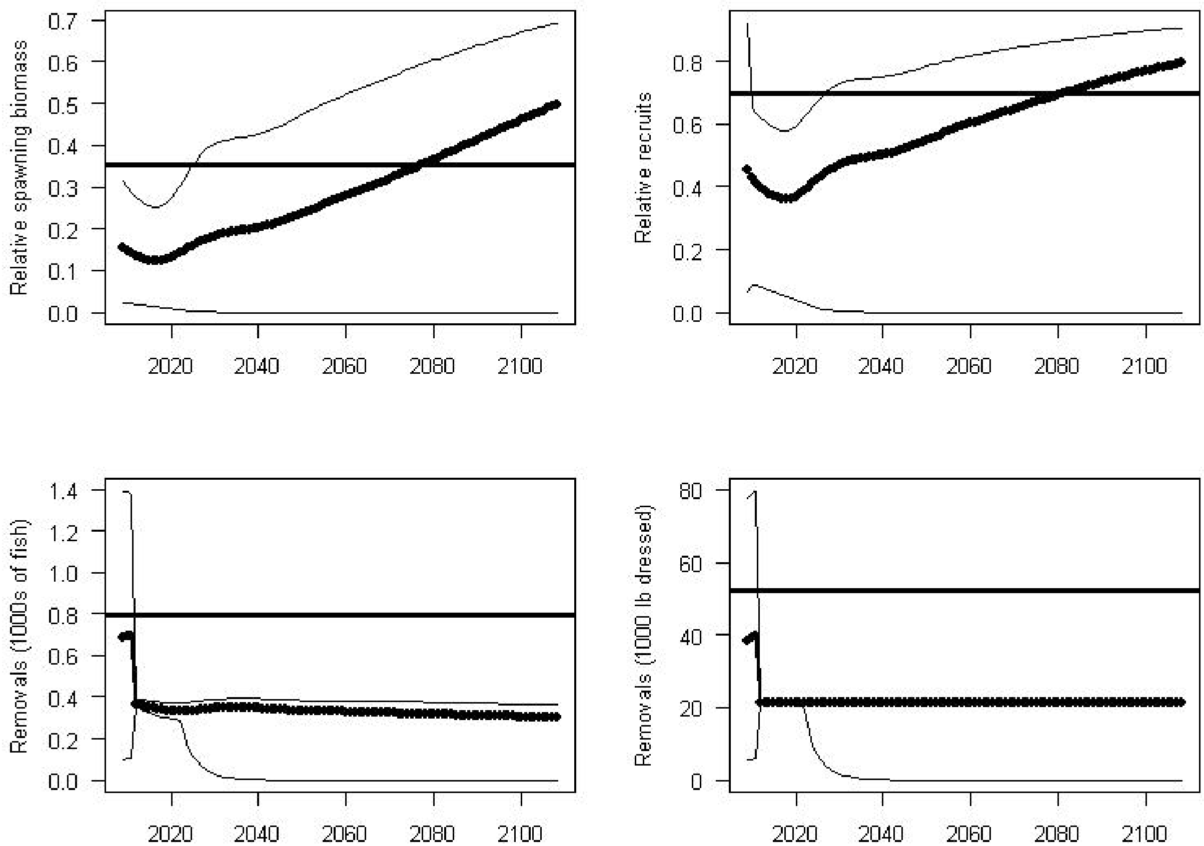


Figure 3.22. Results for the Fixed Removals projection scenario, 2009-2108. The heavy dotted line gives the median projection, while thin solid lines give 95% uncertainty bounds. The horizontal line represents the corresponding value that would be anticipated at MSY.

3.8. Appendix 1: Age-Length Key

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 (Natanson et al. 1995), determine the number of sharks at each age within a series of arbitrary length-classes (10 cm for dusky 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	28	29	30	31	32	33	34
80-90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	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	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	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100-110	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	0.0	0.0	0.0	0.0	0.0	0.0	0.0
110-120	81.8	18.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	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	33.3	33.3	16.7	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	0.0	0.0	0.0	0.0	0.0	0.0
130-140	25.0	0.0	12.5	12.5	12.5	12.5	12.5	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	0.0	0.0	0.0	0.0	0.0	0.0	0.0
140-150	0.0	0.0	0.0	25.0	75.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
150-160	0.0	0.0	0.0	25.0	50.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
160-170	0.0	0.0	0.0	0.0	0.0	80.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
170-180	0.0	0.0	0.0	0.0	0.0	33.3	33.3	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	0.0	0.0	0.0
180-190	0.0	0.0	0.0	0.0	0.0	25.0	0.0	25.0	25.0	0.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
190-200	0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3	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	0.0	0.0	0.0
200-210	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0	40.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
210-220	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0	0.0	20.0	0.0	0.0	40.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
220-230	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
230-240	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	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
240-250	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	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
250-260	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
260-270	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
270-280	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
280-290	0.0	0.0	0.0	0.0	0.0	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	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
290-300	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
300-310	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0	0.0	20.0	20.0	20	0.0	0.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0
310-320	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0	0.0	12.5	12.5	0.0	25	12.5	0.0	0.0	12.5	0.0	0.0	12.5	0.0	0.0
320-330	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.1	18.2	9.1	0.0	18.2	27.3	0.0	0.0	9.1	9.1
330-340	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0	0.0	0.0	0.0	0.0	0.0	20.0	20.0	0.0	20.0	20.0	0.0	0.0	0.0
340-350	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	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	0.0	0.0	0.0	0.0	50	0.0	0.0	0.0	0.0	0.0
350-360	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
360-370	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
370-380	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
380-390	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
390-400	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

3.9. 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 Dusky Shark

SECTION IV: Research Recommendations

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

1. DATA WORKSHOP RESEARCH RECOMMENDATIONS

1.1 LIFE HISTORY WORKING GROUP

- Increase research on post-release survivorship of all shark species by gear type
- Update age and growth and reproductive studies of dusky sharks.
- Develop empirically based estimates of natural mortality
- Continue tagging efforts

1.2 COMMERCIAL STATISTICS WORKING GROUP

No research recommendations were provided.

1.3 RECREATIONAL STATISTICS WORKING GROUP

No research 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

The greatest source of uncertainty about dusky sharks is clearly the amount of human induced removals (e.g., discards) that are occurring. However, it is difficult to recommend a single course of action to improve this situation, as uncertainty in removals stems from a number of sources (species misidentification, non-reporting, etc.). Nevertheless, improving the reliability of removal data would help assessment modeling immensely.

Another suggestion for improving the reliability of assessment advice is the development of a stock-wide fishery independent monitoring program. The present assessment is based on a combination of spatially-restricted fishery independent surveys and several fishery dependent surveys. The former are not ideal in that observed trends may better represent localized dynamics than stock wide trends; the latter are deficient in that observed trends may often reflect changes in catchability (for instance, due to differences among vessels, captains, and changes in targeting) rather than absolute abundance.

Finally, further assessment work would benefit from a consistent life history sampling program that gathers annual samples of length and age-frequencies. The current hodgepodge of length-at-age samples is not sufficient to implement catch-age or catch-length models, and is only marginally useful for constructing selectivity curves because temporal changes in age-frequencies are confounded with selectivity. Although an attempt was made to use existing age-length data to produce selectivity curves for the present assessment, this approach is clearly not ideal.

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.

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.

SEDAR

Southeast Data, Assessment, and Review

SEDAR 21

HMS Dusky Shark

SECTION V: Review Workshop Report

May 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 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	

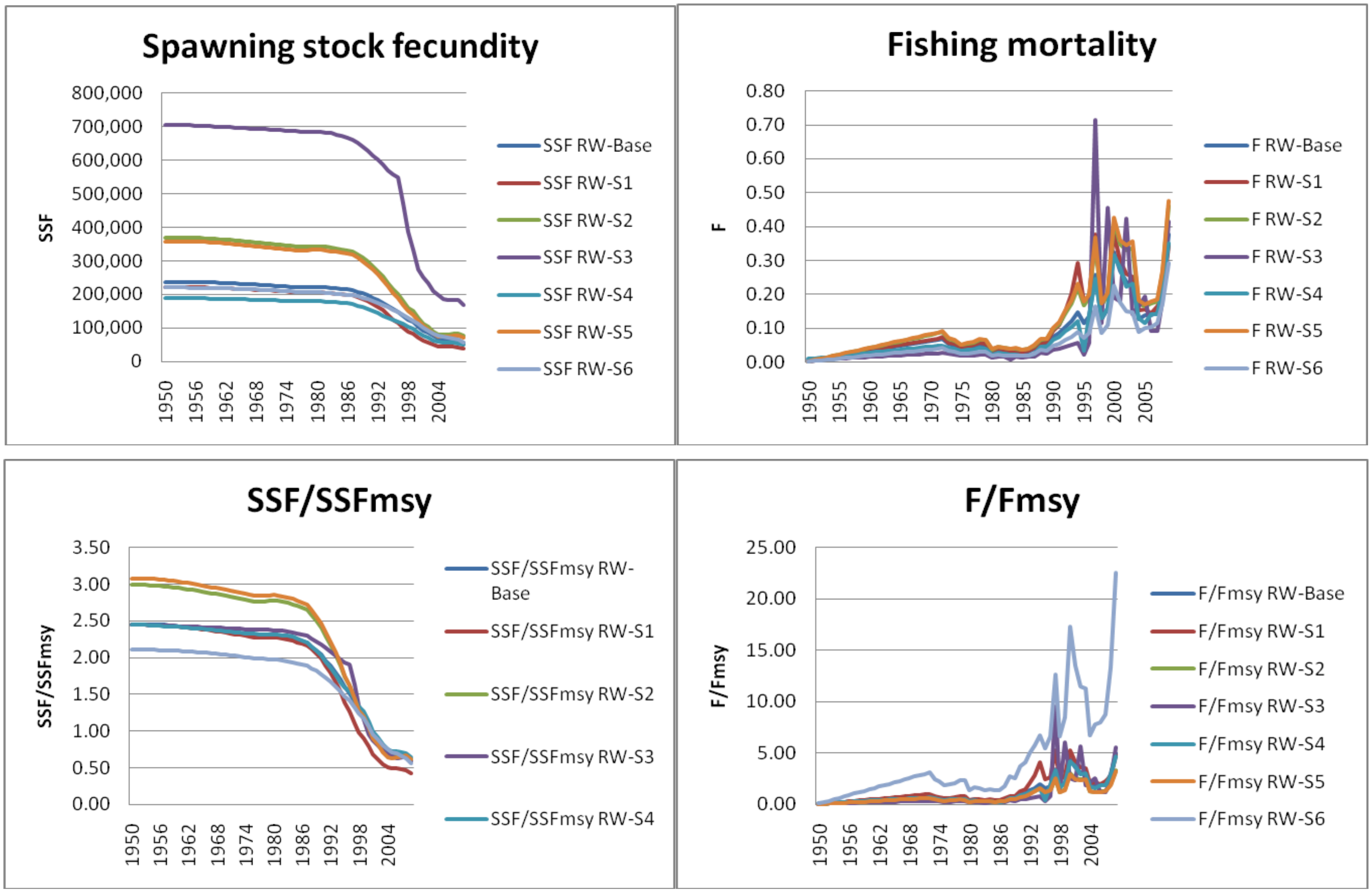


Figure 1. Time trajectories of key stock status indicators for Atlantic blacknose shark. Four trajectories are shown: SSF (spawning stock fecundity; top left panel), total apical F (top right panel), relative biomass (bottom left panel), and relative fishing mortality (bottom right panel). Each line within a panel is a different sensitivity analysis.

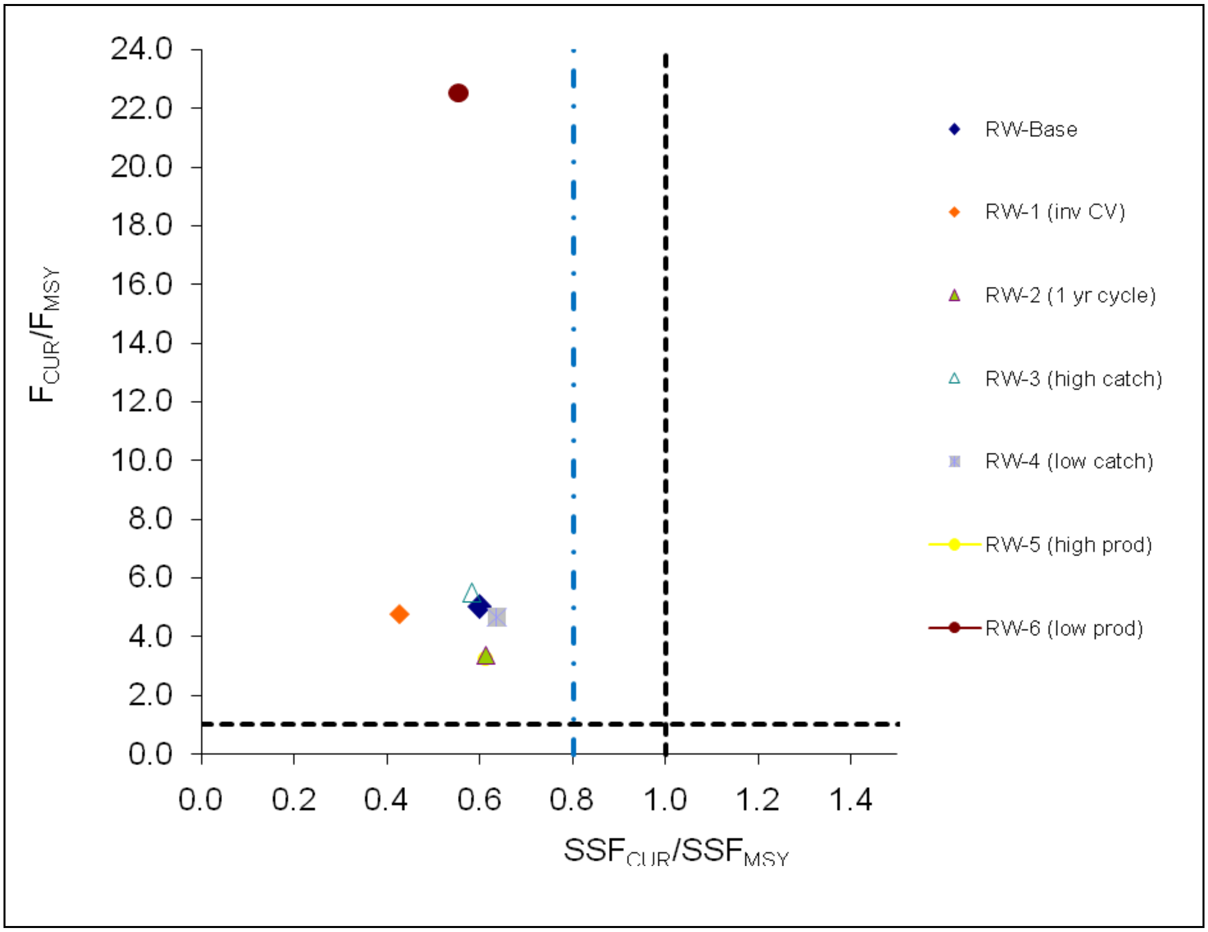


Figure 2. Phase plot of stock status for Atlantic blacknose shark, MSST shown as blue vertical dashed line.

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	

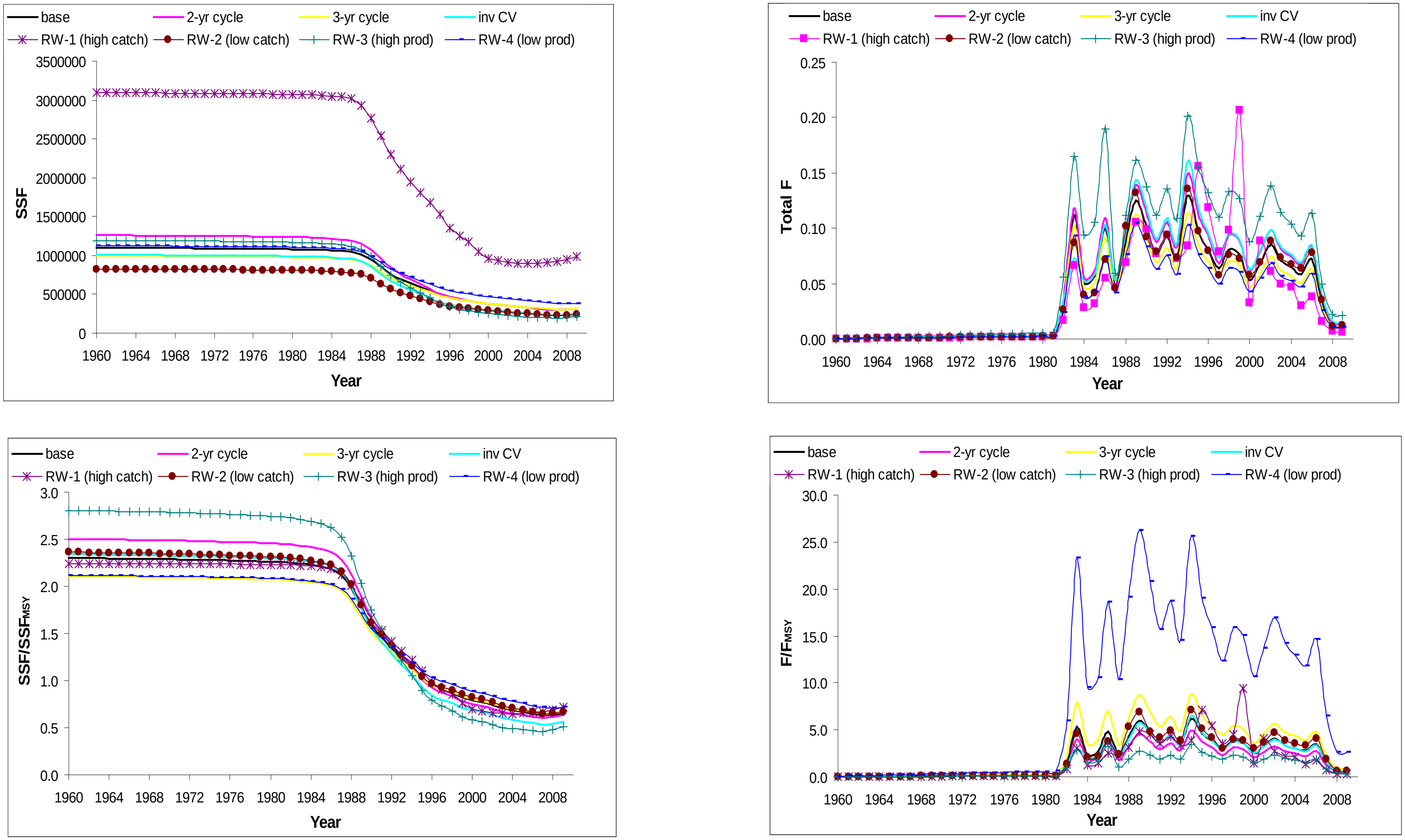


Figure 3. Time trajectories of key stock status indicators for sandbar shark. Four trajectories are shown: SSF (spawning stock fecundity; top left panel), total apical F (top right panel), relative biomass (bottom left panel), and relative fishing mortality (bottom right panel). Each line within a panel is a different sensitivity analysis.

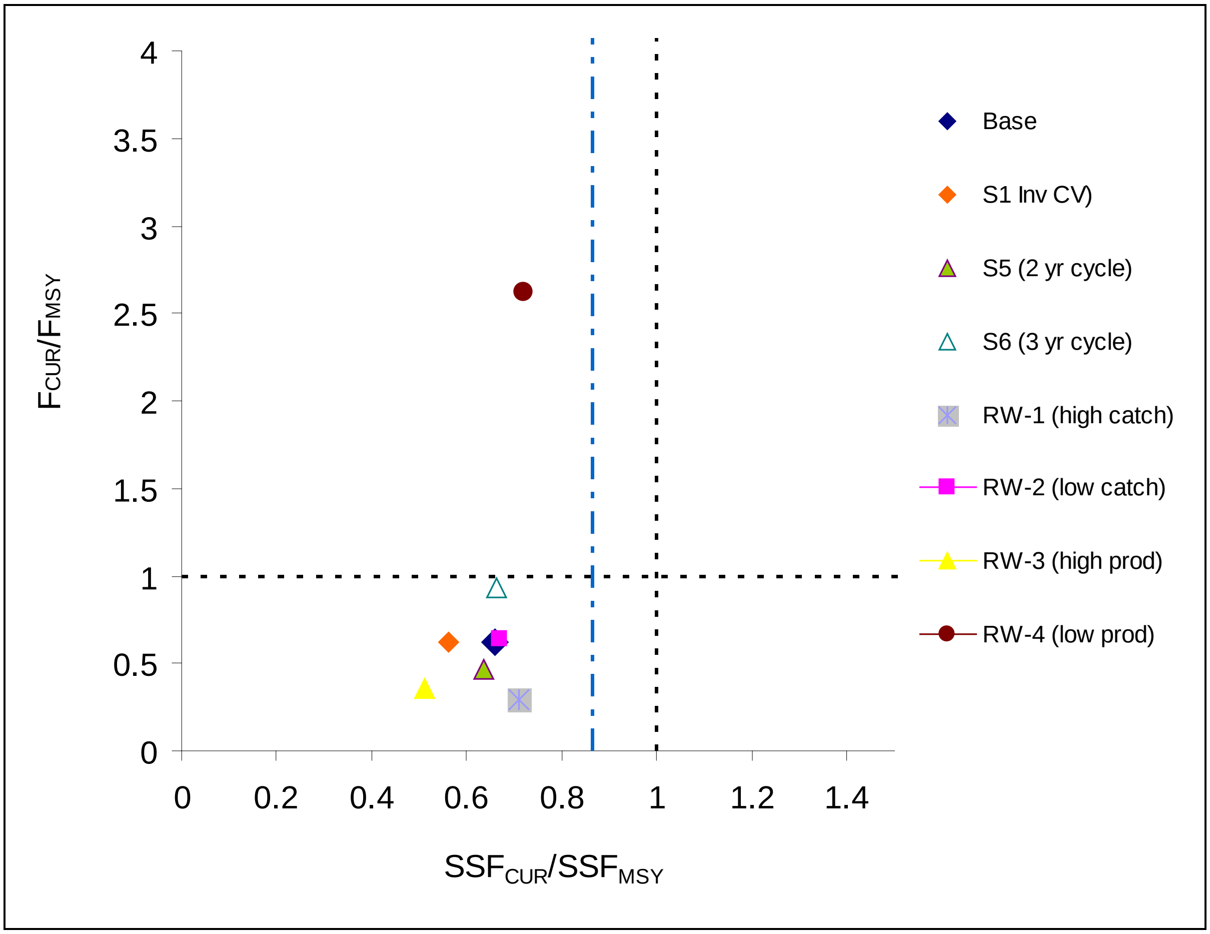


Figure 4. Phase plot of stock status for sandbar shark, MSST shown as blue vertical dashed line.

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

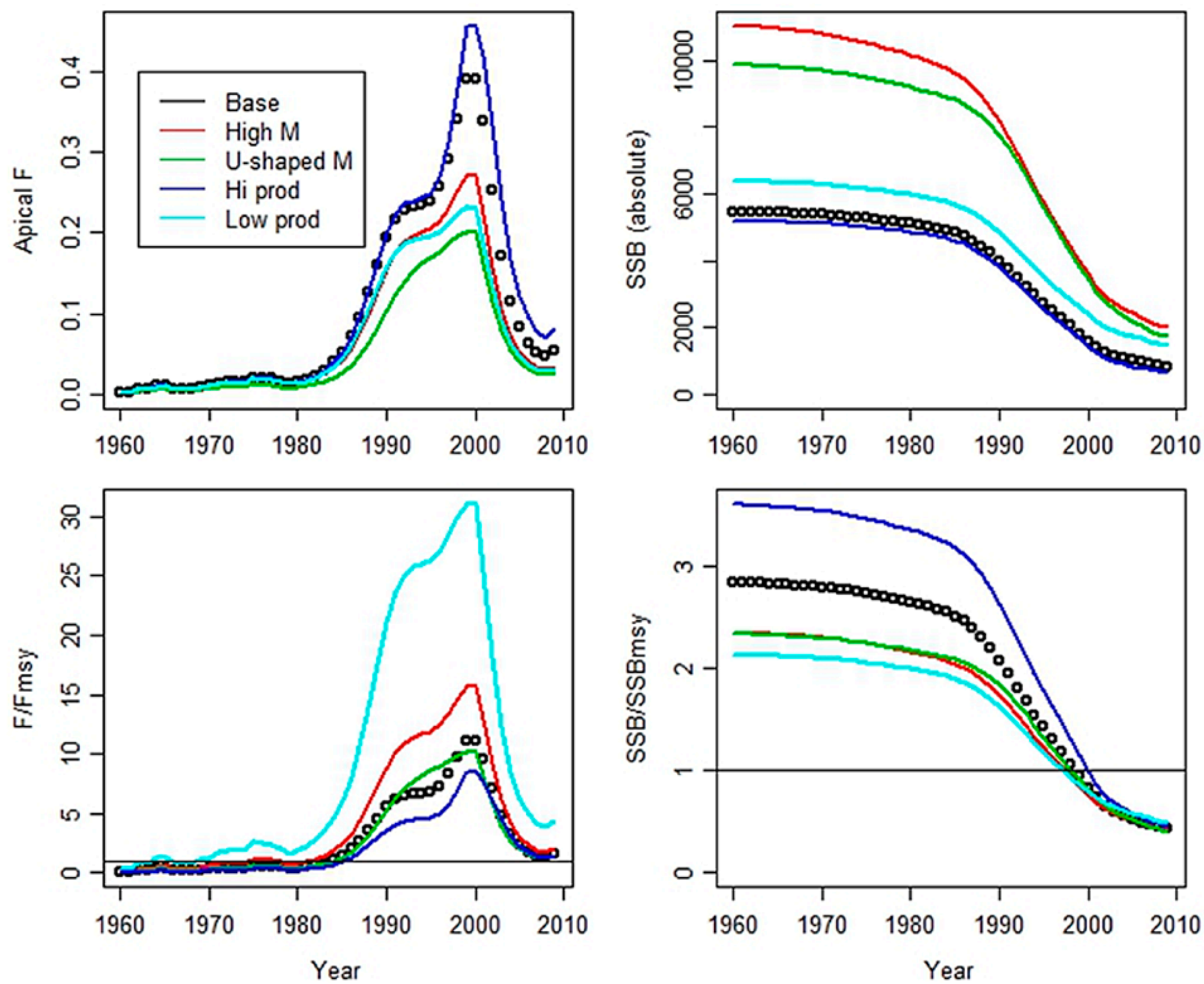


Figure 5. Time trajectories of key stock status indicators for dusky shark. Four trajectories are shown: total apical F (top left panel), SSB (spawning stock biomass; top right panel), relative fishing mortality (bottom left panel) and relative biomass (bottom right panel). Each line within a panel is a different sensitivity analysis.

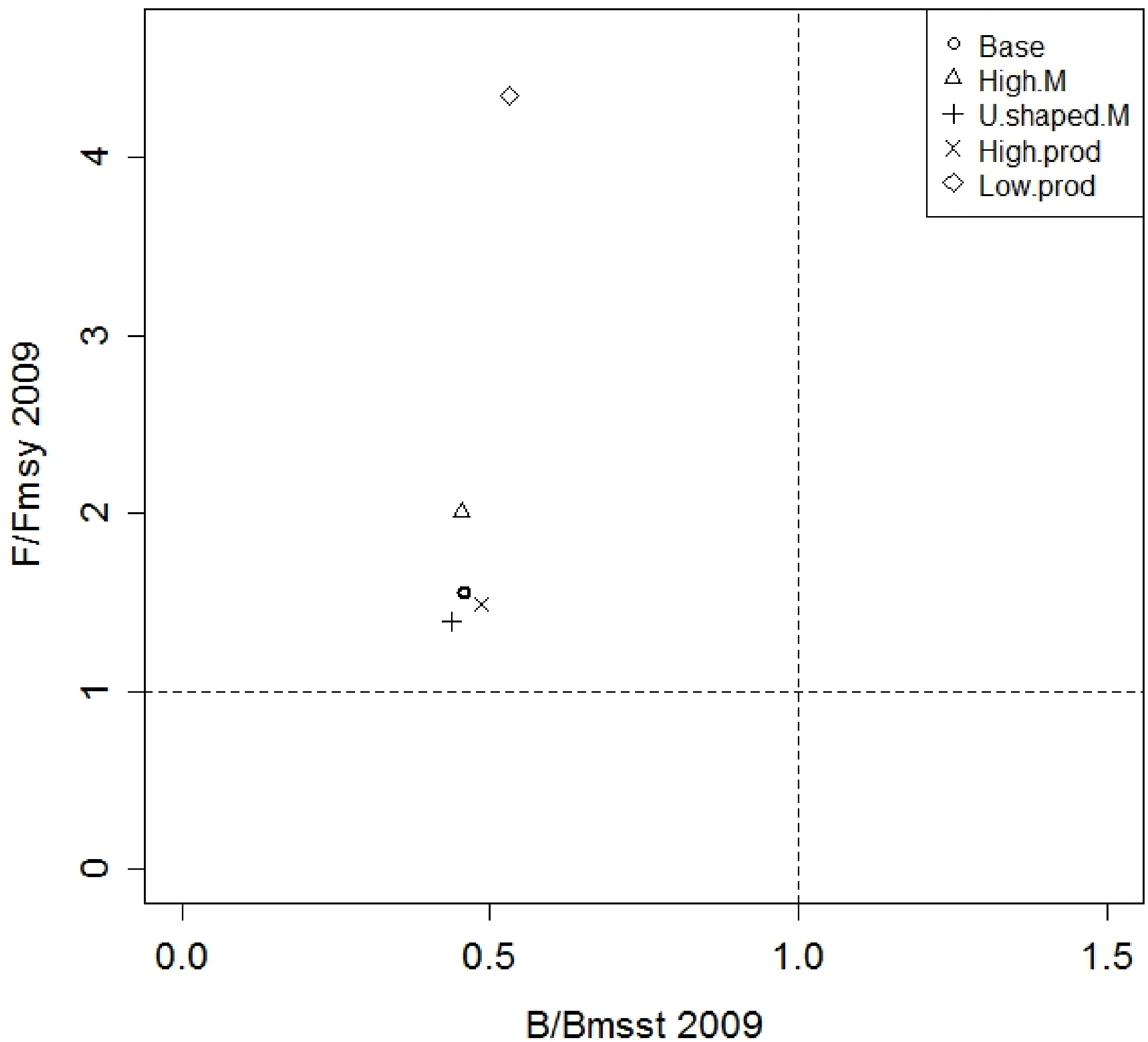


Figure 6. Phase plot of stock status for dusky shark (note that BMSST is used as a denominator for the X axis and not B_{MSY} as for the other species).

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.

Restrepo, V. R., G. G. Thompson, P. M. Mace, W. L. Gabriel, L. L. Low, A. D. MacCall, R. D. Methot, J. E. Powers, B. L. Taylor, P.R. Wade, and J. F. Witzig. 1998. Technical guidance on the use of precautionary approaches to implementing National Standard 1 of the Magnuson-Stevens Fishery Conservation and Management Act. NOAA Technical Memo. NMFS-F/SPO-31, 54p. National Technical information Center, 5825 Port Royal Road, Springfield, VA 22161.

Appendix I

SEDAR 21 HMS Sharks
Review Workshop 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

Observers
....SERO
....SERO

Staff
Julie Neer ....SEDAR
Tyree Davis...NMFS Miami

SEDAR

Southeast Data, Assessment, and Review

SEDAR 21

HMS Dusky Shark

Section VI: Addenda and Post-Review Updates

May 2011

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

6 Revisions

This addendum documents the results of several additional runs requested by reviewers at the SEDAR 21 Review Workshop (RW) for dusky sharks. A total of seven additional sensitivity analyses were run to provide verification that the results of the assessment were robust to assumptions about underlying stock productivity, choice of selectivity curves, choice of indices, and index weighting. 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 were noticed in Table 3.6. These have been corrected in Table 6.1. Additionally, it was found that the labels "Removals (wgt)" and "Removals (#'s)" were transposed in original projection tables (3.9-3.15).

6.1.2 Sensitivity analyses

Reviewers requested seven sensitivity runs to better understand how assessment outputs were related to key model assumptions. Requested runs were:

- S13: Revised DW Rankings Scenario. The initial DW rankings run (Dusky sensitivity run S11) provided extremely poor fits to indices; reviewers suggested rerunning this scenario with the CV for the highest ranked indices fixed to 0.22 (which is half the CV estimated from S11).
- S14: Full selectivity for PLL, NELL, and LPS starting at age 0 (Table 6.2).
- S15: Same as S14, but with BLL, NELL selectivity set to that of PLL in S14.
- S16: Variance for random walk on fishing mortality increased from 0.10 to 0.14
- S17: High productivity scenario. Assumed a biennial reproductive cycle, 10 pups per reproducing female, and a value for maximum pup survival of exp(-M0)=0.97.
- S18: Low productivity scenario. Assumed a triennial reproductive cycle, 4 pups per reproducing female, and a value for maximum pup survival of exp(-M0)=0.51
- S19: LPS index excluded

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." Projections were run for sensitivity runs thought to encapsulate the range of possible underlying productivity, mortality, and states of the stock in the terminal year of the assessment. These runs included the original "Base" run, as well as S3 (High M scenario), S4 (U-shaped M scenario), S17 (High productivity scenario), and S18 (Low productivity scenario). For each scenario, a scalar parameter ψ was estimated as in Equations 3.21 and 3.22 to scale up abundance to the level of absolute removals. For each scenario, we estimated the (1) the year in which F=0 would result in a 70% chance of recovery ($YearF{=}0_{p70}$), (2) the target rebuilding year, which was calculated as

$Year_{rebuild}$=($YearF=0_{p70}$)+40

(recall generation time is estimated at 40 years), (3) the apical F that would result in a probability of 0.5 of rebuilding by $Year_{rebuild}$, (4) the apical F that would result in a probability of 0.7 of rebuilding by $Year_{rebuild}$, (5) the fixed level of removals which would allow recovery of the stock with a probability of 0.5 by $Year_{rebuild}$, (6) the fixed level of removals which would allow recovery of the stock with a probability of 0.7 by $Year_{rebuild}$, (7) the probability of rebuilding with the estimated fishing mortality in 2009 by 2408, and (8) the probability of rebuilding if applying the estimated level of removals in 2009 up to 2408. Each scenario assumed that management measures would be implemented in 2013; in the interim, the fishing mortality estimated in 2009 was applied.

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 S3-High M. The implied prior distribution of steepness is a function of both pup survival and low biomass and spawners-per-recruit at F=0 (ϕ_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 6.3. Despite decreasing CV when trying to fit the DW rankings scenario, sensitivity S13 still resulted in poor fit to indices and was not recommended for use as an ‘alternate state of nature’ by the review panel. All other runs indicated that the stock was overfished and overfishing was occurring. A revised phase plot including results from all sensitivity runs in provided in Figure 6.1. Time series plots were produced for runs considered by reviewers to have encapsulated uncertainty in assessment results (Figure 6.2).

6.2.2 Projection results

Results of projections are summarized in Table 6.3. The target year for rebuilding ranged between 2081 and 2257 depending on the state of nature of the stock. All scenarios suggested that fishing mortality needed to be reduced in order to meet rebuilding targets. Since removals are generally not known for this stock, this will most likely need to be accomplished using effort reductions. The low productivity scenario was the most extreme, with projections indicating that effort needs to be reduced to about

1/30 of it's current value to result in a 70% chance of stock recovery by 2257 (to reduce apical F from around 0.03 to around 0.001). By contrast, projections of the high productivity scenario suggested that a reduction of fishing mortality by about 47% percent would be sufficient to rebuild the stock to MSY levels within the projection time frame.

6.2.3 Implied distributions of steepness

Implied priors on steepness are plotted in Figures 6.3 and 6.4.

6.4 Tables

Table 6.1. Summary of results for the original base and sensitivity runs (S1-S12) for dusky shark, together with sensitivity runs requested by the review panel (S13-S19). Highlighted fields indicate fields in which errors have been corrected. Relative spawning stock biomass is defined as in Equation 3.3.

Run	Description	F_{MSY}	SSB_{MSY}/SSB_0	SSB_{2009}/SSB_{MSST}	SSB_{2009}/SSB_{MSY}	F_{2009}/F_{MSY}	Pup survival	Steepness
Base	--	0.035	0.35	0.47	0.44	1.59	0.89	0.51
R2008	Retrospective to 2008	0.034	0.36	--	--	--	0.84	0.50
R2007	Retrospective to 2007	0.034	0.35	--	--	--	0.86	0.50
R2006	Retrospective to 2006	0.034	0.36	--	--	--	0.84	0.50
S1	Hierarchical index	0.033	0.36	0.44	0.41	6.50	0.82	0.49
S2	Decreased BLL q	0.035	0.35	0.57	0.53	1.18	0.90	0.51
S3	High M	0.017	0.43	0.45	0.42	2.01	0.95	0.32
S4	U shaped M	0.019	0.43	0.44	0.41	1.39	0.96	0.32
S5	No additional variance	0.035	0.35	0.57	0.53	1.28	0.89	0.51
S6	VIMS, NELL only	0.036	0.35	0.70	0.66	0.40	0.93	0.52
S7	All fishery indep	0.032	0.36	0.06	0.05	4.95	0.80	0.48
S8	All indices	0.034	0.36	0.17	0.16	2.12	0.86	0.50
S9	Logistic sel for PLL	0.025	0.36	0.70	0.65	1.16	0.95	0.53
S10	Equal weighting	0.034	0.36	1.11	1.03	1.50	0.85	0.50
S11	A priori rankings	0.033	0.36	1.38	1.29	1.14	0.88	0.49
S12	Power curve for historical F	0.035	0.35	0.42	0.39	1.61	0.89	0.51
S13	DW weighting (lower, fixed CV)	0.035	0.35	1.13	1.05	0.82	0.88	0.51
S14	Full selection at age 0	0.032	0.35	0.51	0.48	1.68	0.90	0.51
S15	S14 + descending selectivity matching PLL	0.039	0.35	0.81	0.75	3.34	0.87	0.50
S16	Variance for F random walk=0.14	0.035	0.35	0.47	0.44	1.34	0.89	0.51
S17	High productivity	0.054	0.28	0.49	0.45	1.49	0.97	0.71
S18	Low productivity	0.007	0.47	0.53	0.50	4.35	0.51	0.25
S19	Exclude LPS	0.036	0.35	0.47	0.44	4.12	0.91	0.52

Table 6.2. Vulnerability (selectivity) parameter for PLL, NELL, and LPS surveys as used in sensitivity run S14. Other sectors used the same selectivites as in the base run. 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)
PLLOP	Double logistic	7.13	9.35	1.41	8.07	0.17
LPS	Double logistic	0.00	34.19	12.82	4.38	0.47
NELL	Constant at 1.0					

Table 6.3. Summary of projection results for dusky shark, in form requested by SEDAR 21 reviewers.

	Terminal conditions					$F_{Year\_rebuild}$		TAC $_{Year\_rebuild}$			
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 2408	P(rebuild with 2009 TAC/removals) by 2408†
RW1:Base	0.056	1.59	0.44	2059	2099	0.026	0.021	27300	20100	0.11	0.46
RW2:High M	0.034	2.01	0.42	2150	2190	0.010	0.005	9500	4400	0.02	0.17
RW3: U-shape M	0.026	1.39	0.41	2107	2147	0.009	0.005	14800	6900	0.08	0.28
RW4:Hi Prod	0.080	1.49	0.45	2041	2081	0.046	0.042	46000	36400	0.12	0.52
RW5:Low Prod	0.030	4.35	0.50	2217	2257	0.003	0.001	6000	3900	0.01	0.06

†Note that uncertainty in terminal stock status translated into uncertain removals in the terminal year of the assessment; this uncertainty was propagated in this set of projection runs

6.5 Figures

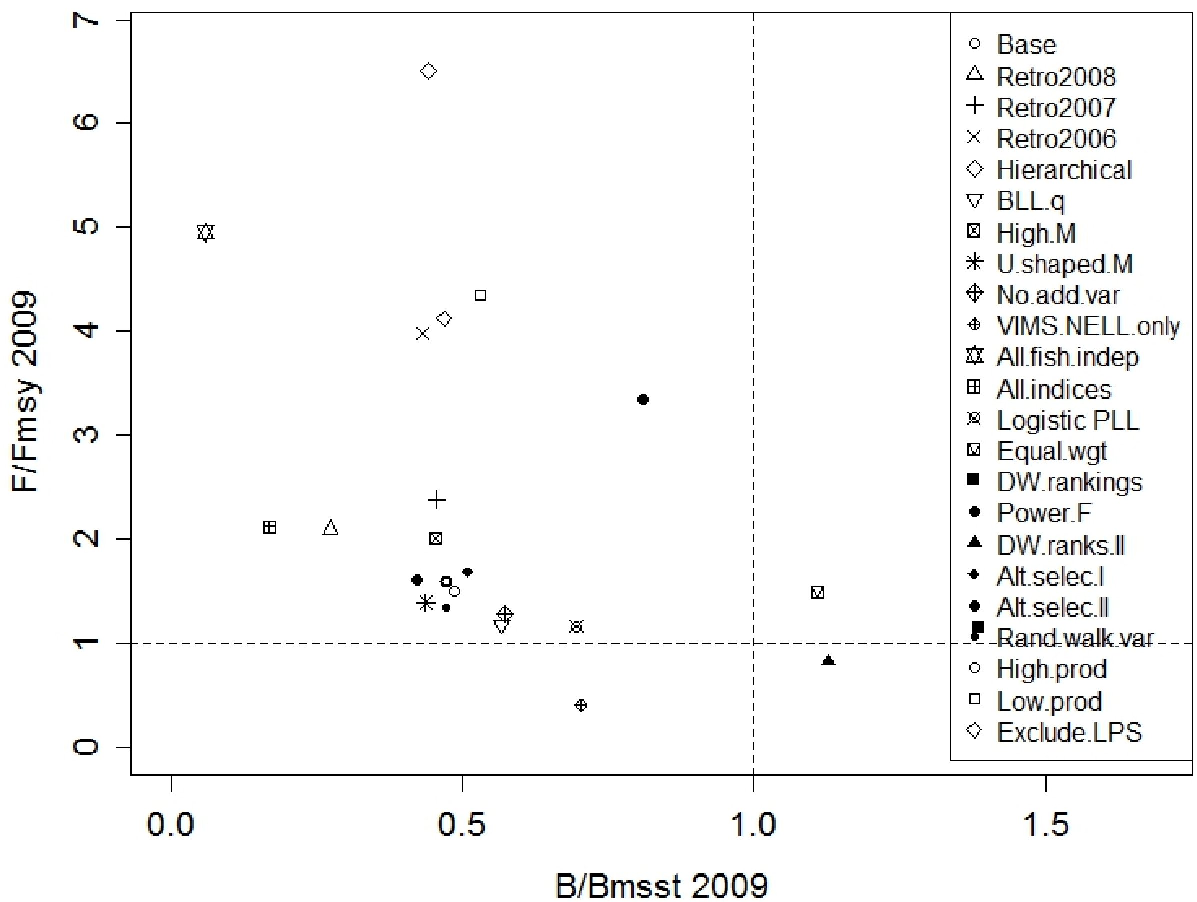


Figure 6.1. Phase plot summarizing stock status in 2009 for original base run and sensitivity analyses, as well as the seven sensitivity runs requested at the review workshop.

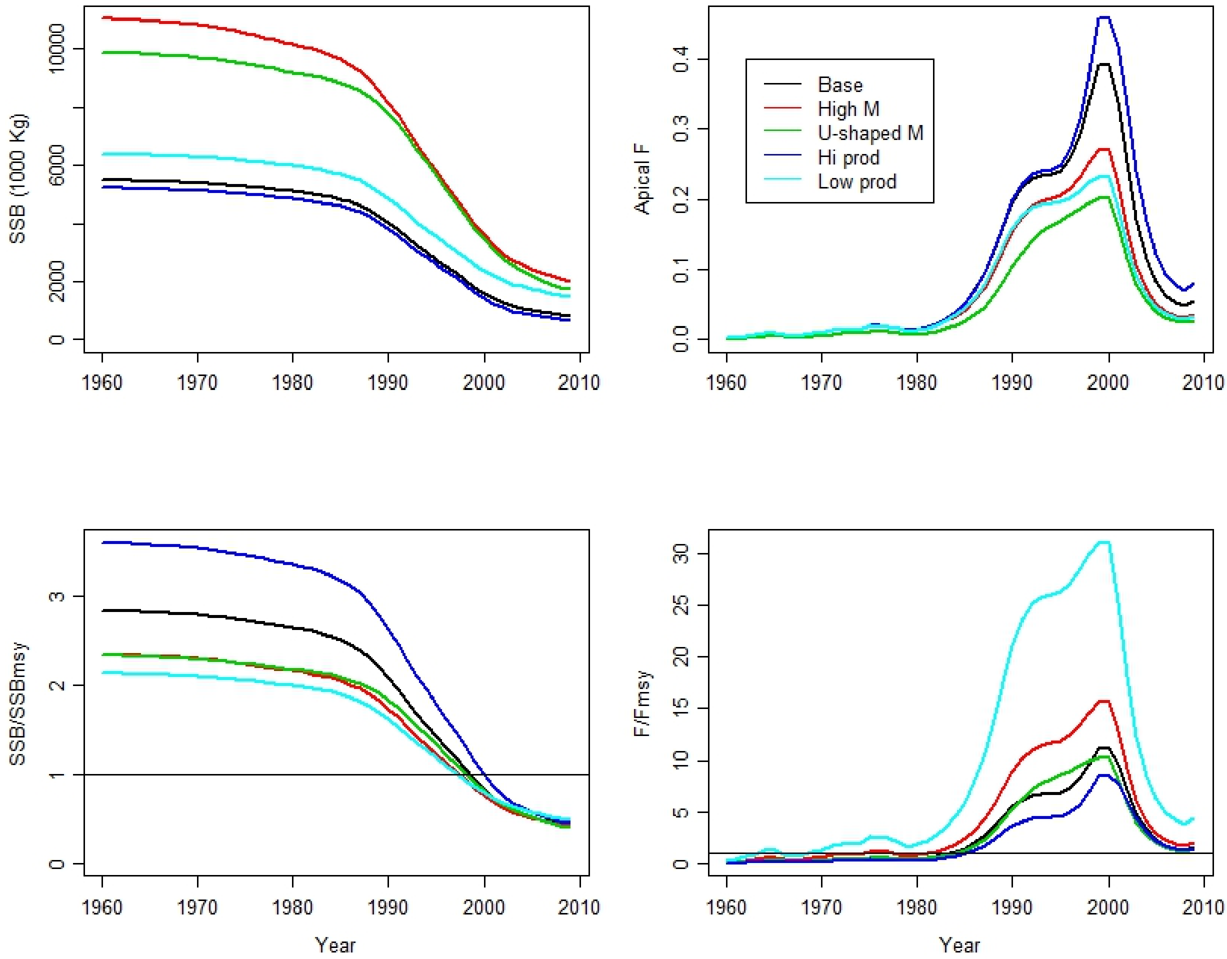


Figure 6.2. Estimated time series of spawning stock biomass (1000s of KG), apical fishing mortality rates, spawning stock biomass in relation to MSY levels, and fishing mortality rates in relation to MSY levels, for five runs thought to encapsulate uncertainty in the “state of nature” of the dusky stock.

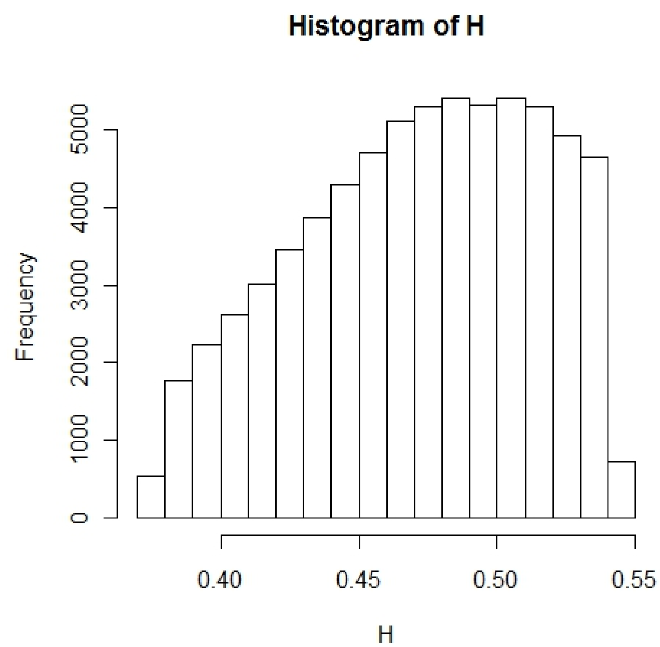


Figure 6.3. Implied steepness prior distribution for the base ASCFM run.

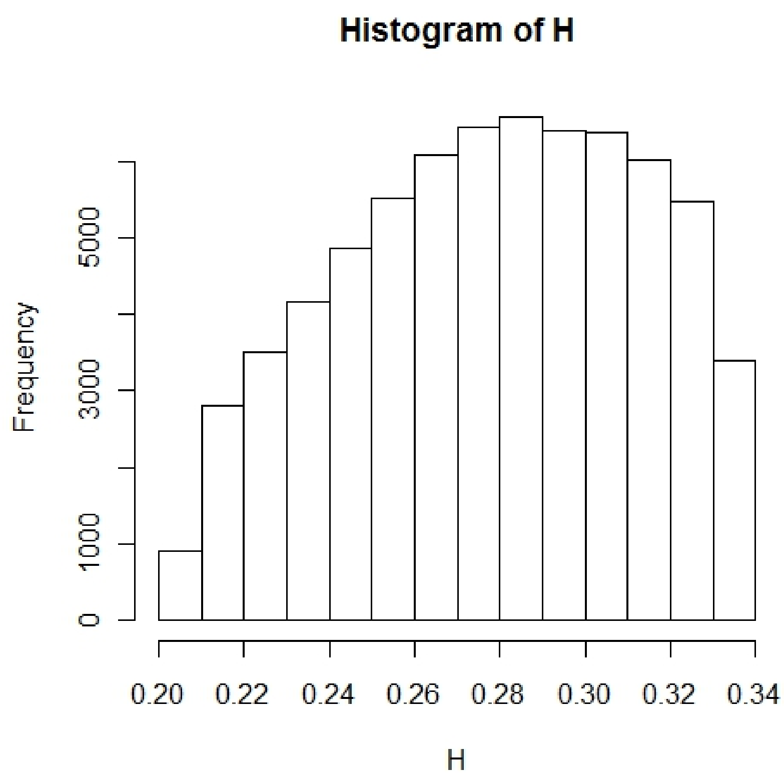


Figure 6.4. Implied steepness prior for sensitivity run S3: Hi M.