SEDAR

Southeast Data, Assessment, and Review

SEDAR 29

Stock Assessment Report

HMS Gulf of Mexico Blacktip Shark

May 2012

SEDAR

4055 Faber Place Drive, Suite 201

North Charleston, SC 29405

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SECTION I: Introduction

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1. SEDAR PROCESS DESCRIPTION

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

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

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

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

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

2. MANAGEMENT OVERVIEW

Presented to the 2011 Data Workshop of the Gulf of Mexico Blacktip Shark Stock Assessment

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1.0 Fishery Management Plans and Amendments

Given the interrelated nature of the shark fisheries, the following section provides an overview of federal shark management primarily since 1993 through 2010 for the Gulf of Mexico blacktip sharks. The following summary focuses only on those management actions that likely affect this species. The latter part of the document is organized according to the Gulf of Mexico blacktip sharks. The management measures implemented under fishery management plans and amendments are also summarized in Table 1.

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

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

In January 1978, the National Marine Fisheries Service (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;
- 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;

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

- 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 the 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 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 new regional commercial quotas and trimester commercial fishing seasons in the Gulf of Mexico: Jan 1-Feb 29 (190.3 mt dw) and July 1-Aug 15 (287.4 mt dw); (first Gulf of Mexico-specific LCS quotas)
- Adjusting the recreational bag (1 shark per vessel per trip) and size limits (minimum size of 4.5 feet forked length);
- 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;

[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.

- 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 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. On April 10, 2008, NMFS released the Final EIS for

Amendment 2 to the Consolidated HMS FMP, which implemented management measures based on the results of those assessments. 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. Based on the stock assessment, the blacktip sharks (*C. limbatus*) were separated for the first time into two stocks, Gulf of Mexico and Atlantic. The stock assessment for Gulf of Mexico blacktip sharks indicated that the stock was not overfished and did not have overfishing occurring. The stock assessment recommended that fishing mortality be maintained and not increased for blacktip sharks in both the Gulf of Mexico and Atlantic regions. NMFS implemented management measures consistent with those stock assessments for sandbar, porbeagle, dusky, blacktip 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 related to blacktip sharks that were implemented in Amendment 2 included:

- Implementing commercial quotas of 439.5 mt dw for Gulf of Mexico non-sandbar LCS and 188.3 mt dw for Atlantic non-sandbar LCS (non-sandbar LCS includes blacktip sharks along with other LCS);
- Establishing a 33 non-sandbar LCS per trip retention limit for directed permit holders and a 3 non-sandbar LCS per trip retention limit for incidental permit holders;
- Modified recreational measures to allow for the retention of one Atlantic sharpnose and one bonnethead shark per person per trip in addition to one shark per vessel per trip;
- Requiring that all Atlantic sharks be offloaded with fins naturally attached; and
- Collecting shark life history information via the implementation of a shark research fishery and establishing a non-sandbar LCS quota (including blacktip sharks) of 50 mt dw for the shark research fishery.

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 (73 FR 25665).

On June 1, 2010 (75 FR 30484), NMFS published the final rule for Amendment 3 to the Consolidated HMS FMP. While the measures were not specific to blacktip sharks, some of them may have resulted in fishermen changing fishing practices. The major measures that might have affected blacktip shark fishing were:

- Establishing new SCS commercial complexes and quotas (Non-blacknose SCS: 221.6 mt dw and blacknose shark: 19.9 mt dw);

- Linking the non-blacknose SCS and blacknose shark fisheries so that both fisheries close when landings of either reaches 80 percent of its quota; and
- Maintain all currently authorized gear types for the Atlantic shark fishery including gillnet gear (prohibiting gillnet gear from South Carolina south had been proposed).

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

On April 28, 2011 (76 FR 23794), NMFS determined that scalloped hammerhead sharks are overfished and experiencing overfishing. Based on the 2010/2011 Southeast Data, Assessment and Review (SEDAR) assessments for sandbar, dusky, and blacknose sharks, NMFS declared the following stock status determinations: sandbar sharks are still overfished, but no longer experiencing overfishing; dusky sharks are still overfished and still experiencing overfishing (i.e., their stock status has not changed); Atlantic blacknose sharks are overfished and experiencing overfishing; and Gulf of Mexico blacknose sharks have an unknown status (76 FR 62331; October 7, 2011). As such, NMFS announced its intent to prepare an EIS under the National Environmental Policy Act (NEPA) to put rebuilding plans and/or new management measures in place, as appropriate.

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

On September 20, 2010 (75 FR 57235), NMFS published an Advanced Notice of Proposed Rulemaking (ANPR) to provide background information and request public comment on potential adjustments to the regulations governing the U.S. Atlantic shark fisheries to address several specific issues and to identify specific goals for management of the shark fisheries in the future. NMFS requested public comment regarding the potential changes to the quotas and/or permit structure and the potential implementation of a catch share program. Public comments on quota structure addressed species complexes/quotas, regions, and retention limits, while comments on permit structure addressed issues associated with permit stacking and “use it or lose it” permits. On April 1, 2011, NMFS received a proposal from some regional stakeholders regarding a catch share program for the Atlantic shark fisheries in the Gulf of Mexico (GOM). These stakeholders recommended establishing an individual fishing quota (IFQ) system for non-sandbar large coastal sharks (LCS). In light of the comments received on the ANPR regarding a catch share program, the stakeholder proposal, and general support from the HMS Advisory Panel, NMFS is considering implementation of a catch share program for the Atlantic shark fisheries. On September 16, 2011 (76 FR 57709), NMFS published a Notice of Intent (NOI) to prepare an EIS and FMP Amendment that would consider catch shares for the Atlantic shark fisheries. The NOI also established a control date for eligibility to participate in an Atlantic shark catch share program, announced the availability of a white paper describing design elements of catch share programs in general and issues specific to the Atlantic shark fisheries, and requested public comment on the implementation of catch shares in the Atlantic shark fisheries.

Table 1 Federal FMP Amendments and regulations affecting Gulf of Mexico blacktip 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) – **blacktip sharks were not assessed by region and were included in the LCS complex**; • **Established calendar year commercial quotas for the LCS (2,436 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.
December 28,1993	58 FR 68556	• **Implementation of a commercial trip limit of 4,000 lb for permitted vessels for LCS.**
February 22, 1994	59 FR 8457	• Established a control date for the Atlantic shark fishery
October 18, 1994	59 FR 52453	• Implementing additional measures authorized by the 1993 FMP • 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

Effective Date	FMP/Amendment	Description of Action
		• Provided for commercial fishery closures when quotas were reached.
May 2, 1995	60 FR 21468	• **Established quota caps from LCs (2,570 mt dw) and pelagic sharks (580 mt dw) at the fishing levels from 1994.**
April 2, 1997	62 FR 16648	• **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; and** • 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.
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 the commercial LCS quota to 1,285 mt dw**; • **Reduced recreational retention limits for all sharks to 1 shark/vessel/trip** except for Atlantic sharpnose (1 Atlantic sharpnose/person/trip); • **Established a recreational minimum size for all sharks except Atlantic sharpnose (4.5 feet)**; • Established a shark public display quota (60 mt ww); • 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 new procedures for counting dead discards and state landings of sharks after Federal fishing season closures against Federal quotas; and established season-specific over- and underharvest adjustment procedures *(effective January 1, 2003)*; • Established ridgeback and non-ridgeback categories of LCS (annual quotas of 783 mt dw for non-ridgeback LCS & 931 mt dw for ridgeback LCS; *effective January 1, 2003; suspended after 2003 fishing year*); and, • Implemented a commercial minimum size for ridgeback LCS (*suspended*).
August 1, 2000	65 FR 47214	• Established closure of three large areas (DeSoto Canyon, Florida East Coast, and Charleston Bump) to pelagic longline fishing and prohibited the use of live bait in the Gulf of Mexico; • The DeSoto Canyon closure was effective on November 1, 2000; and • The Florida East Coast and Charleston Bump closures were effective March 1, 2001.
March 6, 2001	66 FR 13441	• **Established an LCS quota of 1,285 mt dw** and an SCS commercial quota of 1,760 mt dw; and • The rule expired on September 4, 2001.
December 28, 2001; extended May 29, 2002	66 FR 67118; extended 67 FR37354	• 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 for the 2002 fishing year; • **NMFS maintained the 1997 LCS commercial quota (1,285 mt dw),** and 1997 SCS commercial quota (1,760 mt dw); • Suspended the commercial ridgeback LCS minimum size, and counting dead discards and state landings after a Federal closure against the quota; • Replaced season-specific quota accounting methods with subsequent-season quota accounting methods; and • The rule expired on December 30, 2002.
September 24,	66 FR 48812	• Changed the requirements for the handling and release guidelines for sea turtles.

Effective Date	FMP/Amendment	Description of Action
2001		
December 27, 2002; extended May 29, 2003	67 FR 78990; extended 68 FR 31987	• Announced the availability of a modeling document that explored the suggestions of the CIE and NRC peer reviews on LCS. • Implemented management measures based on the results of both the 2002 SCS and LCS stock assessments; • Implemented commercial management measures for the 2003 fishing year based on the best available science; • **Established the LCS ridgeback/non-ridgeback split established in the 1999 FMP (ridgeback quota: 783 mt dw and non-ridgeback quota: 931 mt dw);** • **Suspended the commercial ridgeback LCS minimum size;** • 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.
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	• Re-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); • Established new 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** (Gulf of Mexico, South Atlantic, and North Atlantic) 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 30, 2004	69 FR 69538	• **Adjusted the percent quota for each region (Gulf of Mexico: 52%, South Atlantic: 41%, and North Atlantic: 7%)** • Established a 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 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 commercially-caught 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

Effective Date	FMP/Amendment	Description of Action
		HMS limited access permits (*effective January 1, 2007*); and • **Mandatory Atlantic shark identification workshops for all Federally permitted shark dealers** (*effective January 1, 2007*).
February 16, 2006	71 FR 8223	• Prohibited 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 through March 31, 2006.
February 7, 2007	72 FR 5633	• Expanded the equipment required for the safe handling, release, and disentanglement of sea turtles caught in the Atlantic shark BLL fishery • Required equipment for BLL vessels consistent with the requirements for the PLL fishery. • Implemented several year-round BLL closures to protect EFH to maintain consistency with the Caribbean Fishery Management Council
June 25, 2007	72 FR 34632	• Prohibited gillnet fishing, including shark gillnet fishing, from November 15 to April 15, between the NC/SC border and 29° 00' N; • Limited exemptions to the fishing prohibitions are provided for gillnet fishing for sharks. (29° 00' N and 26° 46.5' N) from December 1 through March 31 of each year; and • Required shark gillnet vessel operators to contact 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.
October 5, 2007	72 FR 57104	• Amended restrictions in the Southeast U.S. Monitoring Area from December 1 through March 31; • Prohibited fishing with or possession of 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; • Established the Southeast U.S. Monitoring Area 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; • Authorized selection of any shark gillnet vessel regulated under the ALWTRP to carry an observer; • Required selected vessels to take observers on a mandatory basis in compliance with the requirements for at-sea observer coverage; and • Prohibited any vessel that fails to carry an observer once selected from fishing.
July 24, 2008	Amendment 2 to the 2006 Consolidated HMS FMP	• Initiated 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 outside of shark research fishery with no sandbar shark retention = 33 non-sandbar LCS/vessel/trip for directed shark permit holders and 3 non-sandbar LCS/vessel/trip for incidental shark permit holders**; 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

Effective Date	FMP/Amendment	Description of Action
		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.
June 1, 2010	Amendment 3 to the 2006 Consolidated HMS FMP	• Established a non-blacknose SCS quota of 221.6 mt and a blacknose-specific quota of 19.9 mt; and, • Added smooth dogfish under NMFS management and establish a federal permit. Delayed implementation of management measures until 2012 fishing season. Established a moth dogfish quota equal to the maximum average annual landings plus two standard deviation (715.5 mt dw).

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).

2.0 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 2 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 69538).

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

Federal Register Cite	Date	Rule or Notice
58 FR 68556	12/28/1993	Interim final rule implementing trip limits
1994		
59 FR 3321	1/21/1994	Extension of comment period for 58 FR 68556
59 FR 8457	2/22/1994	Notice of control date for entry
59 FR 25350	5/16/1994	**LCS commercial fishery closure announcement**
59 FR 33450	6/29/1994	Adjusts second semi-annual 1994 quota
59 FR 38943	8/1/1994	**LCS commercial fishery closure announcement**
59 FR 44644	8/30/1994	**Reopens LCS fishery with new closure date**
59 FR 48847	9/23/1994	Notice of public scoping meetings
59 FR 51388	10/11/1994	**Rescission of LCS closure**
59 FR 52277	10/17/1994	Notice of additional scoping meetings
59 FR 52453	10/18/1994	Final rule implementing interim final rule in 1993 FMP
59 FR 55066	11/3/1994	**LCS commercial fishery closure announcement**
1995		
60 FR 2071	1/6/1995	**Proposed rule to adjust quotas**
60 FR 21468	5/2/1995	Final rule indefinitely establishes LCS quota at 1994 level
60 FR 27042	5/22/1995	**LCS commercial fishery closure announcement**
60 FR 30068	6/7/1995	Announcement of Shark Operations Team meeting
60 FR 37023	7/19/1995	Adjusts second semi-annual 1995 quota
60 FR 38785	7/28/1995	ANPR - Options for Permit Moratoria
60 FR 44824	8/29/1995	Extension of ANPR comment period
60 FR 49235	9/22/1995	**LCS commercial fishery closure announcement**
60 FR 61243	11/29/1995	Announces Limited Access Workshop
1996		
61 FR 21978	5/13/1996	**LCS commercial fishery closure announcement**
61 FR 37721	7/19/1996	Announcement of Shark Operations Team meeting.
61 FR 39099	7/26/1996	**Adjusts second semi-annual 1996 quota**
61 FR 43185	8/21/1996	**LCS commercial fishery closure announcement**
61 FR 67295	12/20/1996	**Proposed rule to reduce Quotas/Bag Limits**
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

Federal Register Cite	Date	Rule or Notice
62 FR 38942	7/21/1997	**LCS commercial fishery closure announcement**
1998		
63 FR 14837	3/27/1998	**LCS commercial fishery closure announcement**
63 FR 19239	4/17/1998	NOA of draft consideration of economic effects of 1997 quotas
63 FR 27708	5/20/1998	NOA of final consideration of economic effects of 1997 quotas
63 FR 29355	5/29/1998	**Adjusts second semi-annual 1998 LCS quota**
63 FR 41736	8/5/1998	**LCS commercial fishery closure announcement**
63 FR 57093	10/26/1998	NOA of draft 1999 FMP
1999		
64 FR 3154	1/20/1999	Proposed rule for draft 1999 FMP
64 FR 14154	3/24/1999	**LCS commercial fishery closure announcement**
64 FR 29090	5/28/1999	**Final rule for 1999 FMP**
64 FR 30248	6/7/1999	**Fishing season notification**
64 FR 37700	7/13/1999	**Technical amendment to 1999 FMP final rule**
64 FR 37883	7/14/1999	**Fishing season change notification**
64 FR 47713	9/1/1999	**LCS fishery reopening**
64 FR 52772	9/30/1999	Notice of Availability of outline for National Plan of Action for sharks
64 FR 53949	10/5/1999	**LCS closure postponement**
64 FR 66114	11/24/1999	**Fishing season notification**
2000		
65 FR 16186	3/27/2000	**Revised timeline for National Plan of Action for sharks**
65 FR 35855	6/6/2000	**Fishing season notification and 2nd semi-annual LCS quota adjustment**
65 FR 47214	8/1/2000	**Final rule closing Desoto Canyon, Florida East Coast, and Charleston Bump and requiring live bait for PLL gear in Gulf of Mexico**
65 FR 47986	8/4/2000	Notice of Availability of National Plan of Action for sharks
65 FR 38440	6/21/2000	Implementation of prohibited species provisions and closure change
65 FR 60889	10/13/2000	Final rule closed NED and required dipnets and line clippers for PLL vessels
65 FR 75867	12/5/2000	**Fishing season notification**
2001		
66 FR 55	1/2/2001	Implementation of 1999 FMP pelagic shark quotas
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**

Federal Register Cite	**Date**	**Rule or Notice**
67 FR 8211	2/22/2002	**Correction to fishing season notification 66 FR 67118**
67 FR 30879	5/8/2002	Notice of availability of SCS stock assessment
67 FR 36858	5/28/2002	Notice of availability of LCS sensitivity document and announcement of stock evaluation workshop in June
67 FR 37354	5/29/2002	Extension of emergency rule and fishing season announcement
67 FR 45393	7/9/2002	Final rule to implement measures under 2001 BiOp (gangion placement measure not implemented), including HMS shark gillnet measures
67 FR 64098	10/17/2002	**Notice of availability of LCS stock assessment and final meeting report**
67 FR 69180	11/15/2002	Notice of intent to conduct an environmental impact assessment and amend the 1999 FMP
67 FR 72629	12/6/2002	Proposed rule regarding EFPs
67 FR 78990	12/27/2002	**Emergency rule to implement measures based on stock assessments and fishing season notification**
2003		
68 FR 1024	1/8/2003	Announcement of 4 public hearings on emergency rule
68 FR 1430	1/10/2003	Extension of comment period for proposed rule on EFPs
68 FR 3853	1/27/2003	Announcement of 7 scoping meetings and notice of availability of Issues and Options paper
68 FR 31983	5/29/2003	Emergency rule extension and fishing season notification
68 FR 45196	8/1/2003	Proposed rule and NOA for draft Amendment 1 to 1999 FMP
68 FR 47904	8/12/2003	Public hearing announcement for draft Amendment 1 to 1999 FMP
68 FR 51560	8/27/2003	Announcement of HMS AP meeting on draft Amendment 1 to 1999 FMP
68 FR 54885	9/19/2003	Rescheduling of public hearings and extending comment period for draft Amendment 1 to 1999 FMP
68 FR 64621	11/14/2003	NOA of availability of Amendment 1
68 FR 66783	11/28/2003	NOI for SEIS
68 FR 74746	12/24/2003	**Final Rule for Amendment 1**
2004		
69 FR 6621	02/11/04	Proposed rule for PLL fishery
69 FR 10936	3/9/2004	SCS fishery closure
69 FR 19979	4/15/2004	VMS type approval notice
69 FR 26540	5/13/2004	N. Atlantic Quota Split Proposed Rule
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 69538	11/30/2004	**Regional quota split final rule and season announcement**
69 FR 71735	12/10/2004	Correction notice for 69 FR 6954

Federal Register Cite	Date	Rule or Notice
2005		
70 FR 11922	3/10/2005	2nd and 3rd season proposed rule
70 FR 21673	4/27/2005	**2nd and 3rd season final rule**
70 FR 24494	5/10/2005	North Carolina Petition for Rulemaking
70 FR 29285	5/20/2005	Notice of handling and release workshops for BLL fishermen
70 FR 48804	8/19/2005	Proposed rule Draft Consolidated HMS FMP
70 FR 48704	8/19/2005	NOA of Draft EIS for Draft Consolidated HMS FMP
70 FR 52380	9/2/2005	Correction to 70 FR 48704
70 FR 53146	9/7/2005	Cancellation of hearings due to Hurricane Katrina
70 FR 54537	9/15/2005	**Notice of LCS data workshop**
70 FR 55814	9/23/2005	Cancellation of Key West due to Hurricane Rita
70 FR 58190	10/5/2005	Correction to 70 FR 54537
70 FR 58177	10/5/2005	Extension of comment period for Draft Consolidated HMS FMP
70 FR 58366	10/6/2005	1st season proposed rule
70 FR 72080	12/1/2005	**1st season final rule, fishing season notification**
70 FR 73980	12/14/2005	Final Agency decision on petition for rulemaking to amend mid-Atlantic closed area
70 FR 76031	12/22/2005	**Notice for Large Coastal Shark 2005/2006 Stock Assessment Workshop**
70 FR 76441	12/27/2005	Rescheduling and addition of public hearings for Consolidated HMS FMP
2006		
71 FR 8223	2/16/2006	Temporary rule prohibiting gillnet gear in areas around the Southeast U.S. Restricted Area
71 FR 8557	2/17/2006	Proposed Rule for third and second trimester seasons
71 FR 12185	3/9/2006	Notice for Large Costal Shark Review Workshop
71 FR 15680	3/29/2006	Proposed rule for gear operation and deployment for BLL and gillnet fishery and complementary closure
71 FR 16243	3/31/2006	**Final rule for second and third trimester seasons**
71 FR 26351	5/4/2006	Scientific research permit for pelagic shark research
71 FR 30123	5/25/2006	Notice of availability of stock assessment of dusky sharks
71 FR 41774	7/24/2006	**Notice of availability of final stock assessment for Large Costal Sharks**
71 FR 58058	10/2/2006	**Final Rule for the HMS Consolidated Fishery Management Plan**
71 FR 58058	10/2/2006	**1st season proposed rule**
71 FR 62095	10/23/2006	Notice of shark dealer identification workshops and protected species safe handling and release workshops
71FR 64213	11/1/2006	Extension of comment period regarding the 2007 first trimester season proposed rule
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

Federal Register Cite	Date	Rule or Notice
		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 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

Federal Register Cite	Date	Rule or Notice
73 FR 35778	6/24/2008	**Final rule for Amendment 2 to the 2006 Consolidated HMS FMP and fishing season notification**
73 FR 35834	6/24/2008	Shark research fishery; Notice of intent; request for applications
73 FR 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
73 FR 79005	12/24/2008	**NMFS establishes the annual quotas for the 2009 shark fishing season**
2009		
74 FR 8913	2/27/2009	Notice of Atlantic shark identification workshops and protected species safe handling, release, and identification workshops
74 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
2010		
75 FR 250	1/5/2010	**Final rule for the 2010 Commercial Quotas and Opening Dates for the Atlantic Shark Fisheries**
75 FR 12700	3/12/2010	**Closure of the Gulf of Mexico Large Coastal Shark Fishery**
75 FR 22103	4/27/2010	Atlantic Coastal Fisheries Cooperative Management Act Provisions; Atlantic

Federal Register Cite	Date	Rule or Notice
		Coastal Shark Fishery
75 FR 44938	7/30/2010	Atlantic Coastal Fisheries Cooperative Management Act Provisions; Atlantic Coastal Shark Fishery
75 FR 30484	6/1/2010	Final Rule for Amendment 3 to the Consolidated HMS FMP
75 FR 53871	8/31/2010	Closure of the Commercial Porbeagle Shark Fishery
75 FR 57235	9/20/2010	Notice of Availability of the Advanced Notice of Proposed Rulemaking for the Future of the Atlantic Shark Fishery
75 FR 57240	9/20/2010	Proposed Rule for the Atlantic Shark Fishery
75 FR 57259	9/20/2010	Request for Applications for Participation in the Atlantic Highly Migratory Species 2011 Shark Research Fishery
75 FR 62690	10/8/2010	Closure of the Commercial Non-Sandbar Large Coastal Shark Research Fishery
75 FR 62506	10/12/2010	Notice of Southeast Data Assessment and Review (SEDAR) 21 Assessment Webinar
75 FR 67251	10/29/2010	Closure of the Commercial Blacknose and Non-Blacknose Small Coastal Shark Fisheries
75 FR 70216	11/17/2010	Notice of Southeast Data Assessment and Review (SEDAR) 21 Assessment Webinar
75 FR 74004	11/30/2010	Request for Nominations for the Atlantic HMS SEDAR Pool
75 FR 75416	12/2/2010	Closure of the Commercial Non-Sandbar Large Coastal Shark Fishery in the Atlantic Region
75 FR 76302	12/8/2010	**Final rule for the 2011 Commercial Quotas and Opening Dates for the Atlantic Shark Fisheries**
2011		
76 FR 13985	3/15/2011	Notice of Fisheries of the Gulf of Mexico and South Atlantic; Southeast Data, Assessment, and Review (SEDAR); Public Meetings
76 FR 14884	3/18/2011	Proposed rule for Atlantic Highly Migratory Species; Modification of the Retention of Incidentally-Caught Highly Migratory Species in Atlantic Trawl Fisheries
76 FR 23794	4/28/2011	Notice of Stock Status Determination for Atlantic highly Migratory scalloped Hammerhead Shark
76 FR 23935	4/29/2011	Proposed Rule to Implement the 2010 International Commission for the Conservation of Atlantic Tunas (ICCAT) Recommendations on Sharks
76 FR 41723	7/15/2011	**Inseason Action to Close the Commercial Gulf of Mexico Non-Sandbar Large Coastal Shark Fishery**
76 FR 44501	7/26/2011	Inseason Action to Close the Commercial Non-Sandbar Large Coastal Shark Research Fishery
76 FR 49368	8/10/2011	Final rule for Atlantic Highly Migratory Species; Modification of the Retention of Incidentally-Caught Highly Migratory Species in Atlantic Trawl Fisheries
76 FR 53343	8/26/2011	Inseason Action to Close the Commercial Porbeagle Shark Fishery
76 FR 53652	8/29/2011	Final Rule to Implement the 2010 International Commission for the Conservation of Atlantic Tunas (ICCAT) Recommendations on Sharks
76 FR 61092	10/3/2011	Notice of Availability of the Stock Assessments for Sandbar, Dusky, and Blacknose Sharks

Federal Register Cite	Date	Rule or Notice
76 FR 62331	10/7/2011	Notice NMFS Makes Stock Determinations and Requests Comments on Future Options to Manage Atlantic Shark Fisheries
76 FR 67121	10/31/2011	Proposed Rule to Establish the Quotas and opening Dates for the 2012 Atlantic Shark Commercial Fishing Season
76 FR 67149	10/31/2011	Request for Applications for Participation in the Atlantic Highly Migratory Species 2012 Shark Research Fishery
76 FR 69139	11/8/2011	Inseason Action to Close the Commercial Atlantic Non-Sandbar Large Coastal Shark Fishery
76 FR 70064	11/10/2011	Notice of Delay in the Effective Date of Federal Atlantic Smoothound Shark Management Measures
76 FR 72382	11/23/2011	Notice on Workshops for the Electronic Dealer Reporting System
76 FR 72383	11/23/2011	Extension of Comment Period and Workshops Schedule for Shark Catch Shares Amendment
76 FR 72891	11/30/2011	90-Day Finding on a Petition To List the Scalloped Hammerhead Shark as Threatened or Endangered Under the Endangered Species Act
77 FR 3393	1/24/2012	**Final Rule to Establish the Quotas and Opening Dates for the 2012 Atlantic Shark Commercial Fishing Season**

Table 3 List of Large Coastal Shark Seasons, 1993-2012

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

Year	Open dates	Adjusted Quota (mt dw)
	July 1 - Sept. 4	697
2002	Jan. 1 - April 15	735.5
	July 1 - Sept. 15	655.5
2003	Jan. 1 - April 15 (Ridgeback LCS) Jan. 1 - May 15 (Non-ridgeback LCS)	391.5 (Ridgeback LCS) 465.5 (Non-ridgeback LCS)
	July 1 - Sept. 15 (All LCS)	424 (Ridgeback LCS) 498 (Non-ridgeback LCS)
2004	GOM: Jan. 1 - Feb. 29 S. Atl.: Jan 1 - Feb. 15 N. Atl.: Jan 1 - April 15	190.3 244.7 18.1
	GOM: July 1 - Aug. 15 S. Atl.: July 1 - Sept. 30 N. Atl.: July 1 - July 15	287.4 369.5 39.6
2005	GOM: Jan 1 - Feb 28 S. Atl.: Jan. 1 - Feb 15 N. Atl.: Jan. 1 - April 30	156.3 133.3 6.3
	GOM: July 6 - July 23 S. Atl.: July 6 - Aug 31 N. Atl.: July 21 - Aug 31	147.8 182 65.2
	GOM: Sept. 1 - Oct. 31 S. Atl.: Sept 1 - Nov. 15 N. Atl.: Sept 1 - Sept. 15	167.7 187.5 4.9
2006	GOM: Jan 1 - April 15 S. Atl.: Jan 1 - Mar. 15 N. Atl.: Jan 1 - April 30	222.8 141.3 5.3
	GOM: July 6 – July 31 S. Atl.: July 6 – Aug. 16 N. Atl.: July 6 – Aug. 6	180 151.7 66.3
	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

Year	Open dates	Adjusted Quota (mt dw)
	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	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 All SHKs except LCS opened Jan 5	NSB GOM: Feb 4 – March 17 NSB Atl.: July 15 – Dec 5 NSB Research: Jan 5 – Oct 12 SB: Jan 5 – Dec 31	390.5 169.7 37.5 87.9
2011 All SHKs except LCS opened Jan 1	NSB GOM: March 1 – July 17 NSB Atl.: July 15 – Nov 15 NSB Research: Jan 1 – July 26 SB: Jan 1 – Dec 31	351.9 190.4 37.5 87.9
2012 All SHKs except LCS opened Jan 24	NSB GOM: Feb 15 – TBD NSB Atl.: Effective Date of E-Dealer or July 15, whichever comes first – TBD NSB Research: Jan 24 – TBD SB: Jan 24 – TBD	392.8 183.2 37.5 87.9

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

Table 4 **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		

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

Table 5. Summary of current shark regulations

<table>
<tr><th>Requirement for Specific Fishery</th><th>Retention Limits</th><th>Quotas</th><th>Other Requirements</th></tr>
<tr><td>Inside the Commercial Shark Research Fishery</td><td>Sandbar: Trip limit is specific to each vessel and owner(s) combination and is listed on the Shark Research Permit.
Non-sandbar LCS: Trip limit is specific to each vessel and owner (s) combination and is listed on the Shark Research Permit.
SCS & Pelagic Sharks:
Directed Permits:
No trip limit for pelagic sharks & SCS
Incidental Permits:
16 pelagic sharks/SCS combined</td><td>Sandbar:
Quota from 2008-2012: 87.9 mt dw
Quota starting in 2013: 116.6 mt dw
Non-sandbar LCS:
Quota from 2008-2012: 37.5 mt dw
Quota starting in 2013: 50 mt dw
SCS:454 mt dw/year
Pelagic Sharks:
Pelagic sharks (not blue and porbeagle): 273 mt dw/year
Blue sharks: 488 mt dw
Porbeagle sharks: 1.7 mt dw/year</td><td>- Need Shark Research Fishery Permit
-100 percent observer coverage when participating in research fishery
- Adjusted quotas (established through Dec. 31, 2012) may be further adjusted based on future overharvests, if any.</td></tr>
<tr><td>Outside the Commercial Shark Research Fishery</td><td>Non-sandbar LCS Until Dec. 31, 2012:
Directed Permit: 33 non-sandbar LCS/vessel/trip
Incidental Permit: 3 non-sandbar LCS/vessel/trip
Non-sandbar LCS As of Jan. 1, 2013:
Directed Permit: 36 non-sandbar LCS/vessel/trip
Incidental Permit: 3 non-sandbar LCS/vessel/trip
SCS & Pelagic Sharks:
Directed Permits:
No trip limit for pelagic sharks & SCS
Incidental Permits:
16 pelagic sharks/SCS combined</td><td>Non-sandbar LCS:
Quota from 2008-2012:
Gulf of Mexico Region: 390.5 mt dw/year;
Atlantic Region: 187.8 mt dw/year
Quota starting in 2013:
Gulf of Mexico Region: 439.5 mt dw/year;
Atlantic Region: 188.3 mt dw/year
Non-Blacknose SCS: 221.6 mt dw/year
Blacknose: 19.9 mt dw/year
Pelagic Sharks:
Pelagic sharks (not blue and porbeagle): 273 mt dw/year
Blue sharks: 488 mt dw
Porbeagle sharks: 1.7 mt dw/year</td><td>-Vessels subject to observer coverage, if selected
- Adjusted quotas (established through Dec. 31, 2012) may be further adjusted based on future overharvests, if any.
- Trips limits can be adjusted inseason</td></tr>
<tr><td rowspan="5">All Commercial Shark Fisheries</td><td colspan="3">Gears Allowed: Gillnet; Bottom/Pelagic Longline; Rod and Reel; Handline; Bandit Gear</td></tr>
<tr><td colspan="3">Authorized Species: Non-sandbar LCS (silky, blacktip, spinner, bull, lemon, nurse, great hammerhead, scalloped hammerhead, smooth hammerhead, and tiger sharks), pelagic sharks (porbeagle, common thresher, shortfin mako, oceanic whitetip, and blue sharks), and SCS (bonnethead, finetooth, blacknose, and Atlantic sharpnose sharks)</td></tr>
<tr><td colspan="3">Landings condition: All sharks (sandbar, non-sandbar LCS, SCS, and pelagic sharks) must have fins naturally attached through offloading; fins can be cut slightly for storage but must remain attached to the carcass via at least a small amount of uncut skin; shark carcasses must remain in whole or log form through offloading. Sharks can have the heads removed but the tails must remain naturally attached.</td></tr>
<tr><td colspan="3">Permits Required: Commercial Directed or Incidental Shark Permit</td></tr>
<tr><td colspan="3">Reporting Requirements: All commercial fishermen must submit commercial logbooks; all dealers must report bi-weekly</td></tr>
<tr><td rowspan="6">All Recreational Shark Fisheries</td><td colspan="3">Gears Allowed: Rod and Reel; Handline</td></tr>
<tr><td colspan="3">Authorized Species: Non-ridgeback LCS (blacktip, spinner, bull, lemon, nurse, great hammerhead, scalloped hammerhead, smooth hammerhead); tiger sharks; pelagic sharks (porbeagle, common thresher, shortfin mako, oceanic whitetip, and blue sharks); and SCS (bonnethead, finetooth, blacknose, and Atlantic sharpnose sharks)</td></tr>
<tr><td colspan="3">Landing condition: Sharks must be landed with head, fins, and tail naturally attached</td></tr>
<tr><td colspan="3">Retention limits: 1 shark > 54” FL vessel/trip, plus 1 Atlantic sharpnose and 1 bonnethead per person/trip (no minimum size)</td></tr>
<tr><td colspan="3">Permits Required: HMS Angling; HMS Charter/Headboat; and, General Category Permit Holders (fishing in a shark tournament)</td></tr>
<tr><td colspan="3">Reporting Requirements: Participate in MRIP and LPS if contacted</td></tr>
</table>

3.0 Control Date Notices

February 16, 2011 (76 FR 57709)

4.0 Management Program Specifications

Table 5 General management information for the Gulf of Mexico blacktip shark

Species	Blacktip shark (*Carcharhinus limbatus*)
Management Unit	Gulf of Mexico,
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	No Overfishing
Current stock biomass status	Not Overfished

Table 6 Specific management criteria for Gulf of Mexico blacktip shark

Criteria	Blacktip - Current		Blacktip - Proposed	
	Definition	Value	Definition	Value
MSST	MSST = [(1-M)*B_{MSY} when M<0.5; 0.5* B_{MSY} when M≥0.5	0.99-1.07E+07	MSST = [(1-M)*B_{MSY} when M<0.5; 0.5* B_{MSY} when M≥0.5	SEDAR 29
MFMT	F_{MSY}	0.20	F_{MSY}	SEDAR 29
MSY	Yield at F_{MSY}	1.56E+07-2.42E+07	Yield at F_{MSY}	SEDAR 29
F_{MSY}	MFMT	0.20	MFMT	SEDAR 29
OY	Yield at F_{OY}	Not Specified	Yield at F_{OY}	SEDAR 29
F_{OY}	$0.75F_{MSY}$	0.15	$0.75F_{MSY}$	SEDAR 29
$F_{current}$	Current Fishing Mortality rate	0.03-0.04	$F_{current}$	SEDAR 29
M	n/a	Varied (see SEDAR 11)	n/a	SEDAR 29
OFL	n/a	n/a	MFMT*$B_{current}$	SEDAR 29
ABC*	n/a	n/a	P*; probability level TBD	SEDAR 29
SSF_{2004}/SSF_{MSY}	Current Relative Biomass Level	2.54-2.56	SSF_{2004}/SSF_{MSY}	SEDAR 29
B_{2004}	Current biomass	1.33E+08-1.93E+09	$B_{current}$	SEDAR 29
B_{MSY}	Biomass at MSY	Not Specified	B_{MSY}	SEDAR 29

*Acceptable Biological Catch

5.0 Stock Rebuilding Information

Gulf of Mexico Blacktip Sharks

NMFS does not currently have a rebuilding plan for blacktip sharks because the stock is not overfished.

6.0 Quota Calculations

Gulf of Mexico Blacktip Sharks

Table 7 Quota calculation details for the Gulf of Mexico LCS complex, which includes blacktip sharks

Current Quota Value	Commercial Quota = 390.5 mt dw (2008-2012)
Next Scheduled Quota Change	2013; commercial quota = 439.5 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 1,045.6 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 for the non-sandbar LCs quota during SEDAR 11 (1,045.6 mt dw). Based on that TAC, the HMS Management Division subtracted average annual recreational landings from 2003-2005 (309.8 mt dw) and discards from 2003-2005 (153.4 mt dw), resulting in a commercial quota of 439.5 mt dw for the Gulf of Mexico region. However, large overharvests during 2007 resulted in the HMS Management Division reducing the commercial quota to 390.5 mt dw during 2008-2012 to account for the overharvests. The quota is scheduled to increase to 439.5 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. While the quota does not include bycatch/discards estimates, the ACL does.

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 the Gulf of Mexico non-sandbar

LCS 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.

7.0 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 8 Annual commercial blacktip shark regulatory summary (managed in the LCS complex 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**	677.8 mt dw***	Atlantic region; calendar year		Gulf of Mexico region; calendar year	33 non-sandbar LCS/vessel/trip; 3 non-sandbar LCS/vessel/trip for incidental permit holders
2009**	677.8 mt dw***	Atlantic region; calendar year		Gulf of Mexico region; calendar year	33 non-sandbar LCS/vessel/trip; 3 non-sandbar LCS/vessel/trip for incidental permit holders
2010**	677.8 mt dw***	Atlantic region; calendar year		Gulf of Mexico region; calendar year	33 non-sandbar LCS/vessel/trip; 3 non-sandbar LCS/vessel/trip for incidental permit holders
2011**	677.8 mt dw***	Atlantic region; calendar year		Gulf of Mexico region; calendar	33 non-sandbar LCS/vessel/trip; 3 non-sandbar

			year	LCS/vessel/trip for incidental permit holders
2012**	677.8 mt dw***	Atlantic region; calendar year	Gulf of Mexico region; calendar year	33 non-sandbar LCS/vessel/trip; 3 non-sandbar LCS/vessel/trip for incidental permit holders

*Limited Access Permits (LAPs) were implemented for the shark and swordfish fisheries under 1999 FMP; †Regions = Gulf of Mexico, South Atlantic, and North Atlantic.

**Under Amendment 2, the base quota for the LCS complex was reduced, two regions were formed (Atlantic and Gulf of Mexico), and sharks are required to be offloaded with all fins naturally attached.

***The total base quota for non-sandbar LCS is 677.8 mt dw. This base quota is split between the two regions and the shark research fishery as follows: Gulf of Mexico = 439.5 mt dw; Atlantic = 188.3 mt dw; and Shark Research Fishery = 50 mt dw. However, from July 24, 2008 through December 31, 2012, to account for overharvests that occurred in 2007, the total adjusted base quota is 615.8 mt dw. This adjusted base quota is split between the regions and the shark research fishery as follows: Gulf of Mexico = 390.5 mt dw; Atlantic = 187.8 mt dw;

Table 9 **Annual recreational blacktip shark regulatory summary**

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	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
2010	Calendar Year	Minimum size =4.5 ft	1 LCS/SCS/pelagic shark combined/vessel/trip
2011	Calendar Year	Minimum size =4.5 ft	1 LCS/SCS/pelagic shark combined/vessel/trip
2012	Calendar Year	Minimum size =4.5 ft	1 LCS/SCS/pelagic shark combined/vessel/trip

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Drafted by GD 1/10/12
Edits per KBG 2/8/10
Edits per MSH 2/23/10

3. ASSESSMENT HISTORY AND REVIEW

The blacktip shark was first assessed individually in 1998 and later in 2002 and 2006. Prior to that, it was part of the Large Coastal Shark complex, which was first assessed in 1991 and subsequently updated in 1994, 1996, and 1998. In the 1998 Shark Evaluation Workshop (NMFS 1998), a Bayesian surplus production modeling approach was used to assess blacktip sharks, concluding that the 1997 stock size was 44-50% of the stock size at MSY. The 2002 Stock Evaluation Workshop saw the use of multiple assessment methodologies, including surplus production, delay difference, and age-structured production models. These different models produced a range of predictions on stock status, but in general indicated that the stock was near and likely above MSY and, with the exception of some of the ASPM (age-structured production model) runs, F was below F_{MSY}. The ASPM baseline run yielded particularly optimistic results, estimating that the stock was well above MSY and F below F_{MSY} (Cortés et al. 2002). Resource status was thus estimated to have improved since the 1998 assessment and the report noted that an increase of 20-50% in the 2000 TAC (total allowable catch) might be sustainable in the long term (Cortés et al. 2002).

The first assessment of blacktip sharks under the SEDAR framework took place in 2006 (SEDAR 11, NMFS 2006). This was the first assessment where two separate stocks, Gulf of Mexico and South Atlantic, were considered. Although the SSASPM (state space, age-structured production model) was used as the base to take advantage of the increasing age-specific biological and selectivity information available, two other Bayesian production models were also run for contrast. All models consistently concluded that the stock was not overfished and overfishing was not occurring, particularly the age-structured models, which estimated very little depletion (SSF_{2004}/SSF_{MSY}=2.54-2.56) and low removal rates (F_{2004}/F_{MSY}=0.03-0.04). Projections with F_{MSY} indicated that the stock would be 1.27 times the size that would produce MSY by the year 2086.

References

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

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

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

4. 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 29

HMS Gulf of Mexico Blacktip Shark

Stock Assessment Report

May 2012

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 29 Gulf of Mexico Blacktip Shark Workshop was held 19-22 March, 2012 in Panama City Florida. In addition to the workshop, several additional webinars were conducted between April and May 2012 to finalize the assessment.

1.1.2 Terms of Reference

1. Update the approved SEDAR 11 Gulf of Mexico Blacktip shark model with data through 2010. Provide a model consistent with the previous assessment configuration to incorporate and evaluate any changes allowed for this update.
2. Evaluate and document the following specific changes in input data or deviations from the benchmark model.
   a. Review updated life history parameters (age and growth and reproductive parameters)
   b. Evaluate fishery-independent abundance indices derived for Mississippi, Alabama, Texas, and Florida (Mote Marine Lab monitoring and Everglades National Park)
   c. Evaluate fishery-dependent abundance indices derived from the Pelagic Longline Observer Program and the Marine Recreational Information Program
   d. Re-examine Mexican landings, catches and removals
   e. Evaluate commercial discard information
3. Document any changes or corrections made to model and input datasets and provide updated input data tables. Provide commercial and recreational landings and discards in pounds and numbers.
4. Update model parameter estimates and their variances, model uncertainties, estimates of stock status and management benchmarks, and provide the probability of overfishing occurring at specified future harvest and exploitation levels if the stock is found to be overfished or with overfishing occurring.
5. Develop a stock assessment report to address these TORs and fully document the input data, methods, and results.

1.1.3. List of Participants

Workshop Panel

Enric Cortés, Lead Analyst .... NMFS Panama City
Ivy Baremore.. NMFS Panama City
Walter Bubley ....TXDPW
John Carlson... NMFS Panama City
Leonardo Castillo...INAPESCA
Dean Courtney .... NMFS Panama City

Trey Driggers .... NMFS Pascagoula
Marcus Drymon .... DISL
Dean Grubbs .... FSU
Jill Hendon .... GCRL
Frank Hester .... DSF, Inc.
Eric Hoffmayer .... NMFS Pascagoula
Bob Hueter .... Mote Marine Lab
Walter Ingram .... NMFS Pascagoula
Cami McCandless .... NMFS Narragansett
Kevin McCarthy .... NMFS Miami
Michelle Passerotti .... NMFS Panama City
David Stiller .... Industry Representative
Mark Twinam .... Industry Representative

Analytic Support

Dana Bethea .... NMFS Panama City
Alyssa Mathers .... NMFS Panama City
Kelcee Smith .... NMFS Panama City

Attendees

Simon Gulak .... NMFS Panama City
Luke Harris .... Commercial Fisherman
Hang Nguyen-Musselman .... Ocean Fresh Seafood
Daylin Munoz Nunez .... EDF
Karen Rodriguez .... NMFS Panama City
Christopher Vanes .... Ocean Fresh Seafood
Xinsheng Zhang .... NMFS Panama City

Staff

Julie Neer .... SEDAR
Karyl Brewster-Geisz .... HMS
Rachael Silvas .... SEDAR
Tyree Davis .... NMFS Miami

Additional Participants via Webinars

Larry Abele .... GMFMC
Jason Adriance .... LDWF
Dr. Beth Babcock .... RSMAS
Heather Balchowsky .... NMFS Miami
Peter Cooper .... HMS
Jennifer Cudney .... HMS

Guy DuBeck..HMS
Jessica Estepa..Greenwire
Loraine Hale.. NMFS Panama City
Jill Jensen..NMFS
Vivian Matter .... NMFS Miami
Delisse Ortiz...HMS
Adam Pollack...NMFS Pascagoula
Kym Walsh ....LDWF
Luke Harris .... Commercial Fisherman
Hang Nguyen-Musselman...Ocean Fresh Seafood
Daylin Munoz Nunez ....EDF
Karen Rodriguez .... NMFS Panama City
Christopher Vanes...Ocean Fresh Seafood
Xinsheng Zhang.. NMFS Panama City

1.1.4 List of Assessment Process Working and Reference Papers

Documents Prepared for the Assessment Process		
SEDAR29-WP-01	Relative abundance of blacktip shark, *Carcharhinus limbatus*, from the eastern Gulf of Mexico	John Carlson, Dana Bethea, John Tyminski, and Robert Hueter
SEDAR29-WP-02	Standardized catch rates of blacktip sharks (*Carcharhinus limbatus*) in the U.S. Gulf of Mexico from the Shark Bottom Longline Observer Program, 1994-2010	John K. Carlson, Loraine Hale, Alexia Morgan, and George Burgess
SEDAR29-WP-03	Indices of Blacktip Shark Based on NMFS Bottom Longline Surveys (1995-2011)	Walter Ingram
SEDAR29-WP-04	Commercial Bottom Longline Vessel Standardized Catch Rates of Blacktip Sharks in the Gulf of Mexico and US South Atlantic, 1996-2010	Kevin McCarthy
SEDAR29-WP-05	Standardized catch rates for Gulf of Mexico Blacktip Sharks from the U.S. Pelagic longline logbook using generalized linear mixed models	Enric Cortés and Ivy Baremore
SEDAR29-WP-06	Standardized catch rates of blacktip sharks from the Everglades National Park Creel Survey	John K. Carlson and Jason Osborne
SEDAR29-WP-07	Tag and recapture data for blacktip shark, *Carcharhinus limbatus*, in the Gulf of Mexico: 1999-2010	Dana M. Bethea, John K. Carlson, and Mark A. Grace
SEDAR29-WP-08	Updated catches of Gulf of Mexico blacktip	Enric Cortés and Ivy

	sharks	Baremore
SEDAR29-WP-09	Reproduction of the blacktip shark *Carcharhinus limbatus* in the Gulf of Mexico	Ivy E. Baremore and Michelle S. Passerotti
SEDAR29-WP-10	A standardized CPUE index of abundance for Gulf of Mexico blacktip sharks from the Marine Recreational Statistics Survey (MRFSS)	Elizabeth A. Babcock
SEDAR29-WP-11	Catch rates and size distribution of blacktip shark *Carcharhinus limbatus* in the northern Gulf of Mexico, 2006-2010	J. Marcus Drymon and Sean P. Powers
SEDAR29-WP-12	Relative abundance of blacktip shark based on a fishery-independent gillnet survey off Texas	Walter Bubley, John K. Carlson,
SEDAR29-WP-13	Standardized catch rates of blacktip sharks (*Carcharhinus limbatus*) collected during a gillnet survey in Mississippi coastal waters, 1998-2011	Eric Hoffmayer, Glenn Parsons, Jill Hendon, and Adam Pollack
SEDAR29-WP-14	Standardized catch rates of blacktip sharks (*Carcharhinus limbatus*) collected during a bottom longline survey in Mississippi coastal waters, 2004-2011	Eric Hoffmayer, Jill Hendon, and Adam Pollack
SEDAR29-WP-15	Standardized catch rates of blacktip sharks (*Carcharhinus limbatus*) collected during a SEAMAP bottom longline survey in Mississippi/Louisiana coastal waters from 2008 to 2011.	Jill M. Hendon, Eric R. Hoffmayer and Adam G. Pollack
SEDAR29-WP-16	Mark/Recapture Data for the Blacktip Shark, *Carcharhinus limbatus*, in the Gulf of Mexico from the NEFSC Cooperative Shark Tagging Program	William Swinsburg, Nancy E. Kohler, Patricia A. Turner, and Camilla T. McCandless
SEDAR29-WP-17	A Preliminary Review of Post-release Live-discard Mortality Estimates for Sharks	Dean Courtney
SEDAR29-WP-18	Updates to age and growth parameters for blacktip shark, *Carcharhinus limbatus*, in the Gulf of Mexico	Michelle S. Passerotti and Ivy E. Baremore
SEDAR29-WP-19	Commercial Bottom Longline Vessel Standardized Catch Rates of Blacktip Sharks in the United States Gulf of Mexico, 1996-2010, with targeting determined using logistic regression	Kevin McCarthy
SEDAR29-WP-20	Dead discards of blacktip sharks in the Gulf of	Kevin McCarthy and

	Mexico shark bottom longline fishery	John Carlson
SEDAR29-WP-21	A combined fishery independent gillnet series for juvenile blacktip sharks in the eastern Gulf of Mexico	John Carlson, Robert Hueter, Eric Hoffmayer, and Walter Ingram
SEDAR29-WP-22	Standardized catch rates of blacktip sharks (Carcharhinus limbatus) collected during bottom longline surveys in Mississippi, Louisiana, and Alabama coastal waters from 2004 to 2010	Eric Hoffmayer, Jill Hendon, Marcus Drymon, Sean Powers, Adam Pollack, and John Carlson
SEDAR29-WP-23	Indices of abundance score cards	SEDAR 29 Panel
Final Stock Assessment Reports		
SEDAR21-SAR	Gulf of Mexico Blacktip Shark	
Reference Documents		
SEDAR29-RD01	SEDAR 11 (LCS) Final Stock Assessment Report	SEDAR 11 Panels
SEDAR29-RD02	Distributions of Sharks across a Continental Shelf in the Northern Gulf of Mexico	J. Marcus Drymon, Sean P. Powers, John Dindo, Brian Dzwonkowski, and Terry Henwood
SEDAR29-RD03	Microsatellite and mitochondrial DNA analyses of the genetic structure of blacktip shark (*Carcharhinus limbatus*) nurseries in the northwestern Atlantic, Gulf of Mexico, and Caribbean Sea	D.B. Keeney, M.R. Heupel, R.E. Hueter, and E.J. Heist
SEDAR29-RD04	Estimation of catches of sandbar (*Carcharhinus plumbeus*) and blacktip (*C. limbatus*) sharks in the Mexican fisheries of Gulf of Mexico (SEDAR 11-DW-06)	R. Bonfil and E. Babcock
SEDAR29-RD05	Abundance Indices Workshop: Developing protocols for submission of abundance indices to the SEDAR process	SEDAR Procedural Workshop I
SEDAR29-RD06	Do differences in life history exist for blacktip sharks, *Carcharhinus limbatus*, from the United States South Atlantic Bight and Eastern Gulf of Mexico?	John K. Carlson, James R. Sulikowski, Ivy E. Baremore
SEDAR29-RD07	Hierarchical analysis of blacknose, sandbar, and dusky shark CPUE indices (SEDAR21-AW-01)	Paul Conn

1.2 STATEMENTS ADDRESSING EACH TERM OF REFERENCE

1.2.1. Term of Reference 1

Update the approved SEDAR 11 Gulf of Mexico Blacktip shark model with data through 2010. Provide a model consistent with the previous assessment configuration to incorporate and evaluate any changes allowed for this update.

First, the model used for GOM blacktip shark in SEDAR 11 was updated with six additional years of catch and CPUE data to run a continuity analysis where all other data inputs and modeling options remained fixed. Continuity data sets are described in Sections 2.1 and 3.2.8. The only changes with respect to the benchmark model used in SEDAR 11 were 1) adding six additional years of catches (2005-2010) to the three catch data streams considered in SEDAR 11, and 2) re-analyzing the five indices of relative abundance considered in SEDAR 11 to also include six additional years of data (2005-2010). All other inputs to the model as well as modeling aspects remained exactly the same as used in SEDAR 11. Although only the state-space, age-structured production model (SSASPM) was selected for use in both SEDAR 11 and SEDAR 29, the Bayesian Surplus Production model used in SEDAR 11 was also used in the continuity run of the current assessment for contrast and completeness. Second, we conducted an extensive set of new analyses incorporating the issues identified in the following TORs.

1.2.2. Term of Reference 2

Evaluate and document the following specific changes in input data or deviations from the benchmark model. a) Review updated life history parameters (age and growth and reproductive parameters); b) Evaluate fishery-independent abundance indices derived for Mississippi, Alabama, Texas, and Florida (Mote Marine Lab monitoring and Everglades National Park); c) Evaluate fishery-dependent abundance indices derived from the Pelagic Longline Observer Program and the Marine Recreational Information Program; d) Re-examine Mexican landings, catches and removals; e) Evaluate commercial discard information.

Multiple changes to biological and fishery inputs used for SEDAR 11 were evaluated in recognition of updated or new information that had become available since that assessment. The main changes considered include:

a) New age and growth and reproductive information for the stock. Details of two new studies aiming to provide updated and more complete information on the age, growth, and reproductive characteristics of blacktip sharks in the Gulf of Mexico are presented in Section 2.2.1.

b) Several fishery-independent relative abundance indices that had not been initiated when SEDAR 11 was conducted (AL and MS longline indices), not available for that assessment (TEXAS), or deemed to need re-consideration (Mote Marine Lab index). Additionally, a recreational creel survey (Everglades National Park) not available for SEDAR 11 was also considered for the current assessment. Section 2.2.3 discusses all these indices.

c) Two fishery-dependent relative abundance indices that were either not evaluated (Pelagic Longline Observer Program) or deemed in need of re-consideration are also discussed in Section 2.2.3.
d) New information on Mexican catches of blacktip sharks thought to originate in the U.S. A detailed description of the estimation procedure, first developed in the 2002 Shark Evaluation Workshop, is provided in Section 2.2.2. This new information in fact led to splitting one of the catch streams used in SEDAR 11 ("Recreational + Mexican") into two separate "Recreational" and "Mexican" catch series.
e) Commercial discards of blacktip sharks not considered in SEDAR 11. This source of removals, as well as all others, is detailed in Section 2.2.2.

1.2.3. Term of Reference 3

Document any changes or corrections made to model and input datasets and provide updated input data tables. Provide commercial and recreational landings and discards in pounds and numbers.

In addition to the changes in input data identified in the TORs, other changes will also be presented throughout this document in the appropriate sections. These include 1) new selectivity functions developed to describe new catch and index series (Sections 2.2.2 and 2.2.3); 2) updated estimates of natural mortality (M) obtained from consideration of a new growth function (Section 2.2.1); and 3) consideration of additional removals (post-release mortality) in both commercial and recreational fisheries (Section 2.2.2).

Shark assessments are typically conducted in numbers mainly because recreational catch estimates in numbers have traditionally been more reliable owing to the small number of animals measured or weighed in the recreational surveys, and also because dead discard estimates from various sources are generated in numbers rather than weight. However, to address this TOR, catch in weight from the different sectors will also be provided (Section 3.1.2.1).

1.2.4 Term of Reference 4

Update model parameter estimates and their variances, model uncertainties, estimates of stock status and management benchmarks, and provide the probability of overfishing occurring at specified future harvest and exploitation levels if the stock is found to be overfished or with overfishing occurring.

All modeling methods are described in Section 3.1 and results in Section 3.2. Measures of overall model fit are provided in Section 3.2.1. Estimates of assessment model parameters and associated measures of precision are presented in Section 3.2.2. Also included are: stock abundance and recruitment (Section 3.2.3), spawning stock fecundity (Section 3.2.4), fishery selectivity (Section 3.2.5), fishing mortality (Section 3.2.6), and stock-recruitment parameters (Section 3.2.7). Further evaluation of uncertainty is presented in Section 3.2.8, which contains continuity, retrospective, and sensitivity analyses, as well as evaluation of model configurations.

Benchmarks and reference points are presented in Section 3.2.9. Since the stock was found not to be overfished with no overfishing occurring, no projections are presented. However, we will consult with NOAA's Highly Migratory Species (HMS) division staff should the need to conduct specific projections arise.

1.2.5 Term of Reference 5

Develop a stock assessment report to address these TORs and fully document the input data, methods, and results.

This is the present document.

2. DATA REVIEW AND UPDATE

2.1 CONTINUITY DATA SETS

The continuity analysis consisted of using the same exact model, data inputs and assumptions used in 2006 for SEDAR 11, but adding six additional years of catch data (2005-2010; Table 2.5.1; Figure 2.6.1) and the same indices updated to 2010 (Figure 2.6.2). Although the same five indices used in 2006 were also used in the continuity run, they all were reanalyzed and had six additional years of data. These indices were: PC Gillnet Juveniles, BLLOP, NMFS LL SE, BLL Logs, and PLL Logs. The Bayesian surplus production model (BSP; McAllister and Babcock 2004) was also used in 2006 and updated herein to include catches and indices up to 2010.

2.2 NEW DATA SOURCES CONSIDERED

2.2.1 Life History

2.2.1.1. Review of Working Papers

SEDAR29-WP-07: Tag and recapture data for blacktip shark, *Carcharhinus limbatus,* in the Gulf of Mexico: 1999-2010.
D. Bethea, J. Carlson and M. Grace

Tag and recapture information for blacktip shark, *Carcharhinus limbatus*, is summarized from the NOAA Fisheries Cooperative Gulf of Mexico States Shark Pupping and Nursery (GULFSPAN) survey at the Panama City Laboratory from 1999-2010 and the NOAA Fisheries Mississippi Laboratories bottom and pelagic longline cruises 2004-2010. 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.

SEDAR29-WP-09: Reproduction of the blacktip shark *Carcharhinus limbatus* in the Gulf of Mexico.
I. Baremore and M. Passerotti

Reproductive and age data were collected for blacktip shark in the Gulf of Mexico from fishery-dependent and –independent sources from 2006-2011. A total of 757 blacktip sharks were sampled for reproductive analysis (399 females, 358 males), of which 742 were aged. Analyses indicate that blacktip sharks are a synchronous, seasonally reproducing species and that females exhibit a biennial ovarian cycle. Male and female reproductive activity (mating, parturition) was relatively truncated, with peaks from March-May. Near-term embryos averaged 38 cm FL, and gestation is approximately 12 months. Fecundity was 4.5 pups per female, and fecundity was found to increase with both maternal size and age. Length at 50% maturity for males and females was estimated to be 105.8 and 119.2 cm FL, respectively, while age at 50% maturity was calculated at 4.8 and 6.3 years. This represents the first comprehensive reproductive study for blacktip sharks in the Gulf of Mexico.

SEDAR29-WP-16: Mark/Recapture Data for the Blacktip Shark, *Carcharhinus limbatus*, in the Gulf of Mexico from the NEFSC Cooperative Shark Tagging Program.
W. Swinsburg, N. Kohler, P. Turner and C. McCandless

Mark/recapture data from the National Marine Fisheries Service (NMFS) Cooperative Shark Tagging Program (CSTP) were summarized for the blacktip shark (*Carcharhinus limbatus*) in the Gulf of Mexico from 1964 through 2011. Data on fork length, life stage, movement, time at large, and displacement are provided. No blacktip sharks in this study moved between the Gulf of Mexico and the Atlantic or Caribbean. Similarly, there was no evidence of exchange between the eastern and western Gulf of Mexico. Blacktip sharks were distributed strictly within the 200 m depth contour. Some (n=33) of these sharks migrated from the United States to Mexican waters within a time period of less than one year. Additional tagging of blacktip sharks in Mexico is necessary to further elucidate these exchange patterns.

SEDAR29-WP-18: Updates to age and growth parameters for blacktip shark, *Carcharhinus limbatus*, in the Gulf of Mexico.
M. Passerotti and I. Baremore

Age and growth data for 742 blacktip sharks were collected from both fishery-dependent and –independent sources in the Gulf of Mexico between 2006 and 2011. Three-parameter von Bertalanffy growth curves were generated for males (n=350), females (n=392), and both sexes combined. Growth parameters were different between sexes (females: $L\infty = 155.32 \pm 2.57$ cm FL, $k = 0.16 \pm 0.01$, $t0 = -2.89 \pm 0.16$; males: $L\infty = 138.55 \pm 2.21$ cm FL, $k = 0.21 \pm 0.01$, $t0 = -2.63 \pm 0.16$). Age and growth data from Carlson et al. (2006) were also obtained, and additional growth curves were generated pooling the previous data with that of the current study. This resulted in separate curves for females (n=599; $L\infty = 150.57 \pm 1.85$ cm FL, $k = 0.19 \pm 0.01$, $t0 = -2.65 \pm 0.12$) and males (n=511; $L\infty = 138.18 \pm 1.89$ cm FL, $k = 0.21 \pm 0.01$, $t0 = -2.60 \pm 0.13$). Log-likelihood ratios indicate parameters for males combined are not significantly different from those presented in Carlson et al. (2006) ($\chi2 = 4.92$, $p = 0.179$), whereas parameters for females are significantly different between combined and 2006 data ($\chi2 = 8.99$, $p = 0.029$). Maximum ages for the current study were 18.5 (females) and 23.5 (males), and represent an increase of 6 years and 12 years over those observed in Carlson et al. (2006) for females and males, respectively.

2.2.1.1 Age and Growth Datasets and Decisions

Prior to SEDAR 29, results of two age and growth studies conducted on blacktip sharks in U.S. waters of the Gulf of Mexico were available. The earliest work was conducted by Branstetter (1987), who provided growth estimates for combined sexes based on a relatively small sample size (n= 54) and maximum observed age of 9.3 years. Subsequently, Carlson et al. (2006) provided sex-specific von Bertalanffy growth function (VBGF) parameter estimates for blacktip sharks from the eastern Gulf of Mexico based on a more robust sample (n= 207 and 161 for females and males, respectively) and higher observed maximum ages (12.5+ years for females and 11.5+ years for males). Updated sex-specific VBGF parameter estimates were presented by Passerotti and Baremore (SEDAR29-WP-18) and were based on a large sample size (n= 392 and 350 for females and males, respectively) and the highest maximum observed ages reported among the three studies (18.5 years for females, 23.5 for males). While VBGF parameter estimates for males and females were significantly different between Carlson et al. (2006) and Passerotti and Baremore (SEDAR29-WP-18), Passerotti and Baremore (SEDAR29-WP-18) also provided growth parameter estimates which combined their data with those of Carlson et al. (2006). Growth parameters resulting from pooled data for males were not significantly different from those of males in Carlson et al. (2006), while parameters for pooled females were slightly significantly different from Carlson et al.'s (2006). The group decided to utilize the growth models presented in SEDAR29-WP-18 that pooled the two datasets as resulting models were based on larger sample sizes (n= 599 and 511 for females and males, respectively) and included the highest observed maximum age estimates (Figure 2.6.3). Growth model parameter estimates are summarized in Table 2.5.2. Although maximum observed age was 23.5 years for males, this estimate was considered to be anomalous because the second oldest aged male was 15.5 years. Although this estimate was thought to be reliable, because of the large gap in ages, the maximum observed age was reduced to the female estimate of 18.5 years. This is noted in Table 2.5.2 with an asterisk.

Decision: Use the growth models presented in SEDAR29-WP-18 from datasets utilizing pooled data.

2.2.1.3 Reproduction Datasets and Decisions

Past studies provide little information regarding the reproduction of blacktip sharks in the Gulf of Mexico aside from brood size and reproductive seasonality (e.g. Baughman and Springer 1950, Clark and von Schmidt 1965), with the exception of Carlson et al. (2006), who determined that 50% of females are mature at an age of 5.7 years and a fork length (FL) of 117.3 cm, while 50%

of males are mature at an age of 4.5 years and a FL of 103.4 cm. Baremore and Passerotti (SEDAR29-WP-09) presented data from a study conducted from 2006-2011 that represents the first comprehensive examination of the reproductive biology of blacktip sharks (n= 399 and 358 for females and males, respectively) in the Gulf of Mexico. The authors established that blacktip sharks in the eastern Gulf of Mexico mate and give birth from March to May and that mature females can reproduce biennially. A comparison of maturity data from Baremore and Passerotti (SEDAR29-WP-09) and Carlson et al. (2006) found no significant difference among estimates, so sex-specific data from both studies were combined to construct maturity ogives. The study with the pooled dataset found males reach 50% maturity at 105.8 cm FL and an age of 4.8 years while females reach 50% maturity at 119.2 cm FL and an age of 6.3 years (Table 2.5.3 and Figure 2.6.4). Additionally, median size and age at maternity were estimated to be 137.6 cm FL and 10.1 years (Table 2.5.4 and Figure 2.6.4). The mean brood size of 169 gravid females was 4.5 with a significant positive relationship between brood size and maternal length as well as brood size and maternal age (Figure 2.6.4). It was suggested that the vector resulting from the regression analysis of brood size to maternal age be used in the stock assessment model to account for the higher fecundity of older females.

Decision: Use maturity schedules estimated for length and age from pooled datasets.

Decision: Reproductive parameters such as fecundity, seasonality, and ovarian periodicity from SEDAR29-WP-09 are recommended.

Decision: The maternity ogive from SEDAR29-WP-09 is recommended.

Decision: Use the fecundity vector, which predicts an increase in fecundity with maternal age, presented in SEDAR29-WP-09.

2.2.2. Catch Statistics

2.2.2.1 Review of working papers

SEDAR29-WP-08: Updated catches of Gulf of Mexico blacktip sharks
E. Cortés and I. Baremore

This document presents updated commercial landings, recreational catches, and dead discard estimates of Gulf of Mexico blacktip sharks up to 2010. Estimated catches of blacktip sharks in neighboring Mexican states are also included. Information on the geographical distribution of both commercial landings 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 presented.

SEDAR29-WP-17: A Preliminary Review of Post-release Live-discard Mortality Estimates for Sharks
D. Courtney

This document reviews the primary scientific literature on post-release live-discard mortality rates in order to develop discard mortality rate estimates by gear type (longline, hook and line, gillnet, and trawl) for use in the Gulf of Mexico blacktip shark stock assessment.

SEDAR29-WP-20: Dead discards of blacktip sharks in the Gulf of Mexico shark bottom longline fishery
K. McCarthy and J. Carlson

Observer reported blacktip shark discard rates from 2006-2010, along with self reported commercial fishing effort data, were used to calculate blacktip shark discards from the shark bottom longline fishery in the Gulf of Mexico. Fishing effort data were available from the coastal logbook program for the years 1993-2010. Beginning in 1993 all commercial vessels with Federal fishing permits (other than those for swordfish, tunas, and shrimp) were required to report landings and effort to the coastal logbook program. The time series was truncated at 2010 because all reports from fishing trips made in 2011 were not available prior to the SEDAR 29 data workshop. Only effort defined as targeting shark (trips with shark landings >2/3 of total landings for the trip) was included in the discard calculations. Total discards were calculated as the product of observer reported yearly mean dead discard rates and the yearly total shark targeted fishing effort (bottom longline hooks fished) reported to the coastal logbook program. Discard rate by hook fished was not available prior to 2006. To calculate discards for the years 1993-2005 the mean dead discard rate across the years 2006-10, weighted by sample size, was used. Yearly total dead discards prior to 2006 were calculated as the product of the weighted mean dead discard rate and the year-specific shark targeted effort.

2.2.2.2 Mexican catches Datasets and Decisions

In SEDAR-11 document LCS05/06-DW-06 (originally SB-02-3) it was assumed that Mexican catches of blacktip shark corresponded to 50% of the sum of small fish caught in the states of Tamaulipas and Veracruz. This percentage was used to take account of the potential mixing of U.S. and Mexican stocks in Mexican fishing grounds. These two states were selected, as in previous assessments, because they are thought to include catches of blacktip sharks that cross into Mexican waters.

New data from Veracruz and Tamaulipas, covering the period 2001-2010, were used to produce estimates of the proportion that blacktip sharks make up in the “cazones” or small shark landings, as well as average weights of blacktip sharks landed. The panel decided to exclude “tiburones” or large shark landings, due to evidence that blacktip sharks make up a very small proportion of the large sharks caught by artisanal fishers in Mexico. The previous assumption that 50% of the sharks were traversing and were therefore part of the US Gulf of Mexico stock was discussed by the panel. The panel members agreed that tagging information supported the assumption that blacktip sharks moved in a north-south direction and therefore 50% was a reasonable estimate. A range was arbitrarily decided upon because reporting rates most likely differ among countries, and there were no records of sharks initially tagged in Mexico. It was recommended that the previous estimates for Mexican catches be used up to 2000, and that the new estimates be applied for 2001-2010. However, after a graphic of the estimated catches was produced, the panel expressed distrust of the drastic decline shown during the 1994-2000 time period. Therefore the estimated blacktip shark landings in each state prior to 2001 were estimated from the percentage of blacktip sharks in the "cazones" landings based on a published study by Castillo-Geniz et al. (1998), which used data collected in 1993-1994. The new estimates were used for 2001-2010, and are shown in Table 2.5.5.

Previous assessments have combined all commercial and recreational fisheries from Mexico. Due to differences in gear selectivity, the two catch streams were split.

Decision: Exclude "tiburones" landings and use only "cazones" as an estimate of blacktip shark landings in Veracruz and Tamaulipas.

Decision: Use new estimates of the percentage of blacktip sharks in the "cazones" landings (20% in both Tamaulipas and Veracruz) and average weights of blacktip sharks landed to construct Mexican catches for 2001-2010.

Decision: Use estimates from Castillo-Geniz et al. (1998) for the percentage of blacktip sharks in the "cazones" landings (32% in Tamaulipas and 25% in Veracruz) up through 2000.

Decision: Divide the total blacktip sharks estimated from the "cazones" landings in half to account for blacktip sharks moving into US waters. A range of percentages (25% and 75%) will be considered for sensitivity runs.

Decision: Split the Recreational + Mexican series into two separate catch streams.

2.2.2.3 Commercial Discards Datasets and Decisions

Commercial dead discards estimated for logbook data

Working paper SEDAR29-WP-20 provided estimates of dead discards of blacktip sharks for the logbook bottom longline data using observed discard proportion from the bottom longline observer program (BLLOP) from 1993-2010 (Table 2.5.6). Only trips where more than 2/3 of the landed species were sharks were used for the estimates, with the assumption that these were shark-targeted trips. The panel discussed the use of this method and the validity of the logbook data. Several panelists expressed a lack of confidence in the logbook data, especially in the most recent years, based on the very low number of hooks (effort) reported in 2009-2010. There was also considerable discussion about under-reporting from state fisheries, especially Louisiana. Panelists attempted to obtain effort data from Louisiana trip ticket information, but the data were unavailable in the time frame of the workshop.

Decision: Use the dead discard rates in the commercial longline fishery that were estimated using the number of hooks and the dead discard rate per hook from the logbook dataset.

Post-release live discard mortality

Working document SEDAR29-WP-17 provided a summary of the literature regarding post release mortality for shark species. Based on the literature, an equation was developed to calculate the total mortality for several fisheries:

Total discard mortality rate = (Dead-discard rate) + (Post-release live-discard mortality rate) * (Live-discard rate)

A point was made to define post-release discard mortality to avoid the confusion that has mired other discussions on this topic. The post-release discard mortality rate is only applied to those sharks that are released alive, which is a very small number in many commercial fisheries. Discard data are also not available for most commercial fisheries, limiting the application of these estimates. Based on observer data, it was determined, that approximately 1.7% of blacktip sharks were released alive by the bottom longline fishery in the Gulf of Mexico.

The best estimate for post-release live discard mortality for commercial longline is from Campana et al. (2009), who estimated the rate to be 19% for blue sharks in the Pacific Ocean. Evidence was presented that both at-vessel mortality and post-release live-discard mortality rates may be proportional to species-specific differences in sensitivity to capture stress and are also confounded by water temperature. As a result, the panel recommended that 19% post-release live-discard mortality rate for blue sharks captured with pelagic longlines in cold water is likely a minimum estimate of the demersal longline post-release live-discard mortality rate for blacktips in warmer water. The panel recommended the use of juvenile blacktip shark post-release live-discard mortality rate from research gillnets (31%; Hueter et al. 2006) as a "central" estimate of blacktip shark longline mortality. In order to evaluate the effect of uncertainty on model results, the panel recommended the use of 19% as a minimum estimate and 73% as a maximum estimate. The value of 73% was obtained from the ratio of 90% (at-vessel mortality rate for subadult blacktip sharks captured in commercial gillnets; Thorpe and Frierson 2009) to 38 (at-vessel mortality rate for juvenile blacktip sharks captured in research gillnets; Hueter and Manire 1994) multiplied by 31% (the research gillnet post release live discard mortality rate of juvenile blacktip sharks captured in research gillnets; Hueter et al. 2006)

$$73\% = 31\% *(90\%/38\%)= 31\%*2.4 = 73\%$$

This calculation assumes that post release live discard mortality rate for blacktip sharks captured in commercial gillnet (73%) is proportional to (2.4 times higher than) that in research gillnet (31%).

Commercial gillnet fisheries in the Gulf of Mexico are negligible, therefore rates were not estimated for commercial gillnets.

Decision: Apply a post-release live discard mortality rate of 31% for commercial bottom longline for the base model, with a range of 19-73% for the low and high sensitivity scenarios.

2.2.2.4. Recreational Landings Datasets and Decisions

The Marine Recreational Fisheries Statistics Survey (MRFSS) is now effectively being replaced by the Marine Recreational Information Program (MRIP), and new estimates for a suite of fish species, including blacktip shark, were produced for the period 2004-2011. The MRFSS estimates were compared to MRIP estimates for A+B1 catches of blacktip sharks in the Gulf of Mexico using the available online comparison tool and found the differences were rather small, ca. 10% on average for the 2004-2010 period compared (Figure 2.6.6).

Previous webinar discussions on this topic produced recommendations to use the MRIP data in place of the MRFSS for 2004-2011. The panel agreed that the differences were very small and therefore recommended the use of the MRIP for the catch statistics.

Decision: Replace MRFSS landings estimates with those from MRIP.

2.2.2.5. Recreational Discards Datasets and Decisions

Post-release live discard mortality

Working document SEDAR29-WP-17 provided a summary of the literature regarding post release mortality for shark species. Based on the literature, an equation was developed to calculate the total mortality for several fisheries:

Total discard mortality rate = (Dead-discard rate) + (Post-release live-discard mortality rate) * (Live-discard rate)

A point was made to define post-release discard mortality to avoid the confusion that has mired other discussions on this topic. The post-release discard mortality rate is only applied to those sharks that are released alive, which can be a substantial number in recreational fisheries. Working document SEDAR29-WP-17 indicated that the best estimate of recreational hook and line post-release discard mortality comes from (Gurshin and Szedlmayer, 2004), who estimated a 10% rate based on tagged Atlantic sharpnose sharks captured with hook and line. The panel discussed using 10% as a minimum estimate, with 20 and 30% estimates used in sensitivity runs as well. Because of the high rate of blacktip shark live discards in the recreational fishery, applying the higher rates to the discards could have a significant impact on the total removals in the recreational fishery. However, the panel decided after much discussion to use 10% for the base case since there is a distinct lack of data on this topic, with a range of 5-15% for sensitivity runs. The panel wished to express its lack of confidence in the estimate of post-release live discard mortality.

Decision: Apply a 10% discard mortality rate to the live discards (B2) from MRIP/MRFSS. A range of 5-15% will be included for the low and high scenario sensitivity runs.

2.2.3 Indices of abundance

2.2.3.1. Review of working papers

SEDAR29-WP-01: Relative abundance of blacktip shark, *Carcharhinus limbatus*, from the eastern Gulf of Mexico
J. Carlson, D. Bethea, J. Tyminski, and R. Hueter

Relative abundance indices were derived for blacktip sharks from fishery-independent surveys conducted at NMFS SEFSC Panama City Laboratory and Mote Marine Laboratory. Fishery-independent catch rates were determined by area and life stage and standardized using a generalized linear modeling approach. Depending on species, the final models varied with factors area, season, year. Trends in abundance were generally stable for all combinations performed.

SEDAR29-WP-02: Standardized catch rates of blacktip sharks (*Carcharhinus limbatus*) in the U.S. Gulf of Mexico from the Shark Bottom Longline Observer Program, 1994-2010
J. Carlson, L. 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 1994-2010. Data were subjected to a Generalized Linear Model (GLM) standardization technique that treats separately 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. Year, set depth and hook type were significant as a main effect in most models. The relative abundance index showed a general flat trend in abundance.

SEDAR29-WP-03: Indices of Blacktip Shark Based on NMFS Bottom Longline Surveys
W. Ingram

Relative abundance indices were developed for blacktip shark for the Gulf of Mexico (GOM) based on data collected during NMFS Bottom Longline Surveys (BLL) from 1995-2011 using survey methodologies have been detailed in numerous past SEDAR documents. Also, there was an additional amount of data incorporated into the modeling process from an expansion of survey effort during 2011. Charts of effort and catch distribution showed good areal coverage of survey effort for most years, and also indicated blacktip shark catch rates were higher in the western GOM. To develop standardized indices of annual average CPUE (# per 100 hook-hours) for blacktip shark for the GOM, a delta-lognormal model was employed. This index is a mathematical combination of yearly CPUE estimates from two distinct generalized linear models: a binomial (logistic) model which describes proportion of positive CPUE values (i.e., presence/absence) and lognormal model which describes variability in only the nonzero CPUE data. A backward selection approach, while using the GLMMIX and MIXED procedures in SAS, was employed to provide yearly index values for both the binomial and lognormal sub-models, respectively. The parameters tested for inclusion in each sub-model were survey year, area, and hook-type. For the binomial submodel, all three parameters were significant at $\alpha = 0.05$ using type 3 statistical tests, while area and hook-type were significant in in the lognormal model. The time series indicated an increase in relative abundance through 2003 and was then relatively stable for the rest of the time series.

SEDAR29-WP-04: Commercial Bottom Longline Vessel Standardized Catch Rates of Blacktip Sharks in the Gulf of Mexico and US South Atlantic, 1996-2010
K. McCarthy

The Coastal Fisheries Logbook Program available catch per unit effort (CPUE) data were used to construct a standardized abundance index for blacktip shark in the Gulf of Mexico as described in SEDAR29-WP04. Data were sufficient to include the years 1996-2010. Data were limited to those reported from vessels which were presumed to actively target large coastal sharks (highest 20% of vessels ranked by large coastal shark CPUE).

Bottom longline catch rate was calculated as weight of blacktip shark per set fished. The delta lognormal model approach (Lo et al. 1992) was used to construct standardized indices of abundance. Yearly mean CPUE ranged from a low of 0.17 in 1996 to approximately 1.8 in 2003. Coefficients of variation for the index were highest during the beginning and end of the time series. Yearly mean CPUE generally increased from 1996-2002, was fairly consistent among years during the period 2002-2006, and decreased after 2006. A continuity analysis of the Gulf of Mexico index constructed for the 2005 blacktip assessment plotted on a common scale with the current Gulf of Mexico blacktip index indicated that while both indices had the same overall trend in CPUE during the period 1996-2004, the yearly mean CPUEs differed between the two indices. Those differences were greatest for the years 1997, 2002, and 2004. The disparity in CPUE was likely due to differences in the vessels identified as targeting large coastal sharks; i.e., additional vessels reported large coastal shark landings after 2004 thereby increasing the universe of vessels for construction of the current Gulf of Mexico index.

SEDAR29-WP-05: Standardized catch rates for Gulf of Mexico Blacktip Sharks from the U.S. Pelagic longline logbook using generalized linear mixed models

E. Cortes and I. Baremore

An updated index of abundance was developed for blacktip shark (*Carcharhinus limbatus*) in the Gulf of Mexico from the US pelagic longline logbook program (1992-2010). Indices were calculated using a two-step delta-lognormal approach that treats the proportion of positive sets and the CPUE of positive catches separately. Standardized indices with 95% confidence intervals are reported. The logbook time series showed an alternating trend, with an initial declining tendency to 1997, followed by an increase to a high peak in 2001, in turn followed by a marked decrease and a partial recovery to 2005, after which the series declined sharply. It is unclear whether the standardization procedure was successful at removing all extraneous effects unrelated to abundance.

SEDAR29-WP-06: Standardized catch rates of blacktip sharks from the Everglades National Park Creel Survey
J. Carlson and J. Osborne

Using voluntary dockside interviews of sport fishers collected by the Everglades National Park, a standardized index of abundance was created for blacktip shark using the delta lognormal method. Factors year, season, area, and fisher were significant main effects in the binomial model and factors year and area and were significant main effects in the lognormal model. There was a spike in abundance from the first few years of the time series around 1983 but the survey expanded it species list in the 1980s to include more than just the "sportfish" species. Therefore, the spike was attributed to better data clarification rather than an increase in abundance. The series remained relatively stable for the remainder of the time series.

SEDAR29-WP-10: A standardized CPUE index of abundance for Gulf of Mexico blacktip sharks from the Marine Recreational Statistics Survey (MRFSS)
E. Babcock

The Marine Recreational Fisheries Statistical Survey (MRFSS) data include estimates of recreational catch and effort from 1981 through 2010. The CPUE index for Gulf of Mexico blacktip sharks is derived by applying a delta-lognormal Generalized Linear Mixed Model (GLMM) to the MRFSS intercept data on the number of blacktip sharks caught (whether kept or released), with potential explanatory variables of year, area, season, region, fishing mode and target species guild. This analysis updates the series developed by Ortiz (2005). The series is quite variable with no clear trend.

SEDAR29-WP-11: Catch rates and size distribution of blacktip shark *Carcharhinus limbatus* in the northern Gulf of Mexico, 2006-2010
J.M. Drymon and S. Powers

Blacktip sharks *Carcharhinus limbatus* are 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 2010, 539 blacktip sharks were captured during 410 bottom longline sets. Nominal and standardized catch per unit effort (CPUE, sharks/100 hooks/hour) and length frequency distributions by sex are presented. Length frequency histograms indicate that the majority of male blacktip sharks sampled span the size at which 50% of the population is mature. Nominal CPUE was highest in 2006 and has varied annually thereafter. The yearly pattern of relative abundance was similar between nominal and standardized indices. Monthly analysis of nominal mean CPUE showed peak occurrence of blacktip sharks during June, in line with previous studies suggesting blacktip sharks may use coastal waters in the northern Gulf of Mexico for parturition of their young.

SEDAR29-WP-12: Relative abundance of blacktip shark based on a fishery-independent gillnet survey off Texas
W. Bubley and J. Carlson

An index of relative abundance was assembled using catch data from a fishery independent gillnet survey by the Texas Parks and Wildlife Department, Coastal Fisheries Division. Stratified random sampling protocol during Spring and Fall seasons was followed and catch per unit effort (CPUE) was determined by catch per hour of soak time. A total of 22,137 gillnets sets were made between 1982 and 2010 along 10 bay systems spanning the entire coast of Texas with a proportion of positive catch at 3.6%. The majority of individuals captured were juveniles and the length distribution did not change significantly over the survey period. Indices of abundance were estimated following the Delta lognormal method by modeling non-zero catch for both juvenile and all sharks excluding young of the year (YOY) individuals in both instances. The standardized and nominal indices for all blacktip sharks (excluding YOY) peaked in 1986 and showed some variability between years, but the overall trend remained level. The standardized and nominal indices for juvenile blacktip sharks (excluding YOY) peaked in 1982 and did not contain any individuals in 1991 but has been increasing until being relatively stable since the mid-2000's.

SEDAR29-WP-13: Standardized catch rates of blacktip sharks (*Carcharhinus limbatus*) collected during a gillnet survey in Mississippi coastal waters, 1998-2011
E. Hoffmayer, G. Parsons, J. Hendon, and A. Pollack

Beginning in 1998, an ongoing monthly standardized gillnet survey has been conducted in Mississippi coastal waters from March to October each year. This fisheries independent dataset was developed to monitor the abundance and distribution of various elasmobranch and teleost species within Mississippi's coastal waters. As a result of 282 net sets and 924 hours of effort, 833 blacktip sharks were collected. Because the work was conducted in a known blacktip nursery area, blacktip shark catch was further divided into young-of-the-young (YOY, age-0) and juvenile catch. Due to the low occurrences of adults in the data, an abundance index was not produced. Standardized catch rates were estimated using a Generalized Linear Mixed modeling approach assuming a delta-lognormal error distribution and negative binomial regressions. Other than slight peaks in 2000 and 2005, standardized total blacktip catch rates remained stable across the time series. Both YOY and juvenile catch rates mimicked the total blacktip index.

SEDAR29-WP-14: Standardized catch rates of blacktip sharks (*Carcharhinus limbatus*) collected during a bottom longline survey in Mississippi coastal waters, 2004-2011
E. Hoffmayer, J. Hendon, and A. Pollack

Beginning in 2004, an ongoing monthly standardized bottom longline survey has been conducted in Mississippi coastal waters from March to October each year. This fisheries independent dataset was developed to monitor the abundance and distribution of various elasmobranch and teleost species within Mississippi's coastal waters. As a result of 333 sets and 431 hours of effort, 196 blacktip sharks were collected. Because the work was conducted in a known blacktip nursery area, blacktip shark catch was further divided into young-of-the-young (YOY, age-0), juvenile and adult catch. Due to the low occurrences of YOY and adult sharks in the dataset, an abundance index was not produced for either of these groups. Standardized catch rates were estimated using a Generalized Linear Mixed modeling approach assuming a delta-lognormal error distribution and negative binomial regression. Other than a slight peak observed in the standardized index for 2005, total blacktip catch rates remained stable across the time series. The juvenile blacktip index mimicked the total blacktip index.

SEDAR29-WP-15: Standardized catch rates of blacktip sharks (*Carcharhinus limbatus*) collected during a SEAMAP bottom longline survey in Mississippi/Louisiana coastal waters from 2008 to 2011
J. Hendon, E. Hoffmayer, and A. Pollack.

In late 2007, a fisheries independent bottom longline survey began in Mississippi and Louisiana coastal waters to monitor the abundance and distribution of various elasmobranch and teleost species. The standardized sampling was conducted monthly (March through October) each year. This survey was initiated to complement the National Oceanographic and Atmospheric Administration, Mississippi Laboratory's offshore monitoring; therefore, methodologies for this project were are identical to NOAA's. As a result, from 2008 through 2011, of 282 sets and 490 hours of effort, 647 blacktip sharks were collected. Because the work was conducted in a known blacktip nursery area, blacktip shark catch was further divided, when possible, into young-of-the-young (YOY, age-0, n=74), juvenile (n=432), and adult (n=88) catch. Data from 2007 was not included in this analysis as it was not a full year's data set. Standardized catch rates were estimated using a Generalized Linear Mixed modeling approach assuming a delta-lognormal error distribution and negative binomial regression. Overall, standardized abundance indices of blacktip sharks have remained relatively stable throughout the survey, except for 2011, which has shown a slight decline for all stages.

SEDAR29-WP-19: Commercial Bottom Longline Vessel Standardized Catch Rates of Blacktip Sharks in the United States Gulf of Mexico, 1996-2010, with targeting determined using logistic regression
K. McCarthy

The Coastal Fisheries Logbook Program available bottom longline catch per unit effort (CPUE) data were used to construct a standardized abundance index for blacktip sharks in the Gulf of Mexico as described in SEDAR29-WP19. Data were sufficient to include the years 1996-2010 in an index of abundance. Trip limit effects were examined by determining the percentage of large coastal shark landings to total landings for each trip included in the analysis. Only 5.65 percent of the all trips (154 of 2,725 trips) reported landings of less than 75 percent large coastal sharks, suggesting that trip limits had little effect on CPUE calculations. Blacktip shark trips were identified using a data subsetting technique (modified from Stephens and MacCall, 2004) intended to restrict the data set to trips with fishing effort in presumptive blacktip shark habitat. Longline catch rate was calculated as weight of blacktip sharks per hook fished. The delta lognormal model approach (Lo et al. 1992) was used to construct a standardized index of abundance. Blacktip sharks standardized catch rates for commercial longline vessels were variable and without trend over much of the period 1999-2007. During the initial three years of the time series, yearly mean CPUE increased. Yearly mean CPUE during two of the final three years (2008, 2010) were similar to those from 1996-1998.

SEDAR29-WP-21: A combined fishery independent gillnet series for juvenile blacktip sharks in the eastern Gulf of Mexico
J. Carlson, R. Hueter, E. Hoffmayer, and W. Ingram

After presentation of SEDAR29-WP-01 that combined fishery independent gillnet data from surveys conducted by the NMFS Panama City Laboratory and Mote Marine Laboratory, the group discussed the potential of combining other fishery independent gillnet data sources and performing a similar analysis. Due to the similarities in gear type and survey design, the group felt that it was more appropriate to combine the Mississippi gillet (SEDAR29-WP-13) with the Panama City Laboratory and Mote datasets (SEDAR29-WP-01) to form a more spatially expansive inshore eastern Gulf of Mexico gillnet dataset. As a result, only one index was used from the Mississippi gillet dataset, which included all blacktip sharks except the young-of-the-year (age 0+). Since there were differences in the accessory data included with the three indices, several factors, including monthly rainfall, previous month rainfall, and bottom and surface temperature, salinity, and dissolved oxygen were removed from the dataset. The factors that remained in the dataset included year, month, location, depth, set time, and effort. Additionally, the factor survey (i.e. MS GN, PCLAB, and Mote) was added to the dataset. Due to differences in both the sample size and the area surveyed among data sets, two alternative weighing factors (sample size and area surveyed) were presented.

SEDAR29-WP-22: Standardized catch rates of blacktip sharks (*Carcharhinus limbatus*) collected during bottom longline surveys in Mississippi, Louisiana, and Alabama coastal waters from 2004 to 2010
E. Hoffmayer, J. Hendon, M. Drymon, S. Powers, A. Pollack, and J. Carlson

Originally three separate indices were created to detail bottom longline survey blacktip shark catches in the Alabama, Mississippi, and Louisiana coastal waters. Detailed information about the three surveys is found within the following documents: SEDAR29-WP-11 for the Alabama index, SEDAR29-WP14 for the inshore Mississippi index, and SEDAR29-WP-15 for the Louisiana/Mississippi index. The SEDAR 29 panel decided that this catch information would be most valuable if an index was created using the data from all three surveys combined. The combined index extended from 2004 to 2010, and resulted in 893 sets and 1,379 blacktip sharks. Standardized catch rates were estimated using a generalized linear mixed modeling approach assuming a delta-lognormal error distribution and negative binomial regression. Due to differences in both the sample size and the area surveyed among data sets, two alternative weighing factors (sample size and area surveyed) were presented.

2.2.3.2. New indices of abundance

Six new fishery-independent indices (SEDAR29-WP-01, 11, 12, 13, 14, 15), and six new fishery-dependent indices (SEDAR29-WP-02, 04, 05, 06, 10, 19) were presented for consideration by the panel (Table 2.5.7). 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 deemed to be appropriately constructed, although in some cases revisions were recommended based on discussion among the participants. 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. whether the index was restricted to marginal habitat or at the limit of a species range). The Pelagic Longline Logbook data (Pelagic Logs) was not used as an index of abundance for SEDAR29 due to low proportions of positive sets in some years, species mis-identification, and misreporting in logbooks.

Index ranking was completed during SEDAR29 with input from 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 reflect 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. For specific reasoning behind the individual index rankings, see 'Justification of Working Group Recommendation' located in the index scorecards (SEDAR 29 –WP-23).

Decision: Combine coastal fishery-independent gillnet and longline surveys.

After the presentation of document SEDAR29-WP-01, that combined fishery-independent data from two sources in a generalized linear modeling framework, discussion amongst the panel ensued relative to combining other fishery-independent data sources that were similar in design. The group recommended that at SEDAR29, data sources from three fishery-independent gillnet surveys (SEDAR29-WP01 and SEDAR29-WP-13) and three longline surveys (SEDAR29-WP-11, SEDAR29-WP-14, SEDAR29-WP-15) would be combined using methods similar to those in SEDAR29-WP-01. Further, due to the differences in sample area, a weighing factor (area surveyed) was added to the generalized linear model to account for these differences (Table 2.5.8, Figure 2.6.7).

Decision: Keep fishery-dependent indices separate.

A summary of fishery-dependent series recommended for base and sensitivity scenarios can be found in Table 2.5.9 and Figure 2.6.8.

Decision: Rank abundance series

Decision: Exclude pelagic longline logbook data

A summary of the decisions made on the ranking and abundance series used in assessment runs is in Table 2.5.10. The base series included most of the same series used in SEDAR11, except for two new series introduced at SEDAR29; a fishery-independent gillnet series off Texas (SEDAR29-WP-13) and a creel survey from the Everglades National Park (SEDAR29-WP-06). The aggregate gillnet and longline series were also included in the base scenario. The sensitivity runs were generally reflective of adding or replacing time series that were deemed of lesser quality or utilizing individual time series that were aggregated during SEDAR 29. Spatial scope of recommended indices can be found in Figure2.6.9.

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2.4 RESEARCH RECOMMENDATIONS

- Conduct age, growth and reproductive studies of blacktip sharks in the western Gulf of Mexico.

- Examine the stock structure of blacktip sharks in the Gulf of Mexico using genetic analyses, continued conventional tagging and advanced tagging technologies.
- Benchmark assessment to be undertaken focusing on treating blacktip sharks in the eastern and western Gulf of Mexico as separate stocks.
- A brief technical document should be produced to define “post release”, ”at vessel mortality”, “status” and other terms for consistency and future discussions.
- Mexican colleagues must be involved in the next assessment to improve data inputs.
- Continue to work to achieve good species identification for weighouts/landings/reporting for commercial fisheries. Continue to have workshops for fishers/dealers to learn species identification. Workshops for recreational fishermen to work towards better species ID are also needed.
- Add a discards section to the logbooks for commercial fisheries.
- More research is necessary on post-release live discard mortality for both commercial and recreational fisheries

2.5 TABLES

Table 2.5.1. Catches of Gulf of Mexico blacktip shark by fleet in numbers used in the continuity analysis. Catches are separated into four fisheries: commercial + unreported catches, recreational catches, Mexican catches, and menhaden fishery discards. Catches for 1981-2004 are identical to those used for SEDAR 11.

Year	Com+Unrep	Recreational + Mexican	Menhaden discards
1981	7261	161954	17495
1982	7261	124603	17933
1983	7844	88980	17714
1984	10712	131959	17714
1985	9950	132272	15964
1986	71435	224930	15746
1987	98806	156674	16402
1988	174842	207083	15964
1989	190962	192279	16839
1990	115002	199323	16402
1991	46484	200210	12684
1992	53236	232849	11153
1993	57102	210606	11372
1994	120028	154194	12200
1995	84862	134884	11200
1996	58666	154722	11153
1997	45221	132184	11372
1998	62486	125280	10935
1999	52304	72013	12028
2000	42131	112581	10279
2001	39397	80034	9622
2002	30040	79944	9404
2003	71540	55778	9185
2004	44174	72734	9404
2005	29000	83812	9404
2006	43679	59248	8966
2007	45768	47353	8966
2008	14051	41125	8966
2009	14538	47807	8966
2010	21000	73069	8966

Table 2.5.2. Summary of life history parameters for blacktip sharks in the Gulf of Mexico.

Life History Workgroup	Summary of Gulf of Mexico blacktip shark biological inputs for 2011 assessment	Reference
Pupping month	May	SEDAR29-WP-09
Growth parameters	Female / Male / Combined	
L_∞ (cm FL)	150.57 / 138.18 / 147.18	SEDAR29-WP-18
K	0.187 / 0.214 / 0.187	SEDAR29-WP-18
t_o (years)	-2.65 / -2.60 / -2.74	SEDAR29-WP-18
Maximum observed age	18.5 / 23.5* years	SEDAR29-WP-18
Sample size	599 / 511 / 1110	SEDAR29-WP-18
Length-weight relationships		
FL in cm	FL = (1.1009)PCL-0.53	LCS05/06-DW10
TL in cm	TL = (1.1955)FL+1.13	LCS05/06-DW10
STL in cm	STL = 1.0183(TL)+1.36	LCS05/06-DW10
WT in kg	WT = $(1\text{x}10^{-5})\text{FL}^{3.05}$	Carlson, unpublished data
Age at 50% maturity ogive		SEDAR29-WP-09
Female	t_{mat} = 6.3 years, a = -6.464, b = 1.020	
Male	t_{mat} = 4.8 years, a = -6.649, b = 1.393	
Size at 50% maturity ogive		SEDAR29-WP-09
Female	FL_{mat} = 119.2 cm FL, a = -28.095, b = 0.236	
Male	FL_{mat} = 105.8 cm FL, a = -24.010, b = 0.227	
Median age at maternity	t_{matern} = 10.1 years, a = -3.892, b = 0.385	SEDAR29-WP-09
Median size at maternity	FL_{matern} = 137.6, a = -10.030, b = 0.073	SEDAR29-WP-09
Reproductive cycle	Biennial	SEDAR29-WP-09
Fecundity	4.5 pups per brood. Pups=0.16(maternal age) + 2.92	SEDAR29-WP-09
Gestation	12 months	SEDAR29-WP-09

* Female maximum age estimate was used due to anomalous value for males

Table 2.5.3. Maturity schedule for blacktip sharks in the Gulf of Mexico using pooled data from SEDAR29-WP-09 and Carlson et al. (2006).

	Females	*a*=-6.464	*b*=1.02		Males	*a*=-6.649	*b*=1.393	
Age=Bands -1.5	Avg pct mat	SE a	SE b	n	Avg pct mat	SE a	SE b	n
0	0.001556	0.6195	0.0942	104	0.001294	0.768	0.1536	105
0.5	0.002589			67	0.002593			70
1.5	0.007146			65	0.010359			53
2.5	0.019570			47	0.040446			20
3.5	0.052451			29	0.145108			23
4.5	0.133080			27	0.406006			33
5.5	0.298594			34	0.733509			33
6.5	0.541405			25	0.917246			46
7.5	0.766025			33	0.978087			30
8.5	0.900787			37	0.994467			23
9.5	0.961801			42	0.998620			21
10.5	0.985881			23	0.999657			13
11.5	0.994862			25	0.999915			7
12.5	0.998141			11	0.999979			3
13.5	0.999329			8	0.999995			3
14.5	0.999758			1	0.999999			1
15.5	0.999913			2	1.000000			1
16.5	0.999969			4				0
17.5	0.999989			1				0
18.5	0.999996			1				0
19.5				0				0
20.5				0				0
21.5				0				0
22.5				0				0
23.5				0	1.000000			1

Table 2.5.4. Maternity schedule for female blacktip sharks in the Gulf of Mexico from SEDAR29-WP-09.

	a = -3.8919 *b* = 0.3848			
Age=band counts-1.5 (years)	Average percent in maternal condition	SE a	SE b	N
0	0.019998	0.40755	0.04606	58
0.5	0.024139			40
1.5	0.035070			31
2.5	0.050695			19
3.5	0.072756			10
4.5	0.103373			16
5.5	0.144860			24
6.5	0.199296			20
7.5	0.267783			28
8.5	0.349531			33
9.5	0.441198			33
10.5	0.537057			20
11.5	0.630252			18
12.5	0.714655			8
13.5	0.786323			8
14.5	0.843921			1
15.5	0.888201			2
16.5	0.921094			3
17.5	0.944909			1
18.5	0.961834			1

Table 2.5.5. Landings of "cazones" or small sharks in the Mexican states of Tamaulipas and Veracruz in 1993-1994 based on data from Castillo-Geniz et al. (1998).

Cazones Species	Tamaulipas Total	%	Veracruz Total	%
Rhizoprionodon terraenovae	5519	59.6	9993	57.0
Sphyrna tiburo	73	0.8	39	0.2
Carcharhinus limbatus	**2975**	**32.1**	**4378**	**25.0**
Carcharhinus acronotus	430	4.6	789	4.5
Squalus cubensis			1470	8.4
Carcharhinus porosus			154	0.9
Carcharhinus signatus			553	3.2
Mustelus norrisi	23	0.2	70	0.4
Squalus asper			72	0.4
Scyliorhinus retifer			14	0.1
Carcharhinus isodon	234	2.5		
Total	9254		17532	

Table 2.5.6. Yearly calculated dead discards of blacktip sharks from Gulf of Mexico bottom longline commercial fishing vessels. Discards are reported as number of fish. "Trips (discards)" is the number of trips with observer reported discards. "Trips (total effort)" is the number of shark-targeted trips (>2/3 shark landings by weight) reporting effort to the coastal logbook program. Total effort is number of hooks.

Year	Trips (discards)	Trips (total effort)	Discard Rate	Discard Rate CV	Total Effort	Calculated Dead Discards
1993		134	134		774,515	3,382
1994		243	243		1,164,170	5,083
1995		424	424		2,124,450	9,276
1996		729	729		2,511,345	10,965
1997		350	350		1,080,150	4,716
1998		331	331		1,189,496	5,194
1999		384	384		1,170,304	5,110
2000		337	337		973,290	4,250
2001		428	428		935,767	4,086
2002		496	496		1,088,609	4,753
2003		547	547		1,074,047	4,689
2004		434	434		789,230	3,446
2005		464	464		1,009,610	4,408
2006	28	576	576	2.244	1,193,336	11,282
2007	23	149	149	2.616	288,210	366
2008	31	136	136	1.994	160,520	371
2009	52	80	80	3.280	65,225	190
2010	64	54	54	2.973	15,380	84

Table 2.5.7. A summary of indices of abundance initially available for review at the SEDAR 29 Workshop for Gulf of Mexico blacktip shark. Juv is defined as sharks ages 1 up until maturity.

Series (Abbreviation)	*Author*	*Reference*	*Area*	*Years*	*Season*	*Biomass/ Number*	*Fishery Type*	*Standardized*	*Selectivity Info*	*Age Range*	*Positive Aspects*	*Negative Aspects*	*Utility for Assessment*
PC GN Gillnet All (PCGN)	Carlson et al.	WP-01	Coastal NW FL	96-10	Apr-Oct	No/net hour	Independent	Lo Method	Length Frequencies	Mostly immature	Long time series, Consistent gear type	Limited spatial coverage	Exclude
PC GN – Juvenile (PC GN Juv)	Carlson et al.	WP-01	Coastal NW FL	96-10	Apr-Oct	No/net hour	Independent	Lo Method	Length Frequencies	Only immature	Long time series, Consistent gear type	Limited spatial coverage	Sensitivity – Model includes Age-1+
Mote GN – Juvenile (MML GN Juv)	Carlson et al.	WP-01	Coastal W FL	95-97,99-10	Mar-Nov	No/net hour	Independent	Lo Method	Length Frequencies	Only immature	Long time series, Consistent gear type	Limited spatial coverage, Missing 1998	Sensitivity – Model includes Age-1+
PC Mote GN Combined – Juvenile (PC MML GN)	Carlson et al.	WP-01	Coastal NW-W FL	95-10	Mar-Nov	No/net hour	Independent	Lo Method	Length Frequencies	Only immature	Longer time series, Greater spatial coverage across coastal Florida	Gear differences	Exclude
PC Longline – All (PC LL)	Carlson et al.	LCS05/06-DW-12	Coastal NW FL	93-00	Apr-Oct	No/100 hook hour	Independent	Lo Method	Length Frequencies	All	Fishery independent	Limited spatial coverage, Gear differences	Sensitivity

Series (Abbreviation)	Author	Reference	Area	Years	Season	Biomass/ Number	Fishery Type	Standardized	Selectivity Info	Age Range	Positive Aspects	Negative Aspects	Utility for Assessment
BLL Observer (BLLOP)	Carlson et al.	WP-02	TX-FL	99-10	Jan-Dec	No/10,000 hook	Dependent	Lo Method	Length Frequencies	Mostly Age-1+	Better quality than logbook, Lengths reported	Mostly eastern Gulf; Missing 2004	Base
Mississippi Lab BLL (NMFS LL SE)	Ingram	WP-03	TX-FL	95-10	Aug-Sept	No/100 hook hour	Independent	Lo Method	Length Frequencies	Mostly Age-1+	Long time series, High spatial coverage		Base
BLL Commercial Logbook (BLL Logs old)	McCarthy	WP-04	TX-FL	96-10	Jan-Dec, Open season only	Pounds/ set	Dependent	Lo Method	Length Frequencies	Mostly mature	High spatial coverage	Species identification, Self-reporting	Exclude
PLL Commercial Logbook (PLL Logs)	Cortés and Baremore	WP-05	TX-FL	92-10	Jan-Dec, Open season only	None reported	Dependent	Lo Method	Length Frequencies	Mostly mature		No inshore data, Self-reported	Exclude
ENP Creel (ENP)	Carlson and Osborne	WP-06	S FL	83-10	Jan-Dec	Dock interviews	Dependent	Lo Method	Length Frequencies	All	Long time series, Species identification	Limited spatial coverage	Base
MRFSS (MRFSS)	Babcock	WP-10	LA-FL	81-10	Jan-Dec	No/1000 angler hours	Dependent	Lo Method	Length Frequencies	All	Long time series	Species identification	Sensitivity
Dauphin Island Sea Lab (AL LL)	Drymon and Powers	WP-11	Coastal AL	06-10	Jan-Dec	No/100 hook hour	Independent	Lo Method	Length Frequencies	Mostly immature	Inshore survey, Same gear as NMFS SE LL	Limited spatial coverage, Short time series	Sensitivity

Series (Abbreviation)	*Author*	*Reference*	*Area*	*Years*	*Season*	*Biomass/ Number*	*Fishery Type*	*Standardized*	*Selectivity Info*	*Age Range*	*Positive Aspects*	*Negative Aspects*	*Utility for Assessment*
Texas PWD GN – All (TEXAS)	Bubley and Carlson	WP-12	TX Bays	92-10	April-June, Sept-Nov	No/net hour	Independent	Lo Method	Length Frequencies	All	Long time series, High spatial coverage across Texas		Base – Model include only Age-1+
Texas PWD GN – Juvenile (TEXAS Juv)	Bubley and Carlson	WP-12	TX Bays	92-10	April-June, Sept-Nov	No/net hour	Independent	Lo Method	Length Frequencies	Only immature	Long time series, High spatial coverage across Texas		Exclude
GCRL Gillnet – YOY (MS GN YOY)	Hoffmayer et al.	WP-13	MS Sound	98-10 (11)	Mar-Oct	No/100 m net hour	Independent	Lo Method	Length Frequencies	Only YOY	Long time series, high spatial coverage		Exclude
GCRL Gillnet – Juvenile (MS GN Juv)	Hoffmayer et al.	WP-13	MS Sound	98-10 (11)	Mar-Oct	No/100 m net hour	Independent	Lo Method	Length Frequencies	Only immature	Long time series	Limited spatial coverage	Exclude
GCRL Gillnet – All (MS GN)	Hoffmayer et al.	WP-13	MS Sound	98-10 (11)	Mar-Oct	No/100 m net hour	Independent	Lo Method	Length Frequencies	All	Long time series	Limited spatial coverage	Sensitivity – Model includes Age-1+
GCRL Bottom LL – Juvenile (MS LL Juv)	Hoffmayer et al.	WP-14	MS Sound	04-10 (11)	Mar-Oct	No/100 hook hour	Independent	Lo Method	Length Frequencies	Only immature	Inshore survey	Limited spatial coverage, Short time series	Exclude
GCRL Bottom LL – All (MS LL)	Hoffmayer et al.	WP-14	MS Sound	04-10 (11)	Mar-Oct	No/100 hook hour	Independent	Lo Method	Length Frequencies	All	Inshore survey	Limited spatial coverage, Short time series	Sensitivity – Model includes Age-1+

Series (Abbreviation)	Author	Reference	Area	Years	Season	Biomass/ Number	Fishery Type	Standardized	Selectivity Info	Age Range	Positive Aspects	Negative Aspects	Utility for Assessment
SEAMAP coastal LL (MS-LA LL)	Hoffmayer and Pollack	WP-15	Coastal MS, LA	08-10 (11)	Mar-Oct	No/100 hook hour	Independent	Lo Method	Frequencies	All	Inshore survey	Limited spatial coverage, Short time series	Sensitivity – Model includes Age-1+
BLL logbook with logistic regression (BLL Logs)	McCarthy	WP-19	TX-FL	96-10	Jan-Dec, Open season only	Pounds/ set	Dependent	Lo Method	Length Frequencies	Mostly mature	High spatial coverage	Species identification, Self-reporting	Sensitivity
Gillnet surveys combined (PC+MML+MS GN)	Carlson et al.	WP-21	FL	95-10	Mar-Oct	No/net hour	Independent	Lo Method	Length Frequencies	Mostly immature	Long time series, Consistent gear type	Limited spatial coverage	Base
Longline surveys combined (MS+MS-LA+AL LL)	Hoffmayer et al.	WP-22	MS, AL, LA	04-10	Jan-Dec	No/100 hook hour	Independent	Lo Method	Length Frequencies	All	Inshore survey		Base

Table 2.5.8. Fishery-independent indices recommended by SEDAR29 for the Gulf of Mexico stock of blacktip sharks, including the corresponding SEDAR document number and run type (base or sensitivity). Index values are absolute. Rankings are the SEDAR 29 Panel's recommendation for index weighting. Juv is defined as sharks ages 1 up until maturity.

	Indices of Blacktip Shark Based on NMFS Bottom Longline Surveys (NMFS LL SE Age 1+) SEDAR29-WP-03 Base		Relative abundance of blacktip shark based on a fishery-independent gillnet survey off Texas (TEXAS Age 1+) SEDAR29-WP-12 Base		Combined PC-Mote GCRL gillnet series (PC+MML+MS GN Age 1+) SEDAR29-WP-21 Base		Combined GCRL DISL SEAMAP longline series (MS+MS-LA+AL LL Age 1+) SEDAR29-WP-22 Base	
Year	Index Values	CV	Index Values	CV	Index Values	CV	Index Values	CV
1982			0.0037	0.34				
1983			0.0012	0.70				
1984			0.0012	0.70				
1985			0.0011	0.56				
1986			0.0032	0.37				
1987			0.0019	0.52				
1988			0.0018	0.48				
1989			0.0036	0.45				
1990			0.0024	0.43				
1991								
1992			0.0002	1.71				
1993			0.0008	0.70				
1994			0.0008	0.70				
1995	0.263	0.44	0.0011	0.62	0.153	0.80		
1996	0.139	0.59	0.0016	0.48	0.115	0.52		
1997	0.280	0.39	0.0003	1.06	0.213	0.43		
1998			0.0007	0.70	0.178	0.50		
1999	0.272	0.28	0.0013	0.56	0.298	0.36		
2000	0.398	0.25	0.0028	0.39	0.269	0.39		
2001	0.620	0.26	0.0009	0.83	0.224	0.36		
2002	0.720	0.23	0.0020	0.43	0.195	0.35		
2003	1.410	0.19	0.0030	0.39	0.218	0.32		
2004	0.854	0.22	0.0056	0.33	0.344	0.29	2.49	0.27
2005	0.519	0.51	0.0031	0.37	0.207	0.35	2.59	0.20
2006	0.568	0.32	0.0050	0.30	0.252	0.32	2.18	0.12
2007	0.597	0.38	0.0014	0.56	0.294	0.32	1.39	0.11
2008	0.320	0.51	0.0057	0.28	0.268	0.32	1.30	0.10
2009	0.821	0.27	0.0070	0.24	0.127	0.47	1.21	0.16
2010	0.815	0.34	0.0065	0.30	0.182	0.46	1.86	0.10

Table 2.5.8 (continued). Fishery-independent indices recommended by SEDAR29 for the Gulf of Mexico stock of blacktip sharks, including the corresponding SEDAR document number and run type (base or sensitivity). Index values are absolute. Rankings are the SEDAR 29 Panel's recommendation for index weighting. Juv is defined as sharks ages 1 up until maturity.

	Relative abundance of blacktip shark, *Carcharhinus limbatus*, from the eastern Gulf of Mexico (PC GN Juv) SEDAR29-WP-01 Sensitivity		Relative abundance of blacktip shark, *Carcharhinus limbatus*, from the eastern Gulf of Mexico (MML GN Age 0+) SEDAR29-WP-01 Sensitivity		Standardized catch rates of blacktip sharks (*Carcharhinus limbatus*) collected during a gillnet survey in Mississippi coastal waters, 1998-2011 (MS GN Juv) SEDAR29-WP-13 Sensitivity		Standardized catch rates of blacktip sharks (*Carcharhinus limbatus*) collected during a Seamap bottom longline survey in Mississippi/Louisiana coastal waters from 2008 to 2011. (MS-LA LL Juv) SEDAR29-WP-15 Sensitivity	
Year	Index Values	CV	Index Values	CV	Index Values	CV	Index Values	CV
1995			1.436	0.21				
1996	0.306	0.52	2.152	0.29				
1997	0.594	0.38	0.787	0.43				
1998	0.431	0.55			0.235	0.70		
1999	0.714	0.39	1.169	0.40	0.174	0.69		
2000	0.504	0.57	1.833	0.35	1.111	0.31		
2001	0.693	0.37	2.391	0.28	0.046	1.82		
2002	0.574	0.34	2.495	0.26				
2003	0.574	0.32	2.306	0.33	0.031	2.66		
2004	0.731	0.31	3.431	0.25	0.074	1.20		
2005	0.635	0.34			0.241	0.81		
2006	0.607	0.35			0.041	1.29		
2007	0.886	0.33			0.277	0.62		
2008	0.753	0.31			0.081	1.19	0.544	0.31
2009	0.360	0.52			0.106	0.89	0.944	0.33
2010	0.603	0.54			0.231	0.53	0.751	0.29

Table 2.5.8 (continued). Fishery-independent indices recommended by SEDAR29 for the Gulf of Mexico stock of blacktip sharks, including the corresponding SEDAR document number and run type (base or sensitivity). Index values are absolute. Rankings are the SEDAR 29 Panel's recommendation for index weighting. Juv is defined as sharks ages 1 up until maturity.

	Catch rates f blacktip shark *Carcharhinus limbatus* in the northern Gulf of Mexico, 2006-2010 (AL LL Age 1+) SEDAR29-WP-11 Sensitivity		Catch rates of blacktip shark *Carcharhinus limbatus* in the northern Gulf of Mexico, 2006-2010 (MS LL Juv) SEDAR29-WP-14 Sensitivity		Standardized catch rates of large coastal sharks from a fishery-independent survey in northeast Florida (PC LL Age 1+) LCS05/06-DW-12 Sensitivity	
Year	Index Values	CV	Index Values	CV		
1993					0.816	0.73
1994					0.386	0.89
1995					1.272	0.61
1996					0.858	0.58
1997					0.926	0.54
1998					0.725	0.97
1999					1.174	0.56
2000					1.844	0.51
2001						
2002						
2003						
2004			0.705	0.49		
2005			1.101	0.36		
2006	1.493	0.24	0.264	0.66		
2007	0.746	0.21	0.359	0.56		
2008	1.119	0.18	0.133	0.97		
2009	0.523	0.67	0.026	2.55		
2010	1.103	0.33	0.583	0.59		

Table 2.5.9. Fishery-dependent indices recommended by SEDAR29 for the Gulf of Mexico stock of blacktip sharks, including the corresponding SEDAR document number and run type (base or sensitivity). Index values are absolute.

	Standardized catch rates of blacktip sharks (*Carcharhinus limbatus*) from the Shark Bottom Longline Observer Program, 1994-2010 (BLLOP) SEDAR29-WP-02 Base		Standardized catch rates of blacktip sharks from the Everglades National Park Creel Survey (ENP) SEDAR29-WP-06 Base		A standardized CPUE index of abundance for Gulf of Mexico blacktip sharks from the Marine Recreational Statistics Survey (MRFSS). SEDAR29-WP-10 Sensitivity		Commercial Bottom Longline Vessel Standardized Catch Rates with targeting determined using logistic regression (BLL Logs) SEDAR29-WP-19 (updated) Sensitivity	
Year	Index Values	CV	Index Values	CV	Index Values	CV	Index Values	CV
1981					1.71	0.99		
1982					0.41	0.98		
1983			0.00786	0.34	1.16	0.99		
1984			0.01046	0.29	0.41	1.02		
1985			0.00796	0.36	0.88	0.94		
1986			0.00814	0.33	1.53	0.86		
1987			0.01232	0.28	0.54	0.88		
1988			0.01425	0.29	1.41	0.85		
1989			0.00703	0.45	1.04	0.88		
1990			0.01173	0.25	1.11	0.87		
1991			0.00651	0.36	1.26	0.86		
1992			0.01278	0.21	0.74	0.84		
1993			0.00608	0.39	0.72	0.86		
1994	23.39	0.40	0.01020	0.21	0.65	0.85		
1995	65.50	0.28	0.00820	0.27	0.92	0.85		
1996	56.05	0.35	0.01187	0.18	1.05	0.85	0.658	0.29
1997	36.87	0.81	0.01019	0.19	1.16	0.86	0.771	0.27
1998	107.78	0.56	0.00742	0.25	1.39	0.82	1.033	0.28
1999	135.01	0.46	0.00704	0.27	0.74	0.83	1.690	0.26
2000			0.00969	0.22	1.54	0.82	1.778	0.27
2001	1.94	1.75	0.00652	0.30	0.78	0.84	1.234	0.27
2002	235.93	0.24	0.00622	0.31	0.73	0.83	1.284	0.25
2003	271.19	0.20	0.00885	0.26	1.09	0.83	1.739	0.24
2004	299.25	0.23	0.00761	0.29	0.86	0.84	1.782	0.24
2005	155.92	0.26	0.00599	0.36	0.99	0.84	1.329	0.25
2006	313.44	0.30	0.00529	0.39	1.34	0.83	1.706	0.25
2007	253.13	0.30	0.00718	0.31	1	0.86	1.700	0.27
2008	191.27	0.31	0.00755	0.33	0.64	0.87	0.787	0.29
2009	229.66	0.29	0.00660	0.37	0.9	0.84	1.324	0.35
2010	154.57	0.29	0.00796	0.35	1.29	0.83	1.112	0.41

Table 2.5.10. A summary of the abundance indices used for base or sensitivity model runs with the associated rank of the time series.

MODEL RUN	DESCRIPTION	DATA SERIES USED	RANK
Base	Base	NMFS LL SE (WP-03)	1
		TEXAS (WP-12)	2
		BLLOP(WP-02)	2
		PC+MML+MS GN (WP-21)	3
		ENP (WP-06)	4
		MS+MS-LA+AL LL (WP-22)	4
Sensitivity1	Add two time series to base	NMFS LL SE (WP-03)	1
		TEXAS (WP-12)	2
		BLLOP(WP-02)	2
		PC+MML+MS GN (WP-21)	3
		ENP (WP-06)	4
		MS+MS-LA+AL LL (WP-22)	4
		PCLL (SEDAR 21)	5
		MRFSS (WP-10)	5
Sensitivity2	Replace observer longline time series with logbook time series	NMFS LL SE (WP-03)	1
		TEXAS (WP-12)	2
		BLL Logs (WP-19)	3
		PC+MML+MS GN (WP-21)	3
		ENP (WP-06)	4
		MS+MS-LA+AL LL (WP-22)	4
Sensitivity3	Disaggregate coastal fishery-independent gillnet and longline data series	NMFS LL SE (WP-03)	1
		TEXAS (WP-12)	2
		BLLOP (WP-02)	2
		ENP (WP-06)	3
		PC GN Juv(WP-01)	4
		MML GN Juv (WP-01)	4
		MS GN (WP-13)	4
		AL LL (WP-11)	5

		MS LL (WP-14)	5
		MS-LA LL (WP-15)	6
Sensitivity4	Disaggregate coastal fishery-independent longline series	NMFS LL SE (WP-03)	1
		TEXAS (WP-12)	2
		BLLOP (WP-02)	2
		PC+MML+MS GN (WP-21)	3
		ENP (WP-06)	4
		AL LL (WP-11)	5
		MS LL (WP-14)	5
		MS-LA LL (WP-15)	6
Sensitivity5	Disaggregate coastal fishery-independent gillnet series	NMFS LL SE (WP-03)	1
		ENP (WP-06)	2
		BLLOP (WP-02)	2
		PC+MML+MS GN (WP-21)	4
		PC GN Juv (WP-01)	5
		MML GN Juv (WP-01)	5
		MS GN (WP-13)	5

2.6 FIGURES

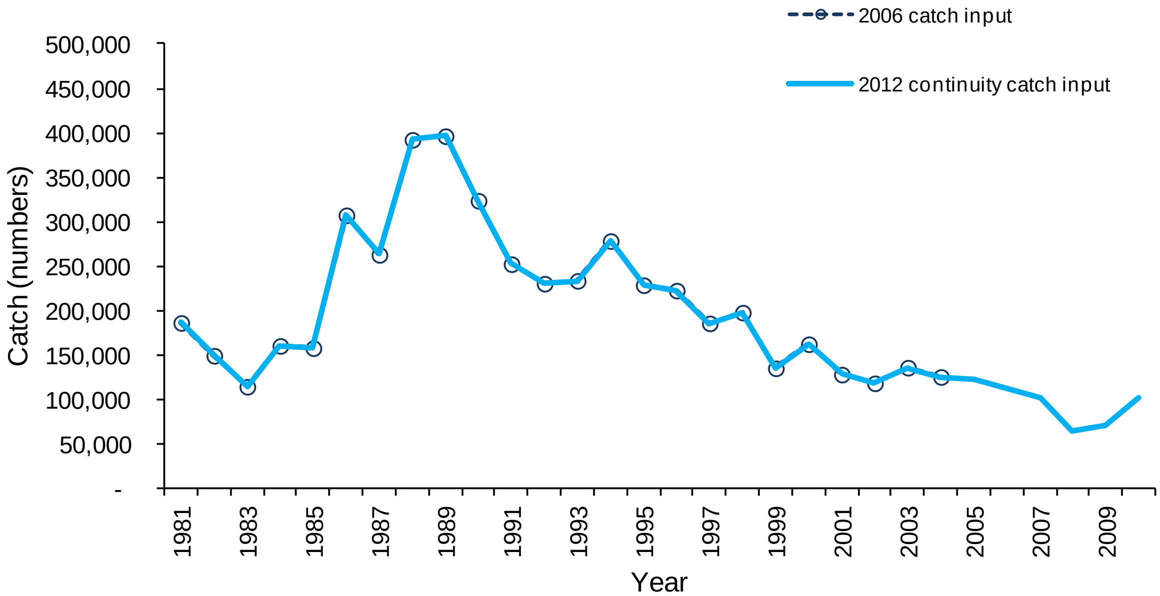


Figure 2.6.1. Catches used in the 2006 assessment (circles) and in the continuity analysis (thick blue line), where six years of data (2005-2010) were added.

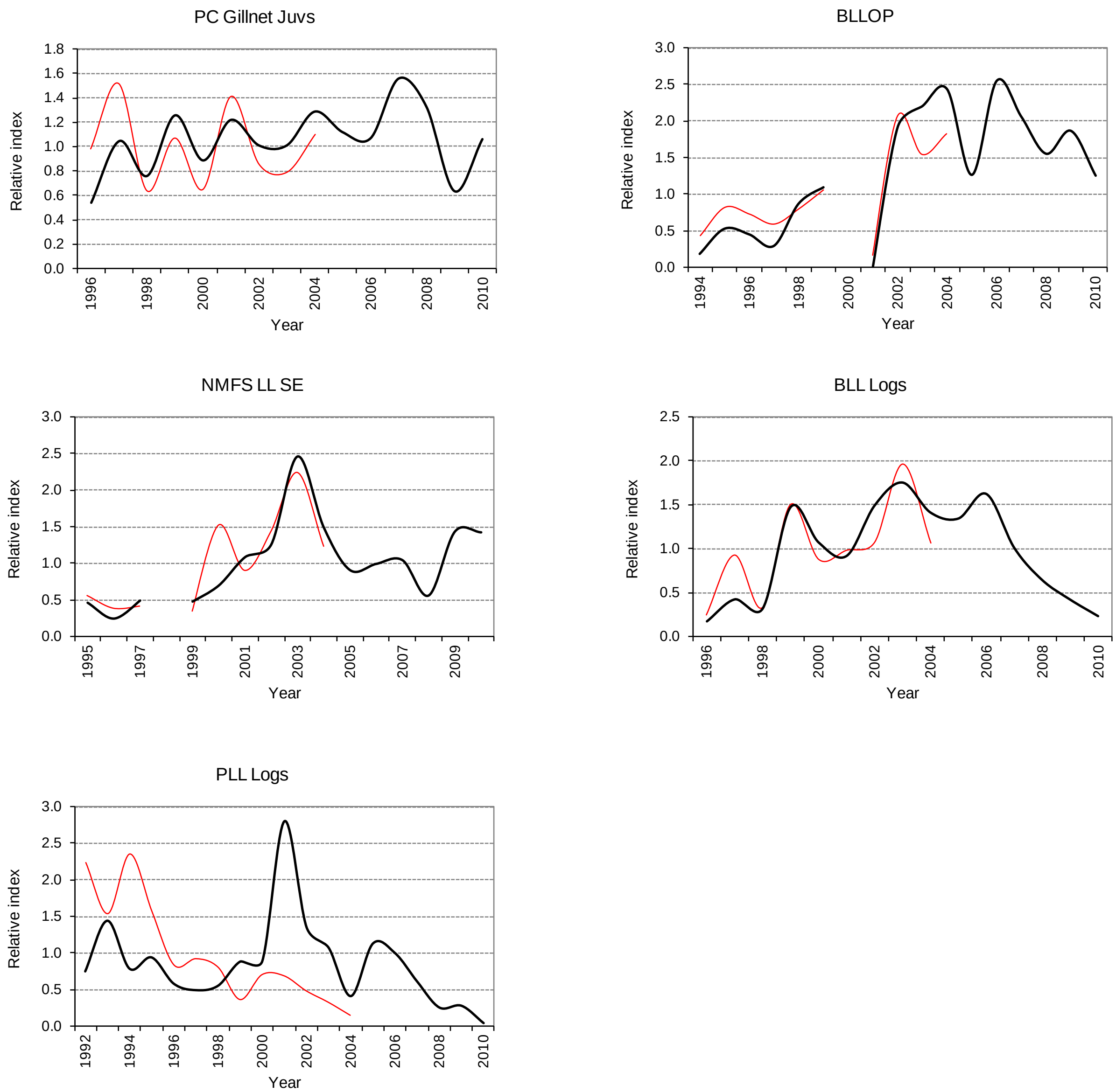
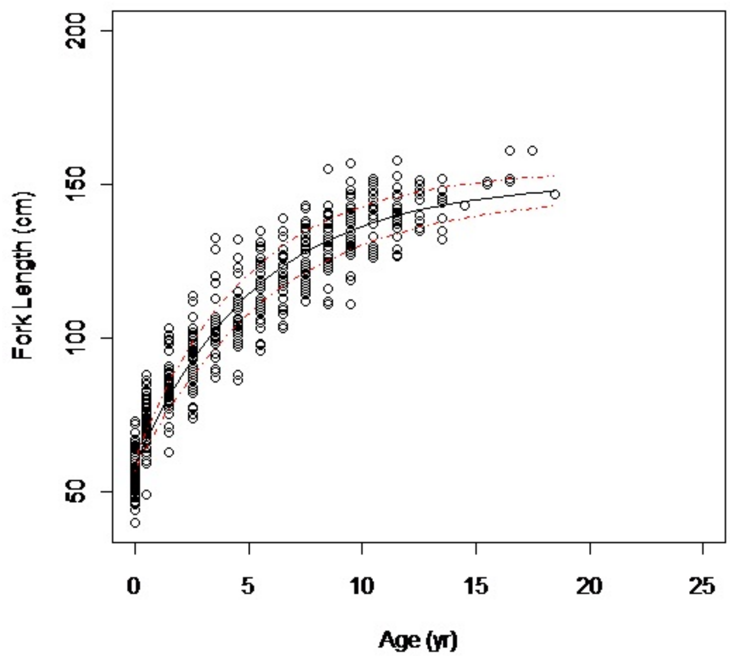


Figure 2.6.2. Indices used in the 2006 assessment (thin red line) vs. current continuity analysis (thick black line). All indices were re-analyzed and are scaled (divided by the mean of overlapping years).



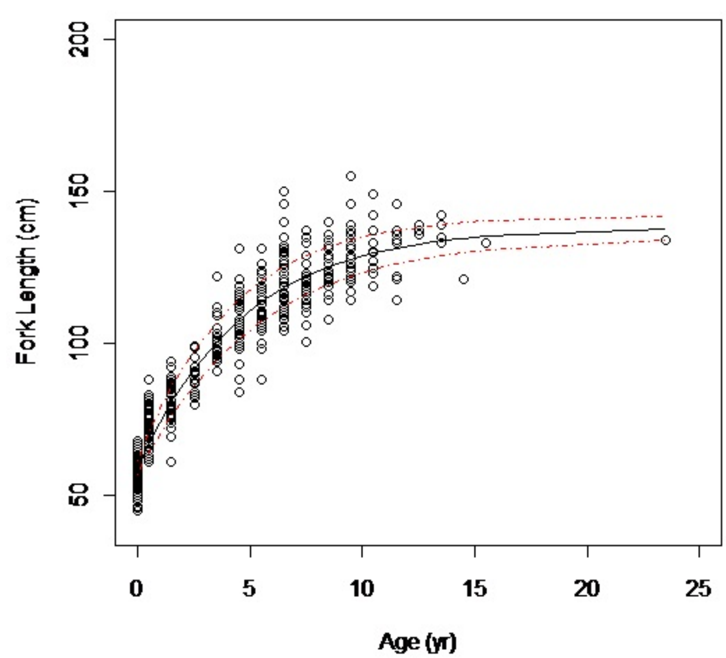


Figure 2.6.3. Von Bertalanffy growth curves for female (top, n=599) and male (bottom, n=511) blacktip sharks in the Gulf of Mexico using pooled data from SEDAR29-WP-18 and Carlson et al. (2006), with 95% confidence intervals indicated in red.

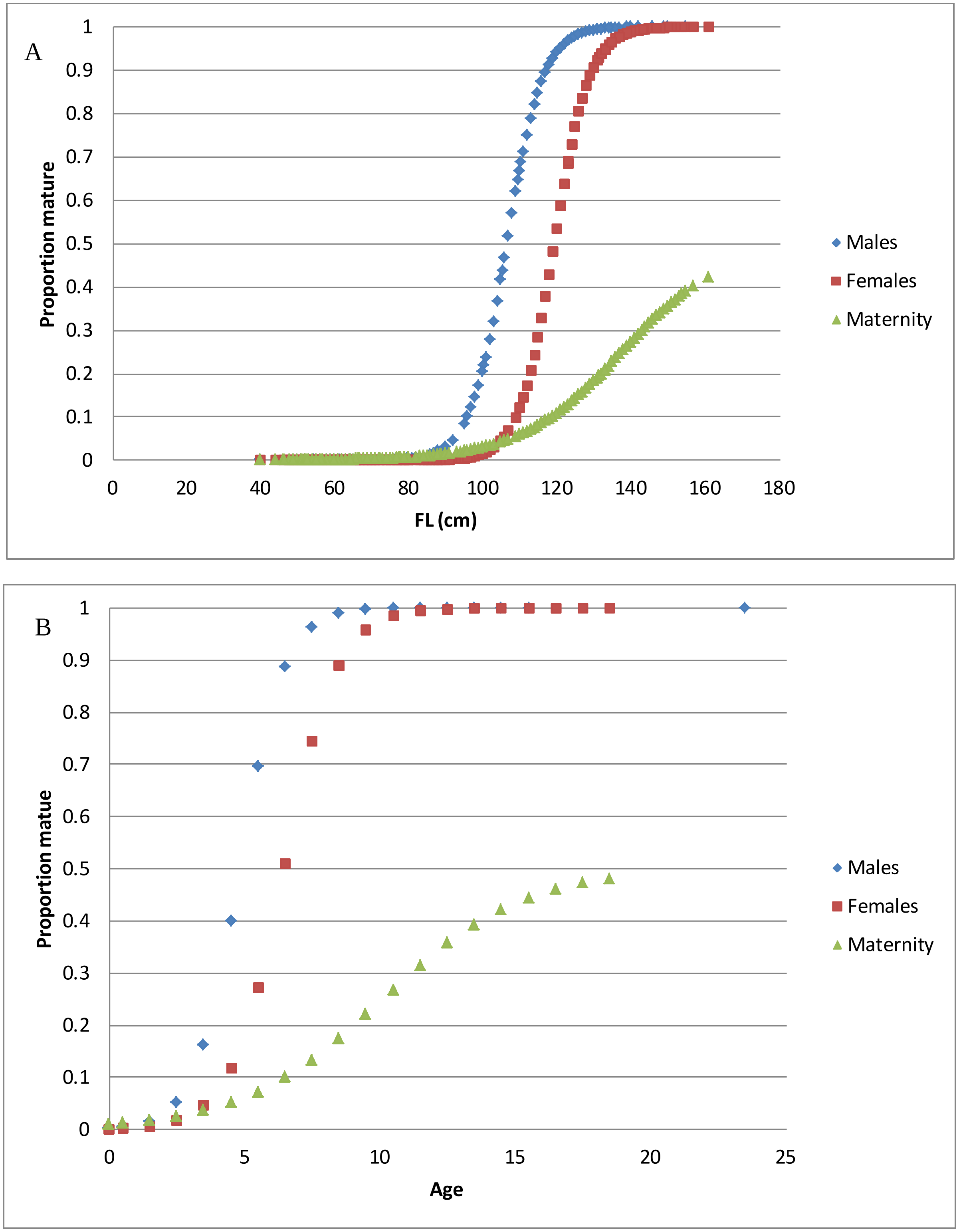


Figure 2.6.4. Size (A) and age (B) ogives for maturity and maternity of blacktip sharks in the Gulf of Mexico from SEDAR29-WP-09.

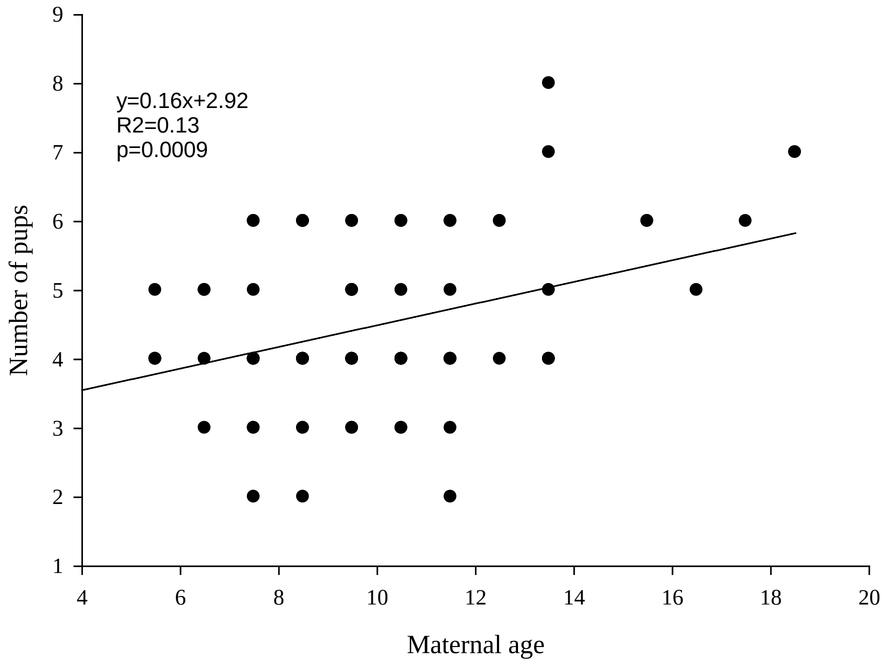


Figure 2.6.5. Relationship between maternal age and fecundity (number of pups) for female blacktip sharks in the Gulf of Mexico (SEDAR-29-WP-09).

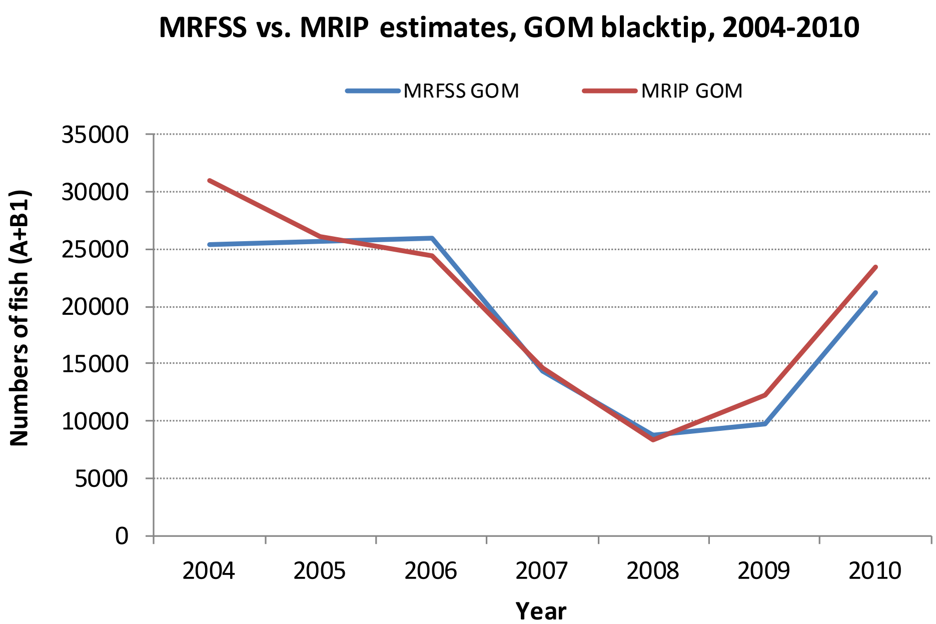


Figure 2.6.6. Marine Recreational Fisheries Statistic Survey vs. Marine Recreational Information Program landings for blacktip sharks in the Gulf of Mexico, 2004-2010.

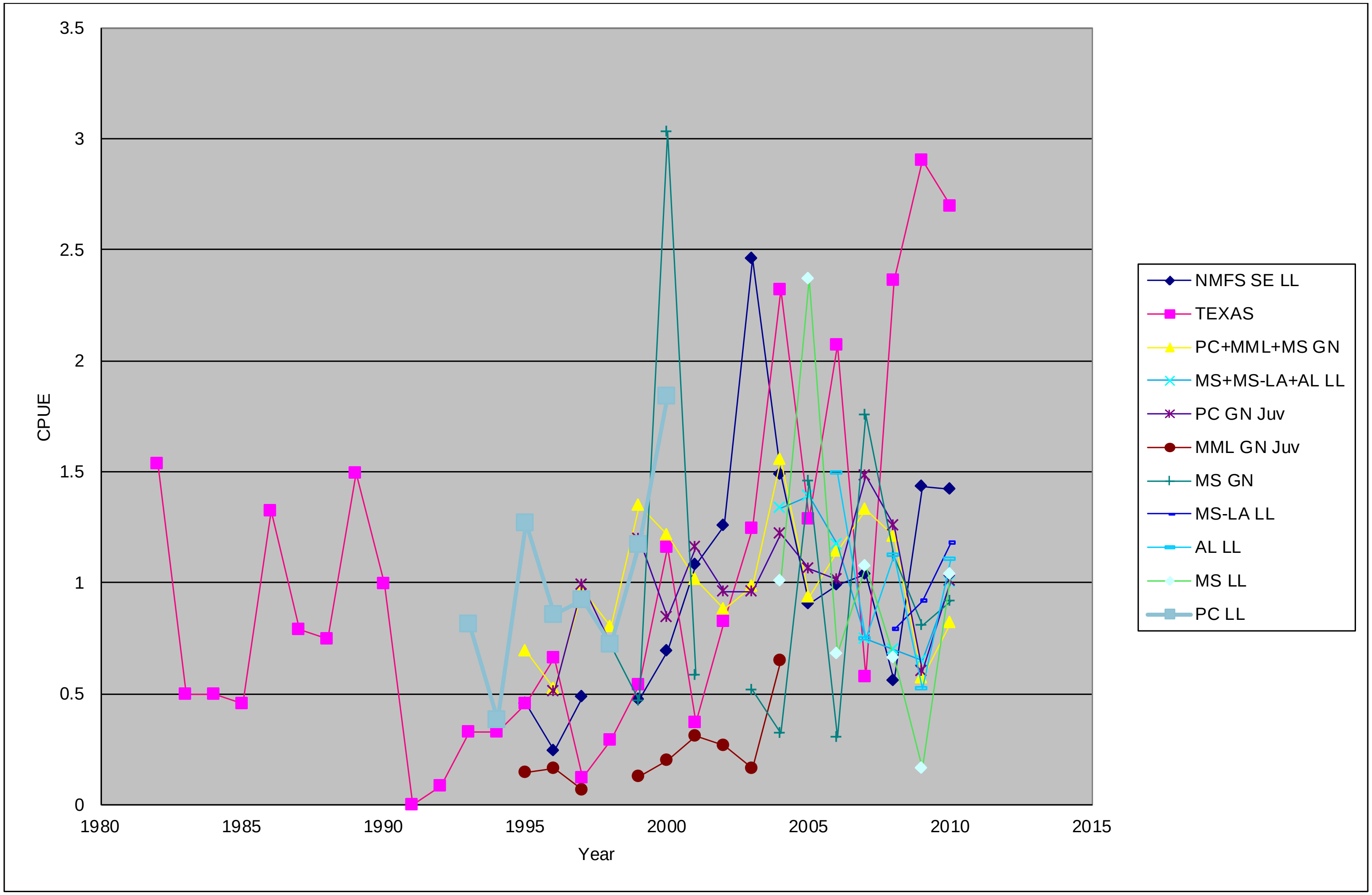


Figure 2.6.7. Plots of mean yearly CPUE for each fishery-independent index recommended for the Gulf of Mexico stock of blacktip sharks (base or sensitivities). Values were normalized to a common scale by dividing yearly CPUE of each index by the mean CPUE of the index.

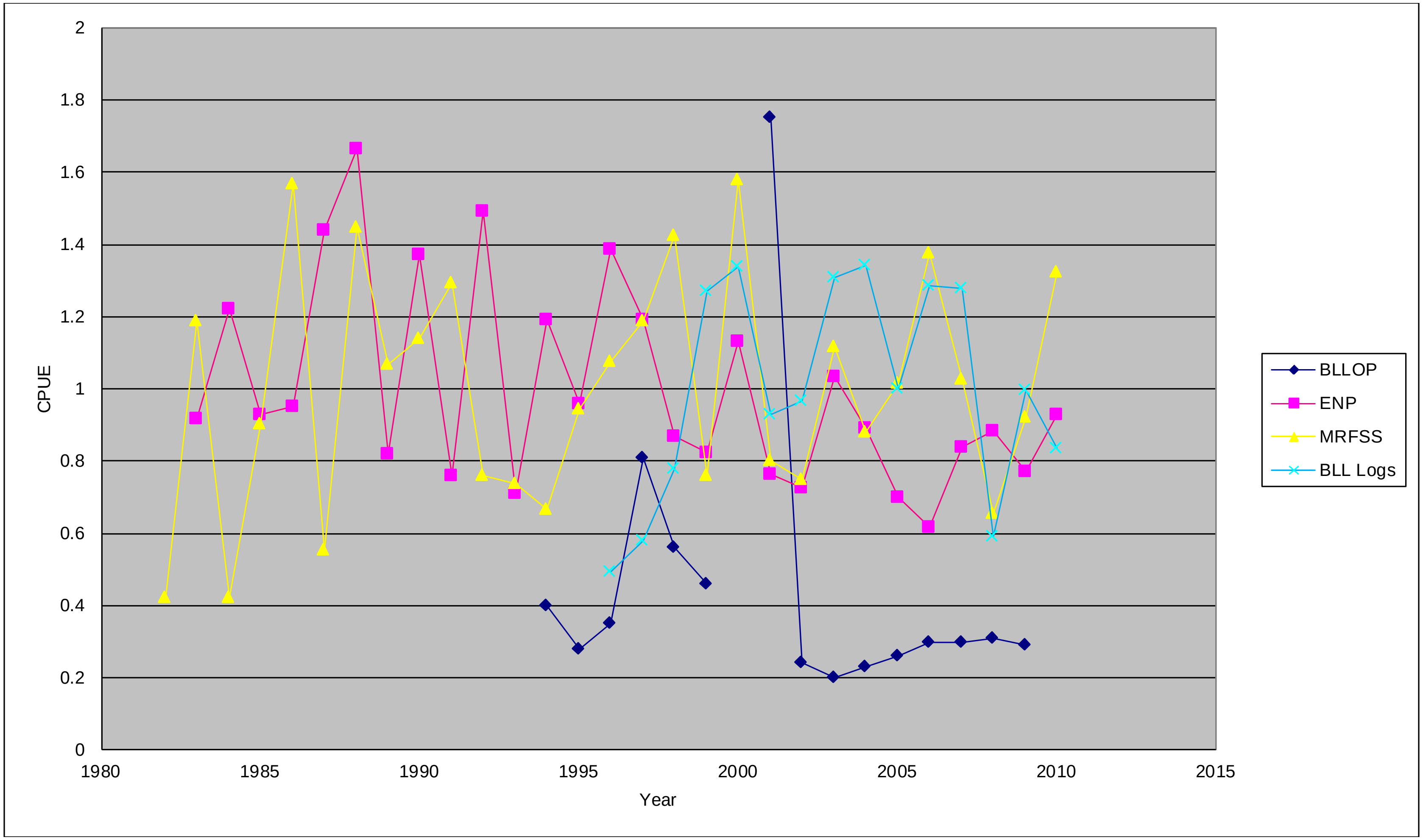


Figure 2.6.8. Plots of mean yearly CPUE for each fishery-dependent index recommended for the Gulf of Mexico stock of blacktip sharks (base or sensitivities). Values were normalized to a common scale by dividing yearly CPUE of each index by the mean CPUE of the index.

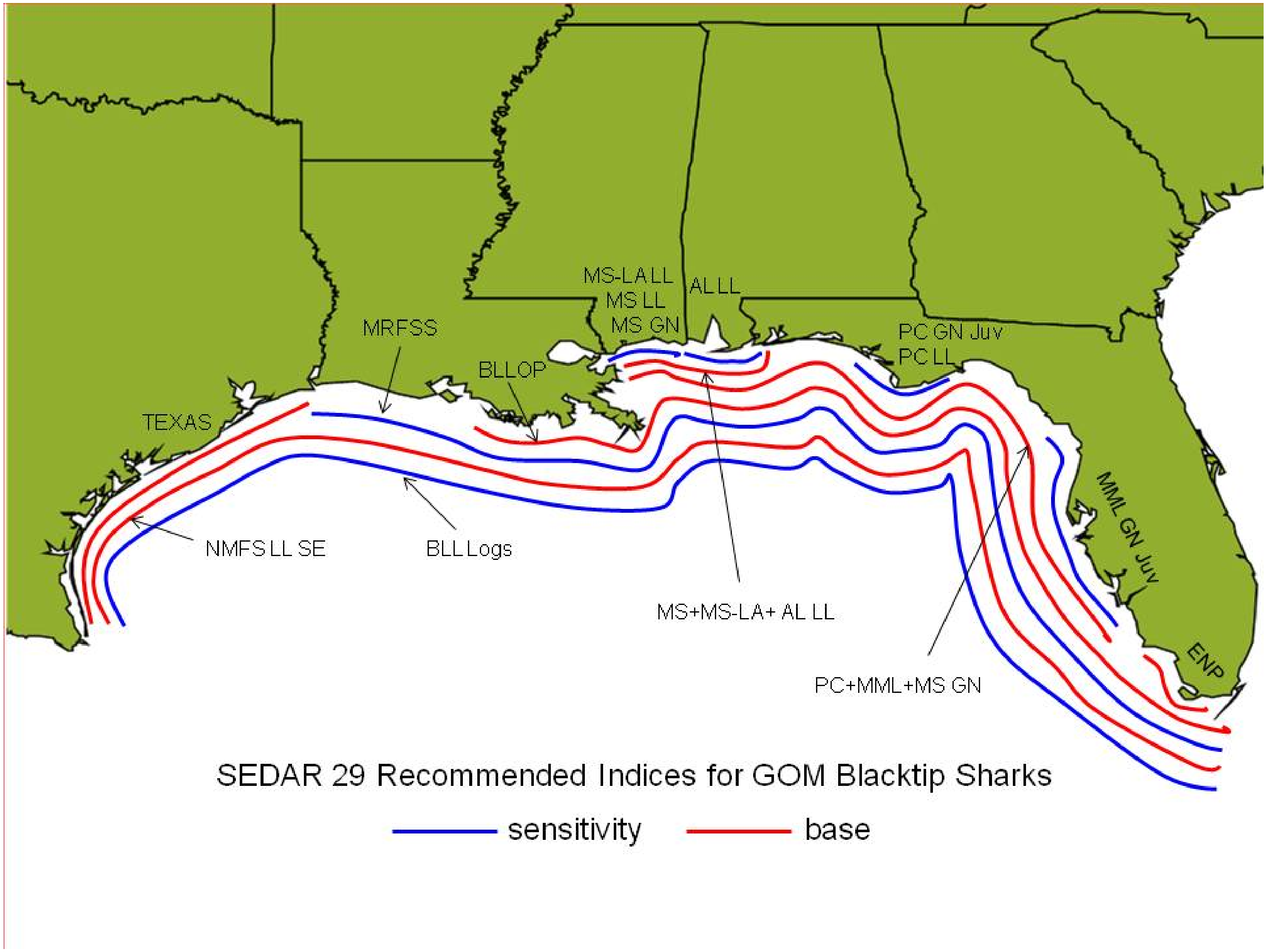


Figure 2.6.9. Approximate linear coverage of specific abundance indices for blacktip shark along the coast of the Gulf of Mexico.

3 STOCK ASSESSMENT MODEL(S) AND RESULTS

3.1 MODEL METHODS: STATE- SPACE AGE-STRUCTURED PRODUCTION MODEL (SSASPM)

3.1.1. Overview

The state-space, age-structured production model (SSASPM) was used as the primary assessment modeling approach. The SSASPM has been used extensively for assessing shark stocks domestically and under the auspices of ICCAT since 2002 (see e.g. ICCAT 2005, SEDAR 21). The SSASPM allows incorporation of several of the important biological (mortality, growth, reproduction) and fishery (selectivity, effort) processes in conjunction with observed catches and CPUE indices. A first step in applying this method is to identify a year in which the stock can be considered to be at virgin conditions. Assuming that there is some basis for deriving historic removals, one can estimate a population trajectory from virgin conditions through a more data-poor historic period when only catch or effort data are available, until a more recent year ("modern period") when more data (e.g., CPUE indices) become available for model fitting. For the present assessment, no information was available to derive historic catch or effort series prior to the initial year of the model, 1981. Thus, the present implementation of SSASPM considers only the modern period.

3.1.2. Data Sources

Catches, indices of abundance, length and age compositions to derive selectivities, selectivities, and biological inputs used in the SSASPM are described next.

3.1.2.1. *Catches*

One of the main changes introduced to the catch streams with respect to SEDAR 11 was splitting the "recreational+Mexican" series into a "recreational" and a "Mexican" series (see Decisions in Section 2.2.2). Further conceptual changes included: 1) using the recreational estimates from MRIP instead of those from MRFSS for 2004-2010 (see Decisions in Section 2.2.2), 2) addition of post-release live discard mortality estimates for B2 (release alive) sharks from MRFSS/MRIP (see Decisions in Section 2.2.2), and 3) addition of dead discard estimates in the "commercial + unreported" series for 1993-2010 (see Decisions in Section 2.2.2) and of post-release live discard mortality estimates (see Decisions in Section 2.2.2). All other procedures for developing catch series are explained in document SEDAR29-WP-08.

Commercial, recreational, and Mexican catches as well as discards from the menhaden fishery are presented in **Table 3.5.1A** and **Figure 3.6.1A** (in numbers, as used in the assessment). As requested in TOR#4 we also developed catch streams in weight (**Table 3.5.1B**; **Figure 3.6.1B**). The intermediate steps for obtaining catch in weight (lb dw) were as follows. Commercial landings are already provided in weight, but dead discards from the bottom longline fishery were estimated in number so average weights from the BLLOP were used to convert numbers into weight. These same average weights were used to convert estimated number of live post release mortality estimates into weight. For recreational catches, estimates of A+B1 catches have recently been made available in weight (lb ww) too. Sharks released alive (B2s) are only available in numbers; we used the ratio of the weight to the number of A+B1 sharks as average weight to multiply B2 catches in numbers and obtain B2 catches in weight. All transformations of ww to dw used a factor of 2.0 (i.e., ww=2dw). For Mexican catches, the original fisheries statistics from Conapesca already report catches in weight (t ww), so they were expressed in lb dw. There is almost no size information to help guide conversion of numbers into weight for the menhaden fishery discards. However, the original De Silva et al. (2001) paper from which these estimates are ultimately derived mentions one 100-cm TL blacktip shark being observed, which would correspond to a weight of 6.58 lb dw, thus this was used as average weight to transform numbers into weight. When expressed in weight compared to numbers, it becomes apparent that the commercial fishery catches larger animals than the Mexican and especially the recreational fishery (**Figure 3.6.1.A** and **3.6.1B**).

3.1.2.2. Length Compositions, Age Compositions, and Selectivities

Size composition of the catch (by length, but especially by age) is not routinely collected for sharks; only limited length information from observer and other programs and some surveys is available. The SSASPM cannot accommodate lengths, but in theory can accept age compositions. Attempts at estimating selectivity within the model through the use of available age compositions (obtained from length compositions through age-length keys as explained below) were unsuccessful and thus, as in previous implementations of the model, selectivities had to be estimated externally to the model.

Available length-frequency information from animals caught in scientific observer programs, recreational fishery surveys, and various fishery-independent surveys was used to generate age-frequency distributions through an age-length key (**Appendix 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 (in the present case the von Bertalanffy function), 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 Assessment Process (AP) Panel decided that age frequencies be estimated using an age-length key. It is recommended that in the future other approaches (e.g., age slicing, stochastic age-frequency estimation using the VBGF [Bartoo and Parker 1983] or probabilistic methods [Goodyear 1997]) be investigated, although some of these methods require more information that may not be available.

The age-frequency distributions thus obtained 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 natural mortality (M) operating, one would expect an age-frequency histogram to decline with age. However, with both M and fishing mortality (F) operating, what is observed instead is an increase in the age frequency that reflects the increase in selectivity with age up to a "fully selected" age. Beyond the "fully selected" age, all subsequent ages are expected to consistently decline because they all experience (approximately) the same F and M. The fully selected age is thus determined by looking at the age-frequency distribution and identifying the "fulcrum" or modal age class, where younger ages show an increasing frequency and all subsequent ages decrease in frequency. The specific algorithm for deriving selectivities is detailed in Appendix 2. Based on the above, the following selectivity curves were fitted statistically or approximated by eye (to accommodate beliefs of the selectivity of a particular gear type) to each catch and CPUE series:

Catches:

<u>Commercial+unreported</u>—Logistic curve, with age at full selectivity of 7 (selectivity curve corresponding to the BLLOP index).

<u>Recreational</u>—A dome-shaped selectivity curve (double exponential) with age 1 being fully selected and only the descending right limb of the curve represented.

<u>Mexican</u>—Same as the recreational selectivity, but with slightly higher selectivity at age.

<u>Menhaden fishery discards</u>—A constant selectivity of 1 was assumed as in SEDAR 11 (expressed in logistic form).

Indices of relative abundance:

PC+MML+MS (gillnet)—In recognition that this composite index consisted of surveys predominantly catching juvenile sharks, a dome-shaped selectivity curve (double exponential) was assumed, with age 1 being fully selected and only the descending right limb of the curve represented.

BLLOP (bottom longline)—Logistic curve (fitted statistically), with age at full selectivity of 7.

NMFS LL SE (bottom longline)—Logistic curve (fitted statistically), but with the ascending portion of the curve prior to the inflection point covering the younger age classes substantially more than the BLLOP curve. The age at full selectivity was 4.

ENP (hook and line)—Also recognizing that this was a predominantly juvenile shark survey, a double exponential curve was assumed with age at full selectivity of 1 followed by a descending right limb steeper than that of the PC+MML+MS gillnet index, which also caught some older animals.

TEXAS (gillnet)—Fully selected age was also 1, but older animals were also represented in the sample, thus a double exponential curve covering older age classes than the ENP and PC+MML+MS gillnet curves was assumed.

MS+MS-LA+AL (bottom longline)—As above, but the sample covered even older animals, thus a double exponential curve with the least slope was assigned.

Logistic curves fitted to the data were:

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

where a_{50} is the median selectivity age (inflection point) and b is the slope. Double logistic curves were expressed as:

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

where a_{50} and c_{50} are the ascending and descending inflection points, and b and d are the ascending and descending slopes, respectively.

All selectivities used in the baseline scenario are summarized in **Table 3.5.2** and **Figure 3.6.2**.

3.1.2.3. *Indices of Relative Abundance*

The standardized indices of relative abundance used in the baseline run of the assessment are presented in **Table 3.5.3** and **Figure 3.6.3**. The AP recommended the use of six indices: four fishery-independent series (PC+MML+MS Gillnet, NMFS LL SE, TEXAS, and MS+MS-LA+AL longline) and two fishery-dependent series (the commercial BLLOP observer index and the recreational ENP index), all of which were standardized by the respective authors through GLM techniques (see Section 2.2.3). The AP recommended use of ranks for index weighting in the baseline run as follows (rankings indicated in parentheses): NMFS LL SE (1), BLLOP and TEXAS (2), PC+MML+MS Gillnet (3), and ENP and MS+MS-LA+AL longline (4). Equal weighting (i.e., no weights) and inverse CV weighting were also investigated. Coefficients of variation (CV) associated with the baseline indices are presented in **Table 3.5.4**.

3.1.2.4. Life History Inputs

The life history inputs used in the assessment are presented in **Table 3.5.5**. These include age and growth, as well as several parameters associated with reproduction, including sex ratio, reproductive frequency, fecundity at age, maturity and maternity at age, and month of pupping, and natural mortality. The SSASPM uses most life history characteristics as constants (inputs) and others are estimated parameters, which are given priors and initial values. The estimated parameters are described in the Parameters Estimated section (3.1.4) of the report.

All biological input values in **Table 3.5.5** match, or were extracted from, information reported in papers described in Section 2.2.1. Additionally, age-specific values of instantaneous natural mortality (M) were estimated through several life history invariant methods commonly used for sharks, more recently for SEDAR21, and include Hoenig's (1983), Chen and Watanabe's (1989), Peterson and Wroblewski's (1984), and Lorenzen's (1996) methods. To ensure positive population growth rates and emulate a density-dependent response, the maximum value of the four methods was taken (see the "GOM blacktip_demographic gamer_2010.xlsm" spreadsheet implementation of a life table to see how M values were derived). For reproduction, the proportion of females in maternal condition, rather than the proportion of mature females, was used as a more realistic measure of reproductive output because the latter does not account for the time it takes for a female to become pregnant and produce offspring after it reaches maturity (Walker 2005).

3.1.3. Model Configuration and Equations

To derive numbers at age for the first model year, one must define a year when the stock could be considered to be at virgin conditions. The AP set the year of virgin conditions at 1981 (as in the previous assessment, SEDAR 11).

Population Dynamics

The dynamics of the model are described below, and are extracted (and/or modified) from Porch (2002). The model begins with the population at unexploited conditions, where the age structure is given by

$$(1) \qquad N_{a,y=1,m=1} = \begin{cases} R_0 & a = 1 \\ R_0 \exp\left(-\sum_{j=1}^{a-1} M_j\right) & 1 < a < A \\ \dfrac{R_0 \exp\left(-\sum_{j=1}^{A-1} M_j\right)}{1-\exp(-M_A)} & a = A \end{cases} ,$$

where $N_{a,y=1,m=1}$ is the number of sharks in each age class in the first model year (y=1), in the first month (m=1), M_j is natural mortality at age, A is the plus-group age, and recruitment (R) is assumed to occur at age 1.

The stock-recruit relationship was assumed to be a Beverton-Holt function, which was parameterized in terms of the maximum lifetime reproductive rate, α:

(2) $$R = \frac{R_0 S\alpha}{1+(\alpha-1)S} \quad .$$

In (2), R_0 is virgin number of recruits (age-1 pups) and S is spawners or “spawning production” (units are number of mature adult females times pup production at age). The parameter α is calculated as:

(3) $$\alpha = e^{-M_0}\left[\left(\sum_{a=1}^{A-1} p_a m_a \prod_{j=1}^{a-1} e^{-M_a}\right) + \frac{p_A m_A}{1-e^{-M_A}} e^{-M_A}\right] = e^{-M_0}\varphi_0 \quad ,$$

where p_a is pup-production at age a, m_a is maturity at age a, and M_a is natural mortality at age a. The first term in (3) is pup survival at low population density (Myers et al. 1999). Thus, α is virgin spawners per recruit (φ_0) scaled by the slope at the origin (pup-survival).

The time period from the first model year (y_1) to the last model year (y_T) is divided into a historic and a modern period (mod), where y_i for i<mod are historic years, and modern years are y_i for which mod ≤ i ≤ T. The historic period is characterized by having relatively fewer data compared to the modern period. The manner in which effort is estimated depends on the period modeled. In the historic period, effort is estimated as either a constant (4a) or a linear trend (4b)

(4a) $$f_{y,i} = b_0 \qquad \text{(constant effort)}$$

or

(4b) $$f_{y,i} = b_0 + \frac{(f_{y=\text{mod},i} - b_0)}{(y_{\text{mod}} - 1)} f_{y=\text{mod},i} \qquad \text{(linear effort)},$$

where $f_{y,i}$ is annual fleet-specific effort, b_0 is the intercept, and $f_{y=\text{mod},i}$ is a fleet-specific constant. As noted above, no historic period was considered in this model implementation for GOM blacktip shark.

In the modern period, fleet-specific effort is estimated as a constant with annual deviations, which are assumed to follow a first-order lognormal autoregressive process:

$$
\begin{aligned}
& f_{y=\mathrm{mod},i} = f_i \exp(\delta_{y,i}) \\
(5) \qquad & \delta_{y,i} = \rho_i \delta_{y-1} + \eta_{y,i} \quad . \\
& \eta_{y,i} \sim N(0, \sigma_i)
\end{aligned}
$$

From the virgin age structure defined in (1), abundance at the beginning of subsequent months is calculated by

$$(6) \qquad N_{a,y,m+1} = N_{a,y,m} e^{-M_a \delta} - \sum_i C_{a,y,m,i} \quad ,$$

where δ is the fraction of the year (m/12) and $C_{a,y,m,i}$ is the catch in numbers of fleet i. The monthly catch by fleet is assumed to occur sequentially as a pulse at the end of the month, after natural mortality:

$$(7) \qquad C_{a,y,m,i} = F_{a,y,i} \left(N_{a,y,m} e^{-M_a \delta} - \sum_{k=1}^{i-1} C_{a,y,m,k} \right) \frac{\delta}{\tau_i} \quad ,$$

where τ_i is the duration of the fishing season for fleet i. Catch in weight is computed by multiplying (7) by $w_{a,y}$, where weight at age for the plus-group is updated based on the average age of the plus-group.

The fishing mortality rate, F, is separated into fleet-specific components representing age-specific relative-vulnerability, v, annual effort expended, f, and an annual catchability coefficient, q:

$$(8) \qquad F_{a,y,i} = q_{y,i} f_{y,i} v_{a,i} \quad .$$

Catchability is the fraction of the most vulnerable age class taken per unit of effort. The relative vulnerability would incorporate such factors as gear selectivity, and the fraction of the stock exposed to the fishery. For this model application to GOM blacktip sharks, both vulnerability and catchability were assumed to be constant over years.

Catch per unit effort (CPUE) or fishery abundance surveys are modeled as though the observations were made just before the catch of the fleet with the corresponding index, i:

$$(9) \qquad I_{y,m,i} = q_{y,i} \sum_a v_{a,i} \left(N_{a,y,m} e^{-M_a \delta} - \sum_{k=1}^{i-1} C_{a,y,m,k} \right) \frac{\delta}{\tau_i} \quad .$$

Equation (9) provides an index in numbers; the corresponding CPUE in weight is computed by multiplying $v_{a,i}$ in (9) by $w_{a,y}$.

State space implementation

In general, process errors in the state variables and observation errors in the data variables can be modeled as a first-order autoregressive model:

$$\begin{aligned} g_{t+1} &= E[g_{t+1}]e^{\varepsilon_{t+1}} \\ \varepsilon_{t+1} &= \rho\varepsilon_t + \eta_{t+1} \end{aligned} \qquad (10)$$

In (10), g is a given state or observation variable, η is a normally distributed random error with mean 0 and standard deviation σ_g, and ρ is the correlation coefficient. E[g] is the deterministic expectation. When g refers to data, then g_t is the observed quantity, but when g refers to a state variable, then those g terms are estimated parameters. For example, effort in the modern period is treated in this fashion.

The variances for process and observation errors (σ_g) are parameterized as multiples of an overall model coefficient of variation (CV):

$$\sigma_g = \ln\left[(\lambda_g CV)^2 + 1\right] \qquad (11a)$$

$$\sigma_g = \ln\left[(\omega_{i,y}\lambda_g CV)^2 + 1\right] \qquad (11b)$$

The term λ_g is a variable-specific multiplier of the overall model CV. For catch series and indices (eq 11b), the additional term, $\omega_{i,y}$, is the weight applied to individual points within those series. Given the AP decision to use ranks of indices as a weighting scheme for the baseline run, the $\omega_{i,y}$ represent those rank weightings (e.g. $\omega_{i,y}$=1 for all points in the NMFS LL SE series) and the same λ_g was applied to all indices. To evaluate the case where indices were weighted by the inverse of their CV, each $\omega_{i,y}$ was fixed to the estimated CV for point *y* in series *i*; for the case where equal weighting for all indices was assumed, all $\omega_{i,y}$ were fixed to 1.

Additional model specifications

Individual points within catch and index series can be assigned different weights, based either on estimated precision or expert opinion. As explained above, all catches were assigned the same weight (1 or no weight) and indices were weighted by an assigned rank, inverse CV, or given the same weight (1 or no weight).

One further model specification was the degree to which the model-predicted values matched catches vs. indices. An overall model CV is estimated (see equations 11a and 11b), and multiples (λ_g) of this overall CV can be specified separately for catches, indices, and effort (see Porch 2002). All catch series were assigned the same CV multiple, all indices were assigned a single same CV multiple, and all effort series were also assigned a single CV multiple. In the case of the effort series, by allowing for large process error it was effectively a free parameter (a log-scale variance of 10 was used); the correlation was fixed at 0.5.

As in 2006 (SEDAR 11), an initial attempt was made to estimate all these multipliers, but the index multiplier hit a boundary solution (upper limit). Attempts to estimate one or more of the multipliers generally resulted in boundary solutions for the multipliers or other estimated parameters. An explanation for this behavior when trying to estimate the index multiplier is likely that the interannual variability within indices is substantial in some cases, and additionally, some indices with similar selectivity had conflicting trends. In 2006, the CV multiplier of indices had to be given a value 5 times the catch CV multiplier (this implies that indices are less certain than catches) for the Hessian to be estimated, while the effort multiplier was fixed at 2. In the present assessment, fixing the multipliers at different values was also investigated, but this generally resulted in poorer fits or other parameter estimates (e.g., pup survival) hitting the upper bound, while conclusions on stock status were unaffected (stock not overfished and overfishing not occurring). It was thus decided to proceed by placing relatively more confidence in the catch series compared to the indices. Placing less certainty in the indices relative to the catch is justified because of the lack of a consistent signal and interannual variability in the indices, which resulted in poorer fits or parameter estimates hitting boundaries likely because the model could not reconcile those conflicting indices. The CV multipliers were thus fixed at 5 (indices), 1 (catches), and 2 (effort).

3.1.4. Parameter Estimation

Parameters were estimated by minimizing the objective function (the negative log joint posterior density function) using AD Model Builder software (Otter Research, Ltd. 2004). The (log) joint posterior distribution was specified up to a proportionality constant and included log likelihood components for observed data (Λ_1), process error components (Λ_2), and prior distribution components (Λ_3). The total objective function was then given by $\Lambda = \Lambda_1 + \Lambda_2 + \Lambda_3$, with each component as described below.

Observed data log likelihood—The observed data log likelihoods were specified as lognormal, but included a number of variance terms that could be estimated or fixed to allow for a wide range of choices for how to fit the data. The objective function takes the sum of the negative log likelihood contributions from indices, catches, and effort. The indices contribution is provided by

$$(12) \qquad \Lambda_1 = 0.5\sum_i \sum_y \sum_m \frac{(\log(I_{i,y,m}) - \log(\tilde{I}_{i,y,m}))^2}{\sigma^2_{i,y}} + \log(\sigma^2_{i,y}),$$

where $I_{i,m,y}$ and $\tilde{I}_{i,m,y}$ give observed and predicted indices, respectively, and

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

The catch and effort contributions have the same form. The term $\mathrm{CV}_{i,y}$ gives the observed CV reported along with index *i* in year *y* (for example, as a byproduct of the CPUE standardization process).

Process errors—Process errors for effort deviations made a contribution to the objective function. The contribution for effort deviations is given by

(14) $$\Lambda_2 = 0.5 \sum_{1982 \le y \le 2010} \frac{\left(\varepsilon_{ey} - \rho_e \varepsilon_{ey-1}\right)^2}{\sigma_e + (y-1)\log\sigma_e}$$

Prior distributions—The model started in 1981 and ended in 2010. Estimated model parameters were pup (age-0) survival, virgin recruitment (R_0), catchability coefficients associated with catches and indices, and fleet-specific effort. Virgin recruitment was given a uniform prior distribution ranging from 10,000 to 1 billion individuals, whereas pup survival was given an informative lognormal prior with median=0.76 (mean=0.79, mode=0.69), a CV of 0.3, and bounded between 0.50 and 0.99. The mean value for pup survival was obtained using life-history invariant methods (see Section 3.1.1.2.4).
The total contribution for prior distributions to the objective function was then

(15) $$\Lambda_3 = \log(p(e^{-M_0})) + \log(p(R_0)) + \sum_i \log(p(q_i)) + \sum_i \log(p(e_i))$$

A list of estimated model parameters is presented in Table 3.6 (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 SSASPM, initial parameter values, minimum and maximum values a parameter could take, and prior densities assigned to parameters.

3.1.5. Uncertainty and Measures of Precision

Numerical integration for this model was done in AD Model Builder (Otter Research Ltd. 2001), which uses the reverse mode of AUTODIF (automatic differentiation). Estimation can be carried out in phases, where convergence for a given phase is determined by comparing the maximum gradient to user-specified convergence criteria. The final phase of estimation used a convergence criterion of 10^{-6}. For models that converge, the variance-covariance matrix is obtained from the inverse Hessian. Uncertainty in parameter estimates was quantified by computing asymptotic standard errors for each parameter (**Table 3.5.6**), which are calculated by ADMB by inverting the Hessian matrix (i.e., the matrix of second derivatives) after the model fitting process. Stability of parameter estimates in the base run was explored through a jitter test, where initial values for some of the estimated parameters were varied individually or simultaneously from within their allowable ranges. Additionally, likelihood profiling was performed to examine posterior distributions for several model parameters. Likelihood profiles are calculated by assuming that the posterior probability distribution is well approximated by a multivariate normal (Otter Research Ltd. 2001). The relative negative log-likelihood (objective function) and AICc (small sample AIC) values are listed in the tables of model results. The relative contribution to the likelihood by model source (catches, indices, effort, recruitment, catchabilities) as well as a breakdown of likelihood by individual catch and index series is depicted in figures.

Uncertainty in data inputs and model configuration was examined through the use of sensitivity scenarios. Thirteen alternative runs are included in this report in addition to the baseline run. We also include continuity (see Section 2.1) and retrospective analyses. In the retrospective analyses of the baseline run, the model was refit while sequentially dropping the last four years of catch and index data to look for systematic bias in key model output quantities over time.

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

<u>Baseline run:</u> the base model configuration assumed virgin conditions in 1981, used the imputed historical catch series (1981-2010), the updated biological parameters, and the 6 base case CPUE indices (the earliest of which, TEXAS, started in 1982). Catches were assumed to be 5 times more certain than the indices. The baseline run used ranks as the preferred option for weighting indices (see Section 3.1.2.3), but inverse CV and equal weighting schemes were also explored.

<u>Scenario 1:</u> Replace BLLOP index with BLL Logs index—Same as the base run, but using the index based on self-reported logbooks (given a rank of 3) rather than on scientific observer reports (**Table 3.5.7**).

<u>Scenario 2:</u> Add two indices—Add two CPUE series to the six of the base run: the PC LL (a localized fishery-independent longline index; rank 5) and the MRFSS index (rank 5). Both indices were also used in a sensitivity run in SEDAR 11; the PC LL index only spans the period 1993-2000, the MRFSS index starts in 1981 (**Table 3.5.8**).

<u>Scenario 3:</u> Disaggregate coastal fishery-independent gillnet and longline indices—Same as the base run, but disaggregating the PC+MML+MS gillnet and MS+MS-LA+AL longline series into their original components (**Table 3.5.9**). The individual gillnet series were all allocated a rank of 4, whereas the longline series received a rank of 5 (MS and AL LL) and 6 (MS-LA LL); the rank for the ENP went from 4 (base run) to 3.

<u>Scenario 4:</u> Disaggregate coastal fishery-independent gillnet index—Same as the base run, but disaggregating the PC+MML+MS gillnet series into its three original components (**Table 3.5.10**). The individual gillnet series were all allocated a rank of 5; the rank for the ENP went from 4 (base run) to 3.

<u>Scenario 5:</u> Disaggregate coastal fishery-independent longline index—Same as the base run, but disaggregating the MS+MS-LA+AL longline series into its three original components (**Table 3.5.11**). The individual longline series received a rank of 5 (MS and AL LL) and 6 (MS-LA LL).

<u>Scenario 6:</u> Lognormal prior for R_0—This consisted of replacing the uniform prior used for virgin recruitment in the baseline run with an informative lognormal prior.

<u>Scenario 7:</u> Hierarchical index—Same as the base run, but using only one hierarchical index of relative abundance weighted by the inverse of the CV (see document SEDAR21-AW-01 and **Table 3.5.12**; **Figure 3.6.4**). The selectivity used for the single index was a weighted average of the selectivities associated with the individual indices (**Figure 3.6.5**). The inverse variance selectivity weights: 0.197 (PC+MML+MS gillnet), 0.086 (BLLOP), 0.169 (NMFS LLSE), 0.099 (ENP), 0.054 (TEXAS), and 0.396 (MS+MS-LA+AL longline) were used to weight the individual selectivity curves. Once a weighted selectivity vector was obtained, a functional form (double exponential curve) was developed to approximate the weighted selectivity for input into the model.

<u>Scenario 8:</u> NMFS LL SE index only—In this run the only index used was the NMFS LL SE fishery-independent series, which had been given the highest rank by the AP. Inverse CV weighting was used as the default.

<u>Scenarios 9 and 10:</u> Low and high catch scenarios—Same as the base run, but using a low and high catch scenario, respectively. The low and high catch series were constructed in an attempt to encapsulate the uncertainty in the magnitude of the catches (this had been recommended by previous CIE reviewers). This was done by introducing variability in the commercial, recreational, and Mexican catch data streams as follows. Commercial landings are reported in weight (not estimated), but then converted into numbers by using average weights from animals observed in the shark bottom longline observer program. Thus, the only way to incorporate uncertainty in this catch stream is in the average weights used for conversion from weight to numbers. Lower and upper 95% confidence limits (CLs) of those average weights were thus computed and used to produce high and low commercial landings scenarios, respectively. Additionally, the baseline run assumed a post-release live discard mortality rate of 31% for commercial bottom longline gear; the AP also recommended 19% and 73% as low and high values (Section 2.2.2.3), which were used in the low and high catch scenarios, respectively. For recreational catches, lower and upper 95% CLs of the estimates of sharks landed and discarded dead in the three recreational surveys (A+B1 in MRFSS terminology) were also computed. Lower and upper 95% CLs were also computed for MRFSS/MRIP estimates of sharks released alive (B2s). Additionally, the baseline run assumed a post-release live discard mortality rate of 10% for hook and line gear; the AP also recommended 5% and 15% as low and high values (Section 2.2.2.5), which were used in the low and high catch scenarios, respectively, as multipliers for the estimated B2s. For Mexican catches, the baseline scenario assumed that 50% of blacktip sharks landed in the states of Tamaulipas and Veracruz belonged to the U.S. stock; the AP recommended 25% and 75% as alternative values (Section 2.2.2.2) to use in low and high

catch scenarios, respectively. Additionally, 95% CLs of the average weights of blacktip sharks landed in the states of Tamaulipas (mean=7.48 kg ww; LCL=6.42; UCL=8.53) and Veracruz (mean=11.91 kg ww; LCL=10.64; UCL=13.18) were generated and used to produce low and high catch Mexican catches. No measures of uncertainty were available for unreported commercial catches or for the menhaden fishery. The low and high catch scenarios are given in **Tables 3.5.13** and **3.5.14** and depicted in relation to the baseline catches in **Figure 3.6.6**.

Scenarios 11 and 12: Low and high productivity scenarios—Same as the base run, but using a low and high productivity scenario, respectively. To incorporate variability in productivity (while ensuring that it remained within biologically credible limits), lower and upper 95% CLs of the three von Bertalanffy growth function parameters given in SEDAR29-WP-18 were obtained: L_∞ (mean=150.6 cm FL; LCL=147.1; UCL=154.8), k (mean=0.187 yr^{-1}; LCL=0.168; UCL=0.205); t_0 (mean=-2.65; LCL=-2.91; UCL=-2.42) (**Figure 3.6.7A**). The new VBGF parameter estimates in turn yielded a new set of natural mortality (M) values through the life history invariant methods (**Table 3.5.15**; **Figure 3.6.7B**). Additionally, 95% CLs were also computed for the litter size vs. maternal age linear relationship given in SEDAR29-WP-09 (slope: mean=0.157; LCL=0.068; UCL=0.247; intercept: mean=2.925; LCL=1.998; UCL=3.852) (**Figure 3.6.7C**).

Scenario 13: MRFSS catches—The only change in this run consisted of using MRFSS catch estimates for 2004-2010 instead of the MRIP estimates used in the baseline run (**Figure 3.6.8**).

3.1.6. Benchmark/Reference points methods

Benchmarks included estimates of absolute population levels and fishing mortality for year 2010 (F_{2010}, SSF_{2010}, B_{2010}, N_{2010}, $Nmature_{2010}$), reference points based on MSY (F_{MSY}, SSF_{MSY}, SPR_{MSY}), current status relative to MSY levels, and depletion estimates (current status relative to virgin levels). In addition, trajectories for F_{year}/F_{MSY} and SSF_{year}/SSF_{MSY} were plotted and phase plots provided.

3.1.7. Projection methods

As discussed in Section 1.2.4 no projections are included in this document. However, in anticipation of a potential request by NOAA's HMS division in the future, we provide estimates of generation time for guidance and reference. The estimate of generation time is about 11.5 years, and was calculated as:

(16)
$$GenTime = \frac{\sum_i i f_i \prod_{j=1}^{i-1} s_j}{\sum_i f_i \prod_{j=1}^{i-1} s_j}$$

where i is age, f_i is the product of (fecundity at age) x (maturity at age), and s_j is survival at age. Maximum age used in the calculations was 18 years. This generation time corresponds to the mean age of parents of offspring produced by a cohort over its lifetime (ν_1; Caswell 2001); other formulae for calculating generation time gave very similar estimates (T: time required by the population to increase by R_0=11.2; A: mean age of parents of offspring in a stable age distribution=10.9; Caswell 2001).

3.2 MODEL RESULTS

3.2.1. Measures of Overall Model Fit

Catches were fit 5 times better than indices and thus were fit very well (**Figure 3.6.9**). The model appeared to have trouble reconciling the conflicting trends and oscillations within and among some of the indices of abundance and compromised with a flat fit. As a result, some of the indices were poorly fit, particularly the BLLOP series, which decreased to a value close to zero in 2001 (with a very large residual) after no observations in 2000, and then immediately increased to a high value in 2002 (**Figure 3.6.10**). The PC+MML+MS gillnet index showed no clear trend, the BLLOP, NMFS LLSE and TEXAS indices showed generally increasing tendencies, the ENP index showed a slightly decreasing trend, and the MS+MS-LA+AL longline index showed a decreasing trend, but with a large increase in the terminal year of data, 2010. In more recent years all indices increased, except for the PC+MML+MS gillnet and BLLOP indices. While catches decreased since approximately 1990, the indices were generally flat or showed increasing trends (**Figure 3.6.3**, bottom panel). In general, the poor fit to some of the indices is caused in part by high interannual variability that does not seem to be compatible with the life history of the species, suggesting that the statistical standardization of the indices done externally to the model may not have included all factors that help explain relative abundance. The relative likelihood values by model source (catch, indices, effort, and recruitment) as well as a breakdown of likelihood by individual catch and index series are shown in **Figure 3.6.11**. Catches were best fit (lowest relative likelihood) and effort process error, worst (**Figure 3.6.11A**). All catches were almost equally well fit (**Figure 3.6.11B**), while the BLLOP index had the worst fit and the MS+MS-LA+AL longline index, the best (**Figure 3.6.11C**).

3.2.2. Parameter estimates and associated measures of uncertainty

A list of model parameters is presented in **Table 3.5.6**. The table includes predicted parameter values with associated SDs, initial parameter values, minimum and maximum allowed values, and prior density functions assigned to parameters. Parameters designated as type “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 3.6.12**. The first four age classes made up almost 50% of the population in any given year and mean age by year varied very little (min=6.4, max=6.7).

The SSASPM does not model age 0s and thus no predicted age-0 recruits are produced, only the estimated virgin number of age-1 recruits (see Section 3.1.3). However, one can calculate an "observed" and an "expected" recruitment for different levels of relative SSF using the Beverton-Holt model reparameterized in terms of steepness (Francis 1992) and maximum lifetime reproductive rate, which are quantities estimated by SSASPM. **Figure 3.6.13** shows "observed" vs. predicted recruits for different levels of SSF depletion. Predicted recruits are given by equation (2) in Section 3.1.3 and "observed" recruits are given by:

$$(17) \qquad R = \frac{4zS}{SPR_0(1-z)+\frac{S(5z-1)}{R_0}}$$

where z is steepness, S is spawners, SPR_0 is the spawning potential ratio at virgin conditions and R_0 is virgin number of recruits.

3.2.4. Spawning Stock Fecundity

Predicted abundance and spawning stock fecundity (numbers x proportion mature x fecundity in numbers) are presented in **Table 3.5.16** and **Figure 3.6.14**. Both trajectories show some depletion from 1981 to about 2000, followed by a stabilization (and a slight uptake in the last three years of data), which generally correspond to decreased catches, effort and F in the past decade as well as increasing tendencies for some of the indices in those years.

3.2.5. Fishery Selectivity

As explained in Section 3.1.2.2 and shown in **Table 3.5.2** and **Figure 3.6.2**, selectivities are estimated externally to the model and a functional form inputted for each fleet and index. In **Figure 3.6.2** one can see that most fleets fully select for immature animals, and that many of the indices include immature animals too.

3.2.6. Fishing Mortality

Predicted total and fleet-specific instantaneous fishing mortality rates are presented in **Table 3.5.17** and **Figure 3.6.15**. Fishing mortality was generally higher for all fleets prior to the mid-1990s, but never approached the estimated F_{MSY} of 0.084. The commercial and recreational fleets, followed by the Mexican fleet, accounted for most of total F. The contribution of the menhaden fishery fleet to total F was minimal. Fishing mortality was lower in the past decade in accordance with decreased effort and catches during that period.

3.2.7. Stock-Recruitment Parameters

See Section 3.2.3 above for additional discussion of the stock-recruitment curve and associated parameters. The predicted virgin recruitment (R_0; number of age 1 pups) was ca. 3,980,000 animals (**Figure 3.6.13** and see next section for further discussion on R_0). The predicted steepness was 0.47 and the maximum lifetime reproductive rate was 3.59, values in line with the life history of this species (Brooks et al. 2010). The estimated pup (age-0) survival was 0.84 (see next section for further discussion on pup survival).

3.2.8. Evaluation of Uncertainty

Estimates of asymptotic standard errors for all model parameters are presented in **Table 3.5.6**. The jitter test confirmed that varying the initial values of some of the estimated parameters individually or simultaneously from within their allowable ranges, did not affect results. Posterior distributions for several model parameters of interest were obtained through likelihood profiling. Prior and posterior distributions for pup survival and virgin recruitment are shown in **Figure 3.6.16**. There appeared to be information in the data since the posteriors for these two parameters were different from the priors. The mode for the posterior of pup survival was estimated at a higher value than the prior mode, whereas the posterior for virgin recruitment of pups was informative in contrast to its diffuse uniform prior (**Figure 3.6.16**).

Posterior distributions were also obtained for several benchmarks. The distribution for spawning stock fecundity in 2010 has considerable overlap with the distribution for virgin conditions. The distributions for total biomass depletion and spawning stock fecundity depletion are wide, but most of the density is concentrated between ca. 0.6 and 0.9, and ca 0.5 and 1.0, respectively (**Figure 3.6.17**). The estimate of F_{2010} ranges from 0 to about 0.05 and the estimate for mature number of fish in 2010 also shows considerable overlap with the corresponding distribution for virgin conditions (**Figure 3.6.18**).

Results of the baseline scenario with the three index weighting schemes (ranks, inverse CV, equal weights) are summarized in **Table 3.5.18**. The three variants estimated that the stock is not overfished and overfishing not occurring. Inverse CV weighting of the base run estimated less depletion than weighting the indices with ranks and a more optimistic status, but the estimated R_0 hit the upper bound. Artificially reducing two CV values that were particularly high (1.747 in 2002 for the BLLOP index and 1.708 in 1992 for the TEXAS index) to 1 did not eliminate the problem. Equal weighting resulted in more depletion and a relatively less optimistic status. Since these three models had the same number of observations and estimated parameters they are directly comparable and the AICc and objective function were lowest for rank weighting, thus indicating a better fit of that model.

Results of the 13 sensitivity analyses are summarized in **Table 3.5.19**. Replacing the BLLOP with the BLL Logs index (sensitivity run 1) had a negligible effect on results and stock status predictions, although the fit to this index was better than that of the BLLOP (**Figure 3.6.19**). Adding two indices to those from the base run (sensitivity run 2) also had virtually no effect on results. The two additional indices (PC LL and MRFSS) were relatively well fit by the model (**Figure 3.6.20**). Disaggregating both the fishery-independent gillnet and longline indices into their original components (sensitivity run 3; **Figure 3.6.21**) also had little effect, as did disaggregating only the fishery-independent gillnet series (sensitivity run 4; **Figure 3.6.22**) or the fishery-independent longline series (sensitivity run 5; **Figure 3.6.23**) although the individual indices were also relatively well fit. Assuming an informative, lognormal distribution for R_0 (sensitivity run 6) resulted in a somewhat less optimistic outcome but parameters were estimated more precisely and the fit (which was directly comparable to that of the base run) was better (**Table 3.5.19**). We also conducted likelihood profiling to approximate posterior distributions for several model parameters for this scenario as was done for the baseline run. All profiles were smoother than the corresponding ones from the base run (**Figures 3.6.24 to 3.6.26**). The mode for the posterior of pup survival was higher and the distribution more skewed to the right than in the baseline run (**Figure 3.6.24**). As in the base run, the distribution for spawning stock fecundity in 2010 shows considerable overlap with the distribution for virgin conditions, and the distributions for total biomass depletion and spawning stock fecundity depletion are also wide, with most of the density concentrated between ca. 0.6 and 0.9, and ca 0.55 and 0.95, respectively (**Figure 3.6.25**). The estimate of F_{2010} ranges from 0 to about 0.035 and the estimate for mature number of fish in 2010 also shows considerable overlap with the corresponding distribution for virgin conditions (**Figure 3.6.26**). Using the hierarchical index of relative abundance (sensitivity run 7) did not affect results appreciably (**Table 3.5.19**). The model interpreted the fluctuations in the index by providing a compromise, flat fit (**Figure 3.6.27**). Using the NMFS LL SE fishery-independent index only (sensitivity run 8) resulted in the least optimistic of all scenarios explored but did not affect status (**Table 3.5.19**). The model again interpreted the fluctuations in this index by providing a compromise, flat fit, but the index was not fit as well as the hierarchical index (**Figure 3.6.28**). Considering catches lower (scenario 9) and higher (scenario 10) than those in the base run did not change status; with lower catches the model estimated less depletion and a more optimistic status, whereas with higher catches more depletion and a less optimistic status were estimated (**Table 3.5.19**) In both scenarios, catches were still fit very well (**Figures 3.6.29** and **3.6.30**).

Assuming lower stock productivity (sensitivity run 11) resulted in a more pessimistic status, with pup survival and steepness approaching their upper and lower bound, respectively, and virgin recruitment hitting the upper bound (**Table 3.5.19**), indicating that the parameters we considered may not have been that biologically reasonable. The high productivity scenario (sensitivity run 12) also resulted in a somewhat more pessimistic status, which may seem counterintuitive at first. However, F_{MSY} and F_{2010} values were two- and six-fold larger than in the base run. Other biological parameter estimates in this scenario also seemed to have very little biological plausibility (maximum lifetime reproductive rate of ca. 14 and steepness of 0.78) for this species of shark (**Table 3.5.19**). Finally, using MRFSS catches for 2004-2010 (sensitivity run 13) had an almost negligible effect on results (**Table 3.5.19**).

3.2.8.1. Continuity analysis

Table 3.5.20 shows the summarized results of the continuity analysis and of the 2006 base run. The base run in 2006 indicated that the stock was not overfished and overfishing was not occurring, a status confirmed by the continuity run, which estimated an even more optimistic status. Note that the magnitude of some of the estimated parameters increased substantially in the continuity run compared to the 2006 base run and the current base run. Catches continued a slow decline with the additional years of data (**Figure 2.6.1**). For indices, the PC Gillnet Juveniles index continued to fluctuate, the BLLOP and NMFS LL SE indices also fluctuated but with a generally increasing trend, the BLL Logs index declined since 2006, and the PLL Logs index increased to a very high peak in 2001, after which it declined rather precipitously (**Figure 2.6.2**). In all, the model still interpreted the fluctuations in relative abundance shown by the indices by fitting a flat trajectory with almost no depletion. Catches were fit very well (**Figure 3.6.31**) and the fit to indices was flat (**Figure 3.6.32**). The relative likelihood values by model source and a breakdown of likelihood by individual catch and index series are shown in **Figure 3.6.33**. As in the 2012 (current) base run, catches were best fit (lowest relative likelihood) and effort process error, worst. All catches were almost equally well fit, while the BLLOP index had the worst fit and the PC Gillnet Juvenile index, the best.

3.2.8.2 Retrospective analysis

Results of the retrospective analysis of the base run are presented in **Table 3.5.21** and **Figure 3.6.34**. Three model output quantities were examined in the analysis: 1) spawning stock fecundity, 2) relative spawning stock fecundity, and 3) relative fishing mortality. The SSF trajectories ran parallel to one another, having vastly different magnitude. In particular, the 2008 and 2006 retrospective runs were of much higher magnitude than the base run, but in both cases R_0 hit the upper bound and the 2006 retrospective run did not converge; the 2009 and 2007 retrospective runs were in between the base and the two other retrospective runs. The relative spawning stock fecundity (SSF/SSF_{MSY}) trajectories for the four retrospective runs were somewhat higher than that of the base run and in close proximity to one another; in ca. 1988 the base run trajectory converged with those of the retrospective runs. The relative fishing mortality (F/F_{MSY}) trajectories did not overlap, except for the 2009 and 2006 retrospective runs, which were very similar and ran closely in parallel during the entire time series. While the trajectories were less than ideal, no systematic pattern of over- or under-estimation of abundance, relative abundance, or fishing mortality was evident.

Because of the boundary solutions encountered (and lack of convergence in one case) with two of the retrospective runs and the unsatisfactory plots, we decided to explore an additional retrospective analysis with sensitivity run 6 (lognormal prior for R_0). Results were much more satisfactory for both the SSF and relative SSF trajectories and while the relative F trajectory was still not ideal, the 2009 and 2008 retrospective run trajectories were in close proximity to that of the base run (**Figure 3.6.35**). For both sets of retrospective runs, status condition did not change with respect to the base run: for the base model retrospectives, status was more optimistic (**Table**

3.5.21) whereas for the sensitivity run 6 retrospectives, status was more pessimistic (**Table 3.5.22**).

3.2.9. Benchmarks/Reference Points

Benchmarks for the MSY reference points for the base run and all sensitivity scenarios are summarized in **Table 3.5.19** and those for the continuity analysis in **Table 3.5.20**. The base model estimated that the stock was not overfished and overfishing was not occurring (**Table 3.5.19**) and that the stock had never been overfished and overfishing had never occurred (**Figure 3.6.36** top; **Figure 3.6.37** top). For some contrast, sensitivity run 6 estimated a somewhat less optimistic status (**Table 3.5.19**) with some more depletion and a relative F trajectory less shallow than that in the base run (**Figure 3.6.36** bottom; **Figure 3.6.37** bottom).

All sensitivity runs estimated that the stock was not overfished and not undergoing overfishing (**Table 3.5.19**). **Figure 3.6.38** is a phase plot showing the outcomes of the base model (with the three weighting options), the continuity analysis, the results of the base models from the 2006 and 2002 assessments, as well as the results obtained with the Bayesian Surplus Production (BSP) base model in 2006 and the BSP 2012 continuity run. Stock status in the base runs did not deviate far from the 2006 base model prediction or that of the continuity analysis. Results of the BSP continuity run were also very consistent with those of the 2006 BSP assessment and were close to the estimate produced in the 2002 assessment (**Figure 3.6.38**). **Figure 3.6.39** shows the outcomes of the base model (rank weighting) in comparison with the 13 sensitivity scenarios. All sensitivity runs estimated a status close to that of the base run, with the only deviations coming from the low and high productivity scenarios (11 and 12) and scenario 8 (NMFS LL SE index only). The results of the retrospective analyses support the conclusions from the base run (**Figure 3.6.40**) and sensitivity run 6 (lognormal prior for R_0; **Figure 3.6.41**). In both cases, all retrospective runs were very near those of the respective base model.

3.3 DISCUSSION

Although most shark species can likely be considered data poor when compared to most teleost stocks, information for (Gulf of Mexico) blacktip sharks is relatively abundant mainly because—together with sandbar sharks—they have been the main target of commercial fisheries in the eastern U.S. seaboard since their inception. As a result, relatively good records of commercial landings exist and biological and fishery information is available, mainly from the directed bottom longline shark fishery observer program. As for many other shark species, however, historical information on the level of removals is lacking. Multiple indices that theoretically track relative abundance, many of them fishery-independent, are also available, with three indices starting at or shortly after the beginning of the period of exploitation considered for this stock in the Gulf of Mexico (1981). How valid it is to consider the stock to be in virgin conditions in 1981 is hard to evaluate, but the alternative of reconstructing catches back in time to an earlier year with little justification seems worse, especially given the lack of indices of relative abundance prior to 1981.

As has been pointed out in previous shark stock assessments, an issue of concern regarding the indices of relative abundance is that many show interannual variability that does not seem to be compatible with the life history of the species, suggesting that the GLMs used to standardize the indices do not include all factors to help track relative abundance. Also, inconsistent signals likely lead to tensions among the different indices when fitting the model, which proposes an abundance trend that represents a compromise solution attempting to accommodate the sometimes different trends displayed by the indices. However, the model cannot ultimately distinguish which of the trends in abundance is most likely to represent reality. We explored the use of different combinations of indices through sensitivity analyses but model predictions did not vary. The AP identified ranks as the preferred way of weighting the indices prior to fitting the model in an effort to avoid bias, and also to avoid the model from being arbitrarily driven by more precise indices (with lower CVs), which may be reflective of larger sample size but not necessarily track real relative abundance. Finally, we also attempted to remove some of the process variation in the indices of relative abundance by computing the hierarchical index used in sensitivity run 7, but stock status predictions did not change appreciably.

Considering the multiple sources of uncertainty that were examined through sensitivity analyses, it can be concluded that the assessment provided a consistent picture of stock status. Indeed, consideration of several sets of indices of relative abundance did not have appreciable effects on results as examined in sensitivity runs 1, 2, 3, 4, 5, 7, and 8. Only scenario 8 (NMFS LL SE index only) relatively worsened stock status, which still remained well within the confines of the non-overfished and non-overfishing quadrant of the phase plot. Exploring the uncertainty associated with catches (sensitivity runs 9, 10, and 13) revealed that while the model responded to different catch levels, the outcome was not significantly affected. Consideration of uncertainty in biological parameters, explored through sensitivity runs 6, 11, and 12, had a larger effect on model results, but did not alter stock status predictions. The low productivity scenario in particular revealed that the model is sensitive to the life history inputs and that considering values of life history parameters representative of very low productivity for this stock can lead to boundary solutions for some estimated parameters.

Despite the significant differences between the inputs used in the 2006 and the current assessment, stock status did not change substantially, although the magnitude of some of the estimated parameters varied significantly (**Table 3.5.20**). The current base model estimated substantially lower virgin recruitment but higher reproductive output (lifetime reproductive rate of 3.59 and steepness of 0.47) than the 2006 assessment (2.64 and 0.40, respectively). Spawning stock fecundity in 2010 was lower than estimated for 2004 in the 2006 assessment (15.3×10^6 vs. 45.5×10^6), and the estimate of MSY for the current base model (1.3×10^6 sharks) was also lower than the 2006 assessment estimate (4.7×10^6 sharks). Differences between the 2006 and current assessment include: the single recreational+Mexican catch series was split into two series, with separate (albeit similar) selectivities; there are now six indices of relative abundance in the base run (vs. five in 2006), three of them not used in 2006 and the other three were re-analyzed and include six more years of data; there are four selectivities for catches (vs. three in 2006), three of which are new, and six selectivities for indices (vs. two), all of which are new; there are new biological parameters, including a new von Bertalanffy growth curve with a slower growth coefficient K=0.19 (vs. 0.23), lifespan is now longer at 18 years (vs. 15), there is a new maternity-at-age ogive (vs. a maturity-at-age ogive) that was used in the assessment, a maternal size vs. litter size relationship is used (vs. fixed fecundity), and there are new estimates of natural mortality at age (ranging from 0.22 to 0.13 vs. 0.26 to 0.10). These changes likely affect the potential productivity of the stock in different directions: the lower K, longer lifespan, and maternity ogive can be associated with a less productive stock, but at the same time there are three more years during which females can produce offspring.

We recognize, as was noted in a previous assessment that also used SSASPM, that the estimation of selectivities externally to the model may not be ideal and may not have captured the uncertainty associated with the sample size used to fit age-length curves, the computation of the age-length key, and subsequent transformation of lengths into ages to produce age-frequency distributions to which selectivity curves were fitted or assigned. As noted in Section 3.1.2.2, SSASPM cannot accommodate length composition data but can accept age composition data as input. However, early attempts at estimating selectivity within the model through the use of available age compositions (obtained from length compositions through the age-length key) were unsuccessful and thus, as in previous implementations of the model, selectivities had to be estimated externally to the model. If representative length composition data from the different surveys and programs become available in the future, we hope to use a length-based, age-structured model. We also note that the age-length key should be improved with the addition of more samples, especially corresponding to the largest/oldest segments of the stock (Appendix 1).

Based on the similar results obtained in the present and 2006 and 2002 assessments, also supported by the use of an alternate modeling platform (BSP), it appears that the combination of a relatively productive stock, limited catches especially in recent years, and stable indices of relative abundance, makes this stock of blacktip sharks in the Gulf of Mexico resilient to overfishing.

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3.5 TABLES

Table 3.5.1A. Catches of Gulf of Mexico blacktip shark by fleet in numbers. Catches are separated into four fisheries: commercial + unreported catches, recreational catches, Mexican catches, and menhaden fishery discards.

Year	Com+Unrep	Recreational	Mexican	Menhaden discards
1981	7261	62435	64247	17495
1982	7261	61932	36156	17933
1983	7844	26539	37550	17714
1984	10712	25499	53258	17714
1985	9950	57984	43762	15964
1986	71435	158292	40073	15746
1987	69772	73915	42142	16402
1988	140261	123238	46239	15964
1989	144784	94246	54320	16839
1990	76851	89665	63659	16402
1991	81034	114980	48262	12684
1992	93187	74974	52856	11153
1993	66863	56425	61613	11372
1994	61986	49942	56715	12200
1995	84807	47083	47730	11200
1996	64433	67426	52332	11153
1997	46823	65621	35968	11372
1998	64099	83954	36589	10935
1999	53091	29885	26662	12028
2000	49816	88886	25838	10279
2001	39985	45526	18707	9622
2002	32020	46606	20545	9404
2003	69352	40965	17300	9185
2004	43810	43860	21086	9404
2005	33409	42934	20947	9404
2006	55073	43443	11491	8966
2007	46276	31387	11264	8966
2008	14460	19529	11595	8966
2009	14909	22222	13989	8966
2010	21404	36879	19482	8966

Table 3.5.1B. Catches of Gulf of Mexico blacktip shark by fleet in weight (lb dw). Catches are separated into four fisheries: commercial + unreported catches, recreational catches, Mexican catches, and menhaden fishery discards.

Year	Com+Unrep	Recreational	Mexican	Menhaden discards
1981	174269	354318	582569	115117
1982	174269	221207	365067	117999
1983	188256	131973	385997	116558
1984	257097	130381	563640	116558
1985	238805	367663	419292	105043
1986	1714436	638404	381050	103609
1987	1674533	241382	387124	107925
1988	3366256	502733	424013	105043
1989	3474810	408445	511940	110801
1990	1844435	382530	588899	107925
1991	1944808	455784	456012	83461
1992	2236499	360098	493774	73387
1993	1604716	178043	582805	74828
1994	1203391	205153	529210	80276
1995	1509692	220256	452910	73696
1996	1275451	251038	500734	73387
1997	1169575	341833	385571	74828
1998	1678156	262052	351363	71952
1999	1595263	184943	257454	79144
2000	1517889	459026	237484	67636
2001	1235489	239821	176545	63313
2002	973867	207397	189210	61878
2003	1441767	210422	154722	60437
2004	1030490	204517	182300	61878
2005	952229	221807	194243	61877
2006	1258323	210350	110531	58999
2007	1085465	133661	106948	58999
2008	402897	66110	106839	58999
2009	448248	222307	128446	58999
2010	631768	121781	174483	58999

Table 3.5.2. Selectivity curves for catches and indices of relative abundance. Functions were fitted by eye except where otherwise indicated. Parameters are ascending inflection point (a_{50}), ascending slope (b), descending inflection point (c_{50}), descending slope (d), and maximum selectivity (max(sel)).

Series	Scenario	Selectivity	a_{50}	b	c_{50}	d	max(sel)
CATCHES							
Commercial + unreported	Base	Logistic*	4.41	0.59			
Recreational	Base	Double exponential	0.02	0.2	0.1	2.8	0.42
Mexican	Base	Double exponential	0.02	0.2	1	3	0.50
Menhaden discards	Base	Logistic	-120	0.2			
INDICES OF ABUNDANCE	Base						
PC+MML+MS Gillnet	Base	Double exponential	0.02	0.2	0.1	1.5	0.35
BLLOP	Base	Logistic*	4.41	0.59			
NMFS LL SE	Base	Logistic*	1.03	0.59			
ENP	Base	Double exponential	0.02	0.10	0.10	1.00	0.29
TEXAS	Base	Double exponential	0.02	0.10	1	2	0.50
MS+MS-LA+AL longline	Base	Double exponential	0.01	0.1	0.1	3	0.43
BLL Logs	Sensitivity	Logistic*	4.41	0.59			
PC LL	Sensitivity	Logistic*	4.41	0.59			
MRFSS	Sensitivity	Double exponential	0.02	0.2	0.1	2.8	0.42
PC Gillnet	Sensitivity	Double exponential	0.02	0.2	0.1	1.5	0.35
MML Gillnet	Sensitivity	Double exponential	0.02	0.1	0.1	1	0.29
MS Gillnet	Sensitivity	Double exponential	0.02	0.1	1	1.4	0.50
MS Longline	Sensitivity	Double exponential	0.02	0.2	0.2	2.3	0.41
MS-LA Longline	Sensitivity	Double exponential	0.02	0.2	0.2	2	0.40
AL longline	Sensitivity	Double exponential	0.01	0.2	3	3	0.66
Hierarchical index	Sensitivity	Double exponential*	0.01	0.1	-97.4	8.3	6.8E-06

* Fitted by least squares

Table 3.5.3. Standardized indices of relative abundance used in the baseline scenario. All indices are scaled (divided by their respective mean).

YEAR	PC+MML+MS GN	BLLOP	NMFS LLSE	ENP	TEXAS	MS+MS-LA+AL LL
1981	-	-	-	-	-	-
1982	-	-	-	-	1.489	-
1983	-	-	-	0.919	0.497	-
1984	-	-	-	1.223	0.491	-
1985	-	-	-	0.930	0.425	-
1986	-	-	-	0.952	1.292	-
1987	-	-	-	1.441	0.771	-
1988	-	-	-	1.666	0.736	-
1989	-	-	-	0.822	1.446	-
1990	-	-	-	1.371	0.976	-
1991	-	-	-	0.761	-	-
1992	-	-	-	1.494	0.077	-
1993	-	-	-	0.711	0.321	-
1994	-	0.148	-	1.192	0.325	-
1995	0.690	0.414	0.459	0.958	0.444	-
1996	0.518	0.354	0.243	1.388	0.628	-
1997	0.962	0.233	0.489	1.192	0.117	-
1998	0.806	0.681	-	0.867	0.278	-
1999	1.350	0.853	0.475	0.823	0.514	-
2000	1.218	-	0.695	1.132	1.122	-
2001	1.013	0.012	1.083	0.762	0.354	-
2002	0.880	1.492	1.256	0.727	0.798	-
2003	0.988	1.714	2.459	1.035	1.188	-
2004	1.557	1.892	1.489	0.889	2.234	1.339
2005	0.938	0.986	0.906	0.700	1.242	1.394
2006	1.140	1.982	0.991	0.619	2.014	1.170
2007	1.331	1.600	1.041	0.840	0.547	0.750
2008	1.213	1.209	0.559	0.883	2.286	0.701
2009	0.573	1.452	1.433	0.771	2.808	0.648
2010	0.824	0.977	1.422	0.931	2.579	0.998

Table 3.5.4. Coefficients of variation (CVs) of the relative abundance indices used in inverse weighting scenarios.

YEAR	PC+MML+MS GN	BLLOP	NMFS LLSE	ENP	TEXAS	MS+MS-LA+AL LL
1981	1	1	1	1	1	1
1982	1	1	1	1	0.345	1
1983	1	1	1	0.338	0.701	1
1984	1	1	1	0.288	0.701	1
1985	1	1	1	0.356	0.561	1
1986	1	1	1	0.334	0.371	1
1987	1	1	1	0.276	0.516	1
1988	1	1	1	0.291	0.480	1
1989	1	1	1	0.453	0.451	1
1990	1	1	1	0.252	0.426	1
1991	1	1	1	0.356	1.000	1
1992	1	1	1	0.213	1.708	1
1993	1	1	1	0.389	0.701	1
1994	1	0.399	1	0.209	0.701	1
1995	0.801	0.277	0.449	0.273	0.619	1
1996	0.523	0.350	0.591	0.179	0.480	1
1997	0.428	0.813	0.390	0.190	1.057	1
1998	0.501	0.562	1	0.252	0.701	1
1999	0.360	0.463	0.286	0.275	0.561	1
2000	0.389	1	0.251	0.224	0.387	1
2001	0.362	1.747	0.263	0.296	0.827	1
2002	0.353	0.244	0.229	0.309	0.426	1
2003	0.320	0.199	0.200	0.260	0.387	1
2004	0.288	0.231	0.228	0.289	0.333	0.274
2005	0.354	0.255	0.518	0.362	0.371	0.198
2006	0.319	0.298	0.319	0.386	0.296	0.118
2007	0.319	0.299	0.384	0.315	0.561	0.111
2008	0.318	0.313	0.516	0.325	0.282	0.103
2009	0.472	0.291	0.268	0.371	0.239	0.158
2010	0.461	0.290	0.347	0.354	0.296	0.103

Table 3.5.5. Life history inputs used in the assessment. All these quantities are treated as constants in the model. Von Bertalanffy growth function parameters are for females.

Age	Proportion maternal	M	Fecundity
1	0.029	0.226	3.082
2	0.042	0.200	3.239
3	0.061	0.183	3.396
4	0.087	0.171	3.554
5	0.123	0.163	3.711
6	0.170	0.156	3.868
7	0.232	0.151	4.025
8	0.307	0.148	4.182
9	0.394	0.145	4.340
10	0.489	0.142	4.497
11	0.584	0.140	4.654
12	0.674	0.139	4.811
13	0.752	0.138	4.968
14	0.817	0.137	5.126
15	0.868	0.136	5.283
16	0.906	0.135	5.440
17	0.934	0.134	5.597
18	0.954	0.134	5.754

Sex ratio:	1:1
Reproductive frequency:	2 yr
Pupping month:	May
Age vs litter size relation:	pups = 0.1572*age + 2.9248
L_{inf}	150.6 cm FL
k	0.187
t_0	-2.65
Weight vs length relation:	$W=0.00001L^{3.0549}$

Table 3.5.6. List of parameters estimated in SSASPM for GOM blacktip shark (baseline run). The list includes predicted parameter values with associated SDs, initial parameter values, minimum and maximum allowed values, and prior density functions assigned to parameters. Parameters that were held fixed (not estimated) are not included in this table.

	Predicted					Prior pdf			
Parameter/Input name	Value	SD	Initial	Min	Max	Type	Value	SD (CV)	Status
Virgin recuitment	3.98E+06	1.13E+07	1.00E+06	1.00E+04	1.00E+09	uniform	-	-	estimated
Pup (age-0) survival	8.39E-01	3.38E-01	7.60E-01	5.00E-01	9.90E-01	lognormal	0.76	(0.3)	estimated
Catchability coefficient PC+MML+MS GN index	1.45E-07	4.30E-07	3.11E-04	1.00E-10	6.22E-03	constant	-	-	estimated
Catchability coefficient BLLOP index	5.51E-08	1.72E-07	1.17E-04	1.00E-10	6.22E-03	constant	-	-	estimated
Catchability coefficient NMFS LL SE index	4.50E-08	1.38E-07	7.01E-04	1.00E-10	6.22E-03	constant	-	-	estimated
Catchability coefficient ENP index	1.83E-07	5.36E-07	1.56E-04	1.00E-10	6.22E-03	constant	-	-	estimated
Catchability coefficient TEXAS index	8.80E-08	2.60E-07	4.25E-04	1.00E-10	6.22E-03	constant	-	-	estimated
Catchability coefficient MS+MS-LA+AL LL index	1.00E-07	3.00E-07	1.17E-04	1.00E-10	6.22E-03	constant	-	-	estimated
Catchability coefficient Com+unrep catch series	2.89E-03	9.39E-03	2.18E-03	1.00E-10	6.22E-02	constant	-	-	estimated
Catchability coefficient Recreational catch series	2.82E-03	8.90E-03	3.53E-03	1.00E-10	6.22E-02	constant	-	-	estimated
Catchability coefficient Mexican catch series	2.14E-03	6.78E-03	3.53E-03	1.00E-10	6.22E-02	constant	-	-	estimated
Catchability coefficient menhaden disc catch series	2.21E-03	7.08E-03	3.74E-03	1.00E-10	6.22E-02	constant	-	-	estimated
Modern effort Com+unrep fleet	1.0	2.94E-01	1.00E+00	2.00E-01	9.91E+01	lognormal	1.0	(0.3)	estimated
Modern effort Recreational fleet	2.0	5.87E-01	2.00E+00	1.00E-01	9.91E+01	lognormal	2.0	(0.3)	estimated
Modern effort Mexican fleet	1.5	4.40E-01	1.50E+00	1.00E-01	9.91E+01	lognormal	1.5	(0.3)	estimated
Modern effort menhaden discard fleet	0.25	7.34E-02	2.50E-01	1.00E-01	9.91E+01	lognormal	0.25	(0.3)	estimated
Overall variance	-0.0579	2.97E-03	-2.00E-01	-2.00E+00	-1.00E-02	constant	-	-	estimated
Effort deviation for Com+unrep fleet in 1981	-1.632	1.14E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep fleet in 1982	-1.631	1.14E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep fleet in 1983	-1.549	1.14E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep fleet in 1984	-1.235	1.14E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep fleet in 1985	-1.3006	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep fleet in 1986	0.6714	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep fleet in 1987	0.6610	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep fleet in 1988	1.3696	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep fleet in 1989	1.42E+00	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep fleet in 1990	7.92E-01	1.12E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep fleet in 1991	8.51E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep fleet in 1992	9.97E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep fleet in 1993	6.71E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep fleet in 1994	5.99E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep fleet in 1995	9.13E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep fleet in 1996	6.41E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep fleet in 1997	3.23E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep fleet in 1998	6.35E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep fleet in 1999	4.49E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep fleet in 2000	3.85E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep fleet in 2001	1.66E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep fleet in 2002	-5.57E-02	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep fleet in 2003	7.11E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep fleet in 2004	2.57E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep fleet in 2005	-1.37E-02	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated

Effort deviation for Com+unrep fleet in 2006	4.82E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep fleet in 2007	3.08E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep fleet in 2008	-8.53E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep fleet in 2009	-8.27E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com+unrep fleet in 2010	-4.69E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Recreational fleet in 1981	0.123	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Recreational fleet in 1982	0.120	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Recreational fleet in 1983	-0.723	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Recreational fleet in 1984	-0.761	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Recreational fleet in 1985	0.0608	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Recreational fleet in 1986	1.0681	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Recreational fleet in 1987	0.3155	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Recreational fleet in 1988	0.8279	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Recreational fleet in 1989	5.66E-01	1.12E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Recreational fleet in 1990	5.21E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Recreational fleet in 1991	7.73E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Recreational fleet in 1992	3.48E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Recreational fleet in 1993	6.42E-02	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Recreational fleet in 1994	-5.75E-02	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Recreational fleet in 1995	-1.16E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Recreational fleet in 1996	2.43E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Recreational fleet in 1997	2.17E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Recreational fleet in 1998	4.61E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Recreational fleet in 1999	-5.66E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Recreational fleet in 2000	5.15E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Recreational fleet in 2001	-1.48E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Recreational fleet in 2002	-1.28E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Recreational fleet in 2003	-2.56E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Recreational fleet in 2004	-1.88E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Recreational fleet in 2005	-2.09E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Recreational fleet in 2006	-1.98E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Recreational fleet in 2007	-5.23E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Recreational fleet in 2008	-9.98E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Recreational fleet in 2009	-8.70E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Recreational fleet in 2010	-3.66E-01	1.12E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Mexican fleet in 1981	0.637	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Mexican fleet in 1982	0.071	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Mexican fleet in 1983	0.111	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Mexican fleet in 1984	0.460	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Mexican fleet in 1985	0.2669	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Mexican fleet in 1986	0.1853	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Mexican fleet in 1987	0.2399	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Mexican fleet in 1988	0.3371	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Mexican fleet in 1989	5.03E-01	1.12E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Mexican fleet in 1990	6.65E-01	1.12E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Mexican fleet in 1991	3.94E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Mexican fleet in 1992	4.87E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Mexican fleet in 1993	6.40E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Mexican fleet in 1994	5.58E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Mexican fleet in 1995	3.86E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated

Effort deviation for Mexican fleet in 1996	4.78E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Mexican fleet in 1997	1.05E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Mexican fleet in 1998	1.22E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Mexican fleet in 1999	-1.94E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Mexican fleet in 2000	-2.26E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Mexican fleet in 2001	-5.47E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Mexican fleet in 2002	-4.56E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Mexican fleet in 2003	-6.28E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Mexican fleet in 2004	-4.31E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Mexican fleet in 2005	-4.38E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Mexican fleet in 2006	-1.04E+00	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Mexican fleet in 2007	-1.06E+00	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Mexican fleet in 2008	-1.03E+00	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Mexican fleet in 2009	-8.45E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for Mexican fleet in 2010	-5.15E-01	1.12E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden fleet in 1981	0.307	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden fleet in 1982	0.337	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden fleet in 1983	0.328	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden fleet in 1984	0.330	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden fleet in 1985	0.2295	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden fleet in 1986	0.2224	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden fleet in 1987	0.2699	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden fleet in 1988	0.2507	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden fleet in 1989	3.13E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden fleet in 1990	2.93E-01	1.12E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden fleet in 1991	4.20E-02	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden fleet in 1992	-8.19E-02	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden fleet in 1993	-5.96E-02	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden fleet in 1994	1.24E-02	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden fleet in 1995	-7.08E-02	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden fleet in 1996	-7.30E-02	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden fleet in 1997	-5.25E-02	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden fleet in 1998	-8.98E-02	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden fleet in 1999	5.05E-03	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden fleet in 2000	-1.51E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden fleet in 2001	-2.17E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden fleet in 2002	-2.42E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden fleet in 2003	-2.65E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden fleet in 2004	-2.42E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden fleet in 2005	-2.43E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden fleet in 2006	-2.91E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden fleet in 2007	-2.92E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden fleet in 2008	-2.94E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden fleet in 2009	-2.96E-01	1.13E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated
Effort deviation for menhaden fleet in 2010	-2.98E-01	1.12E+00	0.00E+00	-7.00E+00	7.00E+00	lognormal	0	1	estimated

Table 3.5.7. Standardized indices of relative abundance used in sensitivity run 1 (BLL Logs replaces BLLOP). Indices are scaled (divided by their respective mean).

YEAR	PC+MML+MS GN	BLL Logs	NMFS LLSE	ENP	TEXAS	MS+MS-LA+AL LL
1981	-	-	-	-	-	-
1982	-	-	-	-	1.489	-
1983	-	-	-	0.919	0.497	-
1984	-	-	-	1.223	0.491	-
1985	-	-	-	0.930	0.425	-
1986	-	-	-	0.952	1.292	-
1987	-	-	-	1.441	0.771	-
1988	-	-	-	1.666	0.736	-
1989	-	-	-	0.822	1.446	-
1990	-	-	-	1.371	0.976	-
1991	-	-	-	0.761	-	-
1992	-	-	-	1.494	0.077	-
1993	-	-	-	0.711	0.321	-
1994	-	-	-	1.192	0.325	-
1995	0.690	-	0.459	0.958	0.444	-
1996	0.518	0.495	0.243	1.388	0.628	-
1997	0.962	0.580	0.489	1.192	0.117	-
1998	0.806	0.778	-	0.867	0.278	-
1999	1.350	1.272	0.475	0.823	0.514	-
2000	1.218	1.338	0.695	1.132	1.122	-
2001	1.013	0.929	1.083	0.762	0.354	-
2002	0.880	0.967	1.256	0.727	0.798	-
2003	0.988	1.309	2.459	1.035	1.188	-
2004	1.557	1.341	1.489	0.889	2.234	1.339
2005	0.938	1.000	0.906	0.700	1.242	1.394
2006	1.140	1.284	0.991	0.619	2.014	1.170
2007	1.331	1.280	1.041	0.840	0.547	0.750
2008	1.213	0.593	0.559	0.883	2.286	0.701
2009	0.573	0.997	1.433	0.771	2.808	0.648
2010	0.824	0.837	1.422	0.931	2.579	0.998

Table 3.5.8. Standardized indices of relative abundance used in sensitivity run 2 (adding PCLL and MRFSS indices). Indices are scaled (divided by their respective mean).

YEAR	PC+MML+MS GN	BLLOP	NMFS LLSE	ENP	TEXAS	MS+MS-LA+AL LL	PCLL	MRFSS
1981	-	-	-	-	-	-	-	1.71
1982	-	-	-	-	1.489	-	-	0.41
1983	-	-	-	0.919	0.497	-	-	1.16
1984	-	-	-	1.223	0.491	-	-	0.41
1985	-	-	-	0.930	0.425	-	-	0.88
1986	-	-	-	0.952	1.292	-	-	1.53
1987	-	-	-	1.441	0.771	-	-	0.54
1988	-	-	-	1.666	0.736	-	-	1.41
1989	-	-	-	0.822	1.446	-	-	1.04
1990	-	-	-	1.371	0.976	-	-	1.11
1991	-	-	-	0.761	-	-	-	1.26
1992	-	-	-	1.494	0.077	-	-	0.74
1993	-	-	-	0.711	0.321	-	0.768	0.72
1994	-	0.148	-	1.192	0.325	-	0.133	0.65
1995	0.690	0.414	0.459	0.958	0.444	-	1.018	0.92
1996	0.518	0.354	0.243	1.388	0.628	-	0.758	1.05
1997	0.962	0.233	0.489	1.192	0.117	-	1.299	1.16
1998	0.806	0.681	-	0.867	0.278	-	0.974	1.39
1999	1.350	0.853	0.475	0.823	0.514	-	1.136	0.74
2000	1.218	-	0.695	1.132	1.122	-	1.914	1.54
2001	1.013	0.012	1.083	0.762	0.354	-	-	0.78
2002	0.880	1.492	1.256	0.727	0.798	-	-	0.73
2003	0.988	1.714	2.459	1.035	1.188	-	-	1.09
2004	1.557	1.892	1.489	0.889	2.234	1.339	-	0.86
2005	0.938	0.986	0.906	0.700	1.242	1.394	-	0.99
2006	1.140	1.982	0.991	0.619	2.014	1.170	-	1.34
2007	1.331	1.600	1.041	0.840	0.547	0.750	-	1.00
2008	1.213	1.209	0.559	0.883	2.286	0.701	-	0.64
2009	0.573	1.452	1.433	0.771	2.808	0.648	-	0.90
2010	0.824	0.977	1.422	0.931	2.579	0.998	-	1.29

Table 3.5.9. Standardized indices of relative abundance used in sensitivity run 3 (disaggregating fishery-independent gillnet and longline series). Indices are scaled (divided by their respective mean).

YEAR	BLLOP	NMFS LLSE	ENP	TEXAS	PC GN	MML GN	MS GN	MS LL	MS-LA LL	AL LL
1981	-	-	-	-	-	-	-	-	-	-
1982	-	-	-	1.489	-	-	-	-	-	-
1983	-	-	0.919	0.497	-	-	-	-	-	-
1984	-	-	1.223	0.491	-	-	-	-	-	-
1985	-	-	0.930	0.425	-	-	-	-	-	-
1986	-	-	0.952	1.292	-	-	-	-	-	-
1987	-	-	1.441	0.771	-	-	-	-	-	-
1988	-	-	1.666	0.736	-	-	-	-	-	-
1989	-	-	0.822	1.446	-	-	-	-	-	-
1990	-	-	1.371	0.976	-	-	-	-	-	-
1991	-	-	0.761	-	-	-	-	-	-	-
1992	-	-	1.494	0.077	-	-	-	-	-	-
1993	-	-	0.711	0.321	-	-	-	-	-	-
1994	0.148	-	1.192	0.325	-	-	-	-	-	-
1995	0.414	0.459	0.958	0.444	-	0.718	-	-	-	-
1996	0.354	0.243	1.388	0.628	0.512	1.076	-	-	-	-
1997	0.233	0.489	1.192	0.117	0.993	0.394	-	-	-	-
1998	0.681	-	0.867	0.278	0.722	-	1.064	-	-	-
1999	0.853	0.475	0.823	0.514	1.195	0.585	0.787	-	-	-
2000	-	0.695	1.132	1.122	0.843	0.916	5.036	-	-	-
2001	0.012	1.083	0.762	0.354	1.159	1.196	0.207	-	-	-
2002	1.492	1.256	0.727	0.798	0.960	1.248	-	-	-	-
2003	1.714	2.459	1.035	1.188	0.960	1.153	0.142	-	-	-
2004	1.892	1.489	0.889	2.234	1.224	1.715	0.333	1.556	-	-
2005	0.986	0.906	0.700	1.242	1.063	-	1.093	2.431	-	-
2006	1.982	0.991	0.619	2.014	1.016	-	0.185	0.582	-	1.498
2007	1.600	1.041	0.840	0.547	1.482	-	1.257	0.792	-	0.748
2008	1.209	0.559	0.883	2.286	1.260	-	0.368	0.294	0.729	1.123
2009	1.452	1.433	0.771	2.808	0.603	-	0.482	0.057	1.265	0.525
2010	0.977	1.422	0.931	2.579	1.009	-	1.045	1.288	1.006	1.107

Table 3.5.10. Standardized indices of relative abundance used in sensitivity run 4 (disaggregating fishery-independent gillnet series). Indices are scaled (divided by their respective mean).

YEAR	PC GN	MML GN	MS GN	BLLOP	NMFS LLSE	ENP	TEXAS	MS+MS-LA+AL LL
1981	-	-	-	-	-	-	-	-
1982	-	-	-	-	-	-	1.489	-
1983	-	-	-	-	-	0.919	0.497	-
1984	-	-	-	-	-	1.223	0.491	-
1985	-	-	-	-	-	0.930	0.425	-
1986	-	-	-	-	-	0.952	1.292	-
1987	-	-	-	-	-	1.441	0.771	-
1988	-	-	-	-	-	1.666	0.736	-
1989	-	-	-	-	-	0.822	1.446	-
1990	-	-	-	-	-	1.371	0.976	-
1991	-	-	-	-	-	0.761	-	-
1992	-	-	-	-	-	1.494	0.077	-
1993	-	-	-	-	-	0.711	0.321	-
1994	-	-	-	0.148	-	1.192	0.325	-
1995	-	0.718	-	0.414	0.459	0.958	0.444	-
1996	0.512	1.076	-	0.354	0.243	1.388	0.628	-
1997	0.993	0.394	-	0.233	0.489	1.192	0.117	-
1998	0.722	-	1.064	0.681	-	0.867	0.278	-
1999	1.195	0.585	0.787	0.853	0.475	0.823	0.514	-
2000	0.843	0.916	5.036	-	0.695	1.132	1.122	-
2001	1.159	1.196	0.207	0.012	1.083	0.762	0.354	-
2002	0.960	1.248	-	1.492	1.256	0.727	0.798	-
2003	0.960	1.153	0.142	1.714	2.459	1.035	1.188	-
2004	1.224	1.715	0.333	1.892	1.489	0.889	2.234	1.339
2005	1.063	-	1.093	0.986	0.906	0.700	1.242	1.394
2006	1.016	-	0.185	1.982	0.991	0.619	2.014	1.170
2007	1.482	-	1.257	1.600	1.041	0.840	0.547	0.750
2008	1.260	-	0.368	1.209	0.559	0.883	2.286	0.701
2009	0.603	-	0.482	1.452	1.433	0.771	2.808	0.648
2010	1.009	-	1.045	0.977	1.422	0.931	2.579	0.998

Table 3.5.11. Standardized indices of relative abundance used in sensitivity run 5 (disaggregating fishery-independent longline series). Indices are scaled (divided by their respective mean).

YEAR	PC+MML+MS GN	BLLOP	NMFS LLSE	ENP	TEXAS	MS LL	MS-LA LL	AL LL
1981	-	-	-	-	-	-	-	-
1982	-	-	-	-	1.489	-	-	-
1983	-	-	-	0.919	0.497	-	-	-
1984	-	-	-	1.223	0.491	-	-	-
1985	-	-	-	0.930	0.425	-	-	-
1986	-	-	-	0.952	1.292	-	-	-
1987	-	-	-	1.441	0.771	-	-	-
1988	-	-	-	1.666	0.736	-	-	-
1989	-	-	-	0.822	1.446	-	-	-
1990	-	-	-	1.371	0.976	-	-	-
1991	-	-	-	0.761	-	-	-	-
1992	-	-	-	1.494	0.077	-	-	-
1993	-	-	-	0.711	0.321	-	-	-
1994	-	0.148	-	1.192	0.325	-	-	-
1995	0.690	0.414	0.459	0.958	0.444	-	-	-
1996	0.518	0.354	0.243	1.388	0.628	-	-	-
1997	0.962	0.233	0.489	1.192	0.117	-	-	-
1998	0.806	0.681	-	0.867	0.278	-	-	-
1999	1.350	0.853	0.475	0.823	0.514	-	-	-
2000	1.218	-	0.695	1.132	1.122	-	-	-
2001	1.013	0.012	1.083	0.762	0.354	-	-	-
2002	0.880	1.492	1.256	0.727	0.798	-	-	-
2003	0.988	1.714	2.459	1.035	1.188	-	-	-
2004	1.557	1.892	1.489	0.889	2.234	1.556	-	-
2005	0.938	0.986	0.906	0.700	1.242	2.431	-	-
2006	1.140	1.982	0.991	0.619	2.014	0.582	-	1.498
2007	1.331	1.600	1.041	0.840	0.547	0.792	-	0.748
2008	1.213	1.209	0.559	0.883	2.286	0.294	0.729	1.123
2009	0.573	1.452	1.433	0.771	2.808	0.057	1.265	0.525
2010	0.824	0.977	1.422	0.931	2.579	1.288	1.006	1.107

Table 3.5.12. Standardized hierarchical index of relative abundance used in sensitivity run 7 with associated CVs. The index is scaled (divided by the mean).

YEAR	Hierarchical index	CV
1981	-	1
1982	1.54	0.61
1983	0.81	0.46
1984	0.97	0.44
1985	0.76	0.45
1986	1.09	0.42
1987	1.15	0.43
1988	1.23	0.43
1989	1.09	0.46
1990	1.19	0.40
1991	0.83	0.56
1992	1.04	0.46
1993	0.63	0.47
1994	0.57	0.50
1995	0.61	0.32
1996	0.64	0.35
1997	0.71	0.31
1998	0.73	0.32
1999	0.81	0.29
2000	0.99	0.29
2001	0.80	0.29
2002	1.05	0.28
2003	1.46	0.30
2004	1.54	0.25
2005	1.15	0.27
2006	1.30	0.26
2007	1.04	0.26
2008	1.02	0.26
2009	1.06	0.29
2010	1.21	0.25

Table 3.5.13. Low catch scenario of GOM blacktip shark used in sensitivity run 9. Catches are by fleet in numbers.

Year	Com+Unrep	Recreational	Mexican	Menhaden discards
1981	7261	55541	28307	17495
1982	7261	59355	16033	17933
1983	7844	23465	16671	17714
1984	10712	23705	23689	17714
1985	9950	54818	19344	15964
1986	71435	150911	17705	15746
1987	69772	71258	18581	16402
1988	140261	119418	20386	15964
1989	144784	92106	23987	16839
1990	76851	84195	28080	16402
1991	81034	108828	21315	12684
1992	93187	68709	23328	11153
1993	66734	52501	27213	11372
1994	57362	46043	25030	12200
1995	81191	44788	21085	11200
1996	60647	62240	23130	11153
1997	44703	59852	16012	11372
1998	61751	71958	16175	10935
1999	51828	27475	11791	12028
2000	49166	76915	11586	10279
2001	39912	39751	8545	9622
2002	31208	40245	9328	9404
2003	67616	33689	7869	9185
2004	42791	32052	9675	9404
2005	32154	34801	9272	9404
2006	54109	36071	5104	8966
2007	44590	23614	5009	8966
2008	13976	14760	5133	8966
2009	14184	14881	6197	8966
2010	20391	27999	8595	8966

Table 3.5.14. High catch scenario of GOM blacktip shark used in sensitivity run 10. Catches are by fleet in numbers.

Year	Com+Unrep	Recreational	Mexican	Menhaden discards
1981	7261	69754	111432	17495
1982	7261	64572	62200	17933
1983	7844	29769	64507	17714
1984	10712	27337	91269	17714
1985	9950	61244	75595	15964
1986	71435	165758	69263	15746
1987	69772	76607	73024	16402
1988	140261	127093	80133	15964
1989	144784	96417	93949	16839
1990	76851	95212	110252	16402
1991	81034	121253	83454	12684
1992	93187	81290	91477	11153
1993	67317	60383	106533	11372
1994	67846	53876	98163	12200
1995	89223	49394	82508	11200
1996	69154	72642	90408	11153
1997	49415	71425	61572	11372
1998	66971	96003	63194	10935
1999	54680	32304	46029	12028
2000	50729	100888	44487	10279
2001	40242	51323	31935	9622
2002	33028	53001	35200	9404
2003	71528	48279	29664	9185
2004	45097	44517	36092	9404
2005	35282	50084	36226	9404
2006	56564	54040	19810	8966
2007	48564	38602	19423	8966
2008	15134	25156	20060	8966
2009	15562	24626	24198	8966
2010	22180	41361	33794	8966

Table 3.5.15. Values of age-specific natural mortality (M) used in the high (low M) and low (high M) productivity scenarios.

Age	Low M	High M
1	0.156	0.232
2	0.136	0.232
3	0.123	0.197
4	0.114	0.197
5	0.108	0.197
6	0.104	0.197
7	0.101	0.197
8	0.098	0.197
9	0.096	0.197
10	0.094	0.197
11	0.092	0.197
12	0.091	0.197
13	0.090	0.197
14	0.089	0.197
15	0.089	0.197
16	0.088	0.197
17	0.088	0.197
18	0.088	0.197

Table 3.5.16. Predicted abundance (numbers) and spawning stock fecundity (numbers) of GOM blacktip shark for the base run.

Year	N	SSF
1981	25,416,350	17,041,000
1982	25,277,890	16,999,000
1983	25,184,480	16,958,000
1984	25,132,570	16,915,000
1985	25,069,170	16,867,000
1986	24,992,980	16,777,000
1987	24,778,260	16,638,000
1988	24,661,440	16,465,000
1989	24,435,700	16,237,000
1990	24,240,080	16,046,000
1991	24,118,140	15,906,000
1992	23,994,580	15,765,000
1993	23,901,120	15,639,000
1994	23,844,690	15,544,000
1995	23,803,250	15,449,000
1996	23,751,480	15,358,000
1997	23,696,230	15,297,000
1998	23,677,540	15,247,000
1999	23,625,600	15,200,000
2000	23,645,060	15,172,000
2001	23,611,120	15,155,000
2002	23,636,440	15,157,000
2003	23,662,860	15,151,000
2004	23,658,940	15,135,000
2005	23,670,790	15,145,000
2006	23,692,630	15,153,000
2007	23,700,670	15,155,000
2008	23,726,260	15,182,000
2009	23,790,250	15,233,000
2010	23,843,650	15,279,000

Table 3.5.17. Estimated total and fleet-specific instantaneous fishing mortality rates by year.

Year	Total F	Fleet-specific F			
		Com+Unrep	Recreational	Mexican	Menhaden disc
1981	0.01312	0.00057	0.00637	0.00608	0.00075
1982	0.01051	0.00057	0.00635	0.00345	0.00077
1983	0.00705	0.00061	0.00273	0.00359	0.00077
1984	0.00844	0.00084	0.00263	0.00509	0.00077
1985	0.01081	0.00079	0.00599	0.00420	0.00069
1986	0.02083	0.00566	0.01639	0.00387	0.00069
1987	0.01247	0.00560	0.00772	0.00409	0.00072
1988	0.01802	0.01138	0.01289	0.00450	0.00071
1989	0.01616	0.01191	0.00992	0.00532	0.00076
1990	0.01638	0.00639	0.00948	0.00625	0.00074
1991	0.01745	0.00678	0.01220	0.00476	0.00058
1992	0.01365	0.00784	0.00798	0.00523	0.00051
1993	0.01256	0.00566	0.00601	0.00610	0.00052
1994	0.01143	0.00526	0.00532	0.00562	0.00056
1995	0.01021	0.00721	0.00502	0.00473	0.00051
1996	0.01281	0.00549	0.00718	0.00518	0.00051
1997	0.01103	0.00400	0.00700	0.00357	0.00052
1998	0.01300	0.00546	0.00894	0.00363	0.00050
1999	0.00647	0.00453	0.00320	0.00265	0.00056
2000	0.01240	0.00425	0.00943	0.00256	0.00047
2001	0.00712	0.00341	0.00486	0.00186	0.00044
2002	0.00739	0.00274	0.00496	0.00204	0.00043
2003	0.00761	0.00589	0.00436	0.00172	0.00042
2004	0.00715	0.00374	0.00467	0.00209	0.00043
2005	0.00704	0.00285	0.00457	0.00207	0.00043
2006	0.00635	0.00468	0.00462	0.00114	0.00041
2007	0.00531	0.00393	0.00334	0.00112	0.00041
2008	0.00362	0.00123	0.00208	0.00115	0.00041
2009	0.00413	0.00126	0.00236	0.00138	0.00041
2010	0.00620	0.00181	0.00391	0.00192	0.00041

Table 3.5.18. Summary of results for base runs with several weighting schemes for GOM blacktip shark. R_0 is the number of age-1 pups at virgin conditions. SSF is spawning stock fecundity (sum of number at age times pup production at age). MSY is expressed in numbers. AICc is the Akaike Information Criterion for small sample sizes, which converges to the AIC statistic as the number of data points gets large. The weighting schemes were: inverse of ranks (ranks), inverse CV weighting (inv CV), and equal weighting (eq weights).

	Base (ranks)		Base (inv CV)		Base (eq weights)	
	Est	CV	Est	CV	Est	CV
AICc	688.51		882.95		778.05	
Objective function	1.76		98.97		46.53	
SSF_{2010}/SSF_{MSY}	**2.62**	0.53	**2.78**	0.45	**2.50**	0.50
F_{2010}/F_{MSY}	**0.07**	2.97	**0.03**	0.42	**0.11**	2.00
N_{2010}/N_{MSY}	2.01	---	2.10	---	1.94	---
MSY	1.34.E+06	---	3.30.E+06	---	9.51.E+05	---
SPR_{MSY}	0.53	0.06	0.54	0.18	0.52	0.10
F_{MSY}	0.084	---	0.081	---	0.084	---
SSF_{MSY}	5.83.E+06	---	1.48.E+07	---	4.13.E+06	---
N_{MSY}	1.09.E+07	---	2.71.E+07	---	7.73.E+06	---
F_{2010}	0.01	2.97	0.002	0.42	0.01	2.00
SSF_{2010}	1.53.E+07	3.16	4.10.E+07	0.005	1.03.E+07	2.19
N_{2010}	2.38.E+07	---	6.20.E+07	---	1.64.E+07	---
SSF_{2010}/SSF_0	0.90	0.33	0.96	0.005	0.85	0.32
B_{2010}/B_0	0.87	0.23	0.91	0.005	0.84	0.23
R_0	3.98.E+06	2.84	1.00.E+07	2.E-05	2.82.E+06	1.87
Pup-survival	0.84	0.40	0.79	0.29	0.85	0.36
alpha	3.59	---	3.37	---	3.63	---
steepness	0.47	---	0.46	---	0.48	---
SSF_0	1.71.E+07	2.84	4.28.E+07	0.00002	1.21.E+07	1.87
SSF_{MSY}/SSF_0	0.34	---	0.35	---	0.34	---

Table 3.5.19. Summary of results for base and sensitivity runs for GOM blacktip shark. R_0 is the number of age-1 pups at virgin conditions. SSF is spawning stock fecundity (sum of number at age times pup production at age). MSY is expressed in numbers. AICc is the Akaike Information Criterion for small sample sizes, which converges to the AIC statistic as the number of data points gets large. Sensitivity runs are: S1 (BLL Logs index), S2 (adding PC LL and MRFSS indices), S3 (disaggregating fishery-independent gillnet and longline indices), S4 (disaggregating fishery-independent gillnet indices), and S5 (disaggregating fishery-independent longline indices).

	Base		S1		S2		S3		S4		S5	
	Est	CV	Est	CV	Est	CV	Est	CV	Est	CV	Est	CV
AICc	688.51		597.56		594.66		649.44		648.27		690.50	
Objective function	1.76		-45.98		6.30		11.12		8.23		7.68	
SSF_{2010}/SSF_{MSY}	**2.62**	0.53	**2.62**	0.51	**2.64**	0.54	**2.61**	0.52	**2.57**	0.51	**2.62**	0.53
F_{2010}/F_{MSY}	**0.07**	2.97	**0.08**	2.69	**0.07**	3.22	**0.08**	2.57	**0.09**	2.41	**0.07**	2.99
N_{2010}/N_{MSY}	2.01	---	2.00	---	2.01	---	2.00	---	1.98	---	2.01	---
MSY	1.34.E+06	---	1.30.E+06	---	1.46.E+06	---	1.18.E+06	---	1.12.E+06	---	1.35.E+06	---
SPR_{MSY}	0.53	0.06	0.52	0.05	0.53	0.06	0.52	0.06	0.52	0.06	0.53	0.06
F_{MSY}	0.084	---	0.085	---	0.084	---	0.085	---	0.085	---	0.084	---
SSF_{MSY}	5.83.E+06	---	5.62.E+06	---	6.37.E+06	---	5.12.E+06	---	4.84.E+06	---	5.88.E+06	---
N_{MSY}	1.09.E+07	---	1.05.E+07	---	1.19.E+07	---	9.61.E+06	---	9.09.E+06	---	1.10.E+07	---
F_{2010}	0.01	2.97	0.01	2.69	0.01	3.22	0.01	2.57	0.01	2.41	0.01	2.99
SSF_{2010}	1.53.E+07	3.16	1.47.E+07	2.87	1.68.E+07	3.41	1.33.E+07	2.76	1.24.E+07	2.60	1.54.E+07	3.19
N_{2010}	2.38.E+07	---	2.30.E+07	---	2.61.E+07	---	2.09.E+07	---	1.96.E+07	---	2.41.E+07	---
SSF_{2010}/SSF_0	0.90	0.33	0.89	0.30	0.90	0.32	0.88	0.32	0.88	0.32	0.90	0.33
B_{2010}/B_0	0.87	0.23	0.87	0.22	0.87	0.23	0.86	0.23	0.85	0.23	0.87	0.23
R_0	3.98.E+06	2.84	3.85.E+06	2.57	4.34.E+06	3.09	3.53.E+06	2.44	3.32.E+06	2.28	4.02.E+06	2.86
Pup-survival	0.84	0.40	0.85	0.41	0.84	0.42	0.85	0.40	0.86	0.40	0.84	0.40
alpha	3.59	---	3.65	---	3.59	---	3.63	---	3.66	---	3.59	---
steepness	0.47	---	0.48	---	0.47	---	0.48	---	0.48	---	0.47	---
SSF_0	1.71.E+07	2.84	1.65.E+07	2.57	1.86.E+07	3.09	1.51.E+07	2.44	1.42.E+07	2.28	1.72.E+07	2.86
SSF_{MSY}/SSF_0	0.34	---	0.34	---	0.34	---	0.34	---	0.34	---	0.34	---

Table 3.5.19 (continued). Summary of results for base and sensitivity runs for GOM blacktip shark. R_0 is the number of age-1 pups at virgin conditions. SSF is spawning stock fecundity (sum of number at age times pup production at age). MSY is expressed in numbers. AICc is the Akaike Information Criterion for small sample sizes, which converges to the AIC statistic as the number of data points gets large. Sensitivity runs are: S6 (lognormal prior for R_0), S7 (hierarchical index), S8 (NMFS LL SE index only), and S9-S10 (low and high catch scenarios).

	S6		S7		S8		S9		S10	
	Est	CV	Est	CV	Est	CV	Est	CV	Est	CV
AICc	653.98		1987.55		17598.40		688.61		688.34	
Objective function	-15.51		-235.48		-110.83		1.80		1.67	
SSF_{2010}/SSF_{MSY}	**2.44**	0.22	**2.58**	0.10	**2.00**	0.10	**2.66**	0.53	**2.51**	0.51
F_{2010}/F_{MSY}	**0.14**	0.33	**0.10**	0.12	**0.27**	0.24	**0.05**	3.76	**0.12**	1.87
N_{2010}/N_{MSY}	1.89	---	1.97	---	1.67	---	2.00	---	1.96	---
MSY	7.00.E+05	---	8.97.E+05	---	3.94.E+05	---	1.46.E+06	---	1.01.E+06	---
SPR_{MSY}	0.50	0.06	0.50	0.01	0.48	0.02	0.53	0.07	0.51	0.06
F_{MSY}	0.090	---	0.110	---	0.110	---	0.070	---	0.096	---
SSF_{MSY}	2.88.E+06	---	3.70.E+06	---	1.57.E+06	---	6.44.E+06	---	4.28.E+06	---
N_{MSY}	5.58.E+06	---	7.08.E+06	---	3.08.E+06	---	1.22.E+07	---	8.05.E+06	---
F_{2010}	0.01	0.33	0.01	0.12	0.03	0.24	0.00	3.76	0.01	1.87
SSF_{2010}	7.01.E+06	0.35	9.54.E+06	0.13	3.15.E+06	0.31	1.71.E+07	3.96	1.07.E+07	2.06
N_{2010}	1.13.E+07	---	1.53.E+07	---	5.67.E+06	---	2.65.E+07	---	1.72.E+07	---
SSF_{2010}/SSF_0	0.80	0.07	0.85	0.02	0.64	0.11	0.92	0.33	0.84	0.32
B_{2010}/B_0	0.80	0.05	0.84	0.02	0.69	0.08	0.88	0.23	0.83	0.23
R_0	2.05.E+06	0.28	2.63.E+06	0.11	1.14.E+06	0.19	4.37.E+06	3.63	2.98.E+06	1.74
Pup-survival	0.93	0.27	0.92	0.14	0.98	0.06	0.82	0.40	0.89	0.40
alpha	3.99	---	3.93	---	4.18	---	3.51	---	3.81	---
steepness	0.50	---	0.50	---	0.51	---	0.47	---	0.49	---
SSF_0	8.77.E+06	0.28	1.13.E+07	0.11	4.88.E+06	0.19	1.87.E+07	3.63	1.28.E+07	1.74
SSF_{MSY}/SSF_0	0.33	---	0.33	---	0.32	---	0.34	---	0.34	---

Table 3.5.19 (continued). Summary of results for base and sensitivity runs for GOM blacktip shark. R_0 is the number of age-1 pups at virgin conditions. SSF is spawning stock fecundity (sum of number at age times pup production at age). MSY is expressed in numbers. AICc is the Akaike Information Criterion for small sample sizes, which converges to the AIC statistic as the number of data points gets large. Sensitivity runs are: S11-S12 (low and high productivity) and S13 (MRFSS catches).

	S11		S12		S13	
	Est	CV	Est	CV	Est	CV
AICc	691.06		685.78		688.50	
Objective function	3.03		0.39		1.75	
SSF_{2010}/SSF_{MSY}	**2.06**	0.82	**2.45**	0.21	**2.60**	0.52
F_{2010}/F_{MSY}	**0.13**	0.12	**0.25**	0.29	**0.08**	2.71
N_{2010}/N_{MSY}	1.72	---	2.30	---	1.99	---
MSY	2.63.E+06	---	2.38.E+05	---	1.23.E+06	---
SPR_{MSY}	0.86	0.01	0.27	0.11	0.52	0.06
F_{MSY}	0.021	---	0.163	---	0.083	---
SSF_{MSY}	6.40.E+06	---	1.81.E+06	---	5.34.E+06	---
N_{MSY}	2.65.E+07	---	1.56.E+06	---	1.00.E+07	---
F_{2010}	0.003	0.12	0.04	0.29	0.01	2.71
SSF_{2010}	1.32.E+07	0.01	4.43.E+06	0.45	1.39.E+07	2.91
N_{2010}	2.38.E+07	---	3.96.E+06	---	2.18.E+07	---
SSF_{2010}/SSF_0	0.93	0.01	0.53	0.26	0.89	0.33
B_{2010}/B_0	0.86	0.02	0.62	0.19	0.86	0.23
R_0	1.00.E+07	4E-07	5.63.E+05	0.20	3.66.E+06	2.58
Pup-survival	0.96	0.24	0.95	0.003	0.85	0.40
alpha	1.35	---	14.26	---	3.62	---
steepness	0.25	---	0.78	---	0.48	---
SSF_0	1.42.E+07	4E-07	8.42.E+06	0.20	1.57.E+07	2.58
SSF_{MSY}/SSF_0	0.45	---	0.21	---	0.34	---

Table 3.5.20. Summary of results for continuity run, 2006 base run, and 2012 (current) base run for GOM blacktip shark. R_0 is the number of age-1 pups at virgin conditions. SSF is spawning stock fecundity (sum of number at age times pup production at age). MSY is expressed in numbers. AICc is the Akaike Information Criterion for small sample sizes, which converges to the AIC statistic as the number of data points gets large.

	Base		Continuity		2006 Base	
	Est	CV	Est	CV	Est	CV
AICc	688.51		681.65		282.50	
Objective function	1.75724		66.2011		-158.52	
SSF_{cur}/SSF_{MSY}	**2.62**	0.53	**2.63**	0.35	**2.56**	0.29
F_{cur}/F_{MSY}	**0.07**	2.97	**0.001**	8.64	**0.03**	1.82
N_{cur}/N_{MSY}	2.01	---	2.63	---	---	---
MSY	1.34.E+06	---	1.39.E+08	---	4.74.E+06	---
SPR_{MSY}	0.53	0.06	0.61	0.08	0.62	---
F_{MSY}	0.084	---	0.19	---	0.20	---
SSF_{MSY}	5.83.E+06	---	5.55.E+08	---	---	---
N_{MSY}	1.09.E+07	---	1.13.E+09	---	---	---
F_{cur}	0.01	2.97	0.0001	8.64	0.01	1.82
SSF_{cur}	1.53.E+07	3.16	1.46.E+09	8.64	5.E+07	1.83
N_{cur}	2.37.E+07	---	3.19.E+09	---	---	---
SSF_{cur}/SSF_0	0.90	0.33	1.00	0.01	0.93	0.04
B_{cur}/B_0	0.87	0.23	0.94	0.01	0.87	0.04
R_0	3.98.E+06	2.84	4.49.E+08	0.29	1.44.E+07	1.79
Pup-survival	0.84	0.40	0.82	8.64	0.82	0.29
alpha	3.59	---	2.67	---	2.64	---
steepness	0.47	---	0.40	---	0.40	---
SSF_0	1.71.E+07	2.84	1.46.E+09	8.63	---	---
SSF_{MSY}/SSF_0	0.34	---	0.38	---	---	---

cur = 2010 for base and continuity, 2004 for Base 2006 assessment

Table 3.5.21. Summary of results of retrospective analyses of the baseline run. R_0 is the number of age-1 pups at virgin conditions. SSF is spawning stock fecundity (sum of number at age times pup production at age). MSY is expressed in numbers. AICc is the Akaike Information Criterion for small sample sizes, which converges to the AIC statistic as the number of data points gets large.

	Base		Retrospective 2009		Retrospective 2008		Retrospective 2007		Retrospective 2006	
	Est	CV	Est	CV	Est	CV	Est	CV	Est	CV
AICc	688.51		684.80		677.63		677.07		682.78	
Objective function	1.75724		2.16745		0.191637		0.696568		3.29945	
SSF_{cur}/SSF_{MSY}	**2.62**	0.53	**2.72**	0.52	**2.72**	0.25	**2.69**	0.55	**2.72**	---
F_{cur}/F_{MSY}	**0.07**	2.97	**0.03**	5.01	**0.02**	0.11	**0.05**	5.44	**0.05**	---
N_{cur}/N_{MSY}	2.01	---	2.06	---	2.05	---	1.97	---	1.99	---
MSY	1.34.E+06	---	2.24.E+06	---	3.31.E+06	---	2.41.E+06	---	3.30.E+06	---
SPR_{MSY}	0.53	0.06	0.54	0.06	0.55	0.05	0.54	0.01	0.55	---
F_{MSY}	0.084	---	0.077	---	0.071	---	0.052	---	0.051	---
SSF_{MSY}	5.83.E+06	---	9.97.E+06	---	1.50.E+07	---	1.09.E+07	---	1.50.E+07	---
N_{MSY}	1.09.E+07	---	1.85.E+07	---	2.77.E+07	---	2.08.E+07	---	2.86.E+07	---
F_{cur}	0.01	2.97	0.00	5.01	0.00	0.11	0.00	5.44	0.00	---
SSF_{cur}	1.53.E+07	3.16	2.71.E+07	5.21	4.09.E+07	0.004	2.93.E+07	5.54	4.09.E+07	---
N_{cur}	2.38.E+07	---	4.15.E+07	---	6.21.E+07	---	4.47.E+07	---	6.20.E+07	---
SSF_{cur}/SSF_0	0.90	0.33	0.94	0.33	0.96	0.003	0.94	5.20	0.96	---
B_{cur}/B_0	0.87	0.23	0.90	0.24	0.91	0.004	0.90	5.20	0.91	---
R_0	3.98.E+06	2.84	6.76.E+06	4.88	1.00.E+07	0.002	7.28.E+06	5.20	1.00.E+07	---
Pup-survival	0.84	0.40	0.80	0.38	0.78	0.29	0.79	0.35	0.78	---
alpha	3.59	---	3.42	---	3.34	---	3.37	---	3.33	---
steepness	0.47	---	0.46	---	0.46	---	0.46	---	0.45	---
SSF_0	1.71.E+07	2.84	2.90.E+07	4.88	4.28.E+07	0.003	3.12.E+07	5.20	4.28.E+07	---
SSF_{MSY}/SSF_0	0.34	---	0.34	---	0.35	---	0.35	---	0.35	---

cur = 2010 for base, 2009 for retrospective 2009, 2008 for retrospective 2008, 2007 for retrospective 2007, and 2006 for retrospective 2006.

Table 3.5.22. Summary of results of retrospective analyses of sensitivity run 6 (lognormal prior for R_0). R_0 is the number of age-1 pups at virgin conditions. SSF is spawning stock fecundity (sum of number at age times pup production at age). MSY is expressed in numbers. AICc is the Akaike Information Criterion for small sample sizes, which converges to the AIC statistic as the number of data points gets large.

	Base		Retrospective 2009		Retrospective 2008		Retrospective 2007		Retrospective 2006	
	Est	CV	Est	CV	Est	CV	Est	CV	Est	CV
AICc	688.51		650.40		643.38		642.69		648.44	
Objective function	1.75724		-15.0334		-16.9368		-16.4916		-13.8688	
SSF_{cur}/SSF_{MSY}	**2.62**	0.53	**2.40**	0.22	**2.37**	0.23	**2.36**	0.22	**2.35**	0.22
F_{cur}/F_{MSY}	**0.07**	2.97	**0.10**	0.33	**0.09**	0.33	**0.19**	0.35	**0.23**	0.36
N_{cur}/N_{MSY}	2.01	---	1.86	---	1.84	---	1.77	---	1.77	---
MSY	1.34.E+06	---	7.04.E+05	---	7.06.E+05	---	6.97.E+05	---	6.96.E+05	---
SPR_{MSY}	0.53	0.06	0.50	0.06	0.51	0.22	0.51	0.01	0.51	0.01
F_{MSY}	0.084	---	0.083	---	0.077	---	0.058	---	0.057	---
SSF_{MSY}	5.83.E+06	---	2.94.E+06	---	2.98.E+06	---	2.95.E+06	---	2.97.E+06	---
N_{MSY}	1.09.E+07	---	5.68.E+06	---	5.76.E+06	---	5.92.E+06	---	5.91.E+06	---
F_{cur}	0.01	2.97	0.01	0.07	0.01	0.33	0.01	0.35	0.01	0.36
SSF_{cur}	1.53.E+07	3.16	7.05.E+06	0.33	7.06.E+06	0.3518	6.98.E+06	0.35	6.99.E+06	0.35
N_{cur}	2.38.E+07	---	1.16.E+07	---	1.16.E+07	---	1.15.E+07	---	1.15.E+07	---
SSF_{cur}/SSF_0	0.90	0.33	0.80	0.33	0.79	0.074	0.79	0.08	0.79	0.08
B_{cur}/B_0	0.87	0.23	0.80	0.22	0.79	0.054	0.79	0.06	0.79	0.06
R_0	3.98.E+06	2.84	2.07.E+06	0.28	2.09.E+06	0.279	2.07.E+06	0.28	2.08.E+06	0.28
Pup-survival	0.84	0.40	0.91	0.28	0.89	0.27	0.88	0.27	0.87	0.27
alpha	3.59	---	3.89	---	3.80	---	3.76	---	3.71	---
steepness	0.47	---	0.49	---	0.49	---	0.48	---	0.48	---
SSF_0	1.71.E+07	2.84	8.86.E+06	0.22	8.93.E+06	0.279	8.88.E+06	0.28	8.89.E+06	0.28
SSF_{MSY}/SSF_0	0.34	---	0.33	---	0.33	---	0.33	---	0.33	---

cur = 2010 for base, 2009 for retrospective 2009, 2008 for retrospective 2008, 2007 for retrospective 2007, and 2006 for retrospective 2006.

3.6 FIGURES

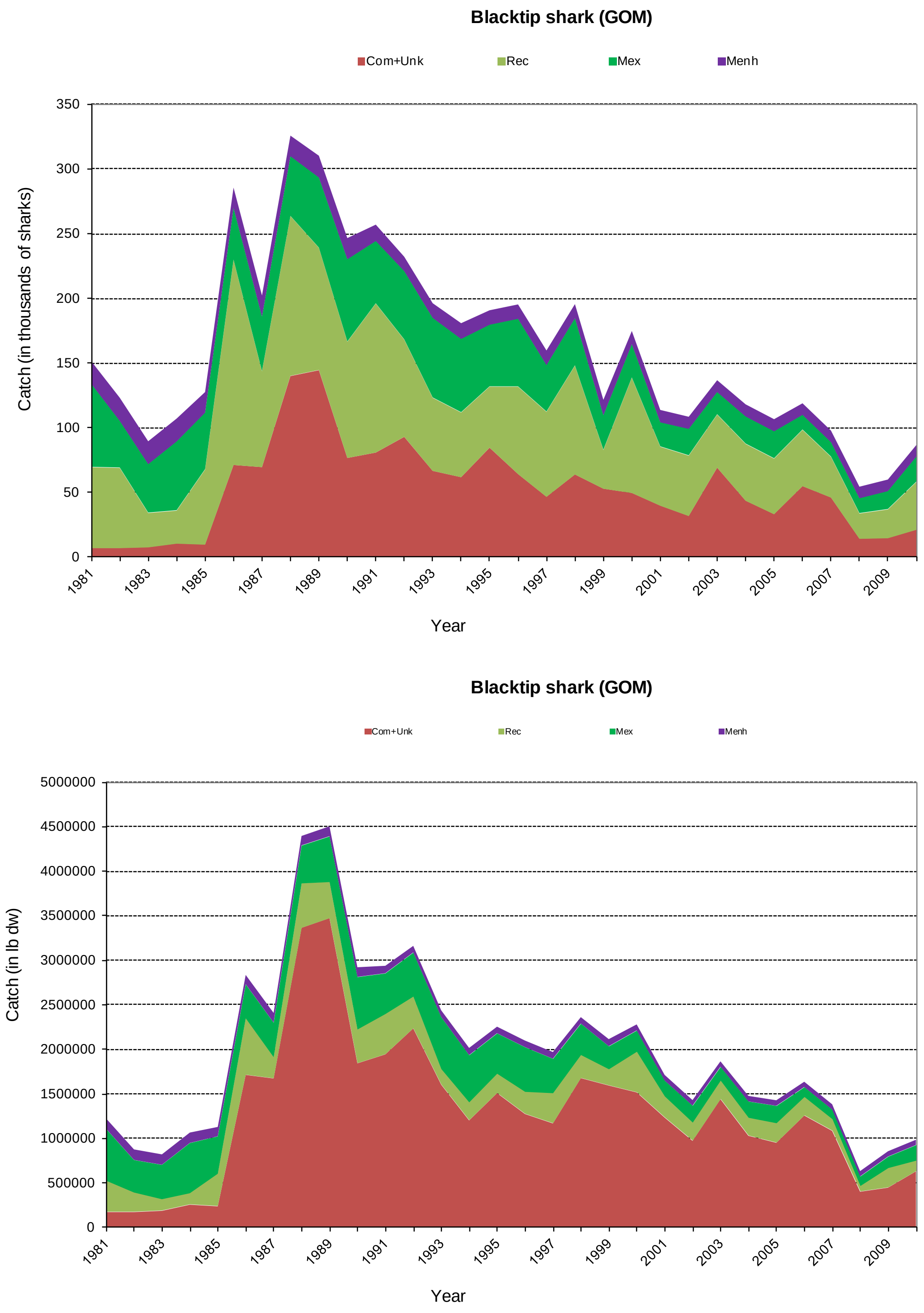


Figure 3.6.1. Catches of Gulf of Mexico blacktip shark by fleet in numbers (top) and weight (lb dw; bottom). Catches are separated into four fisheries: commercial + unreported catches, recreational catches, Mexican catches, and menhaden fishery discards.

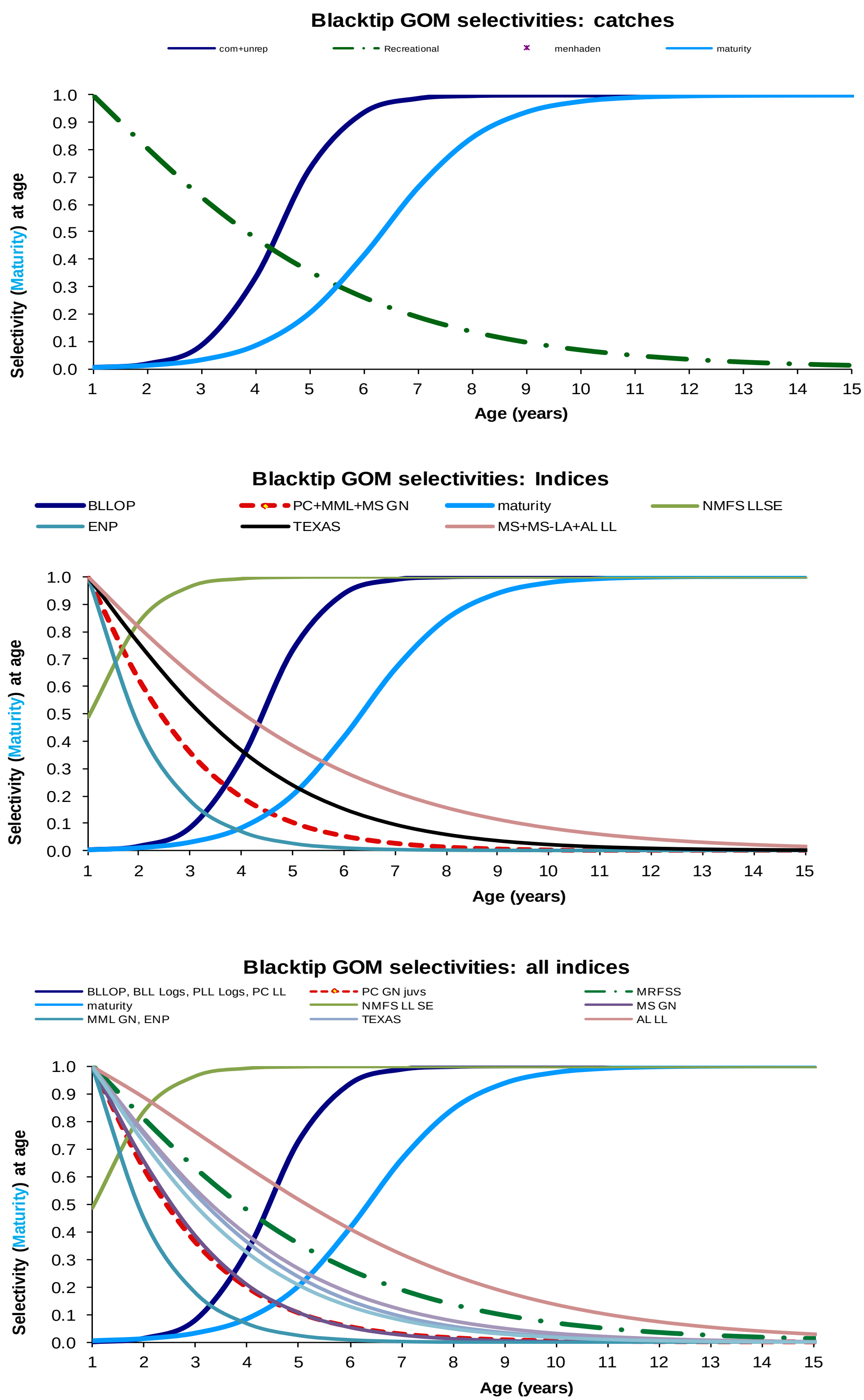
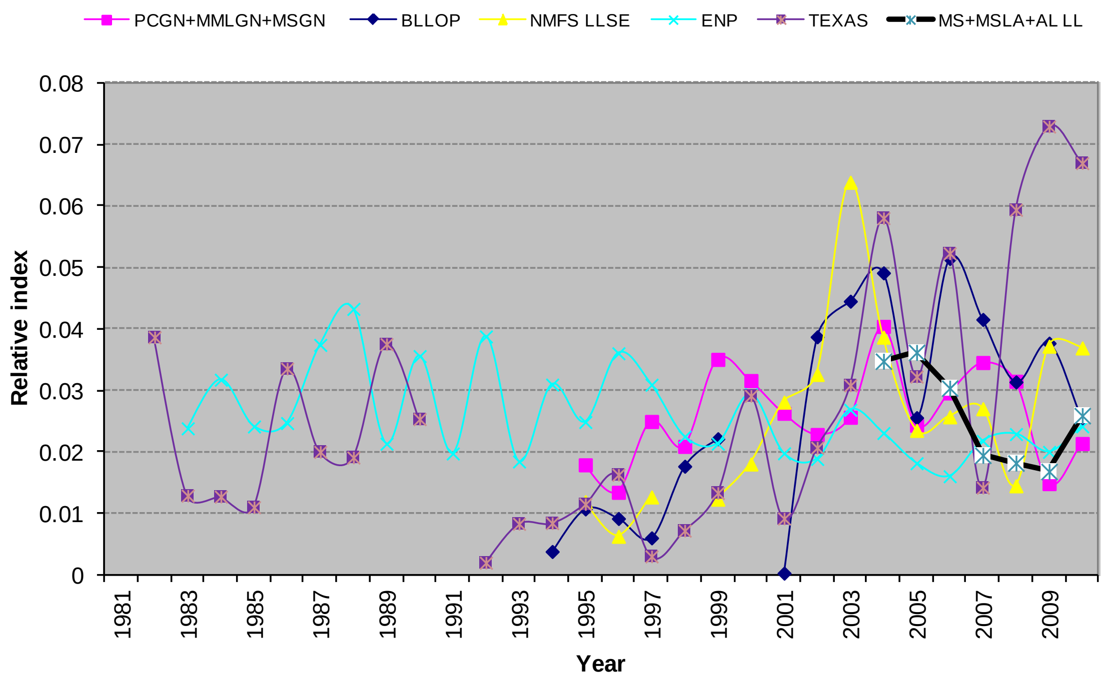


Figure 3.6.2. Selectivity curves for catches (upper panel), baseline indices of relative abundance (middle panel), and all indices of relative abundance (bottom panel). The maturity ogive for GOM blacktip shark has been added to the upper panel.



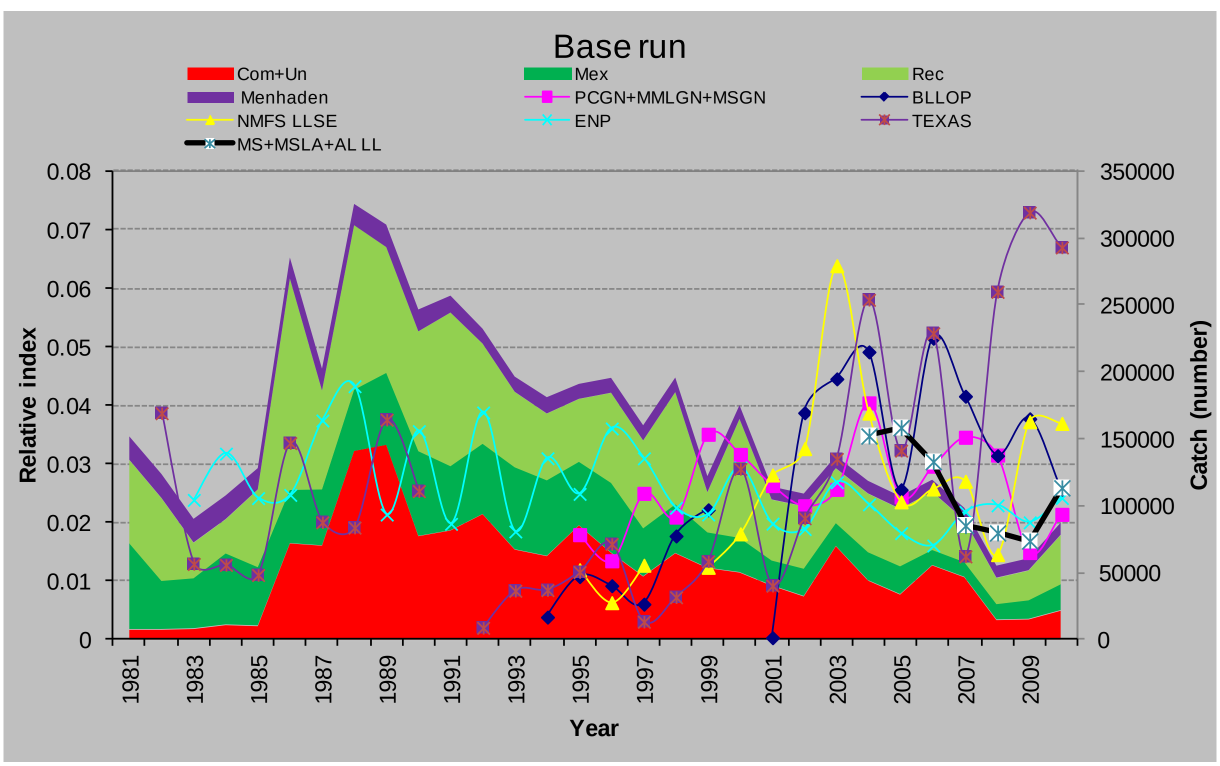


Figure 3.6.3. Indices of relative abundance used for the baseline scenario (top panel). All indices are statistically standardized and scaled (divided by their respective mean and a global mean for overlapping years for plotting purposes). Same indices superimposed on catches (bottom panel).

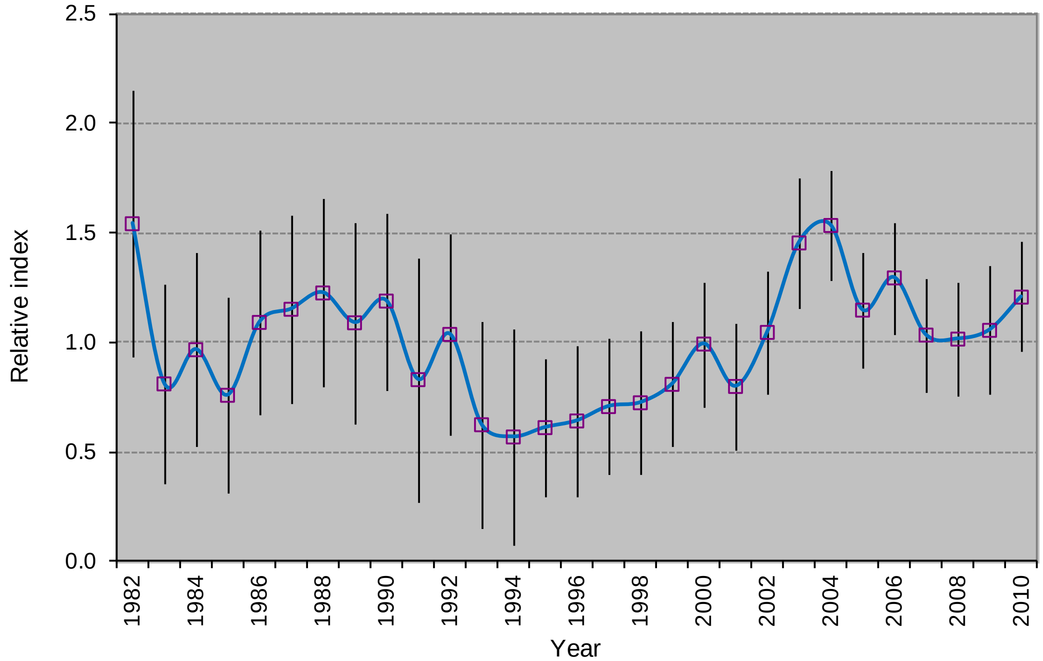


Figure 3.6.4. Hierarchical index of relative abundance used in sensitivity run 7. The index is scaled (divided by its mean). Vertical bars are ± 1 CV.

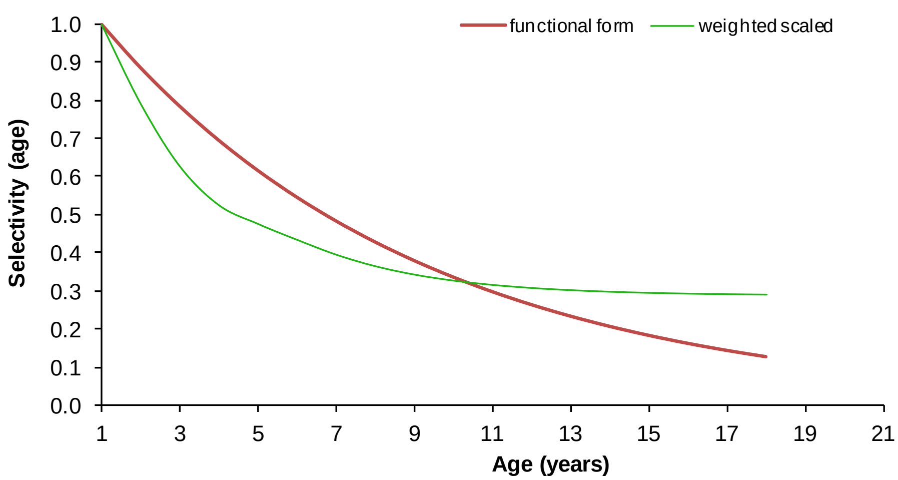


Figure 3.6.5. Selectivity for the hierarchical index. “Weighted scaled” is the selectivity obtained by weighting the base run selectivities by the inverse variance weights reported in Section 3.1.5 and scaled to the maximum value; “functional form” is an approximation of the weighted selectivity for input into sensitivity run 7.

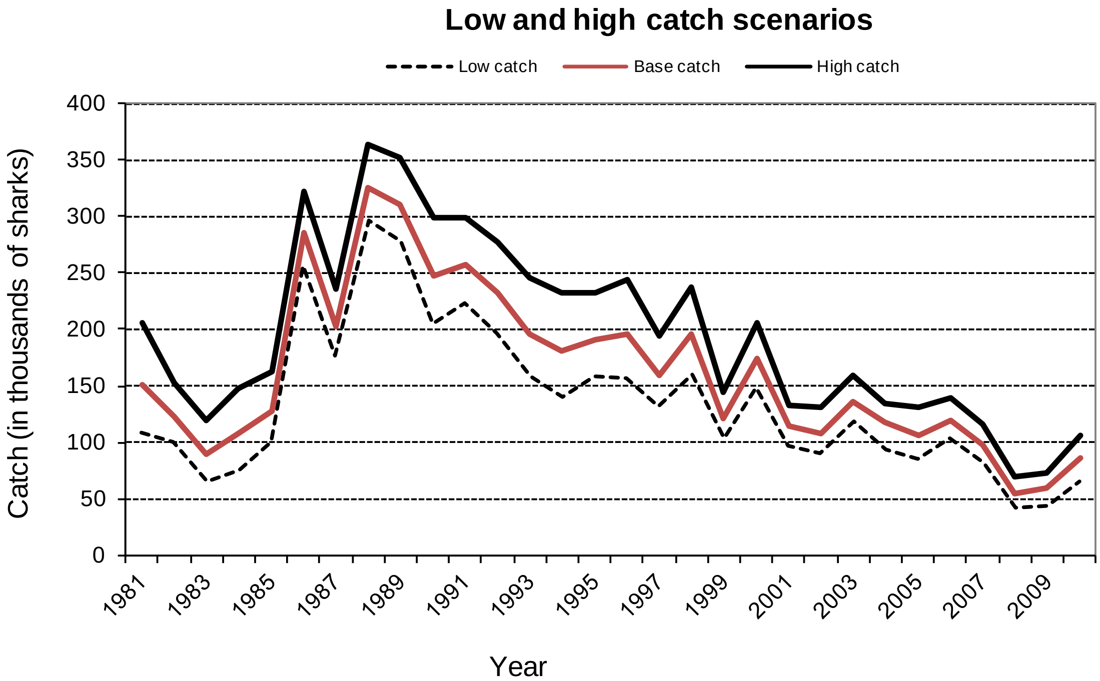
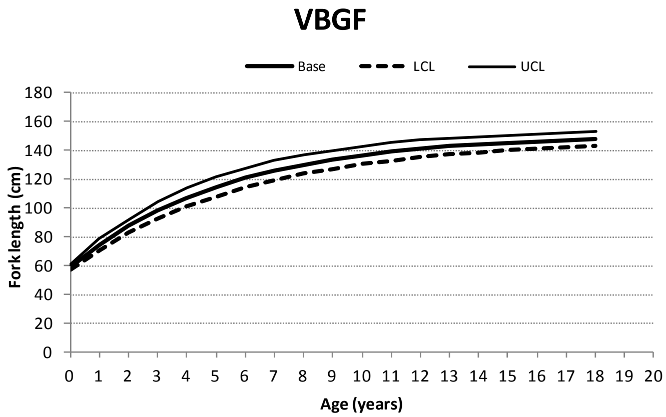
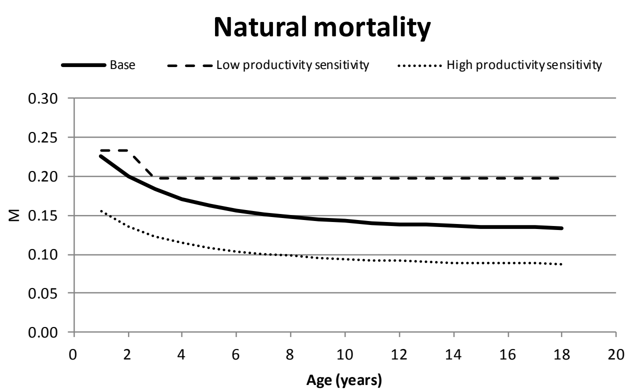


Figure 3.6.6. Low and high total catch estimates for GOM blacktip shark used in sensitivity runs 9 and 10.

A



B



C

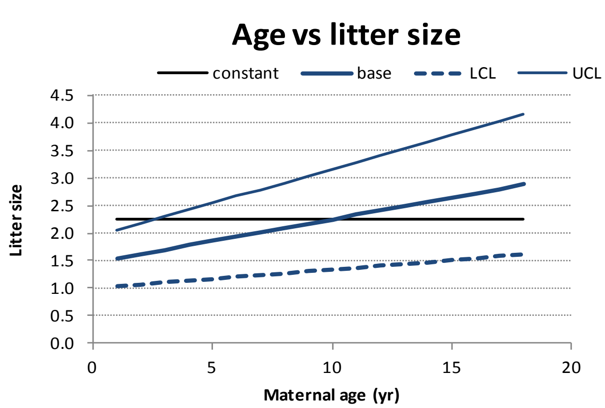


Figure 3.6.7. Ninety five percent CLs of von Bertalanffy growth function parameter estimates (A), derived low and high M vectors (B), and 95% CLs of maternal age vs. litter size relationship (C) for use in low and high productivity runs 11 and 12.

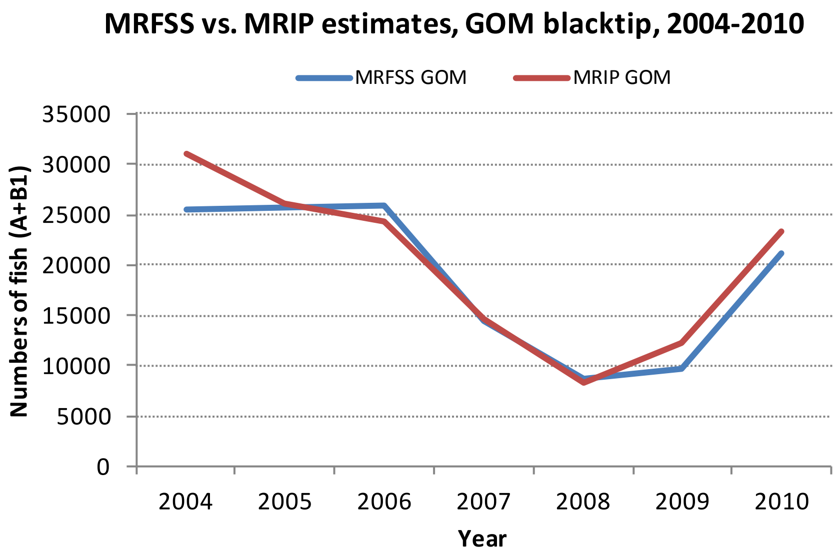


Figure 3.6.8. MRFSS vs. MRIP (Marine Recreational Information Program) catches (A+B1) of GOM blacktip sharks for use in sensitivity run 13.

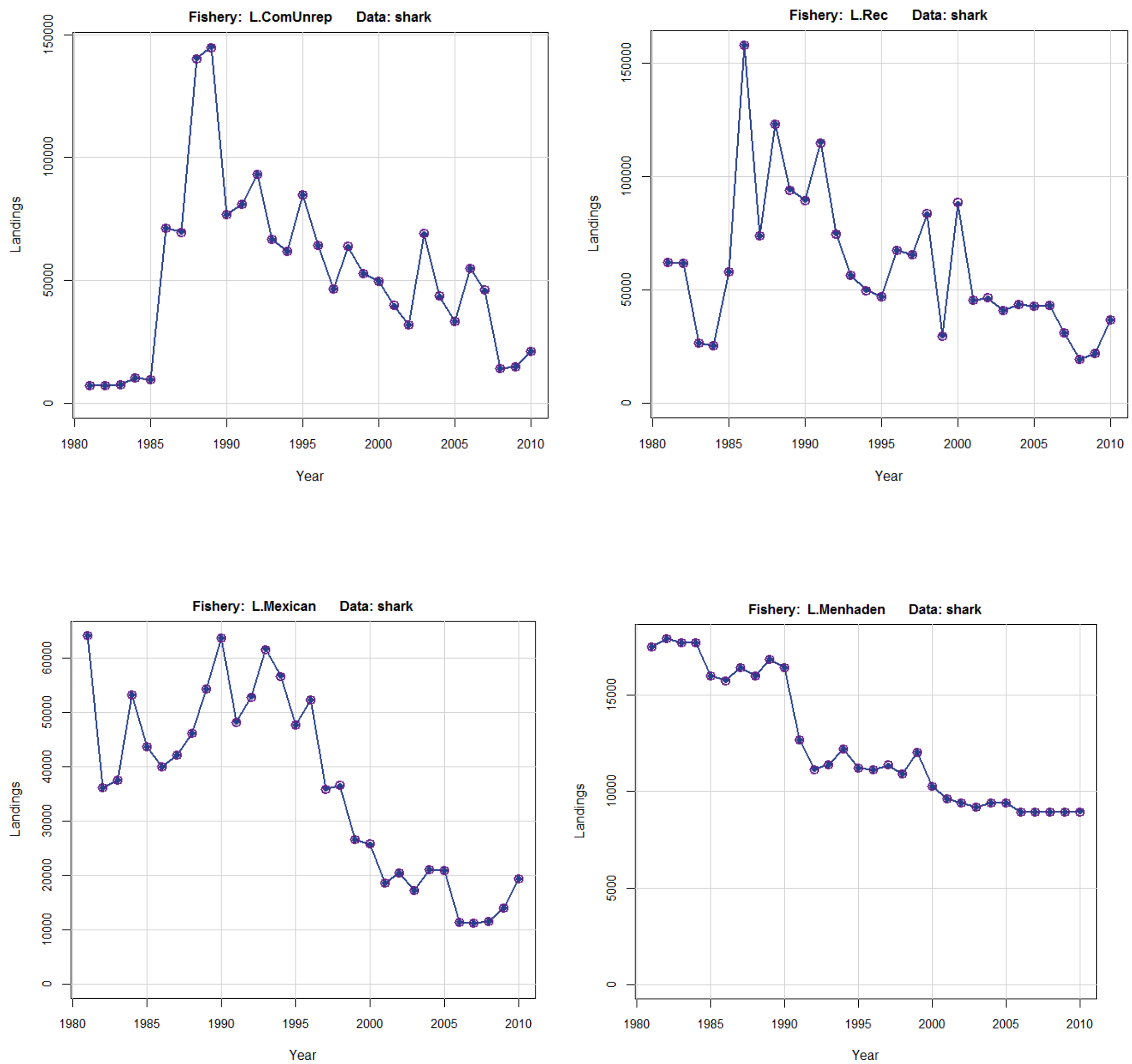


Figure 3.6.9. Predicted fits to catch data for the base run.

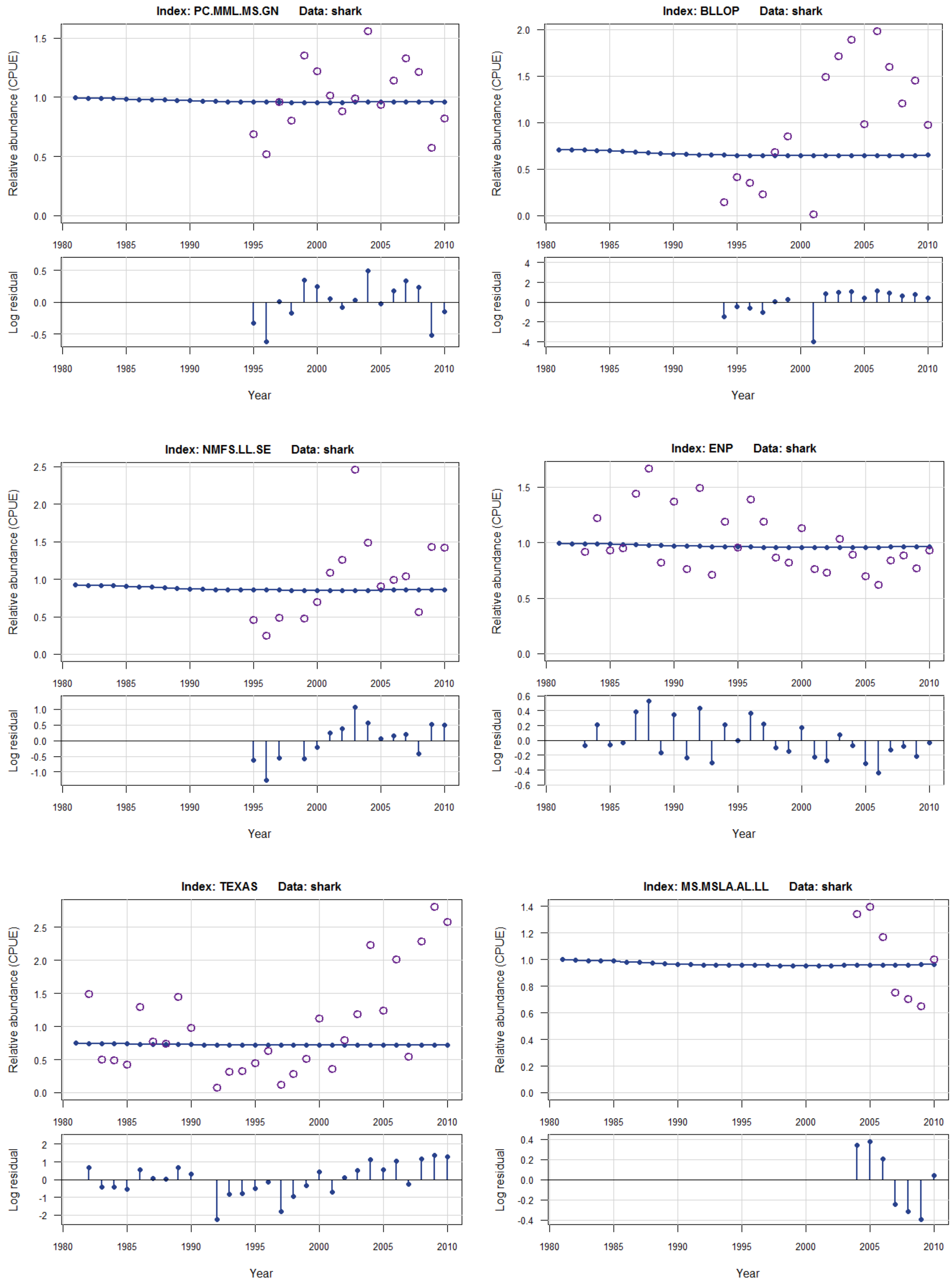
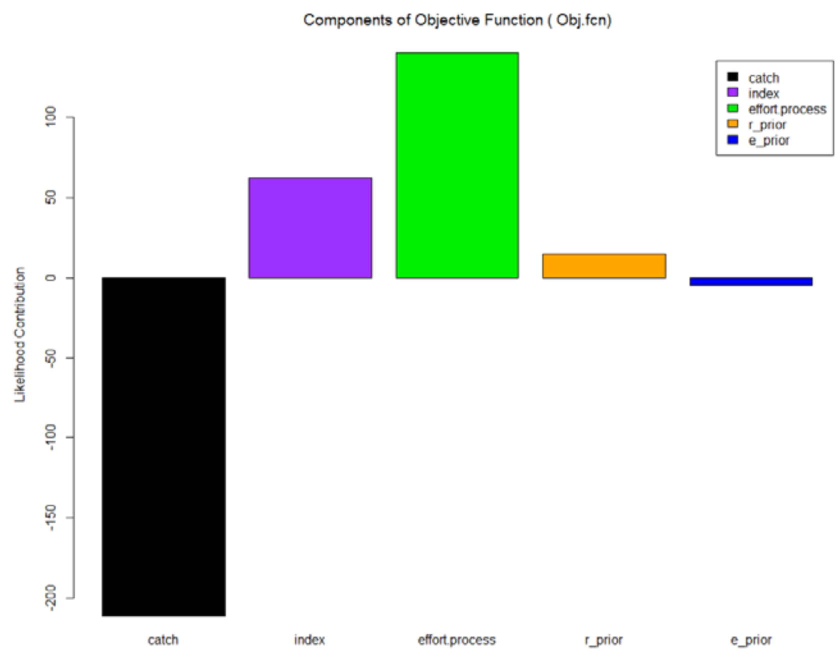


Figure 3.6.10. Predicted fits to indices and residual plots for the base run.

A



B

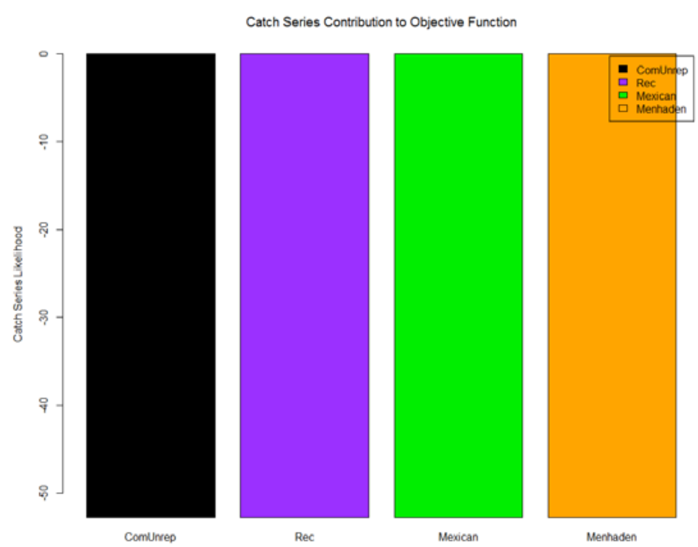


Figure 3.6.11. Contribution to relative likelihood by category for GOM blacktip shark: A) model sources (the recruitment component includes both priors on virgin number of pups and pup survival), B) catch series (they only differ to the second decimal place and appear to be equal).

C

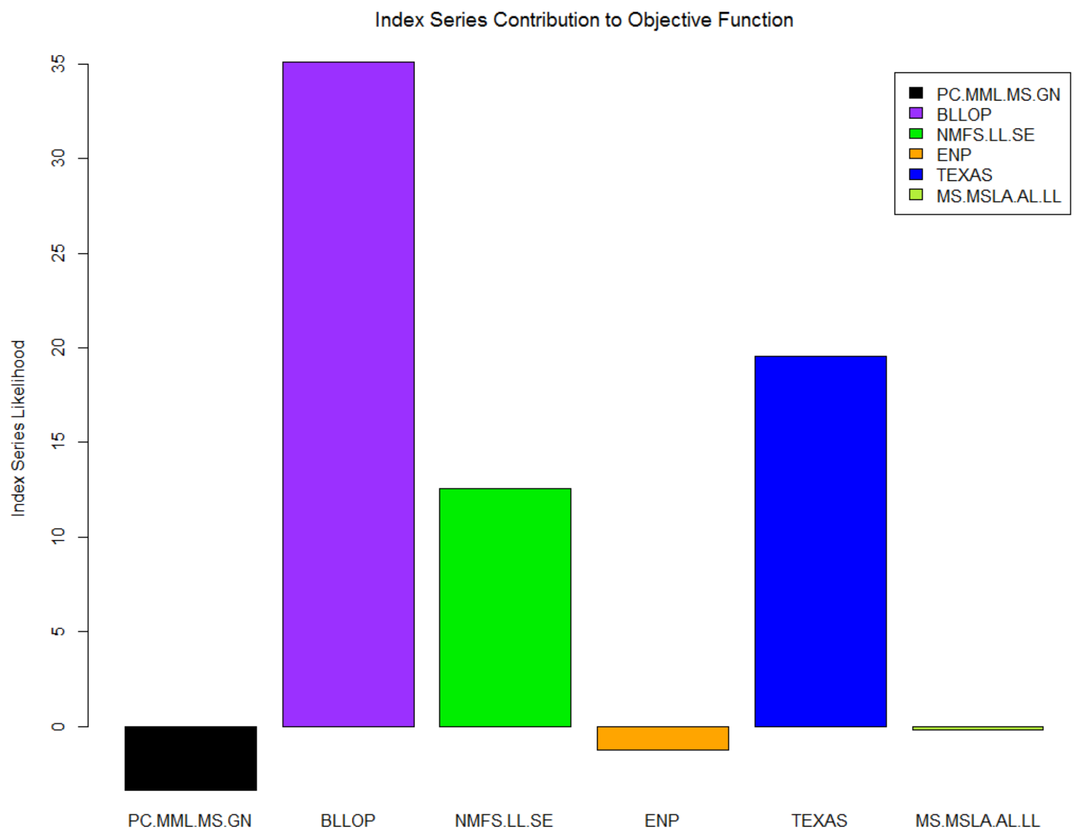


Figure 3.6.11 (continued). Contribution to relative likelihood by category for GOM blacktip shark: C) index series

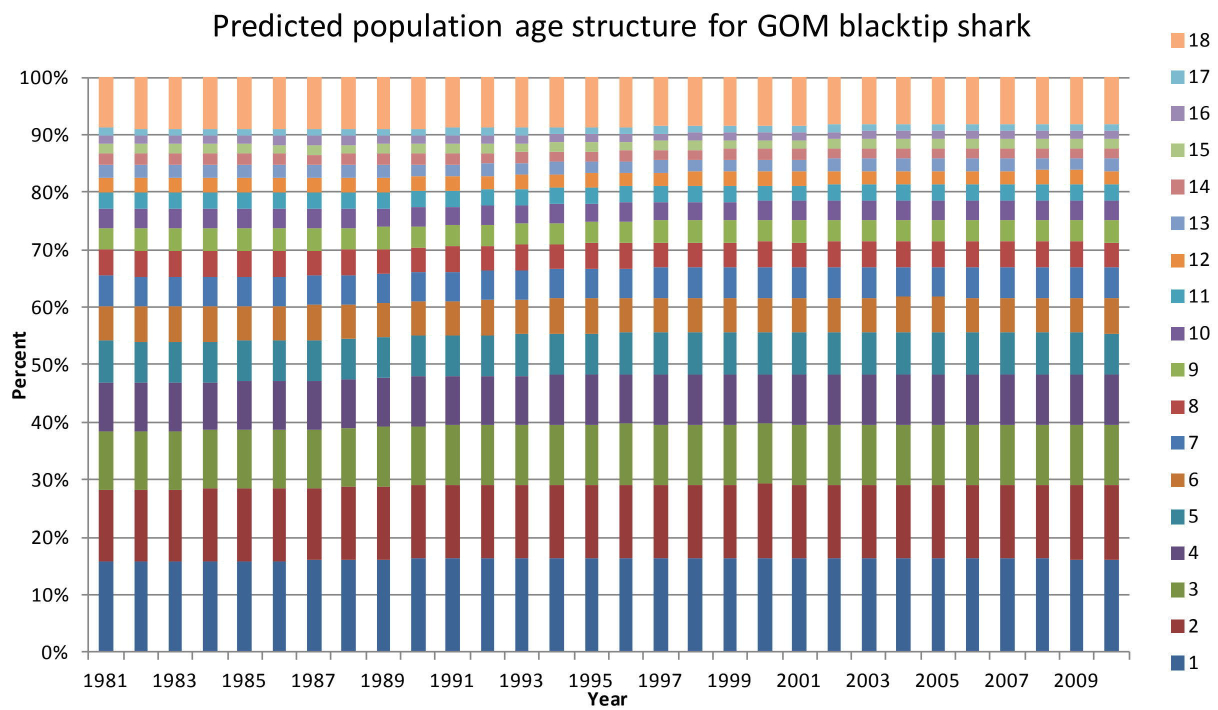


Figure 3.6.12. Predicted abundance at age for GOM blacktip shark.

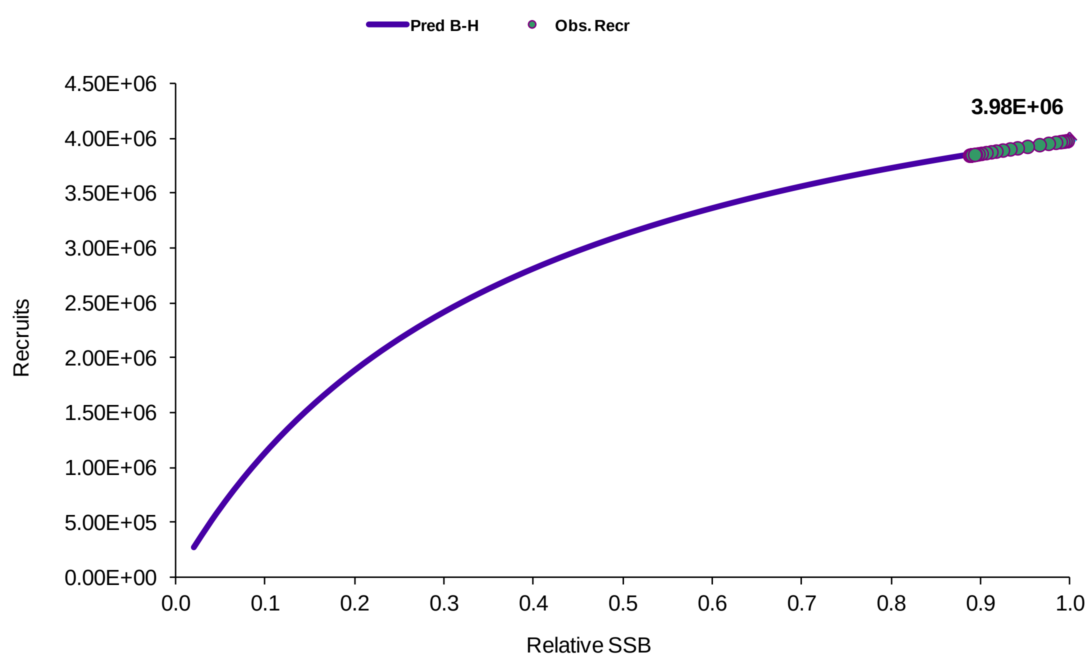


Figure 3.6.13. Predicted and “observed” Beverton-Holt recruitment (number of age-1 pups) for GOM blacktip sharks at different levels of SSF depletion. The label shows the estimated virgin number of (age-1) recruits.

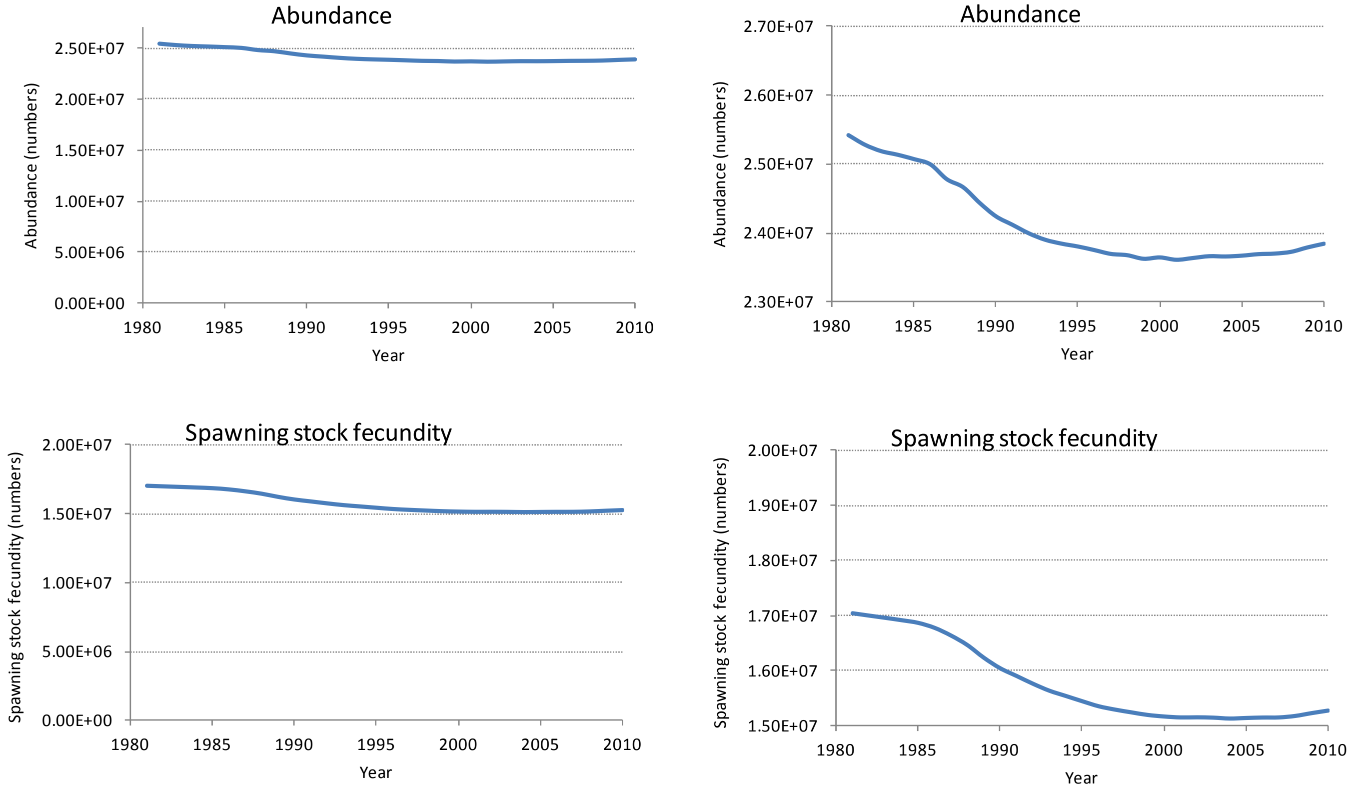


Figure 3.6.14. Predicted abundance and spawning stock fecundity trajectories for GOM blacktip sharks. The Y-axis of the plots on the left starts at 0, whereas the plots on the right show a zoom-in of the Y-axis.

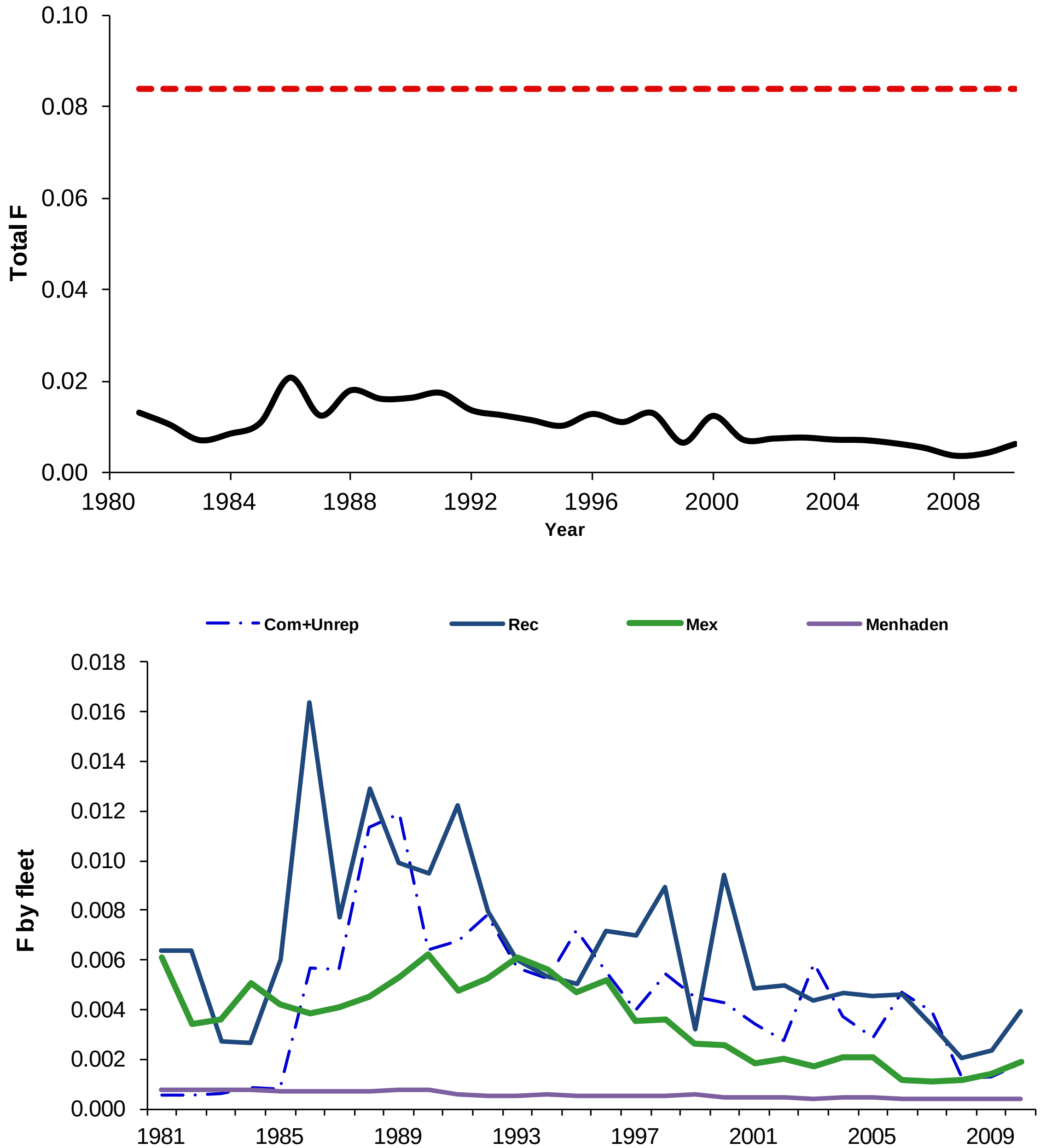
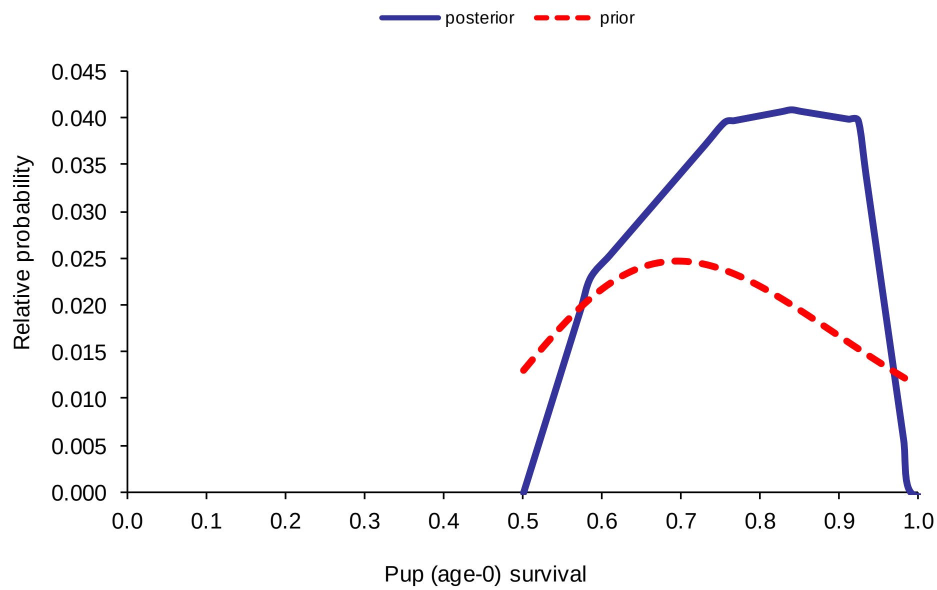


Figure 3.6.15. Estimated total fishing mortality (top) and fleet-specific F (bottom) for GOM blacktip shark. The dashed line in the top panel indicates F_{MSY} (0.084).



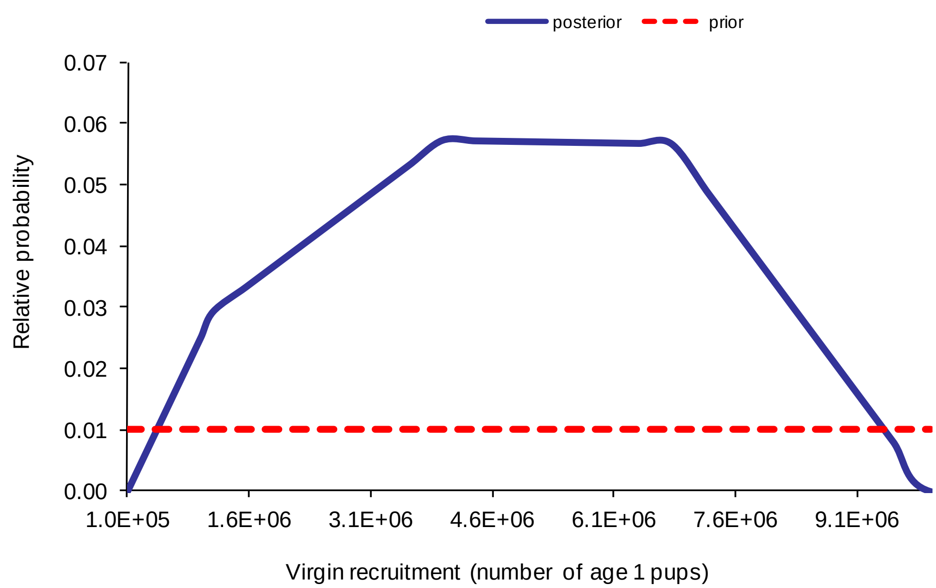
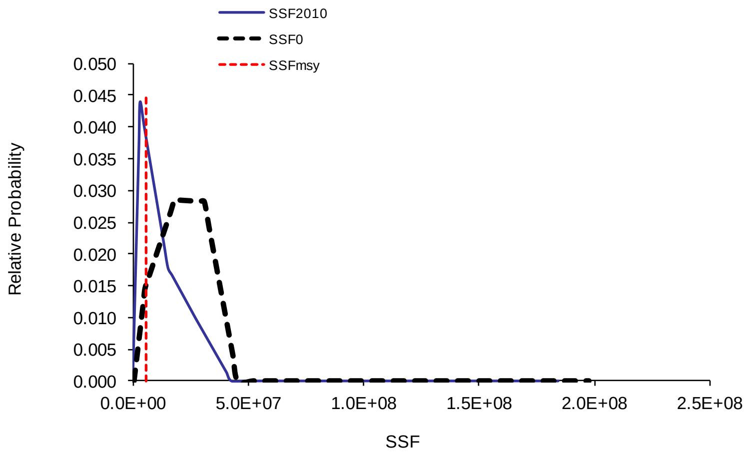
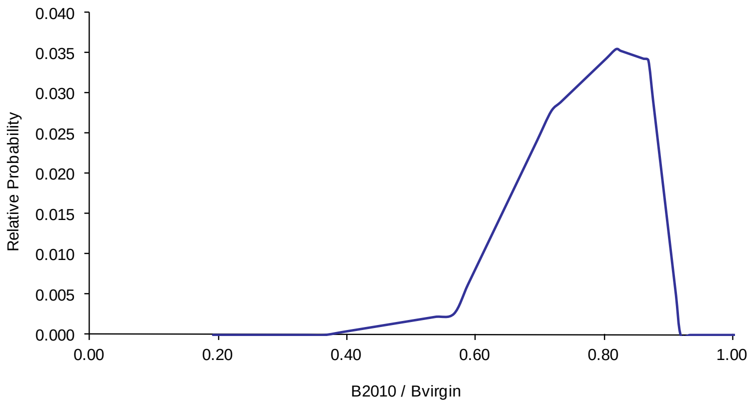


Figure 3.6.16. Profile likelihoods for pup survival and virgin recruitment. Both prior and posterior distributions are shown.





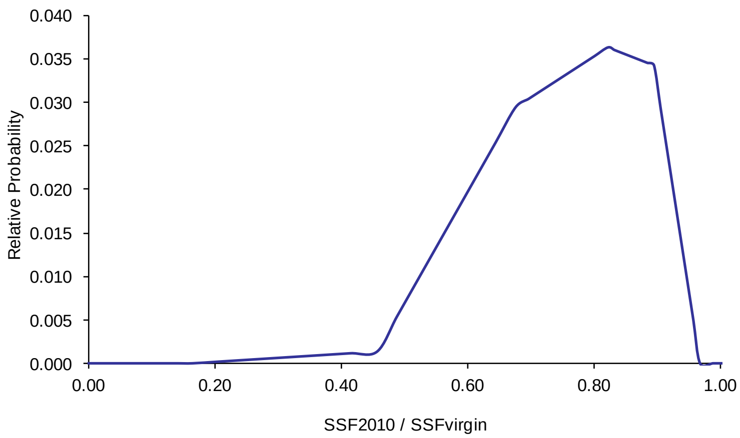


Figure 3.6.17. Profile likelihoods for spawning stock fecundity (SSF) in virgin conditions and in 2010 (top), depletion in biomass (middle), and SSF depletion (bottom).

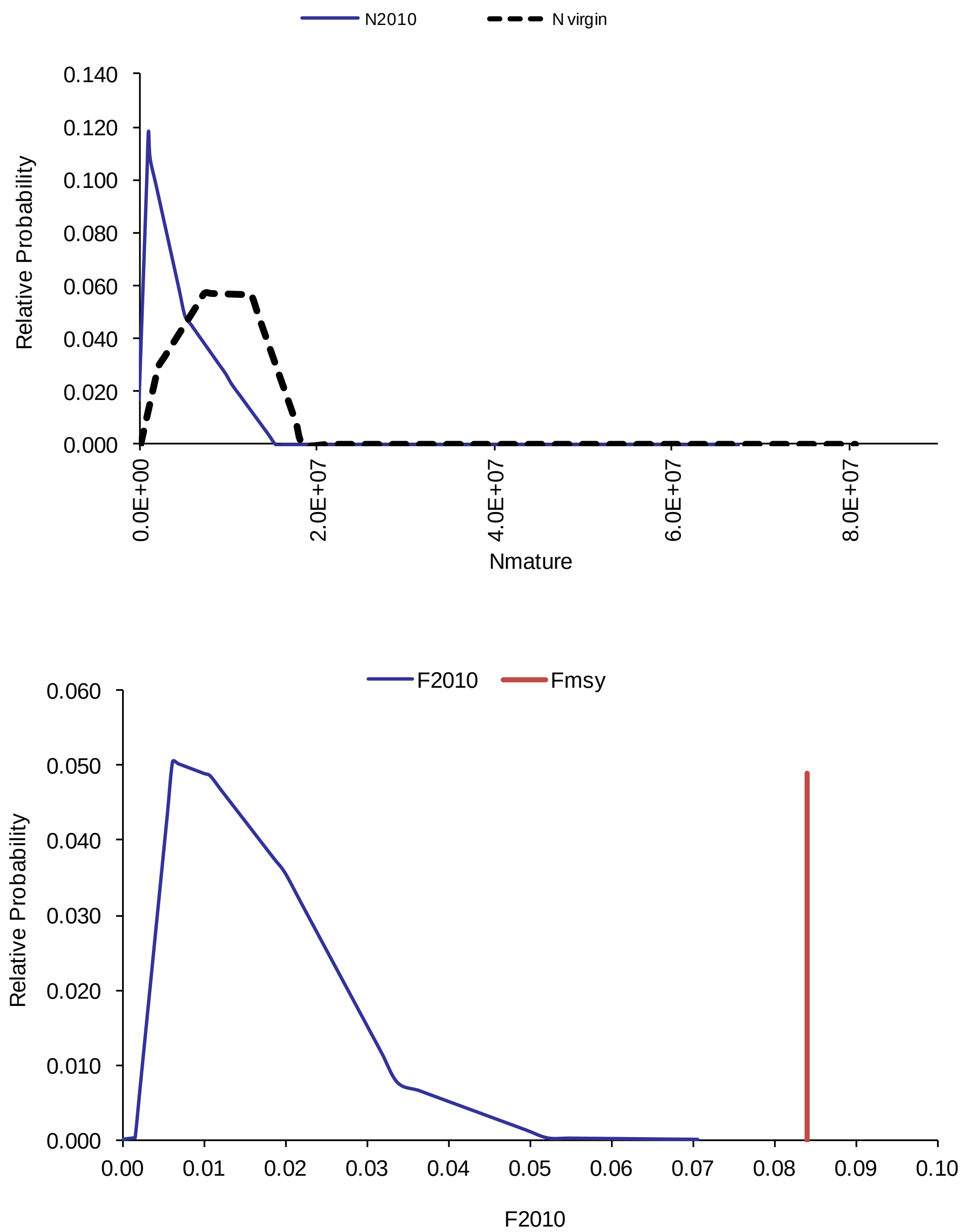
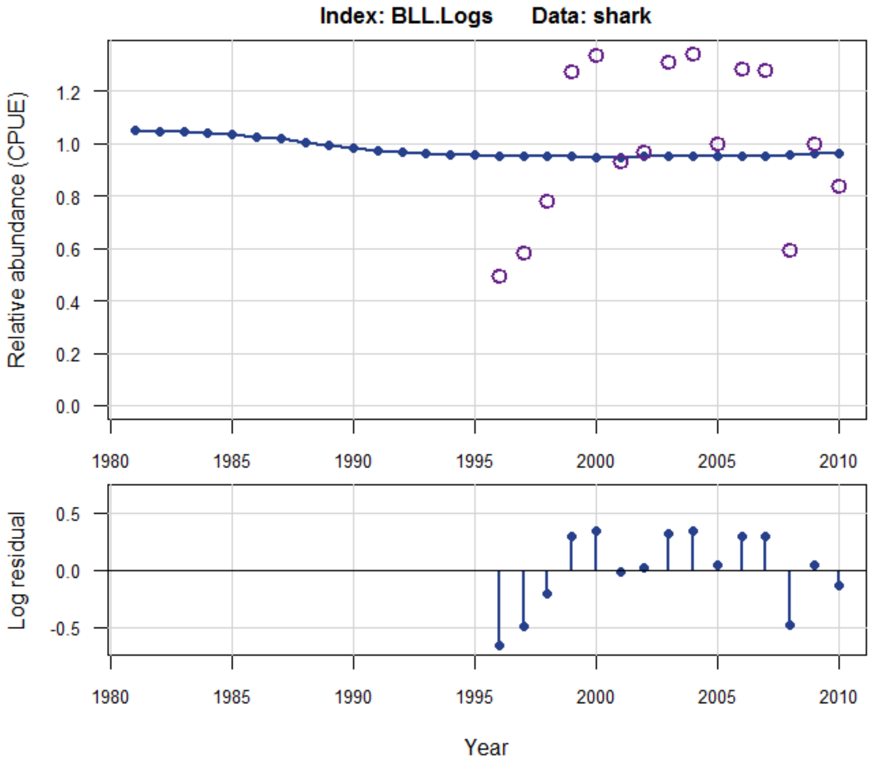


Figure 3.6.18. Profile likelihoods for number of mature individuals in virgin conditions and in 2010 (top) and for fishing mortality in 2010 (bottom).



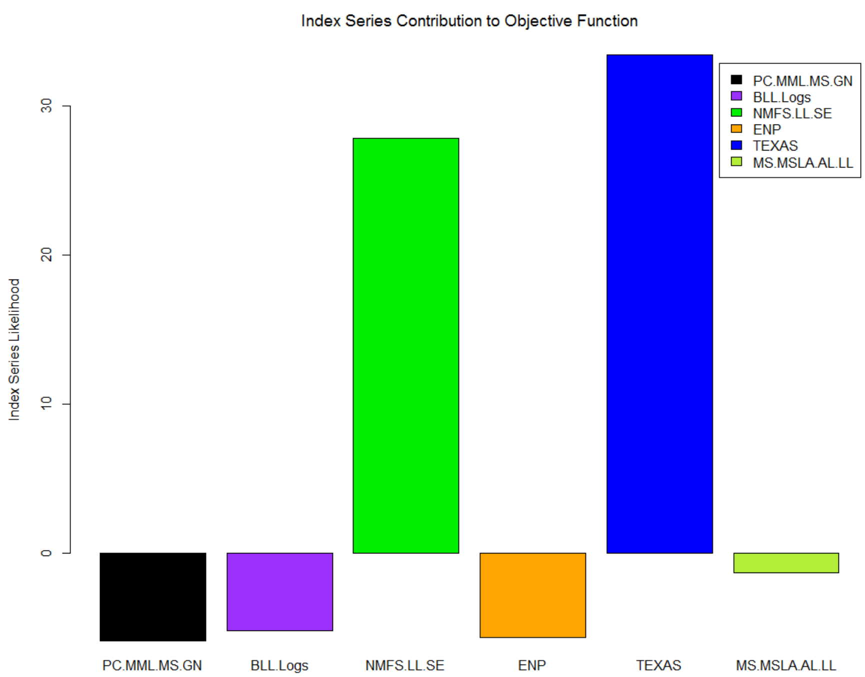
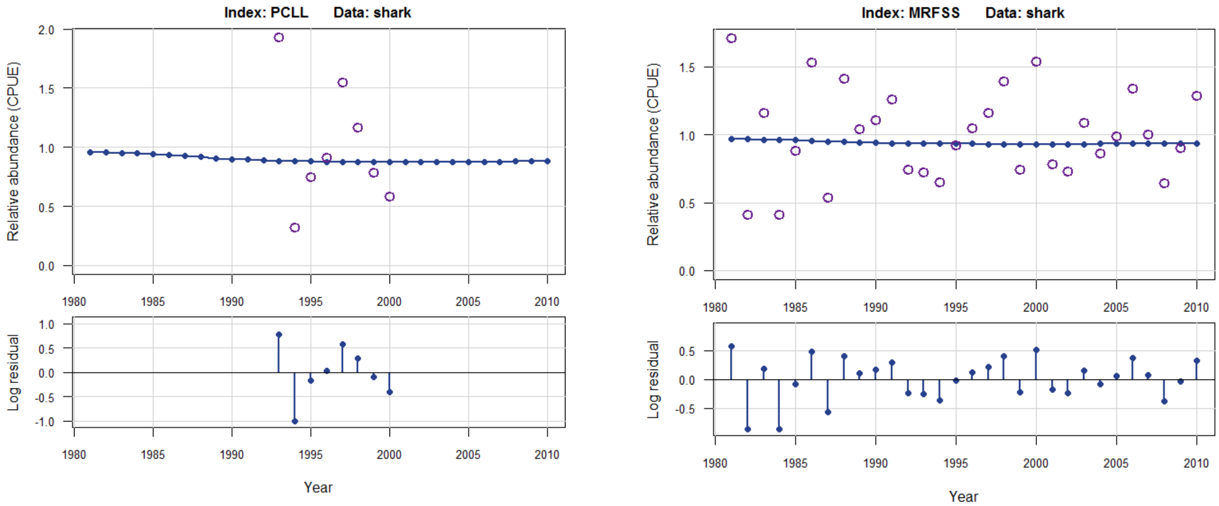


Figure 3.6.19. Predicted fit to the BLL Logs index (top) and contribution to the relative likelihood by index (bottom) for sensitivity run 1.



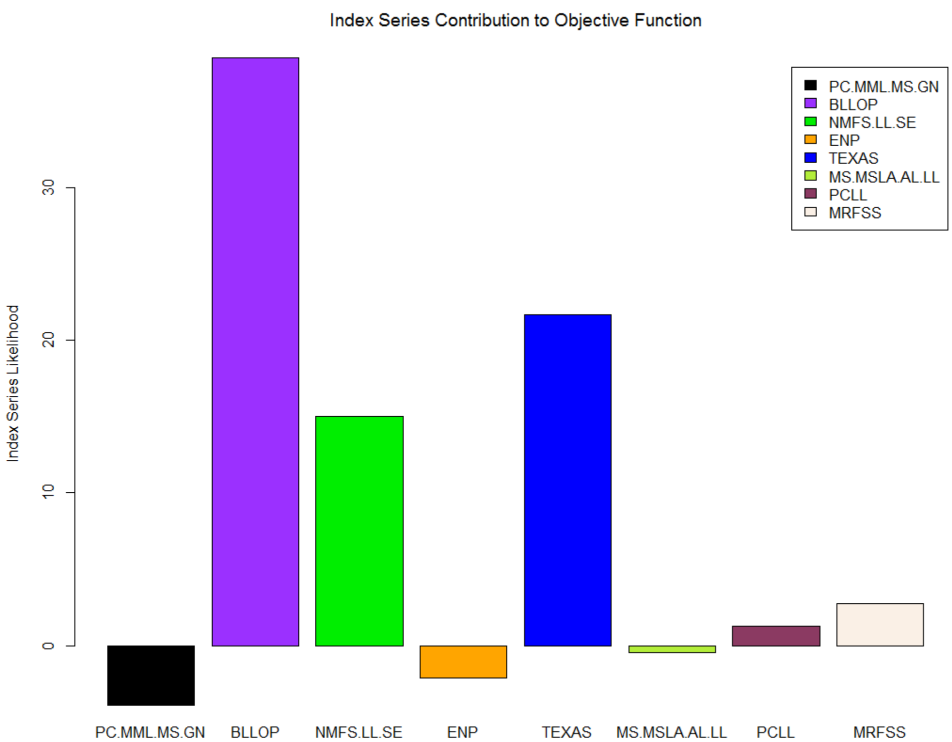


Figure 3.6.20. Predicted fits to the PC LL and MRFSS indices (top) and contribution to the relative likelihood by index (bottom) for sensitivity run 2.

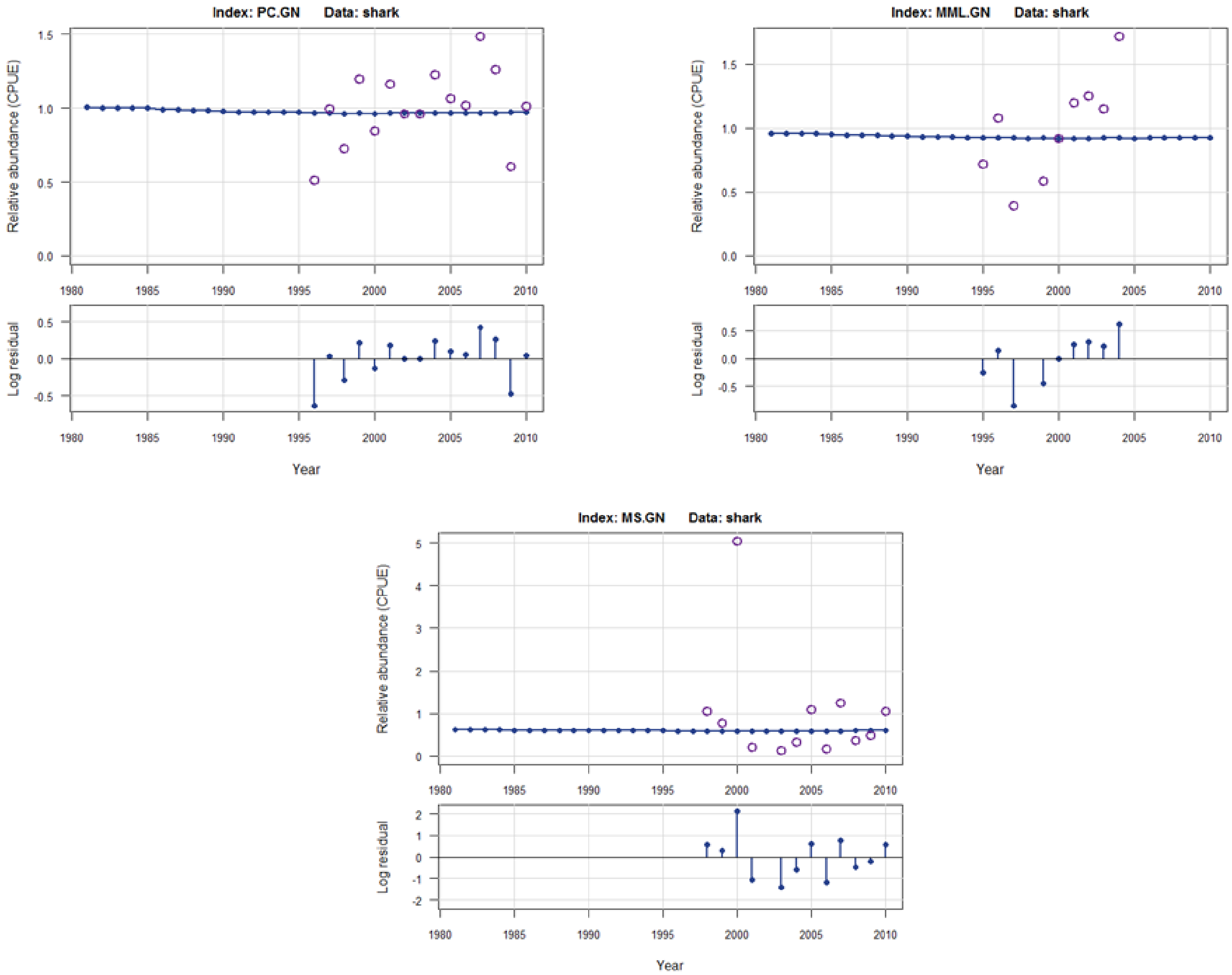


Figure 3.6.21. Predicted fits to the disaggregated fishery-independent gillnet indices for sensitivity run 3.

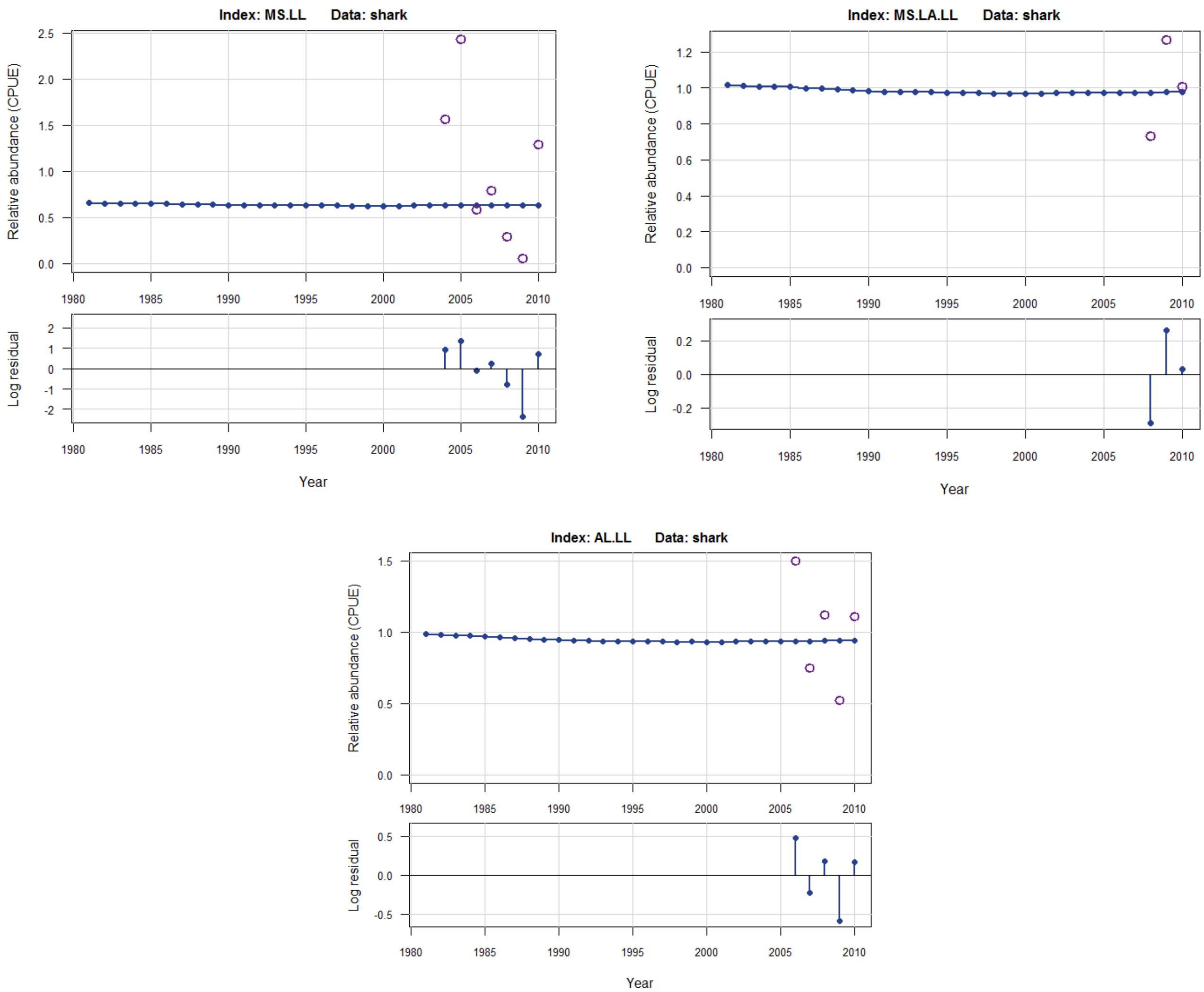


Figure 3.6.21 (continued). Predicted fits to the disaggregated fishery-independent longline indices for sensitivity run 3.

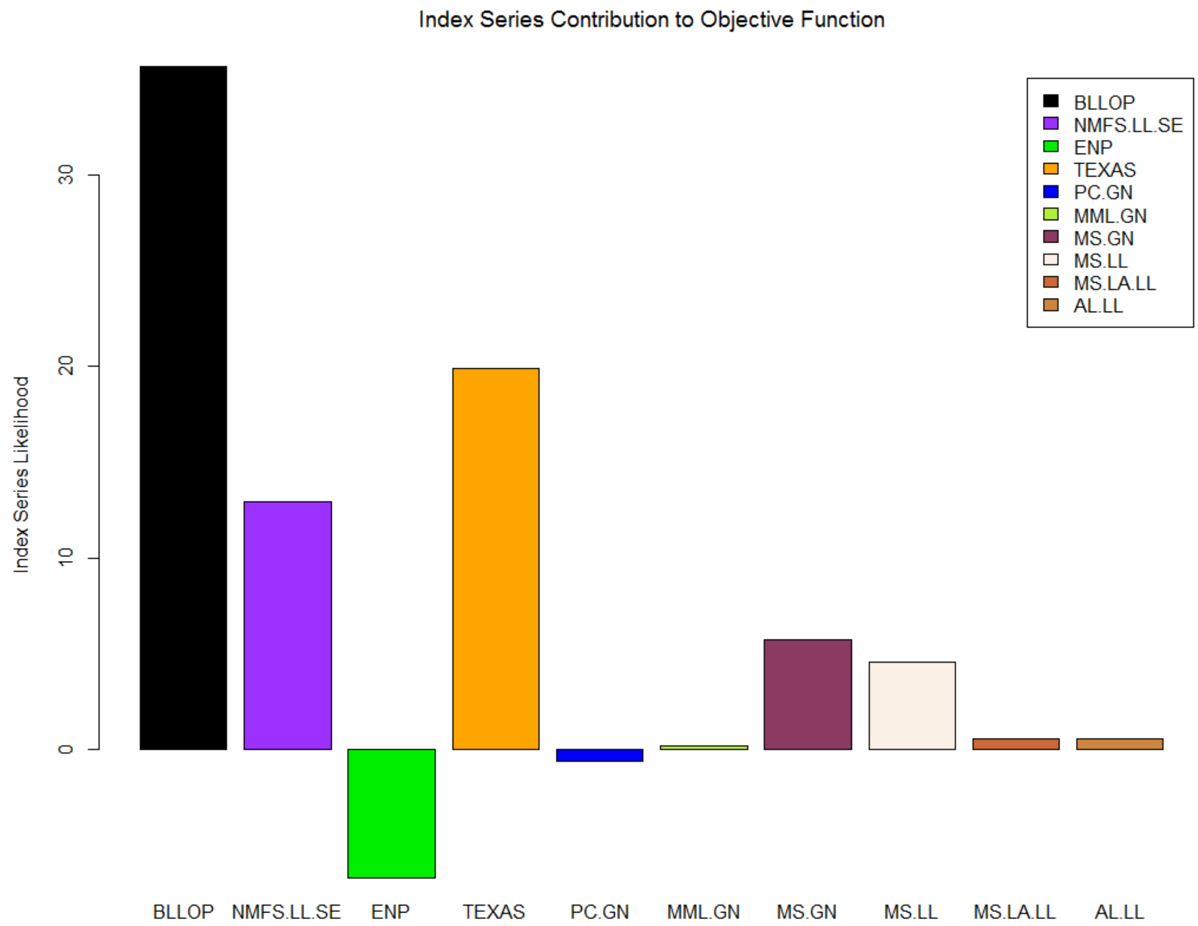


Figure 3.6.21 (continued). Contribution to the relative likelihood by index for sensitivity run 3.

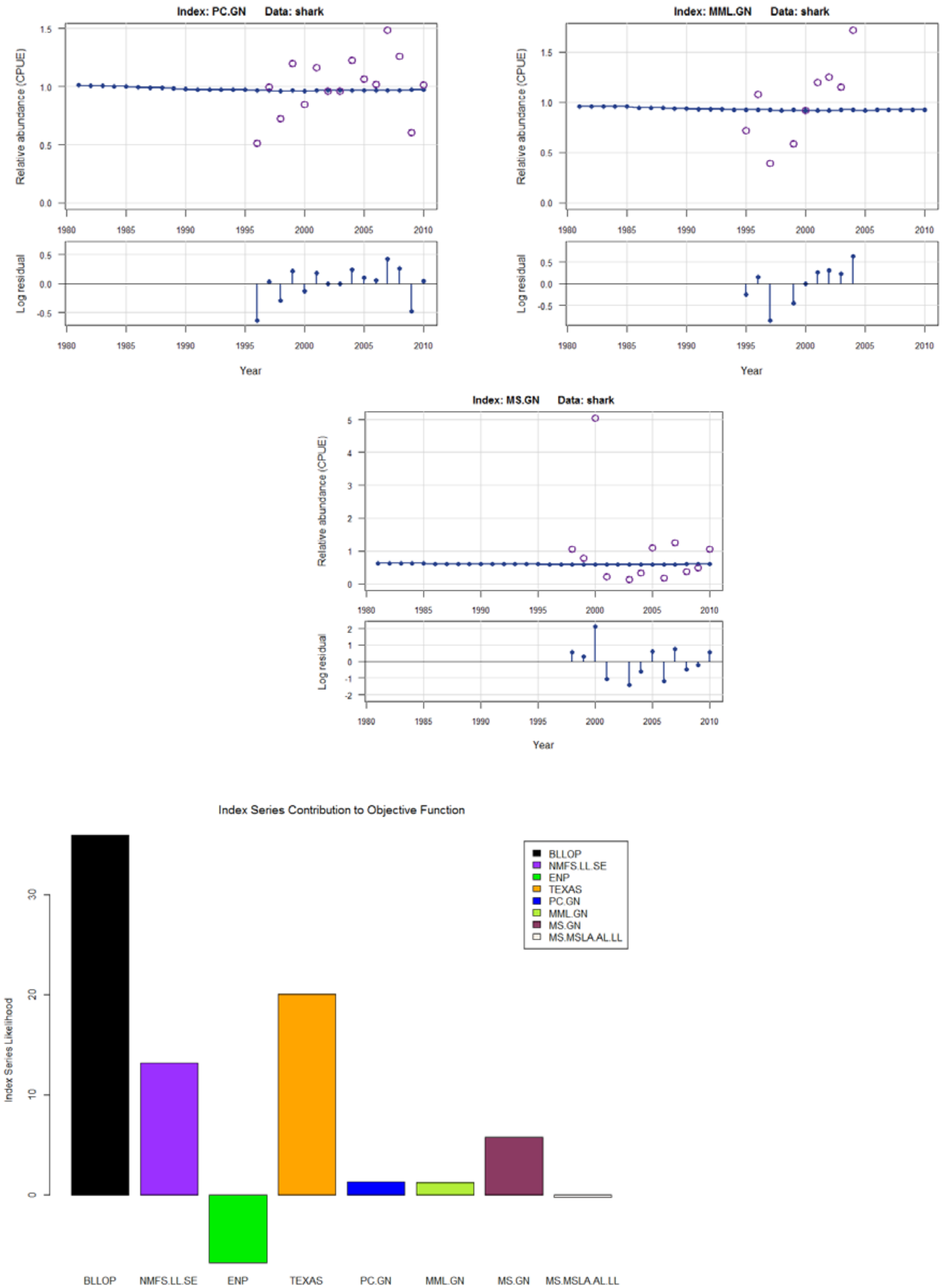


Figure 3.6.22. Predicted fits to the disaggregated fishery-independent gillnet indices (top) and contribution to the relative likelihood by index (bottom) for sensitivity run 4.

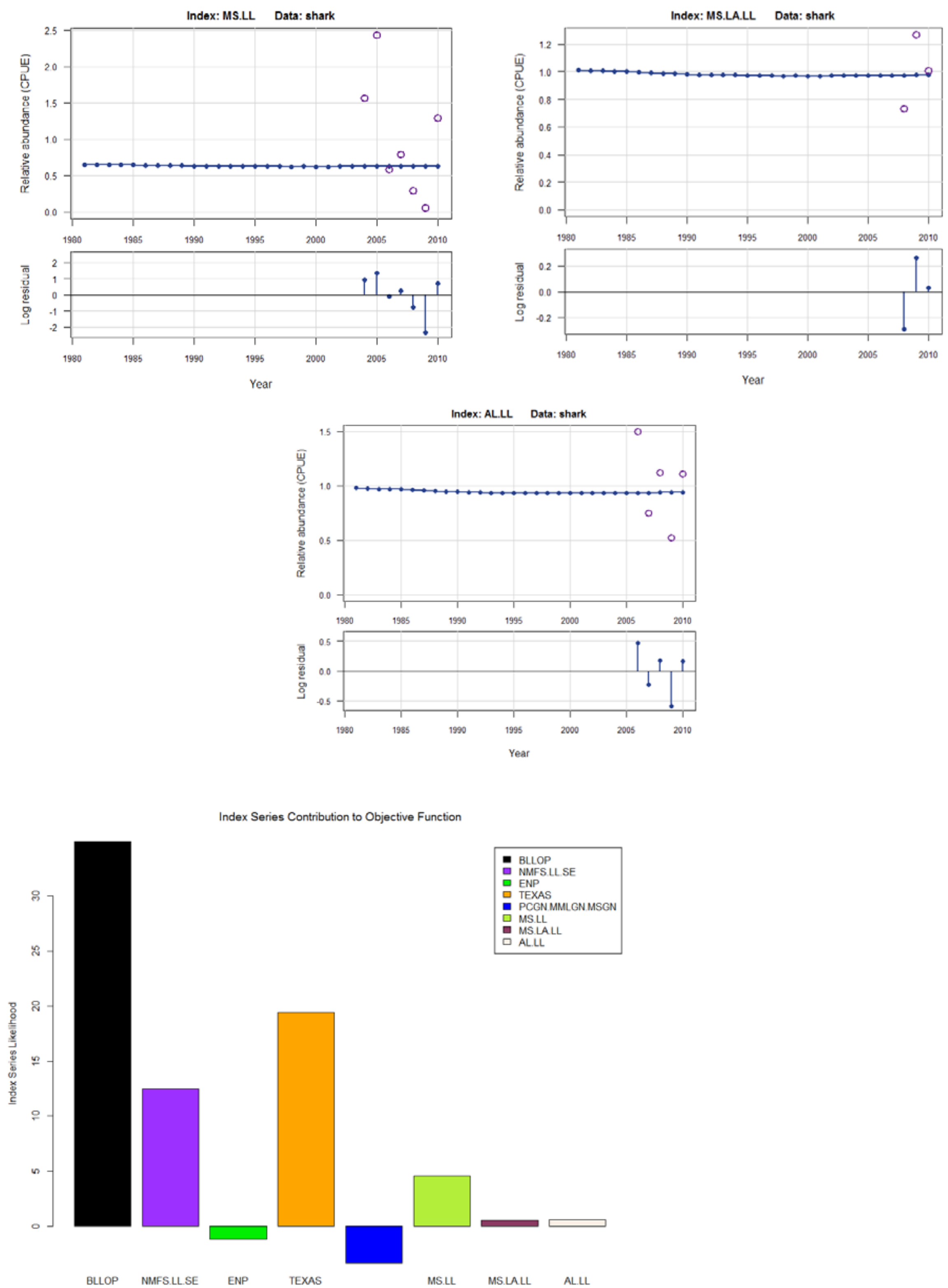
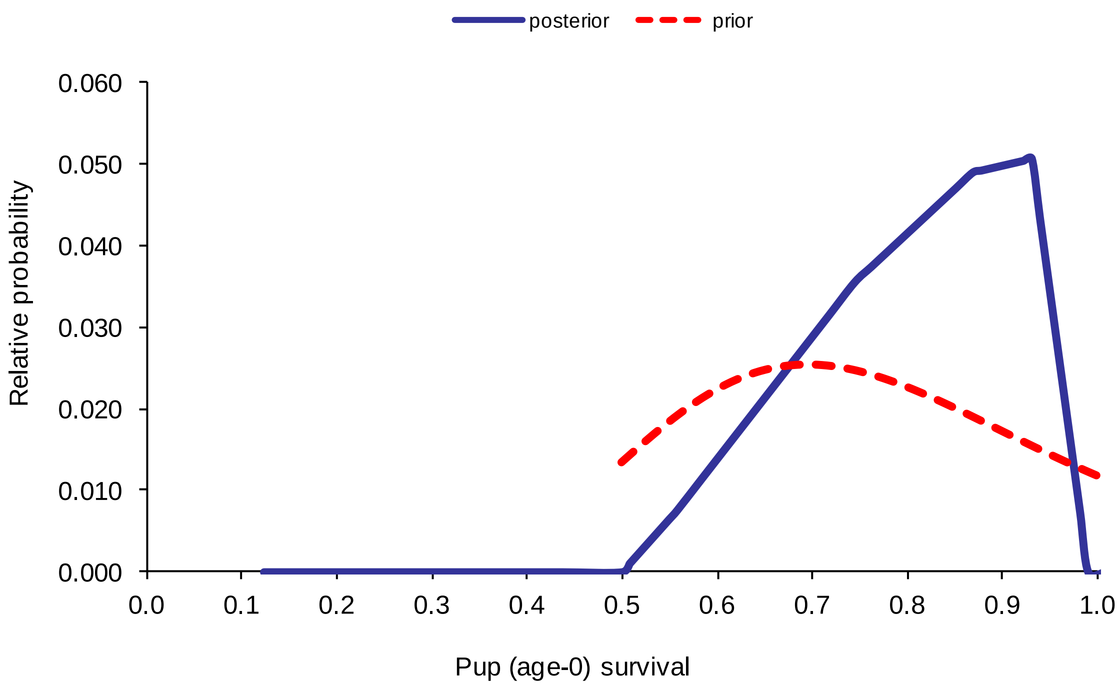


Figure 3.6.23. Predicted fits to the disaggregated fishery-independent longline indices (top) and contribution to the relative likelihood by index (bottom) for sensitivity run 5.



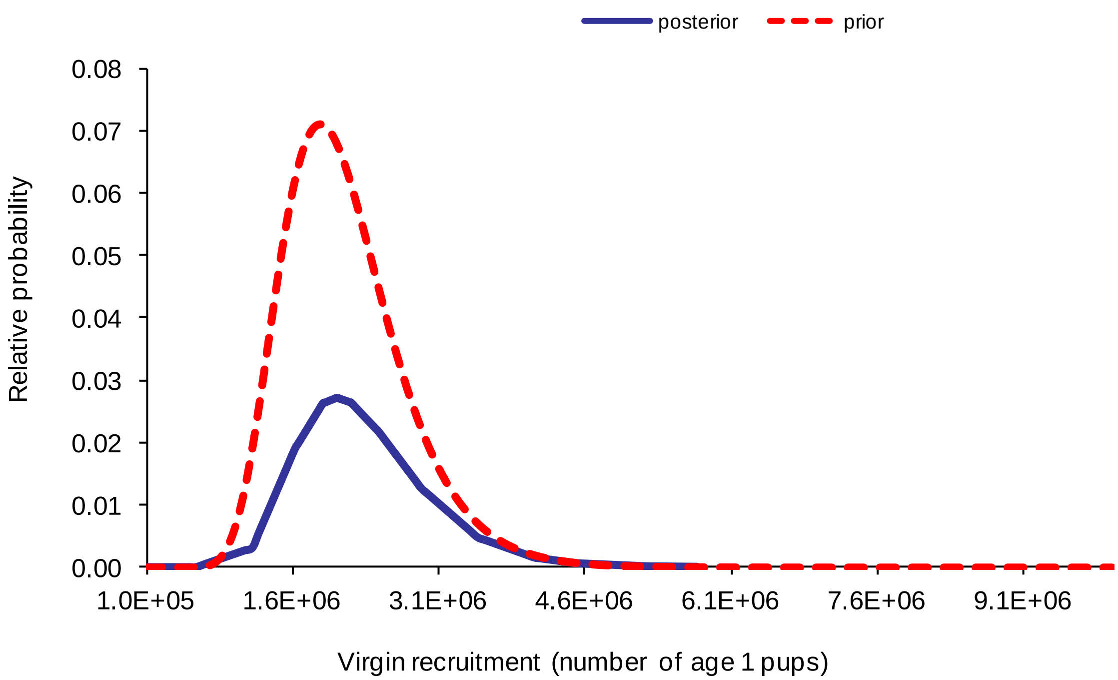


Figure 3.6.24. Profile likelihoods for pup survival and virgin recruitment for sensitivity run 6 (lognormal prior for R_0). Both prior and posterior distributions are shown.

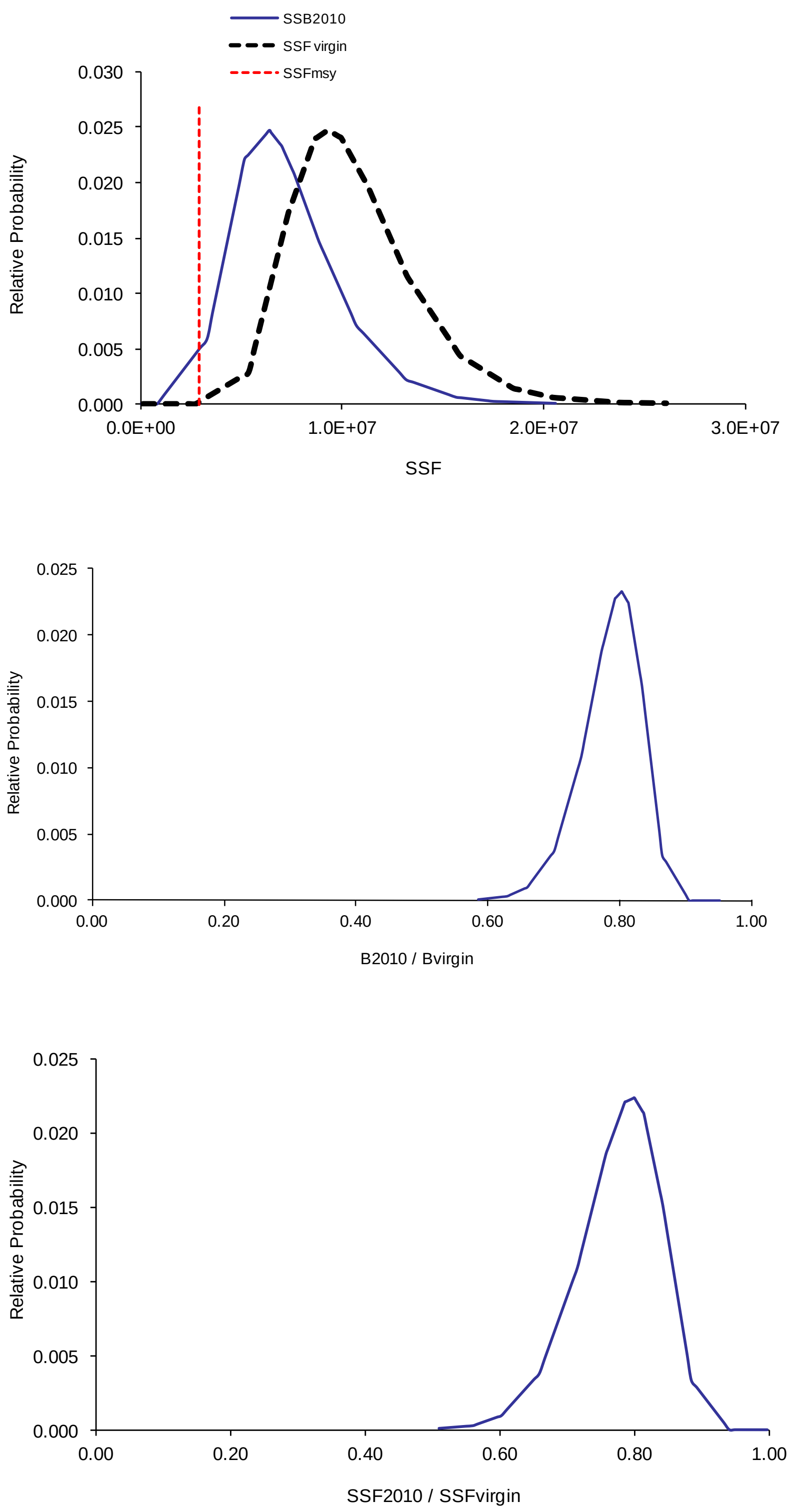
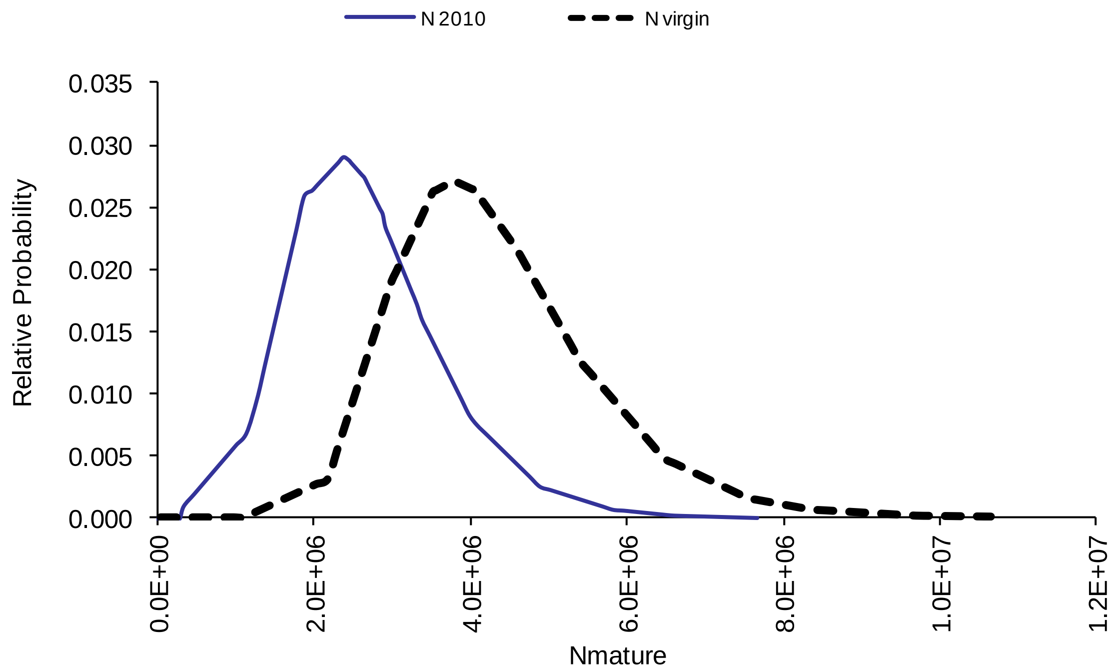


Figure 3.6.25. Profile likelihoods for spawning stock fecundity (SSF) in virgin conditions and in 2010 (top), depletion in biomass (middle), and SSF depletion (bottom) for sensitivity run 6 (lognormal prior for R_0).



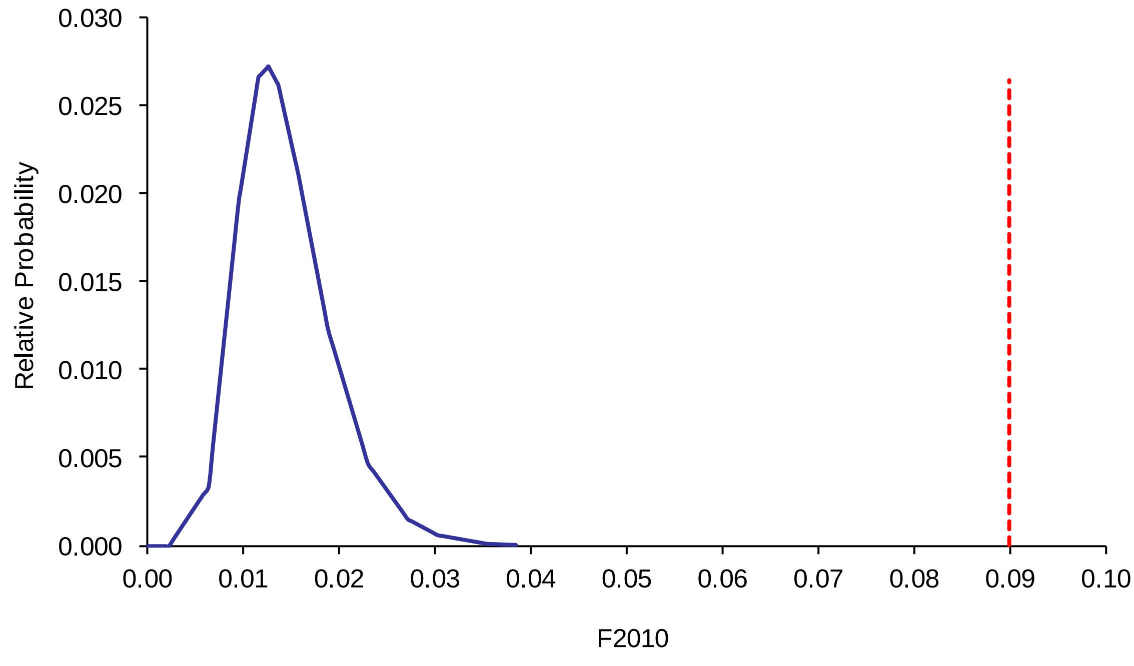


Figure 3.6.26. Profile likelihoods for number of mature individuals in virgin conditions and in 2010 (top) and for fishing mortality in 2010 (bottom) for sensitivity run 6 (lognormal prior for R_0).

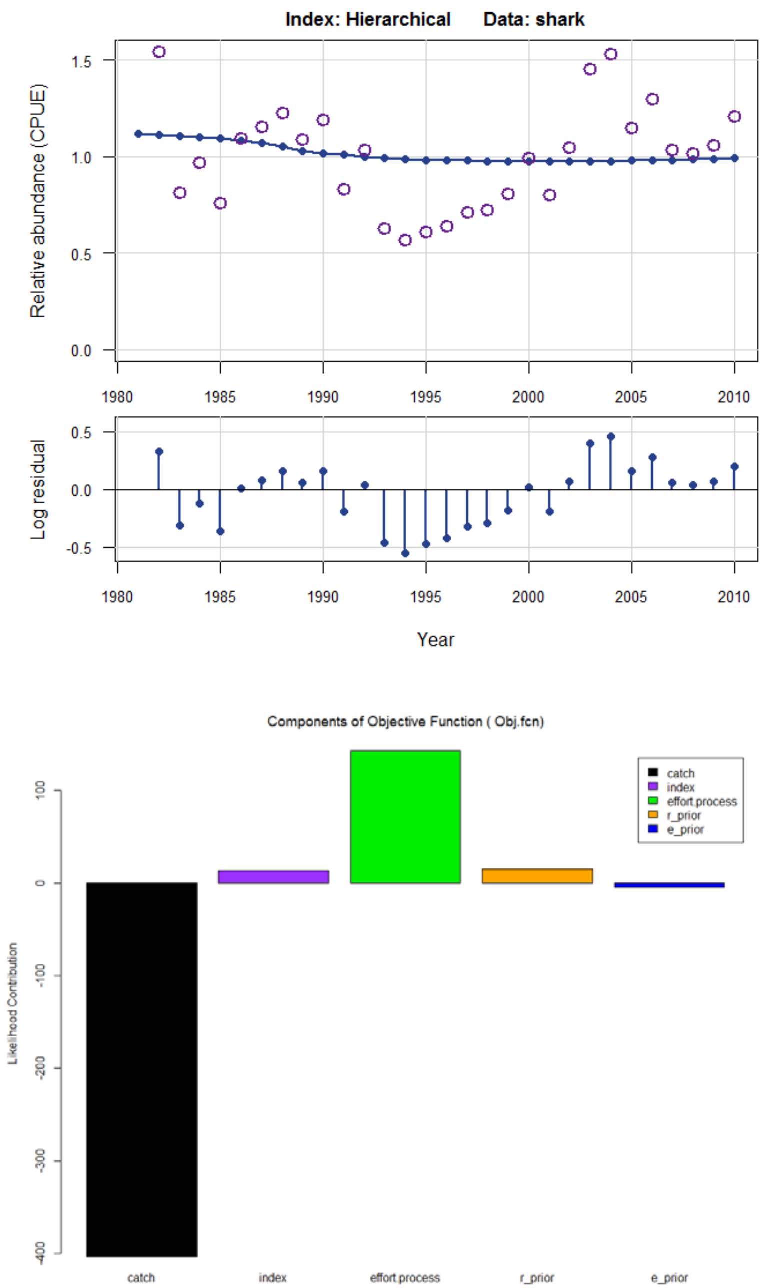
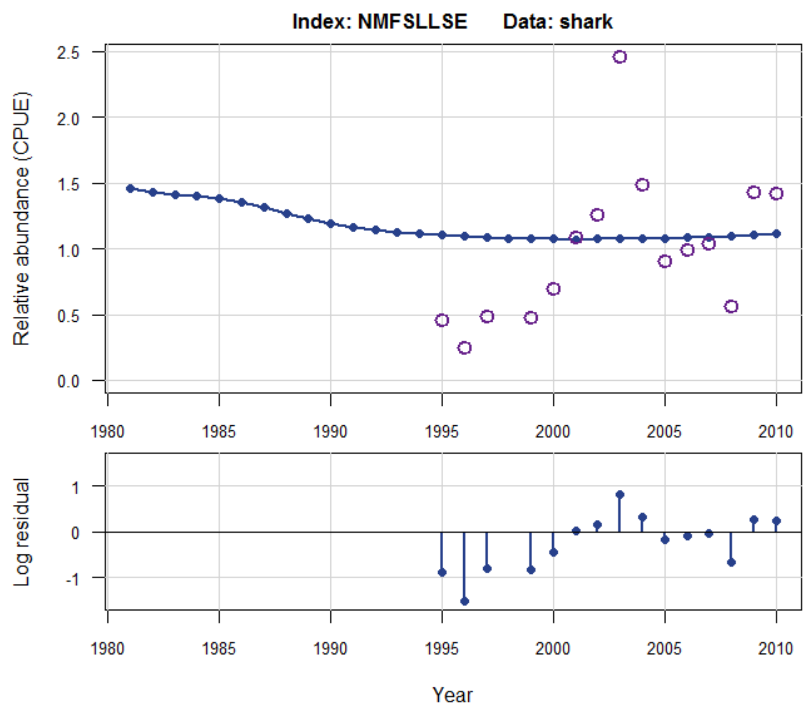


Figure 3.6.27. Predicted fit to the hierarchical index (top) and contribution to the relative likelihood by data source (bottom) for sensitivity run 7.



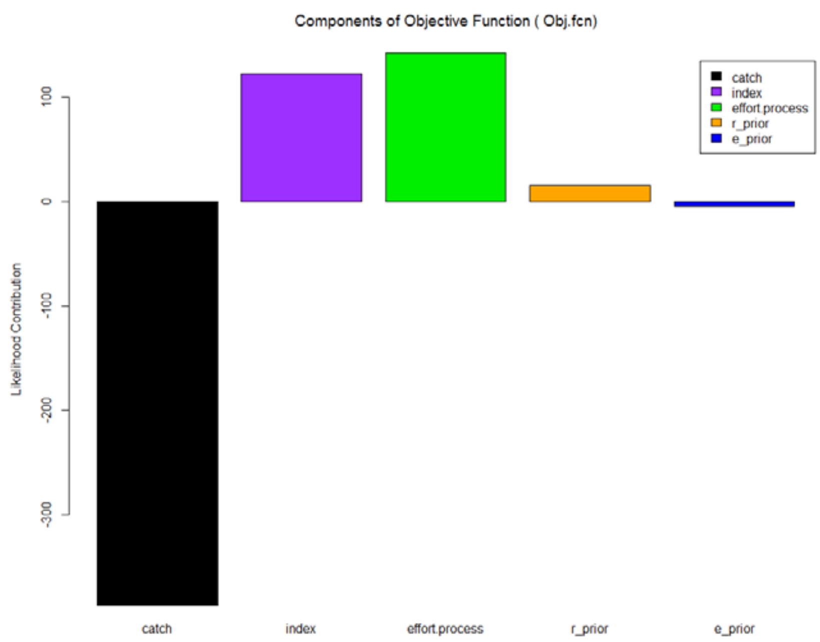


Figure 3.6.28. Predicted fit to the NMFS LL SE index (top) and contribution to the relative likelihood by data source (bottom) for sensitivity run 8.

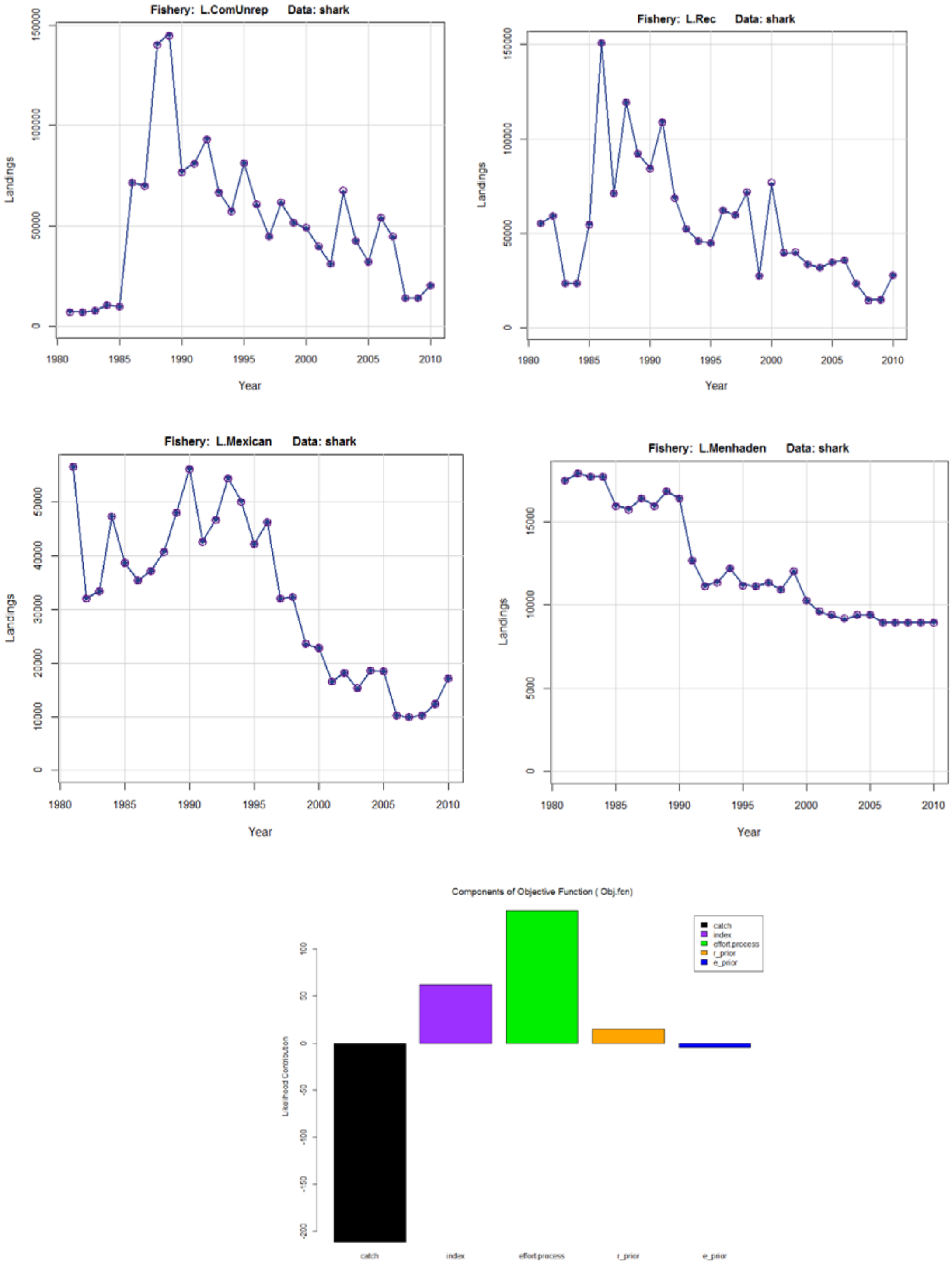


Figure 3.6.29. Predicted fit to catches in the low catch sensitivity run (9) and contribution to the relative likelihood by data source (bottom).

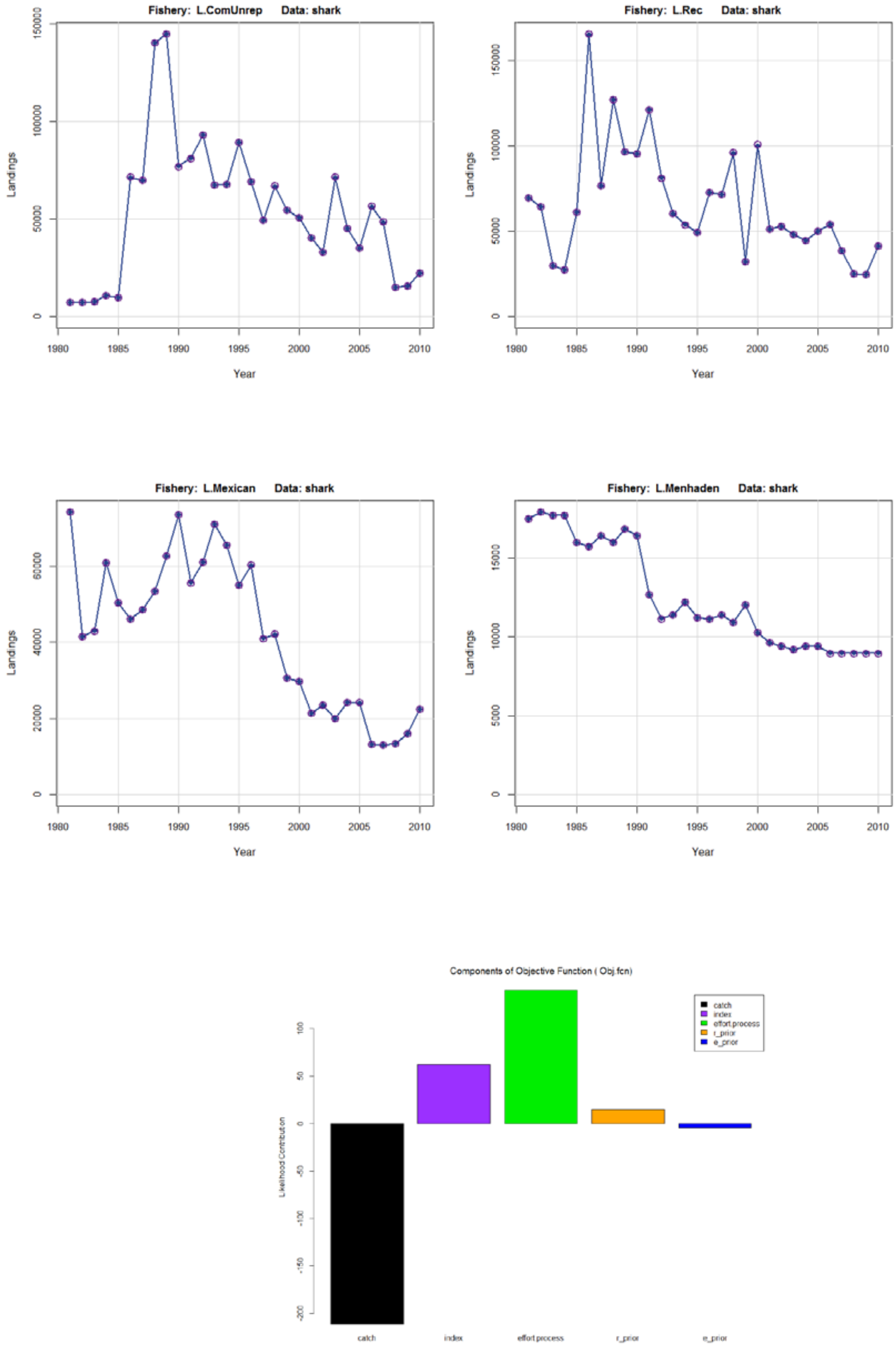


Figure 3.6.30. Predicted fit to catches in the high catch sensitivity run (10) and contribution to the relative likelihood by data source (bottom).

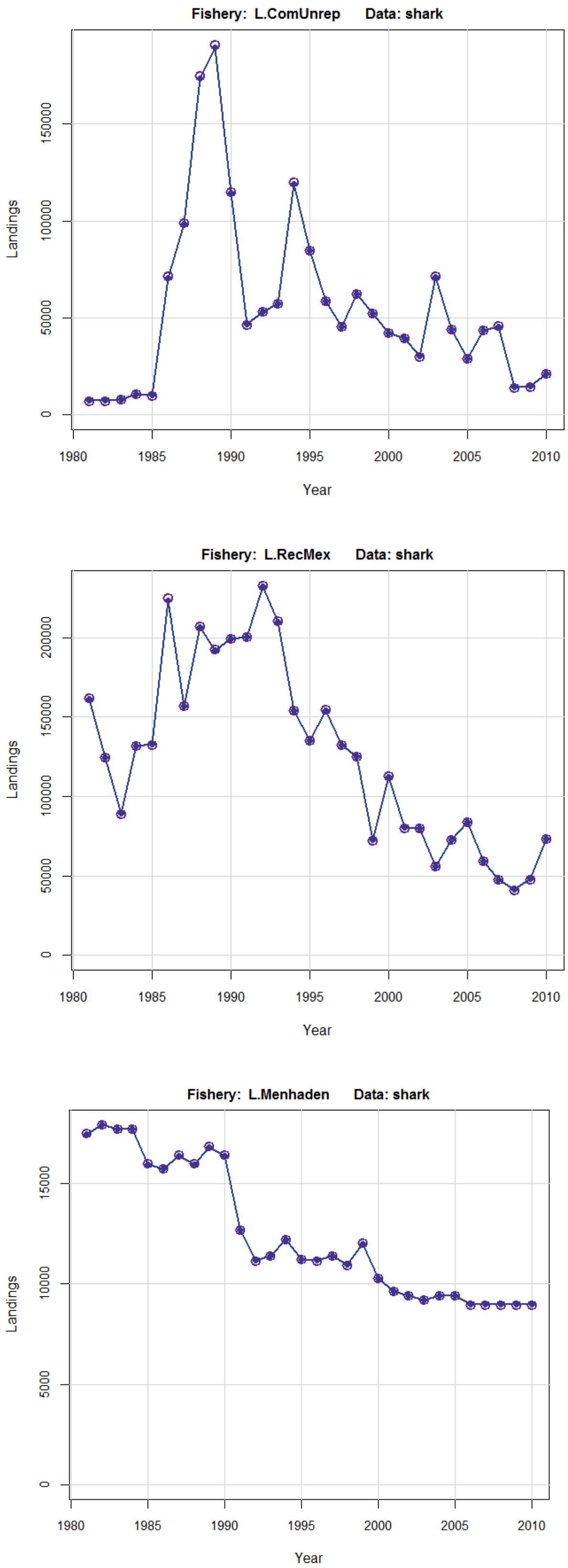


Figure 3.6.31. Predicted fits to catch data in the continuity run.

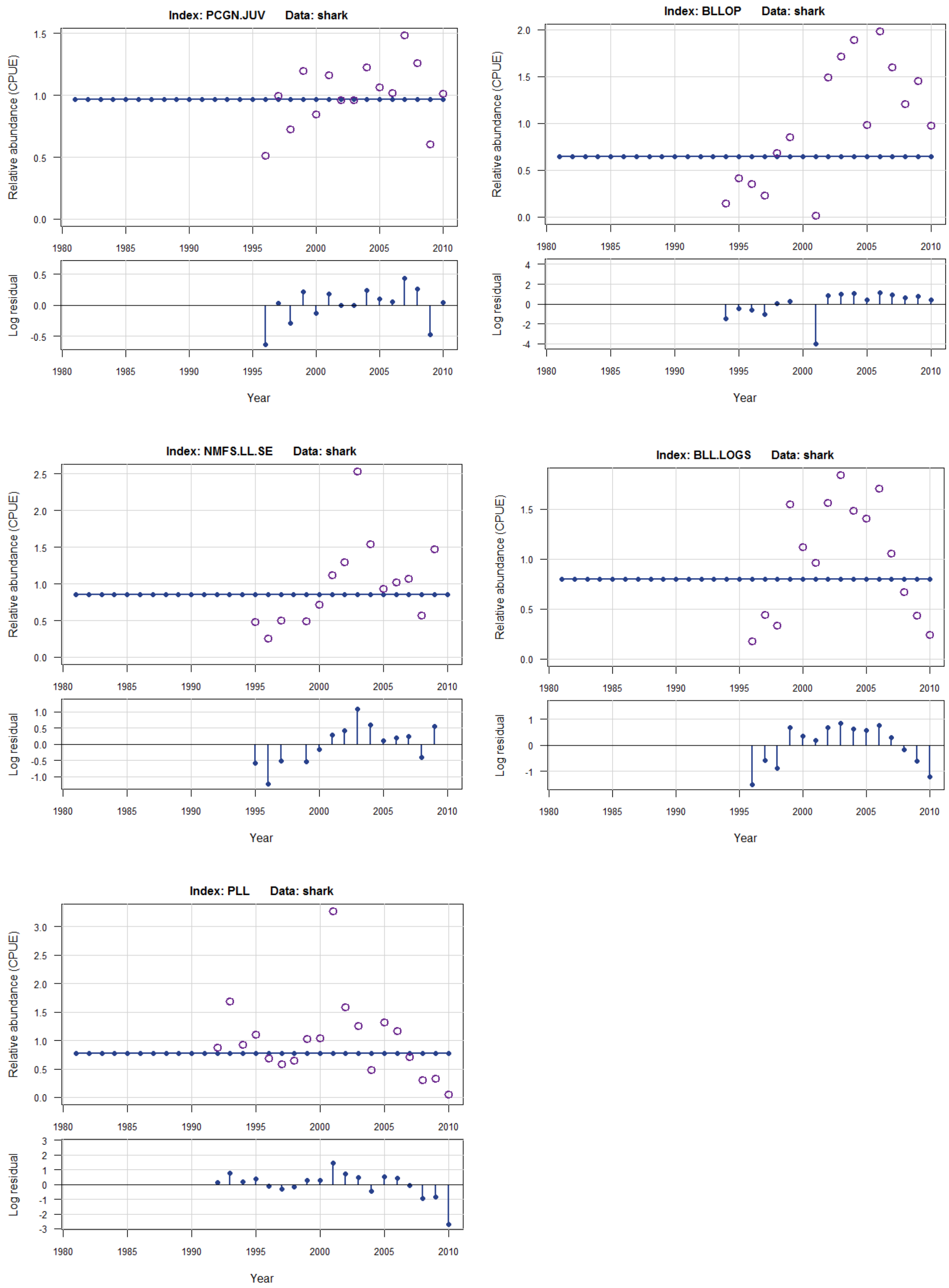


Figure 3.6.32. Predicted fits to indices and residual plots in the continuity run.

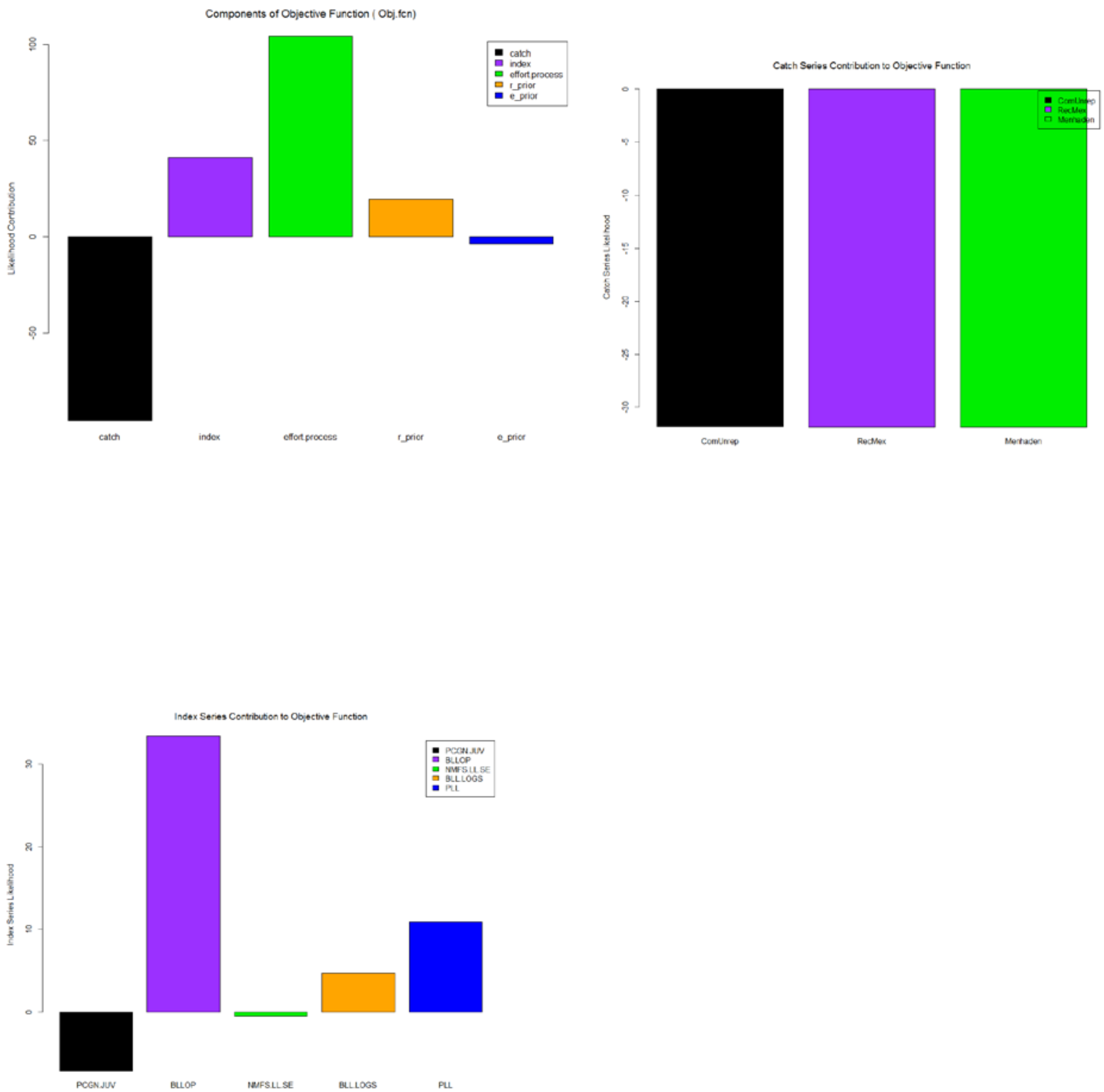


Figure 3.6.33. Contribution to relative likelihood by category in the continuity run: by model source (the recruitment component includes both priors on virgin number of pups and pup survival; top left), catch series (they only differ to the second decimal place and appear to be equal; top right), and index series (bottom).

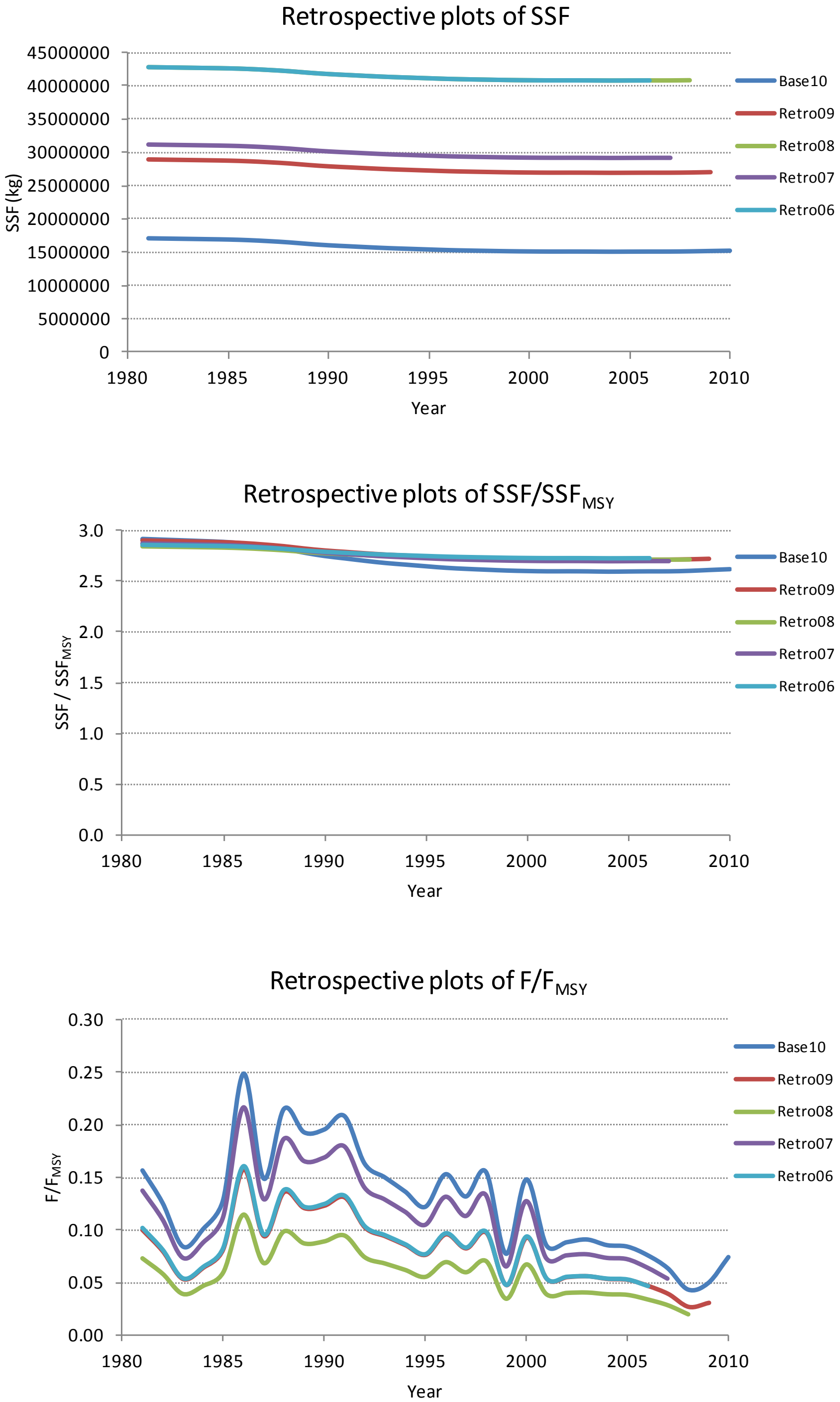


Figure 3.6.34. Retrospective analysis of the baseline run for GOM blacktip shark with last four years of data sequentially removed from the model. Model quantities examined include spawning stock fecundity (top), relative spawning stock fecundity (middle), and relative fishing mortality rate (bottom).

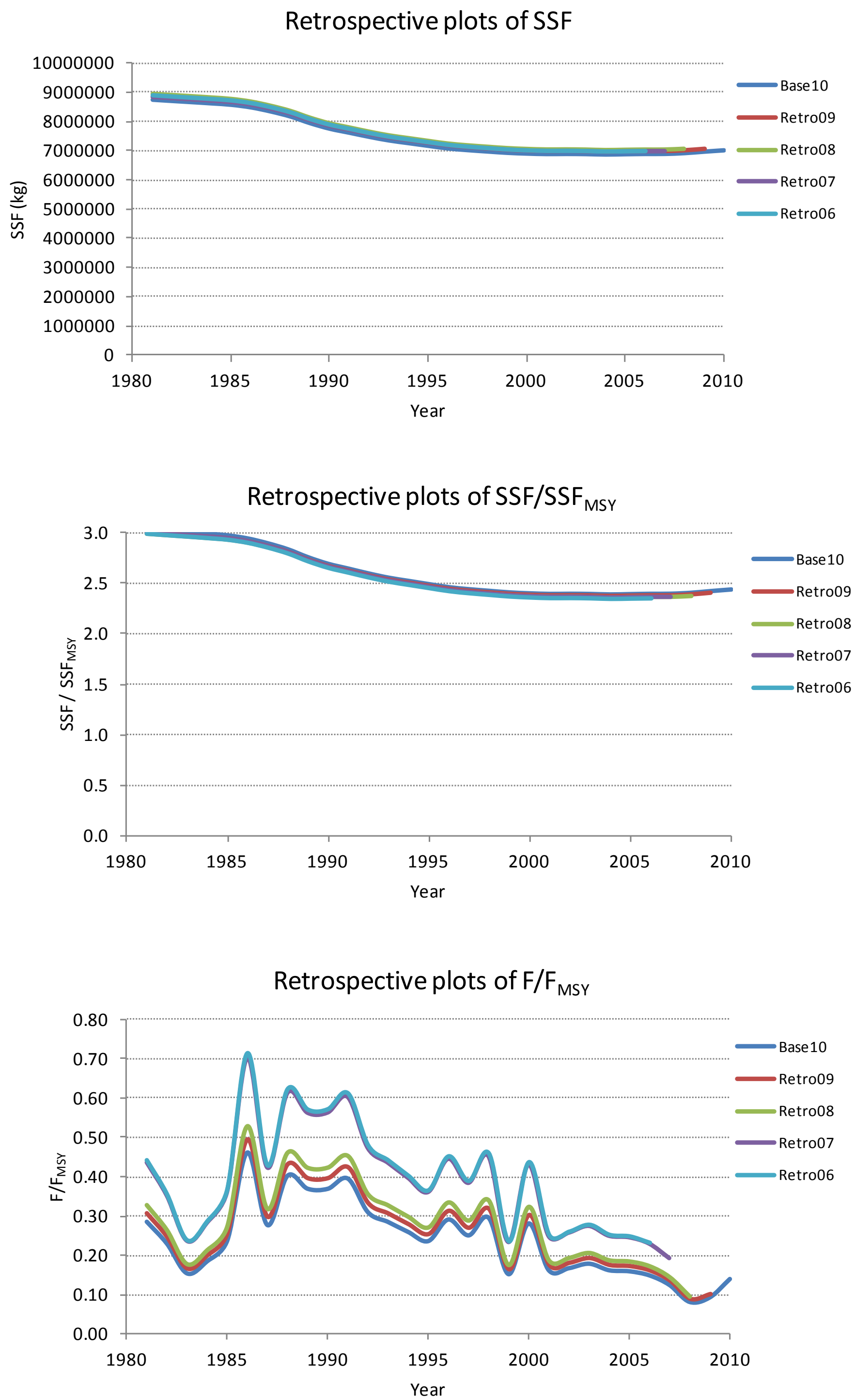


Figure 3.6.35. Retrospective analysis of sensitivity run 6 (lognormal prior for R_0) for GOM blacktip shark with last four years of data sequentially removed from the model. Model quantities examined include spawning stock fecundity (top), relative spawning stock fecundity (middle), and relative fishing mortality rate (bottom).

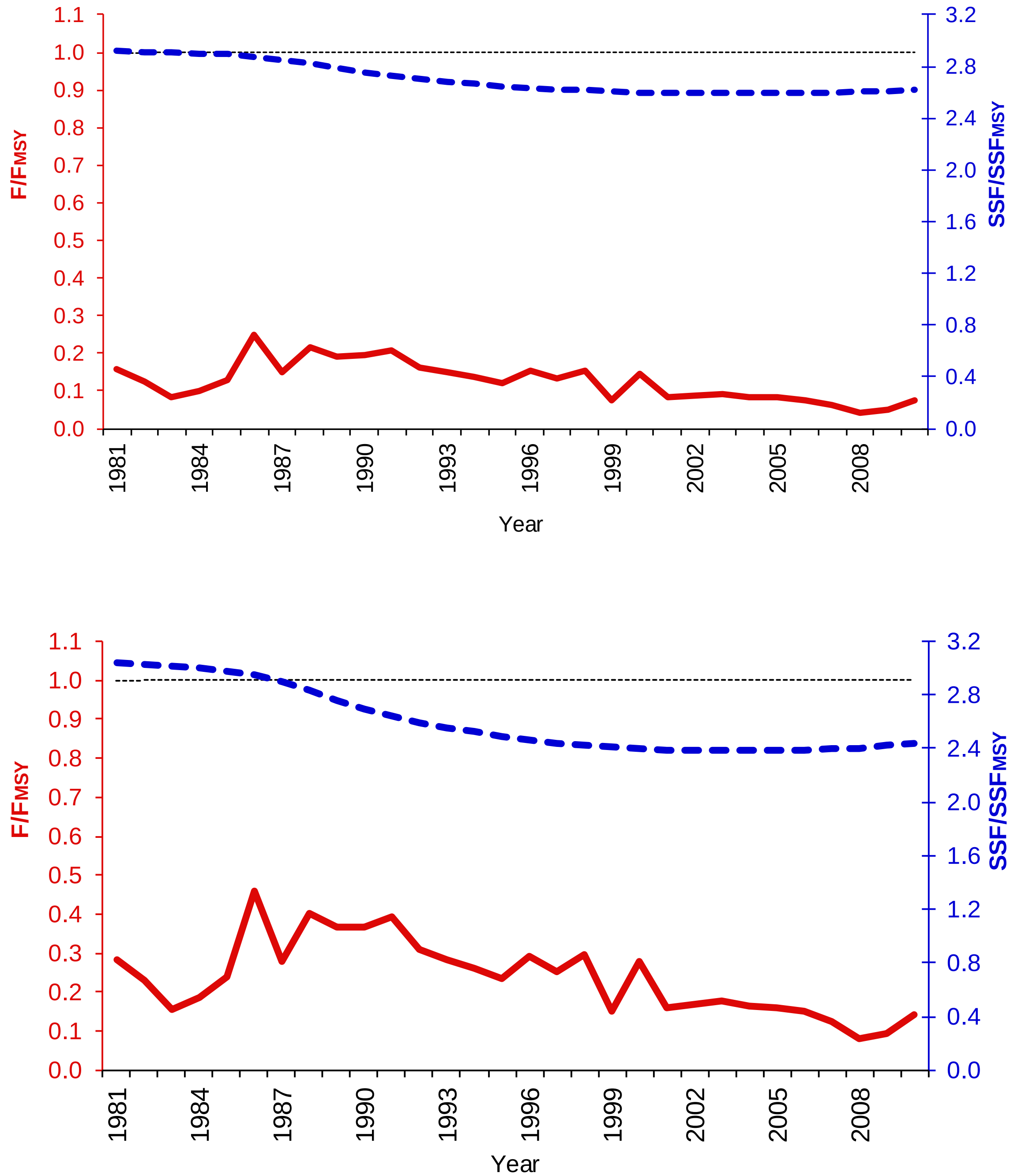


Figure 3.6.36. Estimated relative spawning stock fecundity and fishing mortality rate trajectories for GOM blacktip shark in the base run (top) and sensitivity run 6 (bottom). The dashed line indicates F_{MSY}.

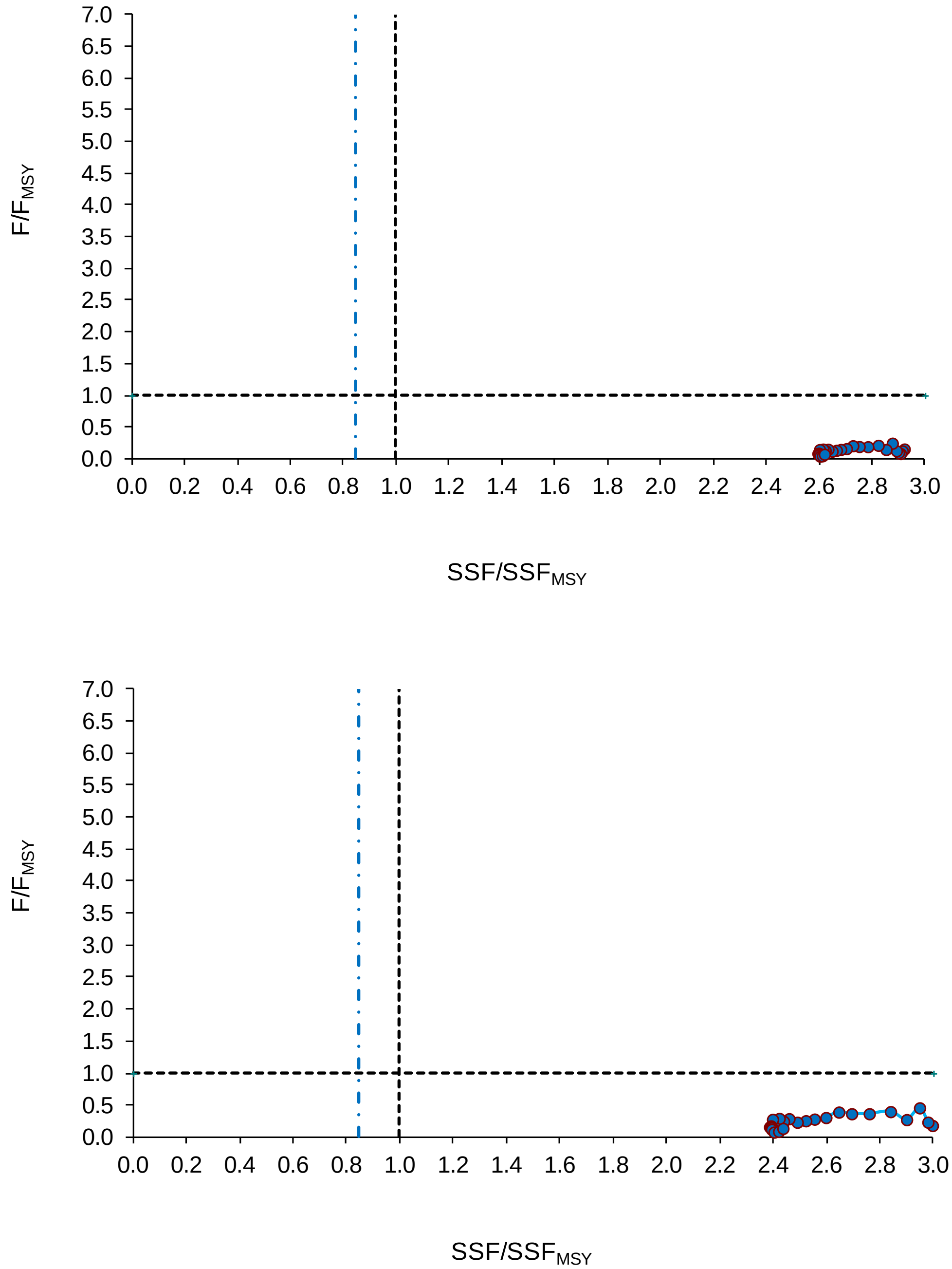


Figure 3.6.37. Phase plot of relative spawning stock fecundity and fishing mortality rate by year for the base run (top) and sensitivity run 6 (bottom). The diamond (2.62, 0.07; not visible; top; and 2.44, 0.14; not visible; bottom) indicates current (for 2010) conditions. The dashed vertical blue line indicates MSST ($(1\text{-}M)*B_{MSY}$).

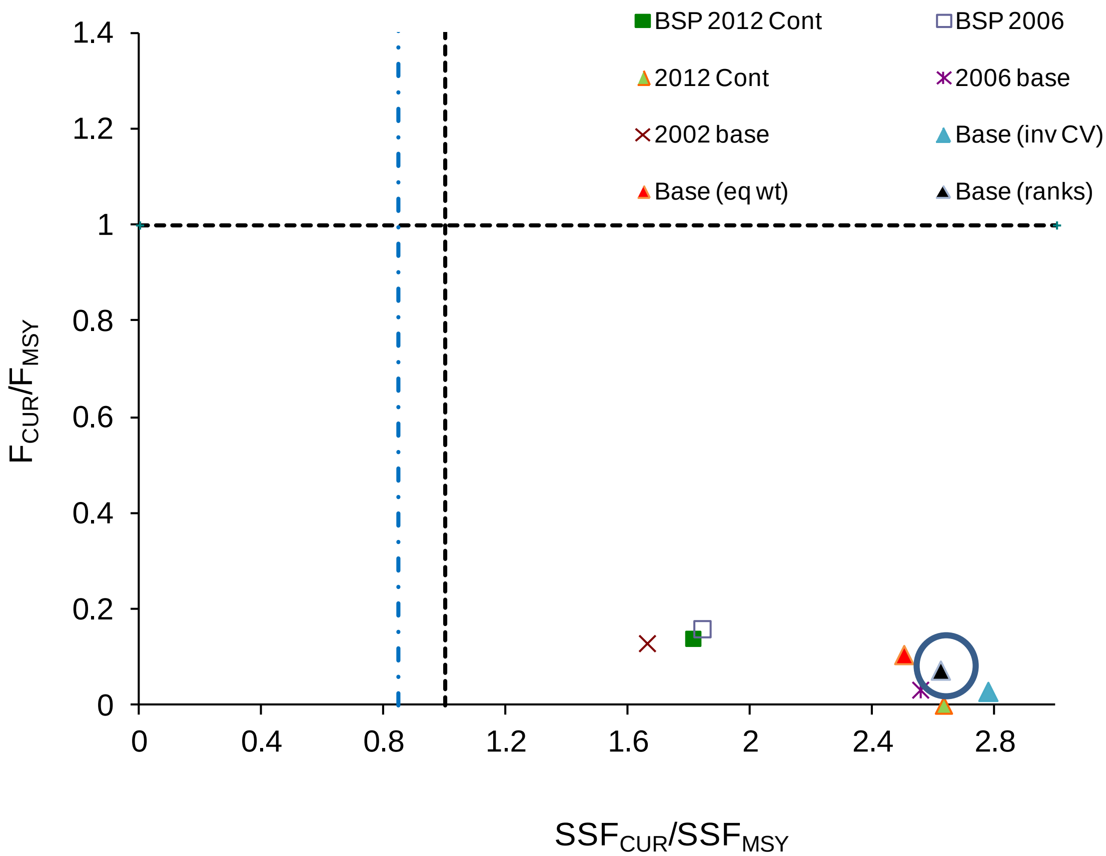


Figure 3.6.38. Phase plot of GOM blacktip shark stock status. Results are shown for the base model (base) with rank weighting (ranks), inverse CV weighting (inv CV), and equal weighting (eq wt), continuity analysis (2012 Cont), 2006 and 2002 assessment base models (2006 base, 2002 base), and Bayesian Surplus Production (BSP) 2006 base model (BSP 2006) and continuity analysis (BSP 2012 Cont). The circle indicates the position of the preferred option for the base run (rank weighting). The vertical dashed line denotes MSST ((1-M)*B_{MSY}), where M is the mean of age1+ values. None of the runs estimated an overfished stock (to the left of the MSST line) or that overfishing was occurring (above the horizontal black line).

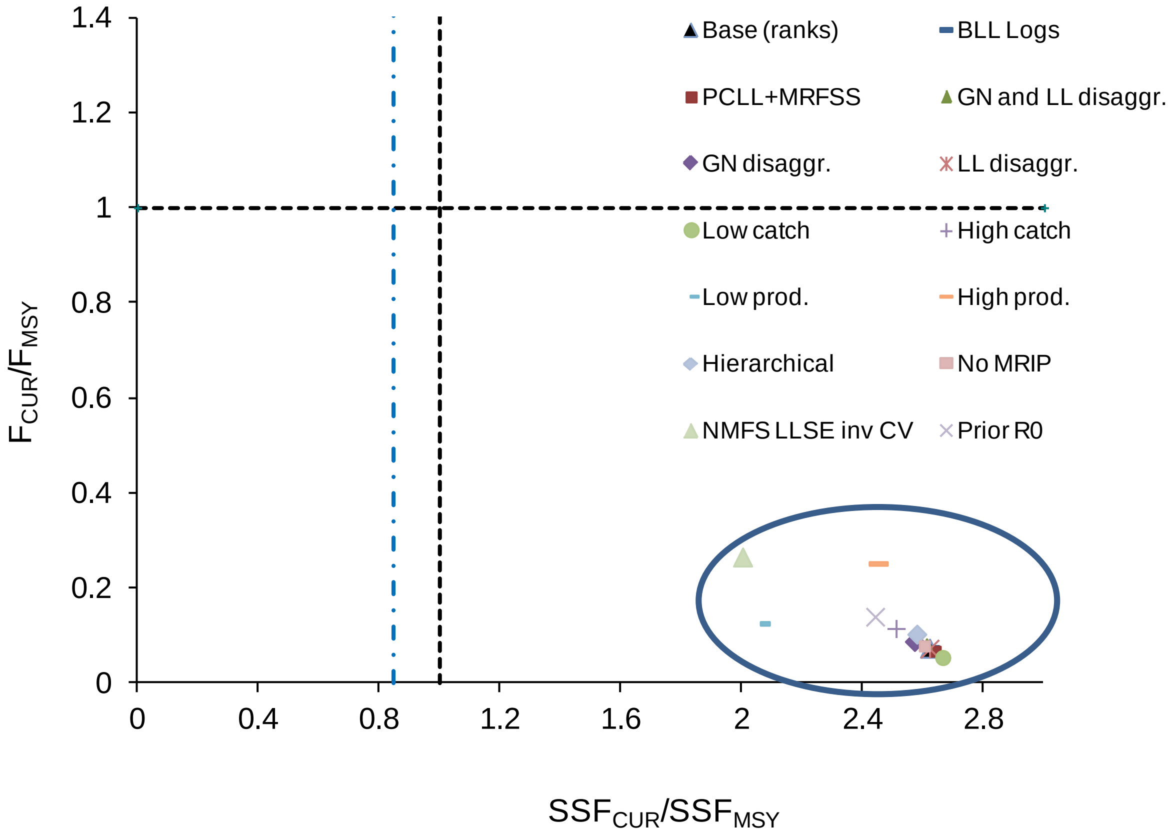


Figure 3.6.39. Phase plot of GOM blacktip shark stock status. Results are shown for the base model (base ranks) and the 13 sensitivity scenarios: S1 (using BLL Logs index instead of BLLOP; BLL Logs), S2 (adding PCLL+MRFSS indices; PCLL+MRFSS), S3 (disaggregating gillnet and longline indices; GN and LL disaggr.), S4 (disaggregating gillnet indices; GN disaggr.), S5 (disaggregating longline indices; LL disaggr.), S6 (using a lognormal prior for R_0; Prior R_0), S7 (using the hierarchical index; Hierarchical), S8 (using the NMFS LLSE index only with inverse CV weighting; NMFS LLSE inv CV), S9 (low catch scenario; Low catch), S10 (high catch scenario; High catch), S11 (low productivity scenario; Low prod.), S12 (high productivity scenario; High prod.), and S13 (Replacing MRIP with MRFSS for 2004-2010; No MRIP). The vertical dashed line denotes MSST ((1-M)*B_{MSY}), where M is the mean of age1+ values. None of the runs estimated an overfished stock (to the left of the MSST line) or that overfishing was occurring (above the horizontal black line). Most scenarios showed little deviation with respect to the base run.

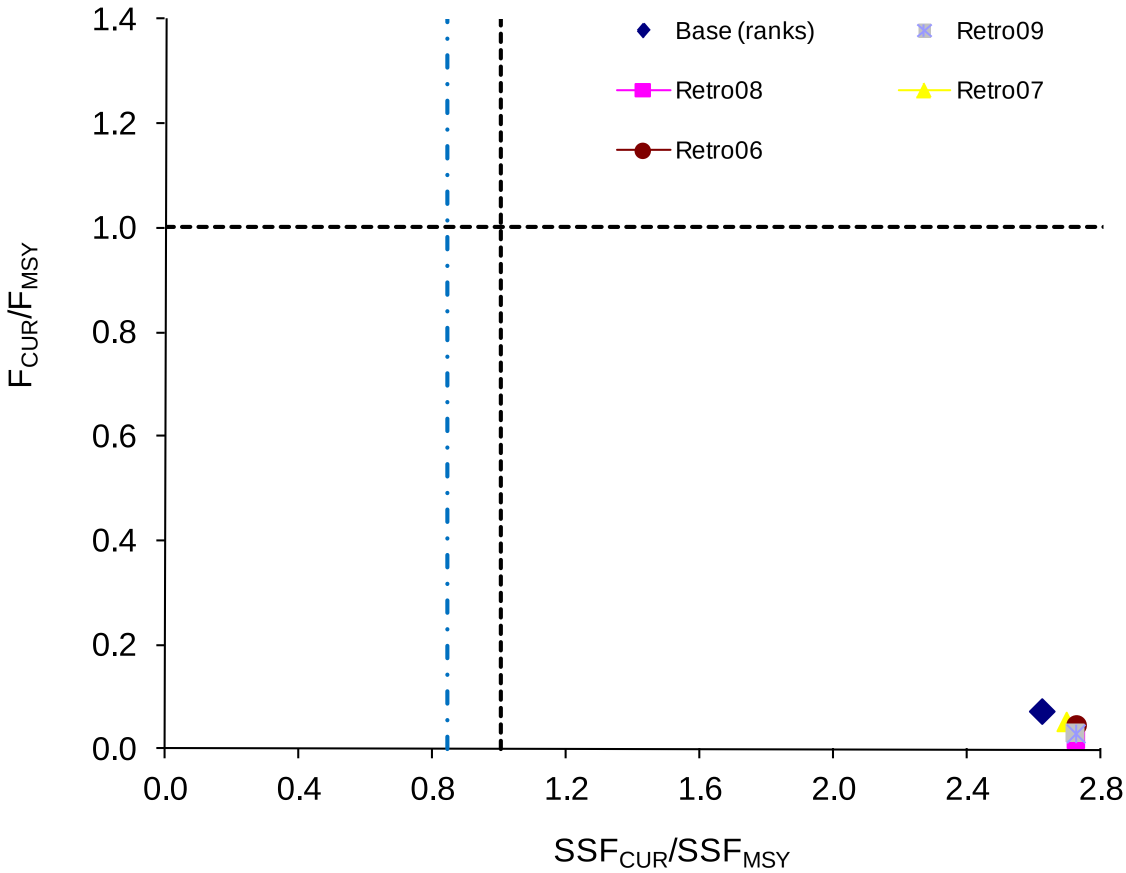


Figure 3.6.40. Phase plot of GOM blacktip shark stock status for the base run (base ranks) and retrospective analysis of that run (sequentially dropping one year from the model: retro09, retro08, retro07, and retro06). The vertical dashed line denotes MSST ($(1\text{-}M)^*B_{MSY}$), where M is the mean of age1+ values. None of the runs estimated an overfished stock (to the left of the MSST line) or that overfishing was occurring (above the horizontal black line). All retrospective runs were clustered in close proximity to the base run.

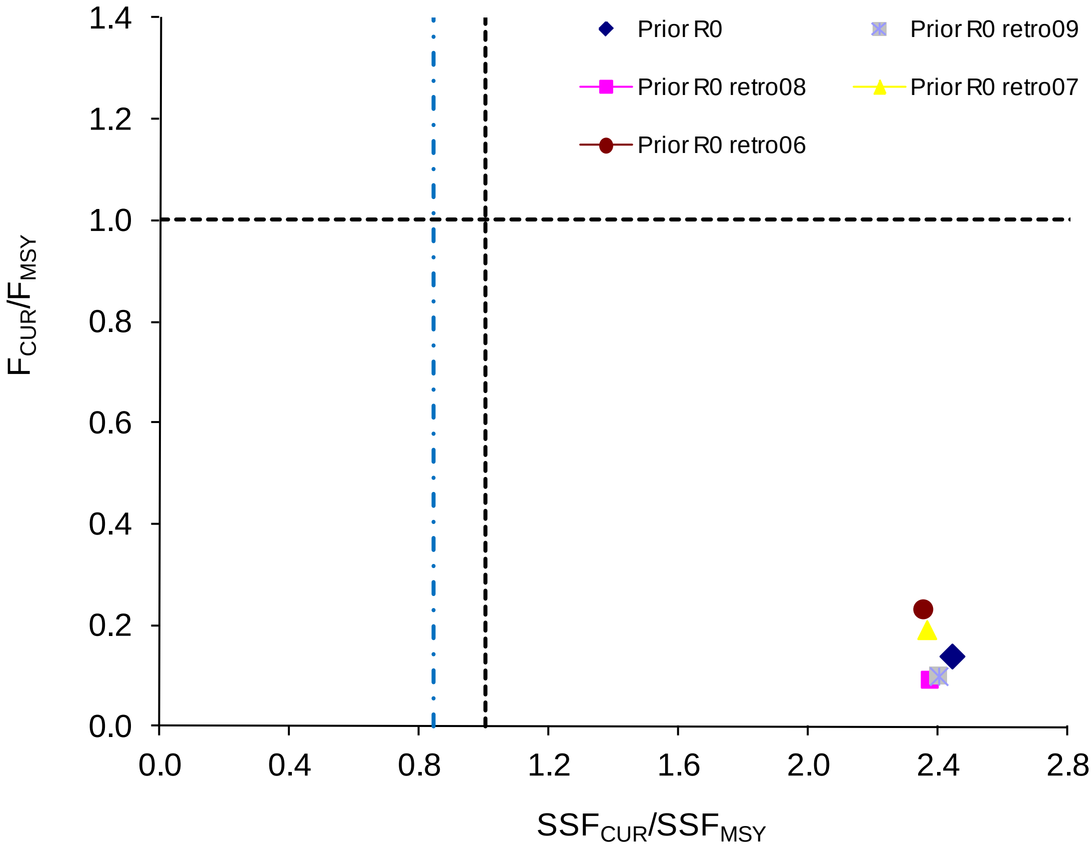


Figure 3.6.41. Phase plot of GOM blacktip shark stock status for sensitivity run 6 (lognormal prior for R_0) and retrospective analysis of that run (sequentially dropping one year from the model: Prior R_0 retro09, Prior R_0 retro08, Prior R_0 retro07, and Prior R_0 retro06). The vertical dashed line denotes MSST ($(1\text{-}M)*B_{MSY}$), where M is the mean of age1+ values. None of the runs estimated an overfished stock (to the left of the MSST line) or that overfishing was occurring (above the horizontal black line). All retrospective runs were very close to sensitivity run 6.

3.7 APPENDICES

Appendix 1. Computation of an age-length key and subsequent transformation of lengths into ages for length sample of interest (implemented in MS Excel)

1. From the original age and growth study (SEDAR29-WP-18), determine the number of sharks at each age within a series of arbitrary length-classes (10 cm for GOM blacktip shark) to cover the full range of lengths of sharks aged

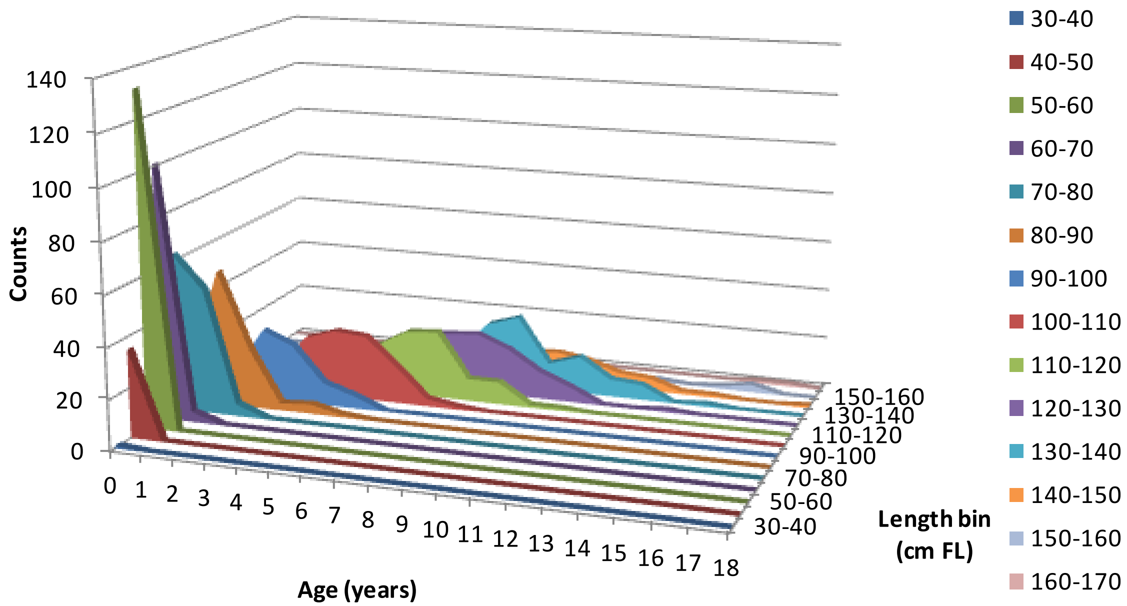
2. Express those numbers as proportions

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. Add up across the length classes the number of sharks of each age.

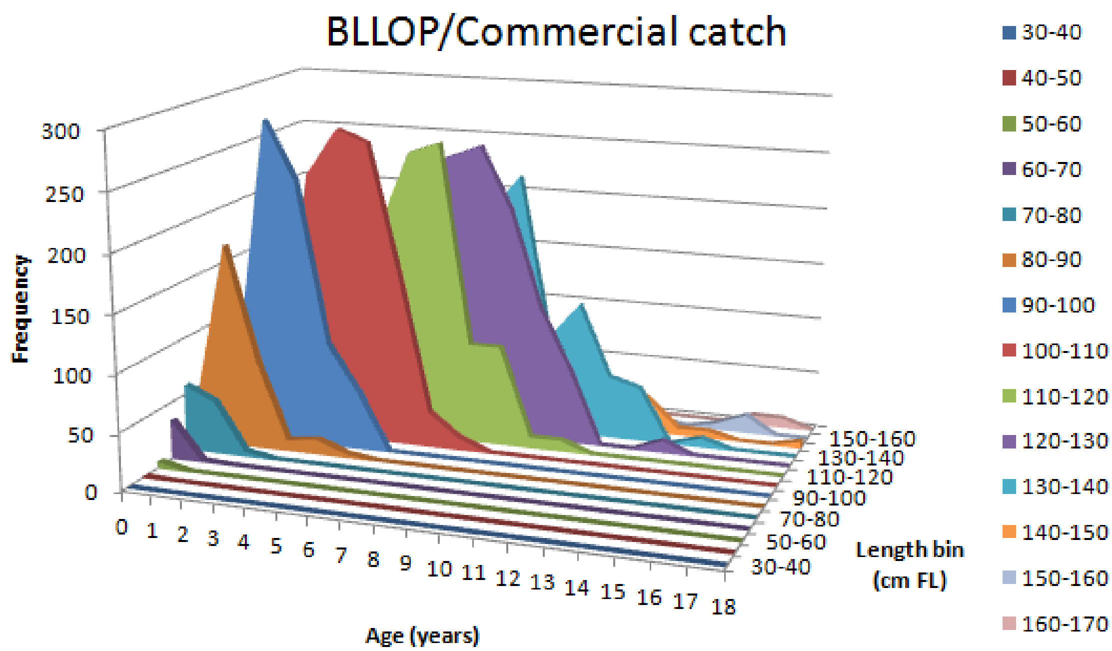
Following is a table of the age-length key, showing the number of sharks at each age within each length class (step 1 above) and a graph of the same data.

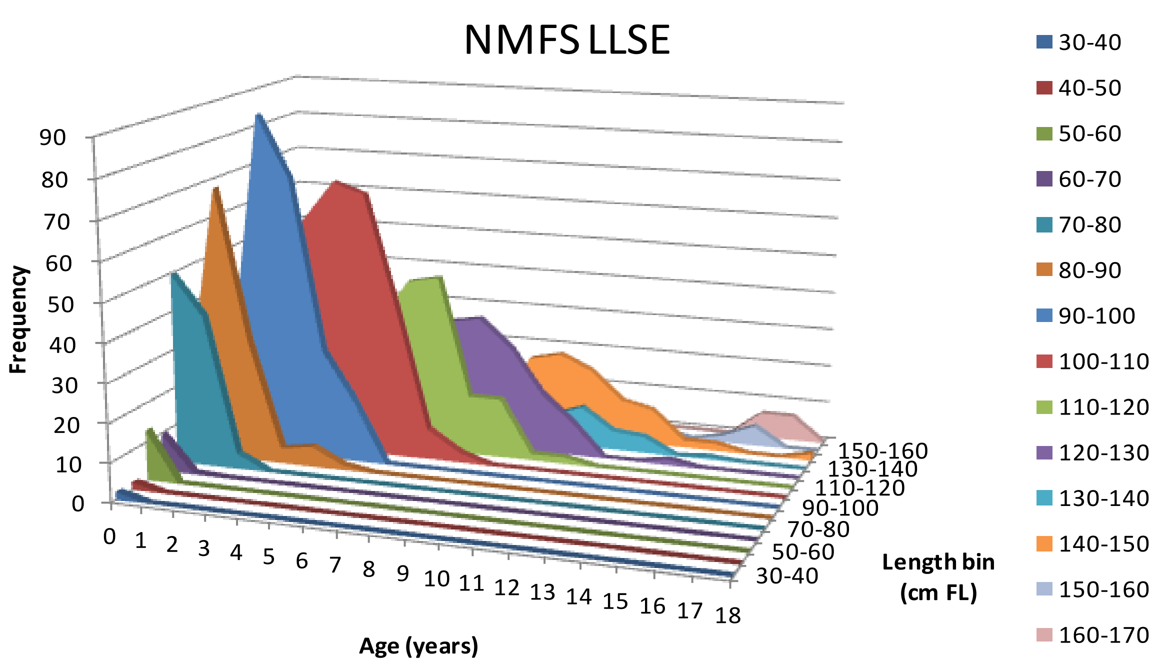
aged sample	Age (years)																		
FL (cm)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
30-40	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40-50	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50-60	132	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60-70	101	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
70-80	63	50	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80-90	14	54	24	3	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0
90-100	0	8	28	23	9	5	0	0	0	0	0	0	0	0	0	0	0	0	0
100-110	0	2	8	23	27	26	15	3	1	0	0	0	0	0	0	0	0	0	0
110-120	0	0	2	5	16	19	26	27	9	9	1	1	0	0	0	0	0	0	0
120-130	0	0	0	2	5	18	22	23	24	19	11	6	0	0	1	0	0	0	0
130-140	0	0	0	1	2	3	12	13	25	29	11	15	7	6	0	1	0	0	0
140-150	0	0	0	0	0	0	2	2	3	11	12	10	6	5	1	1	0	0	1
150-160	0	0	0	0	0	0	0	0	1	3	2	2	1	1	0	1	3	0	0
160-170	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0

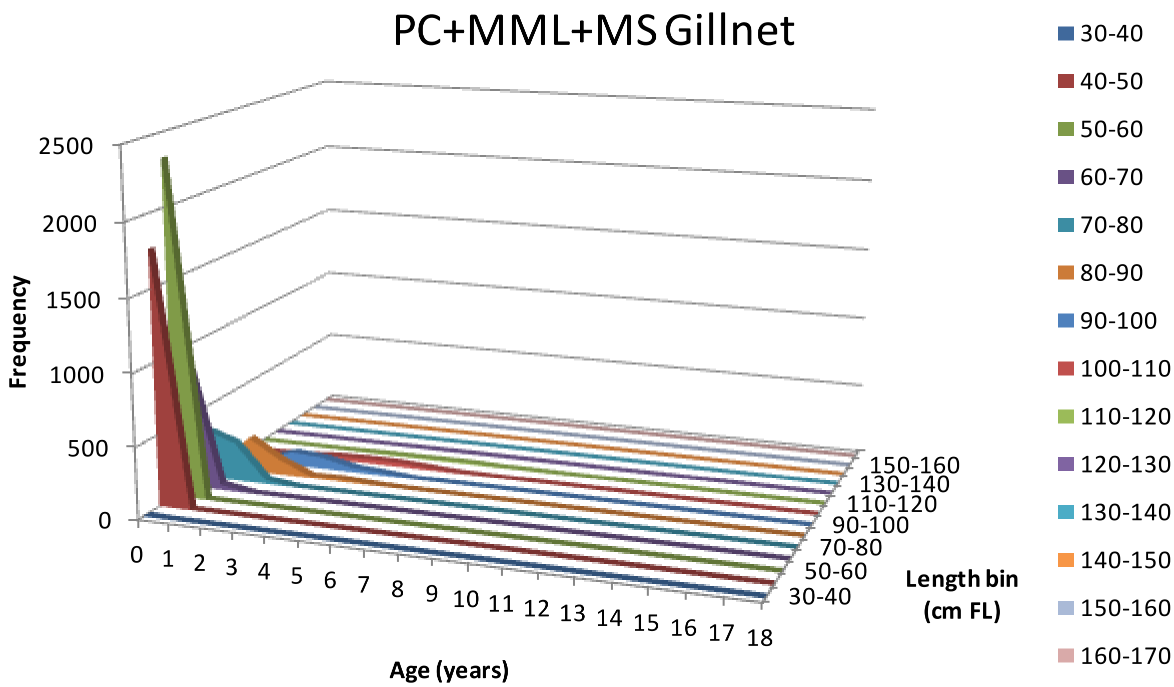


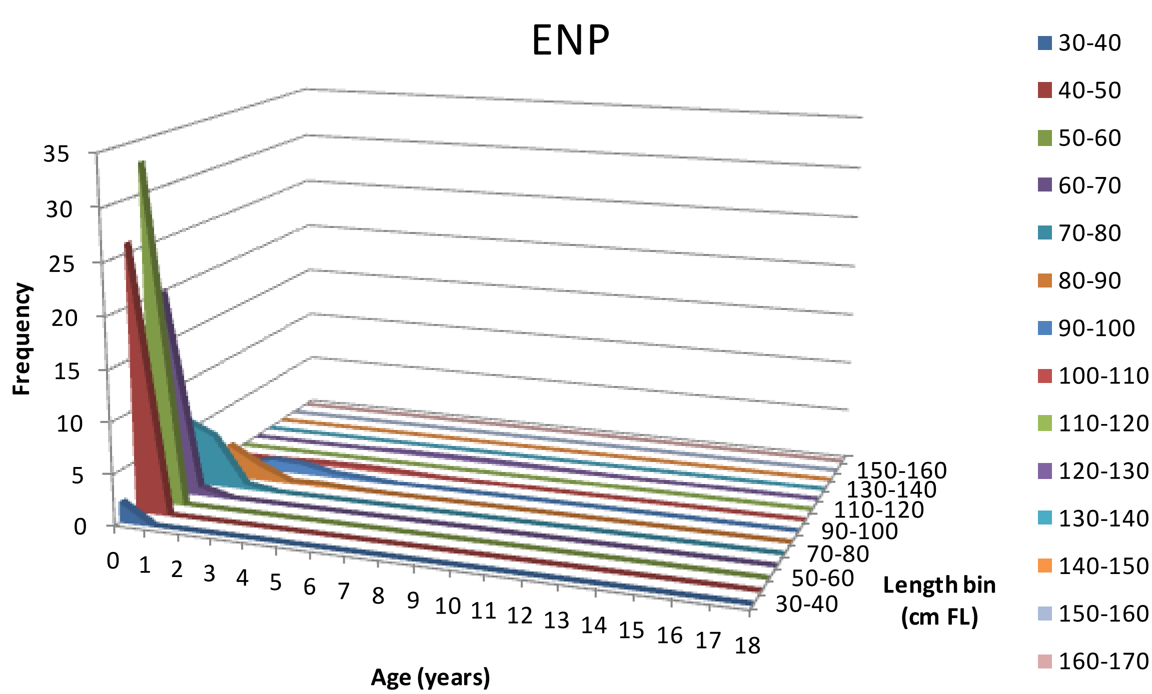
The next set of graphs shows the age-frequency distributions obtained by applying the age-length key to length data corresponding to the six relative abundance indices in the baseline run and all other indices used in sensitivity analyses. Selectivity functions were later fitted to these age-frequency data (catch series assigned the same selectivity are also indicated in the title).

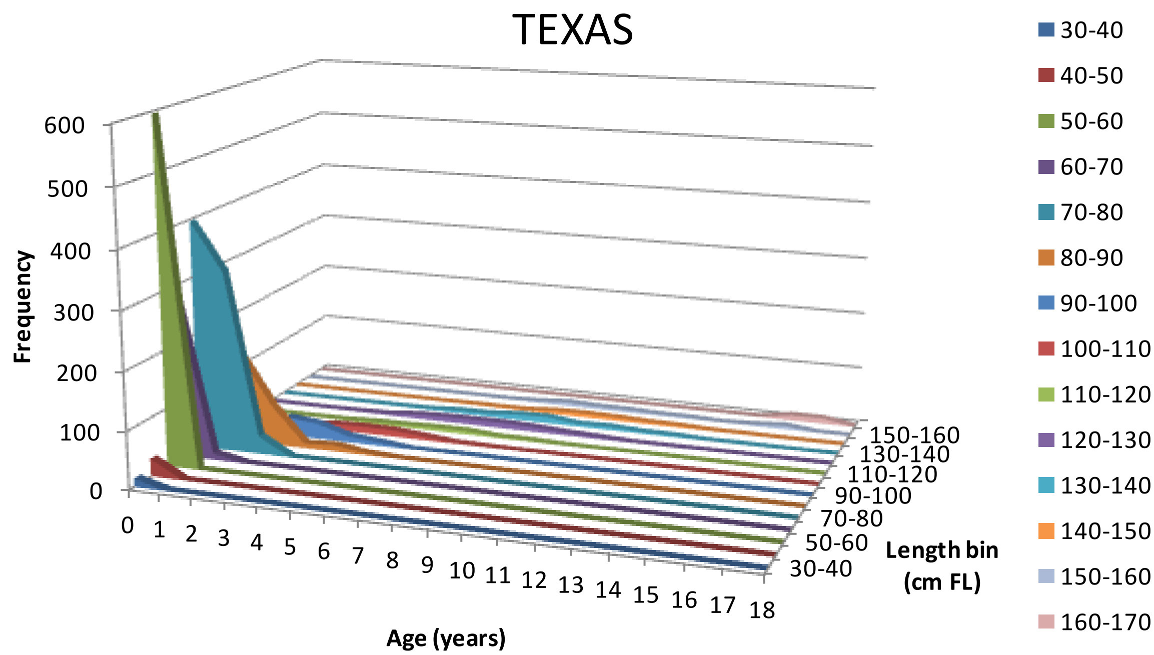
BASELINE INDICES

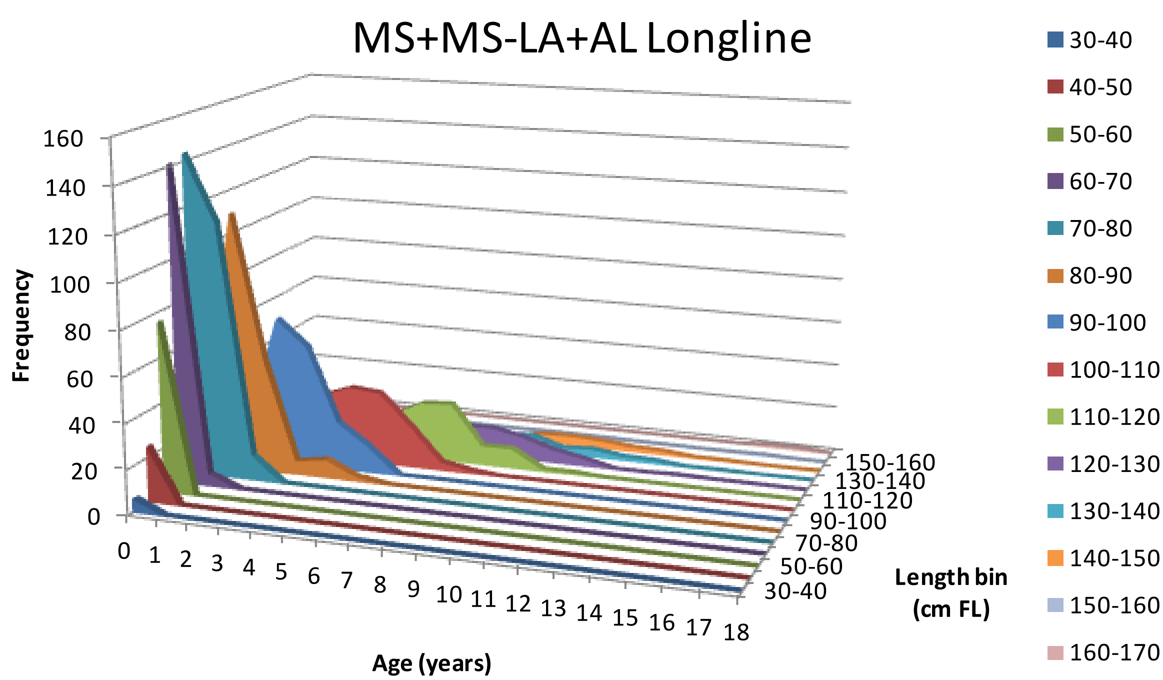




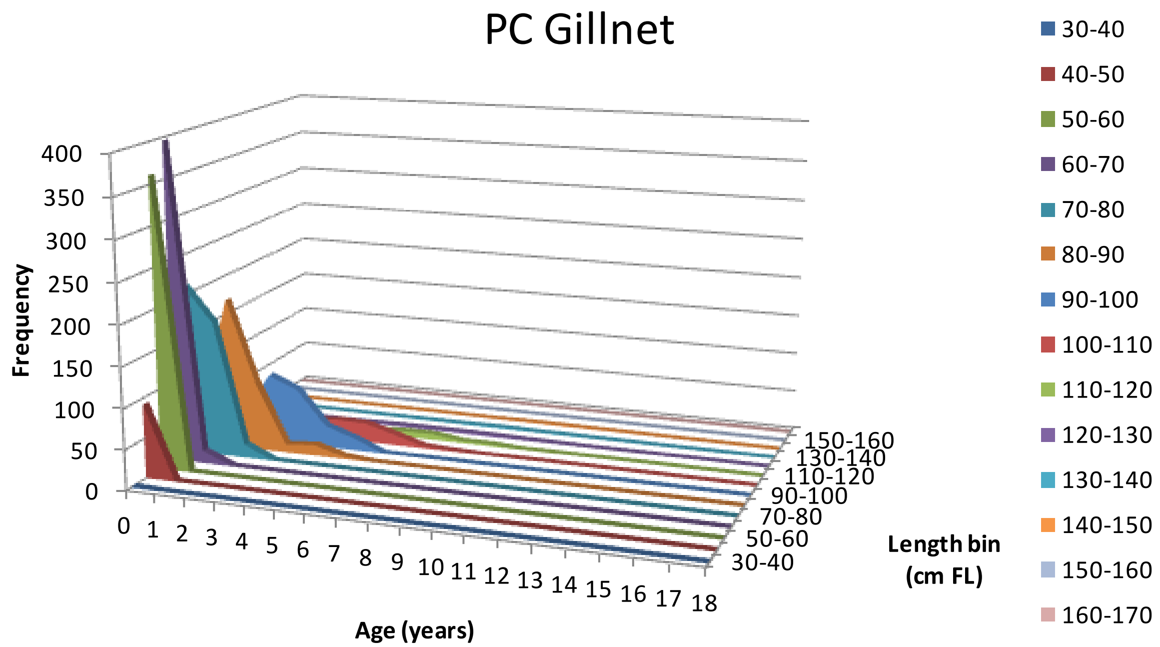

PC+MML+MS Gillnet
Frequency
2500
2000
1500
1000
500
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Age (years)
150-160
130-140
110-120
90-100
70-80
50-60
30-40
Length bin (cm FL)
30-40
40-50
50-60
60-70
70-80
80-90
90-100
100-110
110-120
120-130
130-140
140-150
150-160
160-170

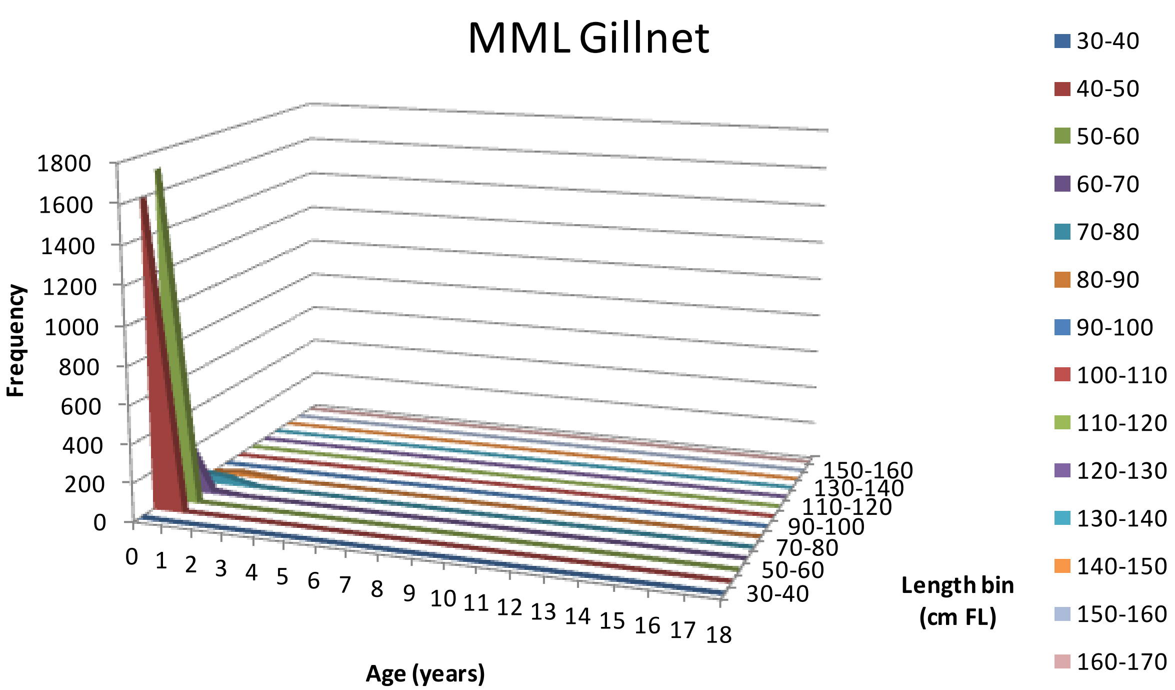

ENP
Frequency
35
30
25
20
15
10
5
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Age (years)
150-160
130-140
110-120
90-100
70-80
50-60
30-40
Length bin (cm FL)
30-40
40-50
50-60
60-70
70-80
80-90
90-100
100-110
110-120
120-130
130-140
140-150
150-160
160-170


TEXAS
Frequency
0
100
200
300
400
500
600
Age (years)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Length bin (cm FL)
30-40
50-60
70-80
90-100
110-120
130-140
150-160
30-40
40-50
50-60
60-70
70-80
80-90
90-100
100-110
110-120
120-130
130-140
140-150
150-160
160-170

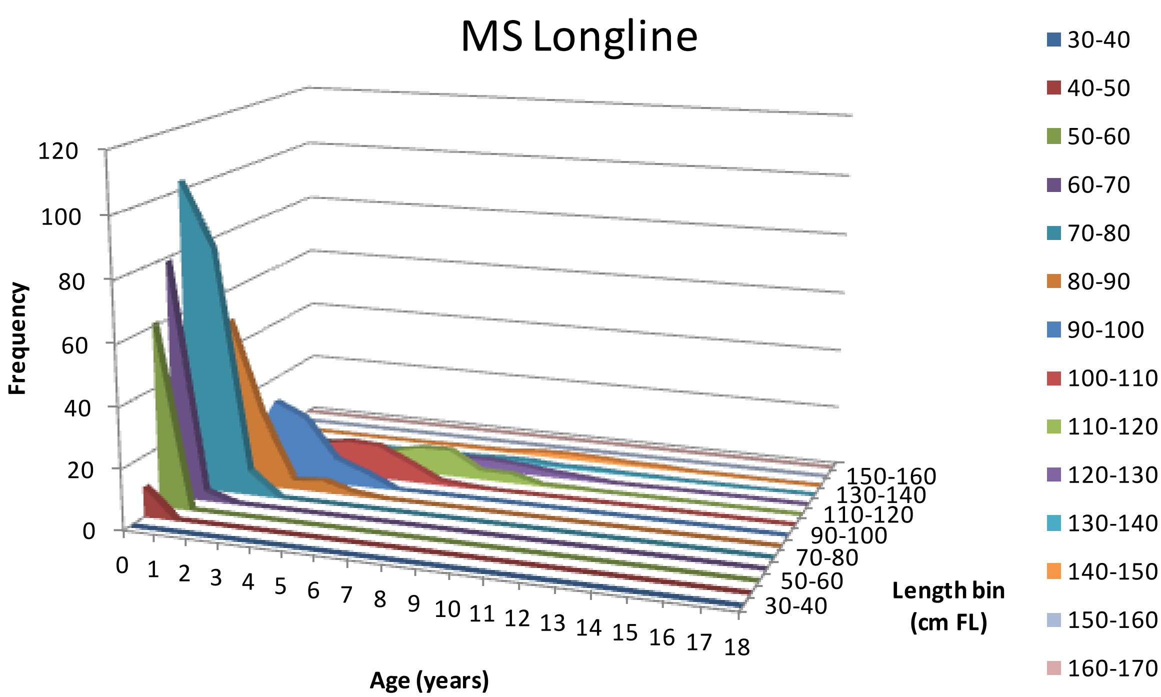

MS+MS-LA+AL Longline
Frequency
0
20
40
60
80
100
120
140
160
Age (years)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Length bin (cm FL)
30-40
50-60
70-80
90-100
110-120
130-140
150-160
30-40
40-50
50-60
60-70
70-80
80-90
90-100
100-110
110-120
120-130
130-140
140-150
150-160
160-170

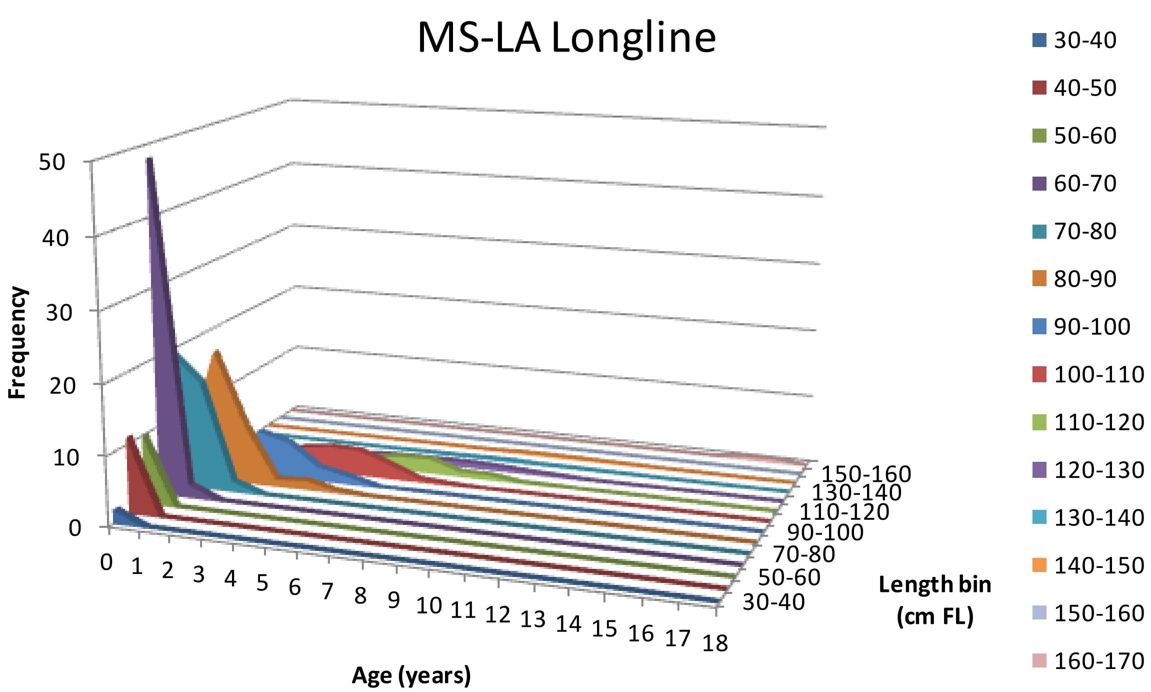
SENSITIVITY INDICES

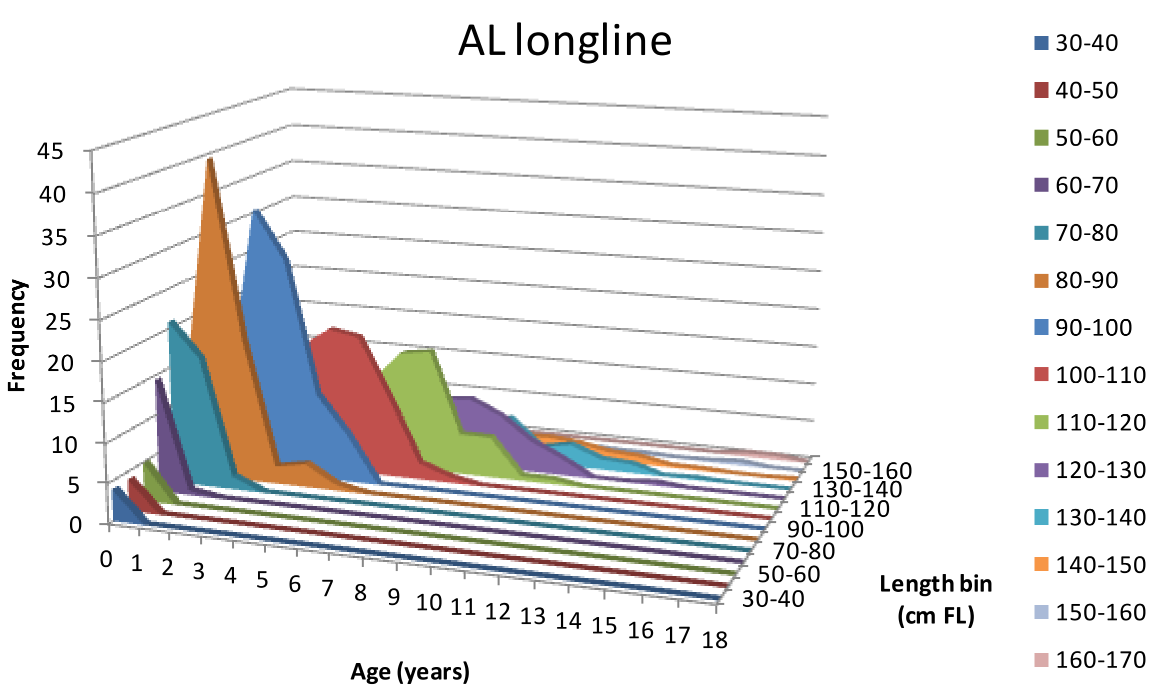





MS Gillnet
Frequency
300
250
200
150
100
50
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Age (years)
150-160
130-140
110-120
90-100
70-80
50-60
30-40
Length bin (cm FL)
30-40
40-50
50-60
60-70
70-80
80-90
90-100
100-110
110-120
120-130
130-140
140-150
150-160
160-170


MS Longline
Frequency
120
100
80
60
40
20
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Age (years)
150-160
130-140
110-120
90-100
70-80
50-60
30-40
Length bin (cm FL)
30-40
40-50
50-60
60-70
70-80
80-90
90-100
100-110
110-120
120-130
130-140
140-150
150-160
160-170


MS-LA Longline
Frequency
50
40
30
20
10
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Age (years)
150-160
130-140
110-120
90-100
70-80
50-60
30-40
Length bin (cm FL)
30-40
40-50
50-60
60-70
70-80
80-90
90-100
100-110
110-120
120-130
130-140
140-150
150-160
160-170


AL longline
Frequency
45
40
35
30
25
20
15
10
5
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Age (years)
150-160
130-140
110-120
90-100
70-80
50-60
30-40
Length bin (cm FL)
30-40
40-50
50-60
60-70
70-80
80-90
90-100
100-110
110-120
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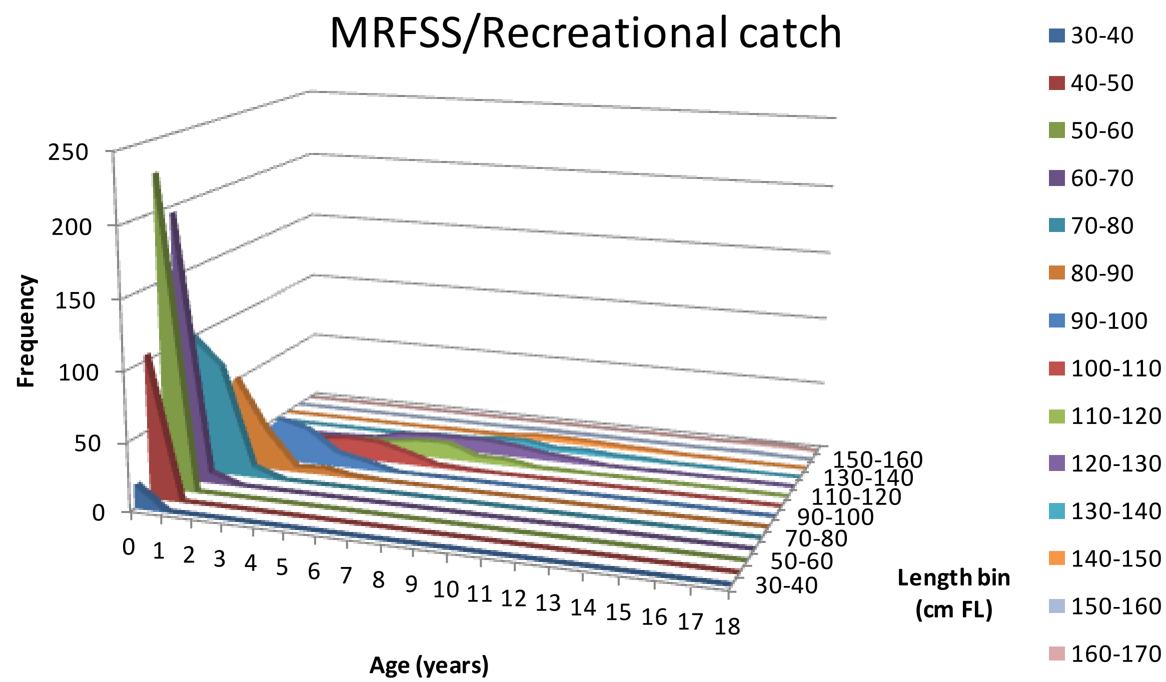
130-140
140-150
150-160
160-170


MRFSS/Recreational catch
250
200
150
100
50
0
Frequency
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Age (years)
150-160
130-140
110-120
90-100
70-80
50-60
30-40
Length bin
(cm FL)
30-40
40-50
50-60
60-70
70-80
80-90
90-100
100-110
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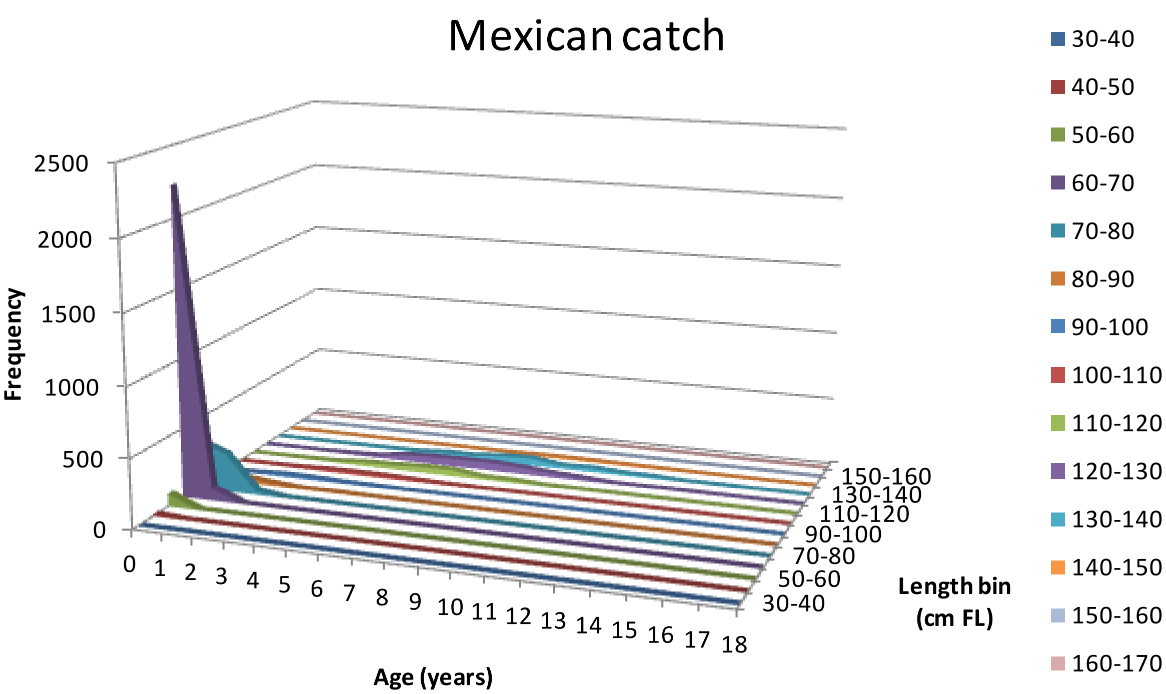
120-130
130-140
140-150
150-160
160-170


Mexican catch
2500
2000
1500
1000
500
0
Frequency
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Age (years)
150-160
130-140
110-120
90-100
70-80
50-60
30-40
Length bin
(cm FL)
30-40
40-50
50-60
60-70
70-80
80-90
90-100
100-110
110-120
120-130
130-140
140-150
150-160
160-170

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 through the fully selected ages

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 exponential could be estimated to capture the decline in selectivity for the older animals

9. Fit a logistic curve by least squares by minimizing the sum of squared residuals of the expected value and the normalized Obs/Exp value

10. If fulcrum age=1 (fully selected), fit a double exponential curve by eye by manipulating parameter values to ensure coverage of all ages represented in the sample