SEDAR

Southeast Data, Assessment, and Review

SEDAR 34

Stock Assessment Report

HMS Bonnethead Shark

September 2013

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 2013 Data Workshop of the Atlantic Sharpnose and Bonnethead Shark Stock Assessments (SEDAR 34)

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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 shark management primarily since 1993 through 2012 for small coastal sharks, particularly Atlantic sharpnose and bonnethead sharks. The summary focuses only on those management actions that likely affect these two species. The latter part of the document is organized according to individual species. The management measures implemented under fishery management plans and amendments are also summarized in Table 1.

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

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

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

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

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

- Mandatory data reporting requirements for foreign vessels;
- A hard cap on the catch of sharks by foreign vessels, which when achieved would prohibit further landings of sharks by foreign vessels;
- Permit requirements for foreign vessels to fish in the Fishery Conservation Zone (FCZ) of the United States;
- Radio checks by foreign vessels upon entering and leaving the FCZ;
- Boarding and inspection privileges for U.S. observers; and
- Prohibition on intentional discarding of fishing gears by foreign fishing vessels within the FCZ that may pose environmental or navigational hazards.

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

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

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

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

- Establishing a fishery management unit (FMU) consisting of 39 frequently caught species of Atlantic sharks, separated into three groups for assessment and regulatory purposes (Large Coastal Sharks (LCS) (22 species), Small Coastal Sharks (SCS) (7 species), and pelagic sharks (10 species))[1];
- Annual quotas of 2,436 mt (dressed weight) for large coastal species group, 580 mt (dressed weight) for the pelagic species group, and no quota for small coastal sharks;
- 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;
- Prohibiting finning of large coastal sharks, small coastal sharks, and pelagic sharks 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

[1] Since this time, Atlantic sharpnose and bonnethead sharks have been managed within the small coastal shark complex.

that at least 50 percent of earned income has been derived from the sale of the fish or fish products or charter vessel and headboat operations or at least $20,000 from the sale of fish during one of three years preceding the permit request;

- Requiring trip reports by permitted fishermen and persons conducting shark tournaments and requiring fishermen to provide information to NMFS under the Trip Interview Program; and,
- Requiring NMFS observers on selected shark fishing vessels to document mortality of marine mammals and endangered species.

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

In 1997, a new quota of 1,760 mt dw/year was established for SCS and new recreational bag limits were set (see Section 2.0 below). In 1999, NMFS published the 1999 FMP, which amended and replaced the 1993 FMP. Management measures related to sharks that changed in the 1999 FMP included:

- Maintaining an SCS quota of 1,760 mt dw/year;
- Reducing recreational retention limits for all sharks to 1 shark of any species at least 54" FL and 1 Atlantic sharpnose per person per trip (no minimum size);
- Expanding the list of prohibited shark species to 19 species[2];
- Established essential fish habitat (EFH) for 39 species of sharks including Atlantic sharpnose and bonnethead sharks;
- Implementing limited access in commercial shark fisheries, including the small coastal shark fishery;
- 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. These changes are explained below under Section 2.0.

[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.

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, in Amendment 1 to the 1999 FMP, 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 affecting small coastal sharks (December 24, 2003, 68 FR 74746) selected in Amendment 1 included, among other things:

- Using maximum sustainable yield as a basis for setting commercial quotas;
- Establishing regional commercial quotas and trimester commercial fishing seasons;
- Removing the minimum size of 54” FL for bonnethead sharks and allowing recreational anglers 1 to possess bonnethead shark per person per trip;
- Establishing a mechanism for changing the species on the prohibited species list; and
- Updating essential fish habitat identifications for five species of sharks.

2006 Consolidated HMS FMP

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

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

- Mandatory workshops and certifications for all vessel owners and operators that have pelagic longline (PLL), bottom longline (BLL) gear, or gillnet 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; and,
- The requirement that the 2nd dorsal fin and the anal fin remain on all sharks through landing.

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

2008 Amendment 2 to the 2006 Consolidated HMS FMP

In 2005/2006, new stock assessments were conducted on the LCS complex, sandbar, blacktip, porbeagle, and dusky sharks. Based on the results of those assessments, NMFS amended the 2006 Consolidated HMS FMP. On April 10, 2008, NMFS released the Final EIS for Amendment 2 to the Consolidated HMS FMP. The final measures in Amendment 2 focused on large coastal sharks. Some of the measures that may have impacted small coastal sharks include:

- Measures to reduce fishing mortality of overfished/overfishing stocks; and,
- Requiring that all Atlantic sharks be offloaded with fins naturally attached.

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

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

On July 24, 2009 (74 FR 36706 and 74 FR 36892), the draft EIS and proposed rule were released, which considered a range of alternative management measures from several different topics including small coastal sharks (SCS) commercial quotas, commercial gear restrictions, pelagic shark effort controls, recreational measures for SCS and pelagic sharks, and smooth dogfish management measures. In order to rebuild blacknose sharks, NMFS proposed to establish a new blacknose shark specific quota of 14.9 mt dw and establish a new non-blacknose SCS quota of 56.9 mt dw. In addition, NMFS proposed to prohibit the landings of all sharks from South Carolina south using gillnet gear, and prohibit the landing of blacknose sharks in the recreational shark fishery. However, based on additional data and analyzes and public comment, in the final EIS (75 FR 13276, March 19, 2010) and final rule (75 FR 30484, June 1, 2010), NMFS finalized measures that:

- established a blacknose shark specific quota of 19.9 mt dw;
- established a new non-blacknose SCS quota of 221.6 mt dw (which includes landings of Atlantic sharpnose and bonnethead sharks);
- linked the blacknose and non-blacknose SCS quotas so that when one quota was reached, both fisheries would close together;
- allowed sharks to be landed with gillnet gear and recreational anglers to be able to retain blacknose sharks, as long as they meet the minimum recreational size limit.

Changes in fishing practices, particularly in the gillnet fishery, have occurred as a result of these regulations due to establishment of a blacknose shark quota which closes the other small coastal shark fishery when 80 percent of the quota is achieved. This may provide additional incentive to either avoid fishing in areas where blacknose sharks are present or discard these sharks at sea.

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

Based on stock assessments completed between 2009 and 2012 for sandbar, dusky, blacknose, scalloped hammerhead, and Gulf of Mexico blacktip sharks, Amendment 5 proposed management measures that would reduce fishing mortality and allow rebuilding of some of these species. The proposed rule and DEIS were released on November 26, 2012 (77 FR 70552).

Amendment 6 to the 2006 Consolidated HMS FMP

In September 2010, NMFS published an Advanced Notice of Proposed Rulemaking (ANPR) (75 FR 57235) to seek public comment on alternative management strategies (quota structure, permit structure, and catch shares) that might better address these issues in the Atlantic shark fisheries. NMFS received comments on a variety of modifications to the existing management structure for the Atlantic shark fisheries, including programs such as catch shares, limited access privilege programs (LAPPs), individual fishing quotas (IFQs), and/or sectors. 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 purpose of the NOI was to establish a control date for eligibility to participate in an Atlantic shark catch share program, announce the availability of a white paper describing design elements of catch share programs in general and issues specific to the Atlantic shark fisheries, announce a catch share workshop at the upcoming HMS Advisory Panel meeting, and request public comment on the implementation of catch shares in the Atlantic shark fisheries.

Table 1 FMP Amendments and regulations affecting Atlantic sharpnose and bonnethead sharks.

Effective Date	FMP/Amendment	Description of Action
January 1978	Preliminary Fishery Management Plan (PMP) for Atlantic Billfish and	• 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

Effective Date	FMP/Amendment	Description of Action
	Sharks	
Most parts effective April 26, 1993, such as quotas, complexes, etc. Finning prohibition effective May 26, 1993. Need to have permit, report landings, and carry observers effective July 1, 1993.	FMP for Sharks of the Atlantic Ocean	• Established a fishery management unit (FMU) consisting of 39 frequently caught species of Atlantic sharks, separated into three groups for assessment and regulatory purposes (LCS, **SCS**, and pelagic sharks); • Established calendar year commercial quotas for the LCS (2,436 mt dw) and pelagic sharks (580 mt dw) and divided the annual quota into two equal half-year quotas that apply to the following two fishing periods – January 1 through June 30 and July 1 through December 31 (no quota established for **SCS**); • Establishing a recreational trip limit of 4 LCS & pelagic sharks/vessel and a daily bag limit of 5 **SCS**/person; • Prohibited finning by requiring that the ratio between wet fins/dressed carcass weight not exceed five percent; • Prohibited the sale by recreational fishermen of sharks or shark products caught in the Economic Exclusive Zone (EEZ); • Required annual commercial permits for fishermen who harvest and sell shark (meat products and fins); and, • Requiring trip reports by permitted fishermen and persons conducting shark tournaments and requiring fishermen to provide information to NMFS under the Trip Interview Program. Other management measures included: establishing a framework procedure for adjusting commercial quotas, recreational bag limits, species size limits, management unit, fishing year, species groups, estimates of maximum sustainable yield (MSY), and permitting and reporting requirements; establishing a permit eligibility requirement that the owner or operator (including charter vessel and headboat owners/operators who intend to sell their catch); and requiring NMFS observers on selected shark fishing vessels to document mortality of marine mammals and endangered species.
July 1, 1999 -Limited access permits issued immediately; application and appeals processed over the next year (measures in italics were delayed)	FMP for Atlantic Tunas, Swordfish and Sharks	• Implemented limited access in commercial fisheries; • Reduced commercial **SCS quota** to 1,760 mt dw, respectively; • Reduced recreational retention limits for all sharks to 1 shark/vessel/trip except for **Atlantic sharpnose** (1 Atlantic sharpnose/person/trip); • Established a recreational minimum size for all sharks **except Atlantic sharpnose** (4.5 feet or 54” FL); • 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)*;
February 1, 2004, except LCS and SCS quotas, and recreational	Amendment 1 to the FMP for Atlantic Tunas, Swordfish and Sharks	• Established gear restrictions to reduce bycatch or reduce bycatch mortality (allowed only handline and rod and reel in recreational shark fishery); • Used maximum sustainable yield as a basis for setting commercial quotas (**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

Effective Date	FMP/Amendment	Description of Action
retention and size limits, which were delayed		with no size limit for **bonnethead** or **Atlantic sharpnose**) (*effective December 30, 2003*); • Established regional commercial quotas and trimester commercial fishing seasons (*trimesters not implemented until January 1, 2005; 69 FR 6964*); and, Other management measures included: 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 on gillnet vessels operating during the right whale calving season.
November 1, 2006, except for workshops	Consolidated HMS FMP	• The requirement that the 2nd dorsal fin and the anal fin remain on all sharks through landing; • Mandatory workshops and certifications for all vessel owners and operators that have PLL, BLL, or gillnet gear on their vessels for fishermen with HMS LAPs (*effective January 1, 2007*); and • Mandatory Atlantic shark identification workshops for all Federally permitted shark dealers (*effective January 1, 2007*).
July 24, 2008	Amendment 2 to the 2006 Consolidated HMS FMP	• 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; • Modified recreational measures to reduce fishing mortality of overfished/overfishing stocks (prohibiting the retention of silky and sandbar sharks for recreational anglers); • Required that all Atlantic sharks be offloaded with fins naturally attached; and, • Implemented BLL time/area closures recommended by the South Atlantic Fishery Management Council.
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.
Proposed rule published Nov. 26, 2012	Amendment 5 to the 2006 Consolidated HMS FMP	• Proposed management measures consistent with recent stock assessments for sandbar, dusky, scalloped hammerhead, Gulf of Mexico blacktip, and Atlantic and Gulf of Mexico blacknose sharks
NOI published Sept. 16, 2011	Amendment 6 to the 2006 Consolidated HMS FMP	• Consider catch shares for the Atlantic shark fisheries

2.0 Emergency and Other Major Rules

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

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, among other things, a SCS commercial quota of 1,760 mt dw that was the same as 1997 quota 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, among other things, NMFS maintained the 1997 SCS commercial quota (1,760 mt dw). That emergency rule expired on December 30, 2002.

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).

Rules in Relation to 2003 Amendment 1

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

Shark Rules After 2006 Consolidated HMS FMP

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

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

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

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

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

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

Federal Register Cite	Date	Rule or Notice
61 FR 67295	12/20/1996	Proposed rule to reduce Quotas/Bag Limits
61 FR 68202	12/27/1996	Proposed rule to establish limited entry (Draft Amendment 1 to 1993 FMP)
1997		
62 FR 724	1/6/1997	NOA of Draft Amendment 1 to 1993 FMP
62 FR 1705	1/13/1997	Notice of 11 public hearings for Amendment 1
62 FR 1872	1/14/1997	Extension of comment period and notice of public hearings for proposed rule on quotas
62 FR 4239	1/29/1997	Extension of comment period for proposed rule on quotas
62 FR 8679	2/26/1997	Extension of comment period for Amendment 1 to 1993 FMP
62 FR 16647	4/7/1997	Final rule reducing quotas/bag limits
62 FR 16656	4/7/1997	LCS commercial fishery closure announcement
62 FR 26475	5/14/1997	Announcement of Shark Operations Team meeting
62 FR 26428	5/14/1997	Adjusts second semi-annual 1997 LCS quota
62 FR 27586	5/20/1997	Notice of Intent to prepare an supplemental environmental impact statement
62 FR 27703	5/21/1997	Technical Amendment regarding bag limits
62 FR 38942	7/21/1997	LCS commercial fishery closure announcement
1998		
63 FR 14837	3/27/1998	LCS commercial fishery closure announcement
63 FR 19239	4/17/1998	NOA of draft consideration of economic effects of 1997 quotas
63 FR 27708	5/20/1998	NOA of final consideration of economic effects of 1997 quotas
63 FR 29355	5/29/1998	Adjusts second semi-annual 1998 LCS quota
63 FR 41736	8/5/1998	LCS commercial fishery closure announcement
63 FR 57093	10/26/1998	NOA of draft 1999 FMP
1999		
64 FR 3154	1/20/1999	Proposed rule for draft 1999 FMP
64 FR 14154	3/24/1999	LCS commercial fishery closure announcement
64 FR 29090	5/28/1999	Final rule for 1999 FMP
64 FR 30248	6/7/1999	Fishing season notification
64 FR 37700	7/13/1999	Technical amendment to 1999 FMP final rule
64 FR 37883	7/14/1999	Fishing season change notification
64 FR 47713	9/1/1999	LCS fishery reopening
64 FR 52772	9/30/1999	Notice of Availability of outline for National Plan of Action for sharks
64 FR 53949	10/5/1999	LCS closure postponement
64 FR 66114	11/24/1999	Fishing season notification
2000		
65 FR 16186	3/27/2000	Revised timeline for National Plan of Action for sharks
65 FR 35855	6/6/2000	Fishing season notification and 2nd semi-annual LCS quota adjustment
65 FR 47214	8/1/2000	Final rule closing Desoto Canyon, Florida East Coast, and Charleston Bump and requiring live bait for PLL gear in Gulf of Mexico
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

Federal Register Cite	Date	Rule or Notice
		vessels
65 FR 75867	12/5/2000	Fishing season notification
2001		
66 FR 55	1/2/2001	Implementation of 1999 FMP pelagic shark quotas
66 FR 10484	2/15/2001	NOA of Final National Plan of Action for the Conservation and Management of Sharks
66 FR 13441	3/6/2001	Emergency rule to implement settlement agreement
66 FR 33918	6/26/2001	Fishing season notification and 2nd semi-annual LCS quota adjustment
66 FR 34401	6/28/2001	Proposed rule to implement national finning ban
66 FR 36711	7/13/2001	Emergency rule implementing 2001 BiOp requirements
66 FR 46401	9/5/2001	LCS fishing season extension
66 FR 48812	9/24/2001	Amendment to emergency rule (66 FR 13441) to incorporate change in requirement for handling and release guidelines
66 FR 67118	12/28/2001	Emergency rule to implement measures based on results of peer review and fishing season notification
2002		
67 FR 6194	2/11/2002	Final rule implementing national shark finning ban
67 FR 8211	2/22/2002	Correction to fishing season notification 66 FR 67118
67 FR 30879	5/8/2002	Notice of availability of SCS stock assessment
67 FR 36858	5/28/2002	Notice of availability of LCS sensitivity document and announcement of stock evaluation workshop in June
67 FR 37354	5/29/2002	Extension of emergency rule and fishing season announcement
67 FR 45393	7/9/2002	Final rule to implement measures under 2001 BiOp (gangion placement measure not implemented), including HMS shark gillnet measures
67 FR 64098	10/17/2002	Notice of availability of LCS stock assessment and final meeting report
67 FR 69180	11/15/2002	Notice of intent to conduct an environmental impact assessment and amend the 1999 FMP
67 FR 72629	12/6/2002	Proposed rule regarding EFPs
67 FR 78990	12/27/2002	Emergency rule to implement measures based on stock assessments and fishing season notification
2003		
68 FR 1024	1/8/2003	Announcement of 4 public hearings on emergency rule
68 FR 1430	1/10/2003	Extension of comment period for proposed rule on EFPs
68 FR 3853	1/27/2003	Announcement of 7 scoping meetings and notice of availability of Issues and Options paper
68 FR 31983	5/29/2003	Emergency rule extension and fishing season notification
68 FR 45196	8/1/2003	Proposed rule and NOA for draft Amendment 1 to 1999 FMP
68 FR 47904	8/12/2003	Public hearing announcement for draft Amendment 1 to 1999 FMP
68 FR 51560	8/27/2003	Announcement of HMS AP meeting on draft Amendment 1 to 1999 FMP
68 FR 54885	9/19/2003	Rescheduling of public hearings and extending comment period for draft Amendment 1 to 1999 FMP
68 FR 64621	11/14/2003	NOA of availability of Amendment 1
68 FR 66783	11/28/2003	NOI for SEIS

Federal Register Cite	Date	Rule or Notice
68 FR 74746	12/24/2003	Final Rule for Amendment 1
2004		
69 FR 6621	02/11/04	Proposed rule for PLL fishery
69 FR 10936	3/9/2004	SCS fishery closure
69 FR 19979	4/15/2004	VMS type approval notice
69 FR 26540	5/13/2004	N. Atlantic Quota Split Proposed Rule
69 FR 28106	5/18/2004	VMS effective date proposed rule
69 FR 30837	6/1/2004	Fishing season notice
69 FR 33321	6/15/2004	N. Atlantic Quota Split Final Rule
69 FR 40734	07/06/04	Final rule for PLL fishery
69 FR 44513	07/26/04	Notice of sea turtle release/protocol workshops
69 FR 47797	8/6/2004	Technical amendment correcting changes to BLL gear requirements
69 FR 49858	08/12/04	Advanced notice of proposed rulemaking; reducing sea turtle interactions with fishing gear
69 FR 51010	8/17/2004	VMS effective date final rule
69 FR 56024	9/17/2004	Regional quota split proposed rule
69 FR 6954	11/30/2004	Regional quota split final rule and season announcement
69 FR 71735	12/10/2004	Correction notice for 69 FR 6954
2005		
70 FR 11922	3/10/2005	2nd and 3rd season proposed rule
70 FR 21673	4/27/2005	2nd and 3rd season final rule
70 FR 24494	5/10/2005	North Carolina Petition for Rulemaking
70 FR 29285	5/20/2005	Notice of handling and release workshops for BLL fishermen
70 FR 48804	8/19/2005	Proposed rule Draft Consolidated HMS FMP
70 FR 48704	8/19/2005	NOA of Draft EIS for Draft Consolidated HMS FMP
70 FR 52380	9/2/2005	Correction to 70 FR 48704
70 FR 53146	9/7/2005	Cancellation of hearings due to Hurricane Katrina
70 FR 54537	9/15/2005	Notice of LCS data workshop
70 FR 55814	9/23/2005	Cancellation of Key West due to Hurricane Rita
70 FR 58190	10/5/2005	Correction to 70 FR 54537
70 FR 58177	10/5/2005	Extension of comment period for Draft Consolidated HMS FMP
70 FR 58366	10/6/2005	1st season proposed rule
70 FR 72080	12/1/2005	1st season final rule, fishing season notification
70 FR 73980	12/14/2005	Final Agency decision on petition for rulemaking to amend mid-Atlantic closed area
70 FR 76031	12/22/2005	Notice for Large Coastal Shark 2005/2006 Stock Assessment Workshop
70 FR 76441	12/27/2005	Rescheduling and addition of public hearings for Consolidated HMS FMP
2006		
71 FR 8223	2/16/2006	Temporary rule prohibiting gillnet gear in areas around the Southeast U.S. Restricted Area
71 FR 8557	2/17/2006	Proposed Rule for third and second trimester seasons
71 FR 12185	3/9/2006	Notice for Large Costal Shark Review Workshop
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

Federal Register Cite	Date	Rule or Notice
71 FR 26351	5/4/2006	Scientific research permit for pelagic shark research
71 FR 30123	5/25/2006	Notice of availability of stock assessment of dusky sharks
71 FR 41774	7/24/2006	Notice of availability of final stock assessment for Large Costal Sharks
71 FR 58058	10/2/2006	Final Rule for the HMS Consolidated Fishery Management Plan
71 FR 58058	10/2/2006	1st season proposed rule
71 FR 62095	10/23/2006	Notice of shark dealer identification workshops and protected species safe handling and release workshops
71FR 64213	11/1/2006	Extension of comment period regarding the 2007 first trimester season proposed rule
71 FR 65086	11/7/2006	Notice of Intent to prepare Amendment 2 to the 2006 Consolidated HMS FMP and status determination for sandbar, blacktip, dusky, the LCS complex, and porbeagle sharks based on the latest stock assessments
71 FR 65087	11/7/2006	Notice of Intent to prepare Amendment 1 to the 2006 Consolidated HMS FMP for Essential Fish Habitat for Some Atlantic Highly Migratory Species
71 FR 66154	11/13/2006	Extension of comment period regarding the 2007 first trimester season proposed rule
71 FR 68561	11/27/2006	Notice of shark dealer identification workshops and protected species safe handling and release workshops
71 FR 75122	12/14/2006	Final Rule and Temporary Rule for the 2007 first trimester season and south Atlantic quota modification
71 FR 75714	12/18/2006	Notice of shark dealer identification workshops and protected species safe handling and release workshops
2007		
72 FR 123	1/3/2007	Notice of public hearings for scoping for Amendment 2 to the 2006 Consolidated HMS FMP
72 FR 5633	2/7/2007	Final rule for gear operation and deployment for BLL and gillnet fishery and complementary closures
72 FR 6966	2/14/2007	Notice of closure of the Small Coastal Shark fishery for the Gulf of Mexico
72 FR 7417	2/15/2007	Revised list of equipment models for careful release of sea turtles in the PLL and BLL fisheries
72 FR 8695	2/27/2007	Notice of new VMS type approval for HMS fisheries and other programs
72 FR 10480	3/8/2007	Proposed rule for second and third trimester seasons
72 FR 11335	3/13/2007	Schedule of public protected resources dehooking workshops and Atlantic shark identification workshops
72 FR 19701	4/19/2007	Notice of Small Costal Shark stock assessment workshop
72 FR 20765	4/26/2007	Final rule for second and third trimester season
72 FR 32836	6/14/2007	Schedule of public protected resources dehooking workshops and Atlantic shark identification workshops
72 FR 34632	6/25/2007	Final rule prohibiting gillnet gear from November 15-April 15 between NC/SC border and 29°00'N.
72 FR 39606	7/18/2007	Notice of Small Costal Shark 2007 peer review workshop
72 FR 41392	7/27/2007	Proposed rule for Amendment 2 to the Consolidated Atlantic Highly Migratory Species Fishery Management Plan
72 FR 52552	9/14/2007	Schedules for Atlantic shark identification workshops and protected species

Federal Register Cite	**Date**	**Rule or Notice**
		safe handling, release, and identification workshops
72 FR 55729	10/1/2007	Proposed rule for 2008 first trimester quotas
72 FR 56330	10/3/2007	Amendment 2 to the Consolidated FMP – extension of comment period
72 FR 57104	10/5/2007	Final rule amending restriction in the Southeast U.S. Monitoring Area
72 FR 63888	11/13/2007	Notice of Small Coastal Shark Stock Assessment - notice of availability
72 FR 67580	11/29/2007	Final rule for 2008 first trimester quotas
2008		
73 FR 11621	3/4/2008	Notice of Atlantic shark identification workshops and protected species safe handling, release, and identification workshops
73 FR 19795	4/11/2008	Proposed rule for renewal of Atlantic tunas longline limited access permits; and, Atlantic shark dealer workshop attendance requirements
73 FR 24922	5/6/2008	Proposed rule for Atlantic tuna fisheries; gear authorization and turtle control devices
73 FR 25665	5/7/2008	Stock Status Determinations; Notice of Intent (NOI) to prepare an Environmental Impact Statement (EIS) for Amendment 3 to the 2006 Consolidated HMS FMP
73 FR 32309	6/6/2008	Notice of Atlantic shark identification workshops and protected species safe handling, release, and identification workshops
73 FR 35778	6/24/2008	Final rule for Amendment 2 to the 2006 Consolidated HMS FMP and fishing season notification
73 FR 35834	6/24/2008	Shark research fishery; Notice of intent; request for applications
73 FR 37932	7/2/2008	Notice of availability; notice of public scoping meetings; Extension of comment period for Amendment 3 to the 2006 Consolidated HMS FMP
73 FR 38144	7/3/2008	Final rule for renewal of Atlantic tunas longline limited access permits; and, Atlantic shark dealer workshop attendance requirements
73 FR 40658	7/15/2008	Final rule for Amendment 2 to the 2006 Consolidated HMS FMP and fishing season notification; correction/republication
73 FR 47851	8/15/2008	Effectiveness of collection-of-information requirements to implement fins-on check box on Southeast dealer form
73 FR 51448	9/3/2008	Notice of Atlantic shark identification workshops and protected species safe handling, release, and identification workshops
73 FR 53408	9/16/2008	Notice of public meeting, public hearing, and scoping meetings regarding the AP meeting and various other hearings/meetings
73 FR 53851	9/17/2008	Atlantic Shark Management Measures; Changing the time and location of a scoping meeting
73 FR 54721	9/23/2008	Final rule for Atlantic tuna fisheries; gear authorization and turtle control devices
73 FR 63668	10/27/2008	Proposed rule for 2009 shark fishing season
73 FR 64307	10/29/2008	Extension of scoping comment period for Amendment 3 to the 2006 Consolidated HMS FMP
2009		
74 FR 8913	2/27/2009	Notice of Atlantic shark identification workshops and protected species safe handling, release, and identification workshops
74 FR26803	6/4/2009	Inseason action to close the commercial Gulf of Mexico non-sandbar large coastal shark fishery

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

Federal Register Cite	Date	Rule or Notice
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
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
2012		
77 FR 8218	2/14/2012	NMFS Announces a Public Meeting for Selected Participants of the 2012 Shark Research Fishery
77 FR 32036	5/25/2012	Inseason Action to Close the Commercial Porbeagle Shark Fishery
77 FR 31562	5/29/2012	NMFS Considers Adding Gulf of Mexico Sharks to Amendment 5 to the 2006 Consolidated HMS FMP
77 FR 32036	5/31/2012	Inseason Action to Close the Commercial Porbeagle Shark Fishery

Federal Register Cite	Date	Rule or Notice
77 FR 35357	6/13/2012	NMFS Announces the Opening Date of the Commercial Atlantic Region Non-Sandbar Large Coastal Fishery
77 FR 37647	6/21/2012	Proposed Rule to Prohibit Retention of Silky Sharks Caught in ICCAT Fisheries
77 FR 39648	7/5/2012	Inseason Action to Close the Commercial Non-Sandbar Large Coastal Shark Fishery in the Gulf of Mexico Region
77 FR 60632	10/4/2012	Final Rule to Prohibit Retention of Silky Sharks Caught in ICCAT Fisheries
77 FR 61562	10/10/2012	Proposed Rule to Establish the Quotas and Opening Dates for the 2013 Atlantic Shark Commercial Fishing Season
77 FR 67631	11/13/2012	Notice of Intent for Applications to the 2013 Shark Research Fishery
77 FR 70552	11/15/2012	Proposed Rule for Amendment 5 to the 2006 Consolidated HMS FMP
77 FR 69596	11/20/2012	Notice to Solicit Nominations for the AP for Atlantic HMS Southeast Data, Assessment, and Review (SEDAR Workshops
77 FR 73608	12/11/2012	Public Hearings for Amendment 5 to the Consolidated HMS FMP
77 FR 75896	12/21/2012	Final Rule for 2013 Commercial Shark Season

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

Year	Open Dates	Adjusted Quota (mt dw)
1993	No season	No Quota
1994	No season	No Quota
1995	No season	No Quota
1996	No season	No Quota
1997	Jan. 1 – June 30	880
	July 1 - Dec 31	880
1998	Jan. 1 – June 30	880
	July 1 - Dec 31	880
1999	Jan. 1 – June 30	880
	July 1 - Dec 31	880
2000	Jan. 1 – June 30	880
	July 1 - Dec 31	880
2001	Jan. 1 – June 30	880
	July 1 - Dec 31	880
2002	Jan. 1 – June 30	880
	July 1 - Dec 31	880
2003	Jan. 1 – June 30	163
	July 1 - Dec 31	163

Year	Open Dates	Adjusted Quota (mt dw)
2004	GOM: Jan. 1 – March 18	11.2
	S. Atl: Jan 1 - June 30	233.2
	N. Atl: Jan 1 - June 30	36.5
	GOM: July 1 – Dec. 31	10.2
	S. Atl: July 1 – Dec. 31	210.2
	N. Atl: July 1 – Dec. 31	33.2
2005	GOM: Jan 1 – April 30	13.9
	S. Atl: Jan. 1 - April 30	213.5
	N. Atl: Jan. 1 - April 30	18.6
	GOM: May 1 – Aug. 31	31
	S. Atl: May 1 – Aug. 31	281
	N. Atl: May 1 – Aug. 31	23
	GOM: Sept. 1 – Dec. 31	32
	S. Atl: Sept. 1 – Dec. 31	201.1
	N. Atl: Sept. 1 – Dec. 31	16
2006	GOM: Jan 1 – April 30	14.8
	S. Atl: Jan 1 – April 30	284.6
	N. Atl: Jan 1 – April 30	18.7
	GOM: May 1 – Aug. 31	38.9
	S. Atl: May 1 – Aug. 31	333.5
	N. Atl: May 1 – Aug. 31	35.9
	GOM: Sept. 1 – Dec. 31	30.8
	S. Atl: Sept. 1 – Dec. 31	263.7
	N. Atl: Sept. 1 – Dec. 31	28.2
2007	GOM: Jan. 1 – Feb. 23	15.1
	S. Atl: Jan 1 – April 30	308.4
	N. Atl: Jan 1 – April 30	18.8
	GOM: May 1 – Aug. 31	72.6
	S. Atl: May 1 – Aug. 31	291.6
	N. Atl: May 1 – Aug. 31	36.2
	GOM: September 1 – Dec. 31	80.4
	S. Atl: September 1 – Dec. 31	297.5
	N. Atl: September 1 – Dec. 31	29.4
2008	GOM: Jan 1 – April 30, 2008	73.2
	S. Atl: Jan 1 – April 30, 2008	354.9
	N. Atl: Jan 1 – April 30, 2008	19.3

Year	Open Dates	Adjusted Quota (mt dw)
	GOM: May 1 – July 24, 2008 S. Atl: May 1 – July 24, 2008 N. Atl: May 1 – July 24, 2008	72.6 74.1 12.0
	July 24 – Dec. 31, 2008	454
2009	Jan. 23 – Dec. 31, 2009	454
2010	June 1 – Nov. 2, 2010	Blacknose Sharks: 19.9 Other Small Coastal Sharks: 221.6
2011	Jan. 1 – Dec. 31, 2011	Blacknose Sharks: 19.9 Other Small Coastal Sharks: 314.4
2012	Jan. 24 – Dec. 31, 2012	Blacknose Sharks: 19.9 Other Small Coastal Sharks: 332.4
2013	Jan. 1 - TBD	Blacknose Sharks: 19.9 Other Small Coastal Sharks: 329.2

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*	*Prohibited on vessels using PLL gear or vessels with HMS Angling/CHB permit and swordfish, billfish, or tuna in possession*
Tiger	*Galeocerdo cuvier*	
	Non-Ridgeback Species	
Blacktip	*Carcharhinus limbatus*	
Spinner	*Carcharhinus brevipinna*	
Bull	*Carcharhinus leucas*	
Lemon	*Negaprion brevirostris*	
Nurse	*Ginglymostoma cirratum*	
Scalloped hammerhead	*Sphyrna lewini*	*Prohibited on vessels using PLL gear or vessels with HMS Angling/CHB permit and swordfish, billfish, or tuna in possession*
Great hammerhead	*Sphyrna mokarran*	
Smooth hammerhead	*Sphyrna zygaena*	
SCS		
Atlantic sharpnose	*Rhizoprionodon terraenovae*	
Blacknose	*Carcharhinus acronotus*	
Bonnethead	*Sphyrna tiburo*	
Finetooth	*Carcharhinus isodon*	
Pelagic Sharks		

Common name	Species name	Notes
Blue	*Prionace glauca*	
Oceanic whitetip	*Carcharhinus longimanus*	*Prohibited on vessels using PLL gear or vessels with HMS Angling/CHB permit and swordfish, billfish, or tuna in possession*
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>
<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:
<u>Directed Permits:</u>
No trip limit for pelagic sharks & SCS
<u>Incidental Permits:</u>
16 pelagic sharks/SCS combined</td><td>Sandbar:
Base Commercial Quota (2013): 116.6 mt dw
Non-sandbar LCS:
Base Commercial Quota(2013): 50 mt dw
SCS:
Base Commercial Non-blacknose SCS Quota: 221.6 mt dw/year
Base Commercial Blacknose Quota: 19.9 mt dw
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 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 As of Jan. 1, 2013:
<u>Directed Permit:</u> 36 non-sandbar LCS/vessel/trip
<u>Incidental Permit:</u> 3 non-sandbar LCS/vessel/trip
SCS & Pelagic Sharks:
<u>Directed Permits:</u>
No trip limit for pelagic sharks & SCS
<u>Incidental Permits:</u>
16 pelagic sharks/SCS combined</td><td>Non-sandbar LCS:
Base Commercial Quota Gulf of Mexico Region: 439.5 mt dw/year;
Base Commercial Quota Atlantic Region: 188.3 mt dw/year
SCS:
Base Commercial Non-blacknose SCS Quota: 221.6 mt dw/year
Base Commercial Blacknose Quota: 19.9 mt dw
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 may be further adjusted based on future overharvests, if any.</td></tr>
<tr><td rowspan="5">All Commercial Shark Fisheries</td><td colspan="3">Gears Allowed: Gillnet; Bottom/Pelagic Longline; Rod and Reel; Handline; Bandit Gear</td></tr>
<tr><td colspan="3">Authorized Species: Non-sandbar LCS (silky, blacktip, spinner, bull, lemon, nurse, great hammerhead, scalloped hammerhead, smooth hammerhead, and tiger sharks), pelagic sharks (porbeagle, common thresher, shortfin mako, oceanic whitetip, and blue sharks), and SCS (bonnethead, finetooth, blacknose, and Atlantic sharpnose sharks)</td></tr>
<tr><td colspan="3">Landings condition: All sharks (sandbar, non-sandbar LCS, SCS, and pelagic sharks) must have fins naturally attached through offloading; fins can be cut slightly for storage but must remain attached to the carcass via at least a small amount of uncut skin; shark carcasses must remain in whole or log form through offloading. Sharks can have the heads removed but the tails must remain naturally attached.</td></tr>
<tr><td colspan="3">Permits Required: Commercial Directed or Incidental Shark Permit</td></tr>
<tr><td colspan="3">Reporting Requirements: All commercial fishermen must submit commercial logbooks; all dealers must report bi-weekly</td></tr>
<tr><td rowspan="6">All Recreational Shark Fisheries</td><td colspan="3">Gears Allowed: Rod and Reel; Handline</td></tr>
<tr><td colspan="3">Authorized Species: Non-ridgeback LCS (blacktip, spinner, bull, lemon, nurse, great hammerhead, scalloped hammerhead, smooth hammerhead); tiger sharks; pelagic sharks (porbeagle, common thresher, shortfin mako, oceanic whitetip, and blue sharks); and SCS (bonnethead, finetooth, blacknose, and Atlantic sharpnose sharks)</td></tr>
<tr><td colspan="3">Landing condition: Sharks must be landed with head, fins, and tail naturally attached</td></tr>
<tr><td colspan="3">Retention limits: 1 shark > 54” FL vessel/trip, plus 1 Atlantic sharpnose and 1 bonnethead per person/trip (no minimum size)</td></tr>
<tr><td colspan="3">Permits Required: HMS Angling; HMS Charter/Headboat; and, General Category Permit Holders (fishing in a shark tournament)</td></tr>
<tr><td colspan="3">Reporting Requirements: Participate in MRIP and LPS if contacted</td></tr>
</table>

Table 5 Summary of current shark regulations

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

3.0 Control Date Notices

February 22, 1994 (59 FR 8457)

September 16, 2011 (76 FR 57709)

4.0 Management Program Specifications

Table 6 General management information for the Atlantic sharpnose shark

Species	Atlantic sharpnose shark (*Rhizoprionodon terraenovae*)
Management Unit	Atlantic Ocean, Gulf of Mexico, and Caribbean Sea
Management Unit Definition	All federal waters within U.S. EEZ of the western north Atlantic Ocean, including the Gulf of Mexico and the Caribbean Sea.
Management Entity	NMFS, Highly Migratory Species Management Division
Management Contacts **SERO / Council**	Karyl Brewster-Geisz N/A
Current stock exploitation status	Not experiencing overfishing
Current stock biomass status	Not overfished

Table 7 General management information for the Bonnethead shark

Species	Bonnethead shark (*Sphyrna tiburo)*
Management Unit	Atlantic Ocean, Gulf of Mexico, and Caribbean Sea
Management Unit Definition	All federal waters within U.S. EEZ of the western north Atlantic Ocean, including the Gulf of Mexico and the Caribbean Sea.
Management Entity	NMFS, Highly Migratory Species Management Division
Management Contacts **SERO / Council**	Karyl Brewster-Geisz N/A
Current stock exploitation status	Not experiencing overfishing
Current stock biomass status	Not Overfished

Table 8 Specific Assessment Summary for Atlantic sharpnose sharks

Criteria	Value
MSST (Minimum Stock Size Threshold)	4,090,000 sharks (based on SSF_{MSY})
MFMT	0.19
B_{MSY}	SSF_{MSY} = 4,590,000 (numbers of sharks)
F_{05}/F_{MSY}	0.74
SSF_{2005}	6,012,300 (numbers of sharks)
SSF_{05}/SSF_{MSY}	1.47

Table 9 Specific Assessment Summary for Bonnethead sharks

Criteria	Value
MSST (Minimum Stock Size Threshold)	1,400,000 sharks (based on SSF_{MSY})
MFMT	0.31
MSY	SSF_{MSY} = 1,990,000 (numbers of sharks)
F_{05}/F_{MSY}	0.6
SSF_{2005}	2,248,700 (numbers of sharks)
SSF_{05}/SSF_{MSY}	1.13

Table 10 Stock Projection Information for Atlantic Sharpnose Sharks

Requested Information	Value
First year under current rebuilding program	N/A
End year under current rebuilding program	N/A
First Year of Management based on this assessment	2016
Projection Criteria during interim years should be based on (e.g., exploitation or harvest)	F=0; Fixed Exploitation; Modified Exploitation; Fixed Harvest*; No specific TAC for Atlantic Sharpnose Sharks F=221.6 mt ww (current commercial quota for non-blacknose SCS)
Projection criteria values for interim years should be determined from (e.g., terminal year, avg of X years)	Average landings of previous 2 years (2010, 2011)

Table 11 Stock Projection Information for Bonnethead Sharks

Requested Information	Value
First year under current rebuilding program	N/A
End year under current rebuilding program	N/A
First Year of Management based on this assessment	2016
Projection Criteria during interim years should be based on (e.g., exploitation or harvest)	F=0; Fixed Exploitation; Modified Exploitation; Fixed Harvest*; No specific TAC for Bonnethead Sharks F=221.6 mt ww (current commercial quota for non-blacknose SCS)
Projection criteria values for interim years should be determined from (e.g., terminal year, avg of X years)	Average landings of previous 2 years (2010, 2011)

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

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

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

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

5.0 Quota Calculations

Atlantic sharpnose and bonnethead sharks

Table 12 Quota calculation details for Atlantic Sharpnose and Bonnethead Sharks. .

Current Quota Value	Base Commercial Quota for all non-blacknose SCS = 221.6 mt dw. Up to 50 percent of base can be carried forward in the event of underharvest.
Next Scheduled Quota Change	Post SEDAR 34 if necessary
Annual or averaged quota ?	Annual quota
If averaged, number of years to average	-
Does the quota include bycatch/discard ?	The quota is based on average landings 2004-2008 and does not include bycatch or discards.

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

Atlantic sharpnose and bonnethead sharks are both included in the non-blacknose SCS quota. The current base commercial quota of 221.6 mt dw/year was established in Amendment 3 to the Consolidated HMS FMP (June 1, 2010) and is equal to average commercial landings for non-blacknose SCS between 2004-2008.

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/discard estimates.

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

The quota is adjusted each year through a season rule. Overharvests are deducted from the following year. Up to 50 percent of the base quota can be added to the following year's commercial non-blacknose SCS quota in the event of underharvest. No overharvests have been experienced for Atlantic sharpnose or bonnethead sharks since implementation of the 1999 FMP. Table 3 shows the history of shark quotas adjusted for under and overharvest.

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

No.

6.0 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 13 **Annual commercial Atlantic sharpnose and bonnethead shark regulatory summary (managed within the SCS complex).**

Note: Regions = Gulf of Mexico, South Atlantic, and North Atlantic.

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

2009	454 mt dw	One region; calendar year	No trip limit for SCS/pelagics for directed permit holders; 16 SCS & pelagic sharks combined/trip for incidental permit holders
2010	212.6 mt dw	One region; calendar year	No trip limit for SCS/pelagics for directed permit holders; 16 SCS & pelagic sharks combined/trip for incidental permit holders
2011	212.6 mt dw	One region; calendar year	No trip limit for SCS/pelagics for directed permit holders; 16 SCS & pelagic sharks combined/trip for incidental permit holders
2012	212.6 mt dw	One region; calendar year	No trip limit for SCS/pelagics for directed permit holders; 16 SCS & pelagic sharks combined/trip for incidental permit holders

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

**Sharks required to be offloaded with all fins naturally attached under Amendment 2 and in subsequent years.

Table 14 **Annual recreational Atlantic Sharpnose and Bonnethead shark regulatory summary (managed within the SCS complex).**

Year	Fishing Year	Size/Bag Limit
1993	Calendar Year	5 SCS sharks/person, no size limit
1994	Calendar Year	
1995	Calendar Year	
1996	Calendar Year	
1997	Calendar Year	2 LCS/SCS/pelagic sharks combined/vessel, no size limit
1998	Calendar Year	
1999	Calendar Year	1 shark, any species, per vessel per trip greater than 54" FL and 1 Atlantic sharpnose per person per trip (no minimum size)
2000	Calendar Year	
2001	Calendar Year	
2002	Calendar Year	
2003	Calendar Year	
2004	Calendar Year	1 shark, any species, per vessel per trip greater than 54" FL and 1 Atlantic sharpnose and 1 bonnethead per person per trip (no minimum size)
2005	Calendar Year	
2006	Calendar Year	
2007	Calendar Year	
2008	Calendar Year	
2009	Calendar Year	
2010	Calendar Year	
2011	Calendar Year	
2012	Calendar Year	

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Drafted by MLC 2-27-2013

Edits per kbg 3-1-2013

Table 7. State Regulatory History

The following tables include the relevant shark management history for Atlantic and Gulf of Mexico states (including the Commonwealth of Puerto Rico). "Confirmed by state" is related to an information request that was sent to individual states in conjunction with the HMS SAFE Report in 2012. States replying "yes" responded to the information request and confirmed information on the current regulations but were unwilling to confirm past regulations. States replying "no" did not reply to confirm current or historical regulations.

State	**Texas**
***Confirmed by State?**	Yes
pre-1995	Sept. 1989: Bag limit set at five sharks per day for both rec and commercial anglers; Sept 1992: Bag limit increased to ten sharks per day. Trotlines were added as allowable gear for sharks.
1996	no new shark regulations
1997	1997: Commercial bag limit of 5 sharks; possession limit of 10 sharks; no min or max size. Recreational bag, possession, and lack of size restrictions same as commercial
1998	1998: commercial fishing for sharks can only be done with rod and reel; no entanglement nets
1999	no new shark regulations
2000	no new shark regulations
2001	no new shark regulations
2002	no new shark regulations
2003	no new shark regulations
2004	Sept: Commercial/Recreational retention limit 1 fish/person/day; Commercial/Recreational possession limit is twice the daily bag limit (i.e., 1 fish/person/day); Commercial/Recreational minimum size 24 in TL
2005	no new shark regulations
2006	By May 2006: no new shark regulations
2007	no new shark regulations
2008	no new shark regulations
2009	Sept: Min size 24" TL for Atlantic sharpnose, blacktip, and bonnethead sharks and 64" TL for all other lawful sharks. Bag limit is 1 shark/person/day, Possession limit is 2 sharks/person; Prohibited species: same as federal regulations
2010	no new shark regulations
2011	no new shark regulations
2012	no new shark regulations

State	**Louisiana**
Confirmed by State?	No
pre-1995	no new shark regulations
1996	no new shark regulations
1997	Ban on entanglement nets

1998	no new shark regulations
1999	no new shark regulations
2000	no new shark regulations
2001	no new shark regulations
2002	no new shark regulations
2003	no new shark regulations
2004	By Feb 2004: Minimum size - 54" except sharpnose; Possession limit - 1 fish/vessel/trip; Trip limit 4,000 lbs dw LCS; Reference to federal regulations; State waters closed to rec/commercial April 1 through June 30
2005	no new shark regulations
2006	By May 2006: Recreational: min size – 54" FL, except Atlantic sharpnose and bonnethead; bag limit - 1 sharpnose/person/day; all other sharks – 1 fish/person/day; Commercial: 4,000 lb LCS trip limit, no min size; Com & Rec Harvest Prohibited: 4/1-6/30; Prohibition: same as federal regulations
2007	no new shark regulations
2008	By Oct 2008: Commercial: 33 per vessel per trip limit, no min size
2009	no new shark regulations
2010	no new shark regulations
2011	no new shark regulations
2012	No minimum size for bonnethead/sharpnose; 1 sharpnose or bonnethead/person/day.

State	**Mississippi**
Confirmed by State?	No
pre-1995	no new shark regulations
1996	no new shark regulations
1997	prohibit taking and possession of sand tiger, bigeye sand tiger, whale, basking, and white sharks; Recreational: bag limit of 4 small coastal sharks (Atlantic sharpnose, Caribbean sharpnose, finetooth, blacknose, smalltail, bonnethead and Atlantic angel shark) per person per day; limit of 3 large coastal and pelagic sharks, in aggregate per vessel per day, same prohibited species as commercial fishers; minimum size of 25 inches total length for small coastal sharks and 37 inches total length for large coastal sharks
1998	no new shark regulations
1999	no new shark regulations
2000	no new shark regulations
2001	no new shark regulations
2002	no new shark regulations
2003	no new shark regulations
2004	By Feb 2004: no new shark regulations
2005	no new shark regulations
2006	By May 2006: no new shark regulations

2007	no new shark regulations
2008	By Oct 2008: Recreational bag limit - LCS/Pelagics 1/person up to 3/vessel; SCS 4/person; Commercial & Prohibited Species - Reference to federal regulations
2009	no new shark regulations
2010	no new shark regulations
2011	SCS minimum size is 25" TL; SCS bag limit is 4/person (possession)
2012	no new shark regulations

State	**Alabama**
Confirmed by State?	No
pre-1995	no new shark regulations
1996	First shark regulations implemented: state shark fishery closes with the federal shark fishery
1997	no new shark regulations
1998	By 1998: only short lines in state waters; time/area and size restrictions on the recreational use of gillnets
1999	no new shark regulations
2000	no new shark regulations
2001	no new shark regulations
2002	no new shark regulations
2003	no new shark regulations
2004	By Feb 2004: Recreational daily bag limit - 2 sharpnose/person/day; all other species - 1fish/person/day; Recreational minimum size all sharks (except sharpnose) - 54" FL
2005	no new shark regulations
2006	By May 2006: Recreational & Commercial non-sharpnose min size – 54” FL or 30” dressed; Prohibition: Atlantic angel, bigeye thresher, dusky, longfin make, sand tiger, basking, whale, white, and nurse sharks
2007	no new shark regulations
2008	no new shark regulations
2009	Recreational & commercial sharpnose bag limit dropped to 1 sharpnose per person per day; no shark fishing on weekends, Memorial Day, Independence Day, or Labor Day
2010	no new shark regulations
2011	Recreational and commercial: 1 sharpnose/person/day and 1 bonnethead person/day (no min size); state waters close when Federal waters close; regardless of open or closed shark season gillnet fishermen targetting other species may retain wharks with a dressed weight not exceeding 10% of total catch
2012	no new shark regulations

State	Florida
Confirmed by State?	Yes
pre-1995	1992: first shark-specific regulations: must hold federal shark permit; commercial and recreational possession limit of 1 shark per person per day or 2 sharks per vessel per day, whichever is less (virtually no commercial shark fishery in state waters); prohibition on landing fins withour corresponding carcass; released sharks should be released in a manner that maximizes survival; recreationally caught sharks cannot be transerred at sea; recreatioanlly cuagth sharks cannot be sold; prohibition on harvest, landing and sale of basking and whale sharks; state shark fishery closes with federal shark fishery; 1994: prior to landing, fins cannot be removed from a shark harvested in state waters; fishermen returning from federal waters with sharks or shark parts harvested in federal waters, cannot fish in state waters; 1995: ban on the use of entanglement nets larger than 500 square feet
1996	no new shark regulations
1997	no new shark regulations
1998	By 1998: ban on longlines; 1998: Added sand tiger, bigeye sandtiger, and white sharks to prohibited species list; prohibition on filleting sharks at sea.
1999	no new shark regulations
2000	no new shark regulations
2001	no new shark regulations
2002	no new shark regulations
2003	no new shark regulations
2004	no new shark regulations
2005	no new shark regulations
2006	March: Same prohibited species as federal regulations, except Caribbean sharpnose is not included
2007	no new shark regulations
2008	no new shark regulations
2009	no new shark regulations
2010	Jan: Commercial/recreational min size – 54” except no min. size on blacknose, blacktip, bonnethead, smooth dogfish, finetooth, Atlantic sharpnose; Commercial/recreational possession limit: 1 shark/person/day max 2 sharks/vessel with 2 or more persons onboard; Allowable gear – hook and line only; prohibtion on the removal of shark heads and tails in state waters; prohibition on harvest of sandbar, silky, and Caribbean sharpnose sharks in state waters; March: prohibition on all harvest of lemon sharks in state waters.
2011	no new shark regulations
2012	Prohibition on harvest of tiger sharks and all hammerhead sharks effective January 1, 2012

State	Georgia
Confirmed by State?	Yes
pre-1995	1950s: ban on gillnets and longlines; All finfish spp. must be landed with head and fins intact

1996	no new shark regulations
1997	no new shark regulations
1998	First shark regulation: prohibition on taking sand tiger sharks; Small Shark Composite (Atl. Sharpnose, bonnethead, spiny dogfish) 30"TL min. size;Creel: 2/person/day All other sharks 2/person/day or 2 /boat/day, whichever is less. 54"TL min. size, only one shark over 84" TL
1999	no new shark regulations
2000	Sharks may not be landed in Georgia if harvested using gillnets
2001	no new shark regulations
2002	no new shark regulations
2003	no new shark regulations
2004	no new shark regulations
2005	no new shark regulations
2006	no new shark regulations
2007	no new shark regulations
2008	no new shark regulations
2009	Recreational: 1 shark from the Small Shark Composite (bonnethead, sharpnose, and spiny dogfish, min size 30" FL; All other sharks - 1 shark/person or boat, whichever is less, min size 54" FL, Prohibited Species: sand tiger sharks, sandbar, silky, bigeye sandtiger, whale, basking, white, dusky, bignose, Galapagos, night, reef, narrowtooth, Caribbean sharpnose, smalltail, Atlantic angel, longfin mako, bigeye thresher, sharpnose sevengill, bluntnose sixgill, and bigeye sixgill.
2010	no new shark regulations
2011	Commercial/Recreational: 2/person/day for bonnethead and sharpnose; minimum size is 30"FL; No gillnets in GA state waters
2012	Commercial/Recreational: 1/person/day for bonnethead and sharpnose

State	**South Carolina**
Confirmed by State?	No
pre-1995	no new shark regulations
1996	no new shark regulations
1997	no new shark regulations
1998	By 1998: federal regs adopted by reference; use of gillnets prohibited in the shark fishery
1999	no new shark regulations
2000	no new shark regulations
2001	no new shark regulations
2002	no new shark regulations
2003	no new shark regulations
2004	By Feb 2004: retention limit of 2 Atlantic sharpnose per person per day and 1 bonnethead per person per day; no min size for recreationally caught bonnethead sharks; reference to federal commercial regulations and closures
2005	no new shark regulations
2006	By May 2006: non-Atlantic sharpnose/bonnethead sharks – 1 shark/boat/trip, min size – 54" FL
2007	no new shark regulations
2008	no new shark regulations
2009	No new shark regulations
2010	no new shark regulations
2011	Defer to Federal regulations; no gillnets in state waters; state permit required for fishing in state waters
2012	no new shark regulations

State	North Carolina
Confirmed by State?	Yes
pre-1995	1990: prohibition on finning 1990 – 7500 lbs per trip, dogfish exempt; unlawful to land fins without carcass; fins no more than 10%; unlawful to land dried fins; required record keeping; Recreational - bag limit is 2 per day 1992 – Reduced fins to no more than 7%
1996	no new shark regulations
1997	No sharks, except Atlantic sharpnose and pelagic sharks, can be taken by commercial gear in state waters; fins must be landed with the carcass; maximum 5% fin-to-carcass ratio; fishers cannot posses or land dried shark fins
1998	No new shark regulations
1999	No new shark regulations
2000	One shark per vessel per day with commercial gear (except Atlantic sharpnose and dogfish) while federal waters are open for species group; 84 inch maximum size limit except for tiger, thresher, bigeye thresher, shortfin mako and hammerhead species; must be landed with head, tail and fins intact; Recreational – bag limit is 1 per person per day with a minimum size of 54" (none on Atlantic sharpnose) and a maximum of 84" (except for tiger, thresher, bigeye thresher, shortfin mako and hammerhead species); Prohibited species – basking, white, sand tiger and whale sharks
2001	No new shark regulations
2002	No new shark regulations
2003	April: Prohibited ridgebacks (sandbar, silky, and tiger sharks) from Large Coastal Group
2004	no new shark regulations
2005	no new shark regulations
2006	Open seasons and species groups same as federal; 4000 lb trip limit for LCS; retain fins with carcass through point of landing; longline shall only be used to harvest LCS during open season, shall not exceed 500 yds or have more than 50 hooks (state waters reopened to commercial fishing); Recreational: LCS (54" FL min size) - no more than 1 shark/vessel/day or 1 shark/person/day, SCS (no min size) – no more than 1 finetooth or blacknose shark/vessel/day and no more than 1 Atlantic sharpnose and 1 bonnethead/person/day, pelagics (no min size) -1 shark/vessel/day; Same prohibited shark species as federal regulations
2007	no new shark regulations
2008	July: Adopted federal regulations of 33 Large Coastal sharks per trip and fins must be naturally attached to carcass
2009	Fins must be naturally attached to shark carcass
2010	no new shark regulations
2011	Director may impose restrictions for size, seasons, area, quantity, etc. via proclamation. ASMFC plan.
2012	no new shark regulations

State	Virginia
Confirmed by State?	No
pre-1995	1991: no longlines in state waters; recreational bag limit of 1 shark per person per day; established a commercial trip limit of___; 1993: mandatory reporting of all shark landings
1996	no new shark regulations
1997	7500 lb commercial trip limit; minimum size of 58 inches FL or 31 inches carcass length (but can keep up to 200 lbs dw of sharks per day less than 31 inches carcass length); prohibition on finning; recreational: possession limit of 1 shark per person per day
1998	By 1998: no longlining in state waters
1999	no new shark regulations
2000	no new shark regulations
2001	no new shark regulations
2002	no new shark regulations
2003	no new shark regulations
2004	no new shark regulations
2005	no new shark regulations
2006	By May 2006: Recreational: bag limit – 1 LCS, SCS, or pelagic shark/vessel/day with a min size of 54" FL or 30" CL; 1 Atlantic sharpnose and bonnethead/person/day with no min size; Commercial: possession limit - 4000 lb dw/day, min size - 58" FL or 31" CL west of the COLREGS line and no min size limit east of the COLREGS line; Prohibitions: fillet at sea, finning, longlining, same prohibited shark species as federal regulations
2007	no new shark regulations
2008	no new shark regulations
2009	ASMFC Plan
2010	no new shark regulations
2011	no new shark regulations
2012	no new shark regulations

State	Maryland
Confirmed by State?	No
pre-1995	no new shark regulations
1996	4000 lb shark limit per person per day; fins must accompany carcass and not exceed 5% fin-to-carcass ratio, state shark fishery closes with federal shark fishery
1997	no new shark regulations
1998	Size limit of 58 inches FL or a carcass less than 31 inches; recreational bag limit of one shark per person per day; by 1998: maximum gillnet mesh size of 6 inches; no longlining in tidal waters.
1999	no new shark regulations
2000	no new shark regulations
2001	no new shark regulations
2002	no new shark regulations
2003	no new shark regulations
2004	By Feb 2004: minimum FL reduced to 54 inches, carcass length the same (31 inches); recreational catch limit of 1 shark per person per day; reference to federal regs 50 CFR 635.
2005	no new shark regulations
2006	By May 2006: no new shark regulations
2007	no new shark regulations
2008	By Oct 2008: no new shark regulations
2009	ASMFC Plan
2010	no new shark regulations
2011	no new shark regulations
2012	no new shark regulations

State	Delaware
Confirmed by State?	Yes
pre-1995	no new shark regulations
1996	no new shark regulations
1997	no new shark regulations
1998	Commercial shark fishermen must hold a federal shark permit even when fishing in state waters, therefore, state regulations match federal regulations; sharks must be landed with meat and fins intact, but head can be removed; any shark not kept must be released in a manner that maximizes survival; taking of basking, white, whale, sand tiger, and bigeye sand tiger prohibited; seasonal gillnet restrictions. Recreational regulations: no more than two sharks per vessel except that 2 sharpnose can also be landed; prohibition on finning and filleting or taking of the 5 prohibited species
1999	no new shark regulations
2000	Creel limit on regulated sharks of 1 shark per vessel per day; creel limit for sharpnose is 2 sharks per day; minimum size on regulated sharks is 54 inches FL; fins must be naturally attached; 14 prohibited species added (Atlantic angel shark, bigeye sixgill shark, bigeye thresher, bignose shark, Caribbean reef shark, Caribbean sharpnose shark, dusky shark, Galapagos shark, longfin mako, narrowtooth shark, night shark, sevengill shark, sixgill shark, smalltail shark)
2001	no new shark regulations
2002	no new shark regulations
2003	no new shark regulations
2004	no new shark regulations
2005	no new shark regulations
2006	no new shark regulations
2007	no new shark regulations
2008	no new shark regulations
2009	ASMFC Plan
2010	no new shark regulations
2011	no new shark regulations
2012	no new shark regulations

State	New Jersey
Confirmed by State?	No
pre-1995	no new shark regulations
1996	no new shark regulations
1997	no new shark regulations
1998	No shark-specific regulations; by 1998: no longline fishing; restrictions on the use of gillnets
1999	no new shark regulations
2000	no new shark regulations

State	New Jersey
2001	no new shark regulations
2002	no new shark regulations
2003	no new shark regulations
2004	By Feb 2004: commercial/recreational possession limit of 2 sharks per vessel; prohibition on finning; dorsal fin to pre-caudal pit must be at least 23 inches in length; total length must be 48 inches in length
2005	no new shark regulations
2006	By May 2006: no sale during federal closures; Finning prohibited; Prohibited Species: basking, bigeye sand tiger, sand tiger, whale and white sharks
2007	no new shark regulations
2008	By Oct 2008: no new shark regulations
2009	ASMFC Plan
2010	no new shark regulations
2011	no new shark regulations
2012	no new shark regulations

State	New York
Confirmed by State?	No
pre-1995	no new shark regulations
1996	no new shark regulations
1997	no new shark regulations
1998	By 1998: prohibition on finning sharks; no other shark regulations
1999	no new shark regulations
2000	no new shark regulations
2001	no new shark regulations
2002	no new shark regulations
2003	no new shark regulations
2004	By Feb 2004: reference to federal regs 50 CFR part 635; prohibited sharks listed
2005	no new shark regulations
2006	By May 2006: no new shark regulations
2007	no new shark regulations
2008	By Oct 2008: no new shark regulations
2009	no new shark regulations
2010	ASMFC plan
2011	no new shark regulations
2012	no new shark regulations

State	Connecticut
Confirmed by State?	Yes
pre-1995	no new shark regulations
1996	no new shark regulations
1997	no new shark regulations
1998	no new shark regulations
1999	no new shark regulations
2000	no new shark regulations
2001	no new shark regulations
2002	no new shark regulations
2003	no new shark regulations
2004	no new shark regulations
2005	no new shark regulations
2006	no new shark regulations
2007	no new shark regulations
2008	no new shark regulations
2009	July: No possession or landing of large coastal shark species by any commercial fishing gear or for commercial purposes.
2010	Feb: Commercial possession of prohibited Small Coastal Sharks: Atlantic sharpnose, finetooth, blacknose, bonnethead until a 2010 quota is set by NMFS; Sandbar shark take prohibited in the commercial and recreational fisheries per ASMFC FMP except under Scientific Collection Permit
2011	Prohibited species same as Federal regulations; No commercial SCS fishing until further notice
2012	no new shark regulations

State	Rhode Island
Confirmed by State?	No
pre-1995	no new shark regulations
1996	no new shark regulations
1997	no new shark regulations
1998	no new shark regulations
1999	no new shark regulations
2000	no new shark regulations
2001	no new shark regulations
2002	no new shark regulations
2003	no new shark regulations
2004	no new shark regulations
2005	no new shark regulations

2006	no new shark regulations
2007	no new shark regulations
2008	no new shark regulations
2009	no new shark regulations
2010	ASMFC plan
2011	no new shark regulations
2012	no new shark regulations

State	**Massachusetts**
Confirmed by State?	No
pre-1995	no new shark regulations
1996	no new shark regulations
1997	no new shark regulations
1998	no new shark regulations
1999	no new shark regulations
2000	no new shark regulations
2001	no new shark regulations
2002	no new shark regulations
2003	no new shark regulations
2004	no new shark regulations
2005	no new shark regulations
2006	By May 2006: Prohibition on harvest, catch, take, possession, transportation, selling or offer to sell any basking, dusky, sand tiger, or white sharks.
2007	no new shark regulations
2008	By Oct 2008: no new shark regulations
2009	no new shark regulations
2010	no new shark regulations
2011	no new shark regulations
2012	no new shark regulations

State	**New Hampshire**
Confirmed by State?	No
pre-1995	no new shark regulations
1996	no new shark regulations
1997	no new shark regulations
1998	no new shark regulations
1999	no new shark regulations
2000	no new shark regulations
2001	no new shark regulations
2002	no new shark regulations

State	**New Hampshire**
2003	no new shark regulations
2004	no new shark regulations
2005	no new shark regulations
2006	no new shark regulations
2007	no new shark regulations
2008	no new shark regulations
2009	No commercial take of porbeagle
2010	no new shark regulations
2011	no new shark regulations
2012	no new shark regulations

State	**Maine**
Confirmed by State?	No
pre-1995	no new shark regulations
1996	no new shark regulations
1997	no new shark regulations
1998	By 1998: large state water closures to gillnets resulting in virtually no gillnet fishery; 1998: no shark regulations
1999	no new shark regulations
2000	no new shark regulations
2001	no new shark regulations
2002	no new shark regulations
2003	no new shark regulations
2004	no new shark regulations
2005	no new shark regulations
2006	no new shark regulations
2007	no new shark regulations
2008	no new shark regulations
2009	Maximum 5 % fin-to-carcass ratio
2010	no new shark regulations
2011	Prohibited species same as Federal regulations; fins attached
2012	Commercial harvest of sharks prohibited in state waters; Rec anglers must possess HMS Angling permit

State	**Puerto Rico**
Confirmed by State?	Yes
pre-1995	no new shark regulations
1996	no new shark regulations
1997	no new shark regulations
1998	no new shark regulations

1999	no new shark regulations
2000	no new shark regulations
2001	no new shark regulations
2002	no new shark regulations
2003	no new shark regulations
2004	Year-round closed season on nurse sharks Shark "finning" is prohibited. PR regulations indicate the need for compliance by local fishers with federal shark regulations.
2005	no new shark regulations
2006	no new shark regulations
2007	no new shark regulations
2008	no new shark regulations
2009	no new shark regulations
2010	no new shark regulations
2011	no new shark regulations
2012	no new shark regulations

3. ASSESSMENT HISTORY AND REVIEW

The bonnethead shark was first assessed individually in 2002 (Cortés 2002) and later in 2007. Prior to that, it was part of the Small Coastal Shark complex, which was first assessed in 1991 and not again until 2002. In 2002, results of Bayesian surplus production (BSP; McAllister and Babcock 2004) and lagged recruitment, survival and growth (LRSG; Hilborn and Mangel 1997) models determined that the stock was not overfished and overfishing was not occurring.

The first assessment of bonnethead sharks under the SEDAR framework was conducted in 2007 (SEDAR 13, NMFS 2007). Although three models were initially presented, it was decided that an age-structured production model (SSASPM; Porch 2002) would be used as the base model given that catch and age-specific biological and selectivity information had become available. The 2007 assessment concluded that the stock was not overfished (SSF_{2005}/SSF_{MSY}=0.99-1.13; range of base and sensitivity model runs) and overfishing was not occurring (F_{2005}/F_{MSY}=0.61-0.64; range of base and sensitivity model runs). However, there was concern that F_{2005} might not accurately depict stock status with respect to overfishing given the variability in estimates of F in the most recent years of the time series (which oscillated above and below the MSY level). The main changes between the 2002 and 2007 assessments included differences in the CPUE series used, inclusion of bycatch estimates from the shrimp trawl fishery as well as fleet-specific catch streams, the use of age-specific biological and selectivity information, and the use of different assessment methods.

References

Cortés, E. 2002. Stock assessment of small coastal sharks in the U.S. Atlantic and Gulf of Mexico. Sustainable Fisheries Division Contribution SFD-01/02-152. 133 pp.

Hilborn, R. and M. Mangel. 1997. The Ecological Detective. Monographs in Population Biology 28. Princeton University Press, Princeton, New Jersey.

McAllister, M.K., and E.A. Babcock. 2004. Bayesian surplus production model with the Sampling Importance Resampling algorithm (BSP): a user's guide. May 2004. Available from ICCAT: www.iccat.int.

NMFS (National Marine Fisheries Service). 2007. Southeast Data, Assessment and Review (SEDAR) 13. Small Coastal Shark complex, Atlantic sharpnose, blacknose, bonnethead, and finetooth shark stock assessment report. NOAA/NMFS Highly Migratory Species Division, Silver Spring, MD.

Porch, C. E. 2002. A preliminary assessment of Atlantic white marlin (*Tetrapturus albidus*) using a state-space implementation of an age-structured model. SCRS/02/68 23pp.

4. SEDAR ABBREVIATIONS

ABC	Allowable Biological Catch
ACCSP	Atlantic Coastal Cooperative Statistics Program
ADMB	AD Model Builder software program
ALS	Accumulated Landings System; SEFSC fisheries data collection program
AMRD	Alabama Marine Resources Division
ASMFC	Atlantic States Marine Fisheries Commission
B	stock biomass level
BAM	Beaufort Assessment Model
BMSY	value of B capable of producing MSY on a continuing basis
CFMC	Caribbean Fishery Management Council
CIE	Center for Independent Experts
CPUE	catch per unit of effort

EEZ	exclusive economic zone
F	fishing mortality (instantaneous)
FMSY	fishing mortality to produce MSY under equilibrium conditions
FOY	fishing mortality rate to produce Optimum Yield under equilibrium
FXX% SPR	fishing mortality rate that will result in retaining XX% of the maximum spawning production under equilibrium conditions
FMAX	fishing mortality that maximizes the average weight yield per fish recruited to the fishery
F0	a fishing mortality close to, but slightly less than, Fmax
FL FWCC	Florida Fish and Wildlife Conservation Commission
FWRI	(State of) Florida Fish and Wildlife Research Institute
GA DNR	Georgia Department of Natural Resources
GLM	general linear model
GMFMC	Gulf of Mexico Fishery Management Council
GSMFC	Gulf States Marine Fisheries Commission
GULF FIN	GSMFC Fisheries Information Network
HMS	Highly Migratory Species
LDWF	Louisiana Department of Wildlife and Fisheries
LGL	LGL Ecological Research Associates
M	natural mortality (instantaneous)
MARMAP	Marine Resources Monitoring, Assessment, and Prediction
MCC	Mary Christman Consulting
MDMR	Mississippi Department of Marine Resources
MFMT	maximum fishing mortality threshold, a value of F above which overfishing is deemed to be occurring
MRFSS	Marine Recreational Fisheries Statistics Survey; combines a telephone survey of households to estimate number of trips with creel surveys to estimate catch and effort per trip
MRIP	Marine Recreational Information Program
MSST	minimum stock size threshold, a value of B below which the stock is deemed to be overfished

MSY	maximum sustainable yield
NC DMF	North Carolina Division of Marine Fisheries
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
OY	optimum yield
SAFMC	South Atlantic Fishery Management Council
SAS	Statistical Analysis Software, SAS Corporation
SC DNR	South Carolina Department of Natural Resources
SEAMAP	Southeast Area Monitoring and Assessment Program
SEDAR	Southeast Data, Assessment and Review
SEFIS	Southeast Fishery-Independent Survey
SEFSC	Fisheries Southeast Fisheries Science Center, National Marine Fisheries Service
SERO	Fisheries Southeast Regional Office, National Marine Fisheries Service
SPR	spawning potential ratio, stock biomass relative to an unfished state of the stock
SSB	Spawning Stock Biomass
SS	Stock Synthesis
SSC	Science and Statistics Committee
TIP	Trip Incident Program; biological data collection program of the SEFSC and Southeast States.
TPWD	Texas Parks and Wildlife Department
Z	total mortality, the sum of M and F

SEDAR

Southeast Data, Assessment, and Review

SEDAR 34

HMS Bonnethead Shark

Assessment Report

September 2013

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

EXECUTIVE SUMMARY

The bonnethead shark is a common, inshore, small coastal sphyrnid species ranging from the Yucatán Peninsula in the Gulf of Mexico to North Carolina in the western North Atlantic Ocean. Tagging and genetic studies show bonnethead movement between the Gulf of Mexico and Atlantic Ocean is minimal, indicating that there are likely two separate stocks. Given that this was a standard assessment, the Panel was limited in changing major assumptions, including splitting the stock. Although some panel members discussed postponing the assessment until two separate stocks could be assessed in a benchmark assessment as soon as possible, the Panel ultimately decided to move forward with the assessment of a single Atlantic and Gulf of Mexico stock in order to provide management with some guidance on the status of this species. A new growth curve and maximum age for the combined Atlantic Ocean and Gulf of Mexico stock were used (maximum age increased to 18 yr compared to 12 yr in the previous assessment) as well as a new maturity ogive and litter size. Based on this new life history information, natural mortality estimates were also updated using several life history invariant methods.

The state-space, age-structured production model (SSASPM) was used as the assessment modeling approach, as in the previous assessment (SEDAR 13 conducted in 2007). This model considers two periods: a more data-poor "historic period" when only catch and/or effort data are available and a "modern period" when more data (e.g., CPUE indices) become available for model fitting. The base model configuration assumed virgin conditions in 1950 (as in SEDAR 13), a historic period spanning 1950-1971, a modern period spanning 1972-2011, it used a historical reconstructed catch series and updated catch series, updated biological parameters, and nine CPUE indices, the earliest of which started in 1972. Estimated model parameters were pup (age-0) survival, virgin recruitment (R_0), catchability coefficients associated with the indices, and fleet-specific effort.

Five catch streams were included: three commercial series (bottom longline, gillnets, and lines), recreational catches, and shrimp bycatch. Because of misgivings with model-generated estimates of bycatch in the shrimp trawl fishery, the Panel opted to use stratified nominal estimates instead. Other changes with respect to the previous assessment included using recreational MRIP estimates instead of MRFSS and adding post-release live discard mortality estimates for the recreational and the three commercial series. A total of nine indices of relative

abundance, all standardized through Generalized Linear Modeling techniques, were recommended for use by the Panel; only one index was fishery dependent. Age-specific selectivity was estimated externally to the model after converting lengths from the different surveys and fisheries into ages through the von Bertalanffy growth curve. A total of six selectivity curves, four flat-topped and two dome-shaped, were assigned to the indices and catch series.

In addition to computing asymptotic standard errors for estimated parameters, scientific uncertainty was incorporated through likelihood profiling to examine distributions for several model parameters and provide approximate probabilities of the stock being overfished and overfishing occurring. Uncertainty in data inputs and model configuration was examined through sensitivity scenarios, the majority of which also represented alternative plausible “states of nature” and were further used in stock projections. Sensitivity runs included using indices with increasing or decreasing trends only, considering a lower bycatch, using a hierarchical index of relative abundance, using a single index that was well fit in the base run, including no indices, starting the model later (in 1972 vs. 1950), considering a more, or less, productive stock, and using the Gulf of Mexico biology, or alternatively, the Atlantic biology, for the combined stock. Three weighting schemes of the CPUE series were trialed (equal weighting, inverse CV weighting, and rank weighting), with inverse CV weighting providing the best fit and being used in all sensitivity runs. A historical analysis comparing results of the current assessment to those from assessments conducted in 2002 and 2007 was also included as well as a retrospective analysis to look for systematic bias in key model output quantities over time.

Catches were dominated by the shrimp trawl discards, which progressively increased up to 2000 and experienced a sharp decline thereafter. The model fit a central tendency through most of the indices and fit some, or at least portions, fairly well while others were hard to fit given large interannual fluctuations in most cases. In general, the fits showed a rather flat tendency prior to the onset of the first index in 1972, followed by a decreasing tendency to about 2002, and then an increasing trend in the last decade. Consequently, predicted abundance and spawning stock fecundity (SSF; defined as numbers x proportion mature x fecundity in numbers) showed slight depletion from 1950 to the beginning of the modern period in 1972, followed by a decreasing trend through the late 1990s, and a progressive increase in the last decade, which corresponds to decreased effort and catches in the shrimp trawl fishery and a majority of the indices of relative abundance showing increasing tendencies in those years. As expected, fishing mortality was dominated by the shrimp trawl fleet and exceeded the estimated F_{MSY} of 0.202 in the baseline run from 1981 to 2004. The contribution of the remaining fleets to total F was much smaller, with the commercial gillnet fleet showing some higher values in the first half of the 1990s. Fishing mortality was lower in the past decade in accordance with decreased shrimp trawl effort and catches during that period. The model estimated a productive stock, with a steepness of 0.66 and current abundance/SSF on the order of 5-6 million animals. The median for the posterior of pup survival was higher than the prior (0.88 vs. 0.77 in the base run), whereas the posterior for virgin recruitment of pups (R_0 ~ 1.8 million animals in the base run) was informative in contrast to its diffuse uniform prior.

The results of the assessment were rather robust to structural assumptions of the model, but in several sensitivity runs the stock was overfished (SSF_{2011}/SSF_{MSY} = 0.12 to 0.73 with $Pr(SSF_{2011}/SSF_{MSST})$=0.56 to 0.99 for the runs using decreasing indices, no indices, or the Atlantic biology) and overfishing was occurring (F_{2011}/F_{MSY} = 1.09 to 3.74 with Pr=0.48 to 0.99 for the runs using no indices or the Atlantic biology) in 2011. All the remaining runs predicted that the stock was not overfished (SF_{2011}/SSF_{MSY} = 1.06 to 1.48 with $Pr(SSF_{2011}/SSF_{MSST})$=0.79 to 0.97) and overfishing was not occurring (F_{2011}/F_{MSY}=0.45 to 0.64 with Pr=0.68 to 0.95) in 2011. The retrospective analysis found no systematic pattern of over- or under-estimation of abundance, relative abundance, or fishing mortality. The continuity analysis found that the stock would not be overfished (SSF_{2011}/SSF_{MSY} = 1.01 with $Pr(SSF_{2011}/SSF_{MSST})$=0.90) but overfishing would be occurring (F_{2011}/F_{MSY}=1.37 with Pr=0.67) if six years of catch and index data were added to the inputs used in the 2007 assessment. Despite significant differences between the inputs used in the 2002 and 2007 assessments and the current assessment, stock status did not change substantially. However, the Panel stressed that there is strong evidence for two separate stocks and strongly recommended that a benchmark assessment for two separate stocks of bonnethead shark be undertaken as soon as possible.

Probabilistic projections at alternative fixed harvest levels were used to provide an approach for reducing the overfishing limit (OFL) to account for scientific uncertainty within individual SSASPM model configurations. Multiple projection scenarios were evaluated with probabilistic projections in an attempt to reflect the full range of plausible states of nature.

Among the multiple projection scenarios evaluated, examples of fixed levels of total annual removals due to fishing during the years 2015 – 2041 which resulted in both the $Pr(SSF_t > SSF_{MSY}) \geq 70\%$, and the $Pr(F_t > F_{MSY}) \leq 30\%$ in the year 2041 from 10,000 Monte Carlo bootstrap projections ranged from 200,000 to 550,000 sharks. The median buffer (percent decrease) from OFL using this approach was 26%. These values represent a proxy P* approach (based on probabilistic projections at alternative fixed levels of removals) used here to determine the removals associated with a 70% probability of overfishing not occurring (P* = 0.3).

Table of Contents

1. WORKSHOP PROCEEDINGS

1.1. INTRODUCTION

1.1.1. Workshop time and Place

The SEDAR 34 Atlantic Sharpnose and Bonnethead Shark Workshop was held June 25-27, 2013 in Panama City, Florida. In addition to the workshop, several additional webinars were conducted between July and September 2013 to finalize the assessment.

1.1.2. Terms of Reference

1. Update the approved SEDAR 13 Bonnethead Shark model with data through 2011. 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 information (age and growth and reproductive parameters)
    b. Evaluate fishery-independent abundance indices derived for Mississippi, Alabama, Georgia, and South Carolina
    c. Evaluate MRFSS/MRIP conversion factors
    d. Evaluate commercial and recreational 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 numbers and weight. Provide available average weights by gear and year used to derive average number of fish calculations.
4. Update model parameter estimates and their variances, model uncertainties, and estimates of stock status and management benchmarks. In addition to the base model, conduct sensitivity analysis to address uncertainty in data inputs and model configuration and consider runs that represent plausible, alternate states of nature.
5. Project future stock conditions regardless of the status of the stock. Develop rebuilding schedules, if warranted. Provide the estimated generation time for each unit stock. Stock projections shall be developed in accordance with the following:

    A) If the stock is overfished, then utilize projections to determine:
    • Year in which F=0 results in a 70% probability of rebuilding (Year F=0p70)
    • Target rebuilding year (Year F=0p70 + 1 generation time) (Yearrebuild)

- F resulting in 50% and 70% probability of rebuilding by Yearrebuild
- Fixed level or removals (TAC) allowing rebuilding of stock with 50% and 70% probability

B) Otherwise, utilize a P* approach to determine:
- The F needed and corresponding removals associated with a 70% probability of overfishing not occurring (P* = 0.3)

C) If data-limitations preclude classic projections (i.e. A, B above), explore alternate projection models to provide management advice.

6. 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
Dean Courtney, Co-Lead Analyst .... NMFS Panama City
Xinsheng Zhang, Support Analyst .... NMFS Panama City
Beth Babcock .... RSMAS
Peter Barile .... Marine Resources & Consulting
Carolyn Belcher .... GA DNR
Jeanne Boylan .... SC DNR
Walter Bubley .... TXDPW
John Carlson .... NMFS Panama City
Trey Driggers .... NMFS Pascagoula
Marcus Drymon .... DISL
Bryan Frazier .... SC DNR
Dean Grubbs .... FSU
Marin Hawk .... ASMFC
Eric Hoffmayer .... NMFS Pascagoula
Bob Hueter .... Mote Marine Lab
Robert Latour .... VIMS
Cami McCandless .... NMFS Narragansett
Adam Pollack .... NMFS Pascagoula
David Stiller .... Industry Representative

Analytic Support

Dana Bethea .... NMFS Panama City
Simon Gulak .... NMFS Panama City
Alyssa Mathers .... NMFS Panama City

Attendees

Grace Casselberry .... NMFS Panama City
Drew Delorenzo .... NMFS Panama City
Shannon Dunnigan .... NMFS Panama City
Rusty Hudson .... DSF, Inc.
Andrea Kroetz .... DISL
Hanna Lang .... NMFS Panama City
Todd Neahr .... Texas Tech
Ashley Pacicco .... NMFS Panama City
Kelcee Smith .... NMFS Panama City

Staff

Andrea Grabman .... SEDAR
Julie Neer .... SEDAR
Karyl Brewster-Geisz.. NMFS HMS

Additional Participants via Webinars

Heather Balchowsky .... NMFS Miami
Peter Cooper.. NMFSHMS
Jennifer Cudney .... NMFS HMS
Guy DuBeck.. NMFS HMS
Mark Grace .... MFS Pascagoula
Jill Hendon .... GCRL/USM
Vivian Matter .... NMFS Miami
Kevin McCarthy.. NMFS Miami
Delisse Ortiz.. NMFS HMS
Jackie Wilson .... NMFS HMS

1.1.4. List of Working Documents and Reference Papers

Documents Prepared for the Assessment Process		
SEDAR34-WP-01	Standardized catch rates of Atlantic sharpnose sharks (*Rhizoprionodon terraenovae*) in the U.S. Gulf of Mexico from the Shark Bottom Longline Observer Program, 1994-2011	John Carlson and Simon Gulak
SEDAR34-WP-02	Standardized catch rates of bonnetheads from the Everglades National Park Creel Survey	John K. Carlson and Jason Osborne

SEDAR34-WP-03	Standardized Catch Rates of Bonnethead and Atlantic Sharpnose Shark from the Southeast Shark Drift Gillnet Fishery: 1993-2011	John Carlson, Alyssa Mathers and Michelle Passerotti
SEDAR34-WP-04	Tag and recapture data for Atlantic sharpnose, *Rhizoprionodon terraenovae*, and bonnethead shark, *Sphyrna tiburo*, in the Gulf of Mexico: 1999-2011	Dana Bethea and Mark Grace
SEDAR34-WP-05	Relative abundance of bonnethead and Atlantic sharpnose sharks based on a fishery-independent gillnet survey off Texas	Walter Bubley and John Carlson
SEDAR34-WP-06	Update to maximum observed age of Atlantic sharpnose sharks (*Rhizoprionodon terraenovae*) in the western North Atlantic Ocean based on a direct age estimate of a long term recapture	Bryan S. Frazier and Joshua K. Loefer
SEDAR34-WP-07	Validated age and growth of the bonnethead (*Sphyrna tiburo*) in the western North Atlantic Ocean	Bryan S. Frazier, Douglas H. Adams, William B. Driggers III, Christian M. Jones, Joshua K. Loefer, Linda A. Lombardi
SEDAR34-WP-08	A preliminary review of post-release live-discard mortality rate estimates in sharks for use in SEDAR 34	Dean Courtney
SEDAR34-WP-09	Standardized catch rates of Atlantic sharpnose (*Rhizoprionodon terraenovae*) and bonnethead (*Sphyrna tiburo*) sharks collected during a gillnet survey in Mississippi coastal waters, 1998-2011	Eric R. Hoffmayer, Glenn R. Parsons, Jill M. Hendon, Adam G. Pollack, and G. Walter Ingram, Jr.
SEDAR34-WP-10	Standardized catch rates of Atlantic sharpnose sharks (*Rhizoprionodon terraenovae*) collected during a bottom longline survey in Mississippi coastal waters, 2004-2011	Eric R. Hoffmayer, Jill M. Hendon, and Adam G. Pollack
SEDAR34-WP-11	Standardized catch rates of Atlantic sharpnose sharks (Rhizoprionodon terraenovae) collected during bottom longline surveys in Mississippi, Louisiana, Alabama, and Texas coastal waters, 2004-2011	Eric Hoffmayer, Adam Pollack, Jill Hendon, Marcus Drymon, and Mark Grace
SEDAR34-WP-12	Atlantic Sharpnose Shark: Standardized index	John Froeschke and J.

	of relative abundance using boosted regression trees and generalized linear models	Marcus Drymon
SEDAR34-WP-13	Atlantic Sharpnose Abundance Indices from SEAMAP Groundfish Surveys in the Northern Gulf of Mexico	Adam G. Pollack and G. Walter Ingram, Jr.
SEDAR34-WP-14	Bonnethead Abundance Indices from SEAMAP Groundfish Surveys in the Northern Gulf of Mexico	Adam G. Pollack and G. Walter Ingram, Jr.
SEDAR34-WP-15	Atlantic Sharpnose and Bonnethead Abundance Indices from NMFS Bottom Longline Surveys in the Western North Atlantic and Northern Gulf of Mexico	Adam G. Pollack and G. Walter Ingram, Jr.
SEDAR34-WP-16	Continuity Runs for Atlantic Sharpnose and Bonnethead SEAMAP Groundfish Surveys and NMFS Bottom Longline Surveys	Adam G. Pollack and G. Walter Ingram, Jr.
SEDAR34-WP-17	Variability in the Reproductive Biology of the Atlantic Sharpnose Shark in the Gulf of Mexico	Eric R. Hoffmayer, Jill M. Hendon, William B. Driggers III, Lisa M. Jones, and James A. Sulikowski
SEDAR34-WP-18	Shrimp Fishery Bycatch Estimates for Atlantic Sharpnose and Bonnethead Sharks in the Gulf of Mexico, 1972-2011	Xinsheng Zhang, Brian Linton, Enric Cortés and Dean Courtney
SEDAR34-WP-19	Standardized catch rates of Atlantic sharpnose and bonnethead sharks from the SEAMAP-South Atlantic Shallow Water Trawl Survey	Enric Cortés and J. Boylan
SEDAR34-WP-20	Updated catches of Atlantic sharpnose and bonnethead sharks	Enric Cortés and Ivy Baremore
SEDAR34-WP-21	Dead discards of Atlantic sharpnose sharks in the shark bottom longline fishery	John Carlson, Kevin J. McCarthy and Simon J.B. Gulak
SEDAR34-WP-22	Preliminary data on the reproductive biology of the bonnethead (*Sphyrna tiburo*) from the southeast U.S. Atlantic coast	Bryan Frazier, Jim Gelsleichter, and Melissa Gonzalez De Acevedo
SEDAR34-WP-23	Interannual site fidelity of bonnetheads	William B. Driggers III,

	(*Sphyrna tiburo*) to two coastal ecosystems in the western North Atlantic Ocean	Bryan S. Frazier, Douglas H. Adams, Glenn F. Ulrich and Eric R. Hoffmayer
SEDAR34-WP-24	Size composition and indices of relative abundance of the Atlantic sharpnose shark (*Rhizoprionodon terraenovae*) in coastal Virginia waters	Robert J. Latour, Christopher F. Bonzek, and J. Gartland
SEDAR34-WP-25	Mark/Recapture Data for the Atlantic Sharpnose Shark (*Rhizoprionodon terranovae)*, in the Western North Atlantic from the NEFSC Cooperative Shark Tagging Program	Nancy E. Kohler, Danielle Bailey, Patricia A. Turner, and Camilla McCandless
SEDAR34-WP-26	Mark/Recapture Data for the Bonnethead (*Sphyrna tiburo)*, in the Western North Atlantic from the NEFSC Cooperative Shark Tagging Program	Nancy E. Kohler, Elizabeth Sawicki, Patricia A. Turner, and Camilla McCandless
SEDAR34-WP-27	Preliminary mtDNA assessment of genetic stock structure of the bonnethead, *Sphyrna tiburo*, in the eastern Gulf of Mexico and northwestern Atlantic	Píndaro Díaz-Jaimes, Douglas H. Adams, Nadia S. Laurrabaquio-Alvarado, Elena Escatel-Luna
SEDAR34-WP-28	Standardized Catch Rates of Bonnethead and Atlantic Sharpnose Shark from the Southeast Sink Gillnet Fishery: 2005-2011	John Carlson, Alyssa Mathers and Michelle Passerotti
SEDAR34-WP-29	Relative abundance of Atlantic sharpnose and bonnethead shark from the northeastern Gulf of Mexico	John K. Carlson, Dana M. Bethea, Eric Hoffmayer, John Tyminski, Robert Hueter, R. Dean Grubbs, Matthew J. Ajemian, and George H. Burgess
SEDAR34-WP-30	Reproductive parameters for Atlantic sharpnose sharks (*Rhizoprionodon terraenovae*) from the western North Atlantic Ocean	William B. Driggers III, Eric R. Hoffmayer, John K. Carlson and Joshua Loefer
SEDAR34-WP-31	Tag-recapture results of bonnethead (*Sphyrna tiburo*) and Atlantic sharpnose	John P. Tyminski, Robert

	(*Rhizoprionodon terraenovae*) sharks in the Gulf of Mexico and Florida Coastal Waters	E. Hueter, John Morris
SEDAR34-WP-32	Standardized catch rates of bonnethead (*Sphyrna tiburo*) from the South Carolina Department of Natural Resources trammel net survey	Bryan S. Frazier and Camilla T. McCandless
SEDAR34-WP-33	Tag and recapture data for Atlantic sharpnose, *Rhizoprionodon terraenovae*, and bonnethead, *Sphyrna tiburo*, sharks caught in the northern Gulf of Mexico from 1998-2011	Jill M. Hendon, Eric R. Hoffmayer, and Glenn R. Parsons
SEDAR34-WP-34	Standardized indices of abundance for Atlantic sharpnose sharks from the Georgia Department of Natural Resources red drum longline survey	C.T. McCandless, C.N. Belcher
SEDAR34-WP-35	Standardized indices of abundance for bonnethead and Atlantic sharpnose sharks from the Georgia Department of Natural Resources ecological monitoring trawl surveys	C.T. McCandless, J.Page, C.N. Belcher
SEDAR34-WP-36	Standardized indices of abundance for bonnethead and Atlantic sharpnose sharks caught during the South Carolina Department of Natural Resources red drum longline and Cooperative Atlantic States Shark Pupping and Nursery gillnet surveys	C.T. McCandless, B.S. Frazier
SEDAR34-WP-37	Standardized indices of abundance for bonnethead and Atlantic sharpnose sharks caught during the Cooperative Atlantic States Shark Pupping and Nursery longline surveys from South Carolina to northern Florida	C.T. McCandless, C.N. Belcher, B.S. Frazier, M. McCallister, R. Ford, J. Gelsleichter
SEDAR34-WP-38	Standardized indices of abundance for Atlantic sharpnose sharks from the University of North Carolina bottom longline survey	Frank Schwartz, Camilla McCandless, and John Hoey
SEDAR34-WP-39	A Summary of Evaluation Worksheets of abundance indices for Atlantic sharpnose shark and bonnethead shark	SEDAR 34 Panel

Final Stock Assessment Reports		
SEDAR34-SAR	Atlantic Sharpnose Sharks	SEDAR 34 Panel
SEDAR34-SAR	Bonnethead Sharks	SEDAR 34 Panel
Reference Documents		
SEDAR29-RD01	SEDAR 13 (SCS) Final Stock Assessment Report	SEDAR 13 Panels
SEDAR29-RD02	Abundance Indices Workshop: Developing protocols for submission of abundance indices to the SEDAR process	SEDAR Procedural Workshop I
SEDAR29-RD03	Characterization of the U.S. Gulf of Mexico and South Atlantic Penaeid and Rock Shrimp Fisheries Based on Observer Data	ELIZABETH SCOTT-DENTON, PAT F. CRYER, MATT R. DUFFY, JUDITH P. GOCKE, MIKE R. HARRELSON, DONNA L. KINSELLA, JAMES M. NANCE, JEFF R. PULVER, REBECCA C. SMITH, and JO A. WILLIAMS
SEDAR29-RD04	Effects of Turtle Excluder Devices (TEDs) on the Bycatch of Three Small Coastal Sharks in the Gulf of Mexico Penaeid Shrimp Fishery	Scott W. Raborn, Benny J. Gallaway, John G. Cole, William J. Gazey & Kate I. Andrews

1.2 STATEMENTS ADDRESSING EACH TERM OF REFERENCE

1.2.1 Term of Reference 1

Update the approved SEDAR 13 bonnethead shark model with data through 2011. Provide a model consistent with the previous assessment configuration to incorporate and evaluate any changes allowed for this update.

First, the model used for bonnethead shark in SEDAR 13 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 more detail in Sections 2.1 and

3.2.7.1. The main changes with respect to the benchmark model used in SEDAR 13 were 1) adding six additional years of catches (2006-2011) to the six catch data streams considered in SEDAR 13, and 2) re-analyzing the 11 indices of relative abundance considered in SEDAR 13 to also include six additional years of data (2006-2011), if appropriate. All other inputs to the model as well as modeling aspects remained the same as used in SEDAR 13. The state-space, age-structured production model (SSASPM) was used in both SEDAR 13 and SEDAR 34. Second, we conducted an extensive set of new analyses incorporating the issues identified in the following TORs as well as additional analyses stemming from discussions held by the Panel.

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 information (age and growth and reproductive parameters); b) Evaluate fishery-independent abundance indices derived for Mississippi, Alabama, Georgia, and South Carolina; c) Evaluate MRFSS/MRIP conversion factors; and d) Evaluate commercial and recreational discard information.

Multiple changes to biological and fishery inputs used for SEDAR 13 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 new information on maximum age and growth and reproductive characteristics of this species in the U.S. South Atlantic, as well as a re-analysis of that information for the Gulf of Mexico and a new analysis of the information for combined areas are presented in Section 2.2.1.

b) Several fishery-independent relative abundance indices that had not been initiated, consisted of too few years, or were not presented or considered for various reasons when SEDAR 13 was conducted (MS gillnet, GA and SC Coastspan longline, GADNR trawl, and SC trammel net), were considered for the current assessment. Section 2.2.3 discusses these as well as other indices that were identified after this TOR was written and the decisions that were made.

c) Although MRIP (Marine Recreational Information Program) have effectively replaced MRFSS (Marine Recreational Fishery Statistics Survey) estimates, they are only available for 2004-2011. Ratio estimators to convert MRFSS to MRIP estimates were developed for this assessment for the period 1981-2003. Section 2.2.2.2 discusses this issue in more detail.

d) SEDAR 13 only considered commercial dead discards from the bottom longline fishery. For the current assessment we also considered post-release live discard mortality from the bottom longline, gillnet, and line commercial fisheries as well as from recreational fisheries. These sources of removals are detailed in Sections 2.2.2.3 and 2.2.2.4. Discussions and decisions related to discards in the shrimp trawl fishery are detailed in Section 2.2.2.5.

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 numbers and weight. Provide available average weights by gear and year used to derive average number of fish calculations.

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 indices of relative abundance (Sections 2.2.3 and 3.1.2.3); 2) new selectivity functions developed to describe new catch and index series (Section 3.1.2.2); and 3) new biological parameters, including von Bertalanffy growth curve parameters, maximum age, fecundity at age, updated estimates of natural mortality (M) at age, proportion mature at age, and pup survival (Section 2.2.1).

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 discard estimates from various sources are generated in numbers rather than weight. However, to address this TOR, catch in weight from the different sectors is also being provided. When applicable, we provide the average weights (back-transformed from average lengths) that were used in the conversions (Section 3.1.2.1).

1.2.4. Term of Reference 4

Update model parameter estimates and their variances, model uncertainties, and estimates of stock status and management benchmarks. In addition to the base model, conduct sensitivity analysis to *address uncertainty in data inputs and model configuration and consider runs that represent plausible, alternate states of nature.*

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 spawning stock fecundity (Section 3.2.3), fishery selectivity (Section 3.2.4), fishing mortality (Section 3.2.5), and stock-recruitment parameters (Section 3.2.6). Further evaluation of uncertainty is presented in Section 3.2.7, which contains historic, continuity, retrospective, and sensitivity analyses, as well as evaluation of model configurations. Benchmarks and reference points are presented in Section 3.2.8. Projections are presented in Section 3.2.9.

1.2.5. Term of Reference 5

Project future stock conditions regardless of the status of the stock. Develop rebuilding schedules, if warranted. Provide the estimated generation time for each unit stock. Stock projections shall be developed in accordance with the following: A) If the stock is overfished, then utilize projections to determine: Year in which F=0 results in a 70% probability of rebuilding (Year F=0p70); Target rebuilding year (Year F=0p70 + 1 generation time) (Yearrebuild); F resulting in 50% and 70% probability of rebuilding by Yearrebuild; and Fixed level or removals (TAC) allowing rebuilding of stock with 50% and 70% probability; B) Otherwise, utilize a P approach to determine: the F needed and corresponding removals associated with a 70% probability of overfishing not occurring* (P* = 0.3); *and C) If data-limitations preclude classic projections (i.e. A, B above), explore alternate projection models to provide management advice.*

An alternative probabilistic projection approach was developed for HMS shark stocks that are not likely to be under a rebuilding plan (i.e. not in an overfished condition). The projection approach was based on discussions held during a workshop to investigate P* statistical analysis techniques for use in age-structured stock assessments of domestic U.S. shark stocks managed under the Highly Migratory Species (HMS) Fisheries Management Plan (FMP) (P* workshop, NOAA/NMFS, Panama City Laboratory, June 11-13, 2013; Report in prep.). During the workshop, several shortcuts to published probabilistic P* approaches currently being implemented (or evaluated) within the framework of the Southeast Data, Assessment, and Review (SEDAR) process were discussed (e.g., Prager and Shertzer 2010, Shertzer et al. 2010). Preliminary analyses with empirical data from comparative model runs indicated that results from some of the shortcuts were comparable to those obtained from published probabilistic P* approaches. However, when the technical merits of each P* shortcut were discussed within the context of application to an existing HMS shark dataset and age-structured stock assessment model (e.g., NMFS 2012a), it became apparent that the distribution of F_{limit} (F_{MSY} for HMS domestic shark stocks) may be poorly characterized in the existing stock assessment model (SSASPM, e.g., NMFS 2012a). Consequently, within the context of application to the existing HMS age-structured stock assessment model, typical P* approaches may not adequately characterize uncertainty in the distribution of F_{limit}. In contrast, alternative probabilistic projection approaches were also discussed at the workshop, including short-term (~5 to 10 year) projections at fixed harvest levels similar to those used by the International Commission for the Conservation of Atlantic Tunas (ICCAT) Standing Committee on Research and Statistics (SCRS) in their Kobe II tables and plots (e.g., SCRS BFT Stock Assessment Meeting Report 2012; their Tables 16-18, and their figures 36-38). It was noted at the workshop, that probabilistic projections at fixed harvest levels do not require estimates of uncertainty for F_{MSY} and accommodate multiple year lags at fixed harvest levels. It was also noted at the workshop that probabilistic projections at fixed harvest levels could be utilized to provide a buffer based on a pre-specified acceptable probability of overfishing (e.g., P* = 0.3; <0.5). Consequently, within the context of application to the existing HMS domestic shark age-structured stock assessment model (SSASPM), probabilistic projections at fixed harvest levels may provide a proxy to a typical P* approach. The methods developed for the alternative probabilistic projection approach are described in section 3.1.7, and the results are presented in section 3.2.9.

1.2.6. Term of Reference 6

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

This is the present document. Recommendations by the Assessment Panel (AP) for future research and data collection are provided in Section 2.4.

2. DATA REVIEW AND UPDATE

2.1. CONTINUITY DATASETS

The continuity analysis consisted of using the same exact model, data inputs and assumptions used in 2007 for SEDAR 13, but adding six additional years of catch data (2006-2011; **Table 2.5.1**; **Figure 2.6.1**) and the same indices updated to 2011 (**Figure 2.6.2**). For shrimp discards, the 2006-2011 values were assumed to be the mean of the 2003-2005 estimates. The same 11 indices used in 2007 were also used in the continuity run. Of those 11 indices, two remained the same as in 2007 because they have been discontinued (MML Gillnet Adults and MML Gillnet Juveniles). The remaining nine indices were all reanalyzed and had six additional years of data, with the exception of the SEAMAP-GOM Early Fall, which covered an early period, and the GNOP, which only had five more years of data. The remaining indices were: PC Gillnet Juveniles, PC Gillnet Adults, ENP, SEAMAP-SA, Texas Gillnet, SC Coastspan Gillnet, and SEAMAP-GOM-Late Fall. Note also that the same exact methodology used in 2007 was not used in the re-analysis of the Texas Gillnet, SEAMAP-GOM Early Fall, and SEAMAP-GOM Late Fall indices.

2.2. N EW DATA SOURCES CONSIDERED

2.2.1. Life History

2.2.1.1. Review of Working Papers

***SEDAR34-WP-04*: Tag and recapture data for Atlantic sharpnose, *Rhizoprionodon terraenovae*, and bonnethead shark, *Sphyrna tiburo*, in the Gulf of Mexico and US South Atlantic: 1998-2011. D.M. Bethea and M.A. Grace**

Tag and recapture information for Atlantic sharpnose, *Rhizoprionodon terraenovae*, and bonnethead shark, *Sphyrna tiburo*, is summarized from the NOAA Fisheries Southeast Fisheries Science Center Elasmobranch Tagging Management System, 1998-2011. Summary information includes numbers of sharks tagged by species, sex, and life stage, numbers of sharks recaptured by species and sex, recapture rates, time at liberty, distance traveled, and change in length for recaptured individuals.

***SEDAR34-WP-07:* Validated age and growth of the bonnethead (Sphyrna tiburo) in the western North Atlantic Ocean.**
B.S. Frazier, D.H. Adams, W.B. Driggers III, C.M. Jones, J.K. Loefer and L.A. Lombardi

The age and growth of the bonnethead shark, *Sphyrna tiburo*, inhabiting the estuarine and coastal waters of the western North Atlantic Ocean from Onslow Bay, North Carolina, south to West Palm Beach, Florida was examined. Vertebrae were collected and successfully aged from 329 females and 216 males. Sex specific von Bertalanffy growth curves were fitted to length at age data. Female von Bertalanffy parameters were $L\infty$= 1032 mm FL, k= 0.18, to = -1.75, and Lo= 291mm FL. Males reached a smaller theoretical asymptotic length, and had a slower growth coefficient, with von Bertalanffy parameters being $L\infty$= 778 mm FL, k= 0.30, to = -1.50, and Lo= 281 mm FL. Maximum observed age was 17.9 years for females, and 12.0 years for males. Annual deposition of growth increments was verified by marginal increment analysis and validated through recapture of 13 OTC injected wild captured specimens. Annual band deposition was validated for age classes 2.5+ to 10.5+ with times at liberty ranging from 1 to 4 years. Age at 50% maturity was 6.8 years for females, and 4.1 years for males. Von Bertalanffy growth parameters were compared to growth parameters from bonnethead sharks collected in the eastern Gulf of Mexico (GOM) to test for differences. Both female and male bonnetheads in the SAB had a significantly higher theoretical asymptotic length, lower coefficient of growth, and lower estimated mean size at birth. Maximum observed age and age at 50% maturity were also higher for both sexes in the SAB.

SEDAR34-WP-22: Preliminary data on the reproductive biology of the bonnethead (*Sphyrna tiburo*) from the southeast U.S. Atlantic coast.
B.Frazier, J. Gelsleichter and M. Gonzalez De Acevedo

Although several previous studies have examined the reproductive biology of the bonnethead (*Sphyrna tiburo*) from Gulf of Mexico (Parsons, 1993; Manire et al., 1995; Manire and Rasmussen, 1997; Lombardi-Carlson et al., 2003) no published study has provided data on their counterparts from the southeastern U.S. Atlantic coast. Because of this, the goal of this study was to provide preliminary data on the reproductive biology of bonnethead populations from the southeastern U.S. Atlantic coast, making use of archived data from the South Carolina Department of Natural Resources (SCDNR) and new data from a currently ongoing, NOAA Fisheries-supported study on bonnethead reproduction being conducted by SCDNR, Georgia Department of Natural Resources (GADNR), and the University of North Florida (UNF). Our specific objectives were to determine size and age at maturity for male and female Atlantic bonnetheads, characterize reproductive seasonality and periodicity, and determine fecundity.

***SEDAR34-WP-23**:* Interannual site fidelity of bonnetheads (*Sphyrna tiburo*) to two coastal ecosystems in the western North Atlantic Ocean.
W.B. Driggers III, B.S. Frazier, D.H. Adams, G.F. Ulrich and E.R. Hoffmayer

Bonnetheads were tagged in the coastal waters of South Carolina from 1998-2012. Of the 2,014 sharks tagged, 112 individuals were recaptured after at least one calendar year at liberty. Over 90% of recaptured individuals were collected in the same estuary or bay where originally tagged. Three bonnetheads were collected off the east coast of Florida during the fall and spring, when the species is not present in South Carolina waters. With two exceptions, tagging data indicate bonnetheads display complete fidelity to specific systems in the coastal waters of South Carolina. All bonnetheads were recaptured in waters off the east coast of the United States and results suggest they remain within the region.

SEDAR34-WP-26**:** Mark/Recapture Data for the Bonnethead (*Sphyrna tiburo*), in the Western North Atlantic from the NEFSC Cooperative Shark Tagging Program.
N.E. Kohler, E. Sawicki, P.A. Turner and C. McCandless

Mark/recapture information from the National Marine Fisheries Service (NMFS) Cooperative Shark Tagging Program (CSTP) covering the period from 1965 through 2012 are summarized for the bonnethead shark (Sphyrna tiburo) in the western North Atlantic. The extent of the tagging effort, areas of release and recapture, and movements and length frequencies of tagged sharks are reported. Two areas were distinguished in order to identify exchange between the Atlantic and Gulf of Mexico. Overall, there was no movement between the Atlantic and Gulf of Mexico and limited exchange (1 fish) between the US and the Mexican-managed portion of the Gulf of Mexico. The true extent of this movement is unclear due to the possibility of under-reporting of recaptures.

SEDAR34-WP-27**:** Preliminary mtDNA assessment of genetic stock structure of the bonnethead, *Sphyrna tiburo*, in the eastern Gulf of Mexico and northwestern Atlantic.
P. Díaz-Jaimes, D.H. Adams, N.S. Laurrabaquio-Alvarado and E. Escatel-Luna

Bonnethead sharks in U.S. waters are currently managed as one population or stock, although the existence of multiple genetically distinct stocks has not been addressed using molecular techniques. Additional information regarding genetic stock delineation is critical for effective management and conservation. The present study provides preliminary results from an ongoing study to evaluate the genetic population structure of bonnethead sharks in the Gulf of Mexico and U.S. south Atlantic. A total fragment of 940 base pairs of the mtDNA-control region was sequenced in 140 bonnethead samples resulting in a high mean haplotype and nucleotide diversity (h=0.8817; π=2.27%) when compared with other shark species. Genetic diversity was typically lower for locations from estuaries known to be nursery grounds. Significant spatial genetic differences were observed among bonnetheads from the Gulf of Mexico and U.S. south Atlantic (ΦCT = 0.0558; P = 0.033), suggesting restricted gene flow between the two areas. Although current data indicate genetic differences exist between bonnetheads inhabiting the Gulf of Mexico and U.S. south Atlantic, these results are preliminary and further analyses from this ongoing study will provide a better understanding of population structure in these two large marine systems.

***SEDAR34-WP-31*:** Tag-recapture results of bonnethead (*Sphyrna tiburo*) and Atlantic sharpnose (*Rhizoprionodon terraenovae*) sharks in the Gulf of Mexico and Florida Coastal Waters.
J.P. Tyminski, R.E. Hueter and J. Morris

Tag-recapture data from Mote Marine Laboratory's Center for Shark Research are summarized for the bonnethead, *Sphyrna tiburo* and Atlantic sharpnose, *Rhizoprionodon terraenovae*, sharks. Of the 7,781 sharks tagged from these two species, there were 246 reported recaptures (3.2 %). The movement patterns were variable but there is evidence of significant inshore-offshore and north-south movements that is likely related to temperature-mediated seasonal migrations. There was no evidence of either species moving from the Gulf of Mexico into the Atlantic or migrations across the Gulf of Mexico.

***SEDAR34-WP-33*:** Tag and recapture data for Atlantic sharpnose, *Rhizoprionodon terraenovae*, and bonnethead, *Sphyrna tiburo*, sharks caught in the northern Gulf of Mexico from 1998-2011.
J.M. Hendon, E.R. Hoffmayer and G.R. Parsons

Routine, monthly (March to October), fishery-independent shark resource sampling has been conducted in Mississippi, Alabama, and Louisiana coastal waters by The University of Southern Mississippi and the University of Mississippi since 1998. Sampling methods have included gillnet, bottom longline (152 m and 1.8 km), and hook-and-line gear. All sharks in good condition were externally tagged with either a dart (7 or 18 cm) or roto tag and were released. The dart tags were imbedded in the dorsal musculature at the base of the first dorsal fin, and the roto tags were punched through the cartilage of the first dorsal fin. From 1998 to 2011, approximately 6,500 sharks have been tagged on these resource surveys. A total of 3,753

Atlantic sharpnose sharks were tagged and 20 of these were recaptured (0.5%), whereas 160 bonnethead sharks were tagged and two of these were recaptured (1.3%). No Atlantic sharpnose or bonnethead shark traveled from the Gulf of Mexico to the Atlantic Ocean or vice versa.

2.2.1.2. New datasets and decisions

Stock definition datasets and decisions

Several mark and recapture documents were presented that showed no movement of tagged bonnetheads between the Gulf of Mexico and Atlantic Ocean and a high degree of site fidelity to specific locations (SEDAR 34 WP-04, SEDAR 34 WP-23, SEDAR 34 WP-26, and SEDAR 34 WP-31, SEDAR 34-33). Preliminary mtDNA evidence of genetic stock structure was presented by Diaz-James et al. (SEDAR 34 WP-27) and showed significant differences in haplotype frequencies between the Gulf of Mexico and Atlantic Ocean. Based on tagging and genetic data presented, there was a consensus that bonnetheads in the Gulf of Mexico and the Atlantic Ocean represent two distinct stocks. However, concern was expressed that since the current stock assessment is not a benchmark assessment and consideration of two new stocks and all the associated data inputs and issues is beyond the scope and TORs of this standard assessment, delaying the current assessment would not provide management with guidance regarding the status of the stock. The panelists discussed the potential benefits and uncertainties of providing one overall assessment for two stocks versus not conducting the assessment and decided that one overall assessment would be appropriate at this time provided the next assessment consider splitting the assessment into two stocks. Additional information on this discussion is provided below.

Decision 1: While tagging and genetic studies show bonnethead movement between the Gulf of Mexico and Atlantic Ocean is minimal to non-existent, in order to provide management with some guidance on the status of these stocks, the Panel decided that an updated overall assessment would be conducted. The Panel also provided a strong recommendation that the next assessment for this species be a benchmark assessment treating bonnetheads in the Gulf of Mexico and the Atlantic Ocean as separate stocks.

Age and Growth Datasets and Decisions

In the previous benchmark assessment (SEDAR 13), no age and growth information was available for the Atlantic Ocean, resulting in parameter estimates from the Gulf of Mexico (SEDAR13-DW-24-V3) being utilized for the combined stock. New age and growth data were presented by Frazier et al. (SEDAR 34 WP-7) spanning the range of bonnethead in the Atlantic Ocean. Data presented increased maximum observed ages (18+ years for females and 12+ years for males), and presented significantly different $L\infty$ and k parameters from previously utilized parameters from the Gulf of Mexico model. In addition to new data for the Atlantic Ocean, data from the Gulf of Mexico were reanalyzed to produce von Bertalanffy growth parameters based on fork length. A combined model using data from the Atlantic Ocean and Gulf of Mexico was also produced. The combined model was significantly different from the Atlantic Ocean and Gulf of Mexico models.

Decision 2: Because of the decision to treat bonnethead sharks from the Atlantic and Gulf of Mexico as a single stock, the Panel decided to use the combined age and growth model parameters from SEDAR 34 WP-07.

Decision 3: As a result of the updated data presented in SEDAR 34 WP-07 and because of the decision to treat bonnethead sharks from the Atlantic and Gulf of Mexico as a single stock, the Panel decided to increase the maximum age of bonnetheads from 12+ years to 18+ years.

Reproductive Datasets and Decisions

Reproductive data were unavailable for the Atlantic Ocean during the SEDAR 13 benchmark assessment, resulting in parameter estimates from the Gulf of Mexico being used for the combined stock. New data for the Atlantic Ocean were presented by Frazier et al. (SEDAR 34 WP-22). There were no new data presented for the Gulf of Mexico. Maturity ogives for the Atlantic Ocean were significantly different from Gulf of Mexico ogives used in SEDAR 13. Length and age at maturity were greater in the Atlantic Ocean than in the Gulf of Mexico. Litter size was smaller for the Atlantic Ocean (8.8) v. the Gulf of Mexico (9.7). A significant relationship existed between maternal fork length and litter size for the Atlantic Ocean; however, no relationship between maternal length and litter size was evident for the Gulf of Mexico and combined models. Combined Gulf of Mexico and Atlantic Ocean ogives, maturity schedules, litter size, and a maternal FL to litter size regression were also generated by Frazier et al. (SEDAR 34 WP-22). Pupping month varied for the Gulf of Mexico (July-September); however, the Atlantic Ocean had a definitive pupping month of September.

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Decision 4: Because of the decision to treat bonnethead sharks from the Atlantic and Gulf of Mexico as a single stock, the Panel decided to use the combined reproductive parameters presented in SEDAR 34 WP-22.

Decision 5: Because of the decision to treat bonnethead sharks from the Atlantic and Gulf of Mexico as a single stock, the Panel decided to use a combined pupping month of August. This was seen by the Panel as a compromise which took into account the variability in pupping month between the Atlantic Ocean and the Gulf of Mexico.

Bonnethead Life History Caveats

As described above, the Panel decided to treat the bonnethead population as a single stock to allow the assessment process to move forward. The Panel did so, recognizing that all life history information indicates that there are separate stocks of bonnethead. A benchmark assessment would be preferred; however, given the uncertainty of the ability of NOAA Fisheries to schedule a new assessment in the immediate future, it was decided it was more important to attempt to assess the population, in order to provide stock status information for management purposes. By using combined life history parameters, neither stock is represented by the most appropriate life history characteristics; instead an averaging of life histories is accomplished. Gulf of Mexico bonnethead will have a greater longevity, greater $L\infty$, lower k, greater length and age at 50% maturity, and lower litter size. Atlantic Ocean bonnetheads, will have a lower $L\infty$, greater k, lower length and age at 50% maturity, greater litter size, and a previously recognized maternal length to litter size relationship will no longer be present.

Decision 6: The Panel recommended moving forward with the standard assessment as a single stock of bonnethead using combined life history parameters. However, the Panel recognized that evidence points to two stocks, and moving forward with combined life history characteristics inserts uncertainty into the assessment.

Decision 7: The Panel recommended that any future assessments of this species be carried out as a benchmark assessment with two recognized stocks.

Decision 8: The Panel recommended attempting to characterize the uncertainty in life history and attempting to provide advice to management that may be wide ranging.

2.2.2. Catch Statistics

2.2.2.1. Review of working papers

***SEDAR 34-WP-08*: A preliminary review of post-release live-discard mortality rate estimates in sharks for use in SEDAR 34**
Dean Courtney

This working paper reviews post-release live-discard mortality rate estimates for sharks from the primary scientific literature for use in SEDAR 34. However, the review is not exhaustive and therefore should be considered preliminary. Discard mortality rates appear to vary among species and by gear type. As a result, this review identifies estimates of post-release live-discard mortality rate by species and by gear type (longline, hook and line, gillnet, and trawl) where available.

***SEDAR 34-WP-18*: Shrimp Fishery Bycatch Estimates for Atlantic Sharpnose and Bonnethead Sharks in the Gulf of Mexico, 1972-2011**
Xinsheng Zhang, Brian Linton, Enric Cortés and Dean Courtney

WinBUGS shrimp bycatch estimates for Atlantic sharpnose and bonnethead sharks in the Gulf of Mexico were generated using the approaches developed by Scott Nichols in the SEDAR 7 Gulf of Mexico red snapper assessment (Nichols 2004a, 2004b) and SEDAR 13 Gulf of Mexico small coastal sharks assessment (Nichols 2007).

***SEDAR 34-WP-20*: Updated catches of Atlantic sharpnose and bonnethead sharks**
Enric Cortés and Ivy Baremore

This document presents updated commercial landings, recreational catches, and discard estimates of Atlantic sharpnose and bonnethead sharks up to 2011. 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.

2.2.2.2. Recreational landings datasets and decisions

The MRIP (Marine Recreational Information Program) has effectively replaced MRFSS (Marine Recreational Fishery Statistics Survey), but new estimates for a suite of fish species, including sharks, are only available for the period 2004-2011. For 1981-2003, MRFSS estimates were adjusted to MRIP using ratio estimators. The new MRIP estimates for this species for the period 1981-2003 were developed specifically for this assessment by SEFSC personnel in charge of recreational statistics (V. Matter, SEFSC, Miami, FL, pers. comm.).

Decision 1: The Panel recommended using MRIP catches for the whole time series, including those obtained with ratio estimators for 1981-2003, because this Program has effectively replaced MRFSS.

2.2.2.3. Recreational discards datasets and decisions

Post-release live discard mortality

Working document SEDAR34-WP-08 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)

Working document SEDAR34-WP-08 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. A point was made that this rate was obtained using only ten tagged sharpnose sharks being monitored for six hours and that it might not be appropriate to use, especially for bonnetheads. The Panel discussed and decided that if the methodology was externally reviewed and accepted in SEDAR 29 than it should be used here. The Panel also decided that in the absence of information specific to bonnetheads, it was appropriate to use the data for Atlantic sharpnose sharks.

Decision 2: Based on what was discussed above, the Panel recommended applying a 10% discard mortality rate to the live discards (B2) from MRIP/MRFSS and including a range of 5-15% for the low and high catch sensitivity scenarios (if implemented), for both Atlantic sharpnose and bonnethead shark.

2.2.2.4. Commercial discards datasets and decisions

Post-release live discard mortality

Working document SEDAR34-WP-08 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)

Estimates of post-release live-discard mortality rate were generated by species and gear type (longline, hook and line, gillnet, and trawl) where available.

Rates from research gillnet studies were used to obtain commercial gillnet post release live discard mortality rates for bonnethead sharks. It was noted that commercial rates would most likely be higher than research gillnet rates. As a result, a minimum sensitivity scenario for bonnethead sharks (40%) was proposed, obtained from research gillnet studies (Hueter et al. 2006). It was proposed that the commercial bottom longline calculated rates from working document SEDAR34-WP-08 (91%) could be used as the high sensitivity scenario for commercial gillnet for bonnethead sharks; the base post release live discard mortality rates could be the midpoint (65.5%) of the respective low (40%) and high (91%) sensitivity ranges.

The Panel discussed the calculated commercial bottom longline rates from SEDAR34-WP-08 and decided that these were sufficient numbers. These calculations followed the SEDAR 29 AP Panel rationale for bottom longline.

There was not sufficient literature to guide the Panel to decide on post release live discard mortality rate estimates for either species caught in commercial trawls.

Decision 3: Based on the evidence above, the Panel recommended applying a post-release live discard mortality rate of 65.5% for commercial gillnet for the base model, with a range of 40-91% for the low and high sensitivity scenarios (if implemented) for bonnethead shark.

Decision 4: Based on the evidence above, the Panel recommended applying a post-release live discard mortality rate of 40% for commercial bottom longline for the base model, with a range of 19-91% for the low and high sensitivity scenarios (if implemented) for bonnethead shark.

2.2.2.5. Shrimp trawl fishery discards datasets and decisions

Working document SEDAR 34-WP-18 provided WinBUGS shrimp bycatch estimates using approaches developed in SEDAR 7 (GOM Red Snapper) and SEDAR 13 (GOM small coastal sharks).

Because the WinBUGS shrimp bycatch estimation model, priors, and datasets used for the SEDAR 13 Gulf of Mexico Atlantic sharpnose and bonnethead sharks assessment were not well documented, the SEDAR 13 results could not be reproduced. WinBUGS bycatch estimates for Atlantic sharpnose and bonnethead sharks in the Gulf of Mexico were presented based on two WinBUGS models with a variety of combinations of prior distribution assumptions, depth-zone strata, and datasets.

As in SEDAR 13, the initial WinBUGS runs had an extremely high bycatch value for 1980 (~800, 000 sharks). WinBUGS estimates of bycatch in the present analysis were high in 2009, 2010 and 2011, but not very different from the overall mean of the SEDAR 13 estimates. One possible reason for the anomalies was the change in observer methods in 2009 to begin identification of sharks to the species level, which increased available data. Before this time period, observers grouped all sharks into one category. Another possible reason was the change from voluntary to mandatory observer coverage in 2007, which greatly improved the representation of the commercial shrimp fleet and again increased available data.

Although not as concerned with the discard estimates for bonnetheads, the Panel decided to use the same methodology as for Atlantic sharpnose shark and decided to speak with Elizabeth Scott-Denton and James Nance from the Shrimp Fishery Observer Program in Galveston, Texas, to get details about the data. The call presented no new information except the program's confidence in the data for 2009-2011, as those were mandatory observer coverage years and Atlantic sharpnose sharks were identified to species level. The Panel also noted that WinBUGS annual shrimp bycatch estimates have very large variances in most years. The Panel decided to replace the estimates of shrimp bycatch generated with WinBUGS with the stratified nominal estimates recommended. Two approaches were recommended to calculate the 2009-2011 mean of observed season/area/depth specific CPUE. Annual shrimp bycatch estimates were calculated based on the 2009-2011 mean of observed season/area/depth-specific CPUE, year/season/area/depth-specific shrimp effort and year-specific net per vessel (see SEDAR 34-WP-18-addendum for details).

<u>Approach 1:</u>

$$\text{Annual\_All\_Tow\_CPUE\_A1}_{[yr,\ sea,\ ar,\ dp]} = \text{Average}(\text{All\_Tow\_CPUE}_{[yr,\ sea,\ ar,\ dp]}) \qquad \text{(Step1)}$$

$$\text{2009\_2011\_Mean\_Annual\_All\_Tow\_CPUE\_A1}_{[sea,\ ar,\ dp]} = \text{Mean}(\text{Annual\_All\_Tow\_CPUE\_A1}_{[yr,\ sea,\ ar,\ dp]}) \qquad \text{(Step2)}$$
$$\text{where yr = 2009, 2010 and 2011}$$

$$\text{Obs\_Bycatch\_A1}_{[yr,\ sea,\ ar,\ dp]} = \text{2009\_2011\_Mean\_All\_Tow\_CPUE\_A1}_{[sea,\ ar,\ dp]} * \text{effort}_{[yr,\ sea,\ ar,\ dp]} * \text{npv}_{[yr]} \qquad \text{(Step3)}$$
$$\text{where yr = 1972 - 2011}$$

$$\text{Obs\_Bycatch\_A1}_{[yr]} = \text{sum}(\text{Observed\_Bycatch\_A1}_{[yr,\ sea,\ ar,\ dp]}) \qquad \text{(Step4)}$$

where yr is year (1972-2011), sea is season (3 seasons), ar is area (4 areas), dp is depth (2 depth-zones), $\text{Annual\_All\_Tow\_CPUE\_A1}_{[yr,\ sea,\ ar,\ dp]}$ is the observed annual all-tow year/season/area/depth-specific CPUE estimated with approach 1, $\text{All\_Tow\_CPUE}_{[yr,\ sea,\ ar,\ dp]}$ is the observed all-tow year/season/area/depth-specific CPUE, $\text{2009\_2011\_Mean\_Annual\_All\_Tow\_CPUE\_A1}_{[sea,\ ar,\ dp]}$ is the 2009-2011 mean of season/area/depth-specific CPUE estimated with approach 1, $\text{effort}_{[yr,\ sea,\ ar,\ dp]}$ is year/season/area/depth-specific effort, $\text{npv}_{[yr]\ i}$ is year-specific nets per vessel, $\text{Obs\_Bycatch\_A1}_{[yr,\ sea,\ ar,\ dp]}$ is the observed year/season/area/depth-specific bycatch estimated with approach 1, $\text{Obs\_Bycatch\_A1}_{[yr]}$ is the observed annual bycatch estimated with approach 1.

Approach 2:

$$\text{Annual\_NZCT\_CPUE\_A2}_{[yr,sea,\ ar,\ dp]} = \exp\{\text{average}[\ln(\text{NZCT\_CPUE}_{[yr,\ sea,\ ar,\ dp]})] + 0.5*\text{var}(\ln(\text{NZCT\_CPUE}_{[yr,\ sea,\ ar,\ dp]}))\} \quad \text{(Step1a)}$$

$$\text{Annual\_All\_Tow\_CPUE\_A2}_{[yr,sea,\ ar,\ dp]} = \text{Annual\_NZCT\_CPUE\_A2}_{[yr,sea,\ ar,\ dp]}*\text{Percent\_of\_NZCT}_{[yr,\ sea,\ ar,\ dp]} \quad \text{(Step1b)}$$

$$\text{2009\_2011\_Mean\_Annual\_All\_Tow\_CPUE\_A2}_{[sea,\ ar,\ dp]} = \text{Mean}(\text{Annual\_All\_Tow\_CPUE\_A2}_{[yr,\ sea,\ ar,\ dp]}) \quad \text{(Step2)}$$

where yr = 2009, 2010 and 2011

$$\text{Obs\_Bycatch\_A2}_{[yr,\ sea,\ ar,\ dp]} = \text{2009\_2011\_Mean\_All\_Tow\_CPUE\_A2}_{[sea,\ ar,\ dp]}*\text{effort}_{[yr,\ sea,\ ar,\ dp]}*\text{npv}_{[yr]} \quad \text{(Step3)}$$

where yr = 1972 - 2011

$$\text{Obs\_Bycatch\_A2}_{[yr]} = \text{sum}(\text{Observed\_Bycatch\_A2}_{[yr,\ sea,\ ar,\ dp]}) \quad \text{(Step4)}$$

$\text{Annual\_NZCT\_CPUE\_A2}_{[yr,sea,\ ar,\ dp]}$ is the observed annual non-zero-catch-tow year/season/area/depth-specific CPUE estimated with approach 2, $\text{NZCT\_CPUE}_{[yr,\ sea,\ ar,\ dp]}$ is the observed non-zero-catch-tow year/season/area/depth-specific CPUE, $\text{Annual\_All\_Tow\_CPUE\_A2}_{[yr,\ sea,\ ar,\ dp]}$ is the observed annual all-tow year/season/area/depth-specific CPUE estimated with approach 2, $\text{Percent\_of\_NZCT}_{[yr,\ sea,\ ar,\ dp]}$ is the observed year/season/area/depth-specific percent of non-zero-catch tows, $\text{2009\_2011\_Mean\_Annual\_All\_Tow\_CPUE\_A2}_{[sea,\ ar,\ dp]}$ is the 2009-2011 mean of season/area/depth-specific CPUE estimated with approach 2, $\text{Obs\_Bycatch\_A2}_{[yr,\ sea,\ ar,\ dp]}$ is the observed year/season/area/depth-specific bycatch estimated with approach 2, $\text{Obs\_Bycatch\_A2}_{[yr]}$ is the observed annual bycatch estimated with approach 2. Basically, estimates of the observed annual all-tow year/season/area/depth- specific CPUE with approach 2 were calculated based on a simplified delta-lognormal model.

Both approaches were performed and compared, using both observer and research data and only observer data. Both CPUE and bycatch estimates were similar using the two approaches. Both CPUE and bycatch estimates were slightly higher with both observer program and research vessel data than with only observer program data. The majority of the data for the years 2009-2011 consisted of observer data, which more closely match shrimp fishery effort. The 2009-2011 mean shrimp bycatch estimates and mean observed CPUE for bonnethead sharks are 232,136 sharks and 0.0440 sharks per net-hour.

Decision 5: The Panel recommended using Approach 2 with observer data only to obtain bycatch estimates because the majority of the data in 2009-2011, which were more reliable, were observer data.

In SEDAR 13, bycatch estimates for the Atlantic had been obtained by scaling the Gulf of Mexico estimates by the ratio of the observed days in the Atlantic (2.2 days on average) to the observed days in the Gulf of Mexico (17.5 days on average) based on observations for 1992-2003. This resulted in a ratio of 12.6%. After the Workshop, this ratio was updated with new information obtained from the Shrimp Fishery Observer Program (L. Scott-Denton, pers. comm.). The average trip length of trips observed in the SA (2.14=2,614 sea days/1,223 trips) was divided by the average trip length of trips observed in the GOM (15.85=22,761 sea days/1,436 trips) for 1992-2011. The new ratio became 13.5%.

Decision 6: Based on updated information from the Shrimp Fishery Observer Program, the Panel recommended using the new ratio of 13.5% to obtain bycatch estimates in the SA based on the GOM estimates.

2.2.3. Indices of abundance

2.2.3.1 Review of working papers

***SEDAR34-WP-02*: Standardized catch rates of bonnetheads 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 bonnethead shark using the delta lognormal method. Data has been collected by ENP personnel since 1972. However, the survey expanded it species list in the 1980s to include more than just the "sportfish" species. Therefore, the time series was analyzed from 1983-2011 following analysis conducted for blacktip shark at SEDAR 29. Factors year, area, target, season, fisher were significant main effects in the binomial model and factors year and area and were significant main effects in the lognormal model. The relative abundance trend was a gradual decline since about 1985.

SEDAR34-WP-03: Standardized Catch Rates of Bonnethead and Atlantic Sharpnose Shark from the Southeast Shark Drift Gillnet Fishery: 1993-2011
J. Carlson, A. Mathers, and M. Passerotti

Catch rate standardization using the Delta lognormal approach for data from the directed shark drift gillnet fishery was developed based on observer programs from 1993-1995 and 1998-2011. For Atlantic sharpnose shark, initial selection of factors indicated the negative of hessian not positive definite for the binomial model when only year was considered as a factor. Given that year is a factor in all model selection no further analysis was performed. For bonnethead shark, year and meshsize were significant as a main effect in the binomial model and year and area in the lognormal model. The relative abundance index was unstable with random peaks throughout the time series likely related to low sample size or missing observations (years with no data) throughout the time series.

SEDAR34-WP-05: Relative abundance of bonnethead and Atlantic sharpnose sharks based on a fishery-independent gillnet survey off Texas
W. Bubley and J. Carlson

This paper determines a relative abundance index for bonnethead and Atlantic sharpnose sharks utilizing a fishery independent gillnet survey by the Texas Parks and Wildlife Department, Coastal Fisheries Division. The protocol for the survey, as it is constituted today, has been ongoing since 1975 with the purpose of monitoring relative abundance and size of organisms, their spatial and temporal distribution, and species composition of the community and selected environmental parameters known to influence their distribution and abundance (Martinez-Andrade and Fisher 2012). These indices are an extension of those examined during SEDAR-13 to include updated data (Fisher 2007).

SEDAR34-WP-09: Standardized catch rates of Atlantic sharpnose (Rhizoprionodon terraenovae) and bonnethead (Sphyrna tiburo) sharks collected during a gillnet survey in Mississippi coastal waters, 1998-2011
E. Hoffmayer, G. Parsons, J. Hendon, A. Pollack, and G. Ingram.

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 270 net sets and 882 hours of effort, 2,557 Atlantic sharpnose and 217 bonnethead sharks were collected. Standardized catch rates were estimated using a Generalized Linear Mixed modeling approach assuming a delta-lognormal error distribution. Other than slight peaks observed in 2000 and 2007, standardized catch rates remained stable across the time series for Atlantic sharpnose and bonnethead sharks, respectively.

SEDAR34-WP-14: Bonnethead Abundance Indices from SEAMAP Groundfish Surveys in the Northern Gulf of Mexico
A. Pollack and W. Ingram, Jr.

The Southeast Fisheries Science Center Mississippi Laboratories have conducted groundfish surveys since 1972 in the northern Gulf of Mexico during the summer and fall under several sampling programs. In 1987, both groundfish surveys were brought under the Southeast Area Monitoring and Assessment Program (SEAMAP). These fisheries independent data were used to develop abundance indices for bonnethead (Sphyrna tiburo). Separate indices were produced using the summer and fall SEAMAP groundfish survey data. Annual abundance indices were more variable in the early years of the index; subsequently in more recent years they appear to show very little variation. Additionally, age 0 sharks were not able to be separated out due to the lack of lengths from the early years of the survey. With the low catches of bonnethead in the summer survey, caution should be exercised before using this index in the stock assessment.

SEDAR34-WP-16: Continuity Runs for Atlantic Sharpnose and Bonnethead SEAMAP Groundfish Surveys and NMFS Bottom Longline Surveys
A. Pollack and W. Ingram, Jr.

In Prior to the Data Workshop for SEDAR 34, we were asked to rerun abundance indices for use in continuity runs of the stock assessment models for Atlantic sharpnose, *Rhizoprionodon terraenovae*, and bonnethead, *Sphyrna tiburo*. Six indices were requested from the SEAMAP Groundfish survey and three were requested from the NMFS Bottom Longline survey. All abundance indices were constructed using the delta-lognormal method outlined by Lo et al. 1992. For the SEAMAP Groundfish indices, in the previous working documents a Bayesian approach was used, which was not able to be replicated and was thus replaced with the delta-lognormal approach. In addition, it is not known which version of the data was used; however, the most current set was used for these runs. The same concern and solution about the version of the data also applies to the NMFS Bottom Longline data. For a full review of the data, model variables and model selection refer to the current working document for SEAMAP Groundfish (SEDAR34-DW-14) and NMFS Bottom Longline (SEDAR34-DW-15).

SEDAR34-WP-19: Standardized catch rates of Atlantic sharpnose and bonnethead sharks from the SEAMAP-South Atlantic Shallow Water Trawl Survey
E. Cortés and J. Boylan

This document presents an updated analysis of the relative abundance of Atlantic sharpnose and bonnethead sharks from the SEAMAP-SA Shallow Water Trawl Survey for 1989-2011. Time series data from this survey were standardized with Generalized Linear Mixed Model (GLMM) procedures. Both series showed increasing trends. Examination of lengths of Atlantic sharpnose and bonnethead sharks over the time period considered revealed no trend. Length-frequency information revealed that mostly immature individuals of these species area caught, but adults are also present.

***SEDAR34-WP-28*:** Standardized Catch Rates of Bonnethead and Atlantic Sharpnose Shark from the Southeast Sink Gillnet Fishery: 2005-2011
J. Carlson, A. Mathers, and M. Passerotti

A standardized catch rate series was developed for Atlantic sharpnose and bonnethead shark using the Delta lognormal approach based on observer data collected in the southeast sink gillnet fishery. Depending on the species, differing factors were found to be significant as main effects in the final model. For Atlantic sharpnose shark, year, season, area, and meshsize were significant in the binomial model and year, target, season and area in the lognormal model. For the bonnethead sharks, year, area, target and season were significant in the binomial model whereas year and meshsize were significant in the lognormal model. The relative abundance index was relatively stable for both species from 2005-2011.

***SEDAR34-WP-29*:** Relative abundance of Atlantic sharpnose and bonnethead shark from the northeastern Gulf of Mexico
J. Carlson, D. Bethea, E. Hoffmayer, J. Tyminski, R. Hueter, D. Grubbs, M. Ajemian, and G. Burgess

Following recommendations at SEDAR29, fishery independent gillnet data sets from several surveys were combined to form a more spatially expansive inshore eastern Gulf of Mexico gillnet dataset. Since there were differences in the accessory data included with the data sets, several factors including temperature, salinity, year, month, location, depth, set time, and effort were used within a generalized linear model to standardize the series. Additionally, the factor “survey” was added to the dataset. A total of 3313 gillnet sets have been made throughout all areas since 1995. The majority of individuals captured were juveniles and the length distribution did not change significantly over the survey period for Atlantic sharpnose shark or bonnethead shark. The abundance trend was relatively stable for Atlantic sharpnose shark with some evidence for an increasing trend in later years. For bonnethead, outside one dip in the time series in 2005, the time series was relatively flat.

***SEDAR34-WP-32*: Standardized catch rates of bonnethead (Sphyrna tiburo) from the South Carolina Department of Natural Resources trammel net survey**
B. Frazier and C. McCandless

The trammel net survey has been conducted since 1991 and is currently an ongoing program. It uses a stratified random sampling protocol from seven different South Carolina estuaries (as strata) with individual sampling sites chosen at random within each estuarine area on a monthly basis. Sampling occurs year round, and all strata are sampled every month. The trammel net program was designed to monitor important recreational finfish species (red drum, spotted seatrout, and flounder), however bonnethead are frequently encountered. Data from this survey were used to look at trends in relative abundance of bonnethead in South Carolina estuarine waters. Bonnethead catch per unit effort (CPUE) in number of sharks per net hour were examined by year. The CPUE was standardized using the Lo et al (2002) method which models the proportion of positive sets separately from the positive catch. Nominal and standardized CPUE results from this survey indicate an increase in bonnethead relative abundance across the survey years.

***SEDAR34-WP-35*: Standardized indices of abundance for bonnethead and Atlantic sharpnose sharks from the Georgia Department of Natural Resources ecological monitoring trawl surveys**
C. McCandless, J. Page, and C. Belcher

This document details the shark catches from the Georgia Department of Natural Resources (GADNR) Ecological Monitoring Trawl Survey conducted from 2003-2011. Catch per unit effort (CPUE) in number of sharks per tow hour were used to examine age 1+ bonnethead and Atlantic sharpnose shark relative abundance in Georgia’s coastal waters. The CPUE was standardized using a two-step delta-lognormal approach that models the proportion of positive catch with a binomial error distribution separately from the positive catch, which is modeled using a lognormal distribution. The standardized indices of abundance from the GADNR trawl survey show no apparent overall trends in age 1+ bonnethead and Atlantic sharpnose shark relative abundance across survey years.

***SEDAR34-WP-36*: Standardized indices of abundance for bonnethead and Atlantic sharpnose sharks caught during the South Carolina Department of Natural Resources red drum longline and Cooperative Atlantic States Shark Pupping and Nursery gillnet surveys**
C. McCandless and B. Frazier

This document details shark catches from the South Carolina Department of Natural Resources (SCDNR), Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) gillnet survey and the SCDNR adult red drum longline survey, both conducted in South Carolina's estuarine waters, with additional nearshore stations in the red drum survey. Catch per unit effort (CPUE) in number of sharks per net hour or sharks per hook hour were used to examine bonnethead and/or Atlantic sharpnose shark relative abundance for gillnet and longline surveys, respectively. The SCDNR red drum time series had to be analyzed in two separate time segments (1998-2006 and 2007-2011) due to a change in gear and sampling design. The CPUE for all time series was standardized using a two-step delta-lognormal approach that models the proportion of positive catch with a binomial error distribution separately from the positive catch, which is modeled using a lognormal distribution. Nominal and standardized CPUE results from the COASTSPAN gillnet survey indicate a decreasing trend in bonnethead relative abundance during the survey years. This survey also shows an overall decreasing trend for total Atlantic sharpnose sharks across survey years; but, once young-of-the year sharks are removed from the gillnet catch, an increasing trend is seen in age 1+ sharks. Atlantic sharpnose shark relative abundance begins an increasing trend during the final years of the 1998-2006 red drum survey. The current red drum survey shows a fairly stable trend in Atlantic sharpnose shark relative abundance.

***SEDAR34-WP-37*: Standardized indices of abundance for bonnethead and Atlantic sharpnose sharks caught during the Cooperative Atlantic States Shark Pupping and Nursery longline surveys from South Carolina to northern Florida**
C. McCandless, C. Belcher, B. Frazier, M. McCallister, R. Ford, and J. Gelsleichter

This document details the shark catches from the Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) longline surveys conducted in estuarine and nearshore waters from South Carolina to northern Florida. Catch per unit effort (CPUE) in number of sharks per hook hour were used to examine age 1+ bonnethead and Atlantic sharpnose shark relative abundance from 2000-2011. The CPUE was standardized using a two-step delta-lognormal approach that models the proportion of positive catch with a binomial error distribution separately from the positive catch, which is modeled using a lognormal distribution. The standardized indices of abundance from the COASTSPAN longline surveys show a peak in abundance in 2001 for bonnethead and Atlantic sharpnose sharks. Relative abundance, for both species, then drops closer to previous levels in 2002 and appears to stabilize before starting an increasing trend in recent years.

2.2.3.2 New indices of abundance

Three new fishery-independent indices (SEDAR34-WP-29, 32, 37), and one new fishery-dependent index (SEDAR34-WP-28) were presented for consideration by the Panel (**Table 2.5.4**). 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 were determined 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 potential 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).

Index ranking was completed during SEDAR34 with input from the assessment biologists for the purpose of weighting the indices in the model runs. Indices could, and frequently did, have similar rankings. 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 Panel ranked fishery-independent indices higher than fishery-dependent indices. For specific reasoning behind the individual index rankings, see SEDAR34-WP-39.

Following recommendations at SEDAR29, that fishery-independent data from multiple sources be combined in a generalized linear modeling framework, some data sets were combined from SEDAR13 data (SEDAR13-DW-06, 21, 27, 30, 38) with new data sources and analyzed prior to the SEDAR34 workshop (e.g., SEDAR34-WP-29, 37). These documents were presented to the Panel and the Panel accepted these as new time series.

Decision 1: Consistent with the approach used in SEDAR 29, the Panel decided to combine coastal fishery-independent gillnet and longline surveys.

Several series that were used for bonnethead at SEDAR13 were not used at SEDAR34. A number of factors were outlined as to why the series were not considered. Series with low sample size in some years or no samples taken in many years such as SEDAR13-DW-09 (The Directed Shark Drift Gillnet Fishery) were removed. Series were not considered if there was questionable species identification such as in SEDAR 13-DW-16 (Marine Recreational Fishery Statistics Survey (MRFSS)) and in self-reported logbook data from SEDAR13-DW-26 and 41. Logbook data was also not utilized if there was a comparable observer program that collected data from the same fishery. Additional series such as SEDAR 13-DW-25 (Northeast Fisheries Observer Program of the coastal gillnet fishery) were deemed not useable because most samples were from areas outside the species range resulting in low sample sizes.

Because the Gulf of Mexico SEAMAP series was utilized at SEDAR13 for summer and fall (SEDAR34-WP-14), it was automatically considered for SEDAR34. However, the author of the analysis had several concerns with the bonnethead data in the summer series because of disjointed catches. Discussion ensued among panel members and it was decided that the summer series for bonnethead would be removed and only the fall series would be utilized.

Decision 2: After reviewing the data, the Panel decided to remove some time series that were used for SEDAR13.

Some panel members were concerned about the difference in bait type used in the Florida, South Carolina and Georgia longline surveys in relation to bonnethead catches (SEDAR34-WP-37).

Some panelists felt that excluding surveys with different bait type is a more appropriate way to analyze the data. Nonetheless, other panelists felt combining all three surveys would increase the temporal and spatial scale of the survey with the data being subjected to a generalized linear model and bait type as a factor. As bait type was not significant in the final model, the Panel concluded to accept the combined Florida-Georgia-South Carolina COASTSPAN longline series for bonnethead. However, the Panel further recommended using the South Carolina and Georgia series separately as a sensitivity series in the assessment, if appropriate.

Decision 3: Based on the preceding discussion, the Panel decided to treat the Atlantic COASTSPAN longline series as a single series.

Summaries of the indices of relative abundance considered and decisions made on the rankings are in **Tables 2.5.4** and **2.5.5**. In general, series that were fishery independent, subject to a random-stratified statistical design, stock-wide and were of long temporal scale were ranked highest. The Texas Parks and Wildlife gillnet survey and the combined Gulf of Mexico gillnet survey were ranked highest and the Atlantic Coastspan Longline Survey was ranked lowest.

Decision 4: Consistent with previous SEDARs, the Panel decided to rank all abundance series.

2.3. LITERATURE CITED

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2.4. RESEARCH RECOMMENDATIONS

- More research is necessary on review/improvement/development of shrimp bycatch estimation models for both data-poor and data-rich species
- More research is necessary on integration of various local abundance indices into a global abundance index based on spatio-temporal, physical-biological characteristics and variability.

2.5. TABLES

Table 2.5.1. Catches of bonnethead shark by fleet in numbers used in the continuity analysis. Catches are separated into six fisheries: commercial bottom longline, gillnet, handline, and bottom longline discards, recreational catches, and shrimp trawl bycatch. Catches for 1950-2005 are identical to those used for SEDAR 13. For shrimp discards, 2006-2011 values are the mean of 2003-2005 values.

Year	Com-BLL	Com-GN	Com-L	Com-BLL disc	Recreational	Shrimp discards
1950	0	0	0	7469.00972	0	103005
1951	0	0	6	13313.7712	0	132351
1952	0	0	13	14513.80729	0	133902
1953	0	0	19	15713.84337	0	154059
1954	0	0	25	16913.87946	0	158973
1955	0	0	32	18113.91555	0	144143
1956	0	0	38	19313.95164	0	131016
1957	0	0	44	20513.98773	0	117923
1958	0	0	51	21714.02382	0	116978
1959	0	0	57	22914.05991	0	131248
1960	0	0	63	15058.32143	0	140670
1961	0	0	70	15759.70212	0	70687
1962	0	0	76	16461.08282	0	92678
1963	0	0	82	17162.46352	0	139034
1964	0	0	89	17863.84422	0	124463
1965	0	0	95	18565.22492	0	134020
1966	0	0	101	19266.60561	0	126382
1967	0	0	108	19967.98631	0	155001
1968	0	0	114	20669.36701	0	141535
1969	0	0	120	21370.74771	0	148218
1970	0	0	127	18450.37606	0	162989
1971	0	0	133	21631.98576	0	167247
1972	0	0	139	21935.46177	0	259608
1973	0	0	146	22238.93778	0	189270
1974	0	0	152	22542.41378	0	255743
1975	0	0	158	22845.88979	0	380381
1976	0	0	164	23149.3658	0	171773
1977	0	0	171	23452.84181	0	332678
1978	0	0	177	23756.31781	0	81139
1979	0	0	183	24059.79382	0	317721
1980	0	0	190	25067	0	159361
1981	0	0	196	39269	0	109637
1982	1	0	202	26115	0	190028
1983	1	0	209	22925	1	91668
1984	3	0	215	15418	2	103355
1985	6	0	221	22607	4	100703
1986	10	0	228	50474	6	323168
1987	16	5496	234	26527	10	204623
1988	24	10991	240	30986	14	182213
1989	40	16487	247	37901	24	119722
1990	74	21983	253	48317	44	271557
1991	113	27478	259	8837	66	104186
1992	190	32974	266	18692	112	154342
1993	349	38470	272	19798	205	142619
1994	680	43965	278	20524	400	121775
1995	1305	49461	285	32112	11168	242057
1996	7324	5259	209	22519	4303	479034
1997	377	14963	190	14995	221	417245
1998	957	1468	225	29065	562	164872
1999	633	9995	832	37341	372	271829
2000	899	16500	42	56436	528	137164
2001	554	19705	70	59017	326	263532
2002	2344	36840	578	51048	1377	305874
2003	3756	6514	109	40066	2207	216626
2004	924	7063	58	42295	543	453898
2005	2109	9942	224	31215	1241	112188
2006	1289	10028	250	24885	675	130616
2007	416	16457	55	42444	218	56931
2008	363	17898	37	22973	190	9416
2009	3901	13362	41	28743	2041	316181
2010	90	6641	17	14683	47	155275
2011	900	8726	152	57023	471	302106

Table 2.5.2. Summary of Recommended Life History Parameters

	Atlantic Ocean	Gulf of Mexico	Single stock
	Female / Male	Female / Male	Female / Male
Growth parameters			
Linf (mm FL)	1032.4 / 778.4	894.9 / 703.5	1009.4 / 723.1
k	0.19 / 0.30	0.28 / 0.54	0.20 / 0.50
t_o (years)	-1.76 / -1.50	-2.13 / -1.60	-2.33 / -1.29
Max observed age (years)	18	7.5	18
Maturity ogive	SEDAR34-WP-07	SEDAR34-WP-07	SEDAR34-WP-07
	Female	Female	Female
FL (mm) at 50% maturity	815.9	662.6	729
a and *b*	*a* = -27.89, *b* = .034	*a* = -33.51, *b* = 0.051	*a* = -12.01, *b* = 0.016
Age (years) at 50% maturity	6.7	2.9	4.6
a and *b*	*a* = -9.07, *b* = 1.357	*a* = -7.36, *b* = 2.521	*a* = -3.32, *b* = 0.716
Reproductive cycle	Annual	Annual	Annual
Fecundity	mean = 8.8 (S.D. = 2.4)	mean = 9.7 (S.D. = 3.1)	mean = 9.3 (S.D. = 2.9)
Maternal size (mm FL) - litter size relationship	y = 0.0241FL-13.796	No significant relationship	No significant relationship
Pupping month	September	August	August
Sex ratio	1:1	1:1	1:1
L-W relationship	WT = 3.462x10-6*FL^3.208	WT = 9.52x10-11*TL(mm)^3.59 and TL (mm)=(1.18)FL(mm)-23.34	WT = 3.462x10-6*FL^3.208

Table 2.5.3. Recommended female bonnethead shark maturity ogive:

Age (years)	Proportion Mature
0.00	0.03
1.00	0.07
2.00	0.13
3.00	0.24
4.00	0.39
5.00	0.56
6.00	0.73
7.00	0.84
8.00	0.92
9.00	0.96
10.00	0.98
11.00	0.99
12.00	0.99
13.00	1.00
14.00	1.00
15.00	1.00
16.00	1.00
17.00	1.00
18.00	1.00

Table 2.5.4. A summary of indices of abundance considered for the bonnethead shark assessment at SEDAR34.

Document Number	Series Name	Type	Years	Season	Spatial	Statistical design	Recommendation	Positive aspects	Negative aspects
SEDAR 13-DW-09	GNOP	Fishery Dependent-Commercial	1993-1995, 2008-2012	Jan-Dec	South Atl	None	Not recommended		
SEDAR 13-DW-16	MRFSS	Fishery Dependent-Recreational	1981-2011	Jan-Dec	South Atl_Gulf of Mexico	None	Not recommended		
SEDAR 13-DW-25	NE Coastal Gillnet Fishery	Fishery Dependent-Commercial	1995-2011	Jan-Dec	North Atlantic	None	Not recommended		
SEDAR 13-DW-26	Gillnet Logbook	Fishery Dependent-Commercial	1998-2011	Jan-Dec	South Atl_Gulf of Mexico	None	Not recommended		
SEDAR 34-DW-02	ENP	Fishery Dependent-Recreational	1983-2011	Jan-Dec	Southwest Florida	None	Base	Long time-series	Spatial limited
SEDAR 34-DW-05	Texas Gillnet	Fishery independent	1975-2011	Apr-Nov	Texas	Stratified	Base	Fishery independent Long time series	Spatial limited
SEDAR 34-DW-14	SEAMAP - GoM - Ext Fall	Fishery independent	1972-2011	Oct-Nov	Gulf of Mexico	Stratified	Base	Fishery independent Long time series	Limited size classes
SEDAR 34-DW-19	SEAMAP - SA	Fishery independent	1989-2011	Apr-Nov	South Atl	Stratified	Base	Fishery independent Long time series	Limited size classes
SEDAR 34-DW-28	Sink GNOP	Fishery Dependent-Commercial	2005-2011	Jan-Dec	South Atlantic	None	Sensitivity	High spatial coverage	Commercial fishing data
SEDAR 34-DW-29	GOM COMBINED GN	Fishery independent	1995-2011	Apr-Oct	East Gulf of Mexico	Stratified/Fixed	Base	Fishery independent	Limited spatial
SEDAR 34-DW-32	SCDNR Trammel Net	Fishery independent	1994-2011	Jan-Dec	South Carolina	Stratified	Base	Fishery independent	Limited spatially
SEDAR 34-DW-35	GADNR Trawl	Fishery independent	2003-2011	Apr-Oct	Georgia	Stratified	Base	Fishery independent	Limited spatial
SEDAR 34-DW-36	SC Coastspan GN	Fishery independent	1998-2011	Apr-Aug	South Carolina	Fixed	Base	Fishery independent	Limited spatial
SEDAR 34-DW-36	SCDNR red drum longline 1998-2006	Fishery independent	1998-2006	Aug-Dec	South Carolina	Fixed	Base	Fishery independent	Limited spatial
SEDAR 34-DW-37	Atl_Coastspan LL	Fishery independent	2000-2011	Apr-Sep	South Carolina/Georgia/Florida	Stratified/Fixed	Base	Fishery indep/High spatial coverage	Shorter time series

Table 2.5.5. A summary of bonnethead shark abundance indices used for base or sensitivity model runs with the associated rank of the time series. All data series were standardized using a lognormal or delta-lognormal generalized linear modeling approach

Document Number	Series Name	Type	Unit	Recommendation	Ranking	Years	Statistical design
SEDAR34-DW-02	ENP	Fishery dependent-recreational	shark/trip	Base	3	1983-2011	No
SEDAR34-DW-05	Texas Gillnet	Fishery independent	shark/net hr	Base	1	1975-2011	Stratified
SEDAR 34-DW-14	SEAMAP - GoM - Ext Fall	Fishery independent	shark/tow	Base	2.5	1972-2011	Stratified
SEDAR 34-DW-19	SEAMAP - SA	Fishery independent	shark/tow	Base	1	1989-2011	Stratified
SEDAR 34-DW-28	Sink GNOP	Fishery dependent-commercial	shark/net area hr	Sensitivity		2005-2011	No
SEDAR 34-DW-29	GOM COMBINED GN	Fishery independent	shark/net hr	Base	1	1995-2011	Stratified/Fixed
SEDAR34-DW-32	SCDNR Trawl	Fishery independent	shark/tow	Base	2.5	1994-2011	Stratified
SEDAR 34-DW-35	GADNR Trawl	Fishery independent	shark/tow	Base	3	2003-2011	Stratified
SEDAR 34-DW-36	SC Coastspan GN	Fishery independent	shark/net hr	Base	2.5	1998-2011	Fixed
SEDAR 34-DW-36	SCDNR red drum longline 1998-2006	Fishery independent	shark/hk hr	Base	3	1998-2006	Fixed
SEDAR 34-DW-37	Atl_Coastspan LL	Fishery independent	shark/hk hr	Base	3	2000-2011	Stratified/Fixed
SEDAR 34-DW-37	Coastspan LL_GA	Fishery independent	shark/hk hr	Sensitivity		2003-2011	Stratified/Fixed
SEDAR 34-DW-37	Coastspan LL_SC	Fishery independent	shark/hk hr	Sensitivity		2000-2011	Stratified/Fixed

Table 2.5.6. All indices recommended by SEDAR34 for bonnethead shark, including the corresponding SEDAR document number and run type (base or sensitivity). Index values are absolute and CV=coefficient of variation.

Document Number	Series Name	Type	Recommendation	Year	Index	CV
SEDAR 34-DW-05	ENP	FD-R	Base	1983	0.015	0.81
				1984	0.058	0.33
				1985	0.038	0.48
				1986	0.031	0.52
				1987	0.03	0.51
				1988	0.039	0.48
				1989	0.031	0.52
				1990	0.025	0.52
				1991	0.023	0.64
				1992	0.038	0.41
				1993	0.032	0.5
				1994	0.029	0.47
				1995	0.029	0.46
				1996	0.027	0.47
				1997	0.031	0.45
				1998	0.023	0.58
				1999	0.014	0.81
				2000	0.019	0.67
				2001	0.017	0.75
				2002	0.016	0.78
				2003	0.015	0.85
				2004	0.018	0.76
				2005	0.014	0.91

				2006	0.011	1.00
				2007	0.014	0.88
				2008	0.02	0.72
				2009	0.015	0.86
				2010	0.015	0.88
				2011	0.011	1.06
SEDAR 34-DW-19	SEAMAP - SA	FI	Base	1989	0.773	0.551
				1990	1.346	0.36
				1991	2.068	0.344
				1992	1.436	0.323
				1993	1.004	0.409
				1994	1.604	0.346
				1995	1.706	0.322
				1996	0.704	0.443
				1997	1.527	0.331
				1998	1.23	0.357
				1999	1.13	0.382
				2000	1.645	0.339
				2001	2.246	0.274
				2002	3.35	0.238
				2003	2.871	0.256
				2004	1.29	0.341
				2005	2.638	0.266
				2006	3.856	0.246
				2007	3.001	0.269
				2008	2.783	0.274
				2009	3.541	0.233

				2010	2.663	0.25
				2011	1.752	0.287
SEDAR 34-DW-05	Texas	FI	Base	1975	0.002	1.939
				1976	0.013	0.497
				1977	0.001	1.837
				1978	0.002	0.995
				1979	0.005	0.554
				1980	0.010	0.336
				1981	0.009	0.633
				1982	0.005	0.307
				1983	0.006	0.250
				1984	0.009	0.210
				1985	0.003	0.329
				1986	0.008	0.225
				1987	0.001	0.558
				1988	0.009	0.236
				1989	0.005	0.272
				1990	0.012	0.229
				1991	0.006	0.250
				1992	0.003	0.344
				1993	0.006	0.270
				1994	0.005	0.305
				1995	0.004	0.329
				1996	0.004	0.251
				1997	0.002	0.427
				1998	0.005	0.287
				1999	0.003	0.344

				2000	0.009	0.222
				2001	0.008	0.220
				2002	0.009	0.262
				2003	0.008	0.224
				2004	0.010	0.250
				2005	0.007	0.220
				2006	0.008	0.196
				2007	0.007	0.262
				2008	0.008	0.225
				2009	0.008	0.185
				2010	0.018	0.168
				2011	0.010	0.184
SEDAR 34-DW-36	SC Coastspan GN	FI	Base	2000	10.124	0.530
				2001	21.084	0.491
				2002	12.684	0.580
				2003	30.155	0.375
				2004		
				2005	21.245	0.294
				2006	26.699	0.289
				2007	13.376	0.556
				2008	51.087	0.269
				2009	23.669	0.362
				2010	13.262	0.348
				2011	5.658	0.568
SEDAR 34-DW-14	SEAMAP - GoM - Ext Fall	FI	Base	1972	0.207	0.396

1973	0.567	0.289
1974	0.426	0.344
1975	0.117	0.405
1976	0.359	0.314
1977	0.213	0.415
1978	0.118	0.416
1979	0.178	0.506
1980	0.094	0.585
1981	0.081	0.506
1982	0.062	0.540
1983	0.066	0.649
1984		
1985	0.011	0.895
1986	0.094	0.450
1987	0.022	0.589
1988	0.040	0.545
1989	0.013	0.744
1990	0.034	0.544
1991	0.024	0.481
1992	0.024	0.545
1993	0.031	0.480
1994	0.029	0.590
1995	0.021	0.653
1996	0.048	0.421
1997	0.032	0.481
1998	0.019	0.508
1999	0.028	0.481
2000	0.025	0.457

				2001	0.031	0.482
				2002	0.056	0.457
				2003	0.058	0.456
				2004	0.068	0.510
				2005	0.054	0.346
				2006	0.042	0.421
				2007	0.107	0.316
				2008	0.110	0.302
				2009	0.103	0.309
				2010	0.067	0.389
				2011	0.081	0.398
SEDAR 34-DW-29	GOM COMBINED GN	FI	Base	1995	1.049	0.19
				1996	0.467	0.27
				1997	1.030	0.21
				1998	1.178	0.27
				1999	1.264	0.23
				2000	0.903	0.26
				2001	1.432	0.19
				2002	1.107	0.18
				2003	1.546	0.18
				2004	1.399	0.20
				2005	0.515	0.38
				2006	1.495	0.24
				2007	1.048	0.24
				2008	1.033	0.23
				2009	1.377	0.20
				2010	1.333	0.23

				2011	1.312	0.19
SEDAR 34-DW-32	SCDNR Trammel net	FI	Base	1994	0.264	0.41
				1995	0.431	0.39
				1996	0.365	0.41
				1997	0.336	0.32
				1998	0.289	0.29
				1999	0.623	0.21
				2000	0.369	0.27
				2001	0.748	0.18
				2002	1.116	0.14
				2003	1.160	0.15
				2004	0.755	0.19
				2005	0.832	0.19
				2006	0.961	0.17
				2007	1.396	0.13
				2008	1.402	0.13
				2009	1.682	0.13
				2010	1.029	0.17
				2011	0.904	0.18
SEDAR 34-DW-37	ATL COASTSPAN LL	FI	Base	2000	15.591	0.34
				2001	63.417	0.50
				2002	40.083	0.63
				2003	39.252	0.25
				2004	60.764	0.21
				2005	39.114	0.22
				2006	51.309	0.17

				2007	32.883	0.23
				2008	45.841	0.19
				2009	44.485	0.18
				2010	89.201	0.12
				2011	71.739	0.16
SEDAR 34-DW-35	GADNR Trawl	FI	Base	2003	3.185	0.16
				2004	2.365	0.23
				2005	0.922	0.35
				2006	1.591	0.14
				2007	1.724	0.17
				2008	0.811	0.19
				2009	2.714	0.13
				2010	1.488	0.15
				2011	1.855	0.14
SEDAR 34-DW-28	Sink GNOP	FD	Base	2005	2114.3	0.26
				2006	651.8	0.25
				2007	3308.1	0.37
				2008	301.3	0.45
				2009	470.2	0.29
				2010	7.6	1.41
				2011	136.8	0.42
SEDAR 34-DW-37	GA COASTSPAN LL	FI	Base	2000	18.667	0.44
				2001		
				2002		
				2003	58.741	0.31

				2004	119.128	0.20
				2005	53.078	0.31
				2006	77.680	0.20
				2007	58.951	0.25
				2008	60.099	0.22
				2009	68.676	0.23
				2010	169.401	0.14
				2011	146.514	0.17
SEDAR 34-DW-37	SC COASTSPAN LL	FI	Base	2000	10.124	0.53
				2001	21.084	0.49
				2002	12.684	0.58
				2003	30.155	0.37
				2004		
				2005	21.245	0.29
				2006	26.699	0.29
				2007	13.376	0.56
				2008	51.087	0.27
				2009	23.669	0.36
				2010	13.262	0.35
				2011	5.658	0.57

2.6. FIGURES

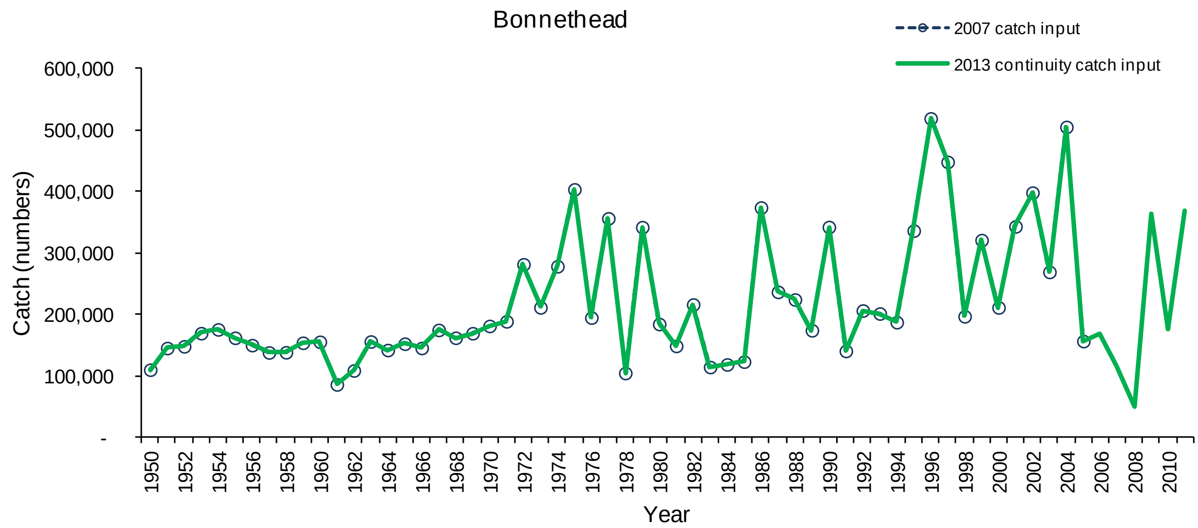


Figure 2.6.1. Catches used in the 2007 assessment (circles) and in the continuity analysis (thick green line), where six years of data (2006-2011) were added.

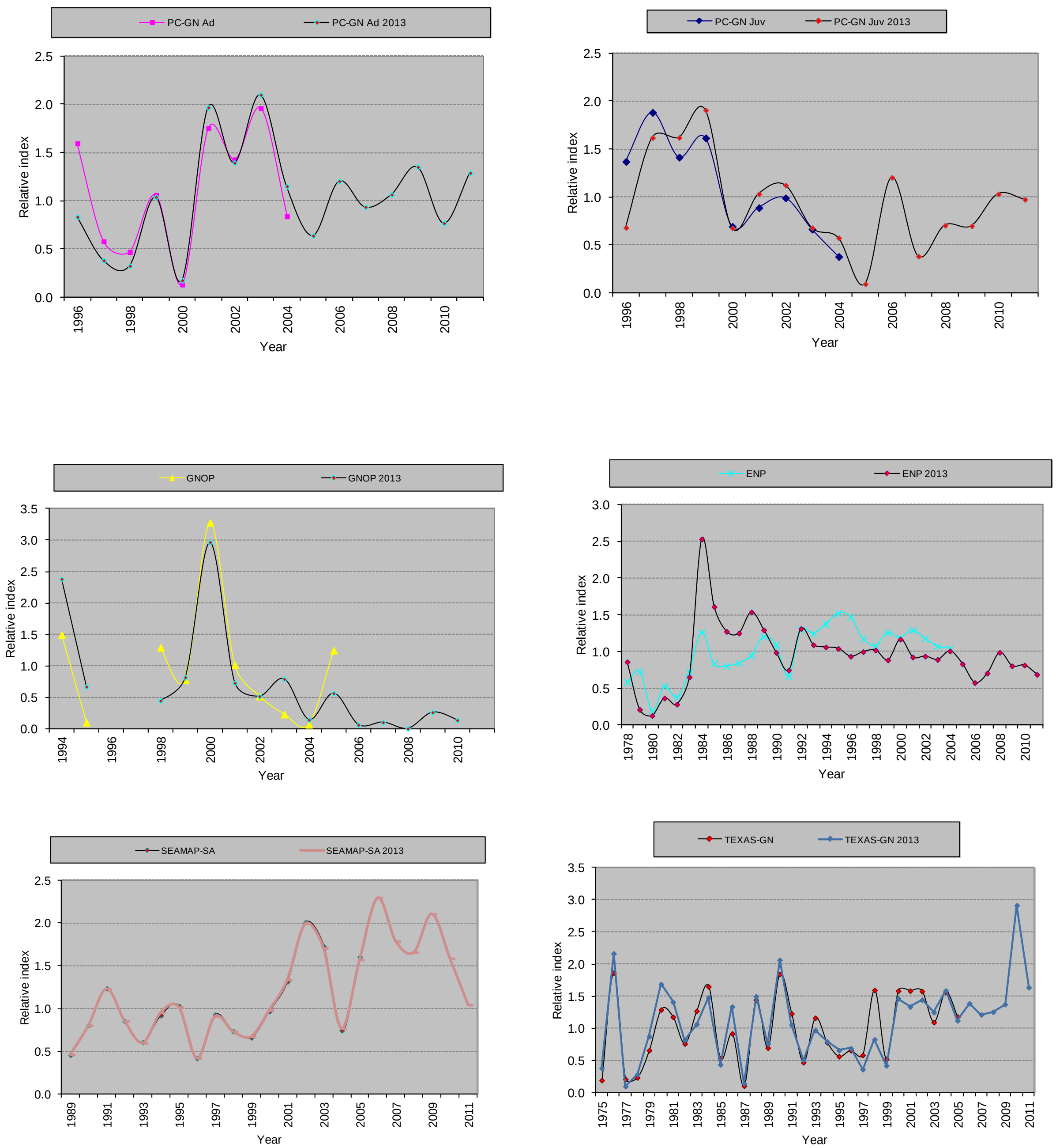
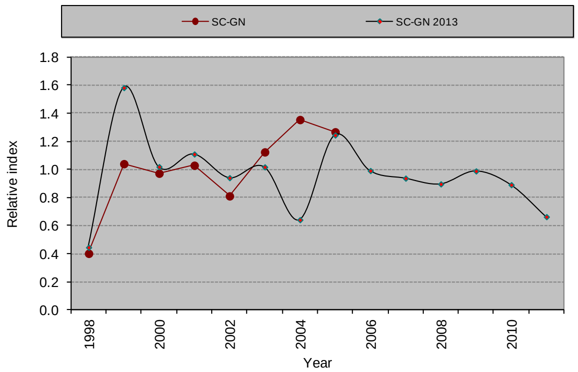
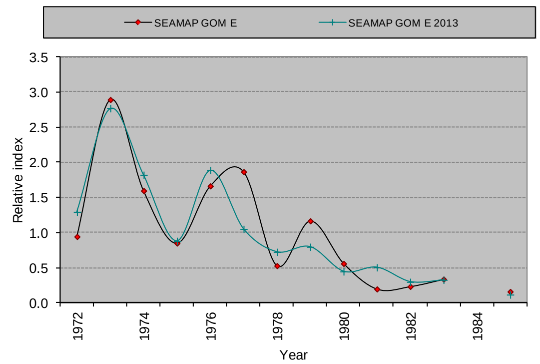


Figure 2.6.2. Indices used in the 2007 assessment vs. current continuity analysis. Only those indices that had additional years and were reanalyzed are shown: PC Gillnet Adults, PC Gillnet Juveniles, GNOP, ENP, SEAMAP-SA, and Texas Gillnet. All indices are scaled (divided by the mean of overlapping years).





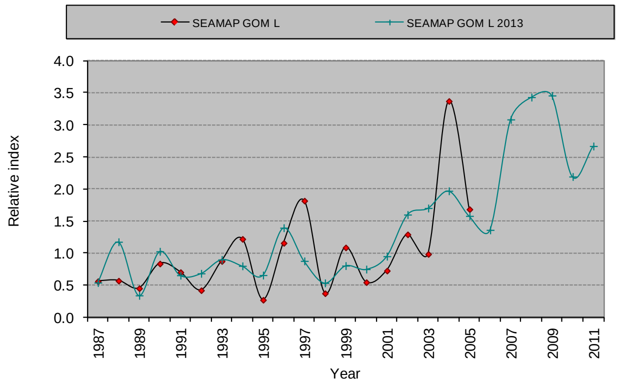


Figure 2.6.2 (continued). Indices used in the 2007 assessment vs. current continuity analysis. Only those indices that had additional years and were reanalyzed are shown: SC Coastspan Gillnet, SEAMAP-GOM-Early Fall, and SEAMAP-GOM-Late Fall. All indices are scaled (divided by the mean of overlapping years).

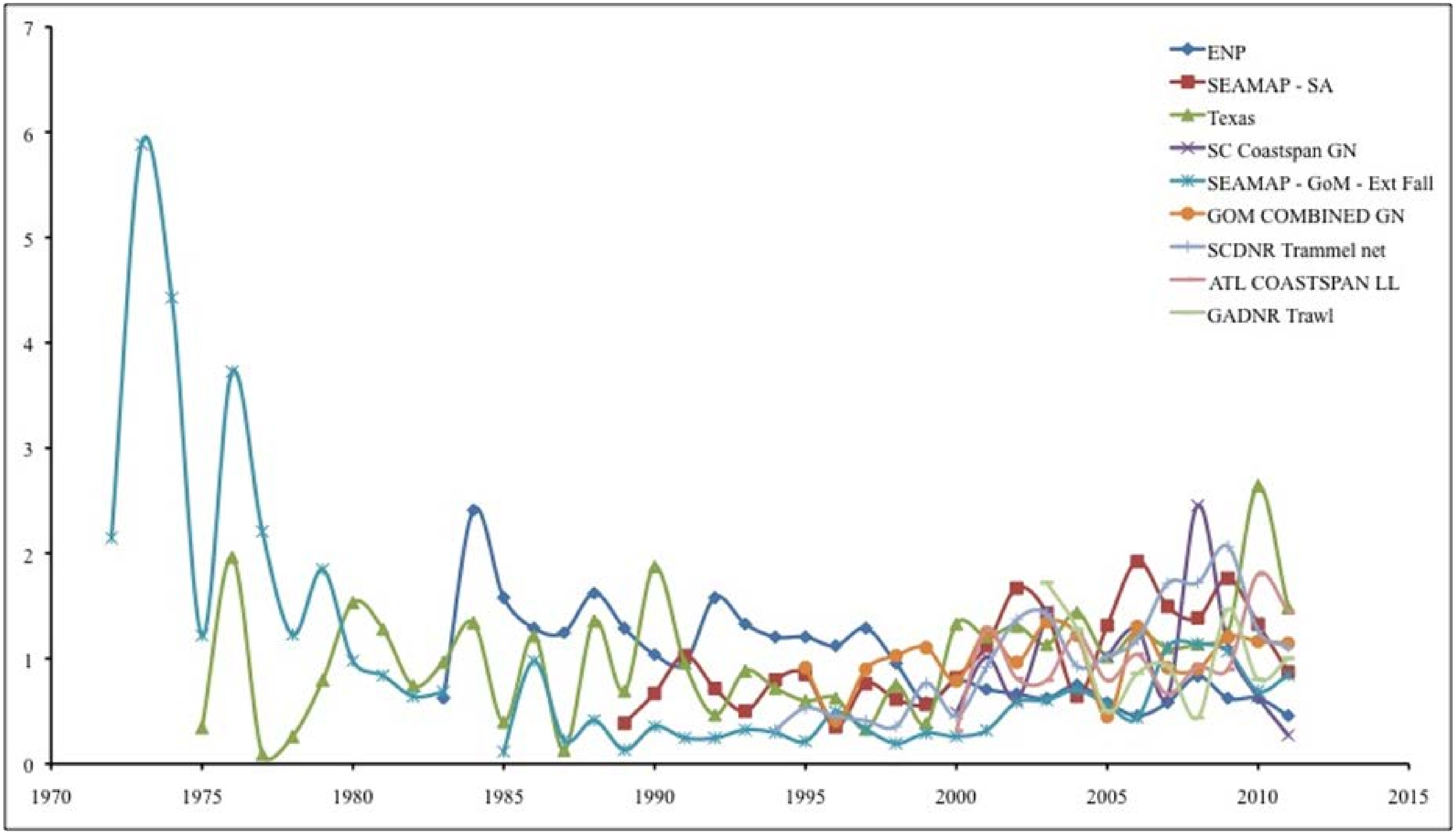


Figure 2.6.3. Relative base indices recommended by SEDAR34 for bonnethead shark. Each index is divided by the mean of its respective index for graphing purposes.

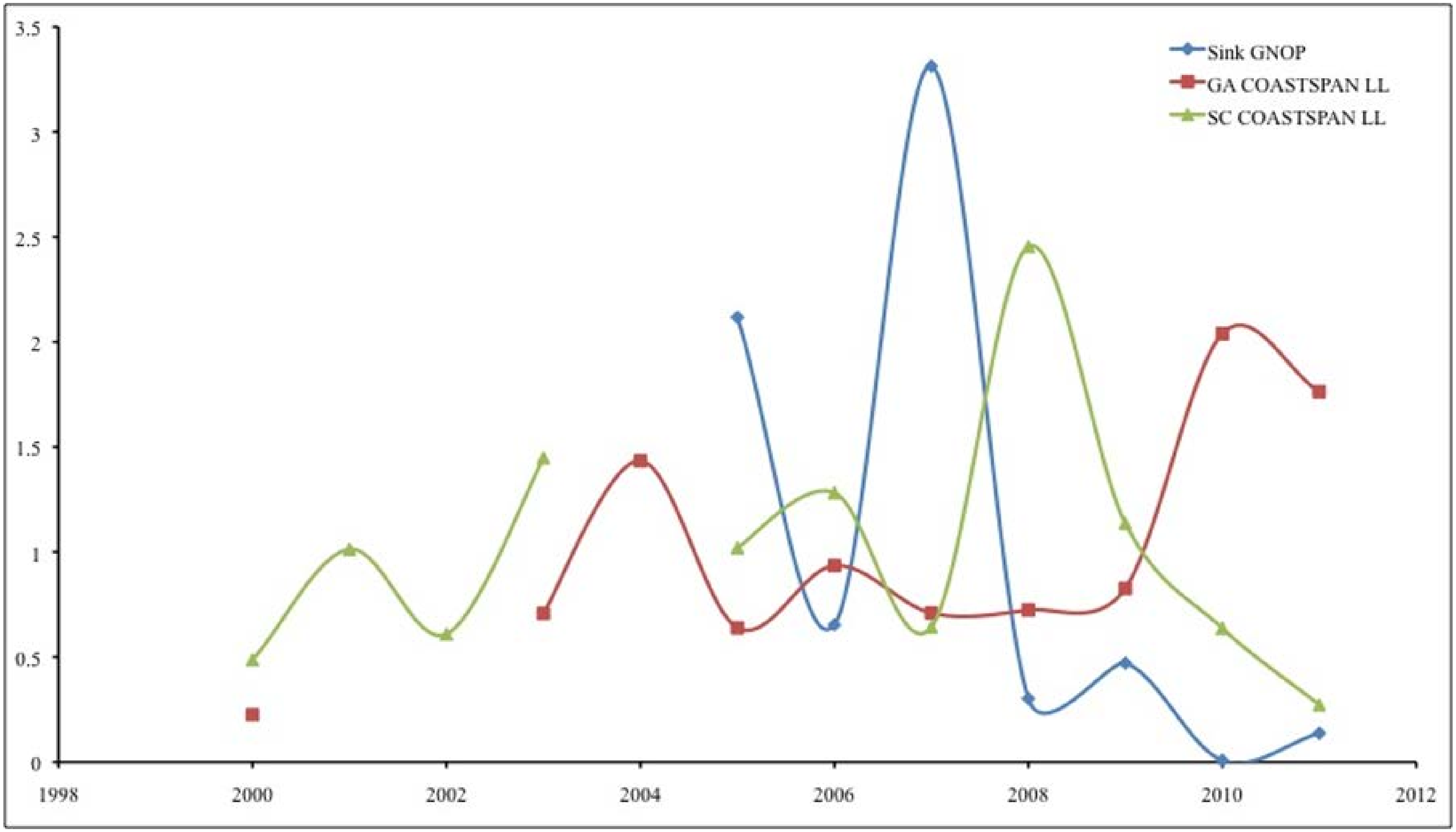


Figure 2.6.4. Relative sensitivity indices recommended by SEDAR34 for bonnethead shark. Each index is divided by the mean of its respective index for graphing purposes.

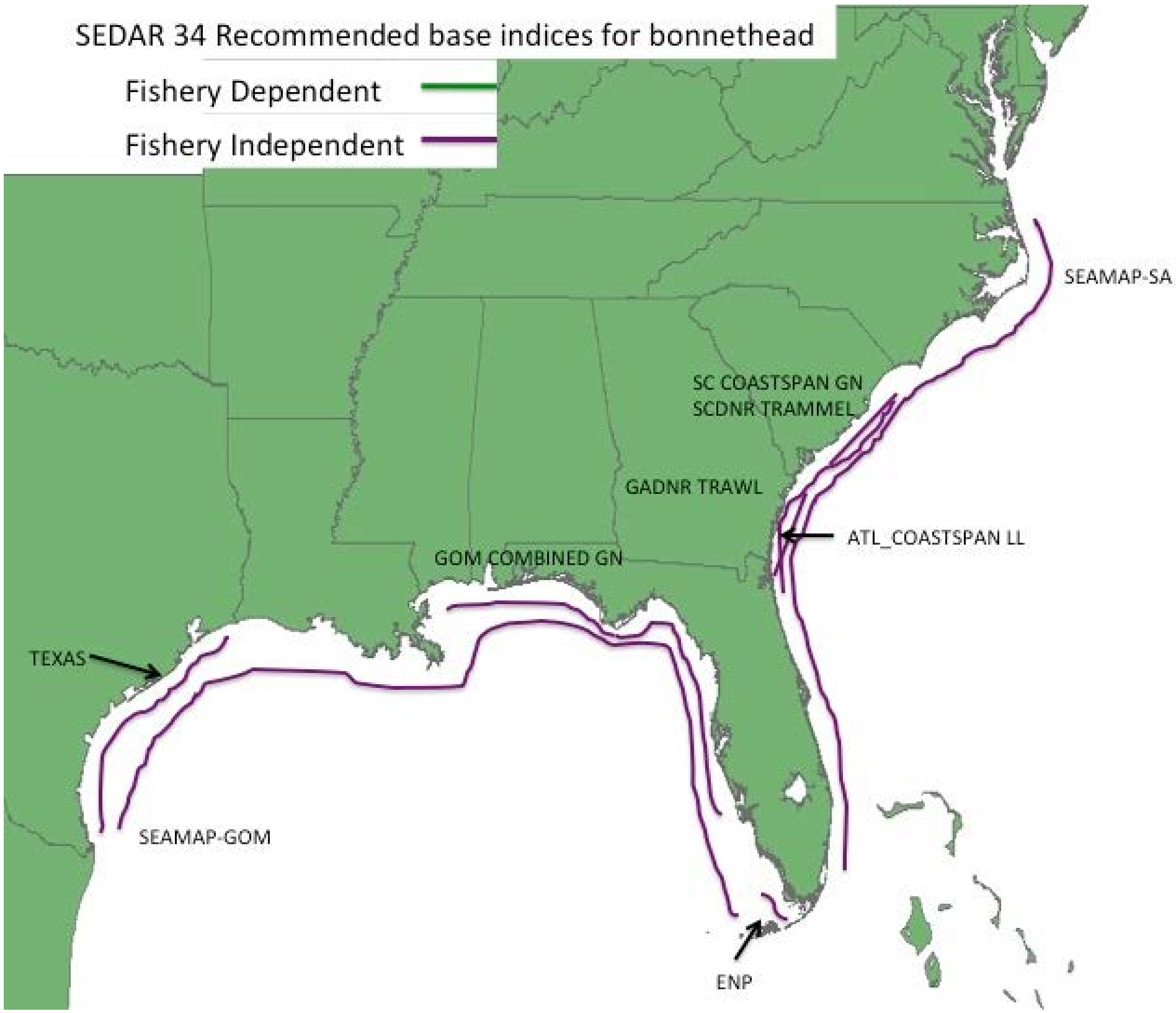


Figure 2.6.5. Distribution of sampling effort for indices recommended for base by SEDAR34 for bonnethead shark.

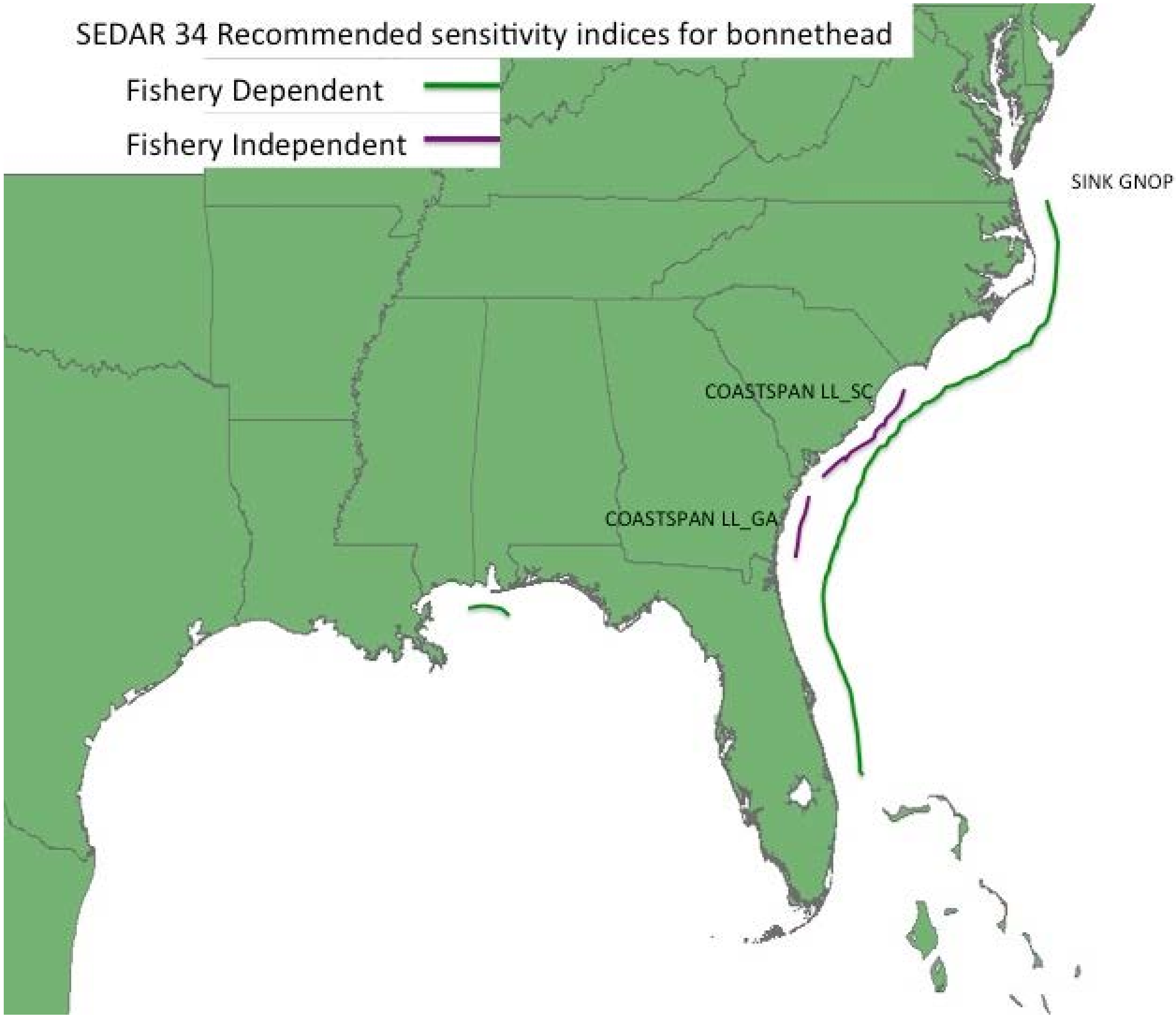


Figure 2.6.6. Distribution of sampling effort for indices recommended for sensitivity by SEDAR34 for bonnethead shark.

3. STOCK ASSESSMENT MODEL 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 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.

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 13 was replacing the estimates of shrimp bycatch generated with WinBUGS with the stratified nominal estimates recommended by the Panel (see decision 5 in Section 2.2.2.5). Further conceptual changes included: 1) using the recreational estimates from MRIP instead of those from MRFSS (see decision 1 in Section 2.2.2.2), 2) addition of post-release live discard mortality estimates for B2 (release alive) sharks from MRFSS/MRIP (see decision 2 in Section 2.2.2.3), and 3) addition of post-release live discard mortality estimates in the commercial bottom longline series and the gillnet and line commercial series (see decisions 3 and 4 in Section 2.2.2.4). All other procedures for developing catch series are explained in SEDAR34-WP-20 and section 2.2.2.

Commercial, recreational, and shrimp fishery catches 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 originally provided in weight. For years where catches were reconstructed (prior to 1995), the grand mean of average weights from the BLLOP for 1994-2011 (4.03 lb dw) was used to multiply numbers and obtain weight for the bottom longline and line fisheries; for the gillnet fishery, the grand mean of average weights from the DGNOP for 2000-2011 (1.68 lb dw) was used to multiply numbers and obtain weight. Year-specific average weights from the BLLOP for 1995-2011 were used to convert estimated number of live post-release mortality estimates into weight for the bottom longline fishery and the line fishery; for the gillnet fishery, the grand mean of average weights from the DGNOP for 2000-2011 (1.68 lb dw) was used to convert numbers into weight. **Appendix 1** lists available annual average weights used for commercial gears. For recreational catches, estimates of A+B1 catches for 1981-2011 were also made available in weight, including MRIP estimates for 2004-2011 and MRIP-adjusted estimates for 1981-2003. For 1950-1980, the mean of the year-specific ratios of catches in weight to catches in numbers for the period 1981-2011 (5.24 lb dw) was used as a multiplier for catches in numbers to obtain catches in weight. Since sharks released alive (B2s) are only available in numbers, we also used the year-specific ratio of the weight to the number of A+B1 sharks as average weight to multiply live post-release mortality estimates in numbers and obtain catches in weight. All transformations of ww to dw used a factor of 2.0 (i.e., ww=2dw). There was very limited size information to help guide conversion of numbers into weight for the shrimp fishery discards. Data from the Shrimp Fishery Observer Program (n=280 available only for 2010-2011) indicated an average size of 56.0 cm TL for observed bonnethead sharks, which corresponds to a weight of 0.70 kg or 0.77 lb dw, which was used as average weight to transform numbers into weight for the whole time series. When expressed in weight compared to numbers, it becomes apparent that both the commercial and recreational fisheries catch larger sharks than the shrimp trawl fishery (**Figure 3.6.1A** 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. Early attempts at estimating selectivity within the model through the use of the limited available age compositions (obtained from length compositions after back-transforming through the von Bertalanffy growth curve 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 multiple fishery-independent surveys was used to generate age-frequency distributions by back-transforming through the von Bertalanffy growth curve (**Appendix 2**). 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 was adopted bearing in mind that it has several 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. Based in part on recommendations from previous peer reviews, it was decided that age frequencies be estimated by back-transforming from the von Bertalanffy growth function.

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 3**. 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

Commercial bottom longline and lines—Logistic curve, with age at full selectivity of 3.

Commercial gillnets—A dome-shaped selectivity curve (double exponential) with maximum selection at age 4.

Recreational hook and line—Logistic curve, with age at full selectivity of 3.

Shrimp trawl fishery discards—A dome-shaped selectivity curve with only the descending right limb and maximum selection at age 1.

Indices of relative abundance

GOM Combined GN, ENP, Texas Gillnet, SEAMAP GOM EF, and GADNR Trawl—Double exponential curve with maximum selection at age 1 (same selectivity pattern assigned to the shrimp trawl fishery discards).

SCDNR Trammel Net— Double exponential with maximum selection at age 8.

SEAMAP-SA and SC Coastspan GN— Double exponential with maximum selection at age 5.

ATL Coastspan LL— Logistic curve, with age at full selectivity of 1.

SINK GNOP and GNOP—Double exponential with maximum selection at age 4 (same selectivity pattern assigned to the commercial gillnet catches). These two indices were not used in any of the runs.

BLLOP and MRFSS— Logistic curve, with age at full selectivity of 3 (same selectivity pattern assigned to the commercial bottom longline, commercial lines, and recreational hook and line catches). These two indices were not used in any of the runs.

Logistic curves fitted to the data were:

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

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

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

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 Panel recommended the use of nine indices, only one of which was fishery dependent (ENP; Everglades National Park creel survey). The other eight indices were: GOM Comb GN (Gulf of Mexico combined gillnet), SCDNR Tram Net (South Carolina Department of Natural Resources trammel net),), SEAMAP-SA (SEAMAP South Atlantic trawl), Texas GN (Texas Parks and Wildlife Department gillnet), SC Coastspan GN (South Carolina Coastspan gillnet), ATL Coastspan LL (Atlantic Coastspan (or combined) longline), SEAMAP GOM EF (SEAMAP Gulf of Mexico Extended Fall), and GADNR Trawl (Georgia Department of Natural Resources Trawl).

The AP assigned ranks as one of the modalities for index weighting in the baseline run as follows (rankings indicated in parentheses): GOM Comb GN (1), SCDNR Tram Net (2.5), ENP (3), SEAMAP-SA (1), Texas GN (1),SC Coastspan GN (2.5), ATL Coastspan LL (3), SEAMAP GOM EF (2.5), and GADNR Trawl (3). Equal weighting (i.e., no weights) and inverse CV weighting were also used. 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 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** were extracted by the Panel from information reported in papers described in Section 2.2.1 and summarized at the Workshop or in ensuing webinars. Additionally, age-specific values of instantaneous natural mortality (M) were estimated through several life history invariant methods commonly used for sharks, which 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 survivorship of the four methods was taken (refer to the "BH_demographic gamer_2013.xlsm" spreadsheet implementation of a life table to see how M values were derived).

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 Panel set the year of virgin conditions at 1950, which was the same as in the previous assessment (SEDAR 13).

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

where $N_{a,y,1}$ is the number of sharks in each age class in the first model year (y=1), in the first month (m=1), M_a is natural mortality at age, A is the plus-group age, and recruitment (R) is assumed to occur at age 1. Recruitment is assumed to occur at age 1 because the stock-recruitment relationship includes survival to age 1 (pup survival; see below).

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

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

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

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).

Recruitment follows a first-order lognormal autoregressive process (see eq. 14). The correlation coefficient ρ was set to 0.5, and η is a normally distributed random error with mean=0 and CV=0.25. These choices reflect a high level of autocorrelation in process error and a low level of process error in recruitment, which is compatible with the life history of sharks, where interannual variation in recruitment is expected to be low. Annual deviations in recruitment were not estimated. Through the reparameterization of the Beverton-Holt curve (eqs. 2 and 3), whereby the virgin number of recruits (R_0) and pup survival (S_0) are given prior pdfs and estimated in a Bayesian framework, all relevant biological information available is fully utilized in describing the recruitment process.

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

where $f_{y,i}$ is annual fleet-specific effort, b_0 is the intercept, and $f_{y=\mathrm{mod},i}$ is a fleet-specific constant. The historic period spanned 1950-1971 and included reconstructed catches, but no indices of relative abundance. The modern period started in 1972 (the first year with an index of relative abundance) and ended in 2011. Following SEDAR 13, historic effort for the bottom longline (BLL) and gillnet (GN) commercial fleets and the shrimp fishery was modeled as a constant with a very small value (eq. 4a) whereas historic effort for the line commercial and the recreational fleet was modeled as a linear trend interpolated from a constant value equal to zero or close to zero in 1950 to a higher value estimated for the first year of the modern period (eq. 4b). Only historic effort for the recreational fleet and the shrimp fishery was estimated.

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 (see also eq. 14):

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

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

(6) $$N_{a,y,m+1} = (N_{a,y,m} e^{-M_a \delta/2} - \sum_i C_{a,y,m,i}) e^{-M_a \delta/2} ,$$

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 in the middle of the month, after natural mortality:

(7) $$C_{a,y,m,i} = F_{a,y,i} \left(N_{a,y,m} e^{-M_a \delta/2} \right) \frac{\delta}{\tau_i} ,$$

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) $$F_{a,y,i} = q_{y,i} f_{y,i} v_{a,i} .$$

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. Both vulnerability and catchability were assumed to be constant over years.

Predicted catch by fleet is compared to observed catch by fleet in the objective function (as in eq. 16; see below). Predicted catch by fleet is obtained as the sum of the predicted age-specific catch by fleet series:

(9) $$\hat{C}_{y,m,i} = \sum_a \hat{C}_{a,y,m,i}$$

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:

(10) $$I_{y,m,i} = q_{y,i} \sum_a v_{a,i} \left(N_{a,y,m} e^{-M_a \delta/2} \right) \frac{\delta}{\tau_i} \quad .$$

Equation (10) provides an index in numbers; the corresponding CPUE in weight is computed by multiplying $v_{a,i}$ in (9) by $w_{a,y}$.

MSY calculation

The values of F_{MSY} and MSY are obtained in SSASPM through a grid search algorithm. F_{MSY} is obtained by solving for the value of F that maximizes equilibrium yield (Y), calculated as Y=YPR(F)·S(F)/φ(F) where

(11) $$YPR(F) = \sum_{a=1}^{A-1} w_a F s_a \frac{(1-\exp(-M - Fs_a))}{(M + Fs_a)} \prod_{j=1}^{a-1} \exp(-M - Fs_j) + \frac{w_A F s_A}{(M + Fs_A)} \prod_{j=1}^{A-1} \exp(-M - Fs_j)$$

(12) $$\varphi(F) = \sum_{a=1}^{A-1} \mu_a E_a \prod_{j=1}^{a-1} \exp(-M - Fs_j) + \frac{\mu_A}{(1-\exp(-M - Fs_A))} \prod_{j=1}^{A} \exp(-M - Fs_j)$$

(13) $$\breve{S}(F) = \frac{R_0 \hat{\alpha} \varphi(F) - R_0 \varphi_0}{\hat{\alpha} - 1} = \frac{4hR_0 \varphi(F) - R_0 \varphi_0 (1-h)}{5h - 1}$$

In the above equations, A is maximum age, w_a is weight at age, s_a is selectivity at age, μ_a is the proportion mature at age, E_a is fecundity at age, R_0 is virgin recruitment, $\hat{\alpha}$ is the maximum lifetime reproductive rate, φ_0 is unexploited spawners per recruit, h is steepness, Š(F) is the equilibrium spawning biomass for a given F and φ(F) is the lifetime production of spawners per recruit for a given F (Brooks et al. 2010).

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:

$$
\begin{aligned}
g_{t+1} &= E[g_{t+1}]e^{\varepsilon_{t+1}} \\
\varepsilon_{t+1} &= \rho\varepsilon_t + \eta_{t+1}
\end{aligned}
\quad . \tag{14}
$$

In equation 14, 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):

$$\sigma_g = \ln\left[(\lambda_g CV)^2 + 1\right] \tag{15a}$$

$$\sigma_g = \ln\left[(\omega_{i,y}\lambda_g CV)^2 + 1\right] \quad . \tag{15b}$$

The term λ_g is a variable-specific multiplier of the overall model CV. For catch series and indices (eq. 15b), the additional term, $\omega_{i,y}$, is the weight applied to individual points within those series. Thus, for indices, $\omega_{i,y}$ vary according to the weighting scheme used (i.e., $\omega_{i,y} = 1$ for equal weighting, $\omega_{i,y}$=1/rank for rank weighting, and $\omega_{i,y}$ = 1/CV for inverse CV weighting) and the same λ_g was applied to all indices.

Additional model specifications

Individual points within catch and index series can be assigned different weights, based either on estimated precision or expert opinion. All reconstructed catches (1950 to 1994 for the commercial BLL, GN, and HL catches; 1950-1980 for the recreational catches; and 1950-1971 for the shrimp bycatch series) were down-weighted to a weight of 2 to reflect the comparatively lower degree of confidence in those reconstructed catches, as was done in SEDAR 13. All indices were weighted by an assigned rank, inverse CV, or given the same weight (1 or no weight) as described above.

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 15a and 15b), 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 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 400 was used); the correlation was fixed at 0.5.

As in previous assessments, 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. As in 2007, the CV multipliers of indices, catch, and effort were all set equal to 1 (implying that the same degree of confidence is assumed for indices, catch, and 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

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

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

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

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

(18) $$\Lambda_2 = 0.5 \sum_{1972 \le y \le 2011} \frac{\left(\varepsilon_{ey} - \rho_e \varepsilon_{ey-1}\right)^2}{\sigma_e + (y-1)\log\sigma_e}$$

Prior distributions—The model started in 1950 and ended in 2011. Estimated model parameters were pup (age-0) survival, virgin recruitment (R_0), catchability coefficients associated with indices, and fleet-specific effort. Virgin recruitment was given a wide uniform prior distribution ranging from 1,000 to 10 billion individuals, whereas pup survival was given an informative lognormal prior with median=0.77 (mean=0.79, mode=0.72), a CV of 0.25, and bounded between 0.50 and 0.99. The mean value for pup survival was obtained using life-history invariant methods (see Section 3.1.2.4).

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

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

A list of estimated model parameters is presented in **Table 3.5.6** (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. However, it must be remembered that these metrics are not always comparable across model runs because different model configurations use different data sets (e.g, more or fewer indices, decreased catches) and thus affect the scale of the likelihood and AIC. For this reason, we decided not to include plots of the relative contribution to the likelihood by model source (catches, indices, effort, recruitment, catchabilities).

We also computed the approximate probability of the stock being overfished and overfishing occurring in the terminal year (2011) by using the likelihood profile of SSF_{2011} and F_{2011} and the point estimates of SSF_{MSY} and F_{MSY}, respectively. In one sensitivity run where likelihood profiling failed (see “Model start in 1972” below), we also performed MCMC with two chains of initial length=2,500,000 with a thinning rate of 100 such that very 100th value or 25,000 runs were saved.

Uncertainty in data inputs and model configuration was examined through the use of sensitivity scenarios in an attempt to depict the range of plausible states of nature. Eleven 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.

Baseline run: the base model configuration assumed virgin conditions in 1950, the historic period spanned 1950-1971, the modern period spanned 1972-2011, it used the historical reconstructed catch series and updated catch series, updated biological parameters, and nine CPUE indices (the earliest of which, SEAMAP-GOM-EF, started in 1972). Catches were assumed to be equally certain to the indices. Three variants were investigated for weighting the indices of relative abundance (equal weights, inverse CVs, and ranks), and inverse CV weighting was adopted as the weighting scheme for all ensuing sensitivity runs (see section 3.2.7).

Increasing and decreasing indices—The motivation for exploring this sensitivity was to inform the model with more consistent indices, rather than using the nine indices from the base run that showed conflicting trends for given time periods. This would in principle free the model from having to reconcile conflicting trends and more explicitly show the consequences of using different subsets of indices. To that end, we fitted simple linear regressions to the nine baseline indices and noted those with increasing or decreasing tendencies. Five indices showed an increasing trend (GOM combined GN, SCDNR Trammel Net, SEAMAP-SA, Texas GN, and ATL Coastspan LL) (**Figure 3.6.4**), three showed a decreasing trend (ENP, SEAMAP-GOM-EF, and GADNR Trawl) (**Figure 3.6.5)**, whereas one showed no trend (SC Coastspan GN)**.**

Low catch—The Panel felt that the large magnitude of the shrimp bycatch series already constituted a high catch scenario and thus decided to consider a low catch scenario only. This scenario was an attempt to capture the uncertainty in the magnitude of the estimated catches, specifically shrimp discards. In light of the overwhelming contribution of the shrimp bycatch series to the total catches, only this series was altered: instead of the values used in the baseline run, the mean of the SEDAR 13 values scaled by the effort exerted by the shrimp fleet were used (**Table 3.5.7**).

Hierarchical index—The motivation for this scenario, which uses a single hierarchical index of relative abundance (see Conn 2010 and SEDAR21-AW-01 for a full description of the method), (**Table 3.5.8**; **Figure 3.6.6**) is that the individual indices in the baseline run are attempting to estimate relative abundance, but are subject to both sampling and process error. While sampling error is assumed to be captured by previous standardization of indices (via CVs), each index is also subject to process variation, which describes the degree to which a given index measures "artifacts" above and beyond relative abundance in the population. The selectivity used for the single index was developed as a weighted average of the age-specific selectivities associated with the individual indices. The inverse variance weights obtained when calculating the hierarchical index were used to weight the individual selectivity curves. A weighted selectivity vector was thus obtained, which has to be approximated by a functional form for input into SSASPM. We approximated the selectivity vector by using a double exponential (dome-shaped) selectivity curve (**Figure 3.6.7**).

SEAMAP-SA index—We also investigated how the model would respond if fitted only to one of the indices of relative abundance that were best fit in the baseline run. To that end, we ran the model with only the SEAMAP-SA index

No indices—Along the same lines, we wanted to see the model response when no indices of relative abundance were present at all to inform the model and contrast with the results of the baseline run.

Model start in 1972—The motivation for this sensitivity was mostly to see the effect that catch reconstruction, with emphasis on the shrimp bycatch series, had on results.

High and low productivity—The aim of this scenario was to incorporate variability in productivity to try to encompass plausible biological limits. To simplify the process we assumed a 10% increase or 10% decrease in the following biological input parameters used in the baseline run: L_∞ (100.9 cm FL) and k (0.194 yr^{-1}) von Bertalanffy growth function parameters, proportion mature at age (up to a maximum of 100%), pup production at age, and natural mortality (M) at age (**Table 3.5.9**).

Atlantic biology and Gulf of Mexico biology—Given the evidence discussed in section 2.2.1 that shows that this species consists of two separate stocks, one in the Atlantic (ATL) and one in the Gulf of Mexico (GOM), but considering that a stock assessment for a single combined stock had to be undertaken as part of SEDAR 34, we ran sensitivity scenarios that attempted to address the concerns expressed in section 2.2.1, particularly "decision 8" ("characterize the uncertainty in life history and attempt to provide advice to management that may be wide ranging"). Thus, in scenario “Atlantic biology” we used the biological inputs for the ATL with all other inputs (catches, indices) unchanged with respect to the base run and in scenario “Gulf of Mexico biology” we used the corresponding biological inputs for the GOM. **Table 3.5.10** shows the area-specific biological inputs.

3.1.6. Benchmark/Reference points methods

Benchmarks included estimates of absolute population levels and fishing mortality for 2011 (F_{2011}, SSF_{2011}, B_{2011}, N_{2011}, $Nmature_{2011}$), reference points based on MSY (F_{MSY}, SSF_{MSY}, SPR_{MSY}), current status relative to MSY and MSST ((1-M)*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

The estimate of generation time for the baseline run is 7.8 years, and was calculated as:

(20)
$$GenTime = \frac{\sum_i i f_i \prod_{j=1}^{i-1} s_j}{\sum_i f_i \prod_{j=1}^{i-1} s_j}$$

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).

Projections were governed with the same set of population dynamics equations as the original assessment model (section 3.1.3), but allowed for uncertainty in initial conditions at the beginning of the time series (2011) as well as in underlying productivity. Projections were run using Monte Carlo bootstrap simulation, where initial numbers (N_{2011}^{boot}) and fishing mortality (F_{2011}^{boot}) were sampled from a bivariate normal distribution. Pup survival at low biomass ($e^{-M_0}{}_{2011}^{boot}$) and equilibrium recruitment ($R_{0\,2011}^{boot}$) were sampled from a second bivariate normal distribution. Expectations were equivalent to posterior modes from SSASPM, and the standard deviations and covariance values were obtained from the Hessian approximation of the variance-covariance matrix at the posterior mode. The bivariate normal approximation was chosen because it reduced the probability of selecting values of the different parameters that were unlikely to have generated the data. A separate bivariate distribution was chosen for $e^{-M_0}{}^{boot}_{2011}$ and $R_{0}{}^{boot}_{2011}$ in order to simulate recruitment variability in the projections (see section 3.1.3 equations 2 and 3).

The first projection year was 2012, and projections were run until the year 2041 (30 years; see below). As a result, the projection interval included multiple generations (generation time c.f., 7.8 years). Projections were implemented with current fishing mortality F_{2011}^{boot} during the first three years (2012, 2013, 2014), and then with the fishing mortality rate evaluated for each projection scenario during the remaining years (2015 – 2041). Projections used the same selectivity as used in the ending year (2011) of SSASPM. Thus, the anticipated allocation of effort within the fishery (between fleets) was assumed to remain the same as that in 2011. Total annual removals due to fishing represented catch (in 1000s) from all fleets combined (i.e., commercial longlines, gillnets, and lines, recreational catches, and shrimp trawl fishery discards; **Table 3.5.1A**).

All projections used 10,000 Monte Carlo bootstrap simulations. Each projection was summarized with respect to the projected distribution in mature spawning stock fecundity (SSF) and fishing mortality rate (F) for each projection year (t). Moments of the distribution were summarized each year (2012 – 2041) using quantiles, with the median used for the central tendency, and the 30th and 70th percentiles used as the lower and upper ranges, respectively. In addition, for the last 10 years of projections (2032 – 2041) and a given fixed level of total annual removals (in 1000s), the $\Pr(SSF_t > SSF_{\mathrm{MSY}})$ was calculated as $1 - \Pr(SSF_t \le SSF_{\mathrm{MSY}})$, where $\Pr(SSF_t \le SSF_{\mathrm{MSY}})$ was calculated as the cumulative relative frequency of $(SSF_{t,boot} \le SSF_{MSY})$ = (cumulative frequency)/(sample size). Analogously, for the last 10 years of projections (2032 – 2041) and a given fixed level of total annual removals (in 1000s), the $\Pr(F_t > F_{\mathrm{MSY}})$ was calculated as $1 - \Pr(F_t \le F_{\mathrm{MSY}})$, where $\Pr(F_t \le F_{\mathrm{MSY}})$ was calculated as the cumulative relative frequency of $(F_{t,boot} \le F_{MSY})$ = (cumulative frequency)/(sample size). All projections were conducted with R statistical software (R Development Core Team; RDCT 2009).

Projection methods followed those developed during SEDAR 21 for an age-structured catch-free model (ASCFM) applied to HMS dusky sharks (NMFS 2011), as modified during SEDAR 29 for a SSASPM model applied to HMS blacktip sharks (NMFS 2012a, 2012b), except as described below. First, during the P* workshop (P* workshop, NOAA/NMFS, Panama City Laboratory, June 11-13, 2013; Report in prep.), it was noted that the projection methodology from SEDAR 29 (NMFS 2012b) may not have adequately characterized recruitment variability. For example, the 30th and 70th percentiles (e.g., NMFS 2012b; their Figures 2.1-2.7) appeared to narrow over time, an implausible result. Consequently, the following changes to the HMS domestic shark projection methodology (e.g., NMFS 2012b) were implemented here, based on recommendations made at the P* workshop to more adequately characterize recruitment variability: 1) Remove pup survival at low biomass (e^{-M0}) from the multivariate normal distribution with F and N (NMFS 2012b); 2) Model F and N together in a bivariate normal distribution; 3) Add uncertainty in equilibrium recruitment, R_0, to the projections; 4) Model uncertainty in R_0 and e^{-M0} together in a separate bivariate normal distribution.

Second, during preliminary projection runs, it was noted that very high fixed levels of total annual removals due to fishing were required to achieve $Pr(SSF_t > SSF_{MSY}) = 70\%$, and $Pr(F_t > F_{MSY}) = 30\%$ from 10,000 Monte Carlo bootstrap projections. However, diagnostic output plots indicated that at the same very high fixed levels of total annual removals there was a high probability that projected stock size would decline ($Pr(SSF_t > SSF_{MSY}) < 30\%$) over longer-term projection periods (e.g., 30 years). In contrast, during preliminary projection runs, it was noted that more moderate fixed levels of total annual removals due to fishing were required to achieve $Pr(SSF_t > SSF_{MSY}) = 70\%$, and $Pr(F_t > F_{MSY}) = 30\%$ from 10,000 Monte Carlo bootstrap projections for longer-term projections (e.g., 30 years). The more moderate fixed levels of total annual removals due to fishing also resulted in relatively more stable population trajectories over time which appeared to approximate equilibrium by about 30 years. Consequently, results are presented here for longer-term (30 years) rather than short-term (~5 to 10 years) probabilistic projections.

Third, during preliminary projection runs, it was noted that the retrospective annual catches in weight computed in the R projections differed from those in SSAPSM. In contrast, retrospective annual catches in numbers computed in the R projections were nearly identical (ca.

1% difference) to those from SSASPM. Annual catch data are currently entered in numbers in SSASPM. Weight at age of the catch is then computed internally in SSASPM by fleet at a monthly time step. In contrast, weight at age of the catch is computed in the R projections for all fleets combined at an annual time step. As a result, projected catch in weight in the R projections may not be directly comparable to catch in weight estimated in SSASPM. Consequently results are presented here for projections at a given fixed level of total annual removals due to fishing in numbers (1000s) rather than in weight.

3.2. MODEL RESULTS

3.2.1. Measures of Overall Model Fit

Inverse CV weighting of the indices was selected as the weighting scheme that provided the best model fit and was thus used in all sensitivity runs (see section 3.2.7). Catches were fit very well with the exception of several points in the shrimp bycatch series from ca. 1985 to 2004 (**Figure 3.6.8**). The model fit a central tendency through most of the indices and fit some, or at least portions, fairly well (SCDNR Trammel Net, SEAMAP-SA, ATL Coastspan LL, and SEAMAP GOM EF), while others were hard to fit given the large interannual fluctuations in most cases (GOM Combined GN, Texas GN, SC Coastspan GN, and GADNR Trawl) (**Figure 3.6.9**). In general, the fits showed a rather flat tendency prior to the onset of the first index in 1972, followed by a decreasing tendency to about 2002, and then an increasing trend in the last decade. Individually, the GOM Combined GN, SCDNR Trammel Net, SEAMAP-SA, Texas GN, and ATL Coastspan LL indices showed increasing tendencies, whereas the ENP, SEAMAP GOM EF, and GADNR Trawl indices showed a decreasing trend and the SC Coastspan GN index showed no trend. In the early part of the modern period, starting in 1972, the SEAMAP GOM EF index showed a decreasing trend, whereas the Texas GN index, which started in 1974, showed large interannual fluctuation (**Figure 3.6.3,** upper panel). Catches progressively increased from 1972 to 2000 and started declining thereafter (**Figure 3.6.3**, bottom panel).

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 Spawning Stock Fecundity

Predicted abundance and spawning stock fecundity (numbers x proportion mature x fecundity in numbers) are presented in **Table 3.5.11** and **Figure 3.6.10**. Both trajectories show slight depletion from 1950 to the beginning of the modern period in 1972, followed by a decreasing trend through the late 1990s, and a progressive increase in the last decade, which corresponds to decreased effort and catches in the shrimp trawl fishery and a majority of the indices of relative abundance showing increasing tendencies in those years.

3.2.4. 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 all fleets and several indices select immature animals, especially the shrimp fleet, which selects age-1s (and age-0s, which are not modeled explicitly but are caught in that fishery).

3.2.5. Fishing Mortality

Predicted total and fleet-specific instantaneous fishing mortality rates are presented in **Table 3.5.12** and **Figure 3.6.11**. Fishing mortality was overwhelmingly dominated by the shrimp trawl fleet and exceeded the estimated F_{MSY} of 0.202 in the baseline run from 1981 to 2004. The contribution of the remaining fleets to total F was much smaller, with the commercial gillnet fleet showing some higher values in the first half of the 1990s. Fishing mortality was lower in the past decade in accordance with decreased shrimp trawl effort and catches during that period.

3.2.6. Stock-Recruitment Parameters

The predicted virgin recruitment (R_0; number of age 1 pups) was on the order of 1,800,000 animals regardless of the variant used to weight the indices in the baseline run (**Figure 3.6.12**). The predicted steepness was 0.65-0.66 and the maximum lifetime reproductive rate was 7.3-7.9.

The estimated pup (age-0) survival at low density ranged from 0.81 to 0.88 (see next section for further discussion on pup survival). In all, the model estimated the stock to be highly productive, which seems in line with the life history of this species (Brooks et al. 2010).

3.2.7. 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 generally 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 3.6.12**. There appeared to be information in the data since the posteriors for these two parameters were different from the priors. The median of the posterior for pup survival was estimated at a higher value than the prior (0.88 vs. 0.77), while the posterior for virgin recruitment of pups was informative in contrast to its diffuse uniform prior (**Figure 3.6.12**).

Posterior distributions were also obtained for several benchmarks. The distribution for spawning stock fecundity in 2011 shows little overlap with the distribution for virgin conditions and most of its density is above the MSST reference point, which translates to a probability of the stock not being overfished ($P(SSF_{2011}>SSF_{MSST})$ of 93% (**Figure 3.6.13**). The distributions for total biomass depletion and spawning stock fecundity depletion are wide, with most of the density concentrated between ca. 0 and 0.75 (**Figure 3.6.13**). The pdf of F_{2011} shows higher density towards the lower values and some density for values up to ca. 0.55; the probability of overfishing not occurring ($P(F_{2011}<F_{MSY})$ was 91% . The overlap between mature number of fish in 2011 and in virgin conditions was very similar to that for biomass or spawning stock fecundity (**Figure 3.6.14**).

Results of the baseline scenario with the three index weighting schemes (ranks, inverse CV, equal weights) are summarized in **Table 3.5.13**. 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 not weighting or weighting the indices with ranks and thus a relatively more optimistic status compared to the other two weighting options, the results of which were very similar. These three models had the same number of observations and estimated parameters and are thus directly comparable. Since the AICc and objective function were lowest for inverse CV weighting, indicating a better fit of that model, it was selected as the method for index weighting for all subsequent sensitivities.

Results of all the sensitivity analyses are summarized in **Table 3.5.14**. Using only the indices of relative abundance that showed an increasing tendency ("increasing indices" sensitivity) resulted in a more optimistic outcome and a better fit to the catches (**Figure 3.6.15**), but the fit to the indices was similar to the corresponding ones in the base run (**Figure 3.6.16**). In contrast, using only the indices of relative abundance that showed a decreasing tendency ("decreasing indices" sensitivity) resulted in a much more pessimistic outcome, as expected. In this scenario, the stock would be overfished and nearing overfishing. The fit to the catches was also better than in the base run and even better than in the "increasing indices" run (**Figure 3.6.17**). In this run, the ENP index was fit considerably better compared to the base run (**Figure 3.6.18**).

Considering catches lower than those in the base run ("low catch" sensitivity) predicted a slightly more optimistic stock status with respect to biomass but the status worsened with respect to overfishing probably because the model estimated a virgin stock size and recruitment about half those in the base run (**Table 3.5.14**). In this scenario the recreational catch was fit a little worse and the shrimp catch, a little better, than in the base run (**Figure 3.6.19**). The estimated relative abundance showed a flatter trend than in the base run, with a less steep decrease from the early 1970s to the 2000s and a less steep increase from the early 2000s to 2011, but overall the fits to the indices were comparable to those in the base run (**Figure 3.6.20**).

Using the hierarchical index of relative abundance (with a dome-shaped selectivity curve) resulted in a less optimistic stock status than in the base run (**Table 3.5.14**). Fits to the catches, particularly the shrimp series, improved with respect to the base run (**Figure 3.6.21**) and the fit to the hierarchical index was similar to that of the SEAMAP-GOM EF index in the base run because this index influenced the computation of the hierarchical index, particularly in the 1970s (**Figure 3.6.22**).

Using the SEAMAP-SA index only ("SEAMAP-SA" sensitivity) resulted in a little more optimistic status than in the base run (**Table 3.5.14**). The fit to the catches was also better than in the base run (**Figure 3.6.23**) and the fit to the SEAMAP-SA index did not differ appreciably from that in the base run (**Figure 3.6.24**). The "No indices" sensitivity run predicted a severely depleted stock with a very high level of overfishing. With no signal from any indices, this scenario fit the catches almost perfectly (**Figure 3.6.25**).

Starting the model in 1972 compared to 1950 improved stock status only slightly and generally had little effect on results, probably because catches in the historic period (1950-1971) were considerably lower than in the modern period (1972-2011) (**Table 3.5.14**). Pup survival had to be fixed (not estimated) in this run because it otherwise hit the upper bound and MCMC was run instead of likelihood profiling. While the fit to the three commercial catch series was comparable to the base run, the fit to the recreational catches, and especially the shrimp bycatch series, deteriorated (**Figure 3.6.26**). The predicted relative abundance showed a steeper decline initially, followed by a flatter trend since the mid-1980s compared to the base run. The fits to the indices improved substantially, particularly for the GOM Combined GN, SCDNR Trammel net, SEAMAP-SA, Texas GN, ATL Coastspan LL, and SEAMAP-GOM EF (**Figure 3.6.27**).

Assuming higher and lower stock productivity, resulted in a more, and less, optimistic status, respectively (**Table 3.5.14**). As expected, the “high productivity” sensitivity run estimated a higher maximum lifetime reproductive rate and steepness than the base run and the “low productivity” sensitivity run, lower values for these two parameters. The fit to the catches (**Figure 3.6.28** for “high productivity” and **Figure 3.6.30** for “low productivity”) and indices (**Figure 3.6.29** for “high productivity” and **Figure 3.6.31** for “low productivity”) for both scenarios were very similar and also similar to those in the base run.

Considering the combined stock with the biology corresponding to the Atlantic or the Gulf of Mexico yielded contrasting results. The “Atlantic biology” sensitivity run resulted in a considerably more pessimistic status than the base run, whereas the “Gulf of Mexico biology” sensitivity run predicted a more optimistic status than the base run. In the “Atlantic biology” run, the stock became overfished with overfishing occurring (**Table 3.5.14**). Fits to the catch data were similar to those of the base run, with the fit to the shrimp series improving somewhat (**Figure 3.6.32**). The estimated relative abundance trajectory was flat or with only a slight upward trend during the 2000s in contrast to the increasing trend in the base run (**Figure 3.6.33**). The fit to the catches in the “Gulf of Mexico biology” sensitivity run became worse for the recreational and especially the shrimp series compared to the base run (**Figure 3.6.34**). The estimated relative abundance trajectory and fits to indices were similar to those in the base run (**Figure 3.6.35**).

3.2.7.1. Continuity analysis

Table 3.5.15 shows the summarized results of the continuity analysis and of the 2007 base run. The base run in 2007 indicated that the stock was not overfished and overfishing was not occurring, but with the addition of six more years of data in the continuity run stock status was close to the MSY level and overfishing was occurring. The continuity run estimated a much higher terminal F compared to the 2007 base run and the current base run. Catches fluctuated, but generally increased with the additional years of data (**Figure 2.6.1**). The same 11 indices as in the 2007 base run were used for the continuity analysis. Two of those indices did not have additional years of data and thus remained unchanged (MML-GN-adults and MML-GN-juveniles) and one covered past years but was reanalyzed (SEAMAP-GOM Early Fall). Of the remaining eight indices, four increased since 2007 (PC-GN-Juveniles, PC-GN-Adults, Texas GN, and SEAMAP-GOM Late Fall) and four decreased (GNOP, ENP, SEAMAP-SA, and SC Coastspan GN) (**Figure 2.6.2**). The six catch series were unevenly fit, with the commercial BLL, commercial gillnet, commercial handline, and commercial BLL discard series fit well, but the catches in the 1950s for the recreational series, and especially the shrimp bycatch series not fit well in multiple years (**Figure 3.6.36**). The model fit a steeper declining trend through the historic period compared to the 2007 base run, followed by a more moderately declining trend in the modern period likely in response to the fluctuations and varying trends in relative abundance exhibited by the different indices (**Figure 3.6.37**).

3.2.7.2. Retrospective analysis

Results of the retrospective analysis of the base run are presented in **Table 3.5.16** and **Figure 3.6.38**. Three model output quantities were examined in the analysis: 1) spawning stock fecundity, 2) relative spawning stock fecundity, and 3) relative fishing mortality. There were no marked retrospective patterns in the SSF or relative spawning fecundity (SSF/SSF_{MSY}) trajectories, which appeared to converge quickly. In contrast, the relative fishing mortality (F/F_{MSY}) trajectories showed some pattern. Trajectories for the 2010, 2009, and 2008 retrospective runs diverged from approximately the mid-1990s to the mid-2000s, but converged before and after that period; however, they did not overlap with the base run almost for the entire period covered by the assessment. The 2007 retrospective run did not converge with the previous three runs but overlapped with the base run before 1980 and between the mid-1980s and mid-

1990s. We conclude that no systematic pattern of over- or under-estimation of abundance or relative abundance was evident. In contrast, relative fishing mortality was underestimated when sequentially dropping one, two, or three years of data, but overestimated (notably form the mid-1990s to the mid-2000s) when dropping four years of data, thus showing no systematic pattern.

3.2.8. Benchmarks/Reference Points

Benchmarks for the MSY reference points for the base run are summarized in **Table 3.5.13**, those for all sensitivity scenarios in **Table 3.5.14**, those for the continuity analysis in **Table 3.5.15**, and those for the retrospective analyses, in **Table 3.5.16**. The base model estimated that the stock was not currently overfished and overfishing was not occurring (**Table 3.5.13**), but that it had been very near or even in an overfished condition several years between 1996 and 2003. The base model also estimated that the stock had been above the overfishing threshold between 1979 and 2004 (**Figures 3.6.39** and **3.6.40**).

As a form of *historical analysis*, **Figure 3.6.41** 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 2007 and 2002 assessments (also using SSASPM), as well as the results obtained with the Bayesian Surplus Production (BSP; McAllister and Babcock 2004) base model and WinBUGS base model in 2007. Stock status in the base runs did not deviate far from the 2007 base model prediction or that of the 2002 base model. Results of the two 2007 surplus production models were more optimistic, whereas the continuity run predicted a more pessimistic status, with overfishing occurring and stock biomass being at MSY level, but still above MSST.

Figure 3.6.42 shows the outcomes of all historical and current base and sensitivity results. With the exception of the “decreasing indices”, “Atlantic biology”, and “No indices” sensitivity runs, all other scenarios estimated that the stock was not overfished and overfishing was not occurring. These three runs predicted the stock biomass would be below the MSST criterion and the “Atlantic biology” and “No indices” runs also estimated that overfishing was occurring. The results of the retrospective analyses support the conclusions from the base run (**Figure 3.6.43).**

In order not to rely solely on the terminal year to determine stock condition, we also computed stock status as the geometric mean of the last three years of the assessment (2009-

2011) and associated a probability with the statement of whether the stock was overfished or overfishing was occurring in the terminal year (2011). **Table 3.5.17** shows that, with the exception of the “decreasing indices”, “Atlantic biology”, and “No indices” runs, there was a very high probability that the stock in 2011 was not overfished (P=0.79-0.97, with most sensitivity scenarios having a P≥0.85). The probability of the stock not being overfished in 2011 in the three scenarios with a negative deterministic outcome ranged from 0.31 to 0.44. Only one sensitivity scenario (“No indices”; P=0.01) and the continuity run (P=0.33) had a probability of overfishing not occurring <0.50. Three other sensitivity runs had probabilities between 0.50 and 0.70 (“Atlantic biology”, “Decreasing indices”, and “Low catch”), whereas all the remaining sensitivity runs had probabilities of overfishing not occurring ranging from 0.86 to 0.95.

3.2.9. Projections

Projections were conducted over a range (21) of fixed levels of total annual removals due to fishing (**Table 3.5.18**). Projections were completed for the baseline (inverse CV weighting) and additional sensitivity configurations evaluated in the stock assessment (**Table 3.5.19**): Projection scenario-1 (Baseline, Inverse CV Weighting), Projection scenario-2 (Sensitivity, Increasing Indices), Projection scenario-3 (Sensitivity, Decreasing Indices), Projection scenario-4 (Sensitivity, Low Catch), Projection scenario-5 (Sensitivity, Hierarchical Index double exponential), Projection scenario-6 (Sensitivity, Model Start in 1972), Projection scenario-7 (Sensitivity, High Productivity), Projection scenario-8 (Sensitivity, Low Productivity), Projection scenario-9 (Sensitivity, SEAMAP-SA), Projection scenario-10 (Sensitivity, Gulf of Mexico Biology), and Projection scenario-11 (Sensitivity, Atlantic Biology). The SSASPM model configurations chosen for projections were intended to be representative of the range of uncertainty in data inputs and model configuration examined in the stock assessment.

Examples from each projection scenario are provided for a given fixed level of total annual removals due to fishing (1,000s) during the years (2012 – 2041) which resulted in both the $Pr(SSF_t > SSF_{MSY}) \geq 70\%$, and the $Pr(F_t > F_{MSY}) \leq 30\%$ in the year 2041 from 10,000 Monte Carlo bootstrap projections (**Table 3.5.19**). These values represent the removals (in 1000s) associated with a 70% probability of overfishing not occurring (P* = 0.3), in response to Term of Reference 5 (section 1.2.5).

Detailed data from each projection run are also provided (**Tables 3.5.20 and 3.5.21, Figures 3.6.44 and Figure 3.6.45)**. The 30th percentile of $SSF_{t,boot}$/ SSF_{MSY} was summarized for each projection year (2012 – 2041) and each fixed level of total annual removals due to fishing (**Figure 3.6.44**). The 30th percentile of $SSF_{t,boot}$/ SSF_{MSY} represents the 70% probability of maintaining SSFt above SSF_{MSY} from 10,000 Monte Carlo bootstrap projections for a given level of fixed removals (in 1000s) and a given year (2012 – 2041) (**Figure 3.6.44**). The $\Pr(SSF_t > SSF_{\mathrm{MSY}})$ was summarized for the last 10 years of projections (2032 – 2041) and a given fixed level of total annual removals (in 1000s) **(Table 3.5.20**). Fixed removals that resulted in $\Pr(SSF_t > SSF_{MSY}) \geq 70\%$ represented at most a 30% probability of exceeding SSF_{MSY} and were highlighted in green. Fixed removals that resulted in $70\% > \Pr(SSF_t > SSF_{MSY}) \geq 50\%$ represented more than a 30% probability of exceeding SSF_{MSY} and at most a 50% probability of exceeding SSF_{MSY} and were highlighted in yellow. Fixed removals that resulted in $\Pr(SSF_t > SSF_{MSY}) < 50\%$ represented more than a 50% probability of exceeding SSF_{MSY} and were highlighted in red.

The 70th percentile of $F_{t,boot}$/ F_{MSY} was summarized for each projection year (2012 – 2041) and each fixed level of total annual removals due to fishing (**Figure 3.6.45**). The 70th percentile of $F_{t,boot}$/ F_{MSY} represents the 30% probability of F_t exceeding F_{MSY} from 10,000 Monte Carlo bootstrap projections for a given level of fixed removals (in 1000s) and a given year (2012 – 2041) (**Figure 3.6.45**). The $\Pr(F_t > F_{\mathrm{MSY}})$ was summarized for the last 10 years of projections (2032 – 2041) and each fixed level of total annual removals due to fishing (**Table 3.5.21**). Fixed landings that resulted in $\Pr(F_t > F_{MSY}) \leq 30\%$ represented at most a 30% probability of exceeding F_{MSY} and were highlighted in green. Fixed landings that resulted in $30\% > \Pr(F_t > F_{MSY}) \leq 50\%$ represented more than a 30% probability of exceeding F_{MSY} and at most a 50% probability of exceeding F_{MSY} and were highlighted in yellow. Fixed landings that resulted in $\Pr(F_t > F_{MSY}) > 50\%$ represented more than a 50% probability of exceeding F_{MSY} and were highlighted in red.

3.3. DISCUSSION

Although there has been and still is some directed commercial fishing for bonnethead sharks and they are also frequently caught in recreational fisheries, catches of this species are dominated by bycatch in the Gulf of Mexico shrimp trawl fishery. Given the Panel's lack of confidence in the

(WinBUGS) model-generated estimates, stratified nominal estimates were used instead, which were on average ca. two times larger than the values used in SEDAR 13. Estimates of removals in the historical period (1950-1971) were kept the same as in SEDAR 13, where they were reconstructed based on expert opinion. The assumption of the stock being in virgin conditions in 1950 thus seems reasonable.

It is noteworthy that of the nine indices of relative abundance recommended for use in the base run, only one was fishery dependent. Furthermore, several individual indices were combined into single Atlantic coastal longline or Gulf of Mexico gillnet indices. Since indices theoretically track relative abundance, inconsistent signals likely lead to tensions among the different indices when fitting the model, which may propose an abundance trend that represents a compromise solution attempting to accommodate the sometimes different trends displayed by the indices. Another issue that has been pointed out in previous shark stock assessments is that many indices show interannual variability that does not seem to be compatible with the life history of the species, which would suggest that the standardization methods were not fully successful in tracking relative abundance. This is not as much of an issue in the current assessment given the higher productivity and life history traits of this species compared to other larger species of sharks. Nevertheless, it is unclear why the model was able to fit some of the indices relatively well, while others were poorly fit.

Since 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. Considering only indices that showed increasing trends resulted in an improvement in stock status, a better fit to the catches and a similar fit to the indices. In contrast, considering only indices that showed decreasing tendencies resulted in improved fits to the catches and indices in at least one case (ENP) and a reversal of stock status, which became overfished and approaching overfishing. We also attempted to remove some of the process variation in the indices by computing a hierarchical index of relative abundance. In this case the fit to the catches also improved, but the index was not fit very well, mirroring the fit of the SEAMAP-GOM EF index in the base run, which disproportionately influenced the computation of the hierarchical index in the early years of the time series (1970s). Fitting to a single index that had been relatively well fit in the base run (SEAMAP-SA) resulted in a similar fit to that index and improved fit to catches. We also explored using no indices at all. In the absence of any signal from indices, the model interpreted that the catches were not sustainable and estimated severe stock depletion and overfishing.

We explored three variants of the base model that used equal weights, inverse CV, and ranks to weight the indices. Since the fit with inverse CV weighting was better, we used this variant of the model for all subsequent sensitivity runs. Exploring the uncertainty associated with catches by considering a lower level of bycatch in the GOM shrimp trawl fishery revealed that the model responded to lowered catch perhaps in an unexpected way in terms of the degree of estimated overfishing, which increased as a result of the model estimating decreased virgin population size and recruitment with respect to the base run. Addressing the possible effect of reconstructing the catch series back to 1950 by starting the model in the modern period (1972) had very little effect on results, probably because of the relatively low magnitude of the historic catches compared to those in the modern period. In this scenario, the fit to the catches worsened, the fit to the indices improved, but pup survival had to be fixed to avoid model convergence problems. Consideration of uncertainty in biological parameters, explored through sensitivity runs that tried to encompass plausible variability in those parameters had a predictable effect on model results, improving stock status when the stock was assumed to be more productive and vice versa, but did not affect results substantially. Finally, using the Atlantic stock or Gulf of Mexico stock biology for the combined stock assessment, while maintaining catches and indices for the combined stock, led to different conclusions. The assessment with the Atlantic stock biology predicted that the stock was overfished with overfishing occurring as a result of a less productive stock and a substantially lower value of F_{MSY} than in the base run. In contrast, the assessment with the Gulf of Mexico stock biology predicted a stock status a little more optimistic than in the base run, with slightly lower productivity but with increased virgin stock size and recruitment than in the base run.

Considering the multiple sources of uncertainty that were examined through sensitivity analyses, it can be concluded that the assessment provided a rather consistent picture of stock status, with the obvious caveat that we assessed a combined stock when recent evidence seems to suggest the existence of two separate stocks. With the exception of three scenarios, all the remaining sensitivity runs we explored in an effort to encapsulate plausible alternate states of nature predicted that the stock of bonnethead sharks was not overfished and overfishing was not occurring, with the probability that the stock was not overfished in 2011 P=0.79-0.97 and the probability of overfishing not occurring in 2011 P=0.86-0.95 (**Table 3.5.17**).

Despite the significant differences between the inputs used in the 2007 and 2002 assessments and the current assessment, stock status did not change substantially, although the current assessment estimated a significantly more productive stock than the 2007 assessment (**Table 3.5.15**). The main differences between the 2007 and current assessment include: the magnitude of the shrimp bycatch series increased ca. three-fold; four additional selectivity functions were introduced; there are now nine indices of relative abundance in the base run (vs. 11 in 2007), but four of them were not used in 2007 and all were re-analyzed and include six more years of data; there are new biological parameters, including a new maximum age of 18 yr (vs. 12), new maturity schedule, new fecundity (4.6 vs. 5.0), and new estimates of natural mortality at age (0.22-0.23 vs. 0.21-0.41), changes which have the combined effect of increasing the productivity of the stock.

As noted in previous assessments that also used SSASPM, the estimation of selectivities externally to the model may not be ideal and not have captured the uncertainty associated with the transformation of lengths into ages to produce age-frequency distributions to which selectivity curves were fitted or assigned. Unfortunately, SSASPM cannot accommodate length composition data but can in theory 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 von Bertalanffy growth function) were unsuccessful and thus, as in previous implementations of the model, selectivities had to be estimated externally to the model. In the future, when benchmark assessments for separate stocks of this species are conducted, we hope to use a length-based, age-structured model.

In all, based on the similar results obtained in the present and 2007 and 2002 assessments, it appears that despite large catches in the 1980s and 1990s, the increased productivity of the stock combined with the decline in catches in the past decade and generally stable or increasing indices of relative abundance, makes the combined stock of bonnethead shark resilient enough to be in a not overfished condition with overfishing not occurring. However, the Panel stressed that there is strong evidence for two separate stocks and that using the biology corresponding to the Atlantic for the assessment for two stocks combined led to a different conclusion on stock status (i.e., the stock was overfished and overfishing was occurring). The Panel thus strongly recommended that a benchmark assessment for two separate stocks of bonnethead shark be undertaken when possible.

Probabilistic projections at alternative fixed harvest levels were used to provide an approach for reducing the overfishing limit (OFL) to account for scientific uncertainty within individual SSASPM model configurations. Multiple projection scenarios were evaluated with probabilistic projections in an attempt to reflect the full range of plausible states of nature evaluated among SSASPM model configurations. Among all projection scenarios evaluated, except Projection scenario-6, examples of fixed levels of total annual removals due to fishing during the years 2015 – 2041 which resulted in both the $Pr(SSF_t > SSF_{MSY}) \geq 70\%$, and the $Pr(F_t > F_{MSY}) \leq 30\%$ in the year 2041 from 10,000 Monte Carlo bootstrap projections ranged from 200,000 to 550,000 sharks (**Table 3.5.19**). Pup survival was fixed in the SSASPM sensitivity configuration Model Start in 1972, which resulted in an unreasonably small buffer (percent decrease from MSY) for Projection scenario-6. The median buffer from OFL from multiple projection scenarios, excluding Projection scenario-6, was 26% (**Table 3.5.19**). These values represent a proxy P* approach (based on probabilistic projections at alternative fixed levels of removals) used here to determine the removals associated with a 70% probability of overfishing not occurring (P* = 0.3).

3.4. LITERATURE CITED

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3.5. TABLES

Table 3.5.1A. Catches of bonnethead shark by fleet in numbers. Catches are separated into five fisheries: commercial longlines, gillnets, and lines, recreational catches, and shrimp trawl fishery discards.

Year	Com-BLL	Com-GN	Com-L	Recreational	Shrimp discards
1950	0	0	0	7469	103005
1951	0	0	0	13314	132351
1952	0	0	0	14514	133902
1953	0	0	0	15714	154059
1954	0	0	0	16914	158973
1955	0	0	0	18114	144143
1956	0	0	0	19314	131016
1957	0	0	0	20514	117923
1958	0	0	0	21714	116978
1959	0	0	0	22914	131248
1960	0	0	0	15058	140670
1961	0	0	0	15760	70687
1962	0	0	0	16461	92678
1963	0	0	0	17162	139034
1964	0	0	0	17864	124463
1965	0	0	0	18565	134020
1966	0	0	0	19267	126382
1967	0	0	0	19968	155001
1968	0	0	0	20669	141535
1969	0	0	0	21371	148218
1970	0	0	0	18450	162989
1971	0	0	0	21632	167247
1972	0	0	0	21935	431994
1973	0	0	0	22239	337059
1974	0	0	0	22542	452655
1975	0	0	0	22846	306837
1976	0	0	0	23149	394129
1977	0	0	0	23453	445248
1978	0	0	0	23756	537590
1979	0	0	0	24060	543578
1980	0	0	0	25067	500643
1981	0	0	0	38616	527697
1982	1	0	0	25533	560776
1983	2	0	0	27131	541521
1984	5	0	0	16998	529723
1985	9	0	0	24953	610403
1986	16	0	0	64858	636283
1987	26	8770	0	34922	831817
1988	38	17541	0	45527	589830
1989	64	26311	0	49350	725577
1990	118	35082	0	52019	712955
1991	180	43852	0	19883	745713
1992	302	52623	0	28990	668671
1993	554	61393	0	29784	645062
1994	1080	70164	0	33715	701299
1995	0	81679	0	53792	614481
1996	0	21771	0	42596	727376
1997	605	19780	312	36701	743053
1998	1527	2113	252	55000	720922
1999	890	13673	1005	61916	785842
2000	1244	18145	38	107758	717388
2001	669	17023	55	131301	641769
2002	879	8318	237	124251	626601
2003	5999	5751	113	80449	503026
2004	1750	5816	61	101614	520457
2005	3368	6888	232	79922	320161
2006	1971	8226	258	67852	312239
2007	638	23847	57	116101	245529
2008	557	14771	39	62986	253015
2009	5984	14415	31	74683	307524
2010	138	3031	18	65029	249498
2011	1375	12065	157	103638	233403

Table 3.5.1B. Catches of bonnethead shark by fleet in weight (lb dw). Catches are separated into five fisheries: commercial longlines, gillnets, and lines, recreational catches, and shrimp trawl fishery discards.

Year	Com-BLL	Com-GN	Com-L	Recreational	Shrimp discards
1950	0	0	0	19569	79623
1951	0	0	0	34882	102308
1952	0	0	0	38026	103506
1953	0	0	0	41170	119088
1954	0	0	0	44314	122886
1955	0	0	0	47458	111422
1956	0	0	0	50602	101275
1957	0	0	0	53747	91154
1958	0	0	0	56891	90424
1959	0	0	0	60035	101455
1960	0	0	0	39453	108738
1961	0	0	0	41290	54641
1962	0	0	0	43128	71640
1963	0	0	0	44966	107473
1964	0	0	0	46803	96210
1965	0	0	0	48641	103597
1966	0	0	0	50478	97694
1967	0	0	0	52316	119816
1968	0	0	0	54154	109407
1969	0	0	0	55991	114572
1970	0	0	0	48340	125991
1971	0	0	0	56676	129282
1972	0	0	0	57471	333931
1973	0	0	0	58266	260547
1974	0	0	0	59061	349903
1975	0	0	0	59856	237185
1976	0	0	0	60651	304662
1977	0	0	0	61446	344177
1978	0	0	0	62241	415557
1979	0	0	0	63037	420186
1980	0	0	0	65675	386997
1981	0	0	0	106422	407910
1982	2	0	0	71022	433480
1983	5	0	0	45069	418596
1984	11	0	0	37457	409476
1985	22	0	0	44052	471841
1986	37	0	0	123317	491847
1987	61	14770	0	78869	642995
1988	89	29540	0	82266	455939
1989	150	44310	0	106784	560871
1990	278	59080	0	127990	551114
1991	423	73850	0	41758	576436
1992	712	88620	0	64617	516883
1993	1305	103390	0	61156	498633
1994	2743	118159	0	82880	542104
1995	0	299648	0	114979	474994
1996	0	79870	0	119073	562262
1997	1841	72566	1500	93136	574380
1998	5081	7753	1329	152735	557273
1999	3203	50161	5721	184938	607456
2000	3615	66566	173	232833	554541
2001	1746	62450	227	385535	496087
2002	2174	33959	927	318847	484363
2003	14070	24579	419	240567	388839
2004	3894	25605	216	217725	402313
2005	5776	27357	628	234306	247485
2006	3806	29875	758	231125	241360
2007	1332	53486	180	397645	189794
2008	1217	60257	128	212648	195580
2009	12600	43561	98	271008	237716
2010	158	11726	31	203130	192862
2011	3823	37526	663	486920	180420

Table 3.5.2. Selectivity curves for catches and indices of relative abundance. Parameters are ascending inflection point (a_{50}), ascending slope (b), descending inflection point (c_{50}), descending slope (d), and maximum selectivity (max(sel)).

Series	Name	Selectivity	a_{50}	b	c_{50}	d	max(sel)
CATCHES							
Commercial bottom longline	Longline age 3	Logistic	0.50	1.87			
Commercial gillnet	Gillnet age 4	Double exponential	3	0.4	6	1	0.81
Commercial line	Longline age 3	Logistic	0.50	1.87			
Recreational	Longline age 3	Logistic	0.50	1.87			
Shrimp trawl	Gillnet age 1	Double exponential	1	2	1.5	1.2	0.30
INDICES OF ABUNDANCE							
GOM Comb GN	Gillnet age 1	Double exponential	1	2	1.5	1.2	0.30
SCDNR Trammel net	Gillnet age 8	Double exponential	10.50	1.00	6	1	0.01
ENP	Gillnet age 1	Double exponential	1	2	1.5	1.2	0.30
SEAMAP-SA	Gillnet age 5	Double exponential	4.9	1	6	1	0.38
Texas Gillnet	Gillnet age 1	Double exponential	1	2	1.5	1.2	0.30
SC Coastspan GN	Gillnet age 5	Double exponential	4.9	1	6	1	0.38
ATL Combined LL	Longline age 1	Logistic	0.25	0.50			
SEAMAP GOM EF	Gillnet age 1	Double exponential	1	2	1.5	1.2	0.30
GADNR Trawl	Gillnet age 1	Double exponential	1	2	1.5	1.2	0.30
Hierarchical index		Double exponential	0.01	0.1	-25	7	0.02

Table 3.5.3. Standardized indices of relative abundance used in the baseline scenario.

YEAR	GOM Comb GN	SCDNR Tram Net	ENP	SEAMAP-SA	TEXAS-GN	SC-GN	ATL Coastspan LL	SEAMAP GOM EF	GADNR Trawl
1972								0.207	
1973								0.567	
1974								0.426	
1975					0.002			0.117	
1976					0.013			0.359	
1977					0.001			0.213	
1978					0.002			0.118	
1979					0.005			0.178	
1980					0.010			0.094	
1981					0.009			0.081	
1982					0.005			0.062	
1983			0.015		0.006			0.066	
1984			0.058		0.009				
1985			0.038		0.003			0.011	
1986			0.031		0.008			0.094	
1987			0.030		0.001			0.022	
1988			0.039		0.009			0.040	
1989			0.031	0.773	0.005			0.013	
1990			0.025	1.346	0.012			0.034	
1991			0.023	2.068	0.006			0.024	
1992			0.038	1.436	0.003			0.024	
1993			0.032	1.004	0.006			0.031	
1994		0.264	0.029	1.604	0.005			0.029	
1995	1.049	0.431	0.029	1.706	0.004			0.021	
1996	0.467	0.365	0.027	0.704	0.004			0.048	
1997	1.030	0.336	0.031	1.527	0.002			0.032	
1998	1.178	0.289	0.023	1.230	0.005			0.019	
1999	1.264	0.623	0.014	1.130	0.003			0.028	
2000	0.903	0.369	0.019	1.645	0.009	10.124	15.59	0.025	
2001	1.432	0.748	0.017	2.246	0.008	21.084	63.42	0.031	
2002	1.107	1.116	0.016	3.350	0.009	12.684	40.08	0.056	
2003	1.546	1.160	0.015	2.871	0.008	30.155	39.25	0.058	3.185
2004	1.399	0.755	0.018	1.290	0.010		60.76	0.068	2.365
2005	0.515	0.832	0.014	2.638	0.007	21.245	39.11	0.054	0.922
2006	1.495	0.961	0.011	3.856	0.008	26.699	51.31	0.042	1.591
2007	1.048	1.396	0.014	3.001	0.007	13.376	32.88	0.107	1.724
2008	1.033	1.402	0.020	2.783	0.008	51.087	45.84	0.110	0.811
2009	1.377	1.682	0.015	3.541	0.008	23.669	44.48	0.103	2.714
2010	1.333	1.029	0.015	2.663	0.018	13.262	89.20	0.067	1.488
2011	1.312	0.904	0.011	1.752	0.010	5.658	71.74	0.081	1.855

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

YEAR	GOM Comb GN	SCDNR Tram Net	ENP	SEAMAP-SA	TEXAS-GN	SC-GN	ATL Coastspan LL	SEAMAP GOM EF	GADNR Trawl
1972	1	1	1	1	1	1	1	0.396	1
1973	1	1	1	1	1	1	1	0.289	1
1974	1	1	1	1	1	1	1	0.344	1
1975	1	1	1	1	1.939	1	1	0.405	1
1976	1	1	1	1	0.497	1	1	0.314	1
1977	1	1	1	1	1.837	1	1	0.415	1
1978	1	1	1	1	0.995	1	1	0.416	1
1979	1	1	1	1	0.554	1	1	0.506	1
1980	1	1	1	1	0.336	1	1	0.585	1
1981	1	1	1	1	0.633	1	1	0.506	1
1982	1	1	1	1	0.307	1	1	0.540	1
1983	1	1	0.81	1	0.250	1	1	0.649	1
1984	1	1	0.33	1	0.210	1	1	1	1
1985	1	1	0.48	1	0.329	1	1	0.895	1
1986	1	1	0.52	1	0.225	1	1	0.450	1
1987	1	1	0.51	1	0.558	1	1	0.589	1
1988	1	1	0.48	1	0.236	1	1	0.545	1
1989	1	1	0.52	0.551	0.272	1	1	0.744	1
1990	1	1	0.52	0.36	0.229	1	1	0.544	1
1991	1	1	0.64	0.344	0.250	1	1	0.481	1
1992	1	1	0.41	0.323	0.344	1	1	0.545	1
1993	1	1	0.5	0.409	0.270	1	1	0.480	1
1994	1	0.405	0.47	0.346	0.305	1	1	0.590	1
1995	0.19	0.389	0.46	0.322	0.329	1	1	0.653	1
1996	0.27	0.409	0.47	0.443	0.251	1	1	0.421	1
1997	0.21	0.317	0.45	0.331	0.427	1	1	0.481	1
1998	0.27	0.289	0.58	0.357	0.287	1	1	0.508	1
1999	0.23	0.213	0.81	0.382	0.344	1	1	0.481	1
2000	0.26	0.266	0.67	0.339	0.222	0.530	0.34	0.457	1
2001	0.19	0.175	0.75	0.274	0.220	0.491	0.50	0.482	1
2002	0.18	0.144	0.78	0.238	0.262	0.580	0.63	0.457	1
2003	0.18	0.152	0.85	0.256	0.224	0.375	0.25	0.456	0.162
2004	0.2	0.189	0.76	0.341	0.250	1	0.21	0.510	0.233
2005	0.38	0.189	0.91	0.266	0.220	0.294	0.22	0.346	0.349
2006	0.24	0.171	1.00	0.246	0.196	0.289	0.17	0.421	0.144
2007	0.24	0.134	0.88	0.269	0.262	0.556	0.23	0.316	0.170
2008	0.23	0.133	0.72	0.274	0.225	0.269	0.19	0.302	0.195
2009	0.2	0.129	0.86	0.233	0.185	0.362	0.18	0.309	0.134
2010	0.23	0.167	0.88	0.250	0.168	0.348	0.12	0.389	0.151
2011	0.19	0.178	1.06	0.287	0.184	0.568	0.16	0.398	0.137

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 mature	M	Fecundity (female pups)	
1	0.069	0.232	4.650	
2	0.131	0.232	4.650	
3	0.236	0.232	4.650	
4	0.388	0.222	4.650	
5	0.565	0.222	4.650	
6	0.726	0.222	4.650	
7	0.844	0.222	4.650	
8	0.917	0.222	4.650	
9	0.958	0.222	4.650	
10	0.979	0.222	4.650	
11	0.990	0.222	4.650	
12	0.995	0.222	4.650	
13	0.997	0.222	4.650	
14	0.999	0.222	4.650	
15	0.999	0.222	4.650	
16	1.000	0.222	4.650	
17	1.000	0.222	4.650	
18	1.000	0.222	4.650	
Sex ratio:		1:1		
Reproductive frequency:		1 yr		
Pupping month:		August		
L_{inf}		100.9	(cm FL)	
k		0.194		
t_0		-2.398		
Weight vs length relation:		$W=0.000003462L^{3.208}$		

Table 3.5.6. List of parameters estimated in SSASPM for bonnethead 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	1.79E+06	2.80E+05	1.15E+07	1.00E+03	1.00E+10	uniform	-	-	estimated
Pup (age-0) survival	8.82E-01	2.05E-01	7.60E-01	2.00E-01	9.90E-01	lognormal	0.77	(0.25)	estimated
Catchability coefficient GOM Comb GN index	6.00E-07	2.32E-07	5.70E-06	1.10E-08	1.00E-05	constant	-	-	estimated
Catchability coefficient SCDNR Trammel net index	1.99E-06	1.10E-06	3.44E-04	1.10E-07	1.00E-04	constant	-	-	estimated
Catchability coefficient ENP index	1.22E-08	4.67E-09	5.70E-07	1.10E-08	1.00E-04	constant	-	-	estimated
Catchability coefficient SEAMAP-SA index	2.44E-06	1.24E-06	3.44E-05	1.10E-08	1.00E-05	constant	-	-	estimated
Catchability coefficient Texas GN index	3.33E-09	1.10E-09	5.70E-08	1.10E-09	1.00E-05	constant	-	-	estimated
Catchability coefficient SC Coastspan GN index	2.03E-05	1.21E-05	2.25E-05	1.10E-08	1.00E-04	constant	-	-	estimated
Catchability coefficient ATL Coastspan LL index	1.55E-05	7.11E-06	6.44E-04	1.10E-07	1.00E-04	constant	-	-	estimated
Catchability coefficient SEAMAP GOM EF index	3.69E-08	1.31E-08	5.70E-07	1.10E-08	1.00E-05	constant	-	-	estimated
Catchability coefficient GADNR Trawl index	8.47E-07	3.47E-07	3.44E-04	1.10E-07	1.00E-04	constant	-	-	estimated
Historic effort Recreational fleet	2.34E-03	2.40E-03	5.00E-03	0.00E+00	1.00E-01	constant	-	-	estimated
Historic effort Shrimp trawl fleet	4.23E-02	1.92E-02	8.00E-02	0.00E+00	1.00E-01	constant	-	-	estimated
Modern effort Commercial BLL fleet	4.90E-02	1.44E-02	5.00E-02	0.00E+00	2.00E-01	constant	-	-	estimated
Modern effort Commercial GN fleet	3.95E-02	1.16E-02	4.00E-02	0.00E+00	2.00E-01	constant	-	-	estimated
Modern effort Commercial L fleet	1.95E-02	5.72E-03	2.00E-02	0.00E+00	2.00E-01	constant	-	-	estimated
Modern effort Recreational fleet	7.97E-02	2.34E-02	8.00E-02	0.00E+00	0.250+00	constant	-	-	estimated
Modern effort Shrimp trawl fleet	0.0006	1.78E-04	6.00E-04	0.00E+00	5.00E-01	constant	-	-	estimated
Overall variance	-6.0996	7.95E-01	-5.50E+00	-3.50E+01	-4.00E-02	constant	-	-	estimated
Effort deviation for Com BLL fleet in 1972	-14.591	2.25E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 1973	-14.652	2.25E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 1974	-14.625	2.25E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 1975	-14.597	2.25E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 1976	-14.5800	2.25E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 1977	-14.5560	2.25E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 1978	-14.5230	2.25E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 1979	-14.4820	2.25E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 1980	-1.44E+01	2.25E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 1981	-1.44E+01	2.25E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 1982	-1.21E+01	2.26E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 1983	-1.14E+01	7.84E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 1984	-1.04E+01	7.87E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 1985	-9.81E+00	7.91E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 1986	-9.18E+00	8.00E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 1987	-8.59E+00	8.12E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 1988	-8.09E+00	8.37E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 1989	-7.51E+00	8.41E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 1990	-6.81E+00	8.47E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 1991	-6.30E+00	8.49E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 1992	-5.70E+00	8.56E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 1993	-5.04E+00	8.60E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 1994	-4.34E+00	8.59E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 1995	-1.35E+01	1.97E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 1996	-1.35E+01	1.97E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 1997	-4.86E+00	8.52E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated

Effort deviation for Com BLL fleet in 1998	-3.95E+00	8.48E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 1999	-4.50E+00	8.45E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 2000	-4.17E+00	8.44E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 2001	-4.80E+00	8.45E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 2002	-4.549	8.46E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 2003	-2.667	8.45E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 2004	-3.932	8.47E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 2005	-3.317	8.49E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 2006	-3.9179	8.45E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 2007	-5.1049	8.41E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 2008	-5.3040	8.35E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 2009	-2.9962	8.29E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 2010	-6.81E+00	8.22E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com BLL fleet in 2011	-4.57E+00	8.15E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 1972	-1.36E+01	2.25E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 1973	-1.36E+01	2.25E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 1974	-1.36E+01	2.25E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 1975	-1.35E+01	2.25E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 1976	-1.35E+01	2.25E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 1977	-1.35E+01	2.25E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 1978	-1.35E+01	2.25E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 1979	-1.34E+01	2.26E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 1980	-1.34E+01	2.26E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 1981	-1.33E+01	2.26E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 1982	-1.33E+01	2.26E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 1983	-1.32E+01	2.26E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 1984	-1.32E+01	2.27E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 1985	-1.32E+01	2.27E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 1986	-1.30E+01	2.27E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 1987	-1.65E+00	8.49E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 1988	-7.69E-01	9.06E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 1989	-2.31E-01	9.50E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 1990	1.54E-01	9.50E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 1991	4.55E-01	9.39E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 1992	0.731	9.42E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 1993	0.943	9.47E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 1994	1.083	9.33E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 1995	1.231	9.12E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 1996	-0.1396	8.97E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 1997	-0.3081	8.74E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 1998	-2.5863	8.64E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 1999	-0.7689	8.52E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 2000	-5.08E-01	8.46E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 2001	-5.83E-01	8.47E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 2002	-1.32E+00	8.53E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 2003	-1.73E+00	8.53E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 2004	-1.78E+00	8.52E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 2005	-1.66E+00	8.55E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 2006	-1.55E+00	8.53E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 2007	-5.59E-01	8.49E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 2008	-1.11E+00	8.42E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 2009	-1.20E+00	8.33E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 2010	-2.82E+00	8.21E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com GN fleet in 2011	-1.49E+00	8.15E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated

Effort deviation for Com L fleet in 1972	-1.30E+01	5.87E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 1973	-1.37E+01	2.25E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 1974	-1.37E+01	2.25E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 1975	-1.37E+01	2.25E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 1976	-1.37E+01	2.25E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 1977	-1.36E+01	2.25E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 1978	-1.36E+01	2.25E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 1979	-1.36E+01	2.25E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 1980	-1.35E+01	2.25E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 1981	-1.35E+01	2.25E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 1982	-13.457	2.26E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 1983	-13.420	2.26E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 1984	-13.390	2.26E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 1985	-13.354	2.26E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 1986	-13.2930	2.26E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 1987	-13.1950	2.27E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 1988	-13.0740	2.28E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 1989	-13.0080	2.28E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 1990	-1.29E+01	2.28E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 1991	-1.28E+01	2.28E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 1992	-1.28E+01	2.28E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 1993	-1.27E+01	2.28E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 1994	-1.27E+01	2.28E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 1995	-1.26E+01	1.97E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 1996	-1.26E+01	1.97E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 1997	-4.60E+00	8.52E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 1998	-4.83E+00	8.48E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 1999	-3.46E+00	8.45E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 2000	-6.74E+00	8.45E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 2001	-6.38E+00	8.45E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 2002	-4.94E+00	8.46E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 2003	-5.71E+00	8.46E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 2004	-6.37E+00	8.47E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 2005	-5.07E+00	8.50E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 2006	-5.03E+00	8.45E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 2007	-6.60E+00	8.41E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 2008	-7.04E+00	8.35E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 2009	-7.33E+00	8.28E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 2010	-7.93E+00	8.22E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Com L fleet in 2011	-5.82E+00	8.15E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 1972	-2.91E+00	5.60E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 1973	-2.87E+00	7.60E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 1974	-2.83E+00	7.61E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 1975	-2.79E+00	7.63E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 1976	-2.76E+00	7.64E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 1977	-2.72E+00	7.66E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 1978	-2.67E+00	7.68E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 1979	-2.62E+00	7.72E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 1980	-2.54E+00	7.66E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 1981	-2.07E+00	7.70E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 1982	-2.45E+00	7.72E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 1983	-2.35E+00	7.76E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 1984	-2.79E+00	7.79E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 1985	-2.37E+00	7.83E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated

Effort deviation for Rec fleet in 1986	-1.35E+00	7.94E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 1987	-1.87E+00	8.04E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 1988	-1.49E+00	8.29E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 1989	-1.34E+00	8.32E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 1990	-1.21E+00	8.35E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 1991	-2.08E+00	8.39E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 1992	-1.62E+00	8.45E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 1993	-1.54E+00	8.47E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 1994	-1.38E+00	8.46E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 1995	-8.74E-01	8.44E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 1996	-1.10E+00	8.44E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 1997	-1.26E+00	8.41E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 1998	-8.86E-01	8.28E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 1999	-7.97E-01	8.20E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 2000	-3.01E-01	7.98E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 2001	-1.39E-01	7.91E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 2002	-1.82E-01	8.08E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 2003	-5.93E-01	8.33E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 2004	-3.91E-01	8.40E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 2005	-6.61E-01	8.44E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 2006	-8.86E-01	8.42E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 2007	-4.10E-01	8.41E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 2008	-1.07E+00	8.40E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 2009	-9.46E-01	8.40E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 2010	-1.13E+00	8.34E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Rec fleet in 2011	-7.22E-01	8.28E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 1972	5.34E+00	7.54E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 1973	5.12E+00	7.50E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 1974	5.46E+00	7.66E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 1975	5.11E+00	7.69E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 1976	5.35E+00	7.69E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 1977	5.53E+00	7.91E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 1978	5.77E+00	8.06E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 1979	5.80E+00	8.04E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 1980	5.75E+00	8.10E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 1981	5.85E+00	8.27E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 1982	5.97E+00	8.46E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 1983	5.93E+00	8.35E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 1984	5.94E+00	8.42E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 1985	6.24E+00	9.15E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 1986	6.29E+00	8.79E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 1987	6.90E+00	1.03E+00	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 1988	6.34E+00	8.63E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 1989	6.66E+00	8.99E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 1990	6.58E+00	8.34E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 1991	6.79E+00	8.72E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 1992	6.62E+00	8.42E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 1993	6.47E+00	7.98E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 1994	6.52E+00	7.77E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 1995	6.35E+00	7.67E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 1996	6.40E+00	7.27E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 1997	6.33E+00	7.02E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 1998	6.23E+00	6.91E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 1999	6.24E+00	6.76E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated

Effort deviation for Shrimp trawl fleet in 2000	6.12E+00	6.76E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 2001	6.00E+00	6.84E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 2002	5.99E+00	6.94E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 2003	5.84E+00	7.19E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 2004	5.97E+00	7.55E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 2005	5.57E+00	8.04E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 2006	5.52E+00	8.13E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 2007	5.25E+00	8.18E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 2008	5.24E+00	8.15E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 2009	5.38E+00	8.03E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 2010	5.15E+00	8.01E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated
Effort deviation for Shrimp trawl fleet in 2011	5.05E+00	7.94E-01	0.00E+00	-1.50E+01	7.00E+00	lognormal	0	1	estimated

Table 3.5.7. Low catch scenario of bonnethead shark. Catches are by fleet in numbers. The lower catch (with respect to the base run) of the shrimp trawl fleet is italicized.

Year	Com-BLL	Com-GN	Com-L	Recreational	Shrimp discards
1950	0	0	0	7469	*103005*
1951	0	0	0	13314	*132351*
1952	0	0	0	14514	*133902*
1953	0	0	0	15714	*154059*
1954	0	0	0	16914	*158973*
1955	0	0	0	18114	*144143*
1956	0	0	0	19314	*131016*
1957	0	0	0	20514	*117923*
1958	0	0	0	21714	*116978*
1959	0	0	0	22914	*131248*
1960	0	0	0	15058	*140670*
1961	0	0	0	15760	*70687*
1962	0	0	0	16461	*92678*
1963	0	0	0	17162	*139034*
1964	0	0	0	17864	*124463*
1965	0	0	0	18565	*134020*
1966	0	0	0	19267	*126382*
1967	0	0	0	19968	*155001*
1968	0	0	0	20669	*141535*
1969	0	0	0	21371	*148218*
1970	0	0	0	18450	*162989*
1971	0	0	0	21632	*167247*
1972	0	0	0	21935	*131493*
1973	0	0	0	22239	*123004*
1974	0	0	0	22542	*122689*
1975	0	0	0	22846	*108340*
1976	0	0	0	23149	*135092*
1977	0	0	0	23453	*159298*
1978	0	0	0	23756	*204536*
1979	0	0	0	24060	*224510*
1980	0	0	0	25067	*157183*
1981	0	0	0	38616	*195389*
1982	1	0	0	25533	*193638*
1983	2	0	0	27131	*188558*
1984	5	0	0	16998	*208036*
1985	9	0	0	24953	*213126*
1986	16	0	0	64858	*245091*
1987	26	8770	0	34922	*271289*
1988	38	17541	0	45527	*232103*
1989	64	26311	0	49350	*252163*
1990	118	35082	0	52019	*247502*
1991	180	43852	0	19883	*276486*
1992	302	52623	0	28990	*258839*
1993	554	61393	0	29784	*244029*
1994	1080	70164	0	33715	*233642*
1995	0	81679	0	53792	*224941*
1996	0	21771	0	42596	*251192*
1997	605	19780	312	36701	*274812*
1998	1527	2113	252	55000	*275534*
1999	890	13673	1005	61916	*266639*
2000	1244	18145	38	107758	*257256*
2001	669	17023	55	131301	*264444*
2002	879	8318	237	124251	*279300*
2003	5999	5751	113	80449	*227773*
2004	1750	5816	61	101614	*193902*
2005	3368	6888	232	79922	*128993*
2006	1971	8226	258	67852	*122258*
2007	638	23847	57	116101	*103001*
2008	557	14771	39	62986	*79989*
2009	5984	14415	31	74683	*108468*
2010	138	3031	18	65029	*78749*
2011	1375	12065	157	103638	*88729*

Table 3.5.8. Standardized hierarchical index of relative abundance used in "hierarchical index" sensitivity, with associated CVs.

	Hierarchical	
YEAR	index	CV
1972	2.12	0.47
1973	5.22	0.40
1974	3.97	0.44
1975	1.11	0.44
1976	2.58	0.36
1977	1.48	0.45
1978	0.90	0.43
1979	1.12	0.42
1980	1.04	0.38
1981	0.93	0.43
1982	0.60	0.36
1983	0.62	0.33
1984	0.99	0.31
1985	0.37	0.35
1986	0.84	0.30
1987	0.29	0.37
1988	0.76	0.30
1989	0.39	0.29
1990	0.65	0.27
1991	0.55	0.26
1992	0.45	0.26
1993	0.47	0.26
1994	0.43	0.25
1995	0.50	0.22
1996	0.36	0.22
1997	0.44	0.22
1998	0.41	0.23
1999	0.47	0.22
2000	0.47	0.21
2001	0.72	0.20
2002	0.85	0.19
2003	0.93	0.18
2004	0.75	0.20
2005	0.66	0.19
2006	0.89	0.18
2007	0.90	0.19
2008	0.92	0.20
2009	1.09	0.19
2010	0.97	0.20
2011	0.80	0.19

Table 3.5.9. 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	0.209	0.256
2	0.209	0.256
3	0.209	0.256
4	0.199	0.244
5	0.199	0.244
6	0.199	0.244
7	0.199	0.244
8	0.199	0.244
9	0.199	0.244
10	0.199	0.244
11	0.199	0.244
12	0.199	0.244
13	0.199	0.244
14	0.199	0.244
15	0.199	0.244
16	0.199	0.244
17	0.199	0.244
18	0.199	0.244

Table 3.5.10. Life history inputs used in the "Atlantic biology" and "Gulf of Mexico biology" sensitivity runs. All these quantities are treated as constants in the model. Von Bertalanffy growth function parameters are for females.

	ATL			GOM		
Age	Proportion mature	M	Fecundity (female pups)	Proportion mature	M	Fecundity (female pups)
1	0.000	0.232	0.000	0.008	0.353	4.835
2	0.002	0.232	0.000	0.090	0.304	4.835
3	0.007	0.232	0.460	0.551	0.276	4.835
4	0.026	0.221	1.331	0.938	0.258	4.835
5	0.092	0.221	2.053	0.995	0.246	4.835
6	0.283	0.221	2.652	1.000	0.238	4.835
7	0.606	0.221	3.147	1.000	0.232	4.835
8	0.856	0.221	3.558	1.000	0.228	4.835
9	0.959	0.215	3.898			
10	0.989	0.211	4.180			
11	0.997	0.207	4.414			
12	0.999	0.204	4.607			
13	1.000	0.202	4.768			
14	1.000	0.200	4.900			
15	1.000	0.199	5.010			
16	1.000	0.198	5.102			
17	1.000	0.197	5.177			
18	1.000	0.196	5.240			

Sex ratio:	1:1		1:1	
Reproductive frequency:	1 yr		1 yr	
Pupping month:	August		August	
Length vs litter size relation:		pups =0.0241FL(mm)-13.796	fixed=	9.67
L_{inf}	103.2	(cm FL)	89.495	(cm FL)
k	0.188		0.282	
t_0	-1.759		-2.128	
Weight vs length relation:	$W=0.000003462L^{3.208}$		$W=9.52E\text{-}11TL(mm)^{3.59}$ TL (mm)=1.18FL(mm)-23.34	

Table 3.5.11. Predicted abundance (numbers) and spawning stock fecundity (numbers) of bonnethead sharks for the base run.

Year	N	SSF
1950	8,840,375	15,963,000
1951	8,695,082	15,791,000
1952	8,579,534	15,593,000
1953	8,485,416	15,381,000
1954	8,407,244	15,168,000
1955	8,341,656	14,969,000
1956	8,285,846	14,791,000
1957	8,238,503	14,636,000
1958	8,197,827	14,504,000
1959	8,162,899	14,391,000
1960	8,133,143	14,295,000
1961	8,107,437	14,213,000
1962	8,085,058	14,142,000
1963	8,065,840	14,080,000
1964	8,049,034	14,027,000
1965	8,034,482	13,981,000
1966	8,021,593	13,940,000
1967	8,010,283	13,904,000
1968	8,000,156	13,872,000
1969	7,991,328	13,844,000
1970	7,983,447	13,818,000
1971	7,976,246	13,795,000
1972	7,969,663	13,661,000
1973	7,723,171	13,434,000
1974	7,602,324	13,152,000
1975	7,394,161	12,853,000
1976	7,339,790	12,565,000
1977	7,215,957	12,237,000
1978	7,047,724	11,856,000
1979	6,813,530	11,440,000
1980	6,616,157	11,037,000
1981	6,477,991	10,621,000
1982	6,303,024	10,200,000
1983	6,114,518	9,808,500
1984	5,979,151	9,468,800
1985	5,868,938	9,086,400
1986	5,604,498	8,590,000
1987	5,340,307	7,889,900
1988	4,698,703	7,237,500
1989	4,631,422	6,632,300
1990	4,317,773	6,018,400
1991	4,108,592	5,457,300
1992	3,805,544	4,964,400
1993	3,660,956	4,569,200
1994	3,585,927	4,225,300
1995	3,452,207	3,921,600
1996	3,387,109	3,745,200
1997	3,349,624	3,683,800
1998	3,360,361	3,686,600
1999	3,408,810	3,705,400
2000	3,426,423	3,696,400
2001	3,453,477	3,683,600
2002	3,496,160	3,704,600
2003	3,540,825	3,813,400
2004	3,666,773	3,943,700
2005	3,715,300	4,126,700
2006	3,912,601	4,397,200
2007	4,109,290	4,656,000
2008	4,293,220	4,976,700
2009	4,516,286	5,326,900
2010	4,666,484	5,704,600
2011	4,888,227	6,069,300

Table 3.5.12. Estimated total and fleet-specific instantaneous fishing mortality rates by year.

Year	Total F	Fleet-specific F				
		Com-BLL	Com-GN	Com-L	Recreational	Shrimp trawl
1950	0.0429	0.0000	0.0000	0.0000	0.0023	0.0423
1951	0.0429	0.0000	0.0000	0.0000	0.0024	0.0423
1952	0.0429	0.0000	0.0000	0.0000	0.0025	0.0423
1953	0.0429	0.0000	0.0000	0.0000	0.0026	0.0423
1954	0.0429	0.0000	0.0000	0.0000	0.0027	0.0423
1955	0.0429	0.0000	0.0000	0.0000	0.0028	0.0423
1956	0.0430	0.0000	0.0000	0.0000	0.0029	0.0423
1957	0.0430	0.0000	0.0000	0.0000	0.0030	0.0423
1958	0.0430	0.0000	0.0000	0.0000	0.0031	0.0423
1959	0.0430	0.0000	0.0000	0.0000	0.0032	0.0423
1960	0.0430	0.0000	0.0000	0.0000	0.0033	0.0423
1961	0.0430	0.0000	0.0000	0.0000	0.0033	0.0423
1962	0.0430	0.0000	0.0000	0.0000	0.0034	0.0423
1963	0.0431	0.0000	0.0000	0.0000	0.0035	0.0423
1964	0.0431	0.0000	0.0000	0.0000	0.0036	0.0423
1965	0.0431	0.0000	0.0000	0.0000	0.0037	0.0423
1966	0.0431	0.0000	0.0000	0.0000	0.0038	0.0423
1967	0.0431	0.0000	0.0000	0.0000	0.0039	0.0423
1968	0.0431	0.0000	0.0000	0.0000	0.0040	0.0423
1969	0.0431	0.0000	0.0000	0.0000	0.0041	0.0423
1970	0.0432	0.0000	0.0000	0.0000	0.0042	0.0423
1971	0.0432	0.0000	0.0000	0.0000	0.0043	0.0423
1972	0.1281	0.0000	0.0000	0.0000	0.0044	0.1264
1973	0.1033	0.0000	0.0000	0.0000	0.0045	0.1018
1974	0.1450	0.0000	0.0000	0.0000	0.0047	0.1429
1975	0.1020	0.0000	0.0000	0.0000	0.0049	0.1004
1976	0.1299	0.0000	0.0000	0.0000	0.0051	0.1280
1977	0.1563	0.0000	0.0000	0.0000	0.0052	0.1540
1978	0.1978	0.0000	0.0000	0.0000	0.0055	0.1948
1979	0.2043	0.0000	0.0000	0.0000	0.0058	0.2011
1980	0.1947	0.0000	0.0000	0.0000	0.0063	0.1916
1981	0.2155	0.0000	0.0000	0.0000	0.0100	0.2114
1982	0.2413	0.0000	0.0000	0.0000	0.0069	0.2372
1983	0.2332	0.0000	0.0000	0.0000	0.0076	0.2292
1984	0.2351	0.0000	0.0000	0.0000	0.0049	0.2314
1985	0.3174	0.0000	0.0000	0.0000	0.0075	0.3115
1986	0.3353	0.0000	0.0000	0.0000	0.0207	0.3269
1987	0.6208	0.0000	0.0076	0.0000	0.0123	0.6035
1988	0.3537	0.0000	0.0183	0.0000	0.0180	0.3451
1989	0.4876	0.0000	0.0313	0.0000	0.0209	0.4742
1990	0.4513	0.0001	0.0460	0.0000	0.0239	0.4386
1991	0.5533	0.0001	0.0622	0.0000	0.0099	0.5387
1992	0.4676	0.0002	0.0820	0.0000	0.0158	0.4552
1993	0.4050	0.0003	0.1013	0.0000	0.0171	0.3942
1994	0.4268	0.0006	0.1166	0.0000	0.0201	0.4148
1995	0.3605	0.0000	0.1351	0.0000	0.0333	0.3486
1996	0.3779	0.0000	0.0343	0.0000	0.0265	0.3672
1997	0.3497	0.0004	0.0290	0.0002	0.0227	0.3403
1998	0.3201	0.0009	0.0030	0.0002	0.0329	0.3102
1999	0.3232	0.0005	0.0183	0.0006	0.0359	0.3126
2000	0.2889	0.0008	0.0238	0.0000	0.0590	0.2759
2001	0.2604	0.0004	0.0220	0.0000	0.0693	0.2466
2002	0.2567	0.0005	0.0106	0.0001	0.0664	0.2434
2003	0.2184	0.0034	0.0070	0.0001	0.0440	0.2088
2004	0.2485	0.0010	0.0067	0.0000	0.0539	0.2371
2005	0.1674	0.0018	0.0075	0.0001	0.0412	0.1593
2006	0.1582	0.0010	0.0084	0.0001	0.0329	0.1516
2007	0.1284	0.0003	0.0226	0.0000	0.0529	0.1164
2008	0.1198	0.0002	0.0131	0.0000	0.0275	0.1146
2009	0.1381	0.0024	0.0118	0.0000	0.0309	0.1319
2010	0.1098	0.0001	0.0023	0.0000	0.0257	0.1051
2011	0.1013	0.0005	0.0089	0.0001	0.0387	0.0946

Table 3.5.13. Summary of results for base runs with several weighting schemes for bonnethead 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). See text for further details.

	Base (eq weights)		Base (ranks)		Base (inv CV)	
	Est	CV	Est	CV	Est	CV
AICc	3487.36		3522.36		3363.98	
Objective function	1355.63		1373.13		1293.94	
SSF_{2011}/SSF_{MSY}	**1.17**	0.46	**1.17**	0.49	**1.27**	0.53
F_{2011}/F_{MSY}	**0.54**	0.67	**0.54**	0.69	**0.50**	0.71
N_{2011}/N_{MSY}	1.10	---	1.10	---	1.16	---
MSY	5.67.E+05	---	5.67.E+05	---	5.89.E+05	---
SPR_{MSY}	0.40	0.17	0.40	0.17	0.39	0.31
F_{MSY}	0.194	---	0.193	---	0.202	---
SSF_{MSY}	4.84.E+06	---	4.89.E+06	---	4.77.E+06	---
N_{MSY}	4.20.E+06	---	4.23.E+06	---	4.20.E+06	---
F_{2011}	0.106	0.67	0.105	0.69	0.101	0.71
SSF_{2011}	5.66.E+06	0.53	5.71.E+06	0.585	6.07.E+06	0.43
N_{2011}	4.63.E+06	---	4.66.E+06	---	4.89.E+06	---
SSF_{2011}/SSF_0	0.36	0.42	0.36	0.459	0.38	0.32
B_{2011}/B_0	0.37	0.38	0.37	0.417	0.39	0.29
R0	1.79.E+06	0.16	1.80.E+06	2.E-01	1.79.E+06	0.16
Pup-survival	0.82	0.24	0.81	0.24	0.88	0.23
alpha	7.32	---	7.28	---	7.88	---
steepness	0.65	---	0.65	---	0.66	---
SSF_0	1.60.E+07	0.16	1.61.E+07	0.17074	1.60.E+07	0.16
SSF_{MSY}/SSF_0	0.30	---	0.31	---	0.30	---
$Nmat_{MSY}$	9.82.E+05	---	9.93.E+05	---	9.62.E+05	---

Table 3.5.14. Summary of results for base and sensitivity runs for bonnethead shark. All runs used inverse CV weighting. 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: increasing and decreasing indices, low catch, hierarchical index, and SEAMAP-SA.

	Base (inv CV)		Increasing indices		Decreasing indices		Low catch		Hierarchical		SEAMAP-SA	
	Est	CV	Est	CV	Est	CV	Est	CV	Est	CV	Est	CV
AICc	3363.98		3438.19		3439.32		3366.07		3463.96		3530.21	
Objective function	1293.94		1273.05		1243.18		1294.98		1196.84		1184.42	
SSF_{2011}/SSF_{MSY}	**1.27**	0.53	**1.40**	0.64	**0.58**	1.07	**1.29**	0.36	**1.06**	0.74	**1.34**	0.77
F_{2011}/F_{MSY}	**0.50**	0.71	**0.45**	0.83	**0.96**	1.04	**0.64**	0.60	**0.58**	0.84	**0.47**	0.95
N_{2011}/N_{MSY}	1.16	---	1.24	---	0.68	---	1.16	---	1.04	---	1.21	---
MSY	5.89.E+05	---	6.07.E+05	---	5.18.E+05	---	2.68.E+05	---	5.59.E+05	---	6.02.E+05	---
SPR_{MSY}	0.39	0.31	0.40	0.30	0.41	0.19	0.39	0.01	0.40	0.18	0.40	0.31
F_{MSY}	0.202	---	0.197	---	0.181	---	0.180	---	0.190	---	0.194	---
SSF_{MSY}	4.77.E+06	---	5.23.E+06	---	4.65.E+06	---	2.40.E+06	---	4.90.E+06	---	5.28.E+06	---
N_{MSY}	4.20.E+06	---	4.50.E+06	---	4.02.E+06	---	2.18.E+06	---	4.22.E+06	---	4.52.E+06	---
F_{2011}	0.101	0.71	0.089	0.83	0.173	1.04	0.116	0.60	0.111	0.84	0.091	0.95
SSF_{2011}	6.07.E+06	0.43	7.32.E+06	0.77	2.71.E+06	1.20	3.10.E+06	0.48	5.21.E+06	0.93	7.07.E+06	1.05
N_{2011}	4.89.E+06	---	5.59.E+06	---	2.74.E+06	---	2.54.E+06	---	4.38.E+06	---	5.46.E+06	---
SSF_{2011}/SSF_0	0.38	0.32	0.43	0.53	0.18	1.12	0.40	0.33	0.33	0.76	0.41	0.75
B_{2011}/B_0	0.39	0.29	0.43	0.48	0.20	1.06	0.40	0.30	0.34	0.69	0.42	0.68
R0	1.79.E+06	0.16	1.92.E+06	0.27	1.69.E+06	0.15	8.84.E+05	0.18	1.79.E+06	0.21	1.93.E+06	0.32
Pup-survival	0.88	0.23	0.80	0.24	0.79	0.24	0.87	0.24	0.79	0.24	0.79	0.24
alpha	7.88	---	7.18	---	7.08	---	7.82	---	7.10	---	7.04	---
steepness	0.66	---	0.64	---	0.64	---	0.66	---	0.64	---	0.64	---
SSF_0	1.60.E+07	0.16	1.72.E+07	0.27	1.51.E+07	0.15	7.90.E+06	0.18	1.60.E+07	0.21	1.72.E+07	0.32
SSF_{MSY}/SSF_0	0.30	---	0.31	---	0.31	---	0.31	---	0.31	---	0.31	---
$Nmat_{MSY}$	9.62.E+05	---	1.06.E+06	---	9.43.E+05	---	4.79.E+05	---	9.95.E+05	---	1.07.E+06	---

Table 3.5.14 (continued). Summary of results for base and sensitivity runs for bonnethead shark. All runs used inverse CV weighting. 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: No indices, Model start 1972, and high and low productivity.

	Base (inv CV)		No indices		Model start 1972		High productivity		Low productivity	
	Est	CV	Est	CV	Est	CV	Est	CV	Est	CV
AICc	3363.98		3840.68		1725.07		3364.06		3366.68	
Objective function	1293.94		1166.01		383.21		1293.98		1295.29	
SSF_{2011}/SSF_{MSY}	**1.27**	0.53	**0.12**	5.39	**1.34**	0.17	**1.33**	0.54	**1.18**	0.35
F_{2011}/F_{MSY}	**0.50**	0.71	**3.74**	4.90	**0.48**	0.24	**0.48**	0.71	**0.55**	0.61
N_{2011}/N_{MSY}	1.16	---	0.22	---	1.21	---	1.18	---	1.13	---
MSY	5.89.E+05	---	4.91.E+05	---	6.04.E+05	---	6.04.E+05	---	5.60.E+05	---
SPR_{MSY}	0.39	0.31	0.41	0.02	0.41	0.10	0.34	0.34	0.44	0.15
F_{MSY}	0.202	---	0.171	---	0.192	---	0.228	---	0.173	---
SSF_{MSY}	4.77.E+06	---	4.56.E+06	---	5.39.E+06	---	5.17.E+06	---	4.46.E+06	---
N_{MSY}	4.20.E+06	---	3.97.E+06	---	4.59.E+06	---	3.85.E+06	---	4.64.E+06	---
F_{2011}	0.101	0.71	0.640	4.90	0.091	0.24	0.110	0.71	0.094	0.61
SSF_{2011}	6.07.E+06	0.43	5.64.E+05	5.45	7.22.E+06	0.14	6.86.E+06	0.45	5.27.E+06	0.35
N_{2011}	4.89.E+06	---	8.86.E+05	---	5.56.E+06	---	4.55.E+06	---	5.25.E+06	---
SSF_{2011}/SSF_0	0.38	0.32	0.04	5.41	0.42	0.10	0.36	0.34	0.39	0.26
B_{2011}/B_0	0.39	0.29	0.04	6.17	0.42	0.09	0.38	0.30	0.39	0.24
R0	1.79.E+06	0.16	1.64.E+06	0.14	1.95.E+06	0.05	1.58.E+06	0.15	2.06.E+06	0.14
Pup-survival	0.88	0.23	0.78	0.25	0.77	---	0.87	0.23	0.89	0.22
alpha	7.88	---	6.99	---	6.89	---	10.34	---	5.89	---
steepness	0.66	---	0.64	---	0.63	---	0.72	---	0.60	---
SSF_0	1.60.E+07	0.16	1.47.E+07	0.14	1.75.E+07	0.05	1.89.E+07	0.15	1.37.E+07	0.14
SSF_{MSY}/SSF_0	0.30	---	0.31	---	0.31	---	0.27	---	0.33	---
$Nmat_{MSY}$	9.62.E+05	---	9.22.E+05	---	1.10.E+06	---	9.07.E+05	---	1.05.E+06	---

Table 3.5.14 (continued). Summary of results for base and sensitivity runs for bonnethead shark. All runs used inverse CV weighting. 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: Atlantic biology and Gulf of Mexico biology.

	Base (inv CV)		ATL biology		GOM biology	
	Est	CV	Est	CV	Est	CV
AICc	3363.98		3489.24		3365.94	
Objective function	1293.94		1356.57		1294.92	
SSF_{2011}/SSF_{MSY}	**1.27**	0.53	**0.73**	0.74	**1.48**	0.31
F_{2011}/F_{MSY}	**0.50**	0.71	**1.09**	0.78	**0.45**	0.59
N_{2011}/N_{MSY}	1.16	---	0.80	---	1.26	
MSY	5.89.E+05	---	3.96.E+05	---	6.03.E+05	
SPR_{MSY}	0.39	0.31	0.50	0.32	0.40	0.14
F_{MSY}	0.202	---	0.106	---	0.203	
SSF_{MSY}	4.77.E+06	---	3.65.E+06	---	5.95.E+06	
N_{MSY}	4.20.E+06	---	5.64.E+06	---	4.29.E+06	
F_{2011}	0.101	0.71	0.115	0.78	0.092	0.59
SSF_{2011}	6.07.E+06	0.43	2.67.E+06	0.55	8.83.E+06	0.32
N_{2011}	4.89.E+06	---	4.54.E+06	---	5.41.E+06	
SSF_{2011}/SSF_0	0.38	0.32	0.25	0.44	0.44	0.23
B_{2011}/B_0	0.39	0.29	0.31	0.40	0.44	0.20
R0	1.79.E+06	0.16	2.19.E+06	0.15	2.20.E+06	0.14
Pup-survival	0.88	0.23	0.85	0.24	0.74	0.23
alpha	7.88	---	4.14	---	6.80	
steepness	0.66	---	0.51	---	0.63	
SSF_0	1.60.E+07	0.16	1.07.E+07	0.15	2.01.E+07	0.14
SSF_{MSY}/SSF_0	0.30	---	0.34	---	0.30	
$Nmat_{MSY}$	9.62.E+05	---	1.06.E+06	---	1.73.E+06	

Table 3.5.15. Summary of results for continuity run, 2007 base run, and 2013 (current) base run (inverse CV weighting) for bonnethead 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 (inv CV)		Continuity		2007 Base	
	Est	CV	Est	CV	Est	CV
AICc	3363.98		4059.78		---	
Objective function	1293.94		1551.88		---	
SSF_{cur}/SSF_{MSY}	**1.27**	0.53	**1.01**	0.40	**1.13**	0.49
F_{cur}/F_{MSY}	**0.50**	0.71	**1.37**	0.75	**0.61**	0.82
N_{cur}/N_{MSY}	1.16	---	0.76	---	0.83	---
MSY	5.89.E+05	---	4.79.E+05	---	5.69.E+05	---
SPR_{MSY}	0.39	0.31	0.53	0.01	0.42	0.17
F_{MSY}	0.202	---	0.351	---	0.311	---
SSF_{MSY}	4.77.E+06	---	1.55.E+06	---	1.99.E+06	---
N_{MSY}	4.20.E+06	---	1.53.E+06	---	1.92.E+06	---
F_{cur}	0.101	0.71	0.480	0.75	0.188	0.82
SSF_{cur}	6.07.E+06	0.43	1.56.E+06	0.62	2.26.E+06	0.72
N_{cur}	4.89.E+06	---	1.17.E+06	---	1.59.E+06	---
SSF_{cur}/SSF_0	0.38	0.32	0.36	0.38	0.41	0.47
B_{cur}/B_0	0.39	0.29	0.34	0.38	0.41	0.47
R0	1.79.E+06	0.16	9.78.E+05	0.27	1.22.E+06	0.29
Pup-survival	0.88	0.23	0.79	0.24	0.70	0.24
alpha	7.88	---	3.56	---	3.14	---
steepness	0.66	---	0.47	---	0.44	---
SSF_0	1.60.E+07	0.16	4.38.E+06	0.27	---	---
SSF_{MSY}/SSF_0	0.30	---	0.35	---	---	---
$Nmat_{MSY}$	9.62.E+05	---	6.95.E+05	---	---	---

Table 3.5.16. Summary of results of retrospective analyses of the baseline run. All runs used inverse CV weighting. 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 (inv CV)		Retrospective 2010		Retrospective 2009		Retrospective 2008		Retrospective 2007	
	Est	CV	Est	CV	Est	CV	Est	CV	Est	CV
AICc	3363.98		3308.77		3252.83		3196.95		3138.06	
Objective function	1293.94		1273.68		1253.03		1232.38		1210.19	
SSF_{cur}/SSF_{MSY}	**1.27**	0.53	**1.19**	0.48	**1.10**	0.51	**1.03**	0.54	**0.93**	0.52
F_{cur}/F_{MSY}	**0.50**	0.71	**0.43**	0.72	**0.58**	0.73	**0.51**	0.76	**0.71**	0.69
N_{cur}/N_{MSY}	1.16	---	1.13		1.08		1.03		0.93	
MSY	5.89.E+05	---	6.13.E+05		6.05.E+05		6.01.E+05		5.67.E+05	
SPR_{MSY}	0.39	0.31	0.38	0.25	0.38	0.25	0.39	0.26	0.40	0.18
F_{MSY}	0.202	---	0.250		0.237		0.233		0.183	
SSF_{MSY}	4.77.E+06	---	4.67.E+06		4.69.E+06		4.74.E+06		4.87.E+06	
N_{MSY}	4.20.E+06	---	4.05.E+06		4.08.E+06		4.10.E+06		4.27.E+06	
F_{cur}	0.101	0.71	0.108	0.72	0.137	0.73	0.118	0.76	0.129	0.69
SSF_{cur}	6.07.E+06	0.43	5.54.E+06	0.44	5.14.E+06	0.48	4.88.E+06	0.54	4.50.E+06	0.60
N_{cur}	4.89.E+06	---	4.59.E+06		4.42.E+06		4.23.E+06		4.00.E+06	
SSF_{cur}/SSF_0	0.38	0.32	0.35	0.34	0.32	0.37	0.30	0.42	0.28	0.48
B_{cur}/B_0	0.39	0.29	0.36	0.30	0.34	0.34	0.32	0.38	0.30	0.44
R0	1.79.E+06	0.16	1.79.E+06	0.15	1.79.E+06	0.16	1.80.E+06	0.16	1.80.E+06	0.17
Pup-survival	0.88	0.23	0.89	0.24	0.88	0.24	0.86	0.24	0.84	0.24
alpha	7.88	---	7.98		7.89		7.68		7.52	
steepness	0.66	---	0.67		0.66		0.66		0.65	
SSF_0	1.60.E+07	0.16	1.60.E+07	0.15	1.60.E+07	0.16	1.61.E+07	0.16	1.61.E+07	0.17
SSF_{MSY}/SSF_0	0.30	---	0.29		0.29		0.30		0.30	
$Nmat_{MSY}$	9.62.E+05	---	9.47.E+05		9.48.E+05		9.59.E+05		9.79.E+05	

cur = 2011 for base, 2010 for retrospective 2010, 2009 for retrospective 2009, 2008 for retrospective 2008, and 2007 for retrospective 2007

Table 3.5.17. Summary of stock status results (relative to SSF_{MSY} and F_{MSY}) for all runs conducted in the assessment. For SSF, stock status with respect to MSY in 2011 (2005 for continuity run and respective year for retrospective runs) and as the geometric mean of 2009-2011 values (2003-2005 for continuity run and 2008-2010 for retrospective 2010 run, etc.) are shown, along with the MSST and the approximate probability of the stock being overfished in the terminal year. For F, stock status with respect to MSY in 2011 (2005 for continuity run and respective year for retrospective runs) and as the geometric mean of 2009-2011 values (2003-2005 for continuity run and 2008-2010 for retrospective 2010 run, etc.) are shown, along with the approximate probability of overfishing occurring in the terminal year.

	SSF				F		
				Geo mean			Geo mean
Run	SSF_{CUR}/SSF_{MSY}	MSST	P_{CUR} (Not overfished)	$SSF_{(CUR-2)\text{ - }CUR}/SSF_{MSY}$	F_{CUR}/F_{MSY}	P_{CUR} (Not overfishing)	$F_{(CUR-2)\text{ - }CUR}/F_{MSY}$
Base (eq wt)	1.17	0.78	0.88	1.09	0.54	0.88	0.62
Base (inv CV)	1.27	0.78	0.93	1.19	0.50	0.91	0.57
Base (ranks)	1.17	0.78	0.85	1.09	0.54	0.89	0.62
Increasing indices	1.40	0.78	0.89	1.32	0.45	0.93	0.51
Decreasing indices	0.58	0.78	0.31	0.54	0.96	0.54	1.09
Low catch	1.29	0.78	0.94	1.23	0.64	0.68	0.57
Hierarchical	1.06	0.78	0.79	0.99	0.58	0.86	0.66
SEAMAP-SA	1.34	0.78	0.85	1.26	0.47	0.90	0.53
No indices	0.12	0.78	0.38	0.14	3.74	0.01	3.42
Start 1972	1.34	0.78	0.94	1.27	0.48	0.93	0.53
High prod	1.33	0.80	0.92	1.23	0.48	0.93	0.55
Low prod	1.18	0.75	0.92	1.12	0.55	0.90	0.62
GOM bio	1.48	0.74	0.97	1.40	0.45	0.95	0.50
ATL bio	0.73	0.79	0.44	0.72	1.09	0.52	1.20
Continuity	1.01	0.74	0.90	0.97	1.37	0.33	1.06
Retrospective 2010	1.19	0.78	0.92	1.10	0.43	0.94	0.48
Retrospective 2009	1.10	0.78	0.88	1.02	0.58	0.88	0.54
Retrospective 2008	1.03	0.78	0.81	0.97	0.51	0.91	0.64
Retrospective 2007	0.93	0.78	0.76	0.88	0.71	0.85	0.84

* Start 1972 run with MCMC

* CUR = 2011 in all cases, except for continuity (2005) and retrospective (2010, 2009, 2008 or 2007) runs

Table 3.5.18. Stock projection information.

Projection information	Value
First projection year	2012
End projection year	2041 (30 years) (One generation is cf., 7.8 years)
Interim projection years at current fishing mortality rate	2012, 2013, 2014 (3 years)
Projection criteria (Iteratively solve for annual fishing mortality at a fixed level of total removals due to fishing)	Fixed removals (2015-2041)
Alternative levels	Fixed removals (1000s)
1	0
2	50
3	100
4	150
5	200
6	250
7	300
8	350
9	400
10	450
11	500
12	550
13	600
14	650
15	700
16	750
17	800
18	850
19	900
20	950
21	1000

Table 3.5.19. Examples from each projection scenario are provided for a given fixed level of total annual removals due to fishing (1,000s of sharks) during the years (2015 – 2041) which resulted in both the $Pr(SSF_t > SSF_{MSY}) \geq 70\%$, and the $Pr(F_t > F_{MSY}) \leq 30\%$ in the year 2041 from 10,000 Monte Carlo bootstrap projections.

Projection scenario	SSASPM configuration	MSY (1000s)	Example of fixed removals (1,000s)	Buffer from MSY (% Decrease)
1	Baseline, Inverse CV Weighting	589	550	7%
2	Sensitivity, Increasing Indices	607	450	26%
3	Sensitivity, Decreasing Indices	518	300	42%
4	Sensitivity, Low Catch	268	200	25%
5	Sensitivity, Hierarchical Index (Double Exp.)	559	400	29%
6*	Sensitivity, Model Start in 1972	604	600	1%
7	Sensitivity, High Productivity	604	550	9%
8	Sensitivity, Low Productivity	560	500	11%
9	Sensitivity, SEAMAP-SA	602	400	34%
10	Sensitivity, Gulf of Mexico Biology	600	550	8%
11	Sensitivity, Atlantic Biology	396	200	50%
Median buffer from MSY, excluding projection scenario-6				26%
Mean buffer from MSY, excluding projection scenario-6				24%

*Some model parameters were fixed within the SASSPM sensitivity configuration, Model Start in 1972, which resulted in an unreasonably small buffer for projection scenario-6.

Table 3.5.20. Probabilities from 10,000 Monte Carlo bootstrap projections that spawning stock fecundity (SSFt) will exceed the level of SSF that will produce MSY (SSF_{MSY}), Pr(SSFt > SSF_{MSY}), for a given year (2032 – 2041) and a given fixed removals level (1,000s); Green Pr ≥ 70%, Yellow 70% > Pr ≥ 50%, Red Pr < 50%.

Panel A. Projection Scenario-1 (Baseline, Inverse CV Weighting)

Alternative levels	Fixed removals (1,000s)	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
1	0	1.00	1.00	1.00	1.00	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99
2	50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3	100	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
4	150	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	1.00	1.00
5	200	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
6	250	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
7	300	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
8	350	0.96	0.97	0.96	0.97	0.97	0.96	0.97	0.96	0.96	0.96
9	400	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
10	450	0.91	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.89	0.89
11	500	0.83	0.83	0.83	0.82	0.82	0.82	0.82	0.82	0.82	0.82
12	550	0.75	0.75	0.74	0.74	0.73	0.73	0.72	0.72	0.72	0.71
13	600	0.63	0.62	0.62	0.61	0.60	0.59	0.59	0.58	0.58	0.57
14	650	0.52	0.51	0.50	0.49	0.48	0.48	0.47	0.46	0.46	0.45
15	700	0.40	0.39	0.38	0.37	0.36	0.35	0.34	0.34	0.33	0.33
16	750	0.29	0.28	0.27	0.26	0.25	0.24	0.24	0.23	0.23	0.22
17	800	0.18	0.17	0.17	0.16	0.15	0.15	0.14	0.14	0.13	0.13
18	850	0.13	0.12	0.11	0.11	0.10	0.10	0.09	0.09	0.08	0.08
19	900	0.07	0.06	0.06	0.05	0.05	0.04	0.04	0.04	0.04	0.04
20	950	0.04	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02
21	1000	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Table 3.5.20 (continued). Probabilities from 10,000 Monte Carlo bootstrap projections that spawning stock fecundity (SSFt) will exceed the level of SSF that will produce MSY (SSF_{MSY}), Pr(SSFt > SSF_{MSY}), for a given year (2032 – 2041) and a given fixed removals level (1,000s); Green Pr ≥ 70%, Yellow 70% > Pr ≥ 50%, Red Pr < 50%.

Panel B. Projection Scenario-2 (Sensitivity, Increasing Indices)

Alternative levels	Fixed removals (1,000s)	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
1	0	0.98	0.98	0.98	0.99	0.99	0.99	0.99	0.99	0.99	0.99
2	50	0.96	0.96	0.96	0.96	0.96	0.96	0.97	0.97	0.97	0.97
3	100	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
4	150	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
5	200	0.91	0.92	0.92	0.91	0.91	0.91	0.91	0.91	0.91	0.91
6	250	0.89	0.89	0.89	0.88	0.88	0.88	0.88	0.88	0.88	0.88
7	300	0.86	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
8	350	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82
9	400	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.76	0.76
10	450	0.73	0.73	0.72	0.72	0.72	0.72	0.71	0.71	0.71	0.71
11	500	0.68	0.67	0.67	0.67	0.66	0.66	0.66	0.66	0.66	0.65
12	550	0.63	0.62	0.62	0.61	0.61	0.61	0.61	0.60	0.60	0.60
13	600	0.56	0.56	0.55	0.55	0.54	0.54	0.54	0.54	0.53	0.53
14	650	0.50	0.50	0.49	0.49	0.49	0.48	0.48	0.47	0.47	0.47
15	700	0.45	0.44	0.44	0.43	0.43	0.42	0.42	0.41	0.41	0.41
16	750	0.39	0.38	0.38	0.37	0.37	0.36	0.36	0.36	0.35	0.35
17	800	0.33	0.33	0.32	0.32	0.31	0.31	0.30	0.29	0.29	0.29
18	850	0.29	0.28	0.28	0.27	0.26	0.26	0.25	0.25	0.24	0.24
19	900	0.24	0.23	0.22	0.22	0.21	0.21	0.20	0.20	0.20	0.19
20	950	0.20	0.19	0.19	0.18	0.18	0.17	0.17	0.16	0.16	0.16
21	1000	0.16	0.15	0.15	0.14	0.14	0.13	0.13	0.13	0.12	0.12

Table 3.5.20 (continued). Probabilities from 10,000 Monte Carlo bootstrap projections that spawning stock fecundity (SSFt) will exceed the level of SSF that will produce MSY (SSF_{MSY}), Pr(SSFt > SSF_{MSY}), for a given year (2032 – 2041) and a given fixed removals level (1,000s); Green Pr ≥ 70%, Yellow 70% > Pr ≥ 50%, Red Pr < 50%.

Panel C. Projection Scenario-3 (Sensitivity, Decreasing Indices)

Alternative levels	Fixed removals (1,000s)	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
1	0	0.97	0.97	0.98	0.99	0.99	0.99	0.99	0.99	0.99	1.00
2	50	0.89	0.89	0.90	0.90	0.90	0.91	0.91	0.91	0.91	0.91
3	100	0.85	0.85	0.85	0.85	0.85	0.86	0.86	0.86	0.86	0.86
4	150	0.83	0.83	0.83	0.84	0.84	0.84	0.84	0.84	0.84	0.84
5	200	0.80	0.81	0.81	0.81	0.81	0.82	0.82	0.82	0.82	0.82
6	250	0.76	0.77	0.77	0.78	0.78	0.78	0.78	0.78	0.78	0.78
7	300	0.72	0.72	0.73	0.73	0.74	0.74	0.74	0.74	0.75	0.75
8	350	0.66	0.67	0.67	0.68	0.68	0.68	0.69	0.69	0.69	0.69
9	400	0.58	0.58	0.59	0.59	0.59	0.60	0.60	0.60	0.60	0.61
10	450	0.48	0.49	0.49	0.49	0.49	0.50	0.50	0.50	0.50	0.50
11	500	0.37	0.37	0.37	0.37	0.38	0.38	0.38	0.38	0.38	0.38
12	550	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28
13	600	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.17
14	650	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.10	0.10	0.10
15	700	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
16	750	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
17	800	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01
18	850	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
19	900	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	950	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	1000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 3.5.20 (continued). Probabilities from 10,000 Monte Carlo bootstrap projections that spawning stock fecundity (SSFt) will exceed the level of SSF that will produce MSY (SSF_{MSY}), Pr(SSFt > SSF_{MSY}), for a given year (2032 – 2041) and a given fixed removals level (1,000s); Green Pr ≥ 70%, Yellow 70% > Pr ≥ 50%, Red Pr < 50%.

Panel D. Projection Scenario-4 (Sensitivity, Low Catch)

Alternative levels	Fixed removals (1,000s)	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
1	0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2	50	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
3	100	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
4	150	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
5	200	0.86	0.86	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
6	250	0.70	0.69	0.69	0.69	0.69	0.68	0.68	0.68	0.68	0.67
7	300	0.48	0.48	0.47	0.46	0.46	0.45	0.45	0.44	0.44	0.43
8	350	0.26	0.25	0.25	0.24	0.23	0.23	0.22	0.22	0.21	0.21
9	400	0.12	0.11	0.10	0.10	0.09	0.09	0.09	0.09	0.08	0.08
10	450	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02
11	500	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
12	550	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	600	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	650	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	700	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	750	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	800	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	850	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	900	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	950	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	1000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 3.5.20 (continued). Probabilities from 10,000 Monte Carlo bootstrap projections that spawning stock fecundity (SSFt) will exceed the level of SSF that will produce MSY (SSF_{MSY}), Pr(SSFt > SSF_{MSY}), for a given year (2032 – 2041) and a given fixed removals level (1,000s); Green Pr ≥ 70%, Yellow 70% > Pr ≥ 50%, Red Pr < 50%.

Panel E. Projection Scenario-5 (Sensitivity, Hierarchical Index)

Alternative levels	Fixed removals (1,000s)	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
1	0	0.98	0.99	0.99	0.99	0.99	0.99	0.99	1.00	1.00	1.00
2	50	0.95	0.95	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
3	100	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
4	150	0.91	0.91	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
5	200	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
6	250	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87
7	300	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.85
8	350	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.80
9	400	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73
10	450	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
11	500	0.59	0.59	0.59	0.59	0.59	0.58	0.58	0.58	0.58	0.58
12	550	0.52	0.52	0.52	0.51	0.51	0.51	0.50	0.50	0.50	0.50
13	600	0.44	0.43	0.43	0.42	0.42	0.41	0.41	0.41	0.41	0.40
14	650	0.37	0.37	0.36	0.36	0.35	0.35	0.35	0.34	0.34	0.34
15	700	0.29	0.29	0.28	0.27	0.27	0.26	0.26	0.26	0.25	0.25
16	750	0.23	0.23	0.22	0.21	0.21	0.21	0.20	0.20	0.20	0.19
17	800	0.18	0.17	0.17	0.16	0.16	0.16	0.15	0.15	0.15	0.14
18	850	0.13	0.13	0.12	0.12	0.12	0.11	0.11	0.11	0.10	0.10
19	900	0.09	0.09	0.09	0.08	0.08	0.08	0.08	0.07	0.07	0.07
20	950	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.04	0.04	0.04
21	1000	0.05	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03

Table 3.5.20 (continued). Probabilities from 10,000 Monte Carlo bootstrap projections that spawning stock fecundity (SSFt) will exceed the level of SSF that will produce MSY (SSF_{MSY}), Pr(SSFt > SSF_{MSY}), for a given year (2032 – 2041) and a given fixed removals level (1,000s); Green Pr ≥ 70%, Yellow 70% > Pr ≥ 50%, Red Pr < 50%.

Panel F. Projection Scenario-6 (Sensitivity, Model Start in 1972)

Alternative levels	Fixed removals (1,000s)	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
1	0	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99
2	50	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99
3	100	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99
4	150	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99
5	200	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99
6	250	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99
7	300	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99
8	350	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99
9	400	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99
10	450	>=0.99	>=0.99	>=0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00
11	500	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
12	550	0.99	0.99	0.98	0.98	0.98	0.98	0.97	0.97	0.97	0.97
13	600	0.93	0.91	0.90	0.89	0.88	0.87	0.86	0.85	0.84	0.84
14	650	0.75	0.72	0.70	0.67	0.65	0.63	0.61	0.59	0.58	0.56
15	700	0.46	0.42	0.39	0.36	0.34	0.32	0.29	0.28	0.26	0.24
16	750	0.18	0.16	0.14	0.12	0.11	0.10	0.09	0.08	0.07	0.07
17	800	0.05	0.04	0.03	0.03	0.02	0.02	0.01	0.01	0.01	0.01
18	850	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	900	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	950	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	1000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 3.5.20 (continued). Probabilities from 10,000 Monte Carlo bootstrap projections that spawning stock fecundity (SSFt) will exceed the level of SSF that will produce MSY (SSF_{MSY}), Pr(SSFt > SSF_{MSY}), for a given year (2032 – 2041) and a given fixed removals level (1,000s); Green Pr ≥ 70%, Yellow 70% > Pr ≥ 50%, Red Pr < 50%.

Panel G. Projection Scenario-7 (Sensitivity, High Productivity)

Alternative levels	Fixed removals (1,000s)	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
1	0	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99
2	50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3	100	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
4	150	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
5	200	1.00	1.00	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
6	250	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
7	300	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
8	350	0.97	0.98	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
9	400	0.96	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
10	450	0.92	0.92	0.92	0.91	0.91	0.91	0.91	0.91	0.91	0.91
11	500	0.86	0.85	0.85	0.85	0.84	0.84	0.84	0.84	0.83	0.83
12	550	0.77	0.77	0.76	0.76	0.75	0.75	0.74	0.74	0.74	0.73
13	600	0.65	0.64	0.63	0.63	0.62	0.61	0.61	0.60	0.60	0.59
14	650	0.54	0.53	0.52	0.51	0.50	0.49	0.49	0.48	0.48	0.47
15	700	0.40	0.39	0.38	0.37	0.36	0.35	0.34	0.34	0.33	0.33
16	750	0.29	0.28	0.27	0.26	0.25	0.24	0.23	0.23	0.22	0.21
17	800	0.19	0.19	0.18	0.17	0.16	0.15	0.15	0.14	0.14	0.14
18	850	0.12	0.11	0.10	0.10	0.09	0.09	0.08	0.08	0.07	0.07
19	900	0.06	0.06	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.03
20	950	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02
21	1000	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Table 3.5.20 (continued). Probabilities from 10,000 Monte Carlo bootstrap projections that spawning stock fecundity (SSFt) will exceed the level of SSF that will produce MSY (SSF_{MSY}), Pr(SSFt > SSF_{MSY}), for a given year (2032 – 2041) and a given fixed removals level (1,000s); Green Pr ≥ 70%, Yellow 70% > Pr ≥ 50%, Red Pr < 50%.

Panel H. Projection Scenario-8 (Sensitivity, Low Productivity)

Alternative levels	Fixed removals (1,000s)	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
1	0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	>=0.99	>=0.99
2	50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3	100	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
4	150	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	200	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	250	0.99	0.99	0.99	0.99	1.00	1.00	1.00	1.00	1.00	1.00
7	300	0.98	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
8	350	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
9	400	0.94	0.94	0.94	0.94	0.94	0.94	0.93	0.93	0.93	0.93
10	450	0.88	0.88	0.88	0.88	0.88	0.88	0.87	0.87	0.87	0.87
11	500	0.81	0.80	0.80	0.80	0.80	0.79	0.79	0.79	0.78	0.78
12	550	0.72	0.71	0.70	0.70	0.69	0.68	0.68	0.68	0.67	0.67
13	600	0.58	0.57	0.56	0.55	0.54	0.54	0.53	0.53	0.52	0.52
14	650	0.46	0.44	0.43	0.42	0.41	0.41	0.40	0.39	0.39	0.38
15	700	0.33	0.32	0.31	0.30	0.29	0.28	0.28	0.27	0.26	0.26
16	750	0.22	0.21	0.20	0.20	0.19	0.18	0.17	0.17	0.16	0.16
17	800	0.14	0.13	0.12	0.11	0.11	0.10	0.10	0.10	0.09	0.09
18	850	0.08	0.08	0.07	0.06	0.06	0.06	0.05	0.05	0.05	0.05
19	900	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.02	0.02
20	950	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01
21	1000	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00

Table 3.5.20 (continued). Probabilities from 10,000 Monte Carlo bootstrap projections that spawning stock fecundity (SSFt) will exceed the level of SSF that will produce MSY (SSF_{MSY}), Pr(SSFt > SSF_{MSY}), for a given year (2032 – 2041) and a given fixed removals level (1,000s); Green Pr ≥ 70%, Yellow 70% > Pr ≥ 50%, Red Pr < 50%.

Panel I. Projection Scenario-9 (Sensitivity, SEAMAP-SA)

Alternative levels	Fixed removals (1,000s)	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
1	0	0.95	0.96	0.96	0.96	0.96	0.96	0.97	0.97	0.97	0.97
2	50	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.93	0.93	0.93
3	100	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
4	150	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87
5	200	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
6	250	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81
7	300	0.78	0.79	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78
8	350	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74
9	400	0.71	0.71	0.71	0.71	0.70	0.70	0.70	0.70	0.70	0.70
10	450	0.67	0.67	0.67	0.67	0.66	0.66	0.66	0.66	0.66	0.66
11	500	0.62	0.62	0.62	0.61	0.61	0.61	0.61	0.61	0.60	0.60
12	550	0.58	0.57	0.57	0.57	0.56	0.56	0.56	0.56	0.55	0.55
13	600	0.52	0.52	0.51	0.51	0.51	0.50	0.50	0.50	0.50	0.49
14	650	0.48	0.48	0.47	0.47	0.46	0.46	0.46	0.46	0.45	0.45
15	700	0.43	0.43	0.42	0.42	0.41	0.41	0.41	0.41	0.40	0.40
16	750	0.39	0.38	0.38	0.38	0.37	0.37	0.36	0.36	0.36	0.36
17	800	0.35	0.34	0.34	0.33	0.33	0.32	0.32	0.32	0.31	0.31
18	850	0.30	0.29	0.28	0.28	0.27	0.27	0.27	0.26	0.26	0.26
19	900	0.26	0.26	0.25	0.25	0.24	0.24	0.23	0.23	0.23	0.23
20	950	0.22	0.21	0.21	0.21	0.20	0.20	0.19	0.19	0.19	0.18
21	1000	0.19	0.18	0.18	0.17	0.17	0.16	0.16	0.16	0.16	0.15

Table 3.5.20 (continued). Probabilities from 10,000 Monte Carlo bootstrap projections that spawning stock fecundity (SSFt) will exceed the level of SSF that will produce MSY (SSF_{MSY}), Pr(SSFt > SSF_{MSY}), for a given year (2032 – 2041) and a given fixed removals level (1,000s); Green Pr ≥ 70%, Yellow 70% > Pr ≥ 50%, Red Pr < 50%.

Panel J. Projection Scenario-10 (Sensitivity, Gulf of Mexico Biology)

Alternative levels	Fixed removals (1,000s)	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
1	0	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99	>=0.99
2	50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3	100	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
4	150	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	200	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	250	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	300	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
8	350	0.99	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
9	400	0.97	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
10	450	0.93	0.93	0.92	0.92	0.92	0.92	0.92	0.92	0.91	0.91
11	500	0.88	0.87	0.87	0.87	0.86	0.86	0.85	0.85	0.85	0.85
12	550	0.79	0.78	0.78	0.77	0.76	0.76	0.75	0.75	0.74	0.74
13	600	0.69	0.68	0.67	0.66	0.65	0.65	0.64	0.63	0.63	0.62
14	650	0.56	0.55	0.54	0.53	0.53	0.52	0.51	0.50	0.50	0.49
15	700	0.43	0.41	0.40	0.39	0.38	0.37	0.36	0.36	0.35	0.34
16	750	0.31	0.30	0.29	0.28	0.27	0.26	0.25	0.25	0.24	0.23
17	800	0.20	0.19	0.18	0.17	0.16	0.16	0.15	0.15	0.14	0.13
18	850	0.13	0.12	0.11	0.10	0.10	0.09	0.09	0.08	0.08	0.08
19	900	0.07	0.07	0.06	0.06	0.05	0.05	0.05	0.04	0.04	0.04
20	950	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02
21	1000	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Table 3.5.20 (continued). Probabilities from 10,000 Monte Carlo bootstrap projections that spawning stock fecundity (SSFt) will exceed the level of SSF that will produce MSY (SSF_{MSY}), Pr(SSFt > SSF_{MSY}), for a given year (2032 – 2041) and a given fixed removals level (1,000s); Green Pr ≥ 70%, Yellow 70% > Pr ≥ 50%, Red Pr < 50%.

Panel K. Projection Scenario-11 (Sensitivity, Atlantic Biology)

Alternative levels	Fixed removals (1,000s)	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
1	0	0.91	0.92	0.92	0.93	0.93	0.94	0.94	0.95	0.95	0.96
2	50	0.87	0.88	0.89	0.90	0.91	0.91	0.92	0.92	0.93	0.93
3	100	0.82	0.84	0.85	0.86	0.87	0.87	0.88	0.88	0.89	0.89
4	150	0.76	0.77	0.79	0.80	0.81	0.82	0.83	0.83	0.84	0.85
5	200	0.67	0.68	0.69	0.71	0.72	0.73	0.74	0.75	0.75	0.76
6	250	0.58	0.59	0.60	0.61	0.62	0.63	0.64	0.65	0.66	0.66
7	300	0.47	0.48	0.49	0.50	0.51	0.51	0.52	0.53	0.53	0.54
8	350	0.37	0.38	0.38	0.39	0.39	0.39	0.40	0.40	0.40	0.41
9	400	0.28	0.28	0.28	0.28	0.28	0.28	0.29	0.29	0.29	0.29
10	450	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
11	500	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.11
12	550	0.08	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.06
13	600	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03
14	650	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01
15	700	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
16	750	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	800	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	850	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	900	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	950	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	1000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 3.5.21. Probabilities from 10,000 Monte Carlo bootstrap projections that fishing mortality (F_t) will exceed the level of F that will produce MSY (F_{MSY}), Pr(Ft > F_{MSY}), for a given year (2032 – 2041) and a given fixed removals level (1,000s); Green Pr ≤ 30%, Yellow 30% > Pr ≤ 50%, Red Pr > 50%.

Panel A. Projection Scenario-1 (Baseline, Inverse CV Weighting)

Alternative levels	Fixed removals (1,000s)	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
1	0	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01
2	50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	150	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	250	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
7	300	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
8	350	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
9	400	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04
10	450	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08
11	500	0.14	0.14	0.14	0.15	0.15	0.15	0.15	0.15	0.16	0.16
12	550	0.25	0.26	0.26	0.26	0.27	0.27	0.27	0.28	0.28	0.28
13	600	0.42	0.43	0.43	0.44	0.44	0.45	0.45	0.45	0.45	0.46
14	650	0.59	0.59	0.60	0.60	0.61	0.61	0.61	0.62	0.62	0.62
15	700	0.74	0.75	0.75	0.75	0.76	0.76	0.76	0.77	0.77	0.77
16	750	0.86	0.87	0.87	0.87	0.88	0.88	0.88	0.88	0.88	0.88
17	800	0.94	0.94	0.94	0.94	0.94	0.95	0.95	0.95	0.95	0.95
18	850	0.97	0.97	0.97	0.97	0.97	0.97	0.98	0.98	0.98	0.98
19	900	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
20	950	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
21	1000	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 3.5.21 (continued). Probabilities from 10,000 Monte Carlo bootstrap projections that fishing mortality (F_t) will exceed the level of F that will produce MSY (F_{MSY}), Pr(Ft > F_{MSY}), for a given year (2032 – 2041) and a given fixed removals level (1,000s); Green Pr ≤ 30%, Yellow 30% > Pr ≤ 50%, Red Pr > 50%.

Panel B. Projection Scenario-2 (Sensitivity, Increasing Indices)

Alternative levels	Fixed removals (1,000s)	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
1	0	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01
2	50	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
3	100	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
4	150	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
5	200	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
6	250	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.08
7	300	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
8	350	0.13	0.13	0.13	0.13	0.13	0.13	0.14	0.14	0.14	0.14
9	400	0.18	0.18	0.18	0.18	0.19	0.19	0.19	0.19	0.19	0.19
10	450	0.23	0.23	0.24	0.24	0.24	0.24	0.25	0.25	0.25	0.25
11	500	0.30	0.30	0.30	0.31	0.31	0.31	0.32	0.32	0.32	0.32
12	550	0.37	0.37	0.38	0.38	0.38	0.39	0.39	0.39	0.39	0.39
13	600	0.46	0.46	0.47	0.47	0.47	0.47	0.48	0.48	0.48	0.48
14	650	0.54	0.55	0.55	0.55	0.56	0.56	0.56	0.56	0.56	0.57
15	700	0.63	0.63	0.63	0.63	0.64	0.64	0.64	0.64	0.65	0.65
16	750	0.70	0.70	0.71	0.71	0.71	0.71	0.71	0.71	0.72	0.72
17	800	0.77	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.79	0.79
18	850	0.83	0.83	0.83	0.84	0.84	0.84	0.84	0.84	0.84	0.84
19	900	0.88	0.88	0.88	0.88	0.88	0.88	0.89	0.89	0.89	0.89
20	950	0.91	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
21	1000	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95

Table 3.5.21 (continued). Probabilities from 10,000 Monte Carlo bootstrap projections that fishing mortality (F_t) will exceed the level of F that will produce MSY (F_{MSY}), Pr(Ft > F_{MSY}), for a given year (2032 – 2041) and a given fixed removals level (1,000s); Green Pr ≤ 30%, Yellow 30% > Pr ≤ 50%, Red Pr > 50%.

Panel C. Projection Scenario-3 (Sensitivity, Decreasing Indices)

Alternative levels	Fixed removals (1,000s)	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
1	0	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01
2	50	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
3	100	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
4	150	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
5	200	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
6	250	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
7	300	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
8	350	0.28	0.28	0.28	0.27	0.27	0.27	0.27	0.27	0.27	0.27
9	400	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.35	0.35	0.35
10	450	0.48	0.48	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47
11	500	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62
12	550	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.74	0.74
13	600	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87
14	650	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
15	700	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
16	750	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
17	800	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
18	850	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
19	900	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
20	950	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
21	1000	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 3.5.21 (continued). Probabilities from 10,000 Monte Carlo bootstrap projections that fishing mortality (F_t) will exceed the level of F that will produce MSY (F_{MSY}), Pr(Ft > F_{MSY}), for a given year (2032 – 2041) and a given fixed removals level (1,000s); Green Pr ≤ 30%, Yellow 30% > Pr ≤ 50%, Red Pr > 50%.

Panel D. Projection Scenario-4 (Sensitivity, Low Catch)

Alternative levels	Fixed removals (1,000s)	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
1	0	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01
2	50	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
3	100	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.01	0.01
4	150	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
5	200	0.10	0.10	0.10	0.10	0.10	0.11	0.11	0.11	0.11	0.11
6	250	0.30	0.30	0.30	0.31	0.31	0.31	0.31	0.31	0.31	0.32
7	300	0.61	0.61	0.62	0.62	0.62	0.63	0.63	0.63	0.63	0.63
8	350	0.87	0.87	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
9	400	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
10	450	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
11	500	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
12	550	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
13	600	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
14	650	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
15	700	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
16	750	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
17	800	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
18	850	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
19	900	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
20	950	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
21	1000	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 3.5.21 (continued). Probabilities from 10,000 Monte Carlo bootstrap projections that fishing mortality (F_t) will exceed the level of F that will produce MSY (F_{MSY}), Pr(Ft > F_{MSY}), for a given year (2032 – 2041) and a given fixed removals level (1,000s); Green Pr ≤ 30%, Yellow 30% > Pr ≤ 50%, Red Pr > 50%.

Panel E. Projection Scenario-5 (Sensitivity, Hierarchical Index)

Alternative levels	Fixed removals (1,000s)	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
1	0	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01
2	50	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
3	100	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
4	150	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
5	200	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
6	250	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
7	300	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
8	350	0.15	0.15	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
9	400	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
10	450	0.29	0.29	0.29	0.29	0.30	0.30	0.30	0.30	0.30	0.30
11	500	0.39	0.39	0.39	0.40	0.40	0.40	0.40	0.41	0.41	0.41
12	550	0.49	0.50	0.50	0.50	0.50	0.50	0.51	0.51	0.51	0.51
13	600	0.61	0.61	0.62	0.62	0.62	0.62	0.62	0.63	0.63	0.63
14	650	0.70	0.70	0.70	0.71	0.71	0.71	0.71	0.71	0.71	0.71
15	700	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.82
16	750	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87
17	800	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.93	0.93
18	850	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
19	900	0.98	0.97	0.97	0.98	0.98	0.98	0.98	0.98	0.98	0.98
20	950	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
21	1000	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99

Table 3.5.21 (continued). Probabilities from 10,000 Monte Carlo bootstrap projections that fishing mortality (F_t) will exceed the level of F that will produce MSY (F_{MSY}), Pr(Ft > F_{MSY}), for a given year (2032 – 2041) and a given fixed removals level (1,000s); Green Pr ≤ 30%, Yellow 30% > Pr ≤ 50%, Red Pr > 50%.

Panel F. Projection Scenario-6 (Sensitivity, Model Start in 1972)

Alternative levels	Fixed removals (1,000s)	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
1	0	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01
2	50	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01
3	100	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01
4	150	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01
5	200	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01
6	250	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01
7	300	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01
8	350	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01
9	400	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01
10	450	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01
11	500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	550	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.03
13	600	0.13	0.14	0.15	0.16	0.17	0.18	0.19	0.20	0.21	0.21
14	650	0.51	0.53	0.55	0.56	0.57	0.59	0.60	0.61	0.62	0.62
15	700	0.88	0.89	0.90	0.91	0.91	0.92	0.92	0.92	0.93	0.93
16	750	0.99	0.99	0.99	0.99	0.99	0.99	1.00	1.00	1.00	1.00
17	800	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
18	850	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
19	900	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
20	950	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
21	1000	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 3.5.21 (continued). Probabilities from 10,000 Monte Carlo bootstrap projections that fishing mortality (F_t) will exceed the level of F that will produce MSY (F_{MSY}), Pr(Ft > F_{MSY}), for a given year (2032 – 2041) and a given fixed removals level (1,000s); Green Pr ≤ 30%, Yellow 30% > Pr ≤ 50%, Red Pr > 50%.

Panel G. Projection Scenario-7 (Sensitivity, High Productivity)

Alternative levels	Fixed removals (1,000s)	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
1	0	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01
2	50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	150	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
5	200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	250	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
7	300	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
8	350	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
9	400	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03
10	450	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
11	500	0.12	0.12	0.12	0.13	0.13	0.13	0.13	0.14	0.14	0.14
12	550	0.22	0.23	0.24	0.24	0.24	0.24	0.25	0.25	0.25	0.26
13	600	0.39	0.40	0.40	0.41	0.41	0.42	0.42	0.43	0.43	0.43
14	650	0.56	0.56	0.57	0.57	0.58	0.58	0.59	0.59	0.59	0.60
15	700	0.73	0.73	0.74	0.74	0.75	0.75	0.75	0.76	0.76	0.76
16	750	0.86	0.86	0.86	0.86	0.87	0.87	0.87	0.87	0.88	0.88
17	800	0.93	0.93	0.93	0.94	0.94	0.94	0.94	0.94	0.94	0.94
18	850	0.97	0.97	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
19	900	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
20	950	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
21	1000	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 3.5.21 (continued). Probabilities from 10,000 Monte Carlo bootstrap projections that fishing mortality (F_t) will exceed the level of F that will produce MSY (F_{MSY}), Pr(Ft > F_{MSY}), for a given year (2032 – 2041) and a given fixed removals level (1,000s); Green Pr ≤ 30%, Yellow 30% > Pr ≤ 50%, Red Pr > 50%.

Panel H. Projection Scenario-8 (Sensitivity, Low Productivity)

Alternative levels	Fixed removals (1,000s)	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
1	0	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01
2	50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	150	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	250	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	300	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	350	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
9	400	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
10	450	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09
11	500	0.17	0.17	0.18	0.18	0.18	0.19	0.19	0.19	0.19	0.20
12	550	0.31	0.31	0.32	0.32	0.33	0.33	0.34	0.34	0.34	0.34
13	600	0.51	0.51	0.52	0.52	0.53	0.53	0.53	0.54	0.54	0.54
14	650	0.68	0.69	0.69	0.70	0.70	0.71	0.71	0.71	0.71	0.71
15	700	0.84	0.84	0.84	0.85	0.85	0.85	0.85	0.85	0.85	0.86
16	750	0.93	0.93	0.93	0.93	0.93	0.93	0.94	0.94	0.94	0.94
17	800	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.98	0.98	0.98
18	850	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
19	900	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
20	950	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
21	1000	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 3.5.21 (continued). Probabilities from 10,000 Monte Carlo bootstrap projections that fishing mortality (F_t) will exceed the level of F that will produce MSY (F_{MSY}), Pr(Ft > F_{MSY}), for a given year (2032 – 2041) and a given fixed removals level (1,000s); Green Pr ≤ 30%, Yellow 30% > Pr ≤ 50%, Red Pr > 50%.

Panel I. Projection Scenario-9 (Sensitivity, SEAMAP-SA)

Alternative levels	Fixed removals (1,000s)	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
1	0	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01
2	50	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
3	100	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
4	150	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09
5	200	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.11	0.11
6	250	0.13	0.13	0.13	0.13	0.13	0.14	0.14	0.14	0.14	0.14
7	300	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.17	0.17	0.17
8	350	0.20	0.20	0.20	0.21	0.21	0.21	0.21	0.21	0.21	0.21
9	400	0.24	0.24	0.25	0.25	0.25	0.25	0.25	0.26	0.26	0.26
10	450	0.29	0.29	0.30	0.30	0.30	0.30	0.31	0.31	0.31	0.31
11	500	0.36	0.37	0.37	0.37	0.37	0.37	0.37	0.38	0.38	0.38
12	550	0.42	0.43	0.43	0.43	0.43	0.44	0.44	0.44	0.44	0.44
13	600	0.50	0.50	0.50	0.50	0.51	0.51	0.51	0.51	0.52	0.52
14	650	0.56	0.56	0.56	0.57	0.57	0.57	0.57	0.57	0.58	0.58
15	700	0.62	0.63	0.63	0.63	0.63	0.63	0.64	0.64	0.64	0.64
16	750	0.68	0.69	0.69	0.69	0.69	0.69	0.70	0.70	0.70	0.70
17	800	0.74	0.75	0.75	0.75	0.75	0.75	0.76	0.76	0.76	0.76
18	850	0.80	0.80	0.80	0.81	0.81	0.81	0.81	0.81	0.81	0.81
19	900	0.84	0.84	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
20	950	0.88	0.88	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
21	1000	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91

Table 3.5.21 (continued). Probabilities from 10,000 Monte Carlo bootstrap projections that fishing mortality (F_t) will exceed the level of F that will produce MSY (F_{MSY}), Pr(Ft > F_{MSY}), for a given year (2032 – 2041) and a given fixed removals level (1,000s); Green Pr ≤ 30%, Yellow 30% > Pr ≤ 50%, Red Pr > 50%.

Panel J. Projection Scenario-10 (Sensitivity, Gulf of Mexico Biology)

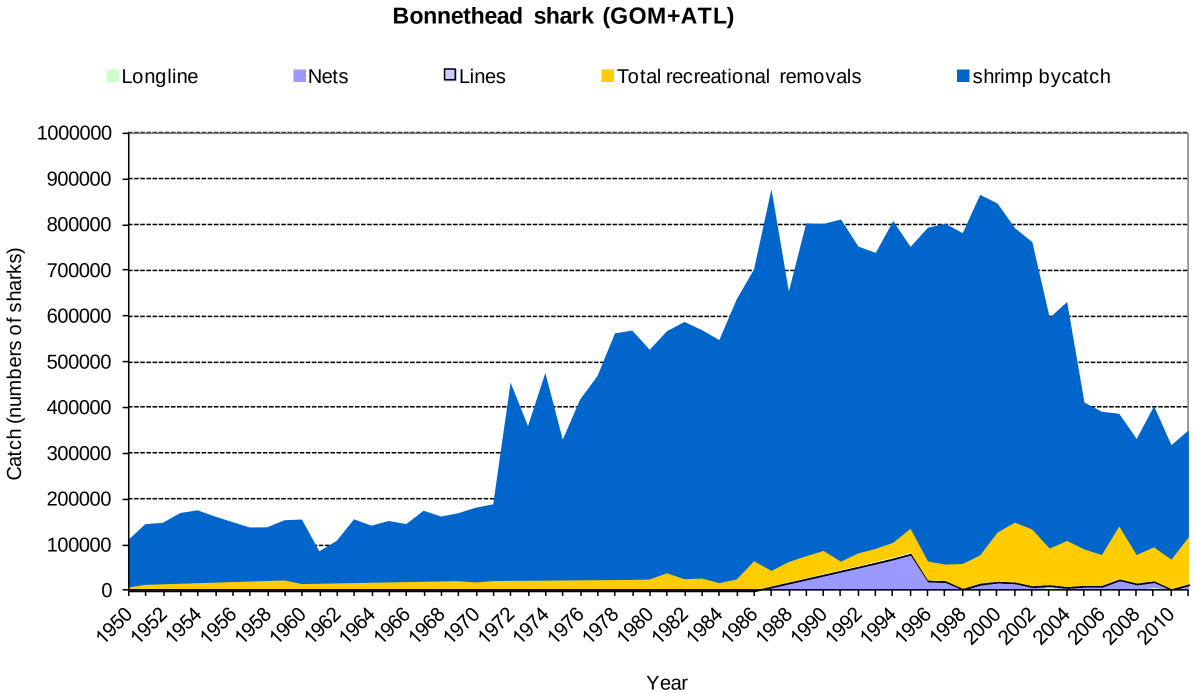
Alternative levels	Fixed removals (1,000s)	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
1	0	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01
2	50	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01
3	100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	150	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	250	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	300	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	350	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01
9	400	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
10	450	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06
11	500	0.10	0.10	0.10	0.11	0.11	0.11	0.11	0.12	0.12	0.12
12	550	0.21	0.22	0.22	0.23	0.23	0.24	0.24	0.25	0.25	0.25
13	600	0.36	0.37	0.37	0.38	0.38	0.39	0.39	0.40	0.40	0.41
14	650	0.53	0.54	0.54	0.55	0.56	0.57	0.57	0.58	0.58	0.58
15	700	0.71	0.72	0.72	0.73	0.74	0.74	0.74	0.75	0.75	0.75
16	750	0.84	0.84	0.85	0.85	0.85	0.86	0.86	0.86	0.86	0.87
17	800	0.93	0.93	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
18	850	0.97	0.97	0.97	0.98	0.98	0.98	0.98	0.98	0.98	0.98
19	900	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
20	950	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
21	1000	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 3.5.21 (continued). Probabilities from 10,000 Monte Carlo bootstrap projections that fishing mortality (F_t) will exceed the level of F that will produce MSY (F_{MSY}), Pr(Ft > F_{MSY}), for a given year (2032 – 2041) and a given fixed removals level (1,000s); Green Pr ≤ 30%, Yellow 30% > Pr ≤ 50%, Red Pr > 50%.

Panel K. Projection Scenario-11 (Sensitivity, Atlantic Biology)

Alternative levels	Fixed removals (1,000s)	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
1	0	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01	<=0.01
2	50	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
3	100	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
4	150	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
5	200	0.14	0.14	0.14	0.14	0.13	0.13	0.13	0.13	0.13	0.13
6	250	0.23	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.21
7	300	0.37	0.37	0.37	0.36	0.36	0.36	0.36	0.36	0.35	0.35
8	350	0.55	0.54	0.54	0.54	0.54	0.54	0.54	0.53	0.53	0.53
9	400	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.71	0.71	0.71
10	450	0.87	0.87	0.87	0.86	0.86	0.86	0.86	0.86	0.86	0.85
11	500	0.95	0.95	0.95	0.95	0.94	0.94	0.94	0.94	0.94	0.94
12	550	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
13	600	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.99
14	650	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
15	700	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
16	750	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
17	800	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
18	850	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
19	900	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
20	950	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
21	1000	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

3.6. FIGURES



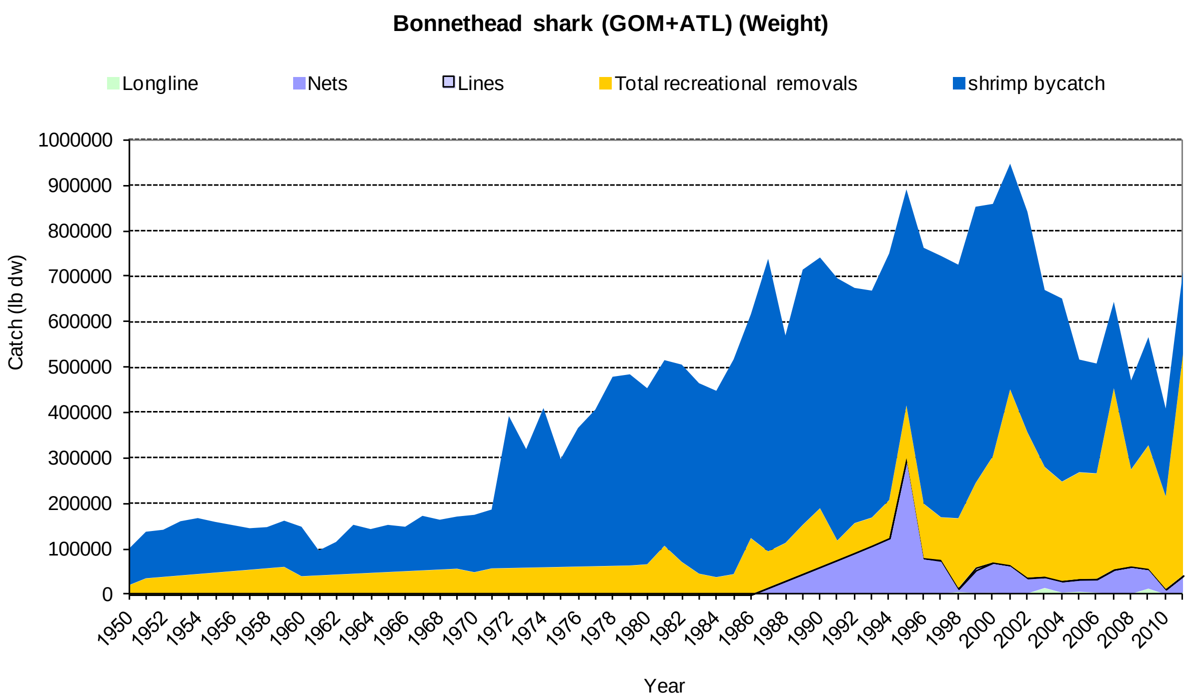


Figure 3.6.1. Catches of bonnethead shark by fleet in numbers (top) and weight (lb dw; bottom). Catches are separated into five fleets: commercial bottom longline, gillnet, and line, recreational, and shrimp trawl discards.

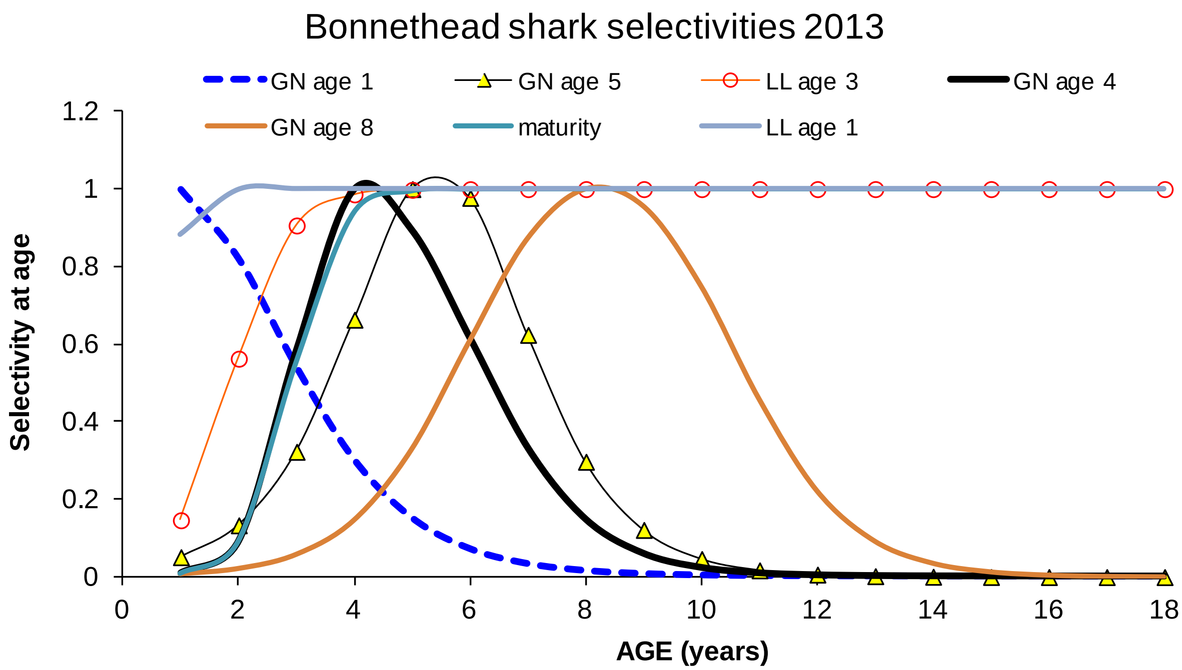
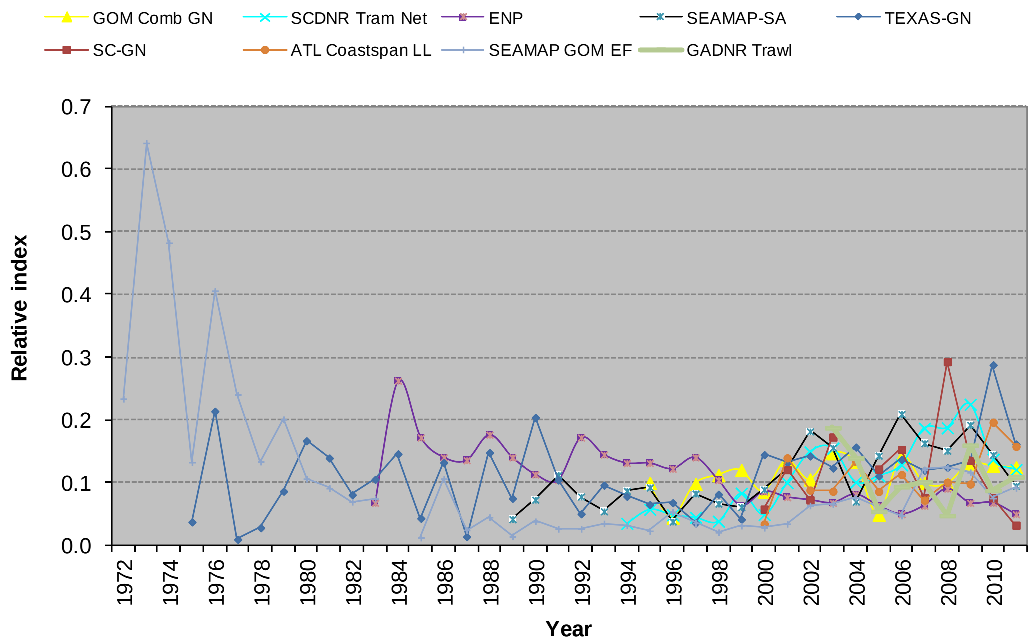


Figure 3.6.2. Selectivity curves for catches and indices of relative abundance used in the baseline run. The maturity ogive has been added for reference. Refer to Table 3.5.2 to see what catch or index of relative abundance series each selectivity curve corresponds to.



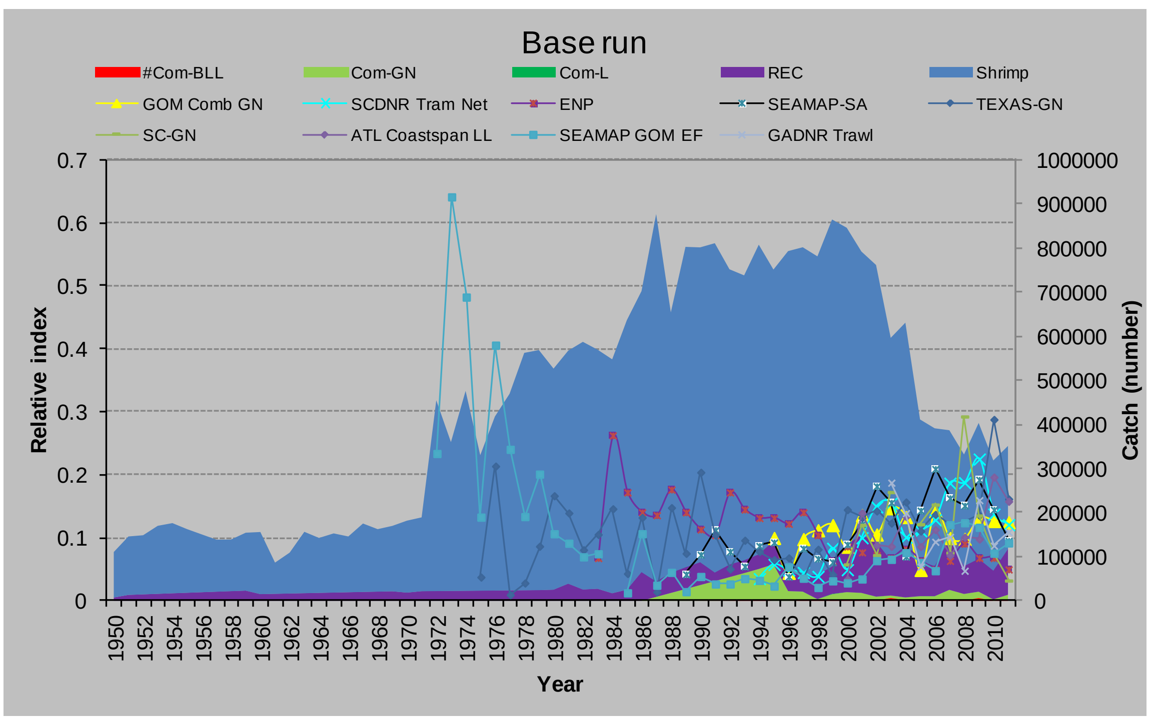


Figure 3.6.3. Indices of relative abundance used for the baseline scenario (top panel). All indices are statistically standardized and scaled (divided by their respective mean and a global mean for overlapping years for plotting purposes). Same indices superimposed on catches (bottom panel).

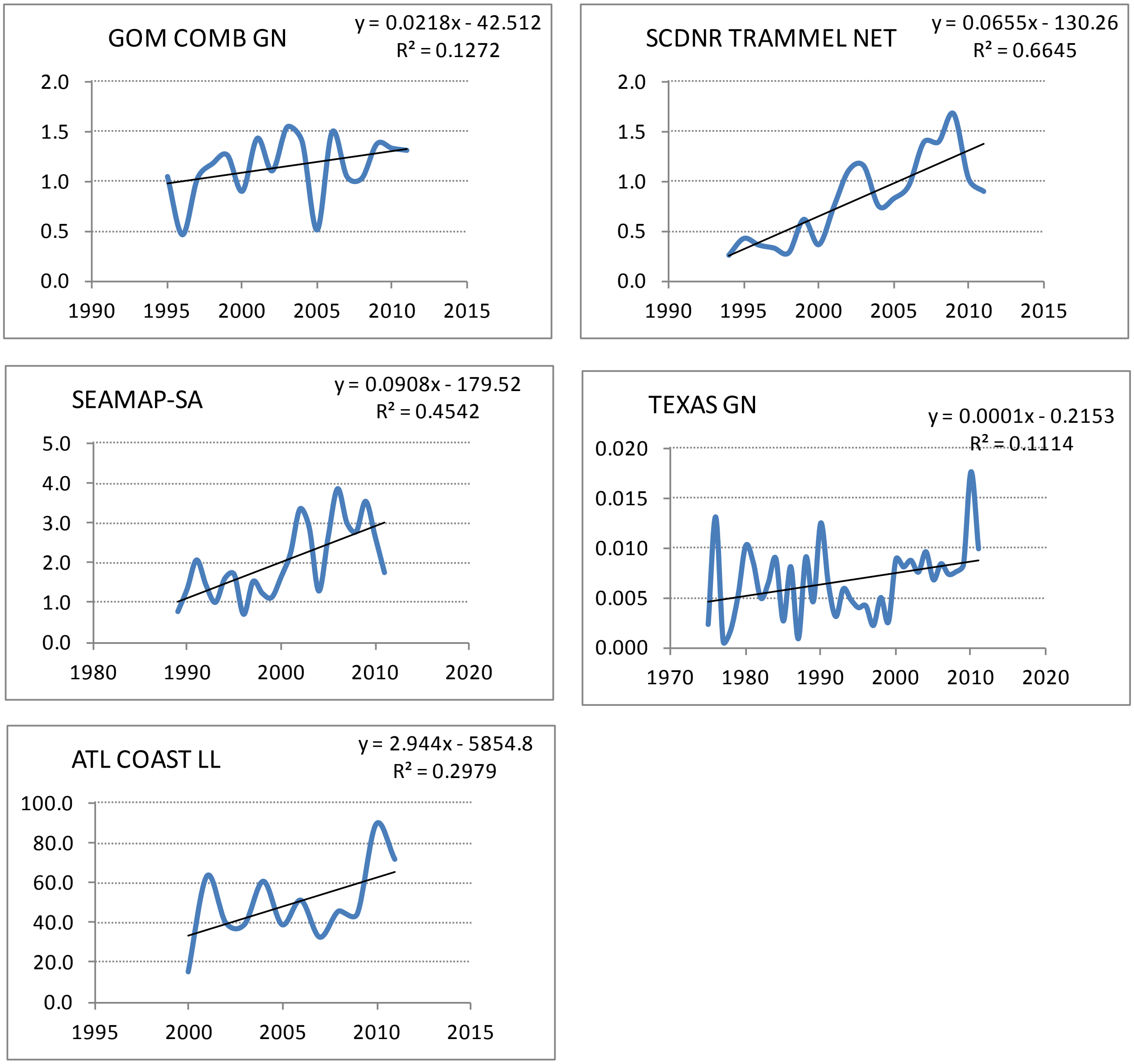


Figure 3.6.4. Indices of relative abundance used for the "increasing indices" scenario. These five indices showed an increasing trend.

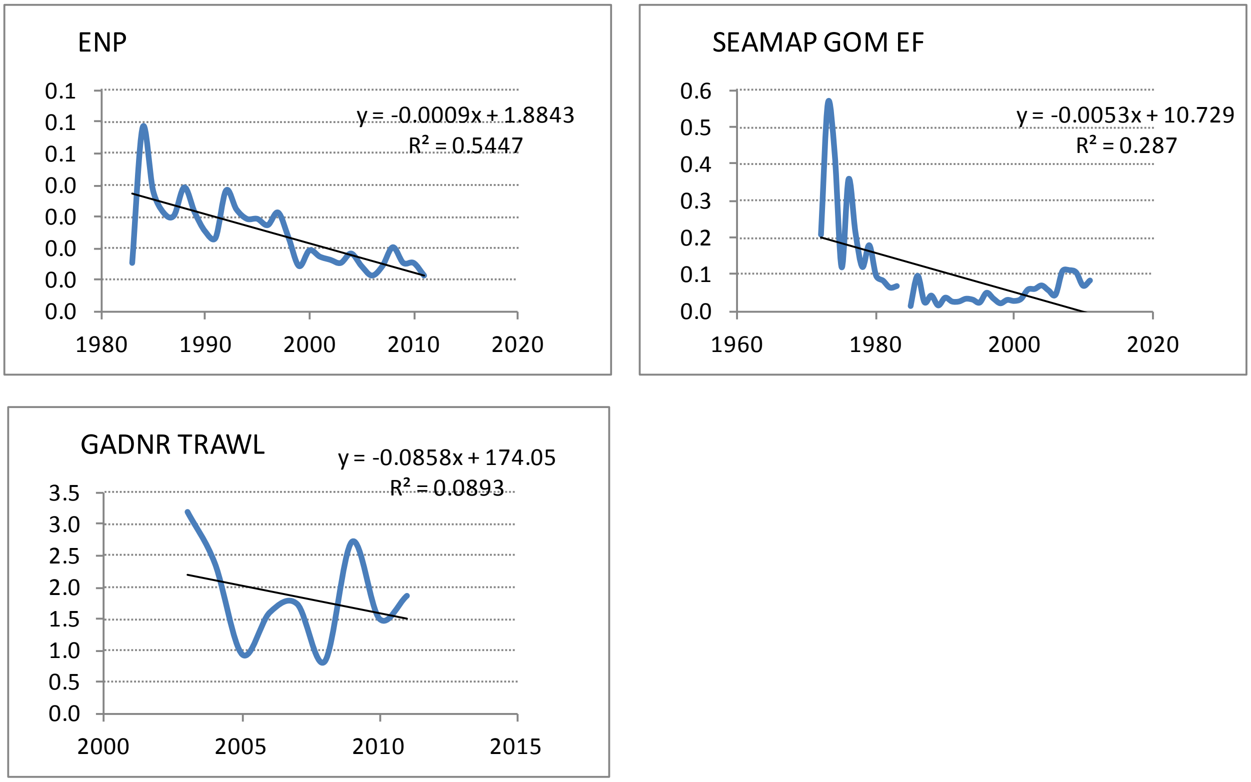


Figure 3.6.5. Indices of relative abundance used for the “decreasing indices” scenario. These three indices showed a decreasing trend.

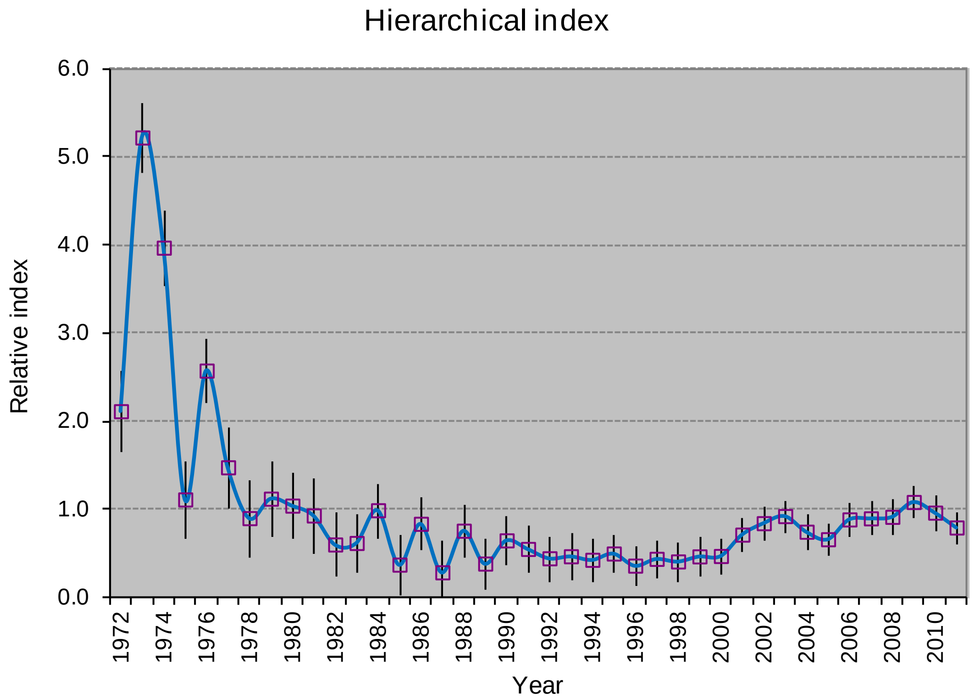


Figure 3.6.6. Hierarchical index of relative abundance used in sensitivity analyses. The index is scaled (divided by its mean). Vertical bars are ± 1 CV.

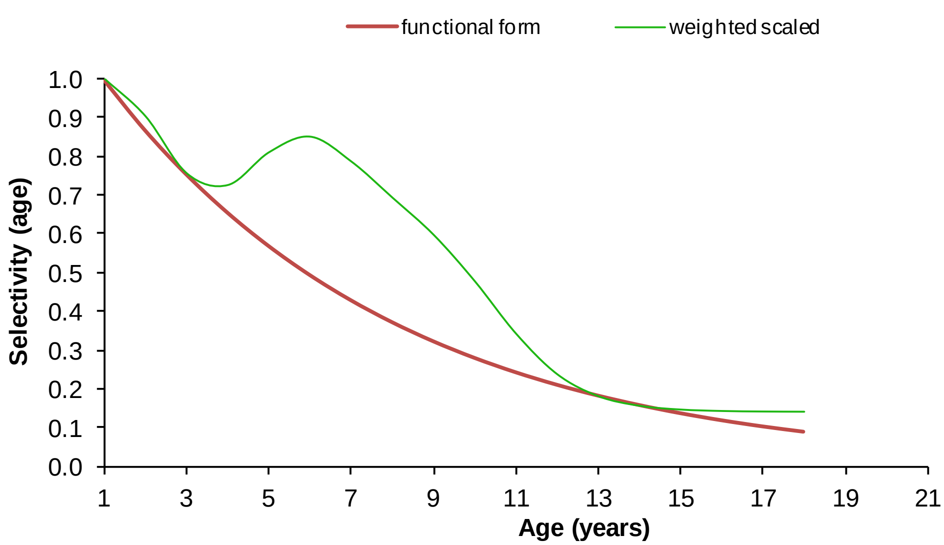


Figure 3.6.7. Selectivities for the hierarchical index. "Weighted scaled" is the selectivity obtained by weighting the base run selectivities by the inverse variance weights and scaled to the maximum value; "functional form" is the double exponential approximation of the weighted selectivity for input into the "hierarchical index" sensitivity run.

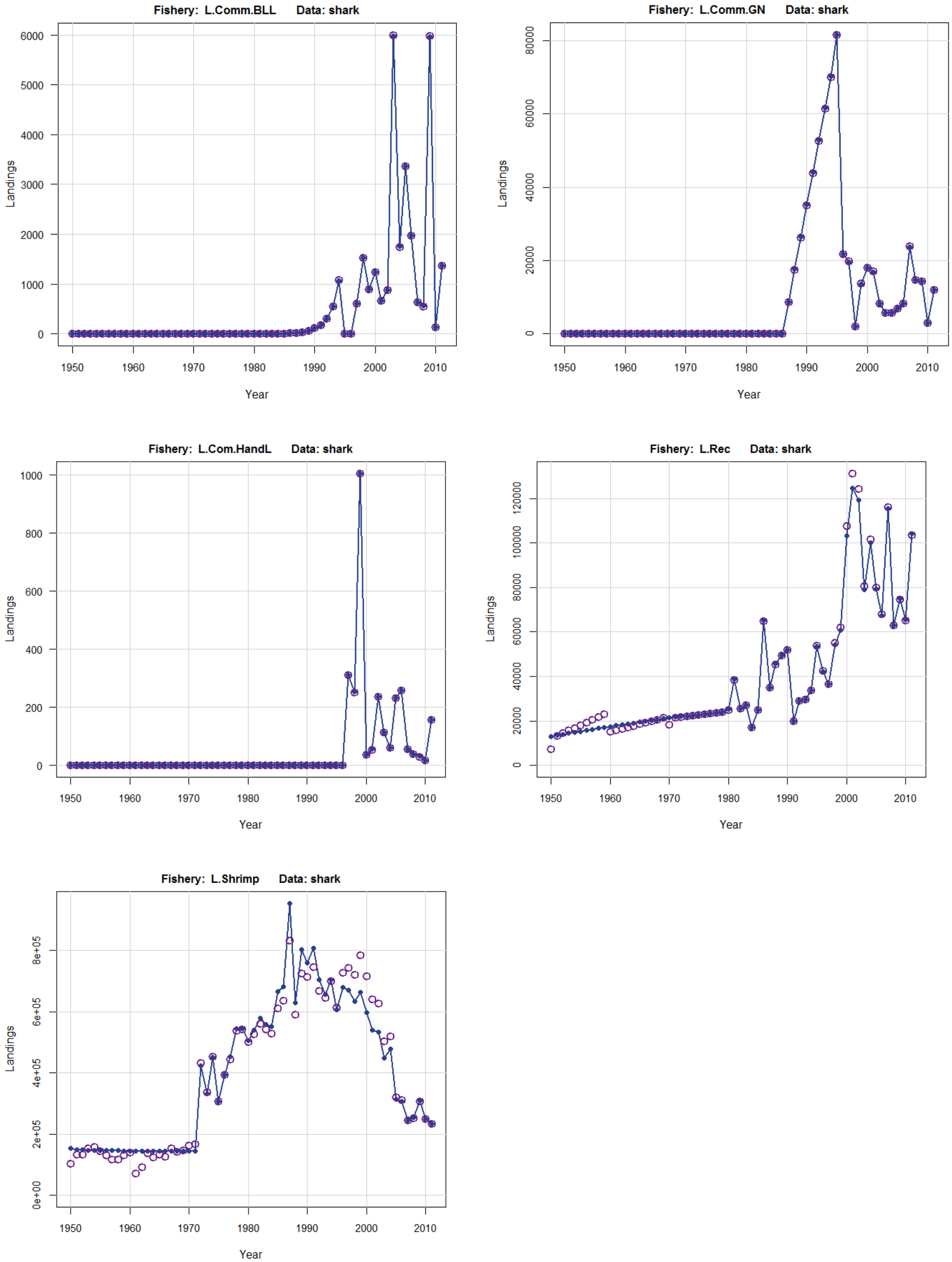


Figure 3.6.8. Predicted fits to the 5 catch data streams for the base run (inverse CV weights).

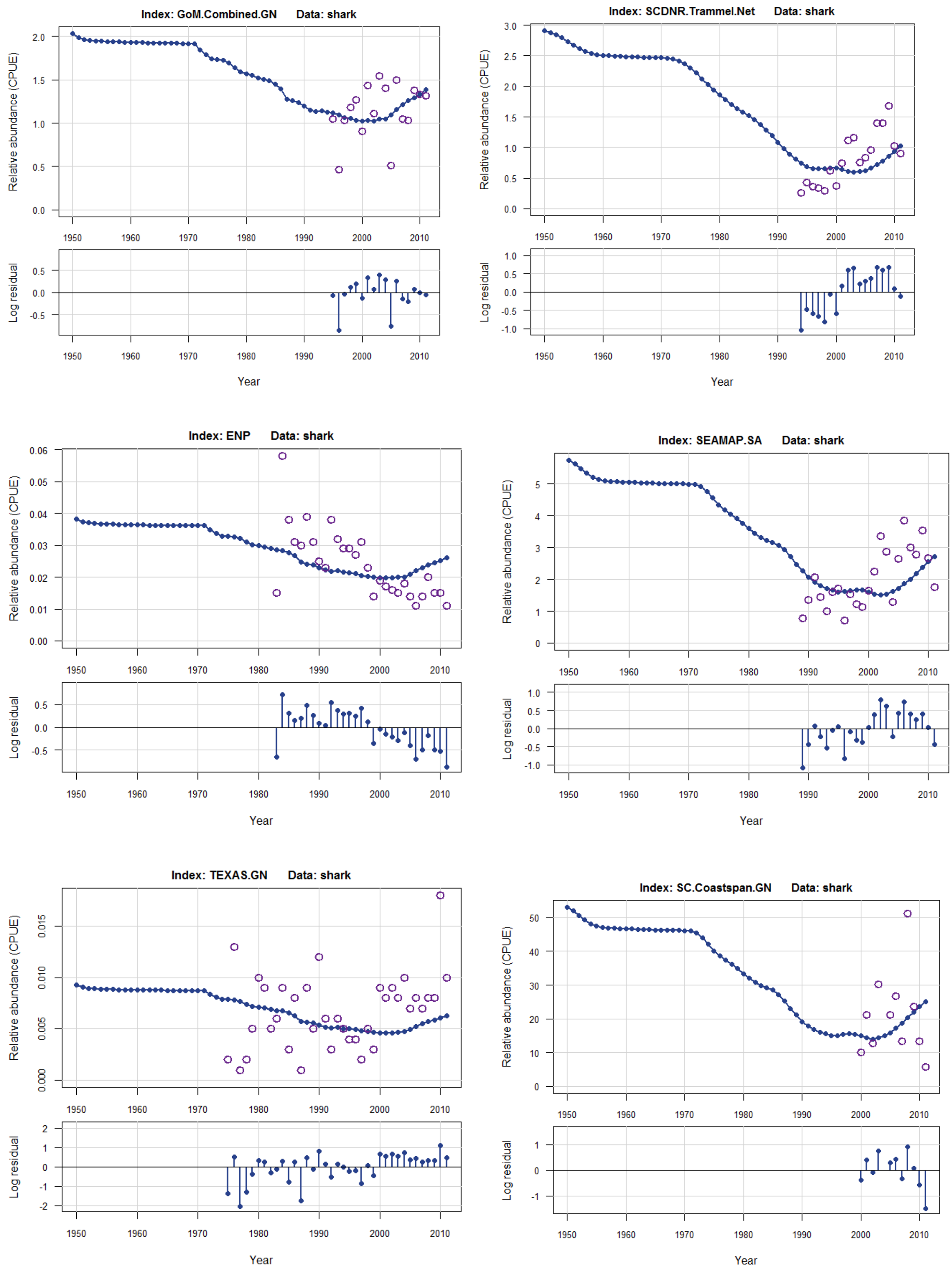


Figure 3.6.9. Predicted fits to indices and residual plots for the base run (inverse CV weights).

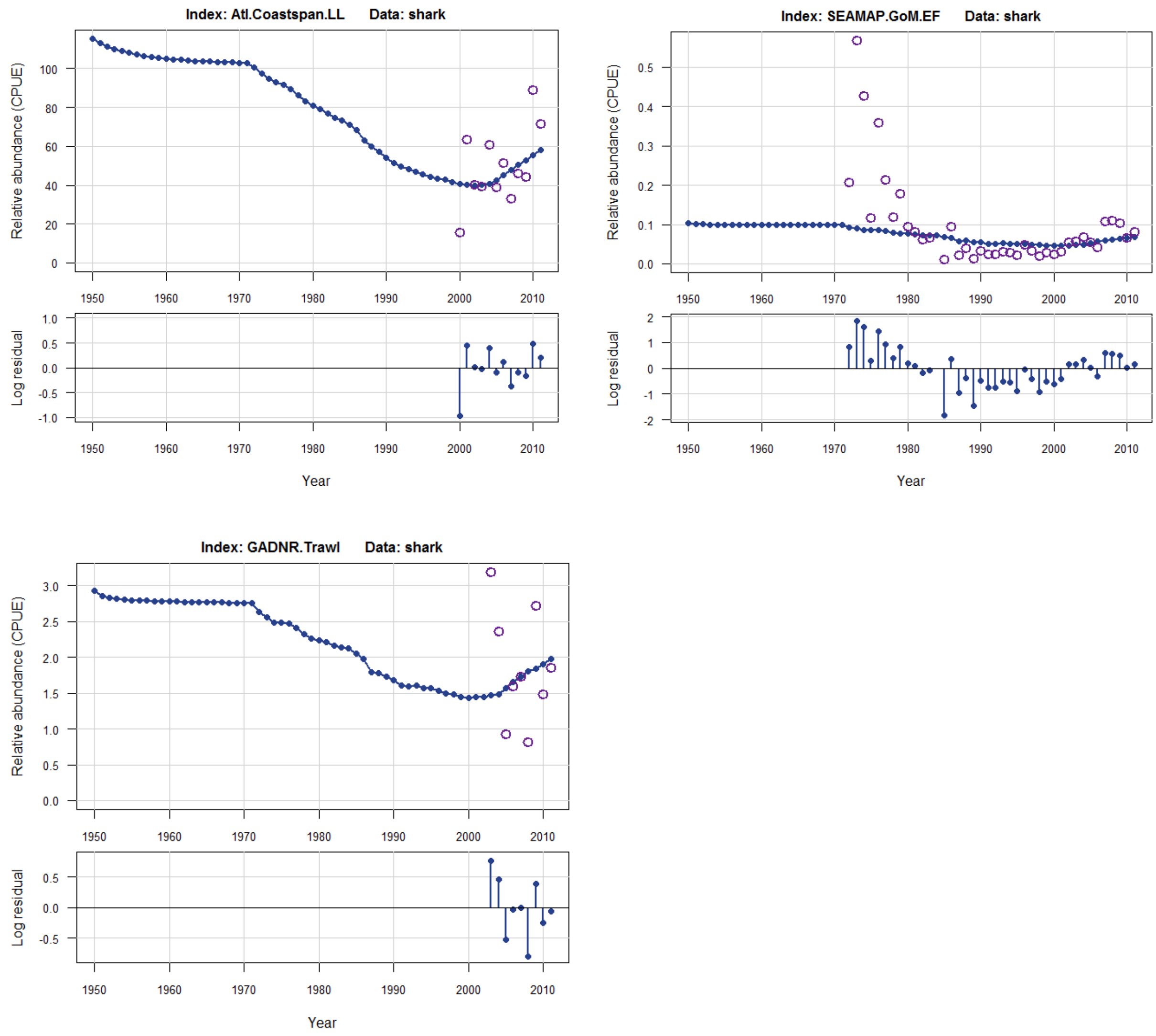


Figure 3.6.9 (continued). Predicted fits to indices and residual plots for the base run (inverse CV weights).

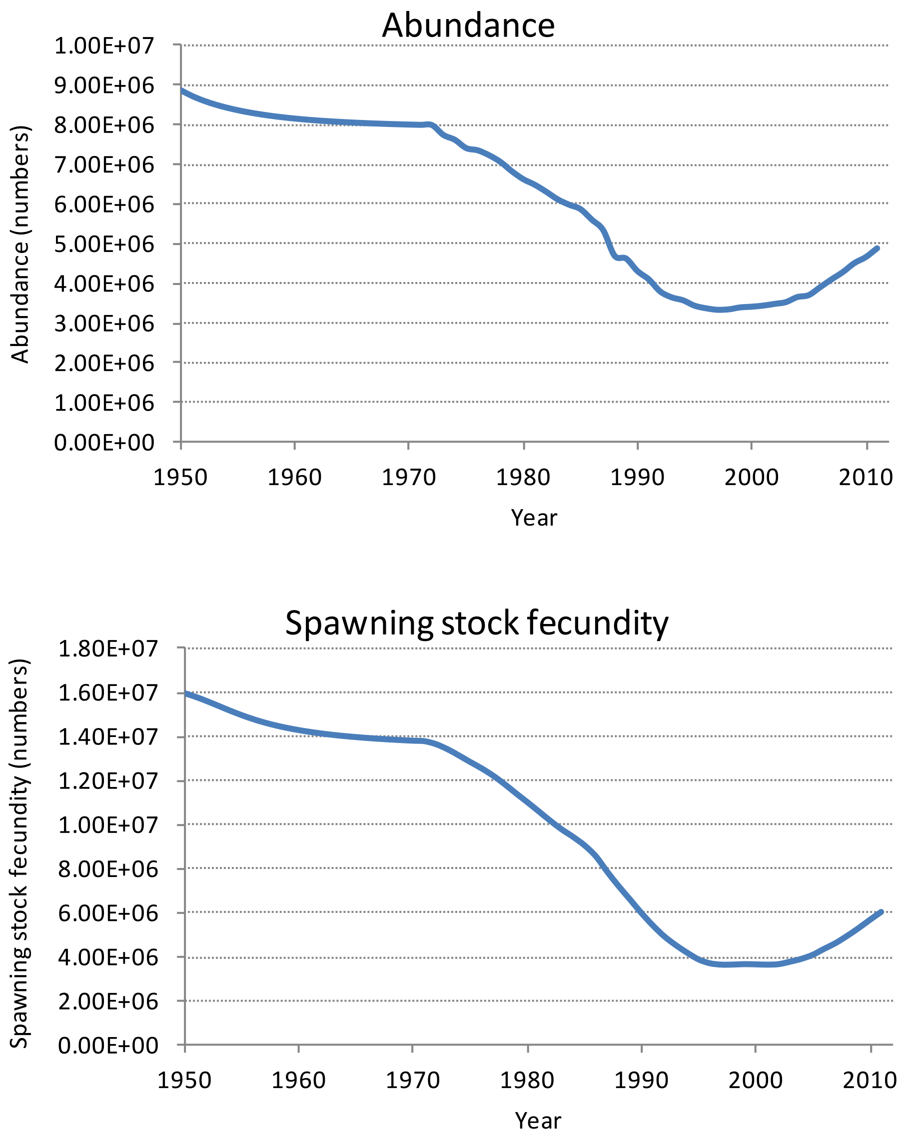


Figure 3.6.10. Predicted abundance and spawning stock fecundity trajectories for bonnethead shark.

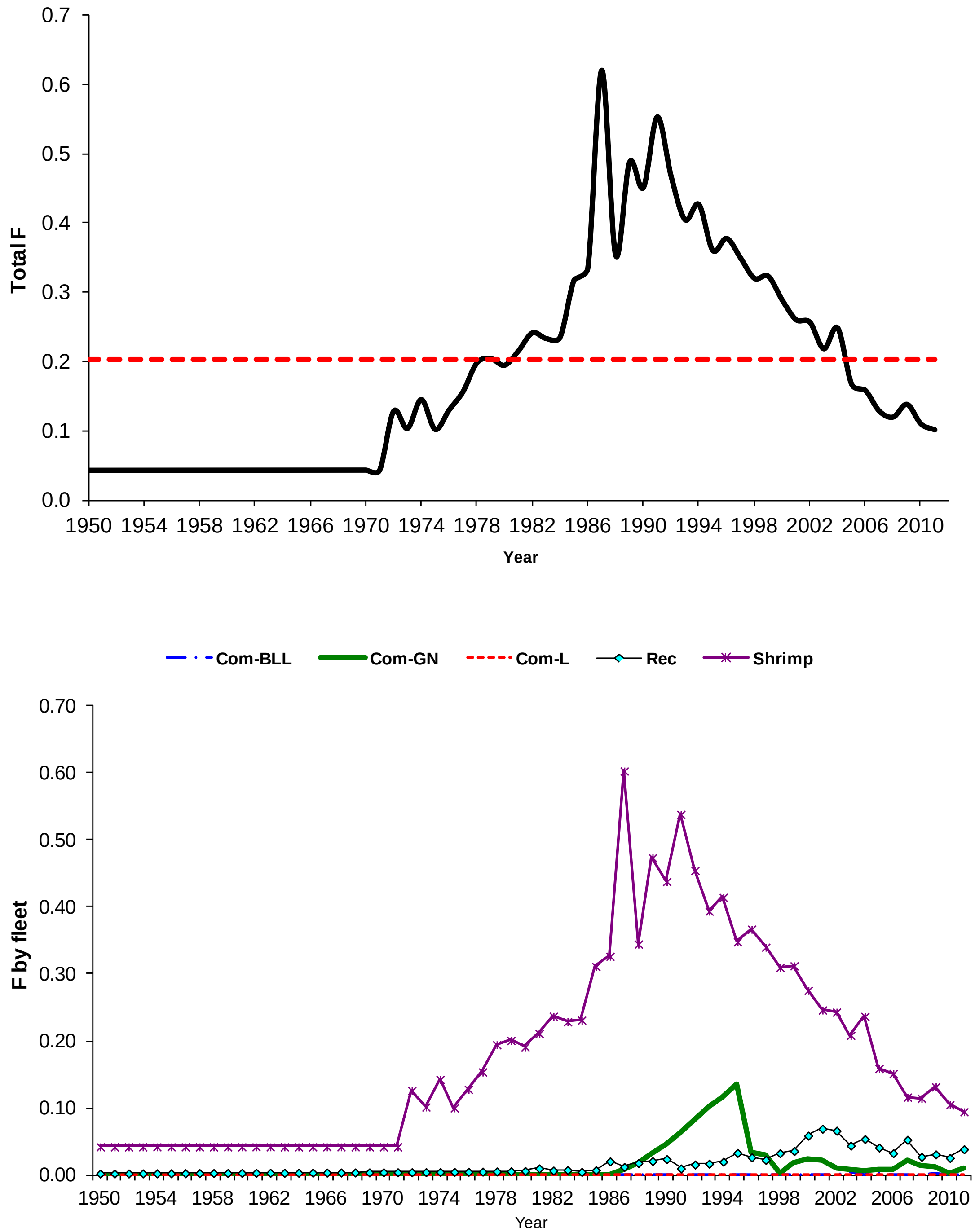
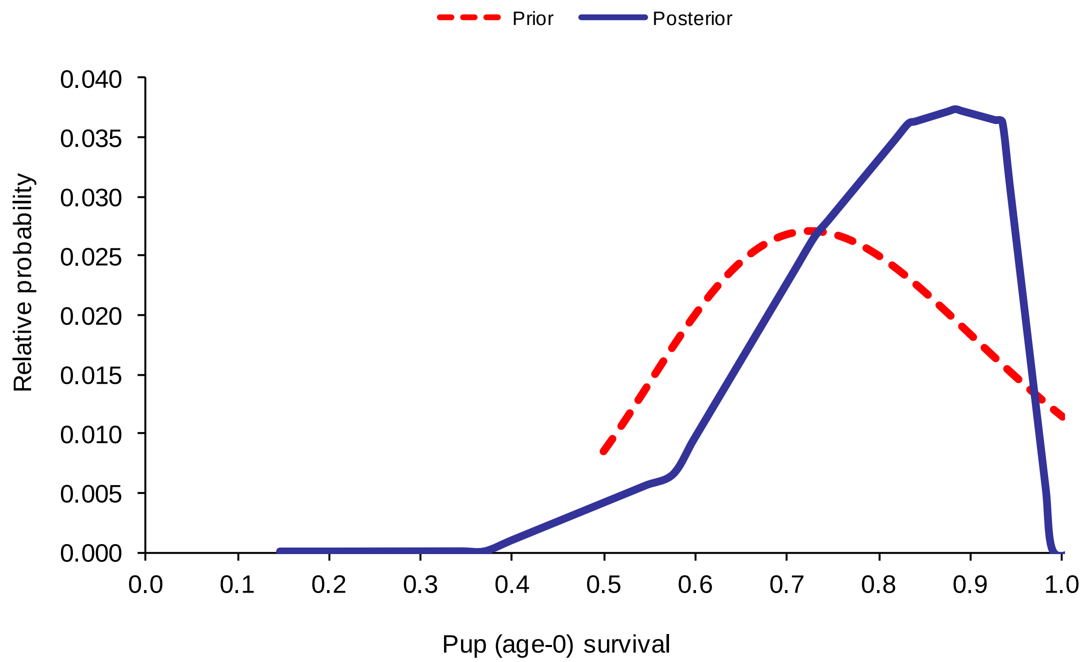


Figure 3.6.11. Estimated total fishing mortality (top) and fleet-specific F (bottom) for bonnethead shark. The dashed line in the top panel indicates F_{MSY} (0.202).



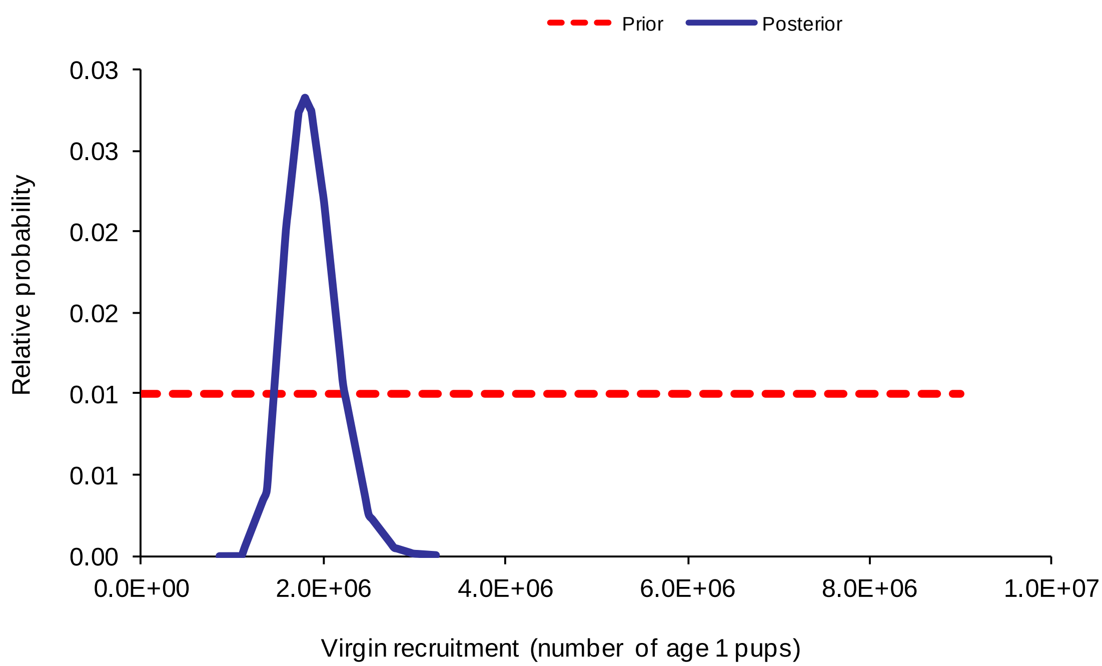


Figure 3.6.12. Prior and posterior distributions for pup survival and virgin recruitment. The prior for R_0 ranged from 10^3 to 10^{10} (not shown here for plotting purposes).

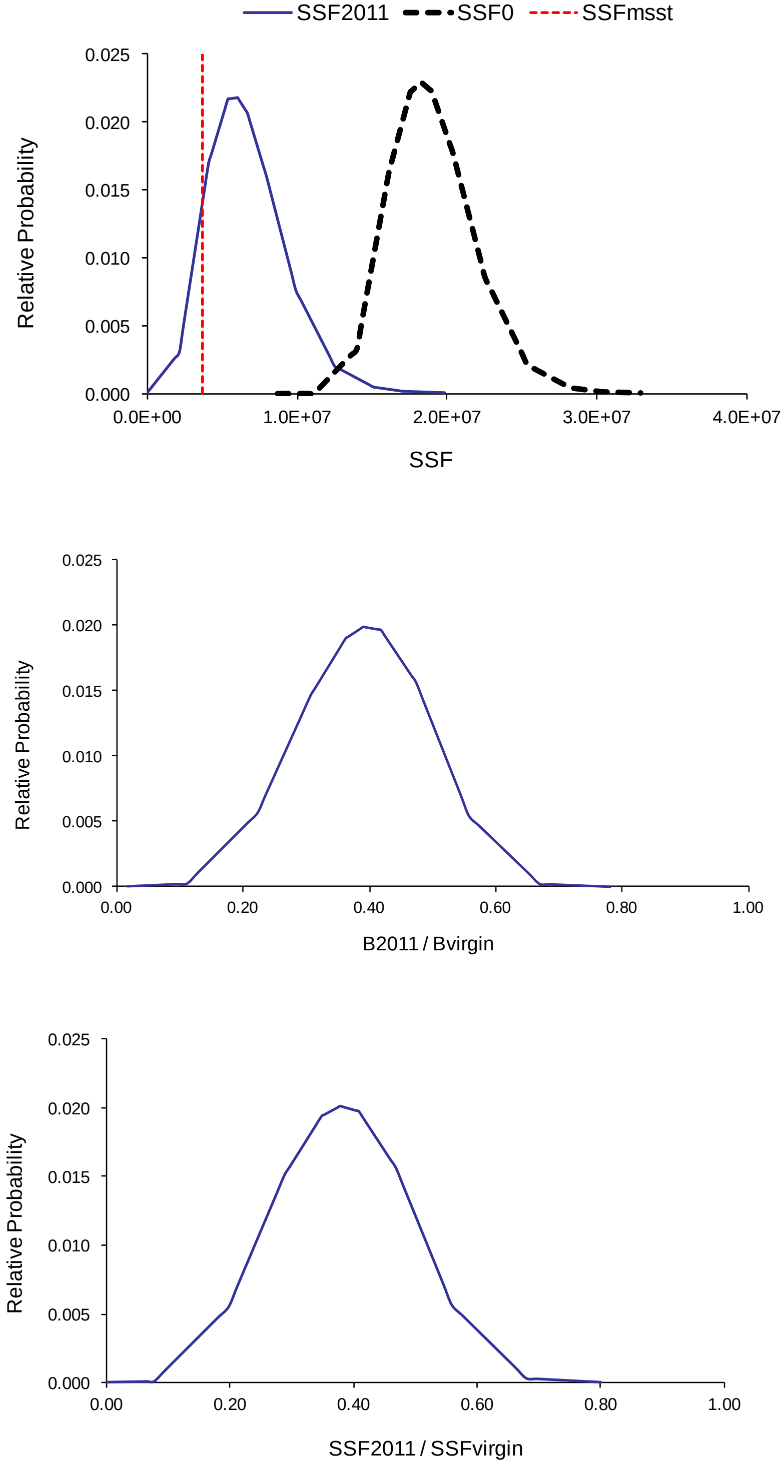


Figure 3.6.13. Profile likelihoods for spawning stock fecundity (SSF) in virgin conditions and in 2011 (top), depletion in biomass (middle), and SSF depletion (bottom). The MSST reference point is indicated in the upper panel.

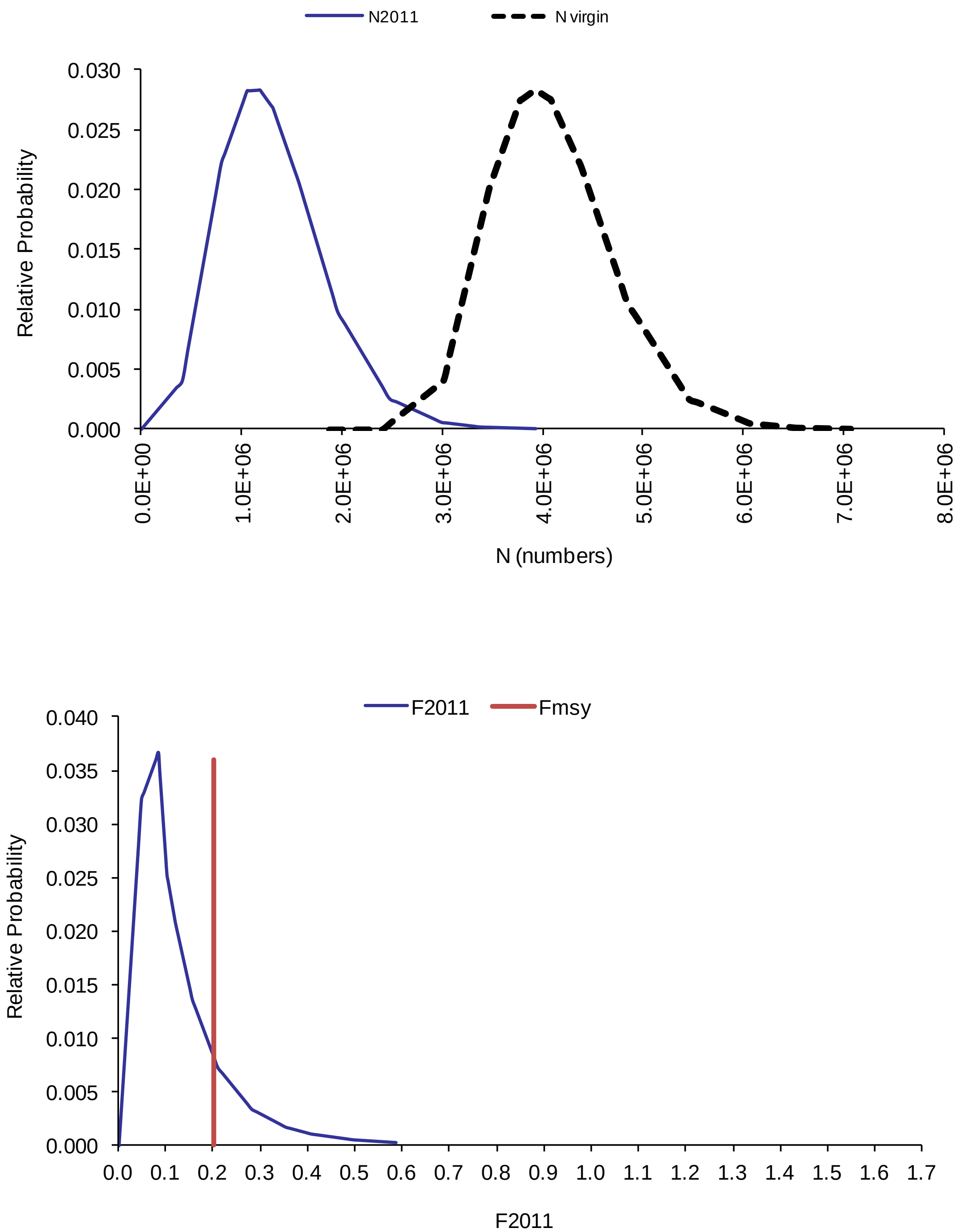


Figure 3.6.14. Profile likelihoods for number of mature individuals in virgin conditions and in 2011 (top) and for fishing mortality in 2011 (bottom). The F_{MSY} reference point is indicated in the bottom panel.

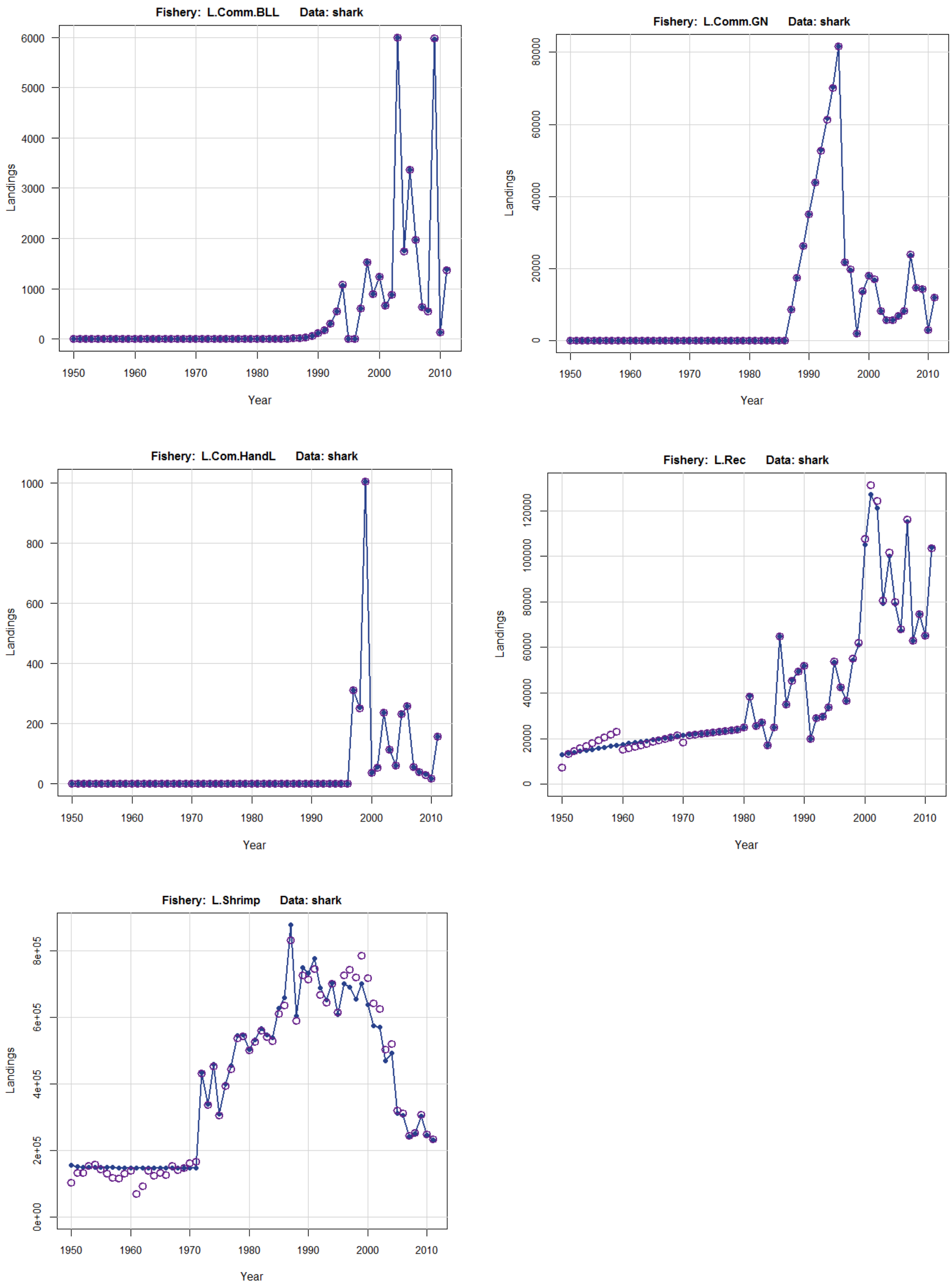


Figure 3.6.15. Predicted fits to the five catch data streams for the “increasing indices” sensitivity run.

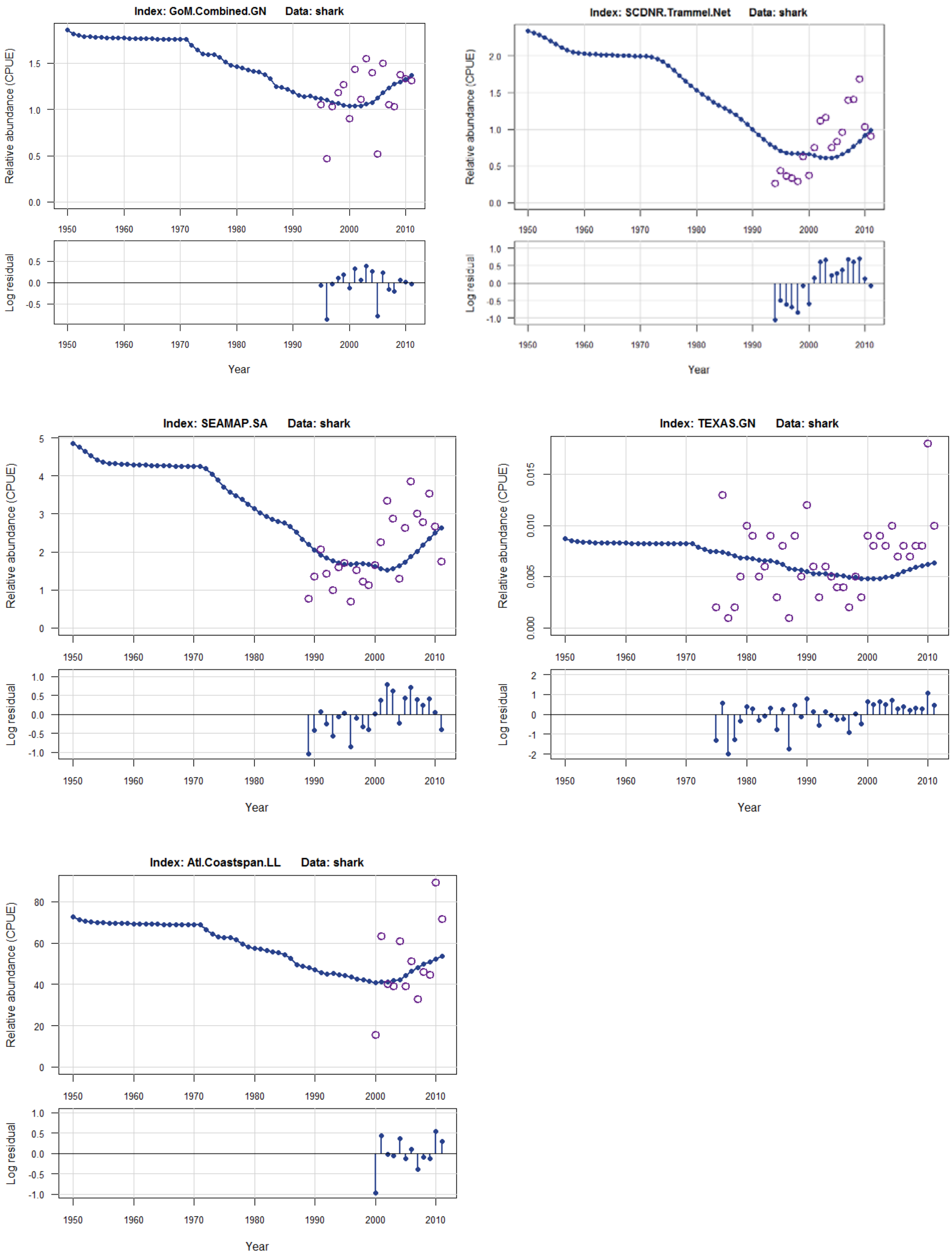


Figure 3.6.16. Predicted fits to indices and residual plots for the "increasing indices" sensitivity" run.

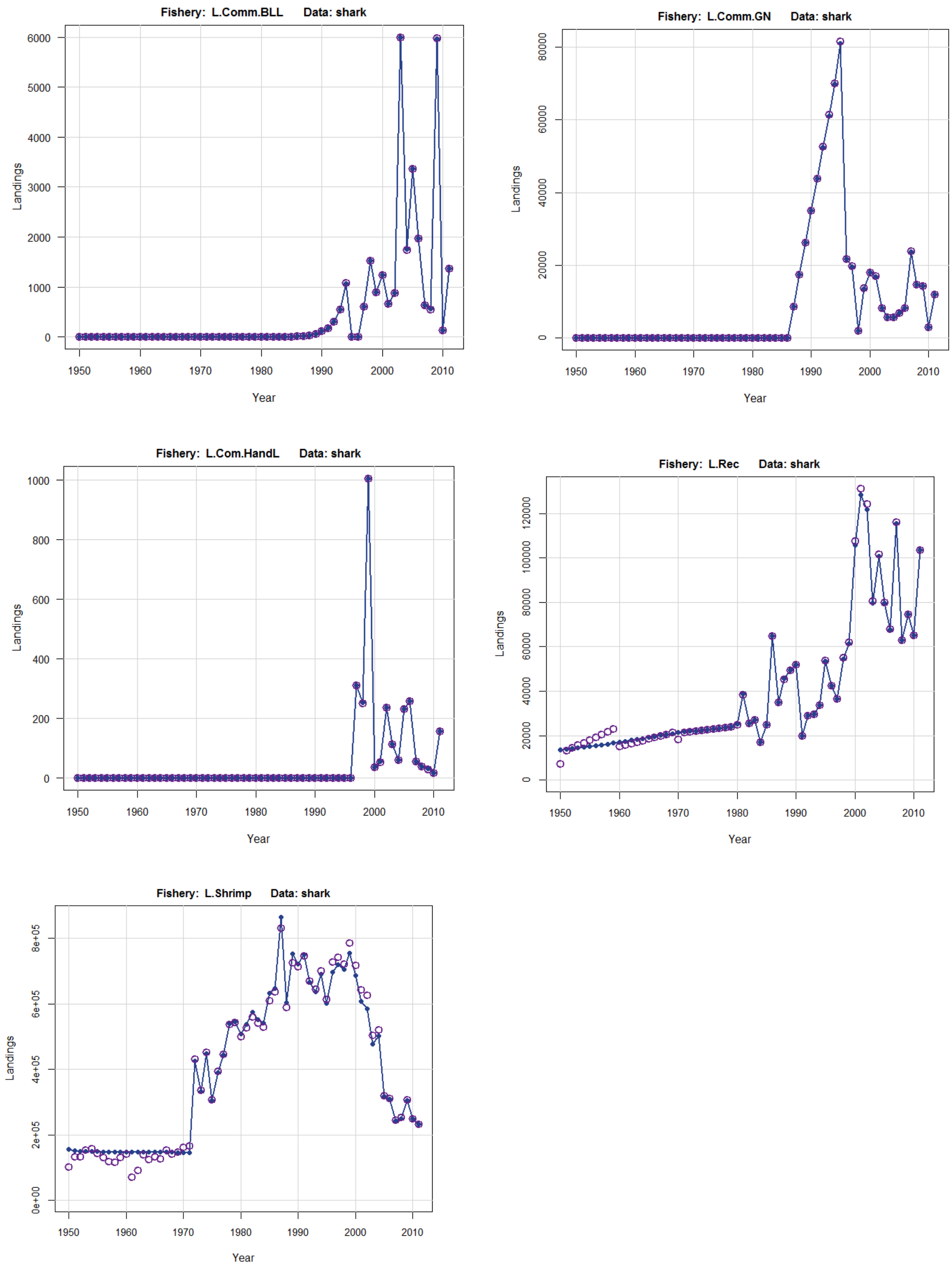


Figure 3.6.17. Predicted fits to the five catch data streams for the “decreasing indices” sensitivity run.

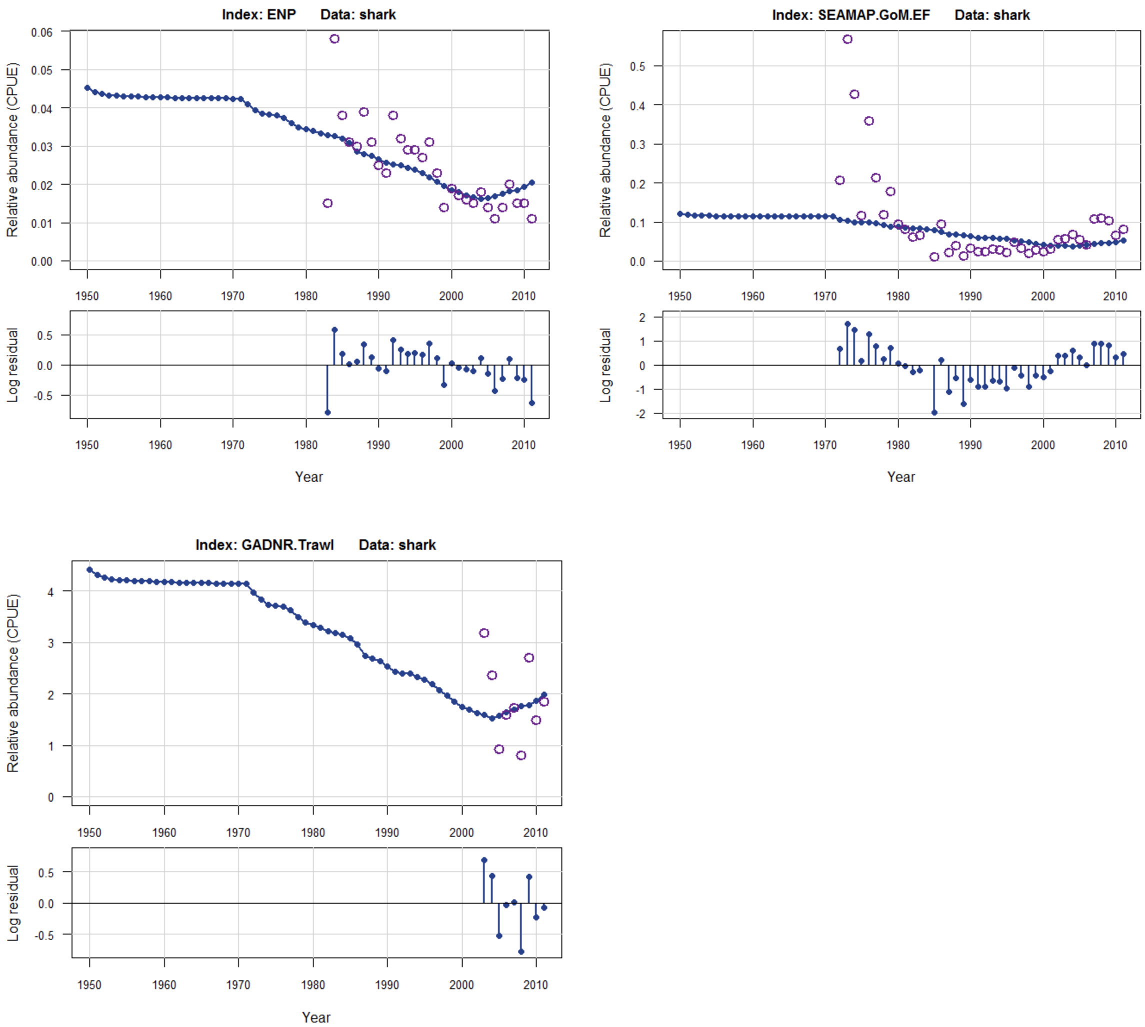


Figure 3.6.18. Predicted fits to indices and residual plots for the "decreasing indices" sensitivity" run.

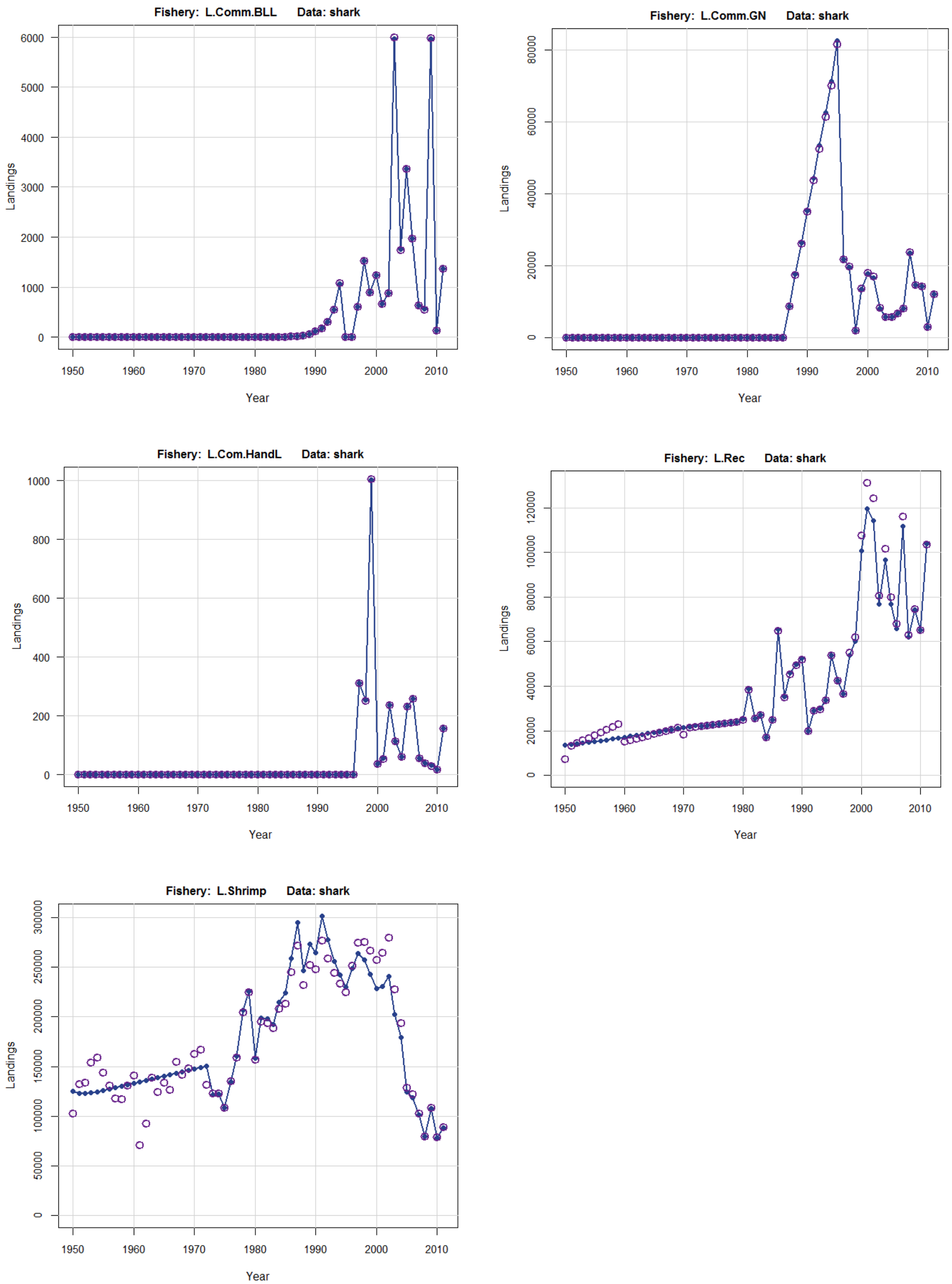


Figure 3.6.19. Predicted fits to the five catch data streams for the "low catch" sensitivity run. Note that the scale on the Y-axis is smaller than in the base run.

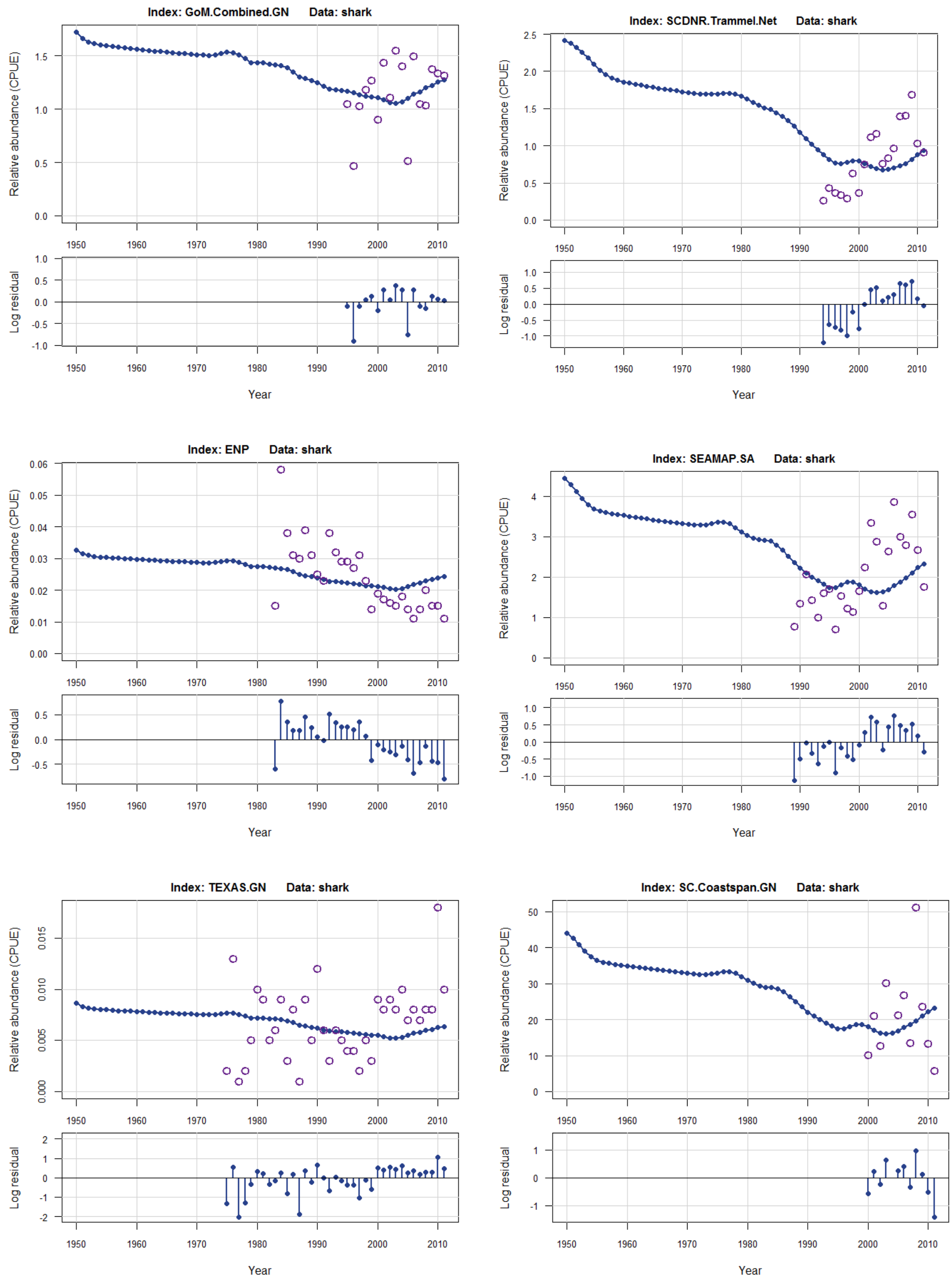


Figure 3.6.20. Predicted fits to indices and residual plots for the "low catch" sensitivity run.

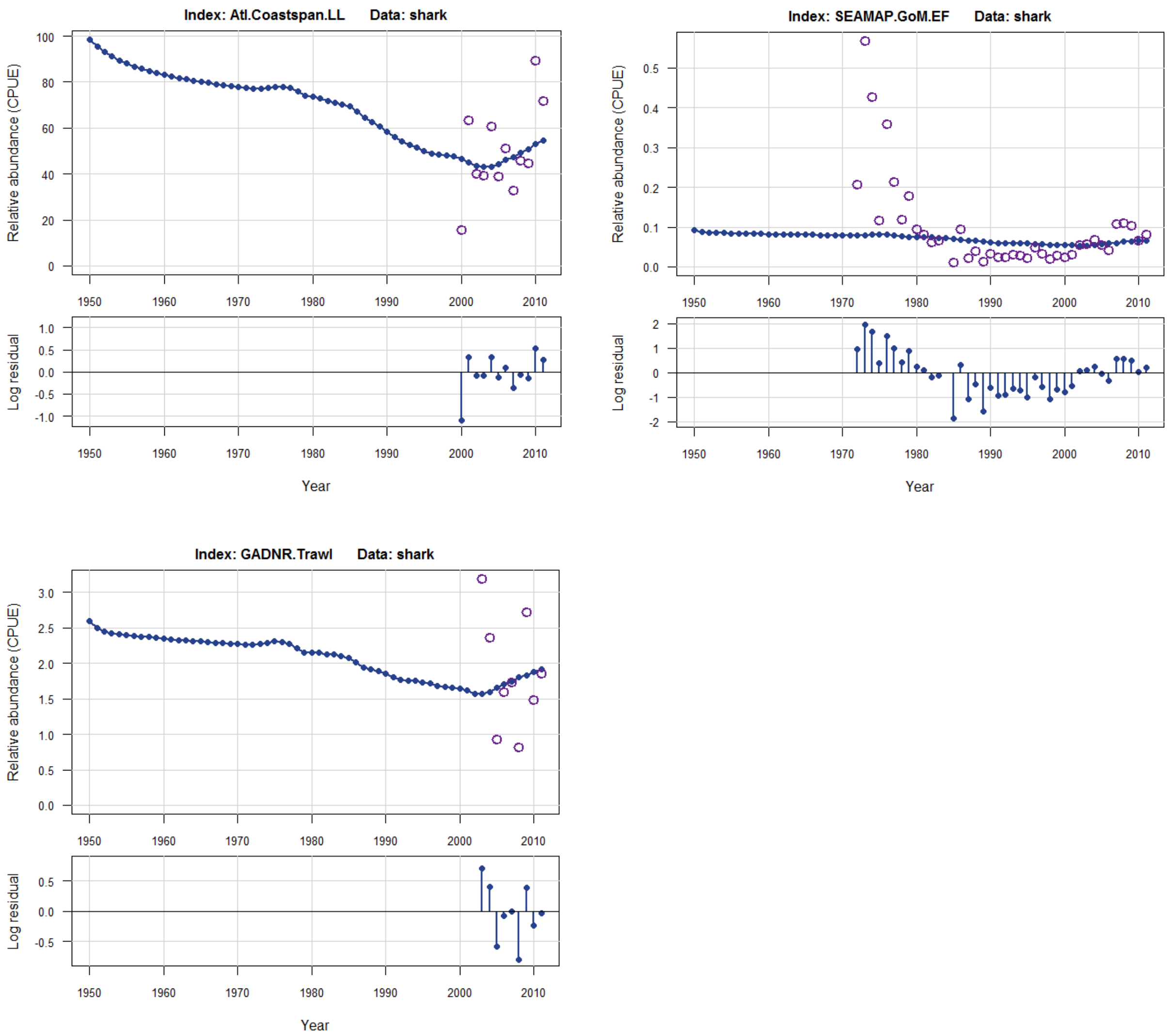


Figure 3.6.20 (continued). Predicted fits to indices and residual plots "low catch" sensitivity run.

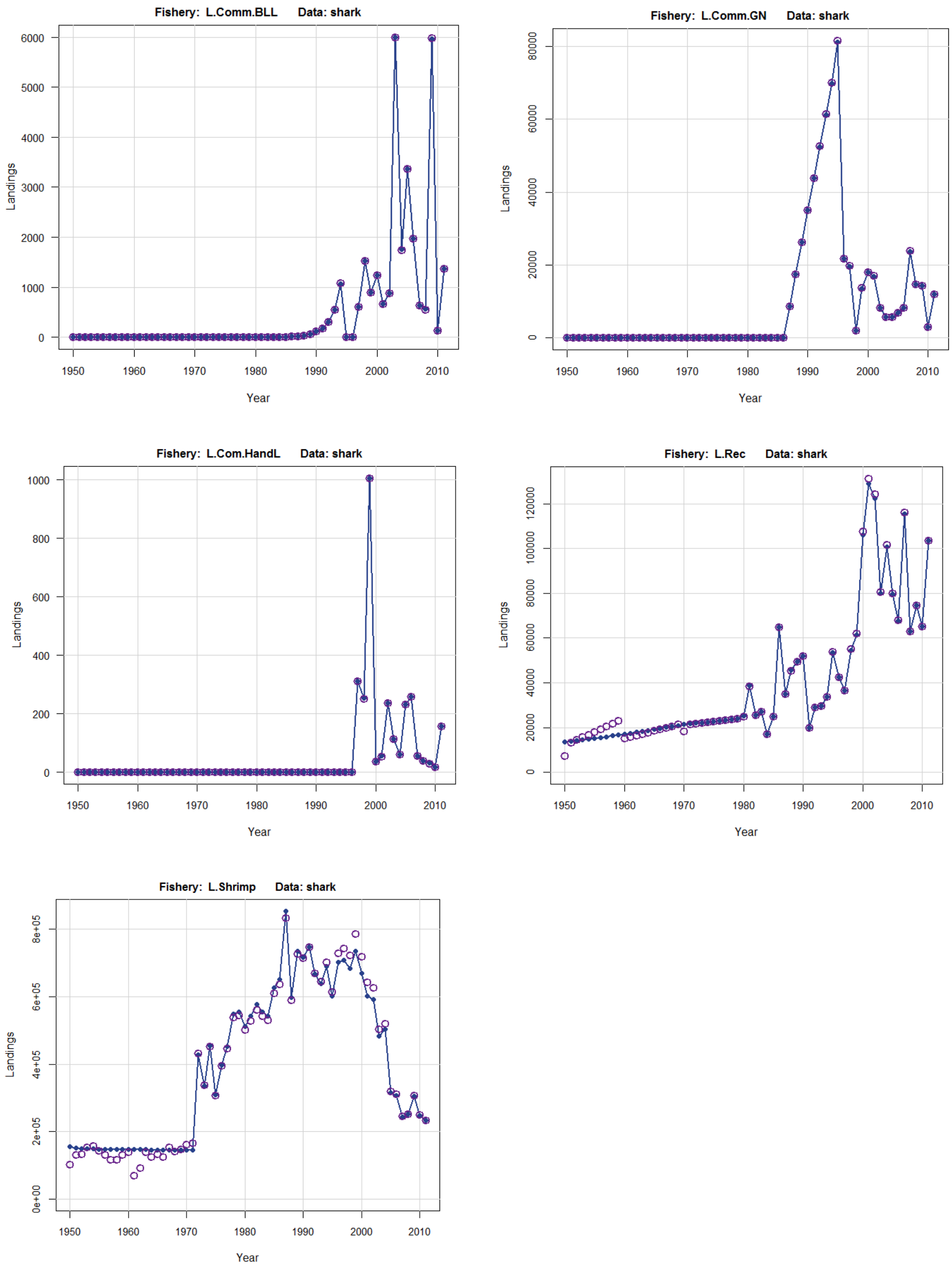


Figure 3.6.21. Predicted fits to the five catch data streams for the "hierarchical index" sensitivity run.

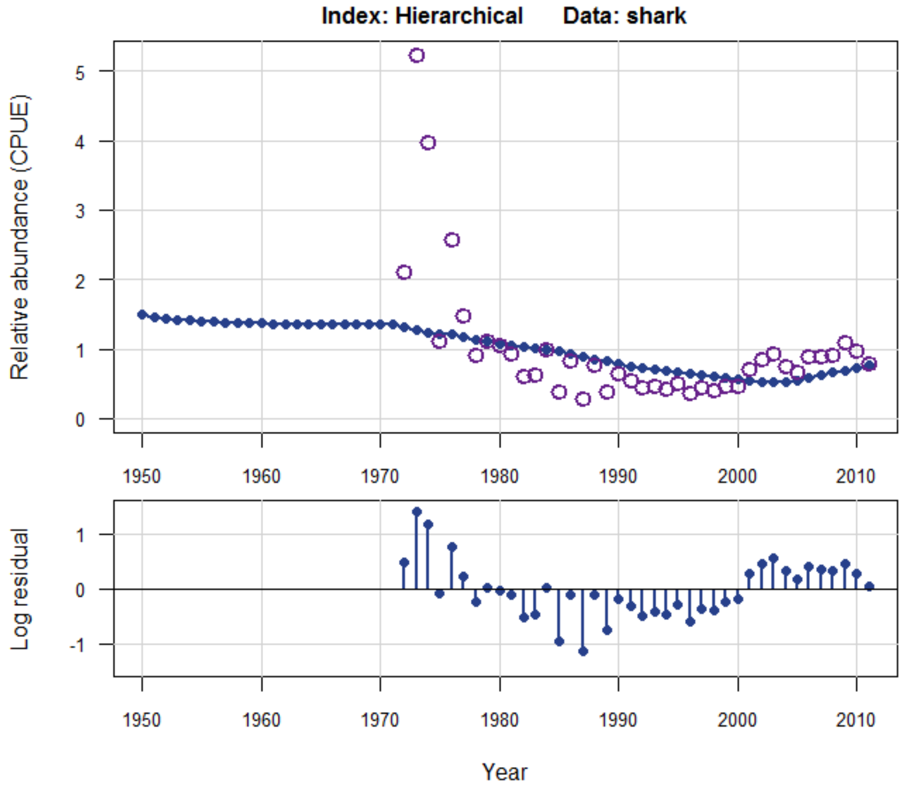


Figure 3.6.22. Predicted fits to the index and residual plots for the “hierarchical index” sensitivity run.

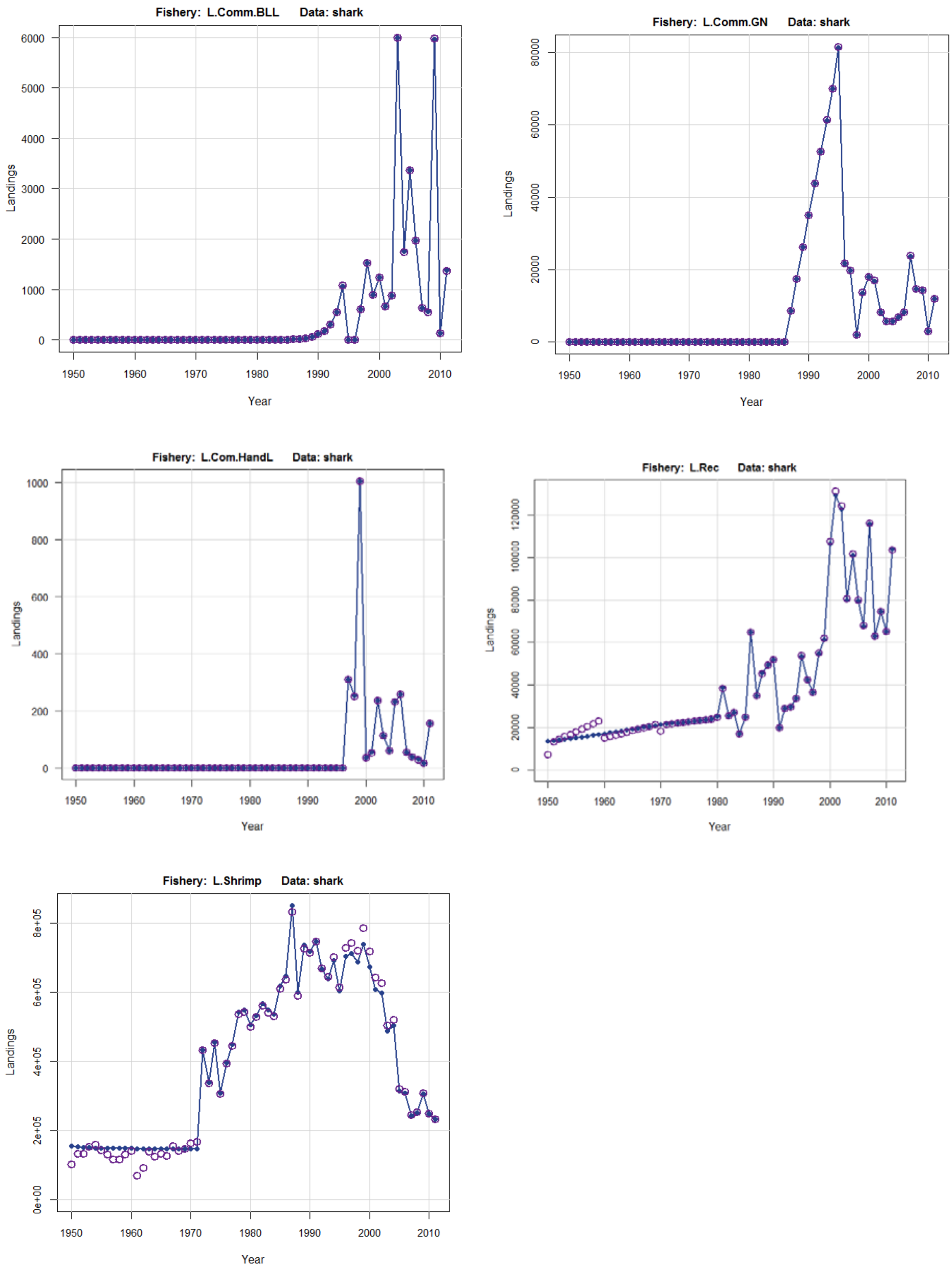
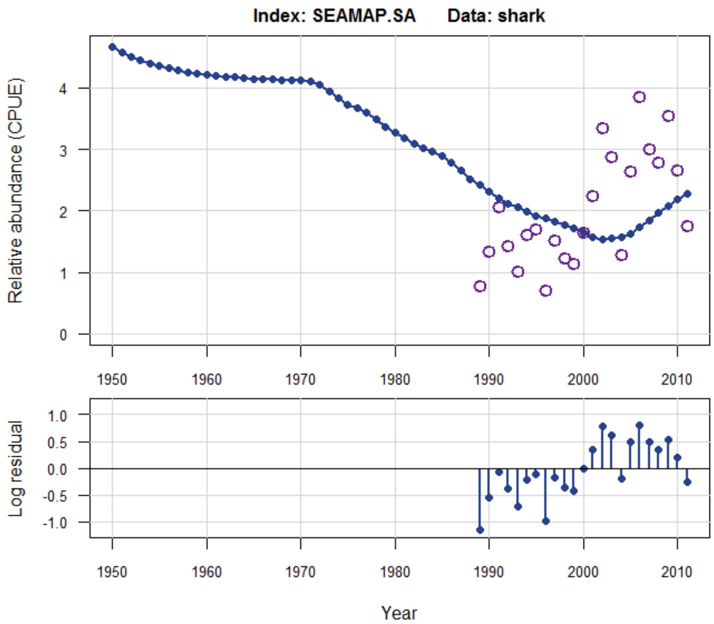


Figure 3.6.23. Predicted fits to the five catch data streams for the “SEAMAP-SA” sensitivity run.



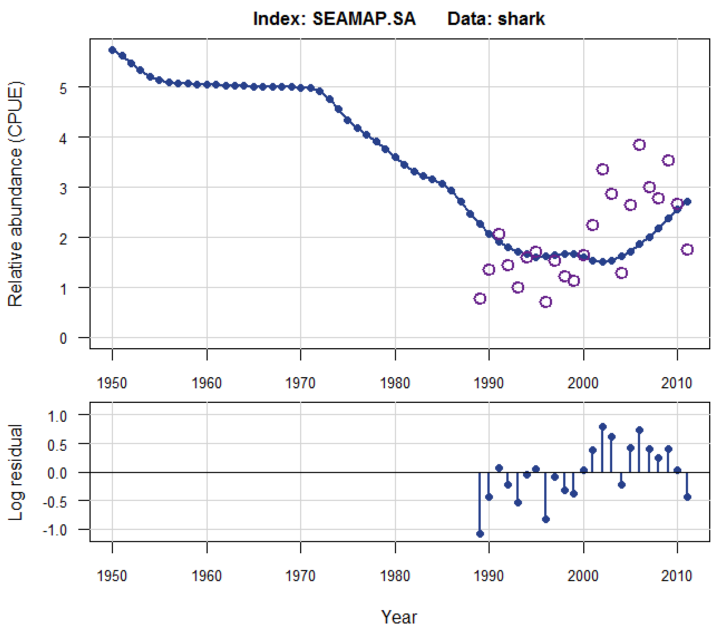


Figure 3.6.24. Predicted fit to the SEAMAP-SA index and residual plot for the “SEAMAP-SA” sensitivity run (top). The bottom panel shows the fit of the index in the base run.

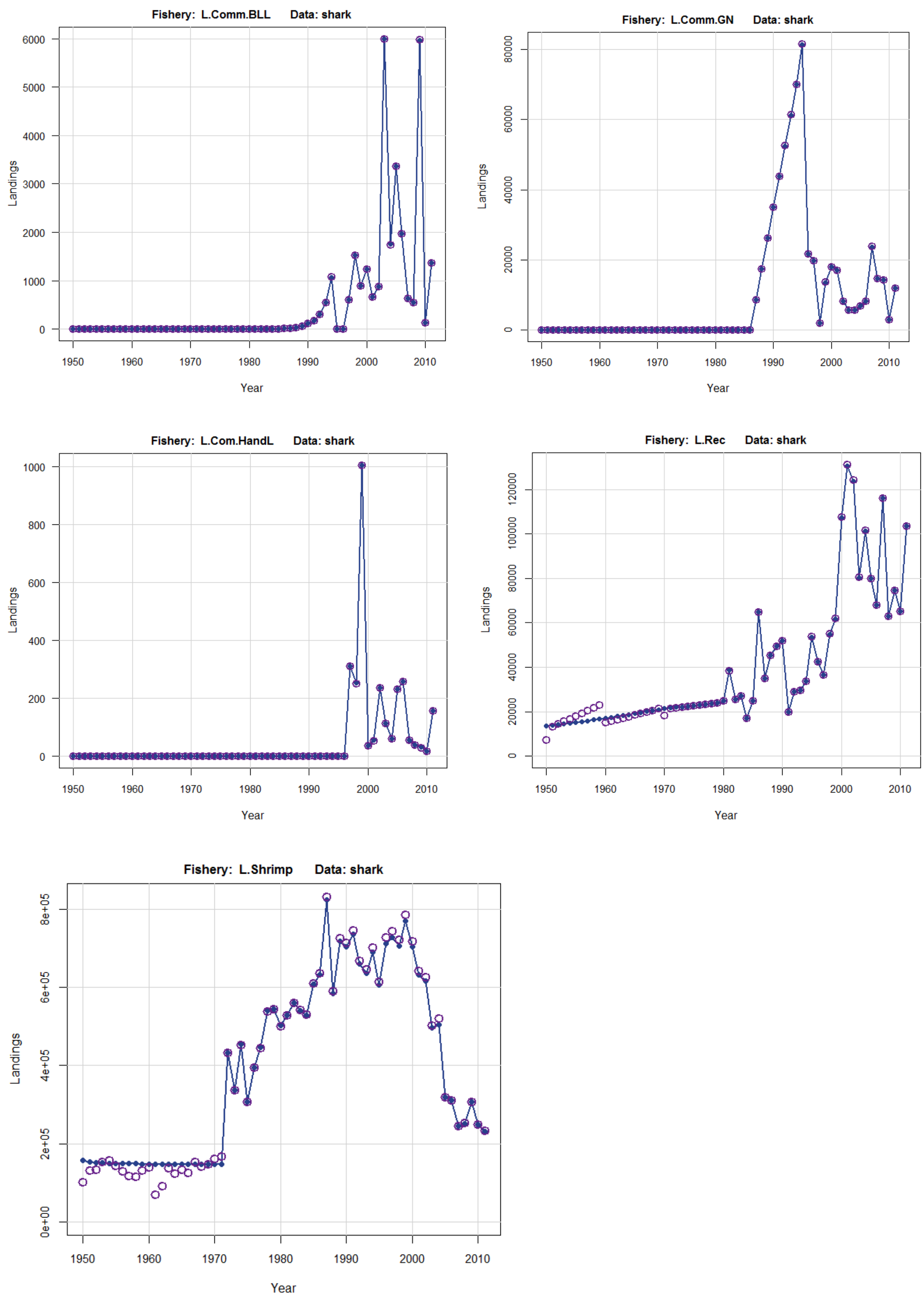


Figure 3.6.25. Predicted fits to the five catch data streams for the "No indices" sensitivity run.

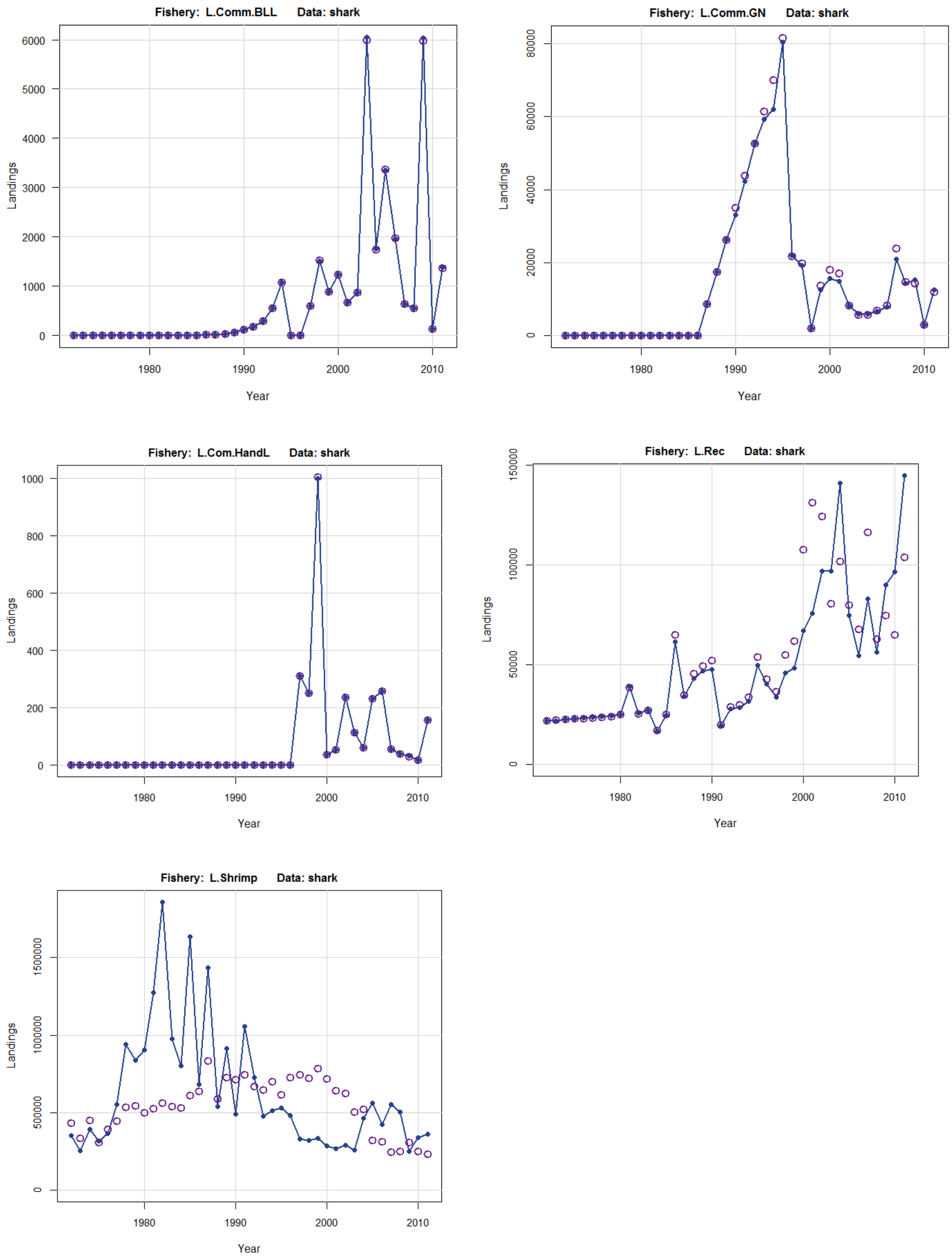


Figure 3.6.26. Predicted fits to the five catch data streams for the “start 1972” sensitivity run.

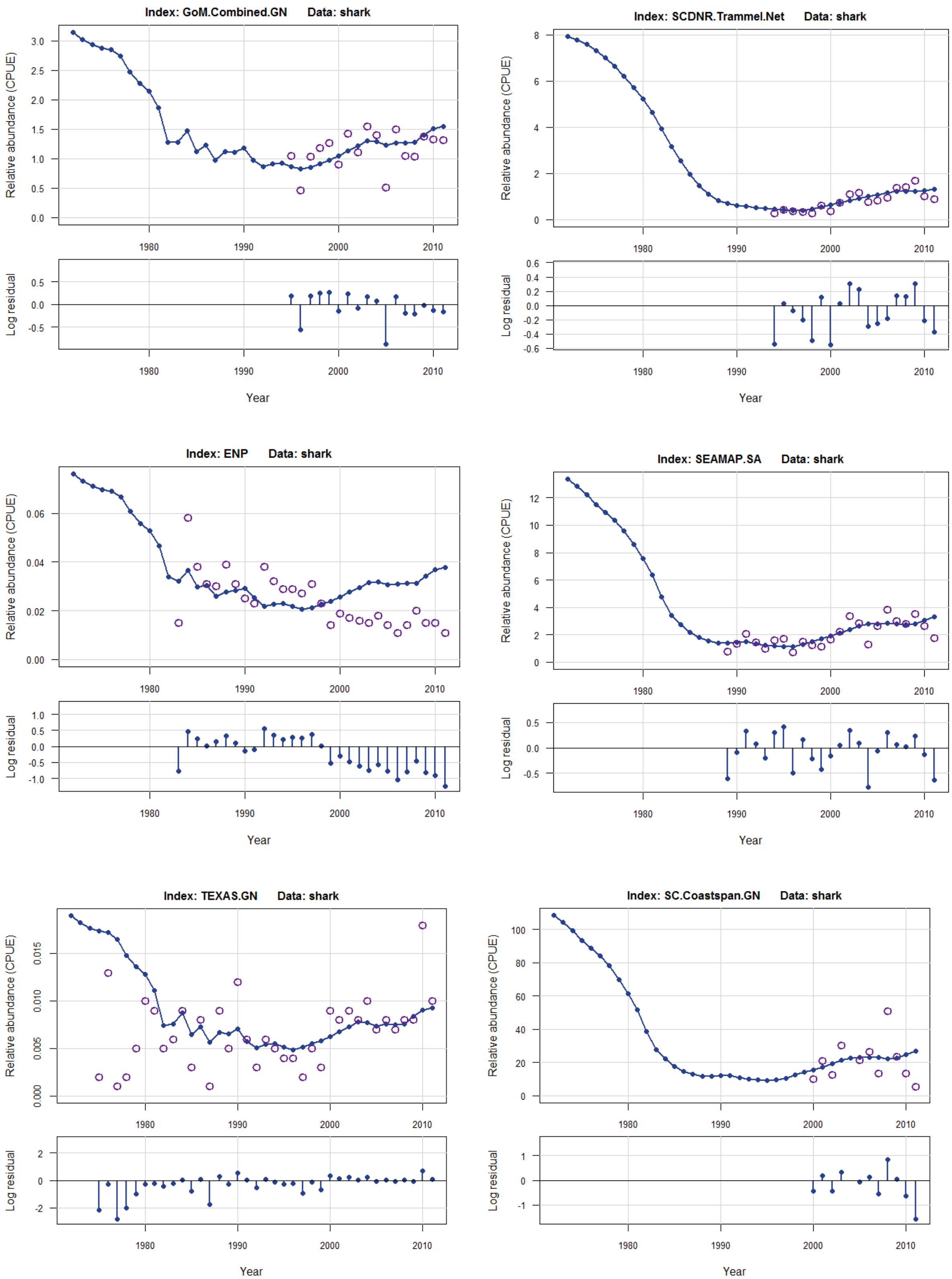


Figure 3.6.27. Predicted fits to indices and residual plots for the "start 1972" sensitivity run.

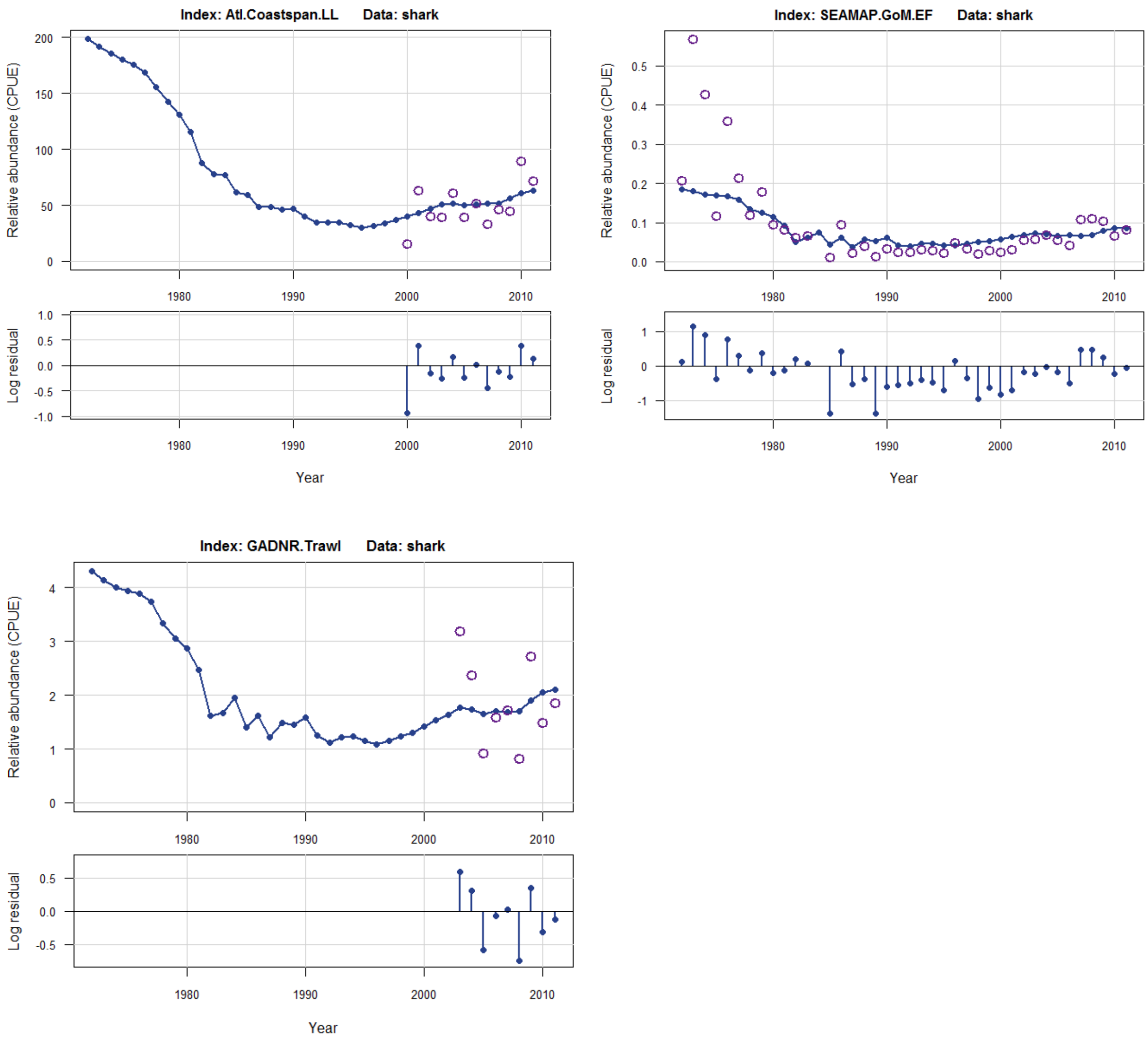


Figure 3.6.27 (continued). Predicted fits to indices and residual plots for the “start 1972” sensitivity run.

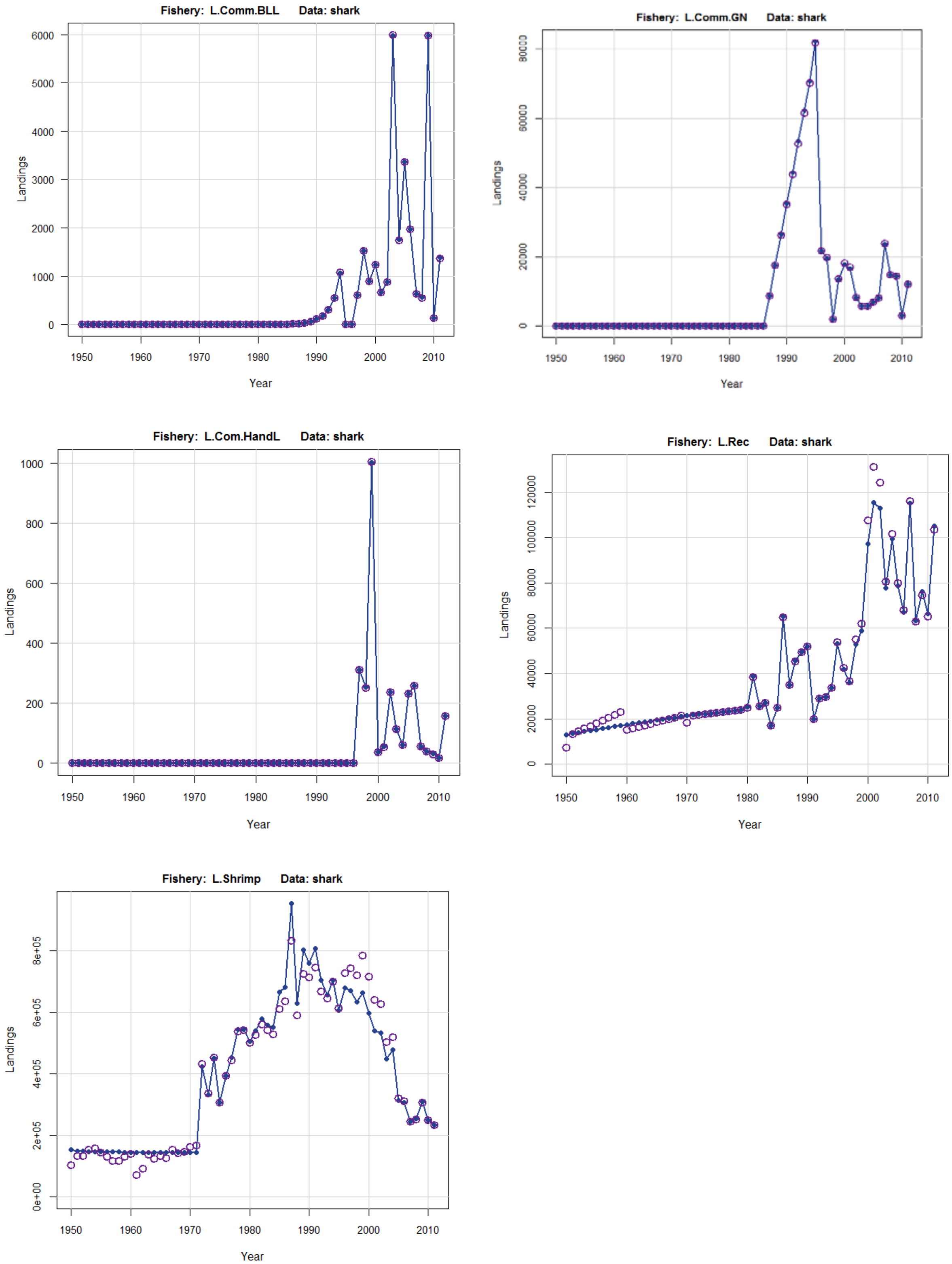


Figure 3.6.28. Predicted fits to the five catch data streams for the "high productivity" sensitivity run.

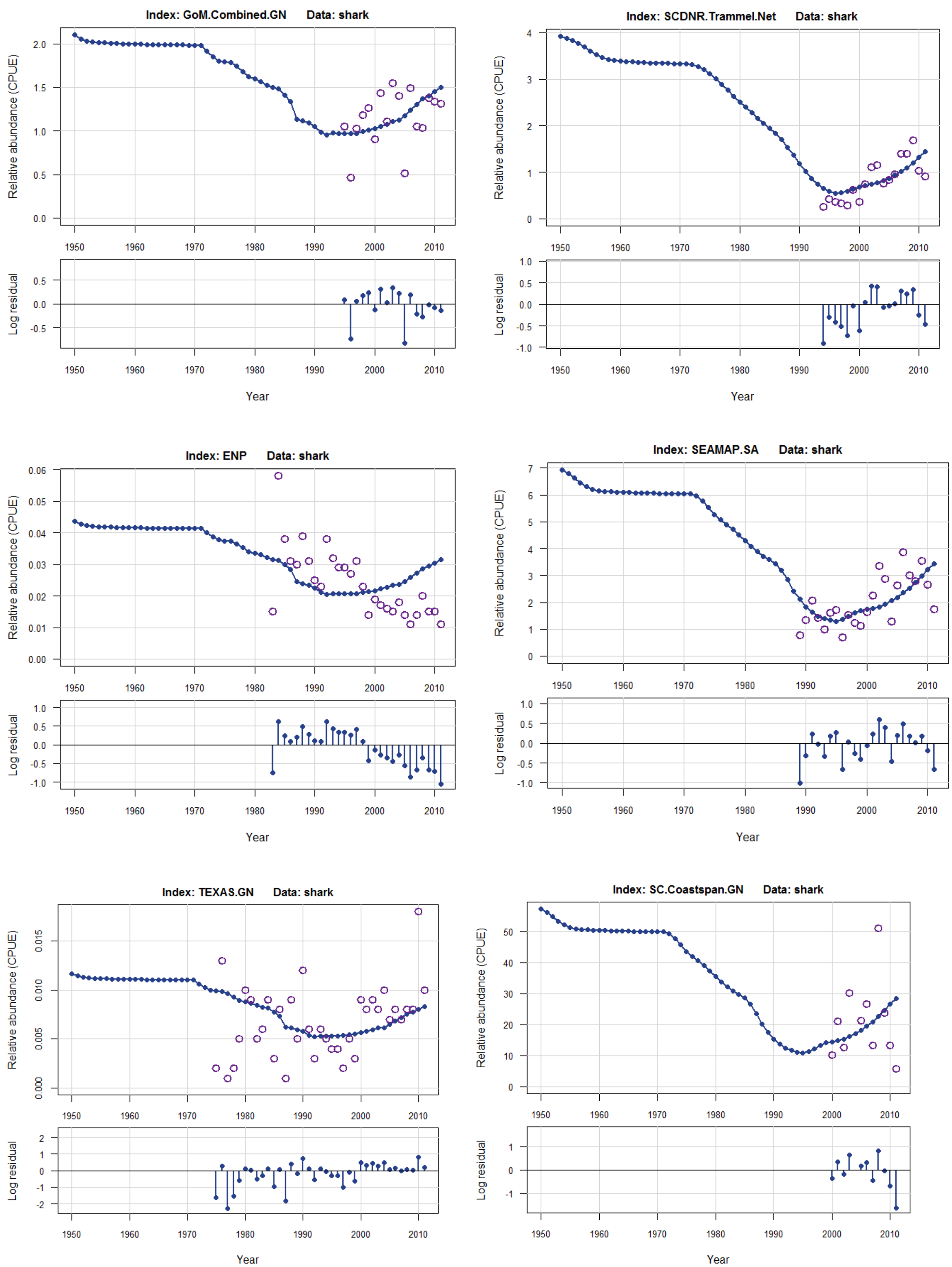


Figure 3.6.29. Predicted fits to indices and residual plots for the "high productivity" sensitivity run.

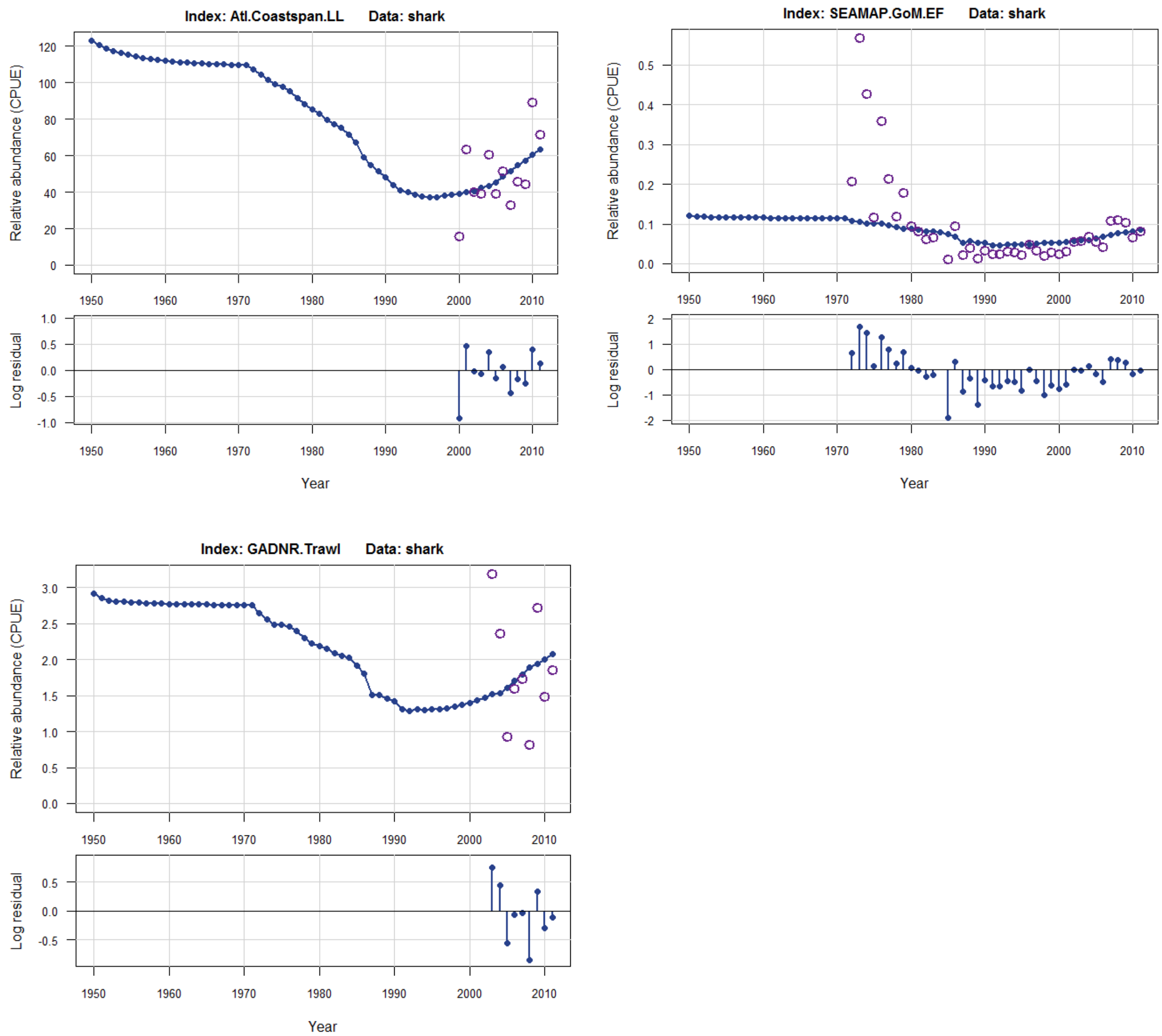


Figure 3.6.29 (continued). Predicted fits to indices and residual plots for the “high productivity” sensitivity run.

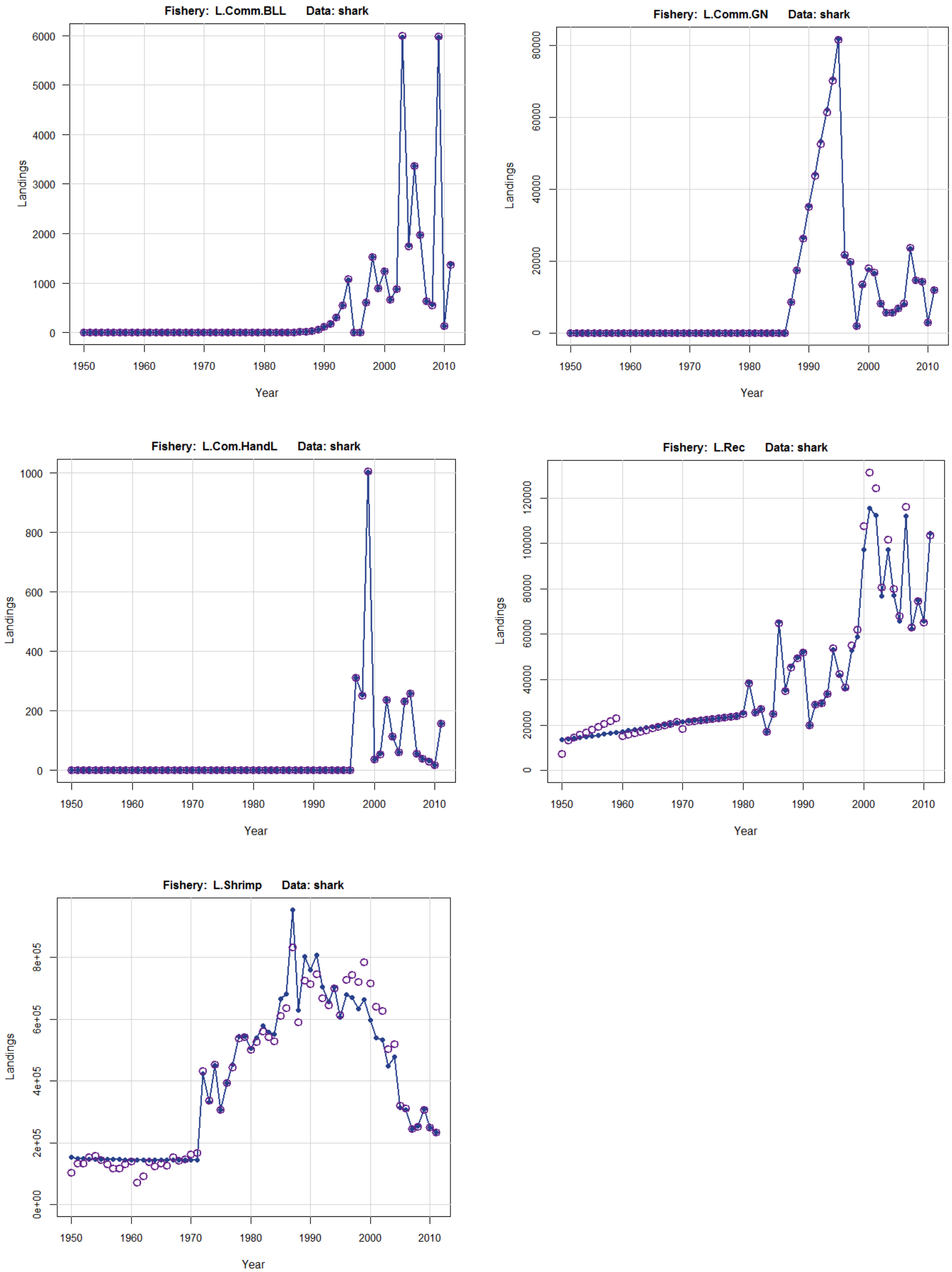


Figure 3.6.30. Predicted fits to the five catch data streams for the "low productivity" sensitivity run.

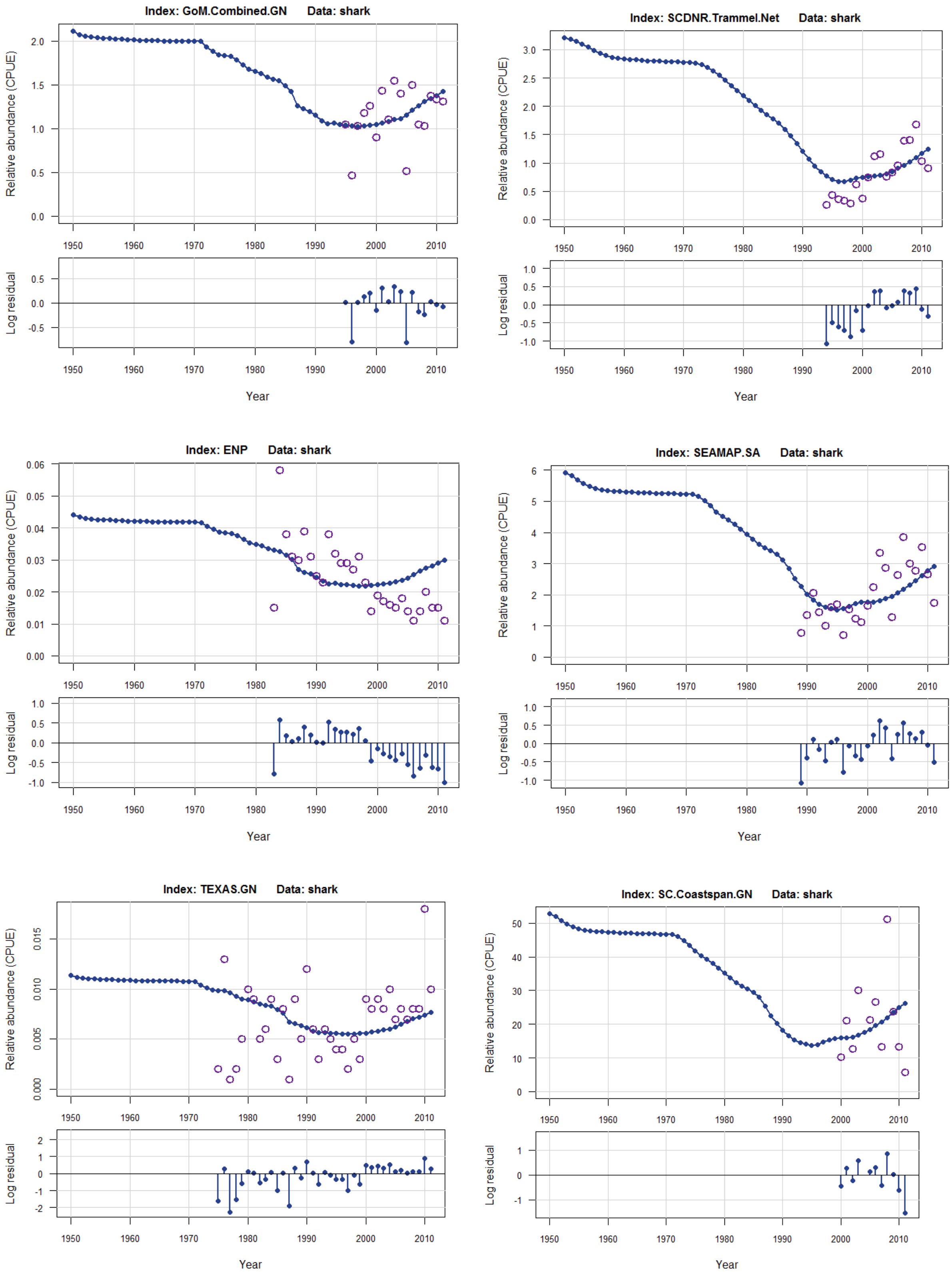


Figure 3.6.31. Predicted fits to indices and residual plots for the "low productivity" sensitivity run.

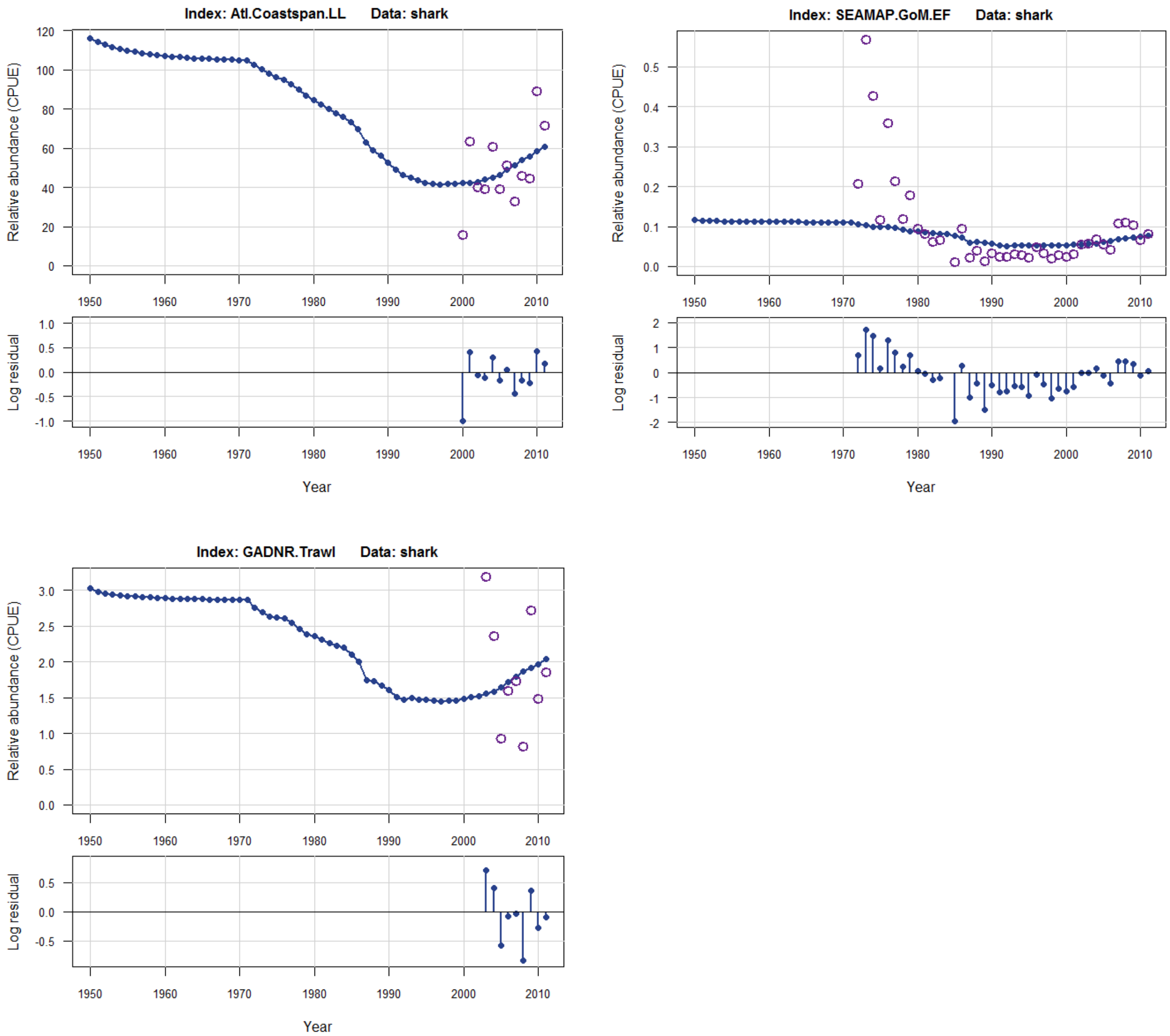


Figure 3.6.31 (continued). Predicted fits to indices and residual plots for the “low productivity” sensitivity run.

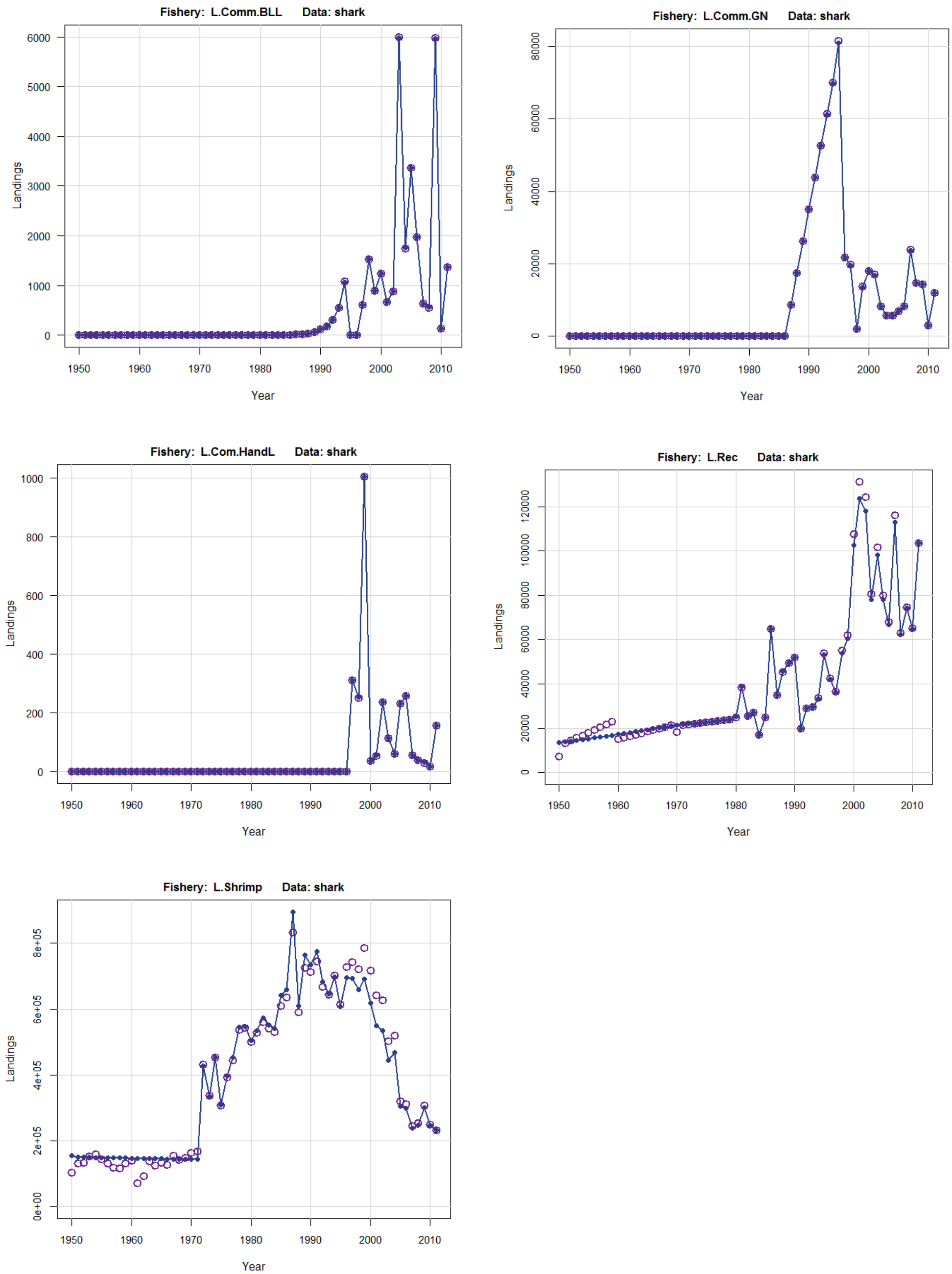


Figure 3.6.32. Predicted fits to the five catch data streams for the "Atlantic biology" sensitivity run.

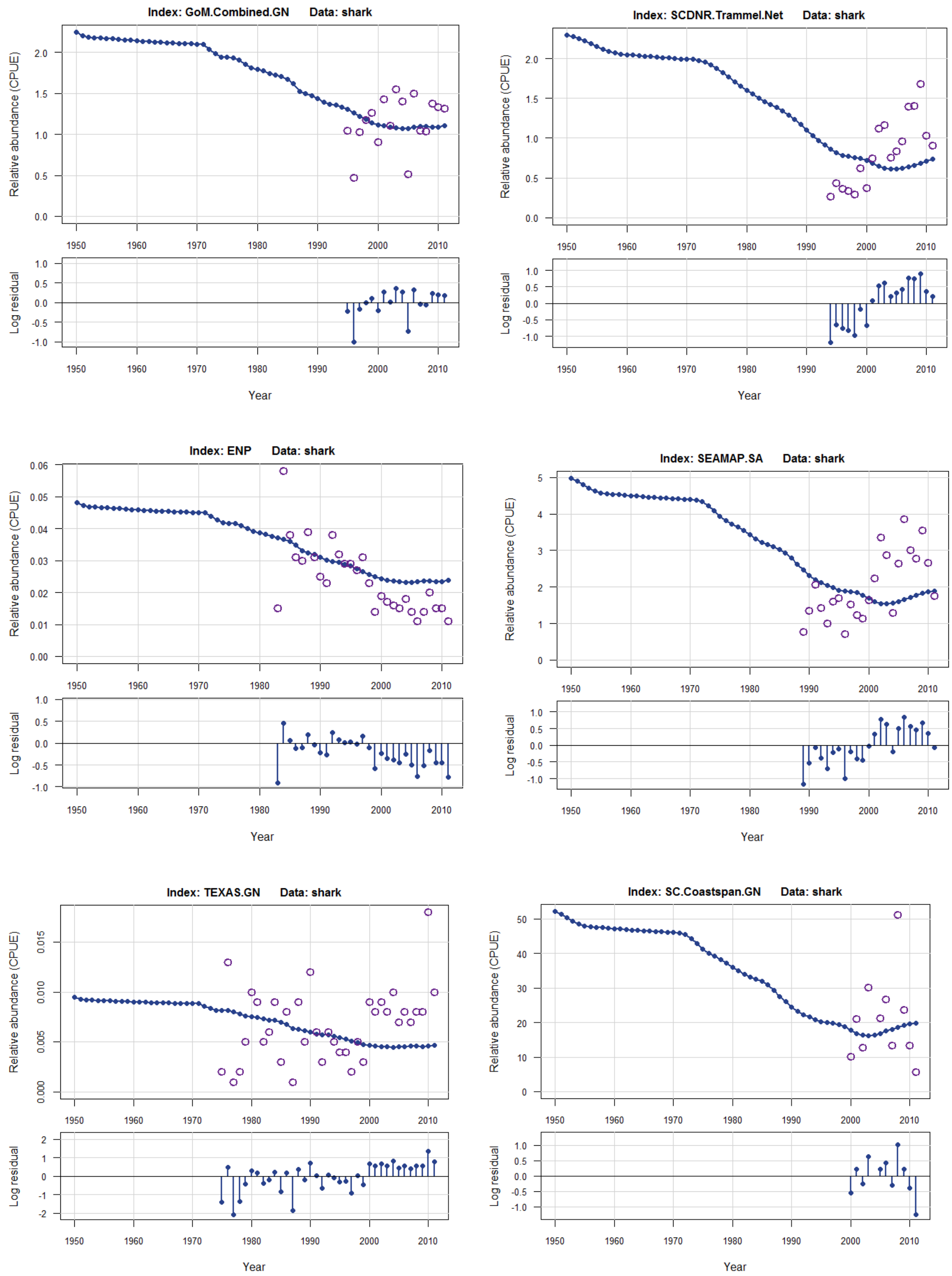


Figure 3.6.33. Predicted fits to indices and residual plots for the "Atlantic biology" sensitivity run.

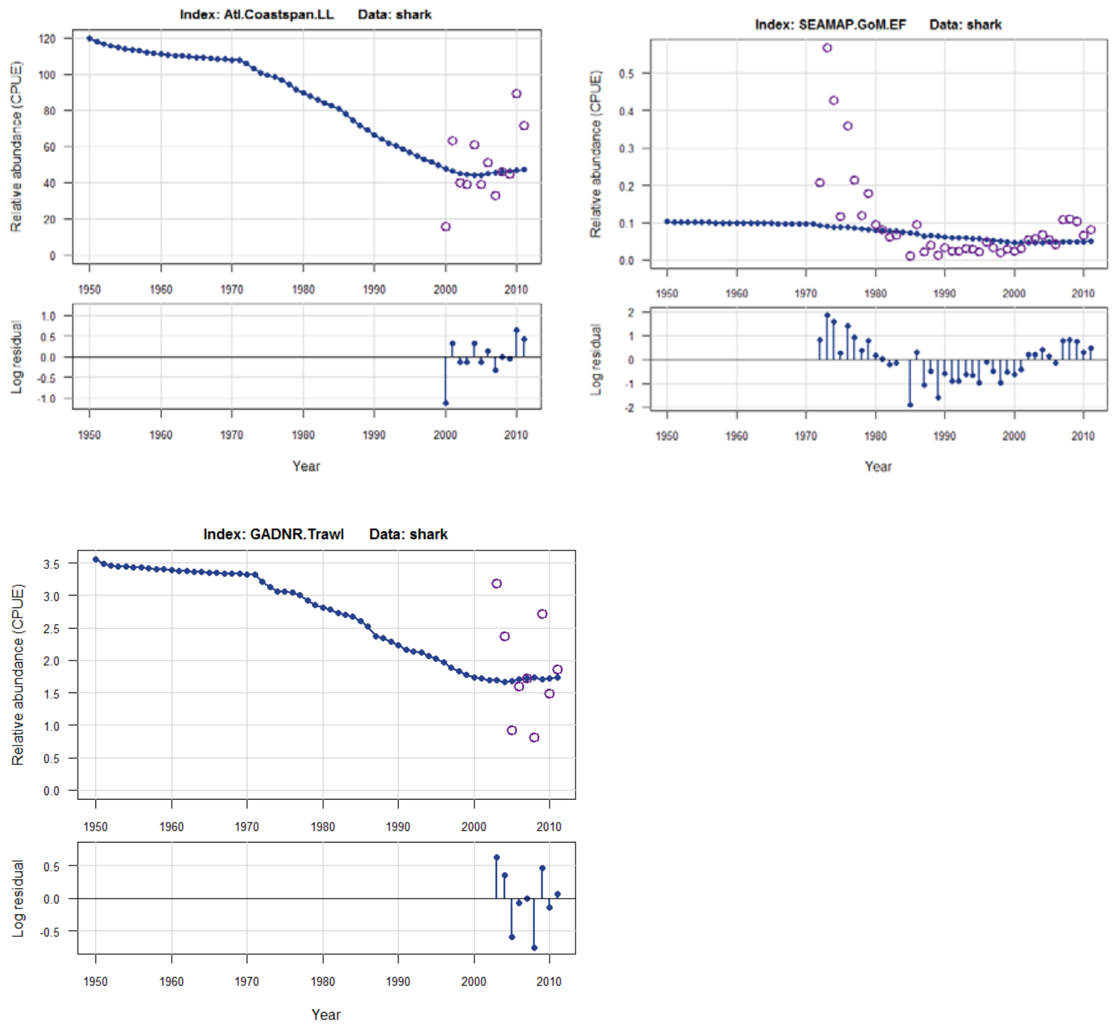


Figure 3.6.33 (continued). Predicted fits to indices and residual plots for the “Atlantic biology” sensitivity run.

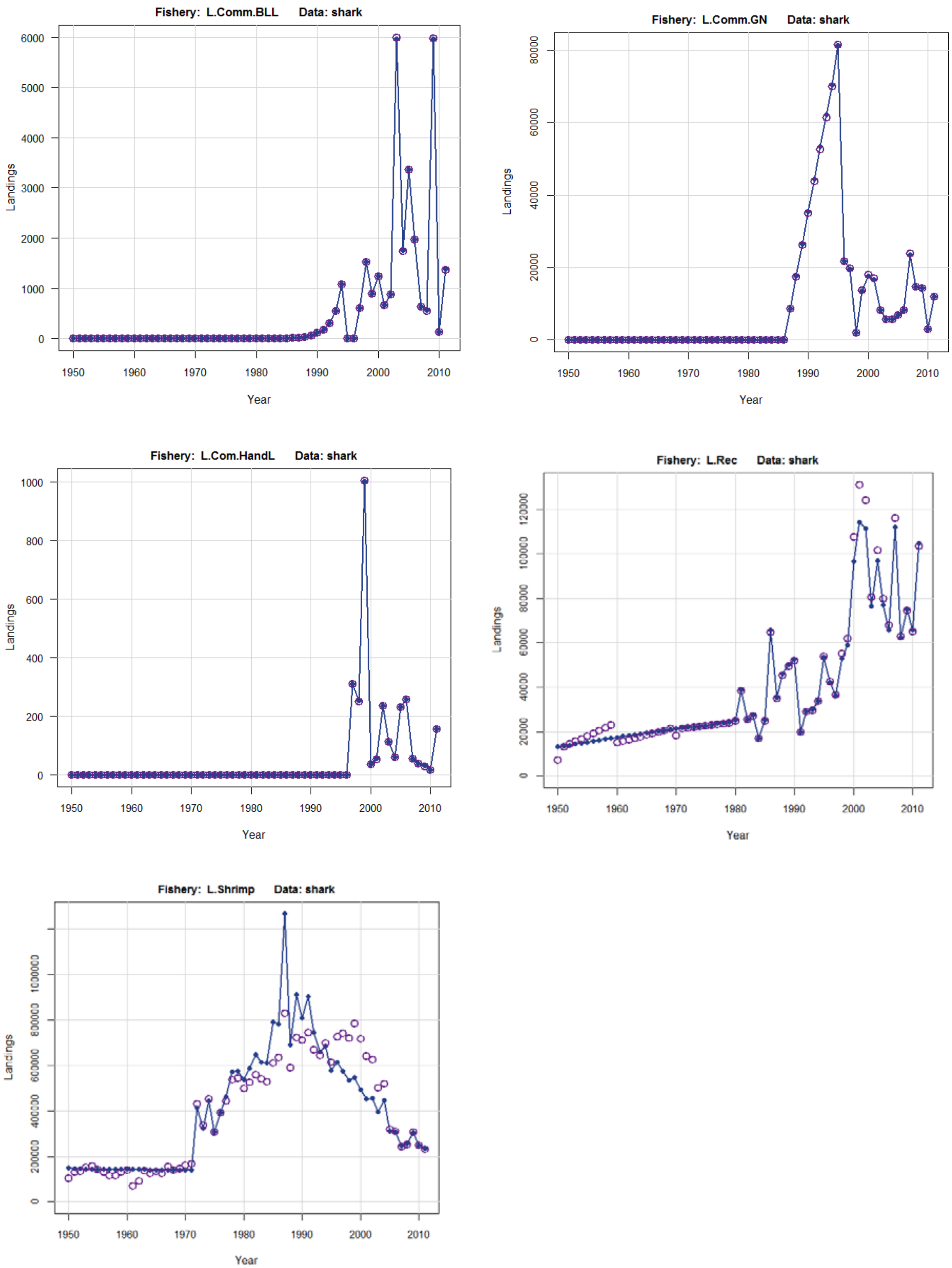


Figure 3.6.34. Predicted fits to the five catch data streams for the "Gulf of Mexico biology" sensitivity run.

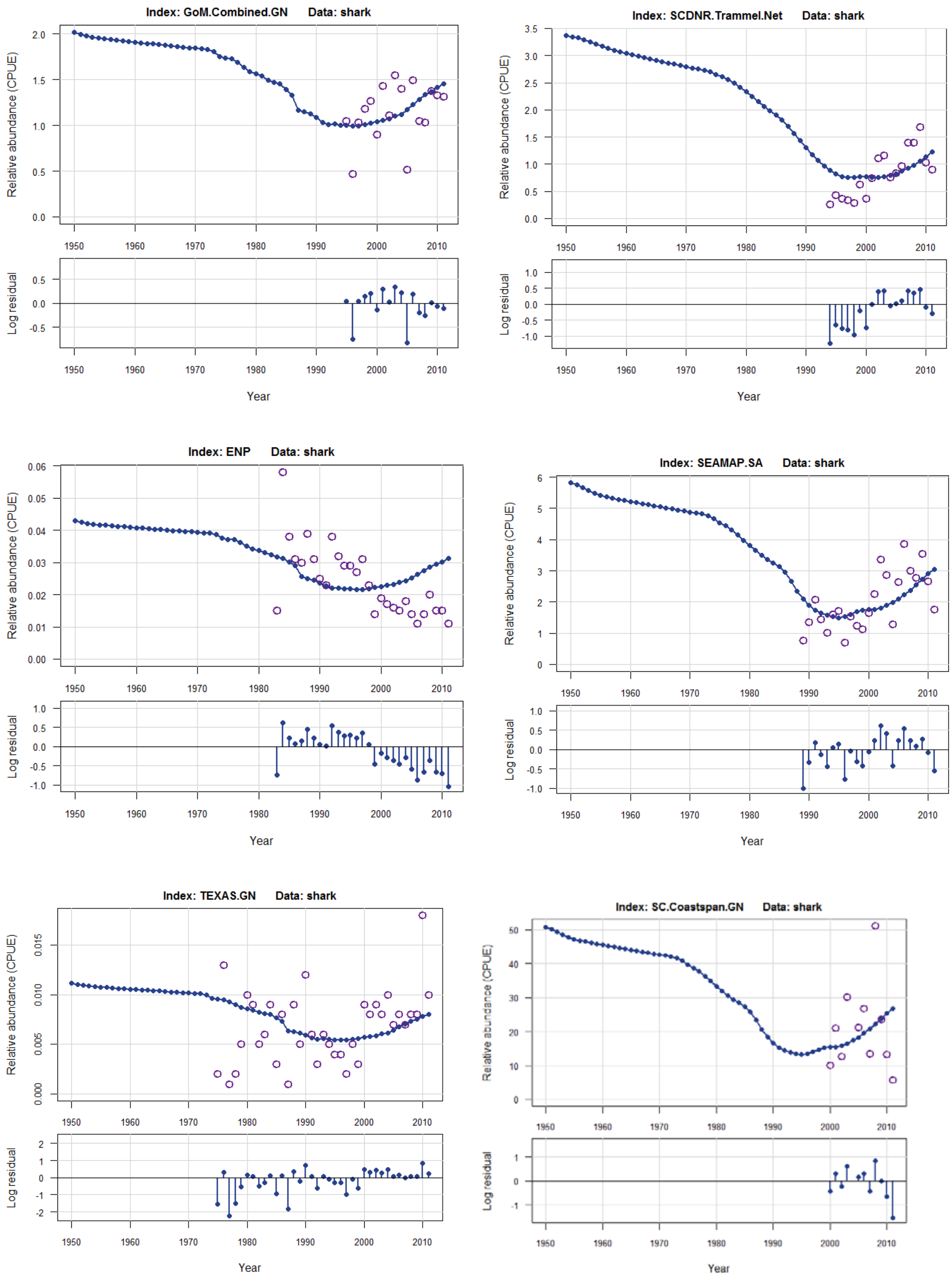


Figure 3.6.35. Predicted fits to indices and residual plots for the "Gulf of Mexico biology" sensitivity run.

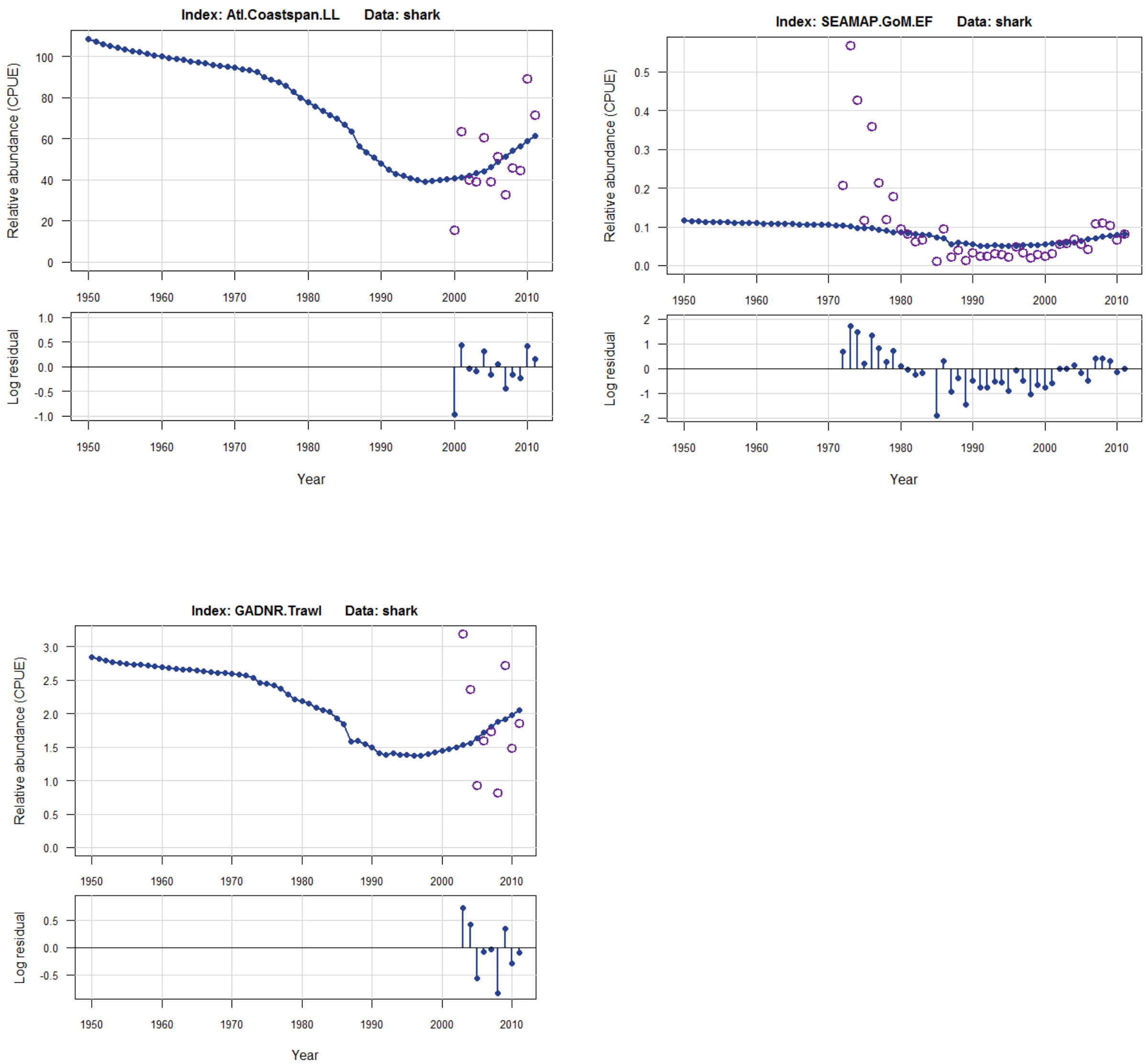


Figure 3.6.35 (continued). Predicted fits to indices and residual plots for the "Gulf of Mexico biology" sensitivity run.

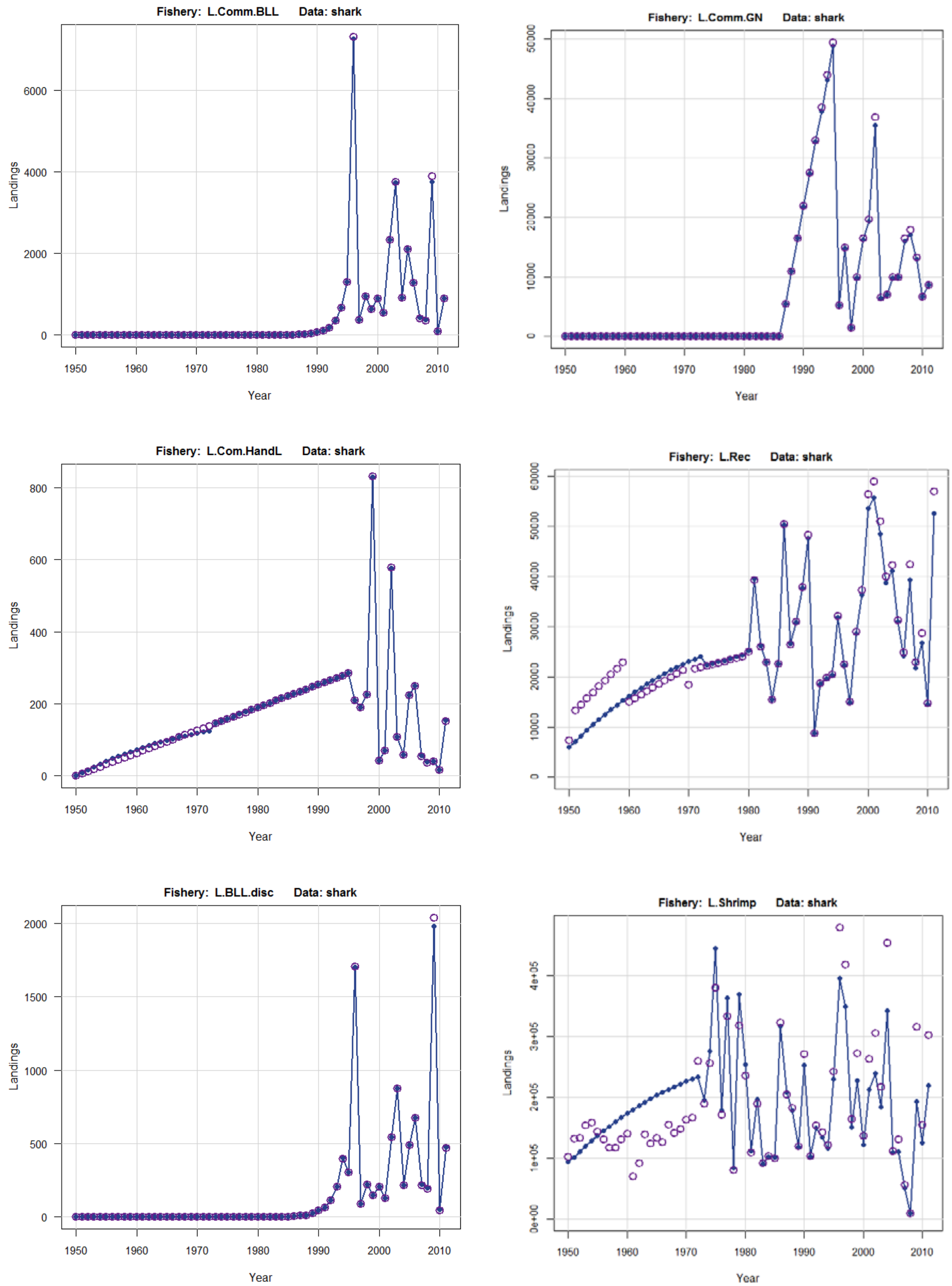


Figure 3.6.36. Predicted fits to the six catch data streams in the continuity run.

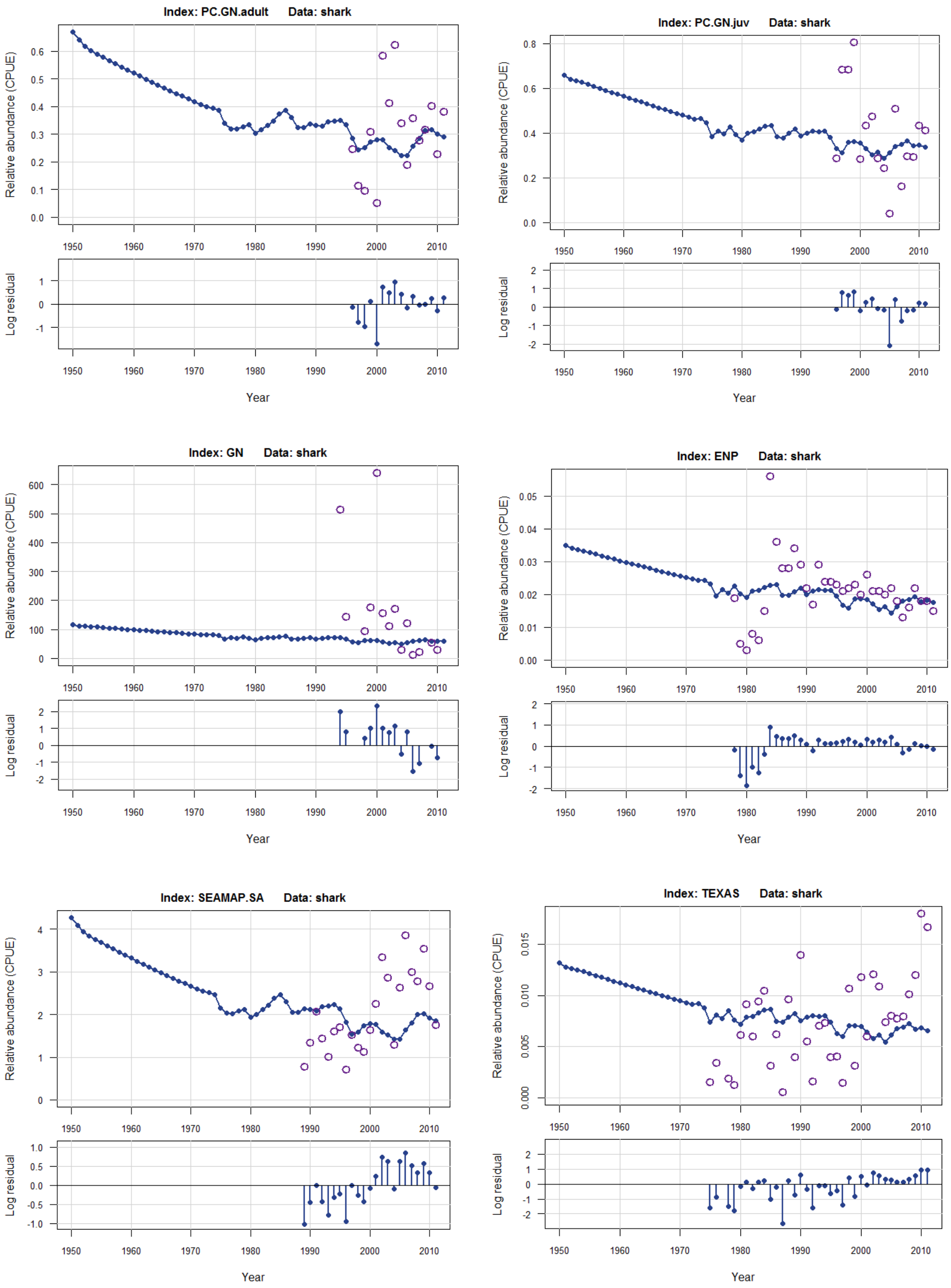


Figure 3.6.37. Predicted fits to indices and residual plots in the continuity run.

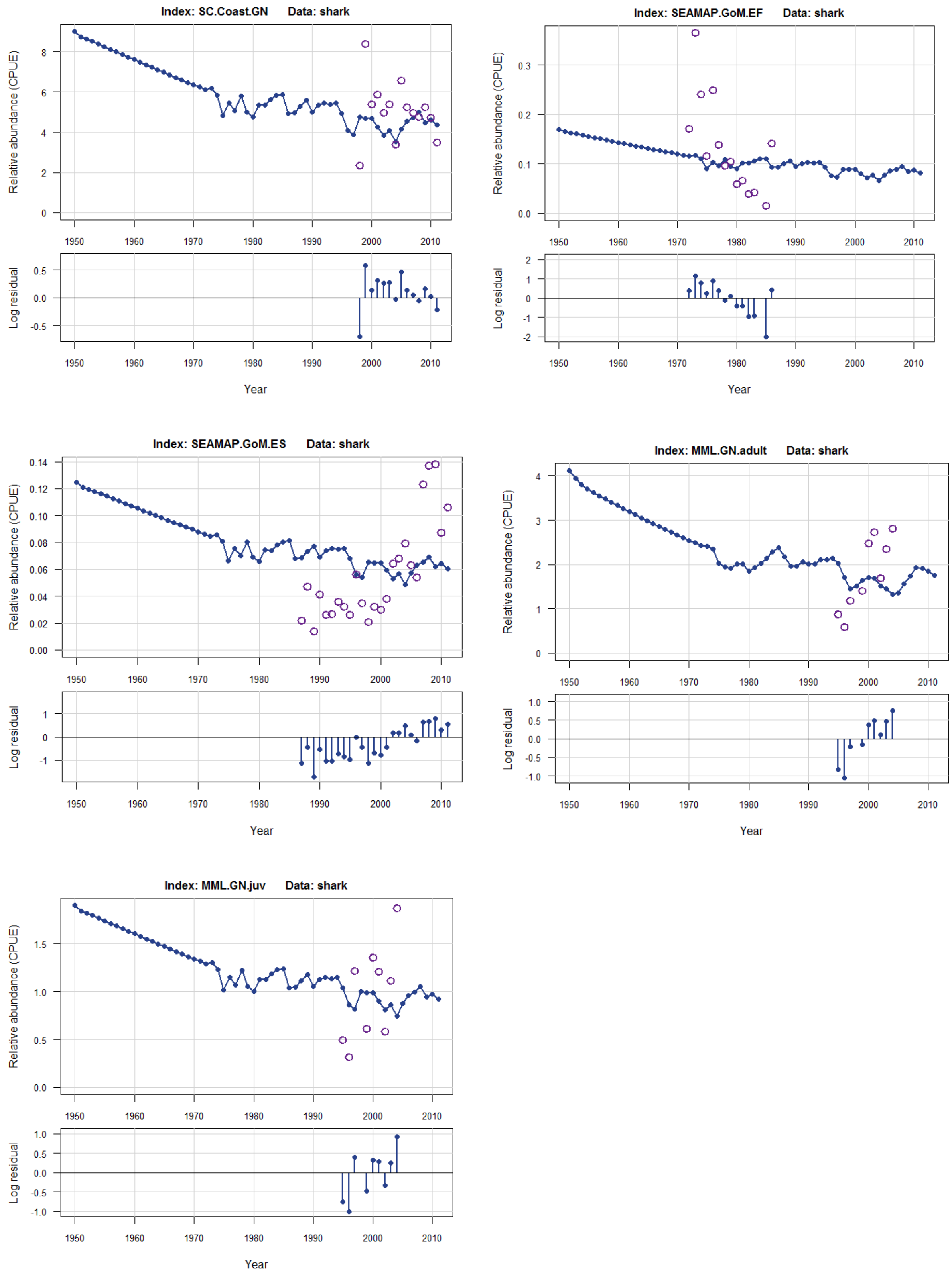


Figure 3.6.37 (continued). Predicted fits to indices and residual plots in the continuity run.

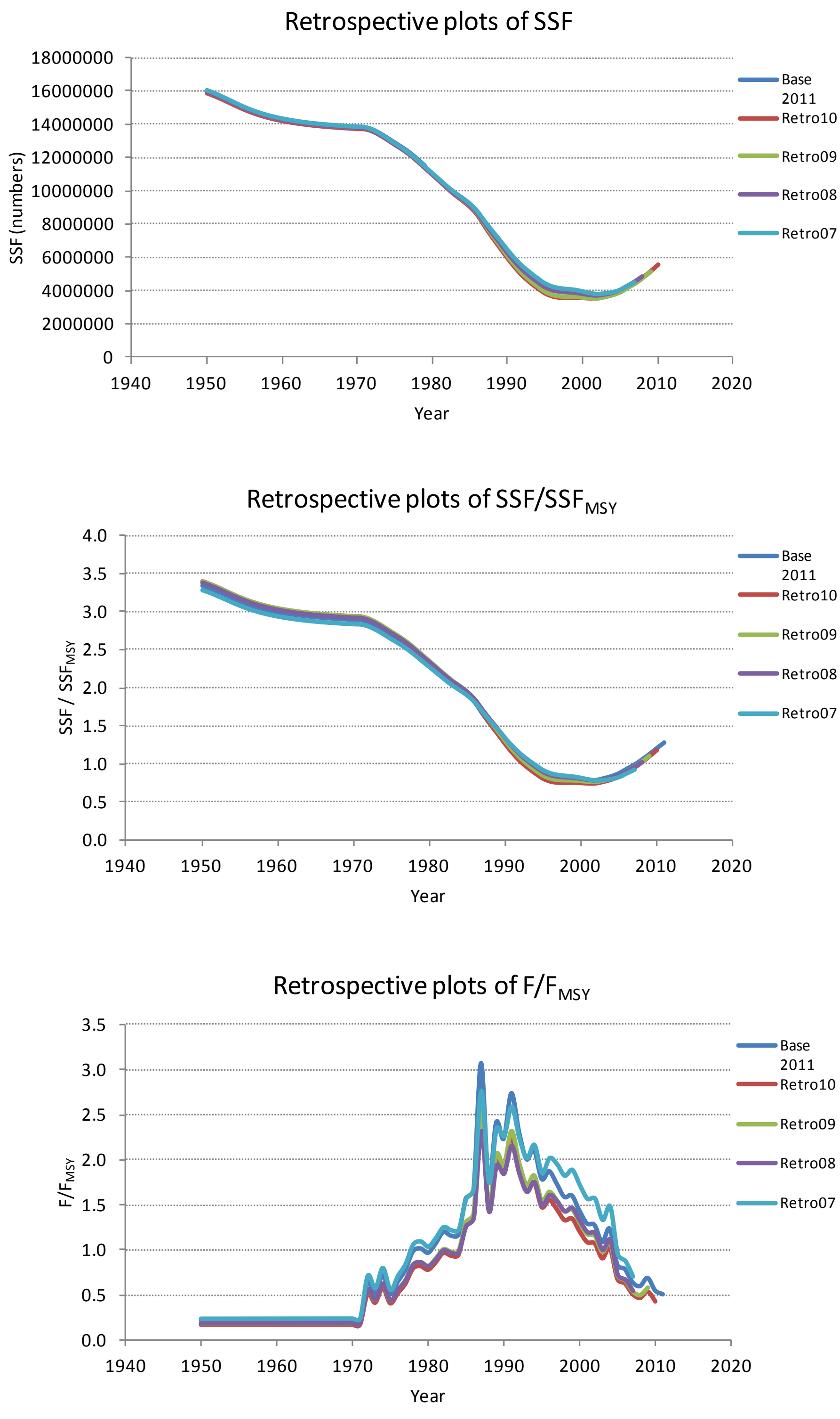


Figure 3.6.38. Retrospective analysis of the baseline run for bonnethead shark with last four years of data sequentially removed from the model. Model quantities examined include spawning stock fecundity (top), relative spawning stock fecundity (middle), and relative fishing mortality rate (bottom).

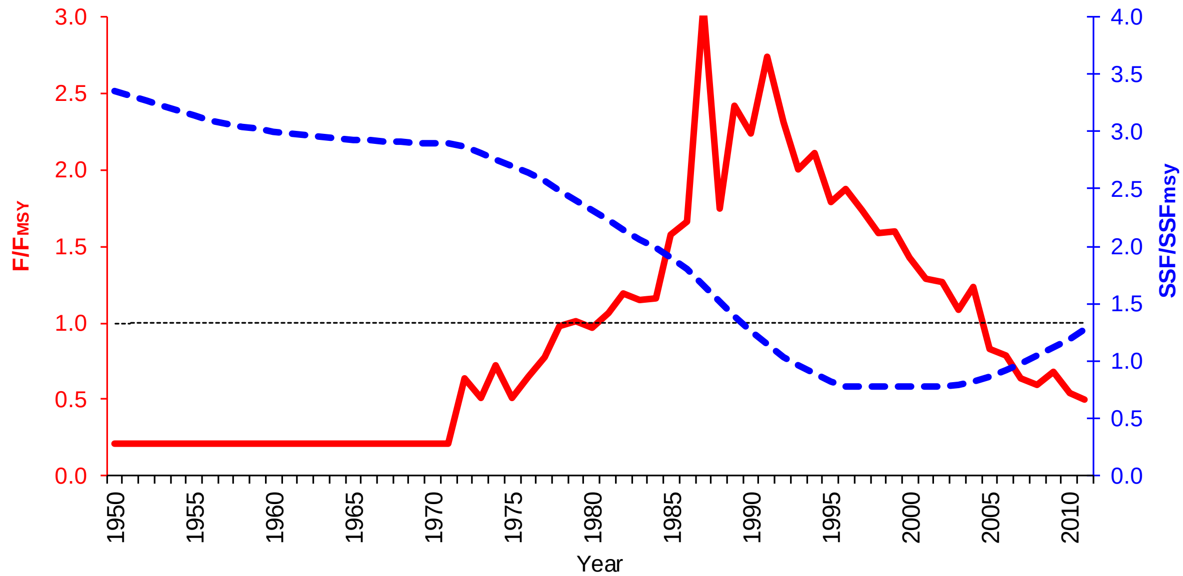


Figure 3.6.39. Estimated relative spawning stock fecundity and fishing mortality rate trajectories for bonnethead shark in the base run. The straight dashed line indicates F_{MSY}.

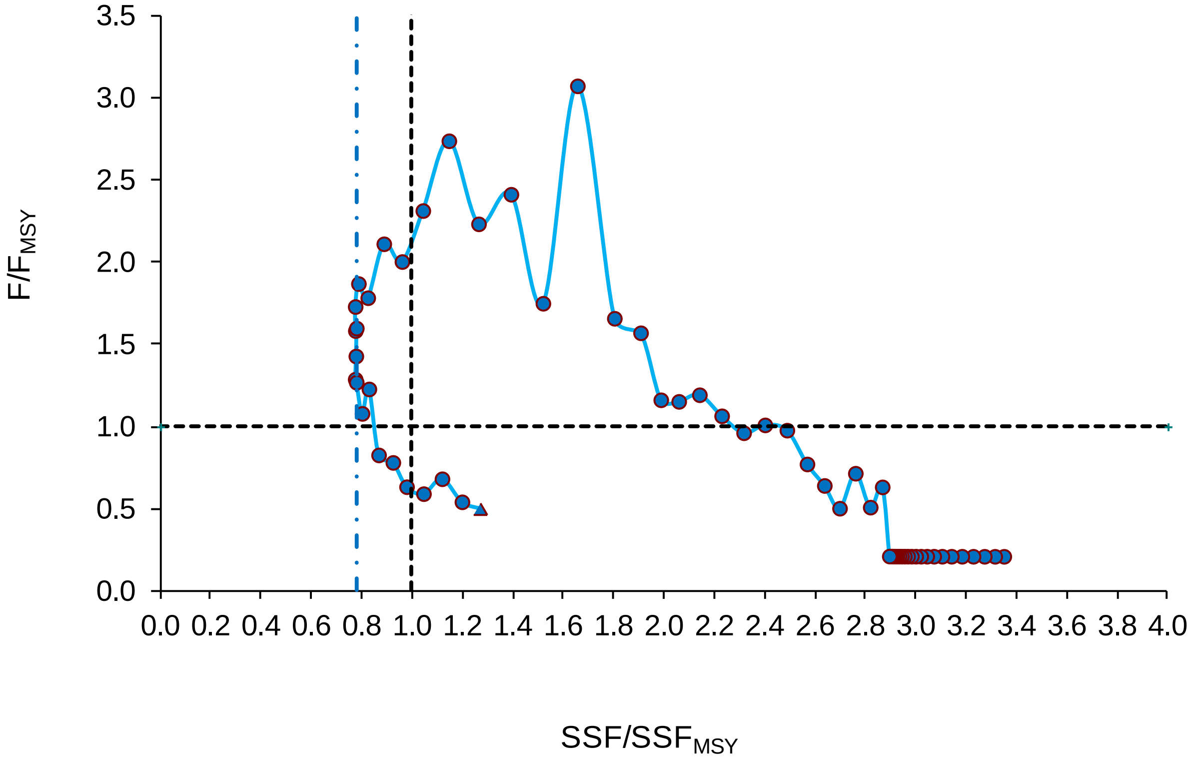


Figure 3.6.40. Phase plot of relative spawning stock fecundity and fishing mortality rate by year for the base run. The triangle (1.27, 0.50) indicates current (for 2011) conditions. The dashed vertical blue line indicates MSST ((1-M)*SSF_{MSY}).

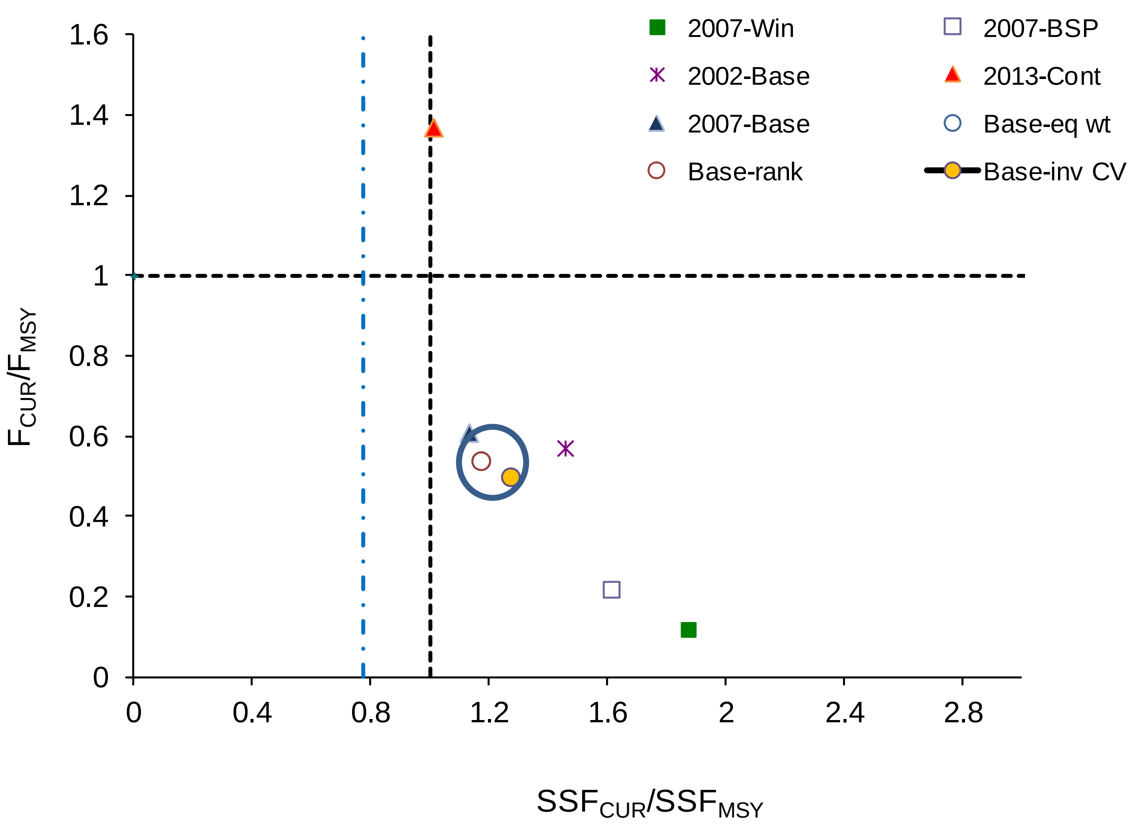


Figure 3.6.41. Phase plot of bonnethead shark stock status. Results are shown for the base model (base) with rank weighting (base-rank), inverse CV weighting (base-inv CV), and equal weighting (base-eq wt), continuity analysis (2013-Cont), 2007 and 2002 assessment base models (2007-Base, 2002-Base), and Bayesian Surplus Production (BSP) 2007 base model (2007-BSP) and Bayesian State-Space Surplus Production WinBUGS 2007 base model (2007-Win). The circle indicates the position of the three variants of the base run. The vertical dashed blue line denotes MSST ($(1\text{-}M)*SSF_{MSY}$), where M is the mean of age1+ values. None of the runs estimated an overfished stock (to the left of the MSST line) and only the continuity run indicated overfishing was occurring (above the horizontal black line). Note that "CUR" refers to different terminal years depending on the assessment: 2011 for this assessment; 2005 for assessments completed in 2007, and 2000 for the 2002 assessment.

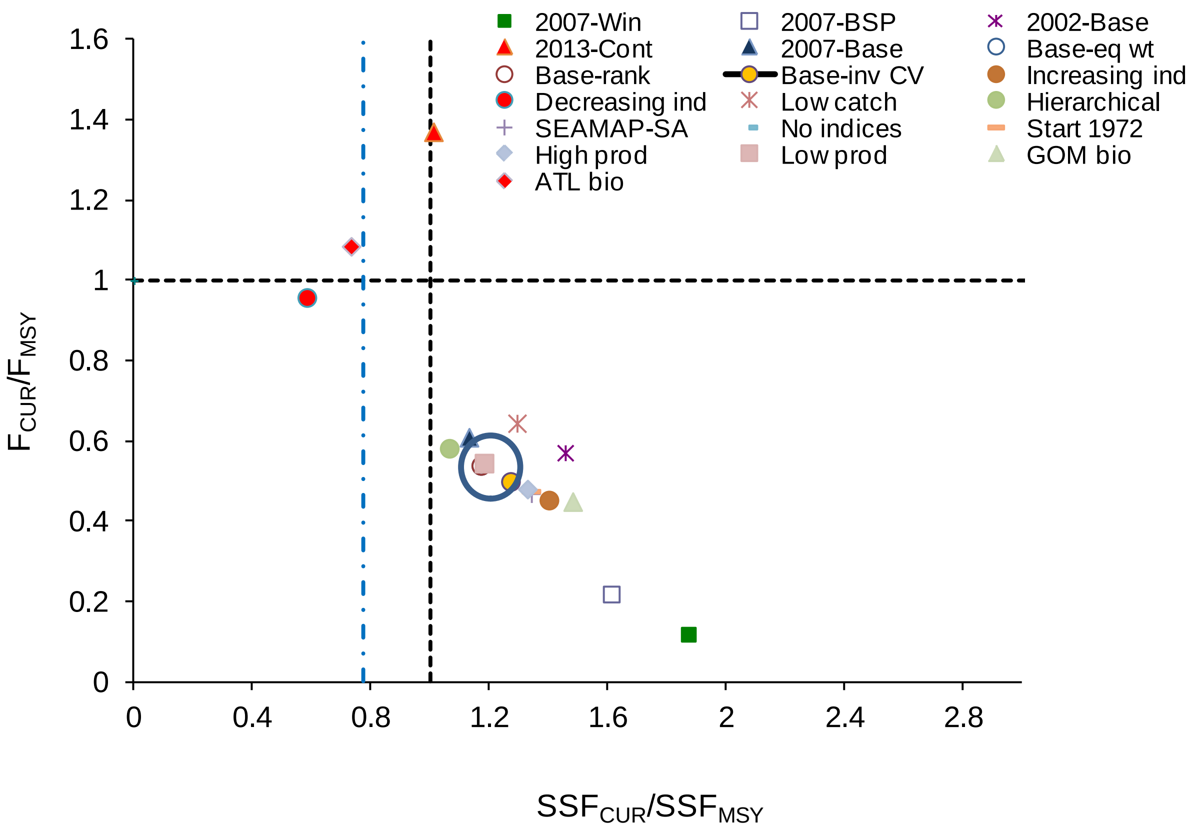


Figure 3.6.42. Phase plot of bonnethead shark stock status. In addition to the results shown in the previous figure, those from all the sensitivity scenarios run are depicted: using increasing and decreasing relative abundance indices only (Increasing ind; Decreasing ind); using the hierarchical index (Hierarchical), using the SEAMAP-SA index only (SEAMAP-SA), using no indices at all (No indices), considering low catches (Low catch), starting the model in 1972 (Start 1972), considering a lower productivity (Low prod) or higher productivity (High prod) than the base run, and assessing the stock with the Gulf of Mexico biology (GOM bio) or Atlantic biology (ATL bio). The vertical dashed blue line denotes MSST ((1-M)*SSF_{MSY}), where M is the mean of age1+ values. Note that "CUR" refers to different terminal years depending on the assessment: 2011 for this assessment; 2005 for assessments completed in 2007, and 2000 for the 2002 assessment. The run that used decreasing indices (Decreasing ind), the run that used the Atlantic biology (ATL bio), and the run that used no indices (No indices; not plotted for ease of viewing; coordinates are (0.12, 3.74)) predicted an overfished stock (to the left of the MSST line); the ATL bio and No indices runs also predicted that overfishing was occurring (above the horizontal black line).

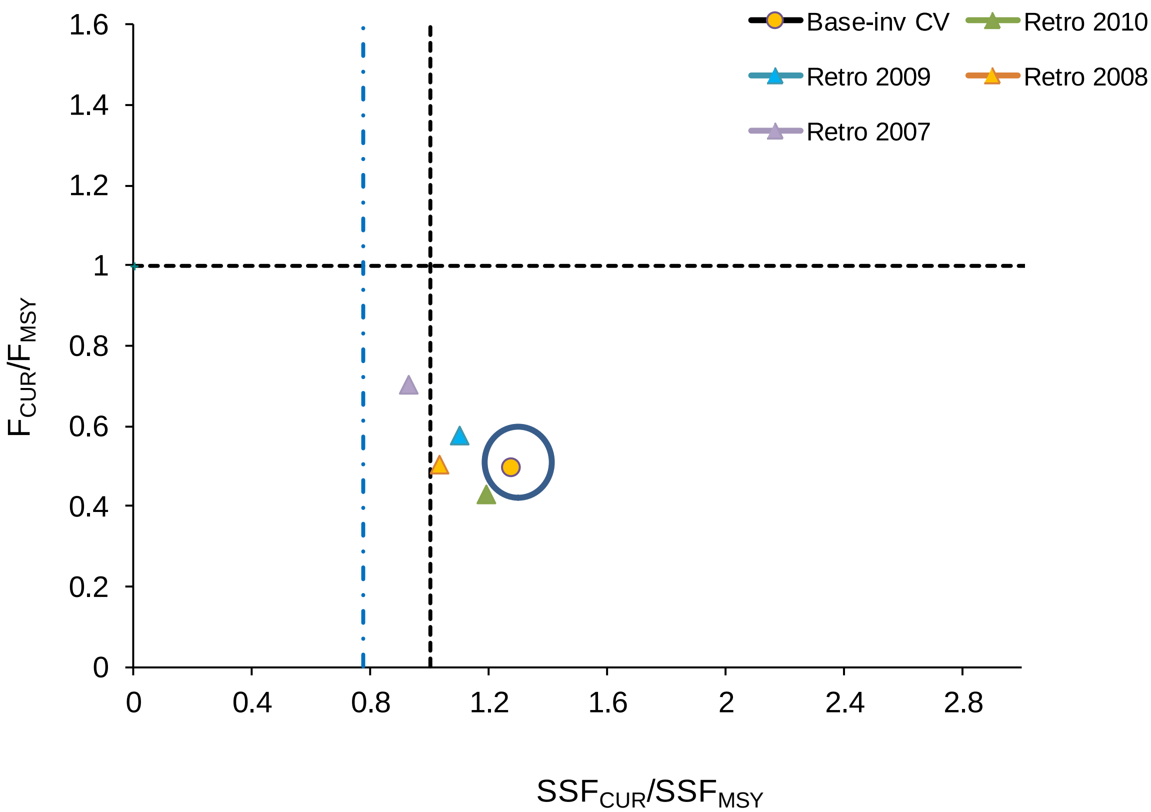


Figure 3.6.43. Phase plot of bonnethead shark stock status for the base run with inverse CV weighting and retrospective analysis of that run (sequentially dropping one year from the model: retro 2010, retro 2009, retro 2008, and retro 2007). The vertical dashed blue line denotes MSST ($(1\text{-}M)*SSF_{MSY}$), 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), but the status progressively became less optimistic with the sequential removal of one year at a time. Note that "CUR" refers to different terminal years depending on the assessment run.

Panel A. Projection Scenario-1 (Baseline, Inverse CV Weighting)

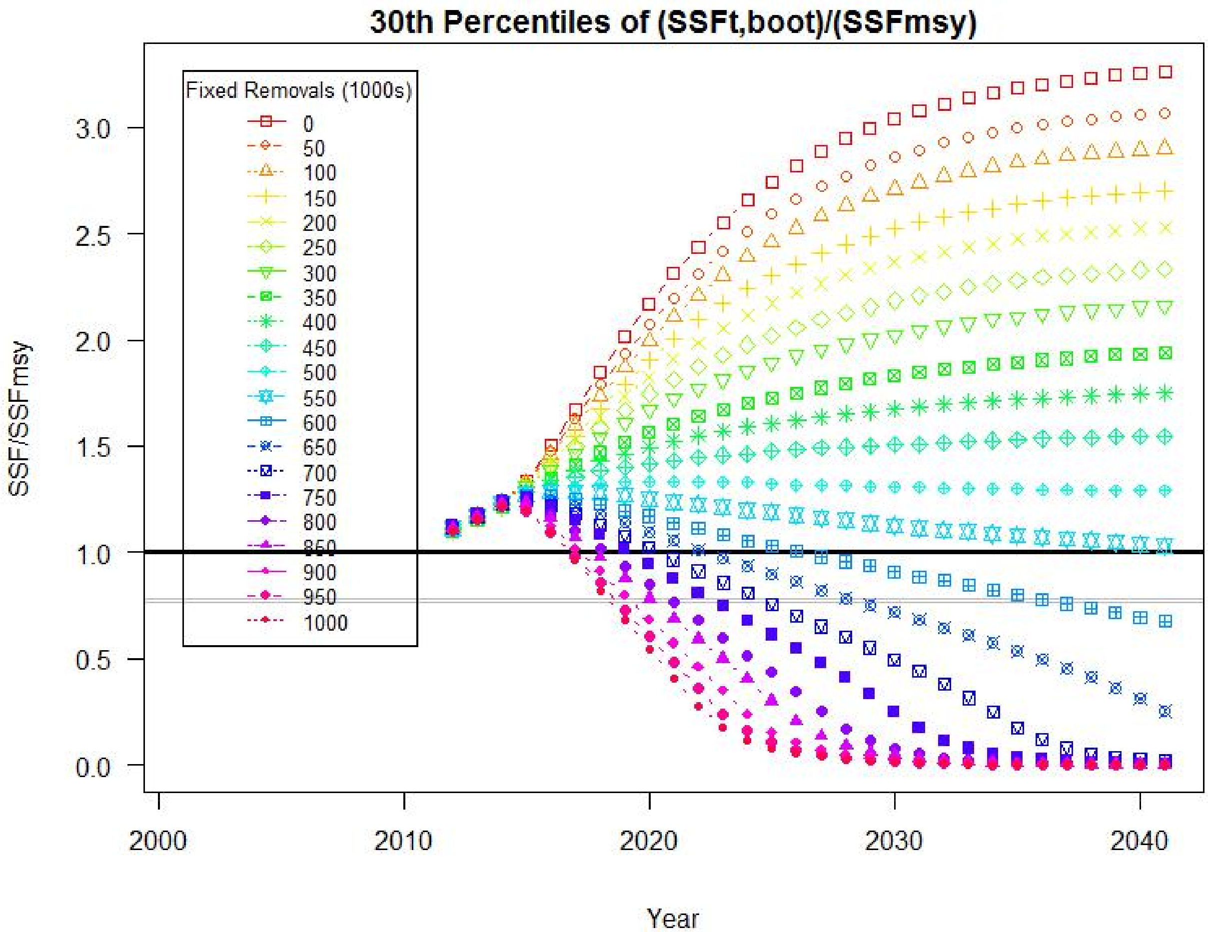


Figure 3.6.44. The 30th percentile of $SSF_{t,boot}$/ SSF_{MSY} represents the 70% probability of maintaining $SSF_{t,}$ above SSF_{MSY} from 10,000 Monte Carlo bootstrap projections for a given level of fixed removals (in 1000s) and a given year (2015 – 2041).

Panel B. Projection Scenario-2 (Sensitivity, Increasing Indices)

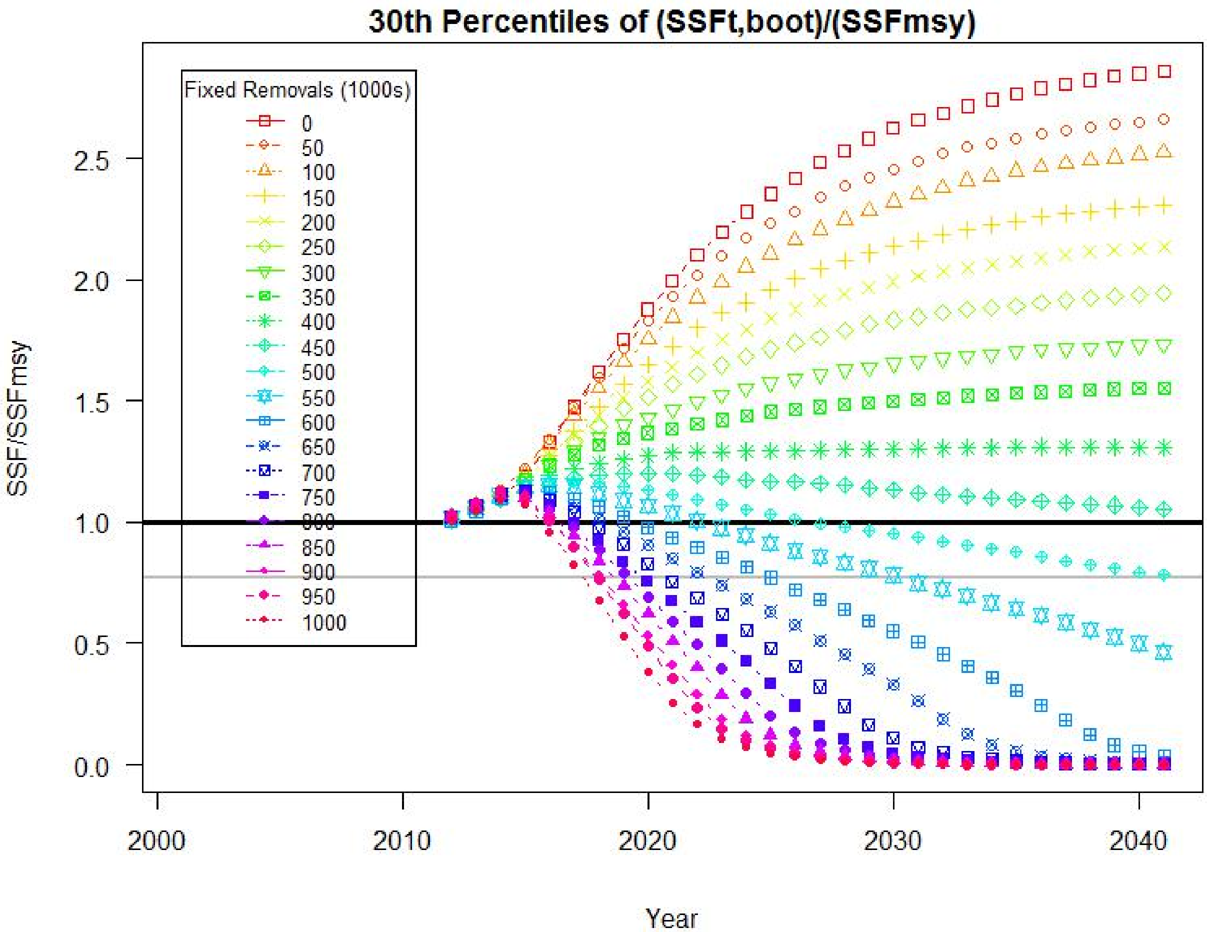


Figure 3.6.44 (continued). The 30th percentile of $SSF_{t,boot}$/ SSF_{MSY} represents the 70% probability of maintaining $SSF_{t,}$ above SSF_{MSY} from 10,000 Monte Carlo bootstrap projections for a given level of fixed removals (in 1000s) and a given year (2015 – 2041).

Panel C. Projection Scenario-3 (Sensitivity, Decreasing Indices)

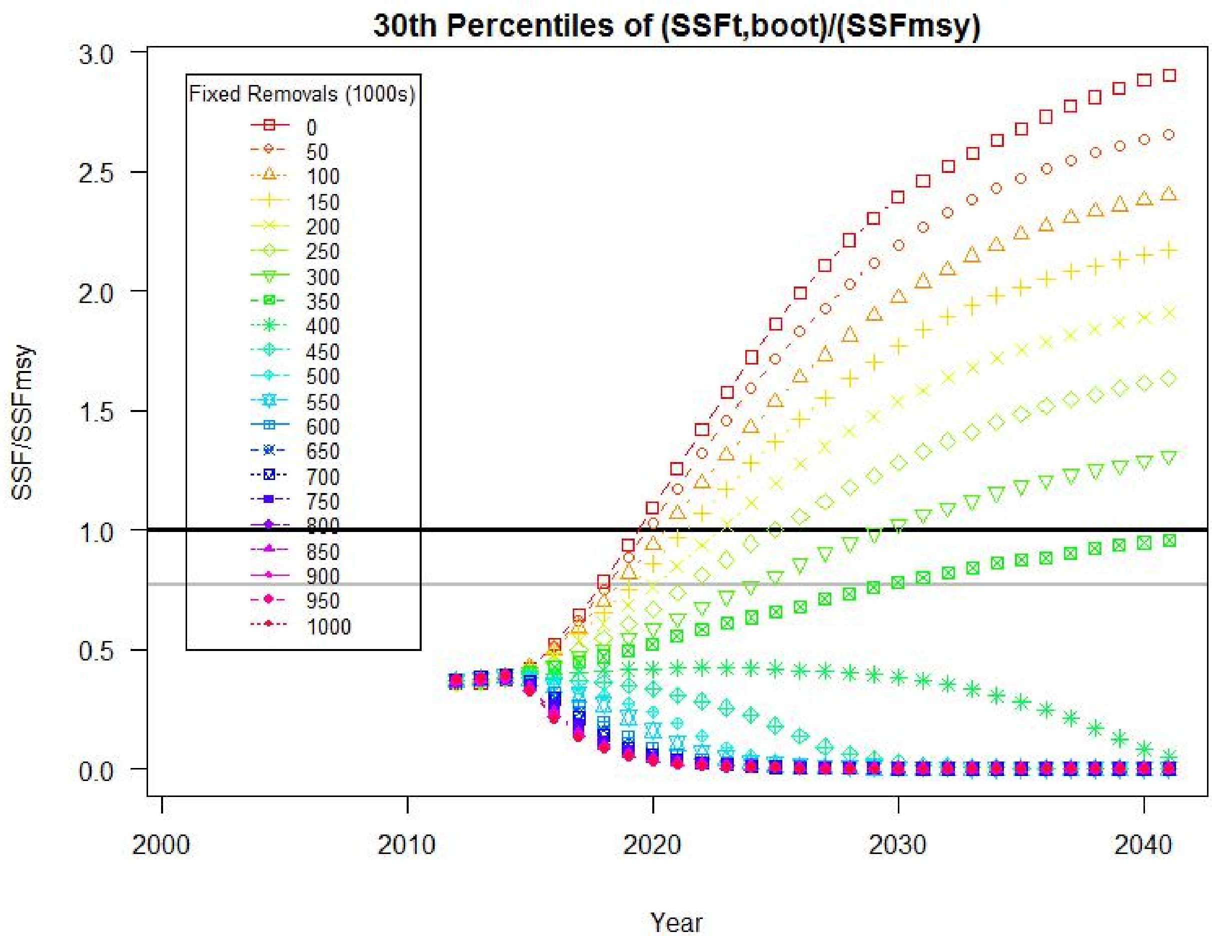


Figure 3.6.44 (continued). The 30th percentile of $SSF_{t,boot}$/ SSF_{MSY} represents the 70% probability of maintaining $SSF_{t,}$ above SSF_{MSY} from 10,000 Monte Carlo bootstrap projections for a given level of fixed removals (in 1000s) and a given year (2015 – 2041).

Panel D. Projection Scenario-4 (Sensitivity, Low Catch)

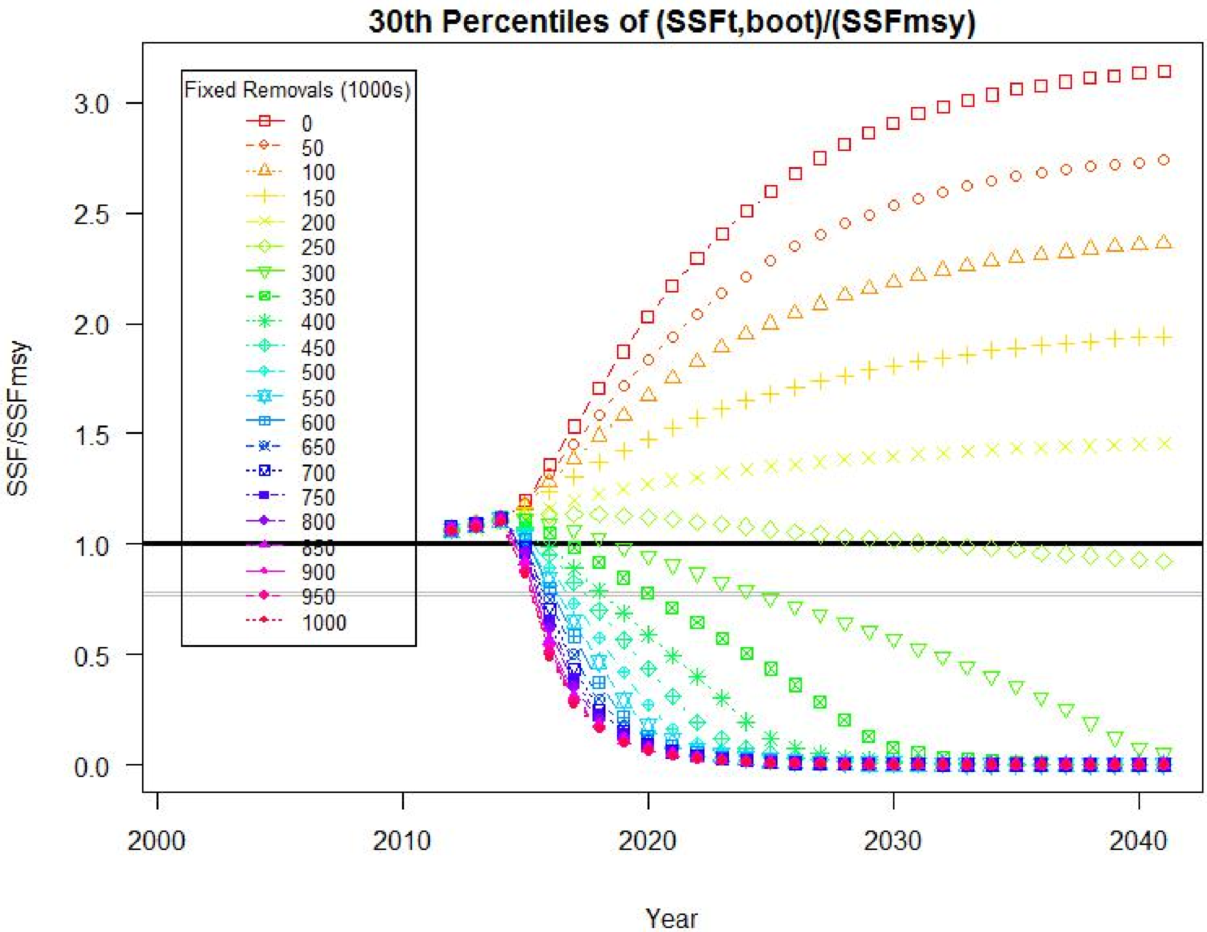


Figure 3.6.44 (continued). The 30th percentile of $SSF_{t,boot}$/ SSF_{MSY} represents the 70% probability of maintaining SSF_t, above SSF_{MSY} from 10,000 Monte Carlo bootstrap projections for a given level of fixed removals (in 1000s) and a given year (2015 – 2041).

Panel E. Projection Scenario-5 (Sensitivity, Hierarchical Index)

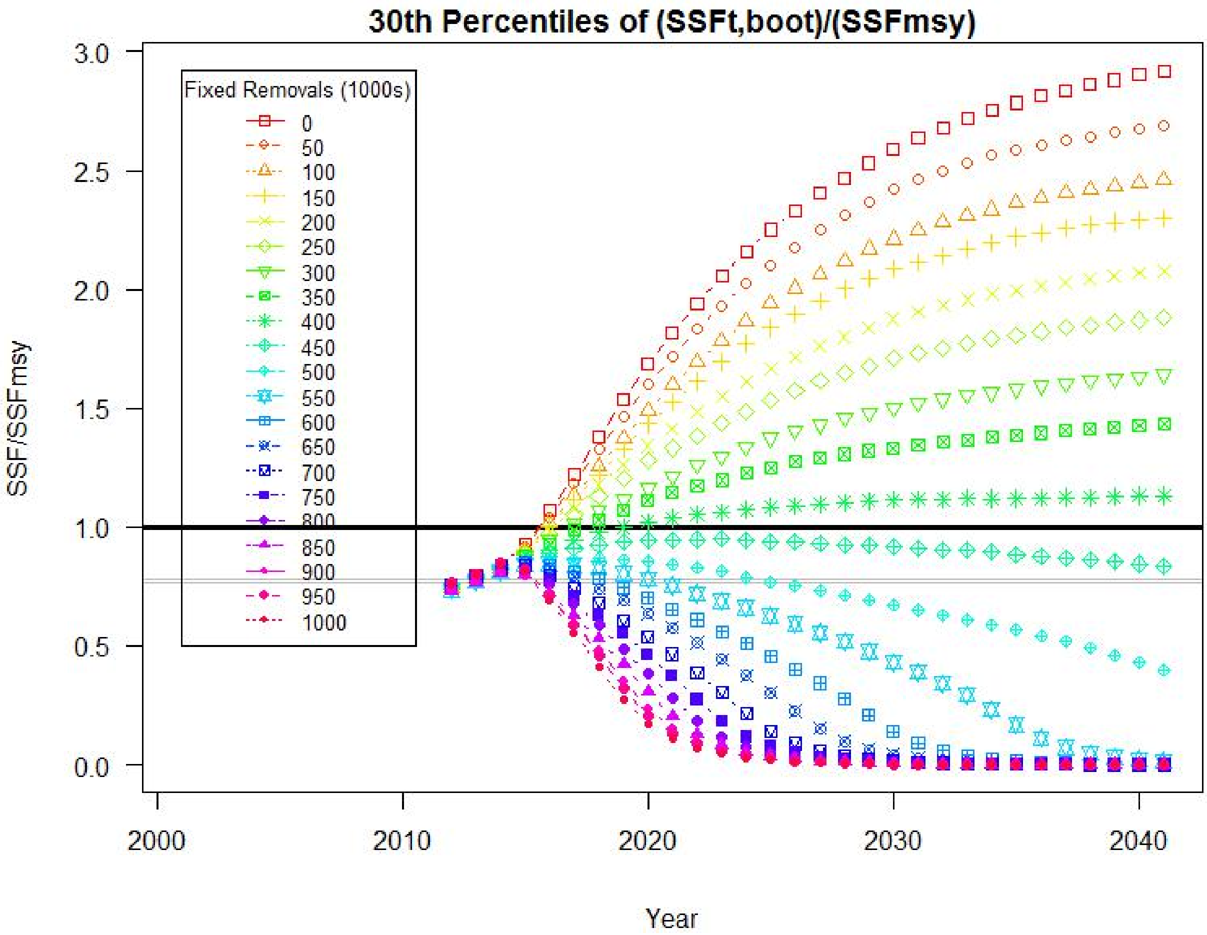


Figure 3.6.44 (continued). The 30th percentile of $SSF_{t,boot}$/ SSF_{MSY} represents the 70% probability of maintaining $SSF_{t,}$ above SSF_{MSY} from 10,000 Monte Carlo bootstrap projections for a given level of fixed removals (in 1000s) and a given year (2015 – 2041).

Panel F. Projection Scenario-6 (Sensitivity, Model Start in 1972)

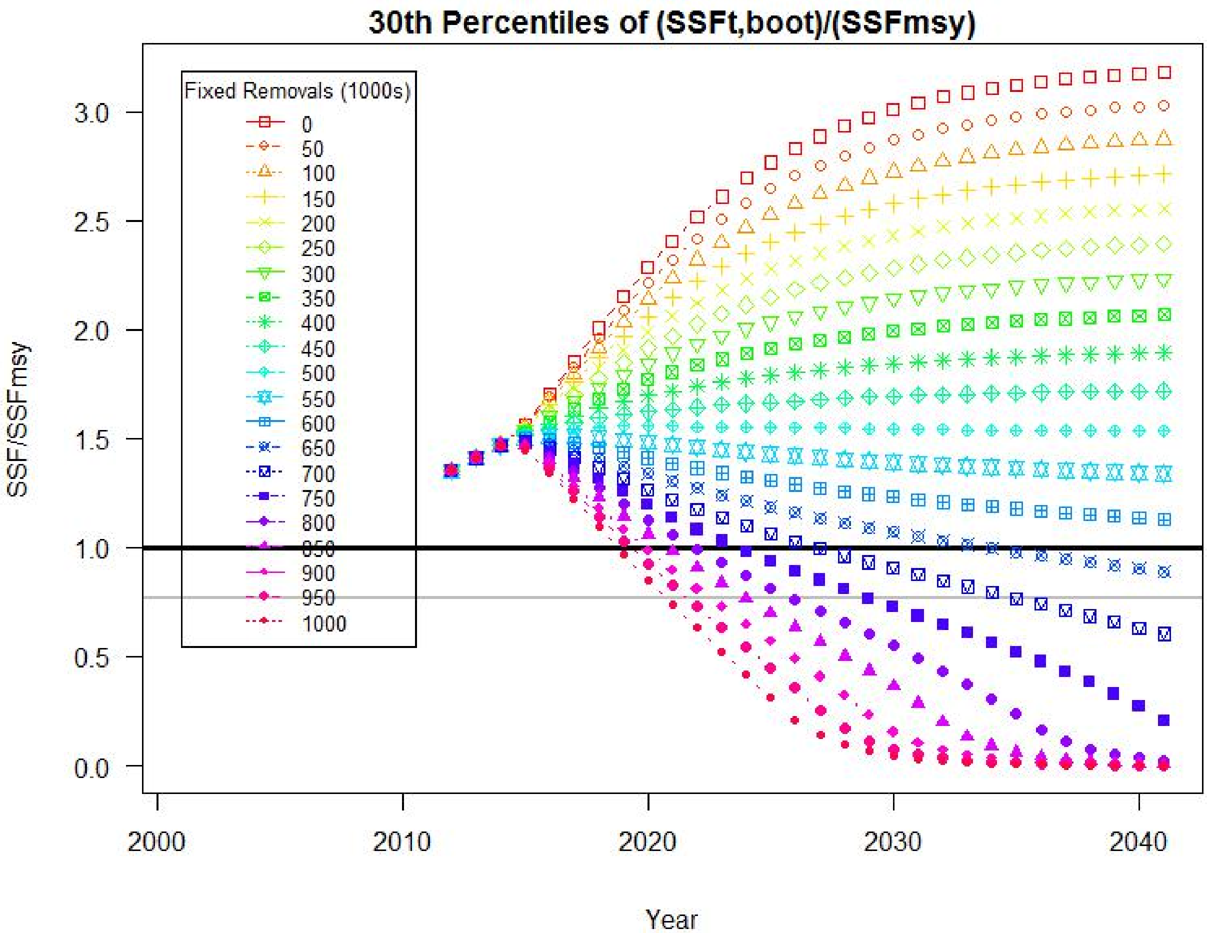


Figure 3.6.44 (continued). The 30th percentile of $SSF_{t,boot}$/ SSF_{MSY} represents the 70% probability of maintaining $SSF_{t,}$ above SSF_{MSY} from 10,000 Monte Carlo bootstrap projections for a given level of fixed removals (in 1000s) and a given year (2015 – 2041).

Panel G. Projection Scenario-7 (Sensitivity, High Productivity)

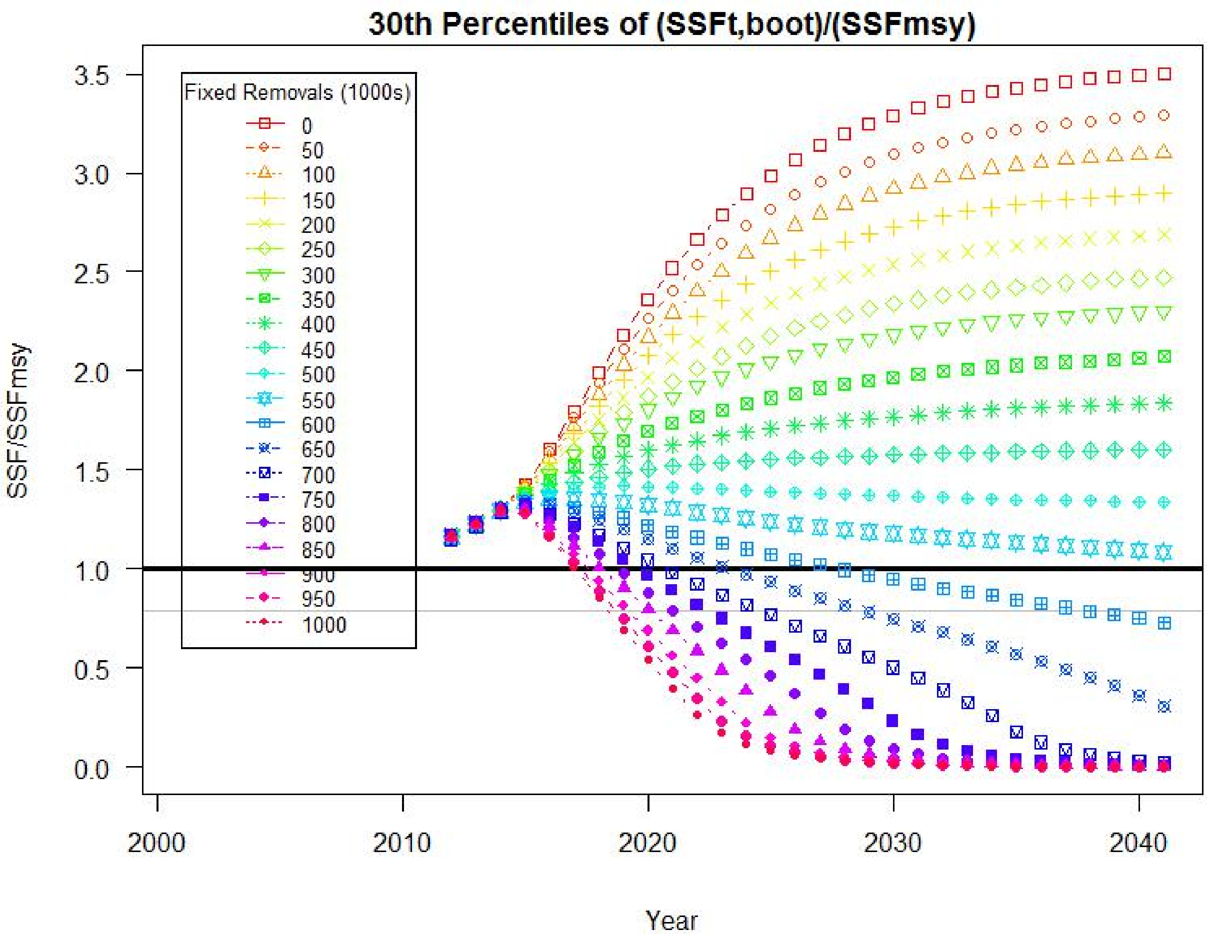


Figure 3.6.44 (continued). The 30th percentile of $SSF_{t,boot}$/ SSF_{MSY} represents the 70% probability of maintaining $SSF_{t,}$ above SSF_{MSY} from 10,000 Monte Carlo bootstrap projections for a given level of fixed removals (in 1000s) and a given year (2015 – 2041).

Panel H. Projection Scenario-8 (Sensitivity, Low Productivity)

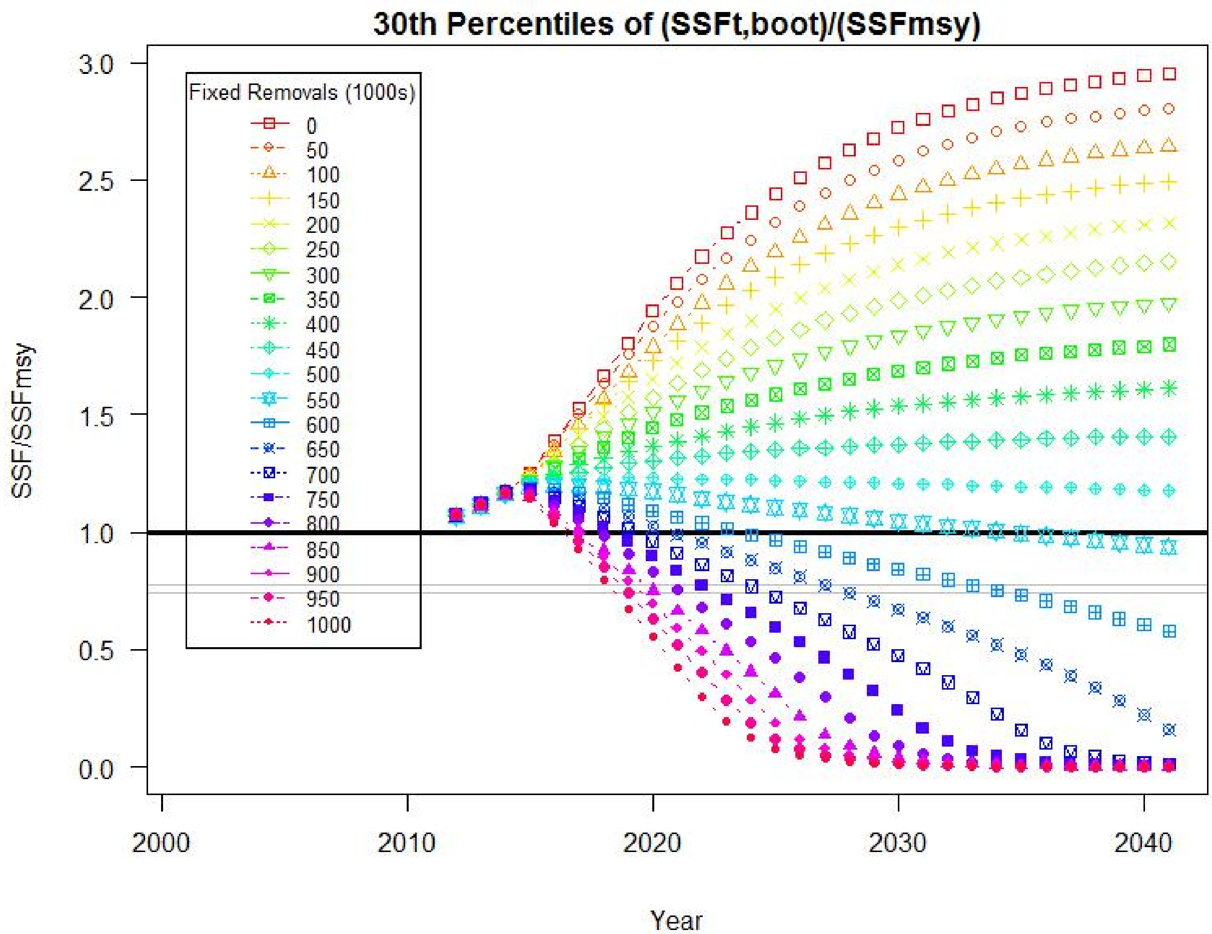


Figure 3.6.44 (continued). The 30th percentile of $SSF_{t,boot}$/ SSF_{MSY} represents the 70% probability of maintaining $SSF_{t,}$ above SSF_{MSY} from 10,000 Monte Carlo bootstrap projections for a given level of fixed removals (in 1000s) and a given year (2015 – 2041).

Panel I. Projection Scenario-9 (Sensitivity, SEAMAP-SA)

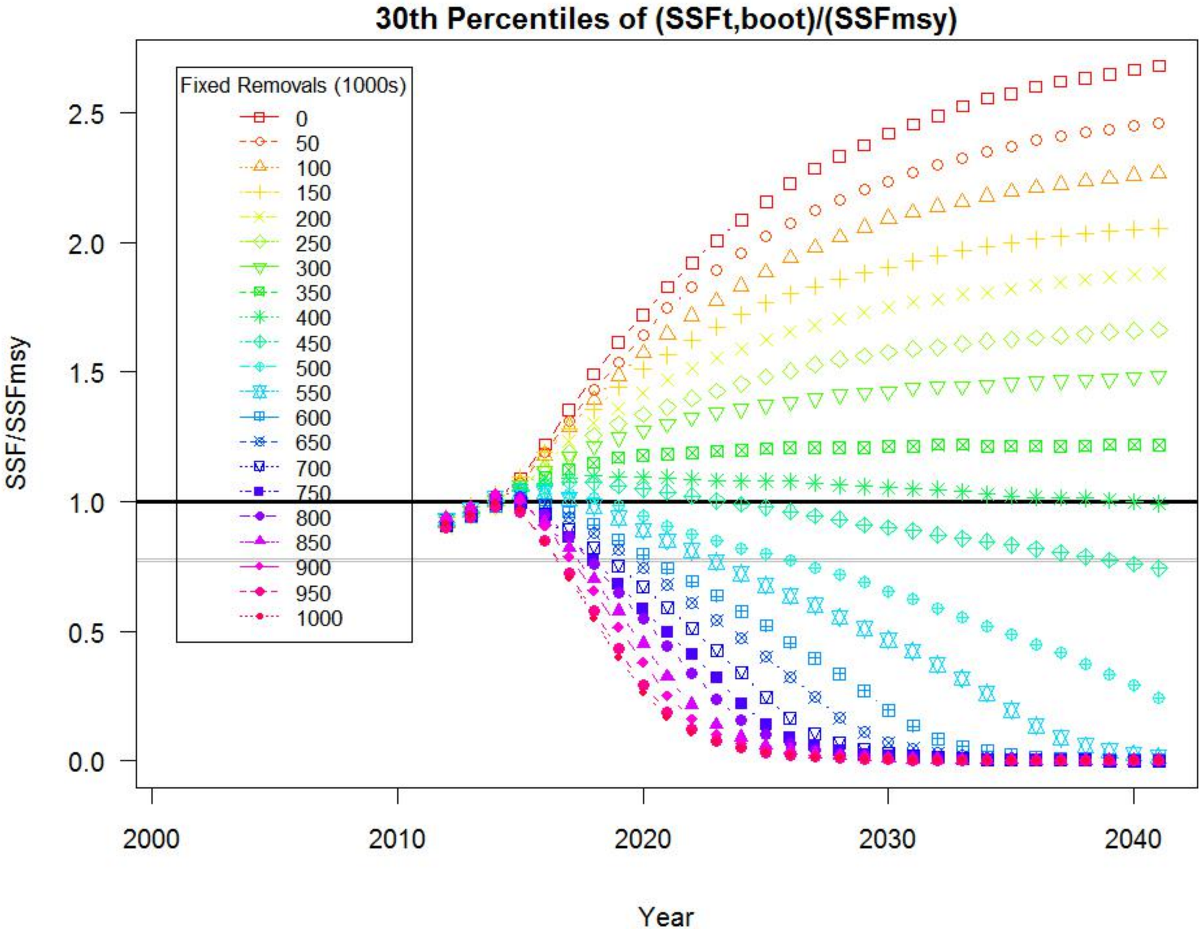


Figure 3.6.44 (continued). The 30th percentile of $SSF_{t,boot}$/ SSF_{MSY} represents the 70% probability of maintaining $SSF_{t,}$ above SSF_{MSY} from 10,000 Monte Carlo bootstrap projections for a given level of fixed removals (in 1000s) and a given year (2015 – 2041).

Panel J. Projection Scenario-10 (Sensitivity, Gulf of Mexico Biology)

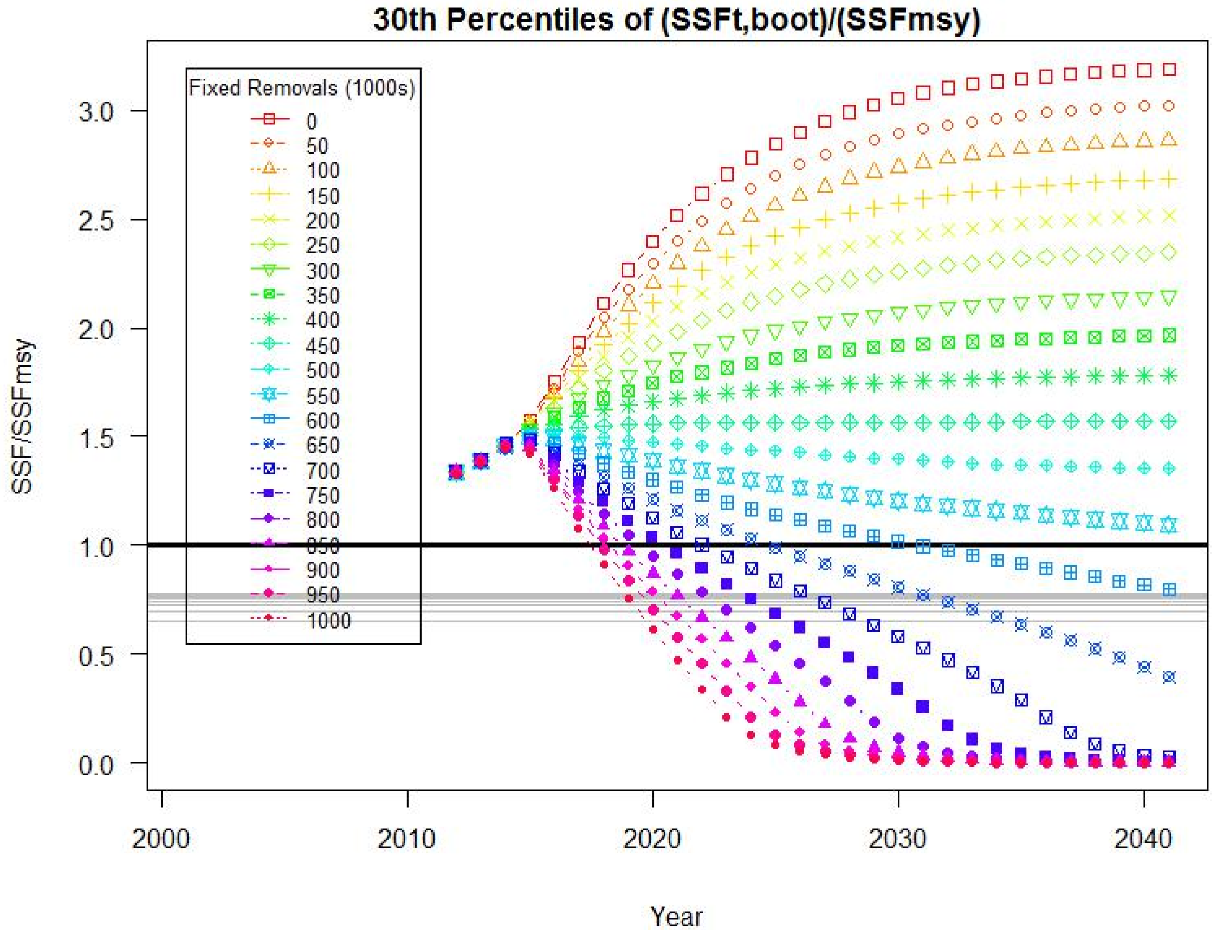


Figure 3.6.44 (continued). The 30th percentile of $SSF_{t,boot}$/ SSF_{MSY} represents the 70% probability of maintaining $SSF_{t,}$ above SSF_{MSY} from 10,000 Monte Carlo bootstrap projections for a given level of fixed removals (in 1000s) and a given year (2015 – 2041).

Panel K. Projection Scenario-11 (Sensitivity, Atlantic Biology)

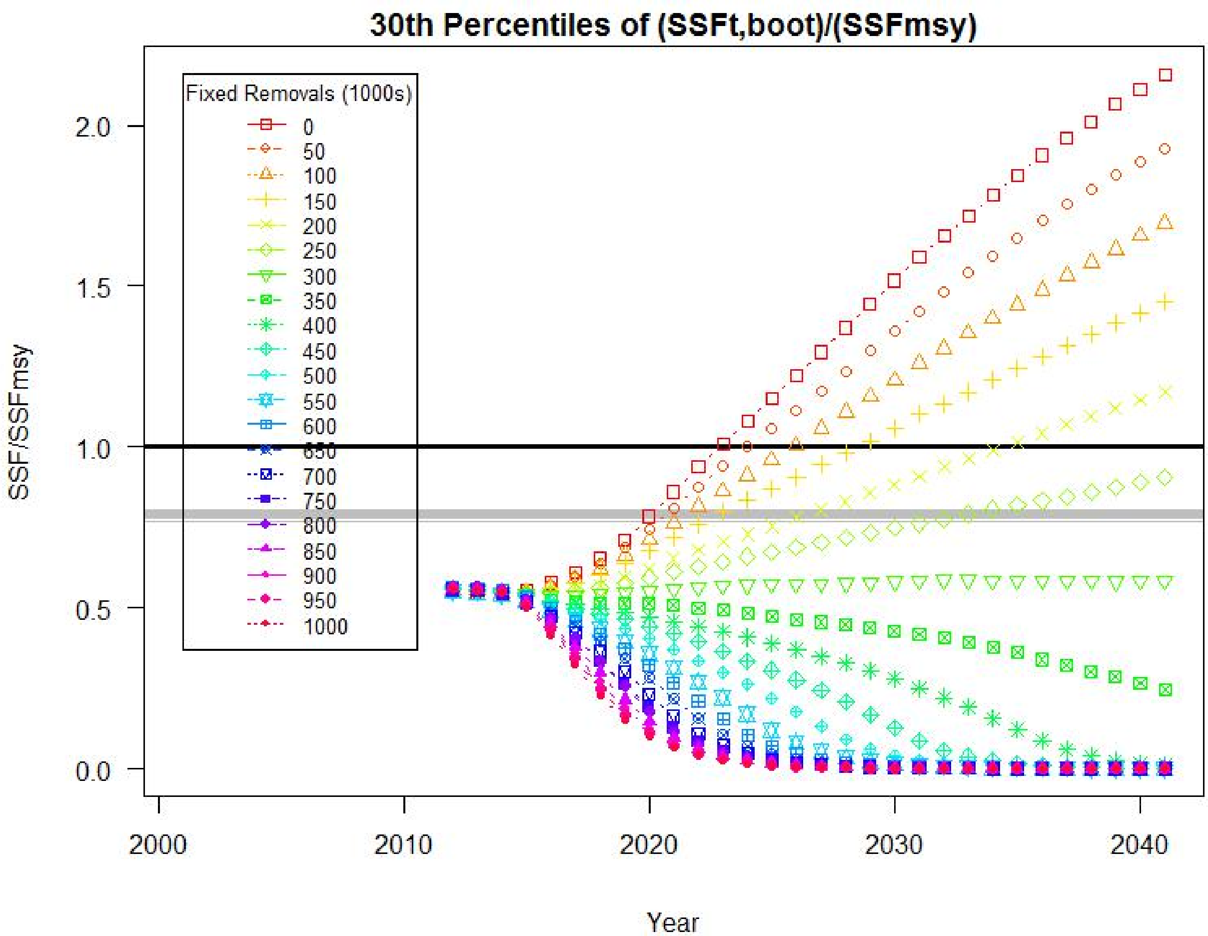


Figure 3.6.44 (continued). The 30th percentile of $SSF_{t,boot}$/ SSF_{MSY} represents the 70% probability of maintaining $SSF_{t,}$ above SSF_{MSY} from 10,000 Monte Carlo bootstrap projections for a given level of fixed removals (in 1000s) and a given year (2015 – 2041).

Panel A. Projection Scenario-1 (Baseline, Inverse CV Weighting)

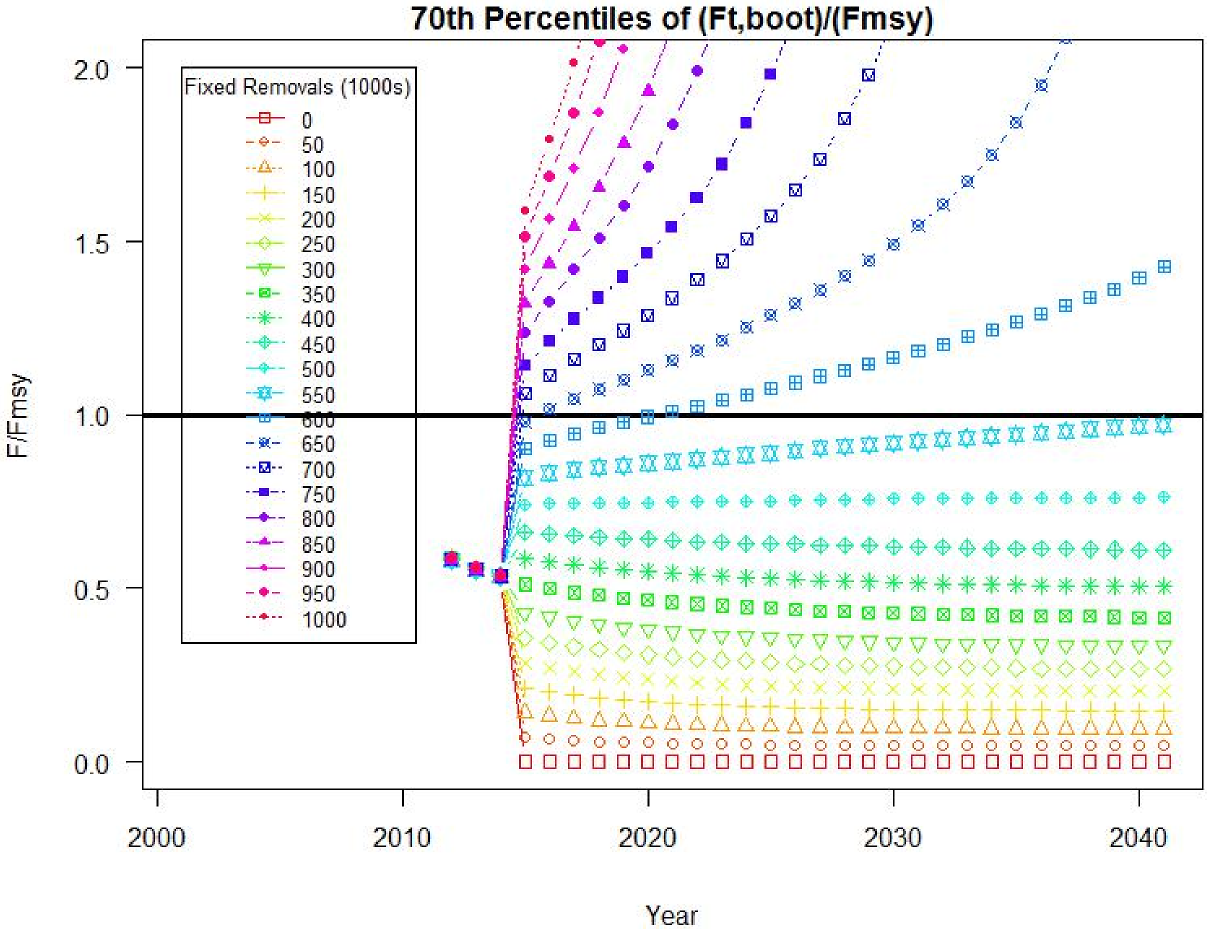


Figure 3.6.45. The 70th percentile of $F_{t,boot}$/ F_{MSY} represents the 30% probability of F_t exceeding F_{MSY} from 10,000 Monte Carlo bootstrap projections for a given level of fixed removals (in 1000s) and a given year (2015 – 2041).

Panel B. Projection Scenario-2 (Sensitivity, Increasing Indices)

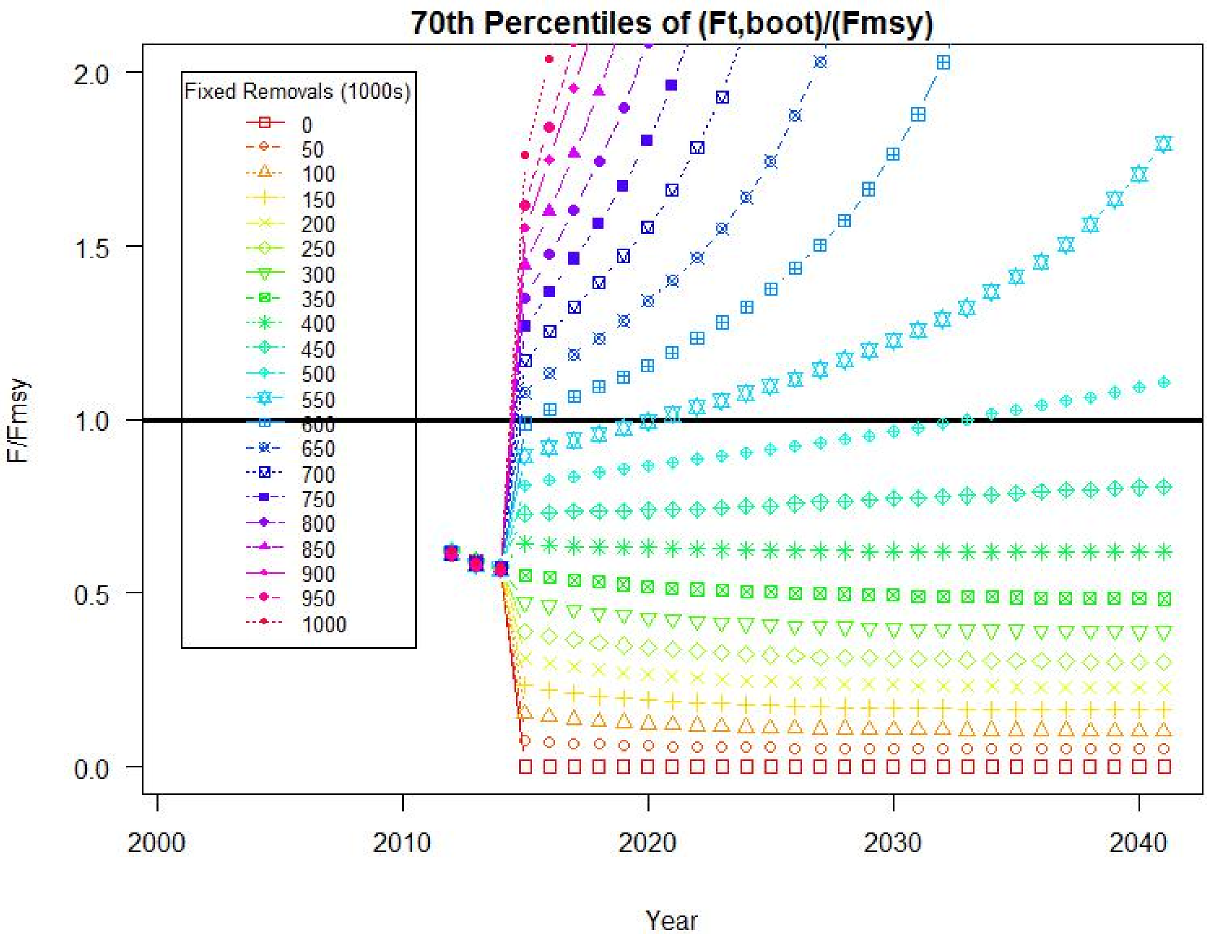


Figure 3.6.45 (continued). The 70th percentile of $F_{t,boot}$/ F_{MSY} represents the 30% probability of F_t exceeding F_{MSY} from 10,000 Monte Carlo bootstrap projections for a given level of fixed removals (in 1000s) and a given year (2015 – 2041).

Panel C. Projection Scenario-3 (Sensitivity, Decreasing Indices)

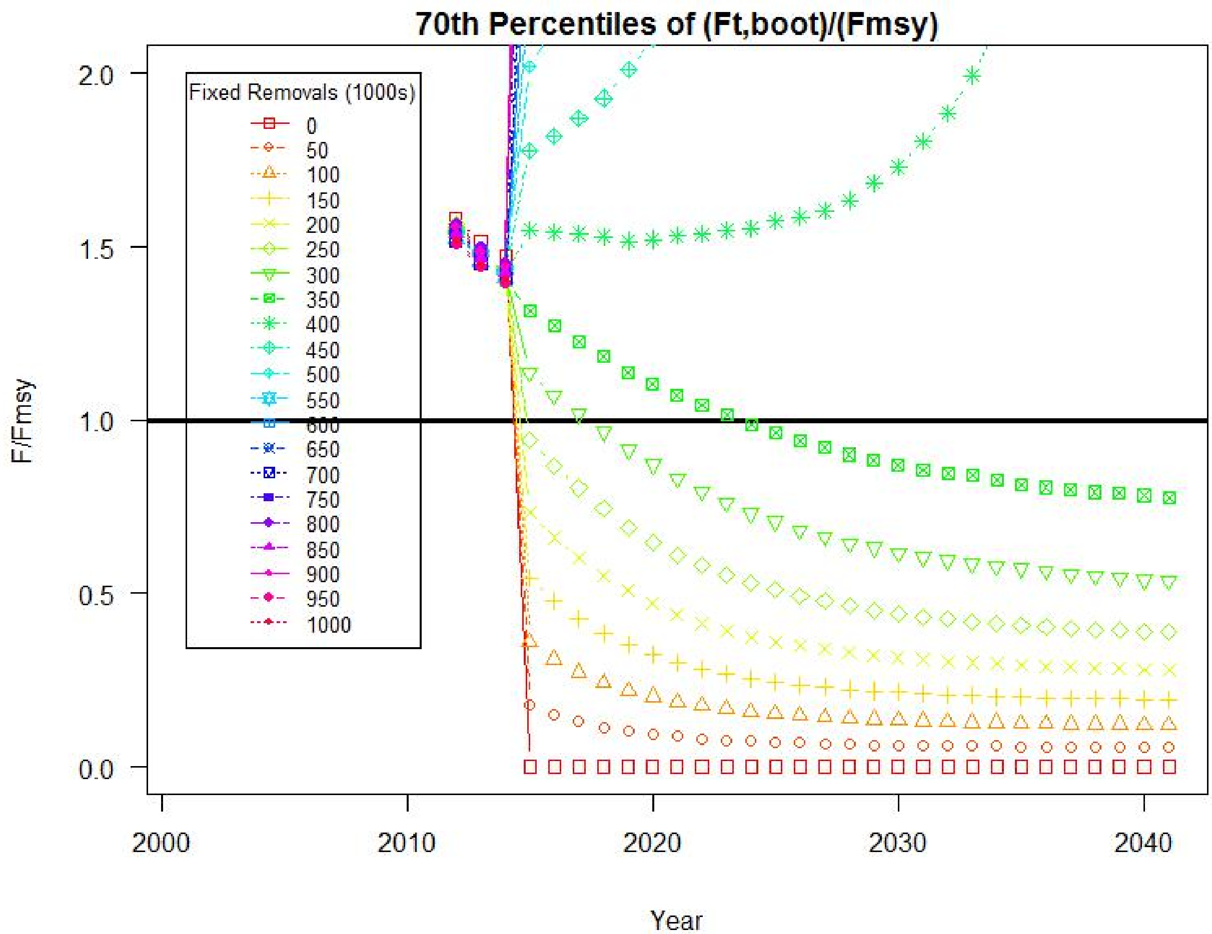


Figure 3.6.45 (continued). The 70th percentile of $F_{t,boot}$/ F_{MSY} represents the 30% probability of F_t exceeding F_{MSY} from 10,000 Monte Carlo bootstrap projections for a given level of fixed removals (in 1000s) and a given year (2015 – 2041).

Panel D. Projection Scenario-4 (Sensitivity, Low Catch)

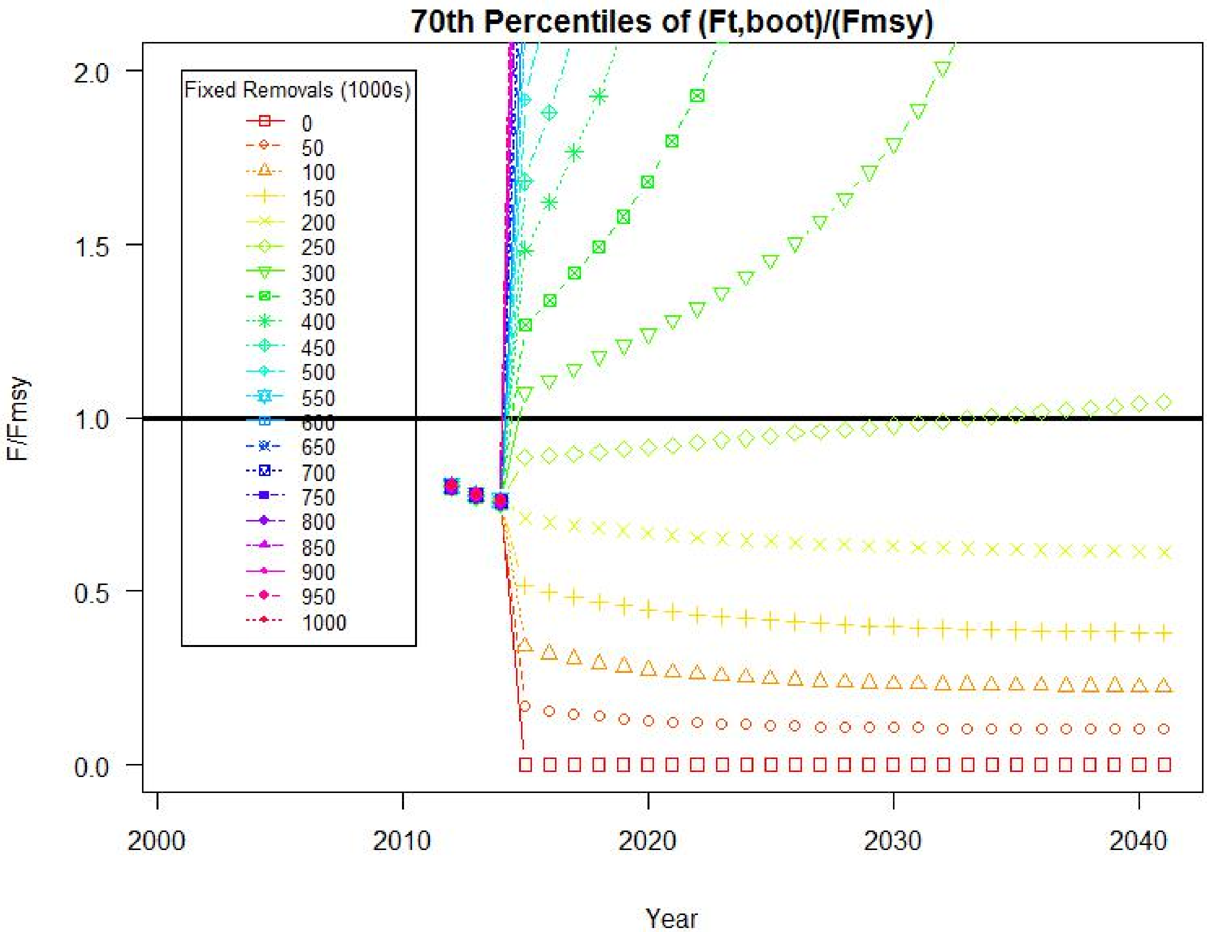


Figure 3.6.45 (continued). The 70th percentile of $F_{t,boot}$/ F_{MSY} represents the 30% probability of F_t exceeding F_{MSY} from 10,000 Monte Carlo bootstrap projections for a given level of fixed removals (in 1000s) and a given year (2015 – 2041).

Panel E. Projection Scenario-5 (Sensitivity, Hierarchical Index db exp)

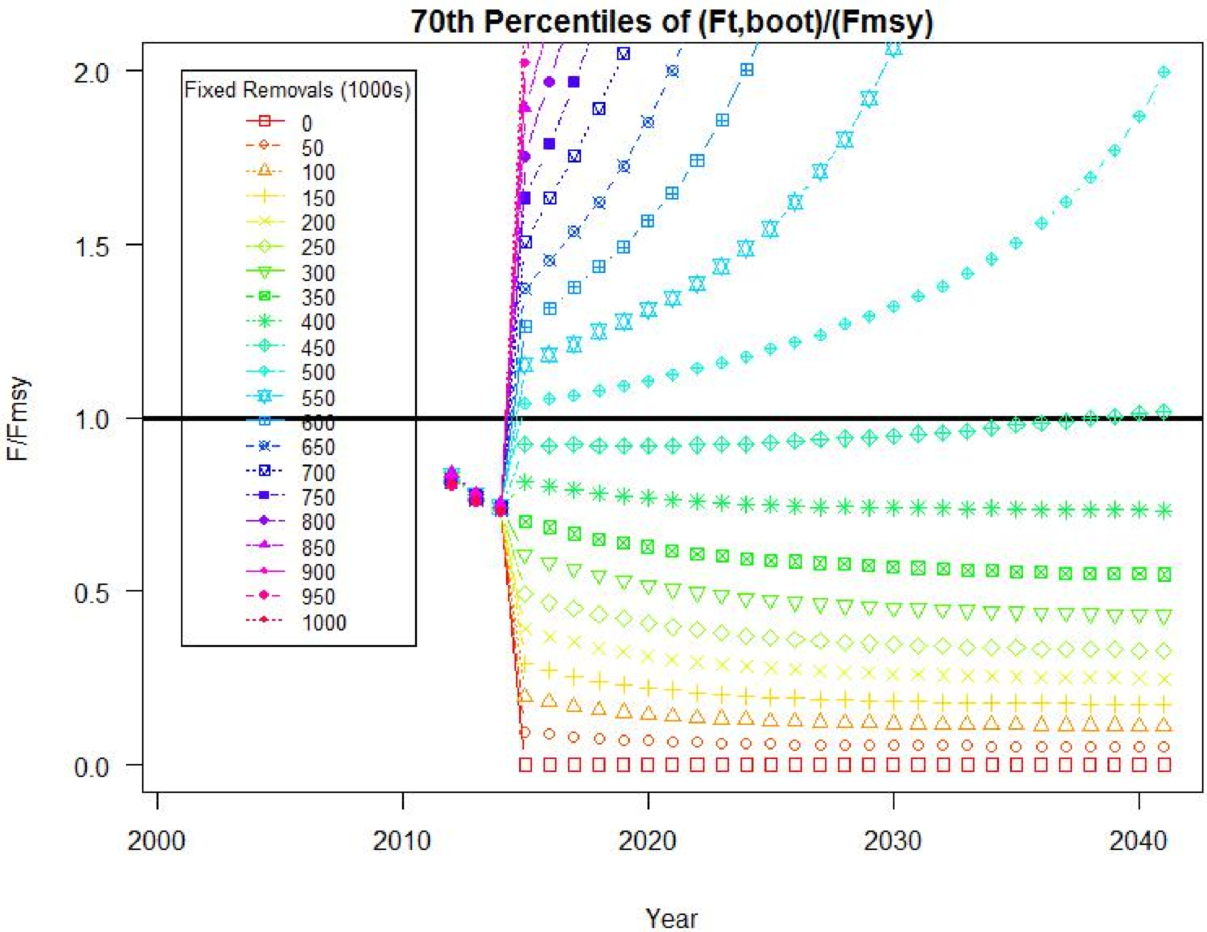


Figure 3.6.45 (continued). The 70th percentile of $F_{t,boot}$/ F_{MSY} represents the 30% probability of F_t exceeding F_{MSY} from 10,000 Monte Carlo bootstrap projections for a given level of fixed removals (in 1000s) and a given year (2015 – 2041).

Panel F. Projection Scenario-6 (Sensitivity, Model Start in 1972)

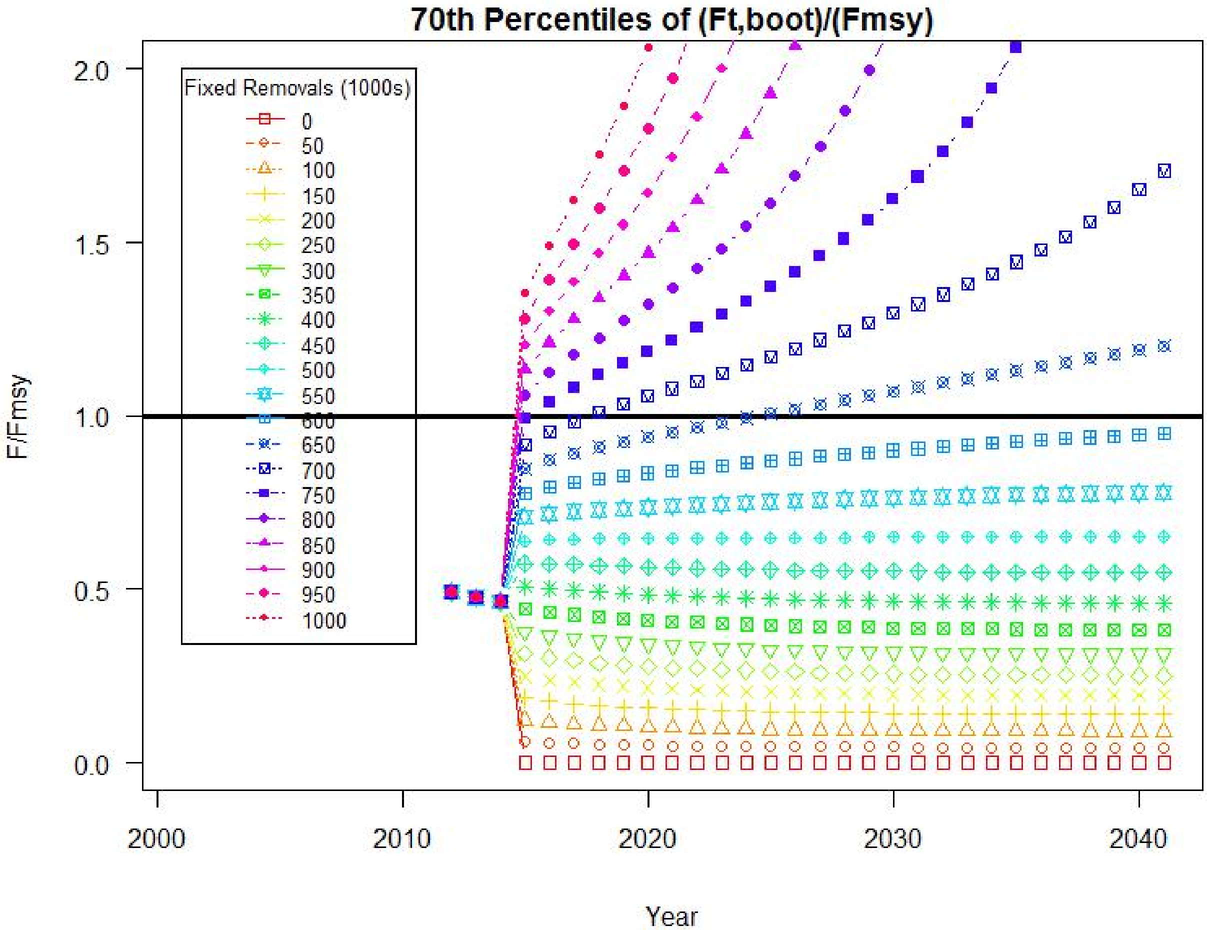


Figure 3.6.45 (continued). The 70th percentile of $F_{t,boot}$/ F_{MSY} represents the 30% probability of F_t exceeding F_{MSY} from 10,000 Monte Carlo bootstrap projections for a given level of fixed removals (in 1000s) and a given year (2015 – 2041).

Panel G. Projection Scenario-7 (Sensitivity, High Productivity)

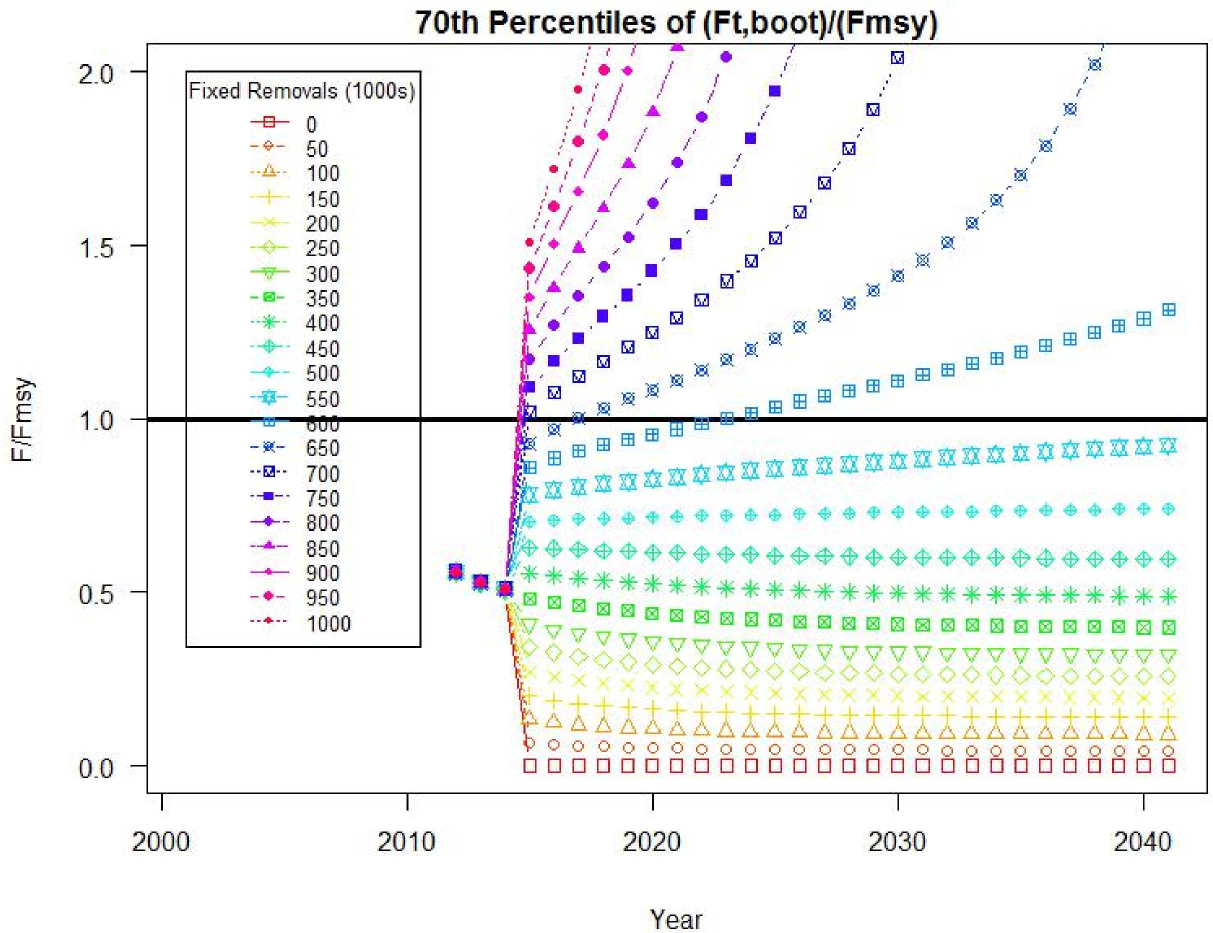


Figure 3.6.45 (continued). The 70th percentile of $F_{t,boot}$/ F_{MSY} represents the 30% probability of F_t exceeding F_{MSY} from 10,000 Monte Carlo bootstrap projections for a given level of fixed removals (in 1000s) and a given year (2015 – 2041).

Panel H. Projection Scenario-8 (Sensitivity, Low Productivity)

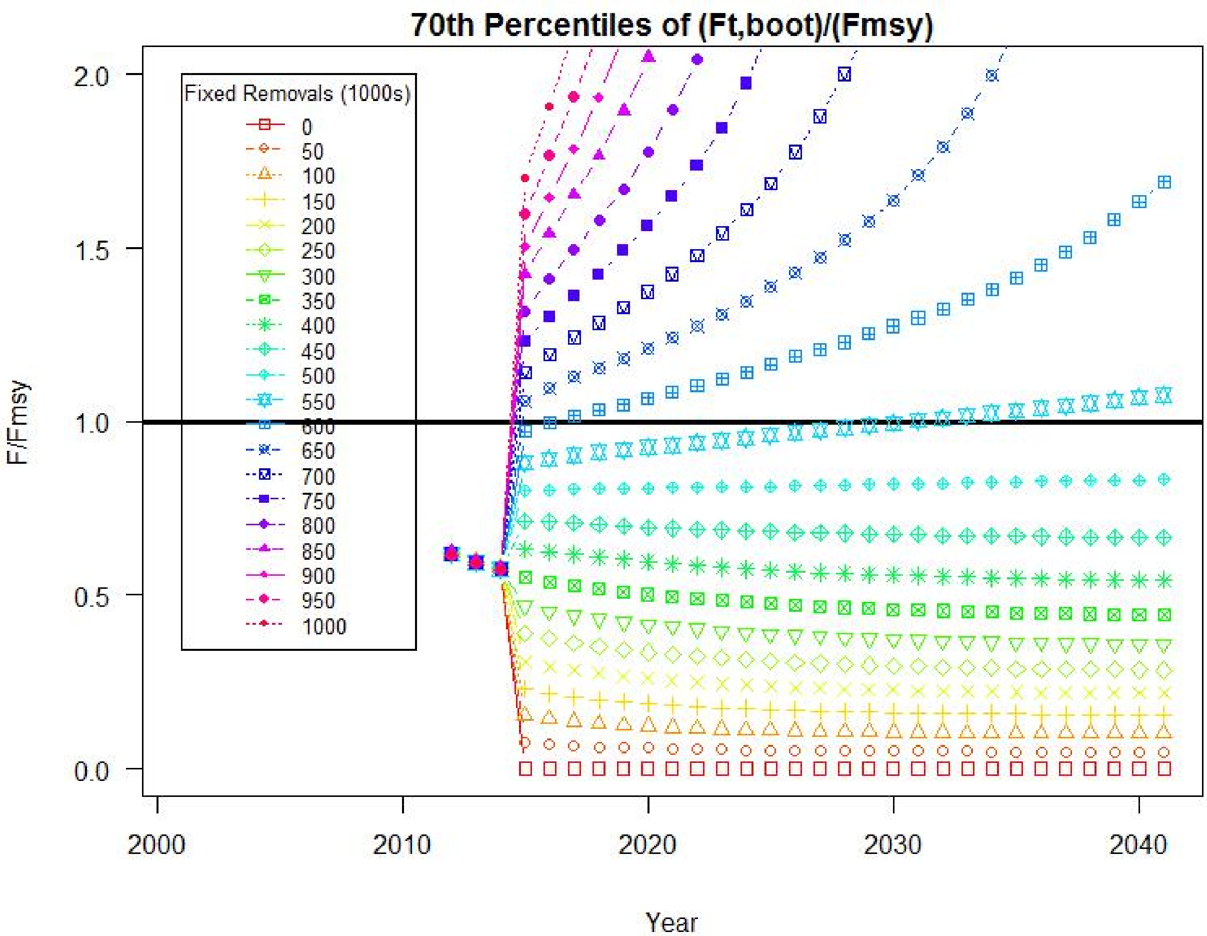


Figure 3.6.45 (continued). The 70th percentile of $F_{t,boot}$/ F_{MSY} represents the 30% probability of F_t exceeding F_{MSY} from 10,000 Monte Carlo bootstrap projections for a given level of fixed removals (in 1000s) and a given year (2015 – 2041).

Panel I. Projection Scenario-9 (Sensitivity, SEAMAP-SA)

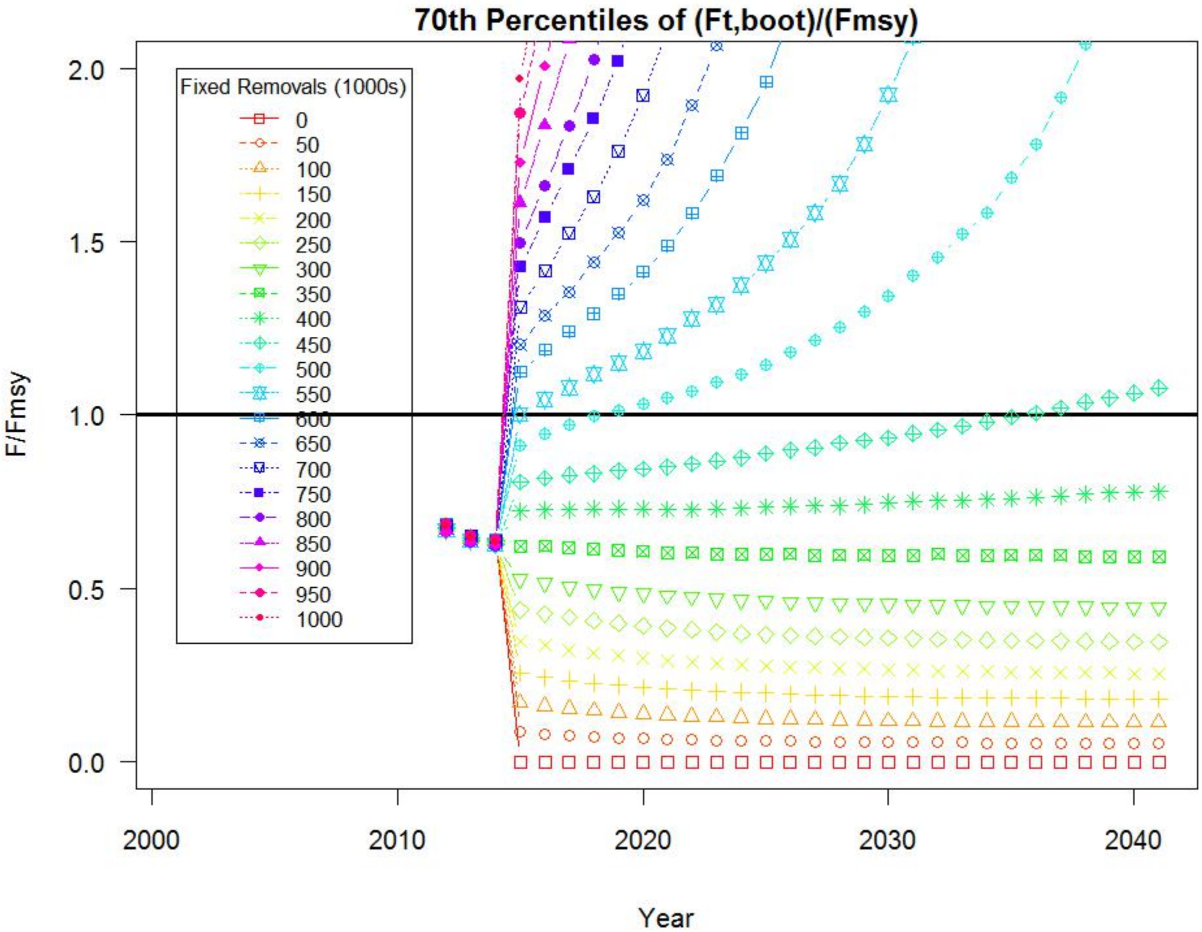


Figure 3.6.45 (continued). The 70^{th} percentile of $F_{t,boot}/ F_{MSY}$ represents the 30% probability of F_t exceeding F_{MSY} from 10,000 Monte Carlo bootstrap projections for a given level of fixed removals (in 1000s) and a given year (2015 – 2041).

Panel J. Projection Scenario-10 (Sensitivity, Gulf of Mexico Biology)

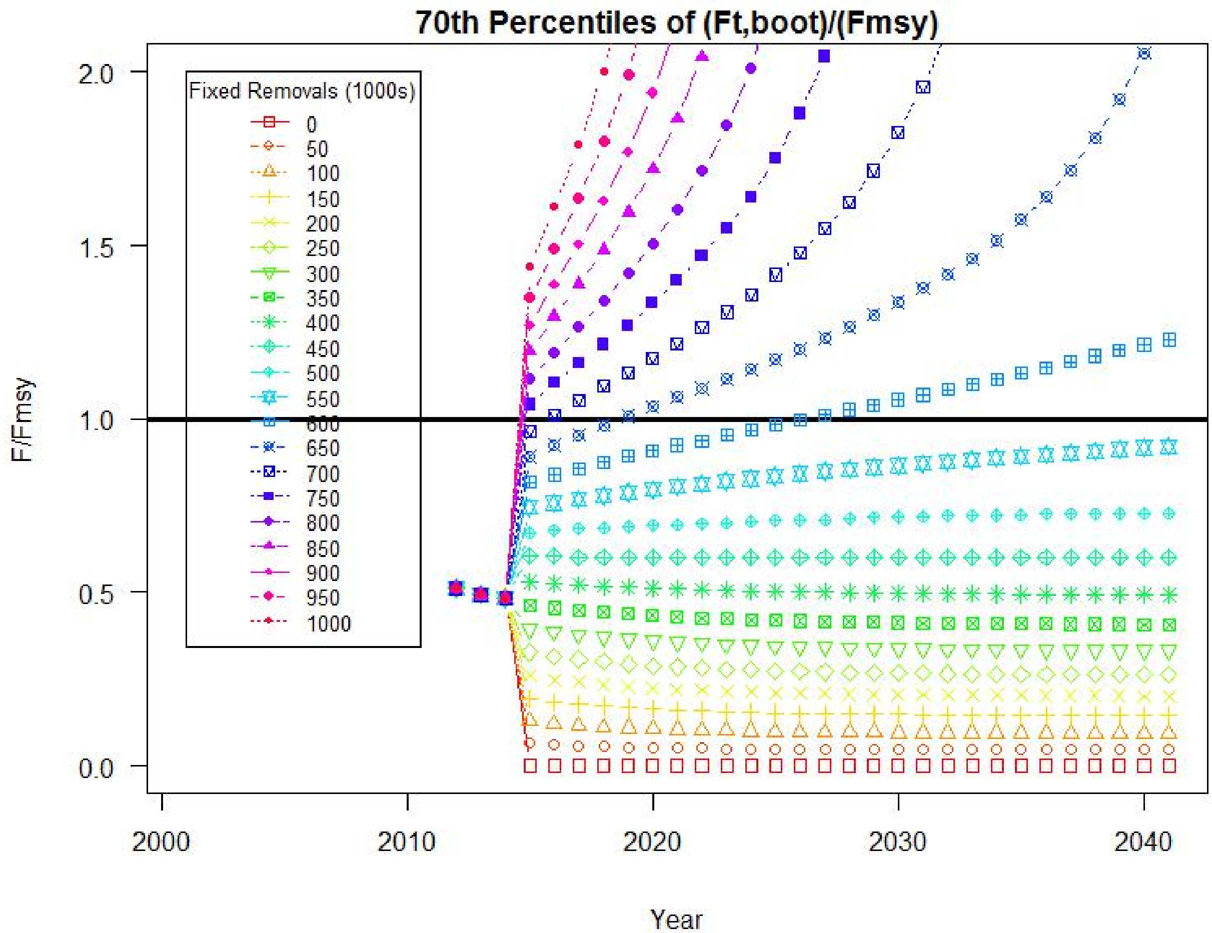


Figure 3.6.45 (continued). The 70th percentile of $F_{t,boot}/ F_{MSY}$ represents the 30% probability of F_t exceeding F_{MSY} from 10,000 Monte Carlo bootstrap projections for a given level of fixed removals (in 1000s) and a given year (2015 – 2041).

Panel K. Projection Scenario-11 (Sensitivity, Atlantic Biology)

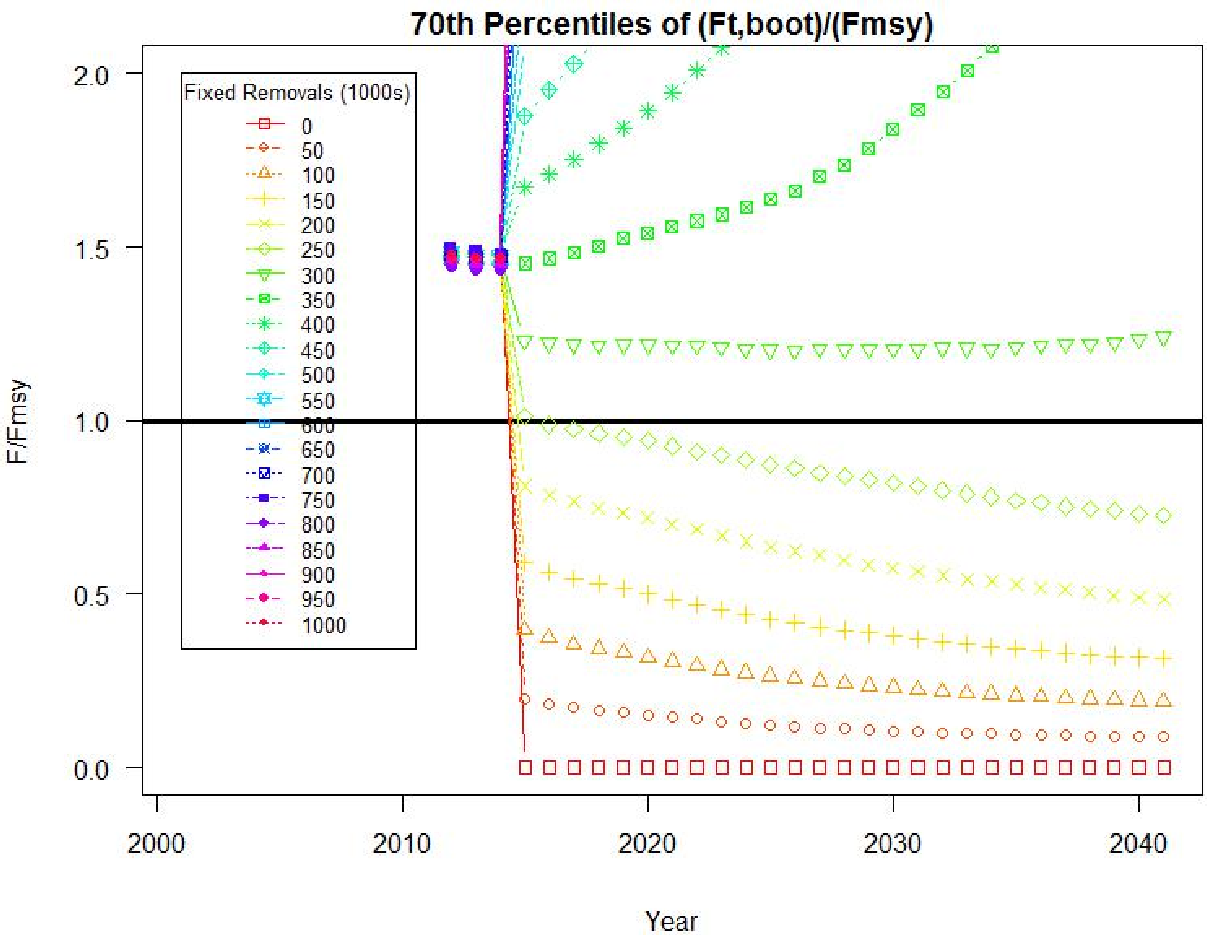


Figure 3.6.45 (continued). The 70th percentile of $F_{t,boot}$/ F_{MSY} represents the 30% probability of F_t exceeding F_{MSY} from 10,000 Monte Carlo bootstrap projections for a given level of fixed removals (in 1000s) and a given year (2015 – 2041).

3.7. APPENDICES

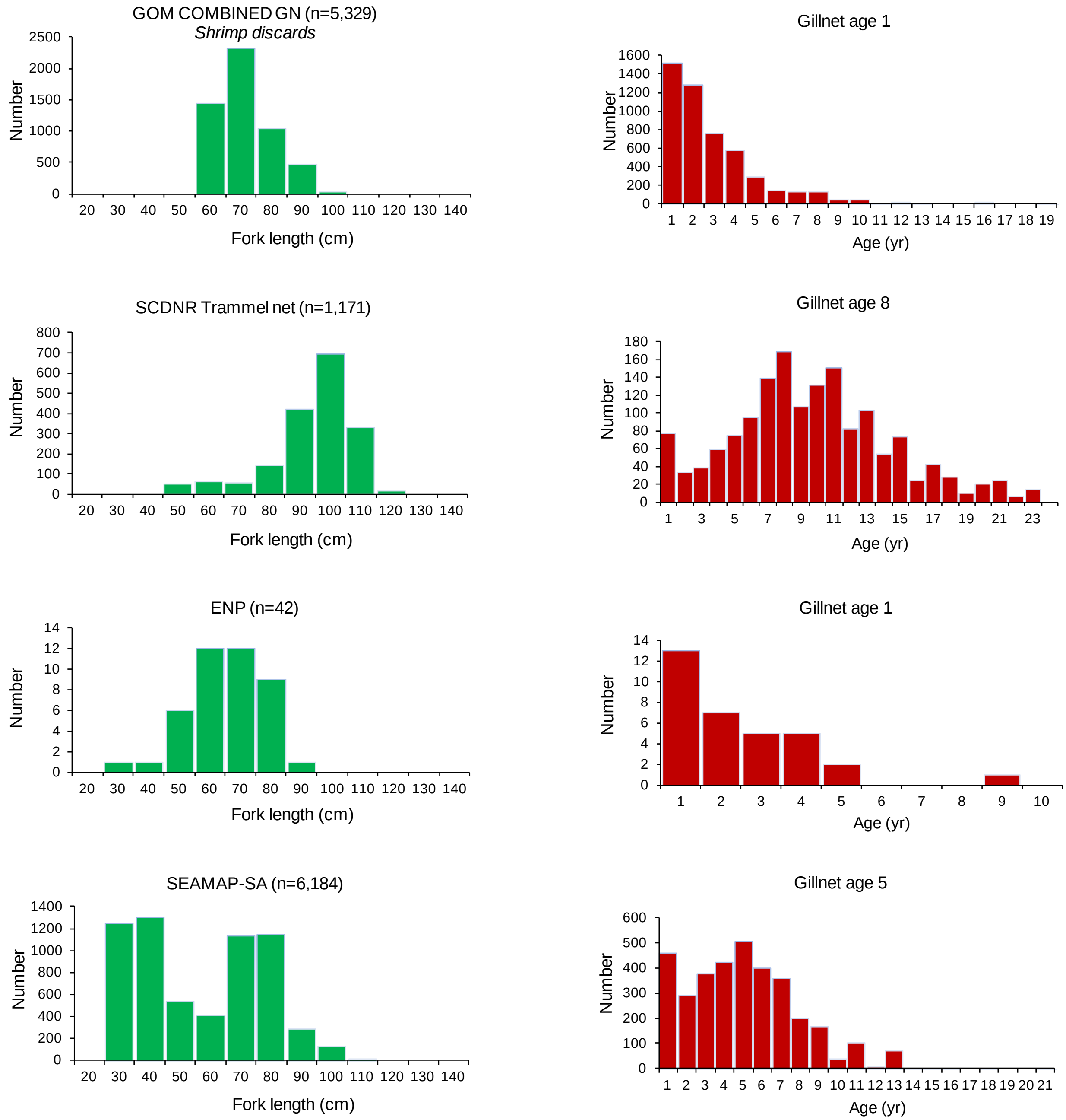
Appendix 1. Average weights (obtained from back-transforming lengths into weights) used for generating catches in weight for some years for commercial gears. BLL is bottom longline; GN is gillnet. See section 3.1.2.1 for details.

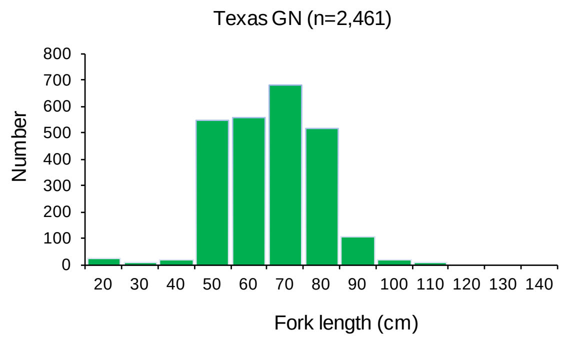
Average weights table

	Weight (lb dw)	
Year	BLL	GN
1993		
1994	5.373	
1995	4.111	
1996	5.058	
1997	4.811	
1998	5.263	
1999	5.694	
2000	*4.596*	0.683
2001	*4.596*	3.508
2002	*4.596*	0.910
2003	3.710	*1.470*
2004	3.521	*1.470*
2005	2.713	2.377
2006	2.932	1.115
2007	3.168	2.094
2008	3.320	1.363
2009	3.197	1.441
2010	1.740	2.800
2011	4.221	0.977
Grand mean	4.034	1.684

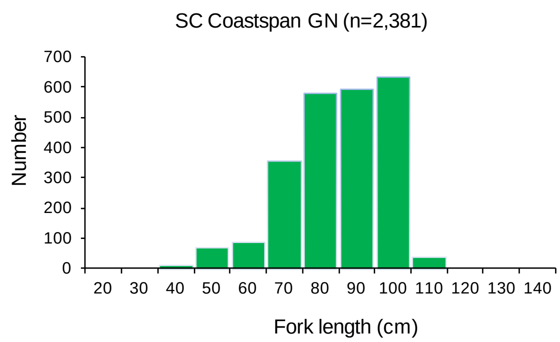
* Italicized value for BLL in 2000-2002 is geometric mean of 1999 and 2003 values
* Italicized value for GN in 2003-2004 is geometric mean of 2002 and 2005 values

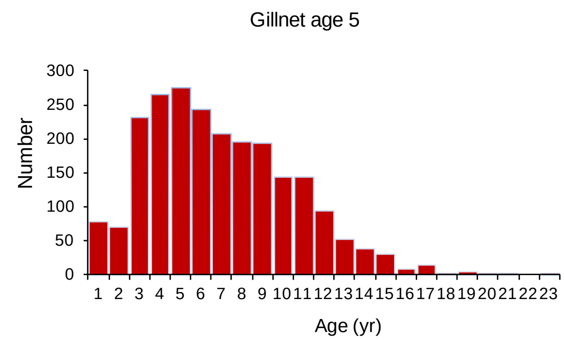
<u>Appendix 2.</u> Age-frequency distributions (right panel) obtained by back-transforming, through the sex-specific von Bertalanffy growth equation, length data (left panel) corresponding to the indices of relative abundance included in the base run. Selectivity functions were later fitted to the age-frequency data (see Table 2.5.2 for details). Figures on the left panel also show the catch series that were assigned the same selectivity as a particular index (in the subtitle in italics); figures in the right panel show the name given to each type of selectivity pattern.

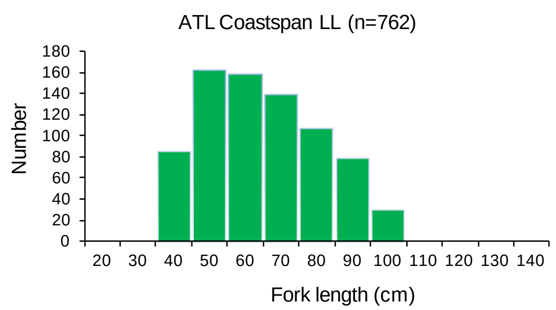



Texas GN (n=2,461)
Number
Fork length (cm)

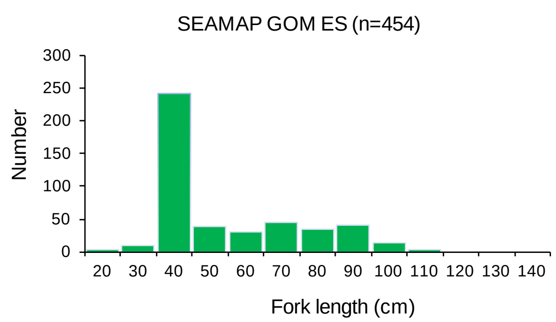

Gillnet age 1
Number
Age (yr)

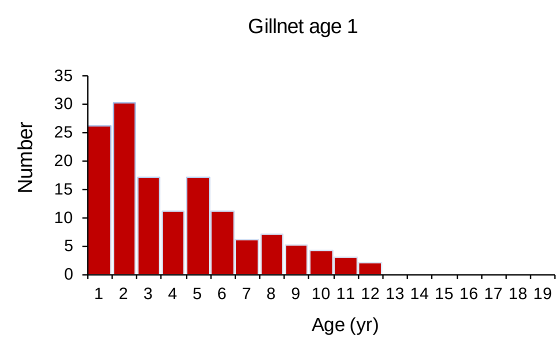

SC Coastspan GN (n=2,381)
Number
Fork length (cm)

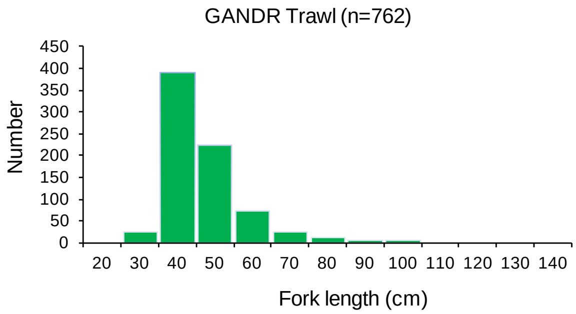

Gillnet age 5
Number
Age (yr)

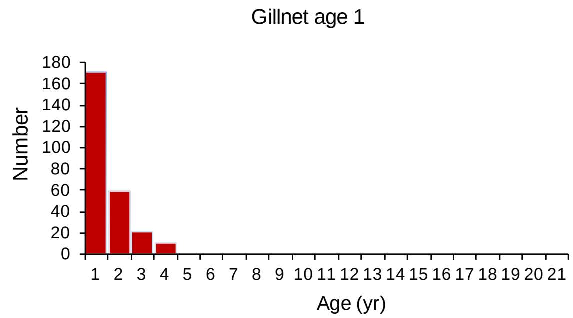

ATL Coastspan LL (n=762)
Number
Fork length (cm)

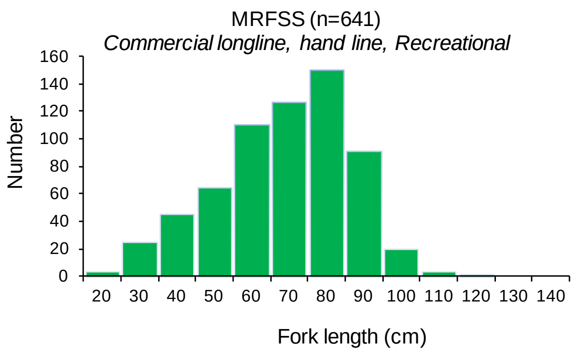

Longline age 1
Number
Age (yr)


SEAMAP GOM ES (n=454)
Number
Fork length (cm)

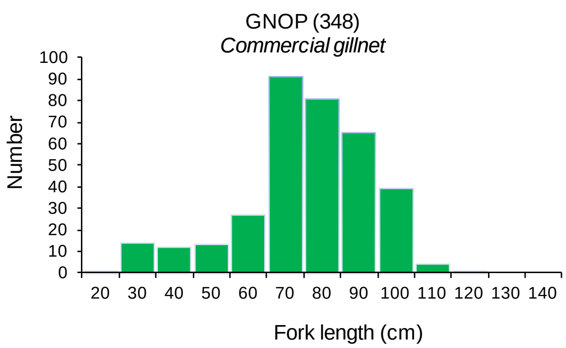

Gillnet age 1
Number
Age (yr)


GANDR Trawl (n=762)
Number
Fork length (cm)


Gillnet age 1
Number
Age (yr)


MRFSS (n=641)
Commercial longline, hand line, Recreational
Number
Fork length (cm)


Longline age 3
Number
Age (yr)


GNOP (348)
Commercial gillnet
Number
Fork length (cm)


Gillnet age 4
Number
Age (yr)

<u>Appendix 3.</u> Algorithm used to estimate selectivities (implemented in MS Excel).

Obtain age-frequencies

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

Calculate the observed proportion at age: Obs[prop.CAA] = freq(age)/Total_samples

Take the natural log of observed proportion at age, plot age against it, and fit a trend line through the fully selected ages

Use the fitted trend line to predict expected proportion at age, E[prop.CAA]=exp(trend line)

Use the ratio of Obs[prop.CAA]/E[prop.CAA] to estimate the non-fully selected ages (i.e. selectivity of ages < *age_full*)

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*)

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

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

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