SEDAR 13 Stock Assessment Report: Small Coastal Shark Complex, Atlantic Sharpnose, Blacknose, Bonnethead, and Finetooth Shark

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SEDAR 13

Stock Assessment Report

Small Coastal Shark Complex,
Atlantic Sharpnose, Blacknose, Bonnethead, and Finetooth Shark

2007

NOAA/NMFS
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Stock Assessment Report

Small Coastal Shark Complex,
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Section I: Introduction

1. SEDAR Overview

SEDAR (Southeast Data, Assessment and Review) was initially developed by the Southeast Fisheries Science Center of the National Marine Fisheries Service (NMFS) and the South Atlantic Fishery Management Council to improve the quality and reliability of stock assessments and to ensure a robust and independent peer review of stock assessment products. SEDAR was expanded in 2003 to address the assessment needs of all three Fishery Management Councils in the Southeast Region (South Atlantic, Gulf of Mexico, and Caribbean) and to provide a platform for reviewing assessments developed through the Atlantic and Gulf States Marine Fisheries Commissions and state agencies within the southeast. In 2005, the SEDAR process was adapted by the NOAA/NMFS Highly Migratory Species Management Division as a means to conduct stock assessments for the large coastal shark and small coastal shark complexes under their jurisdiction.

SEDAR strives to improve the quality of assessment advice provided for managing fisheries resources in the Southeast US by increasing and expanding participation in the assessment process, ensuring the assessment process is transparent and open, and providing a robust and independent review of assessment products.

SEDAR is organized around three workshops. First is the Data Workshop, during which fisheries, monitoring, and life history data are reviewed and compiled. Second is the Assessment workshop, 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. All workshops are open to the public.

SEDAR workshops are organized by SEDAR staff and the appropriate management agency. Data and Assessment Workshops are chaired by the SEDAR coordinator. 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 and 3 reviewers appointed by the Center for Independent Experts (CIE), an independent organization that provides independent, expert reviews of stock assessments and related work. The Review Workshop Chair is appointed by the Acting Director of the Southeast Fisheries Science Center.

SEDAR 13 was charged with assessing the large coastal shark complex, Atlantic sharpnose shark blacknose shark, bonnethead shark, and finetooth shark under the jurisdiction of the Highly Migratory Species Management Division.

2. Management History

2.1 The 1993 Fishery Management Plan

In 1989, the five Atlantic Fishery Management Councils asked the Secretary of Commerce 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.

In 1993, the Secretary of Commerce, through the National Marine Fisheries Service (NMFS), implemented the FMP for Sharks of the Atlantic Ocean. At that time, the stock assessment indicated that the estimated maximum sustainable yield (MSY) for SCS was 2,590 metric tons (mt) dressed weight (dw). Based on this and landings estimates that indicated fishing mortality was below F_{MSY}, NMFS identified the status of SCS as fully fished. No direct commercial restrictions (e.g., quotas) were implemented although the commercial restrictions for the other shark species affected the SCS fishery (e.g., permits and reporting). The management measures that directly affected SCS fishermen 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 shark (LCS), SCS, and pelagic sharks);
- Establishing calendar year fishing year for commercial quotas and dividing 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 (this did not affect SCS fishermen until a quota was established in 1997, see section 3 below);
- Establishing a recreational trip limit of four sharks per vessel for LCS or pelagic shark species groups and a daily bag limit of five sharks per person for sharks in the SCS species group;
- Requiring that all sharks not taken as part of a commercial or recreational fishery be released uninjured;
- Establishing a framework procedure for adjusting commercial quotas, recreational bag limits, species size limits, management unit, fishing year, species groups, estimates of maximum sustainable yield, and permitting and reporting requirements;
- Prohibiting finning by requiring that the ratio between wet fins/dressed carcass weight not exceed 5 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 (meat products and fins);
- Establishing a permit eligibility requirement that the owner or operator (including charter vessel and headboat owners/operators who intend to sell their catch) must show proof that at least 50 percent of earned income has been derived from the sale of the fish or fish products or charter vessel and headboat operations or at least $20,000 from the sale of fish during one of three years preceding the permit request;
- Requiring trip reports by permitted fishermen and persons conducting shark tournaments and requiring fishermen to provide information to NMFS under the Trip Interview Program; and,

- Requiring NMFS observers on selected shark fishing vessels to document mortality of marine mammals and endangered species.

2.2 The 1997 Rule

Other than monitoring the landings, few actions were taken for SCS between implementation of the 1993 FMP and a rule in 1997 that established a SCS quota. In June 1996, NMFS convened a stock assessment to examine the status of LCS stocks. This stock assessment did not include an assessment for small coastal sharks. However, in response to the stock assessment, in 1997, NMFS reduced 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). Additionally, due to concerns over increasing SCS landings on a fully fished stock, NMFS established a commercial SCS quota of 1,760 mt dw. As with LCS and pelagic sharks, NMFS split this quota equally between the two fishing seasons (January 1 to June 30 and July 1 to December 31).

In this rule, NMFS also reduced the LCS commercial quota and prohibited five LCS species. NMFS was sued on the LCS commercial measures in this rule, not the recreational measures or the SCS quota.

2.3 The 1999 Fishery Management Plan for Atlantic Tunas, Swordfish, and Sharks

In 1996, amendments to the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) modified the definition of overfishing and established new provisions to halt overfishing and rebuild overfished stocks, minimize bycatch and bycatch mortality to the extent practicable, and identify and protect essential fish habitat. Accordingly, in 1997, NMFS began the process of creating a rebuilding plan for overfished highly migratory species (HMS), including LCS, consistent with the new provisions.

In June 1998, NMFS held another LCS stock assessment. As with the 1996 quota, this stock assessment did not examine the status of SCS. Based in part on the results of the 1998 LCS stock assessment, in April 1999, NMFS published the final Fishery Management Plan for Atlantic Tunas, Swordfish and Sharks (1999 FMP), which included numerous measures to rebuild or prevent overfishing of Atlantic sharks in commercial and recreational fisheries. The 1999 FMP replaced the 1993 FMP. Management measures related to SCS that changed in the 1999 FMP included:

- Reducing the commercial SCS quota to 359 mt dw;
- Reducing recreational retention limits for all sharks to one shark per vessel per trip with a 4.5 foot fork length minimum size and one Atlantic sharpnose per person per trip, no minimum size;
- Expanding the list of prohibited shark species to include three species of SCS (Caribbean sharpnose, smalltail, and angel shark);
- Implementing limited access in commercial fisheries;
- Establishing a shark public display quota for all public display sharks including SCS;

- 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). NMFS was sued by several groups on the Atlantic shark commercial measures implemented in the 1999 FMP and on the recreational shark regulations adopted in the 1999 FMP.

On June 30, 1999, NMFS received a court order from Judge Merryday relative to the May 1997 lawsuit on the commercial LCS quota. Specifically, the order enjoined NMFS from enforcing the 1999 regulations with respect to Atlantic shark commercial catch quotas (LCS, pelagic, and SCS) and fish-counting methods (including the counting of dead discards and state commercial landings after Federal closures), which were different from the quotas and fish counting methods prescribed by the 1997 Atlantic shark regulations. A year later, on June 12, 2000, the court issued an order clarifying that NMFS could proceed with implementation and enforcement of the 1999 prohibited species provisions (64 FR 29090, May 28, 1999). No injunction was placed on the changes to the recreational retention limits so those measures went into place in June 1999.

On November 21, 2000, Southern Offshore Fishing Association (SOFA) *et al*. and NMFS reached a settlement agreement for the May 1997 and June 1999 lawsuits regarding the commercial shark management measures. On December 7, 2000, Judge Merryday 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, new stock assessments of both LCS and SCS, and the establishment of the 1997 LCS and SCS quotas until the stock assessments were complete. The settlement agreement did not address any regulations affecting the pelagic shark, prohibited species, or recreational shark fisheries. 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, among other things, established the SCS commercial quotas at 1997 levels (1,760 mt dw). This SCS quota was maintained through 2002 via different emergency rules.

On September 20, 2001, Judge Roberts ruled against the Recreational Fishing Alliance and stated that the recreational retention limits were consistent with the Magnuson-Stevens Act.

2.4 The 2002 SCS Stock Assessment

On May 6, 2002 (67 FR 30879), NMFS announced the availability an SCS stock assessment. Based on the results of the stock assessment, NMFS determined that the SCS complex, Atlantic sharpnose, finetooth, blacknose, and bonnethead sharks were not overfished. Additionally, the SCS complex, Atlantic sharpnose, blacknose, and bonnethead sharks were not experiencing overfishing. However, finetooth sharks were experiencing overfishing.

Based in part on these results, NMFS implemented via an emergency rule an annual quota of 326 mt dw for 2003 (67 FR 78990, December 27, 2002; extended 68 FR 31987, May 29, 2003), and announced its intent to conduct an environmental impact statement and amend the 1999 FMP (67 FR 69180, November 15, 2002). The emergency rule was an interim measure to maintain the status of sharks pending the re-evaluation of management measures in the context of the rebuilding plan through this FMP amendment.

2.5 Amendment 1 to the 1999 FMP and 2004 Rules

Based on the 2002 SCS and LCS stock assessments, NMFS re-examined many of the shark management measures in Amendment 1 to the 1999 FMP for Atlantic Tunas, Swordfish, and Sharks(December 24, 2003, 68 FR 74746). The changes in Amendment 1 affected all aspects of shark management. The final management measures that would affect SCS fishermen included, among other things:

- Using MSY as a basis for setting commercial quotas (the annual SCS complex quota was established at 454 mt dw);
- Establishing regional commercial quotas (North Atlantic, South Atlantic, and Gulf of Mexico);
- Establishing trimester commercial fishing seasons (January through April, May through August, September through December);
- Adjusting the recreational bag and size limits (one shark per vessel per trip with a 4.5 foot fork length minimum size and one Atlantic sharpnose or bonnethead shark per person per trip, no minimum size);
- Establishing gear restrictions to reduce bycatch or reduce bycatch mortality, establishing a time/area closure off the coast of North Carolina;
- Establishing a mechanism for changing the species on the prohibited species list;
- Updating essential fish habitat identifications for five species of sharks (including one SCS, finetooth sharks); and,
- Changing the administration for issuing permits for display purposes.

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).

2.6 The 2006 Consolidated Highly Migratory Species FMP

In 2003, NMFS began the process to amend the 1999 FMP and consolidate the 1999 FMP with the Atlantic Billfish FMP. This process was completed in 2006 (71 FR 58058, October 2, 2006). The Consolidated HMS FMP contained numerous actions. The only action directly relevant to SCS was the decision to collect more information (from observer programs, state agencies, and Regional Fishery Management Councils) in order to target the most appropriate management measures to prevent overfishing of finetooth sharks. In the Consolidated HMS FMP, NMFS examined numerous datasets including state landings data and observer data to determine what fisheries were catching finetooth sharks. NMFS determined that many fisheries catch finetooth sharks as bycatch. Thus, taking action to limit the amount of finetooth sharks landed by those fisheries could increase effort in those other fisheries resulting in more dead discards of finetooth sharks.

2.7 Amendment 2 to the Consolidated HMS FMP

As a result of the 2005/2006 stock assessments (LCS, dusky, and porbeagle), NMFS is amending shark management. None of the management measures in this upcoming amendment are expected to affect SCS fisheries directly (e.g., no changes to the SCS quota). Nonetheless, given the overlapping nature of all shark fisheries, it is likely that some of the management measures would impact SCS fisheries (e.g., changing the LCS quota may result in changes to SCS effort). Scoping for this amendment ends on February 5, 2007. The final rule implementing these changes is expected by January 2008. Depending on the results of this stock assessment, NMFS may need to amend the SCS management measures in a separate rulemaking.

2.8 Commercial Fishing Seasons

Until recently, the SCS commercial fishery had never been closed. In almost all years, few SCS were reported landed compared to the available quota. On March 18, 2004, the SCS fishery in the Gulf of Mexico region closed for the first time (69 FR 10936, March 9, 2004). At that time, NMFS had dealer reports indicating that the Gulf of Mexico region had caught 20.7 mt dw of its 11.2 mt dw seasonal quota (January 1 through April 30). NMFS later found out that the region had not overharvested the quota. Rather, LCS species were being misidentified as SCS. In 2006, the Gulf of Mexico region exceeded its first season quota by 527 percent (78.0 mt dw landed with a quota of 14.8 mt dw). Quota from the South Atlantic region was transferred to the Gulf of Mexico region to cover this overharvest (71 FR 75122, December 14, 2006).

2.9 The Gillnet Fishery

As described in the Consolidated HMS FMP, while SCS are caught recreationally and commercially on bottom longline gear, most of the commercial fishermen who actively target SCS are gillnet fishermen. These few fishermen use a variety of gillnet methods to catch SCS including drifting and striking. Additionally, many gillnet fishermen targeting other species in that same area (the east coast of Florida) also catch, and if they have a shark permit, land SCS. Because of concerns regarding right whale calving, these gillnet fisheries are also managed under the Marine Mammal Protection Act via the Large Whale Take Reduction Plan. These regulations include, but are not limited to, high observer coverage (100 percent in the past) during right whale calving season (November 15 through March 31 each year). Additionally, in the 2003 Amendment 1 to the 1999 FMP, NMFS required all gillnet vessels with a directed shark permit to use vessel monitoring systems (VMS) during right whale calving season. Furthermore, due to other endangered species concerns, the fishery has elevated observer coverage compared to other HMS fisheries in the remaining portion of the year.

From March 9, 2001, to April 9, 2001, the shark gillnet fishery was closed, with the exception of strikenets, off of east Florida due to a large number of leatherback sea turtle takes (14 leatherback turtles were taken in 62 drift gillnet sets). As a result of these takes, NMFS established requirements for the gillnet gear to be checked for sea turtles and other protected species at least once every two hours (July 9, 2002, 67 FR 45393).

On January 22, 2006, a right whale calf was found dead off Jacksonville Beach, Florida. The calf had been entangled in gillnet gear recently before its death. The necropsy indicated that the entanglement ultimately led to the whale's death. As a result, NMFS closed the area via temporary action to all gillnet fishing (February 16, 2006, 71 FR 8223). On November 15, 2006, NMFS published a second emergency rule that once again closes the core right whale calving area to all gillnet fishing from November 15 through April 15, 2007 (71 FR 66470, November 15, 2006). Also on November 15, 2006 (71 FR 66482), NMFS published a proposed rule that would expand the restricted area, close the area to gillet fishing or possession during right whale calving season, and exempt the use of strikenet gear for sharks and gillnet fishing for Spanish mackerel south of 29^{0}00'N lat. The comment period on this proposed rule was extended to January 31, 2007 (January 16, 2006, 72 FR 1689).

2.10 Exempted Fishing Permits

Under 50 CFR 635.32, and consistent with 50 CFR 600.745, NMFS may authorize for limited testing, public display, and scientific data collection purposes, the target or incidental harvest of species managed under an FMP or fishery regulations that would otherwise be prohibited. Exempted fishing may not be conducted unless authorized by an Exempted Fishing Permit (EFP) Display Permit, or a Scientific Research Permit (SRP) issued by NMFS in accordance with criteria and procedures specified in those sections. As necessary, an EFP, Display Permit, or a SRP would exempt the named party(ies) from otherwise applicable regulations under 50 CFR part 635. Such exemptions could address fishery closures, possession of prohibited species, commercial permitting requirements, and retention and minimum size limits.

In the 1999 FMP, NMFS established a 60 mt ww shark public display quota for the purpose of collecting sharks for aquariums and other instances of public display. In order to collect sharks under this quota, fishermen must apply for a Display Permit. This allows them to collect sharks during closed seasons and also allows them to collect sharks that may be prohibited, such as sand tiger sharks. NMFS also issues Display Permits for the collection of other HMS for public display. As outlined in another document submitted to this data workshop, SCS are collected under Display Permits, EFPs, and SRPs.

2.11 Essential Fish Habitat

Under the Magnuson-Stevens Act, each FMP must describe and identify essential fish habitat (EFH) for the fishery, minimize to the extent practicable adverse effects on that EFH caused by fishing, and identify other actions to encourage the conservation and enhancement of EFH. In 1999, NMFS identified EFH for all actively managed species of sharks. In Amendment 1, NMFS updated EFH for five species, including one species of SCS, the finetooth shark. In Amendment 1 to the Consolidated HMS FMP, NMFS is examining the need for changes and updates to the existing EFH and related management measures, as needed.

Table 1. Summary of current shark regulations

PROHIBITED SPECIES

The following sharks cannot be kept commercially or recreationally: Whale, basking, sand tiger, bigeye sand tiger, white, dusky, night, bignose, Galapagos, Caribbean reef, narrowtooth, longfin mako, bigeye thresher, sevengill, sixgill, bigeye sixgill, Caribbean sharpnose, smalltail, and Atlantic angel sharks. There is a mechanism in place to add or remove species, as needed, via rulemaking.

COMMERCIAL REGULATIONS

Management Unit	**Species that can be retained**	**Quota (mt dw)**	**Regional Quotas**	**Authorized Gears**
Large Coastal Sharks - directed commercial retention limit of 4,000 lb dw per trip - incidental retention limit	Sandbar, silky, tiger, blacktip, bull, spinner, lemon, nurse, smooth hammerhead, scalloped hammerhead, great hammerhead	1,017	NA = 7% SA = 41% GM = 52%	Pelagic or Bottom Longline; Gillnet; Rod and Reel; Handline; Bandit Gear
Pelagic Sharks - no directed retention limit - incidental retention limit	Shortfin mako, thresher, oceanic whitetip	488	None	
	Porbeagle	92		
	Blue	273		
Small Coastal Sharks - no directed retention limit - incidental retention limit	Atlantic sharpnose, blacknose, finetooth, bonnethead	454	NA = 3% SA = 87% GM = 10%	

Additional remarks:
- All sharks not retained must be released in a manner that ensures the maximum probability of survival
- Finning is prohibited for all sharks no matter what species
- Fishing seasons: January 1 to April 30; May 1 to August 30; September 1 to December 31
- Fishing regions: NA = Maine through Virginia; SA = N. Carolina through East Florida and Caribbean; GM = Gulf of Mexico
- Quota over- and underharvest adjustments will be made for the same season the following year; no reopening that season
- Count state landings after Federal closure against Federal quota
- Time/area closure for vessels with bottom longline gear on board: January through July between 35" 41'N to 33" 51'N and west of 74" 46'W, roughly following the 60 fathom contour line, diagonally south to 76" 24'W and north to 74" 51'W . Area is open in July 2007, pending quota.
- Vessel Monitoring Systems required for all gillnet vessels in all areas during right whale calving season and from January through July for all vessels with bottom longline gear on board between 33" 00' N and 36" 30'N
- Limited access; Exempted Fishing Permit (EFP) requirements; Display permits for collection for public display
- Observer and reporting requirements
- For incidental limited access permit holders: 5 large coastal sharks per trip; a total of 16 pelagic or small coastal sharks (all species combined) per vessel per trip
- Vessel with bottom longline gear on board must: (1) have non-stainless steel corrodible hooks; (2) have a dehooking device (when approved), linecutters, and a dipnet on board; (3) move 1 nmi after an interaction with a protected species; and (4) post sea turtle handling and release guidelines in the wheelhouse

RECREATIONAL REGULATIONS

Management Unit	**Species that can be kept**	**Retention Limit**	Authorized Gear
Large Coastal, Pelagic, and Small Coastal Sharks	LCS: Sandbar, silky, tiger, blacktip, bull, spinner, lemon, nurse, smooth hammerhead, scalloped hammerhead, great hammerhead Pelagic: shortfin mako, thresher, oceanic whitetip, porbeagle, blue SCS: Atlantic sharpnose, blacknose, finetooth, bonnethead	1 shark per vessel per trip (all species) with a 4.5 feet fork length minimum size; allowance for 1 Atlantic sharpnose and 1 bonnethead per person per trip (no minimum size)	Rod and Reel; Handline

Additional remarks:
Harvested sharks must have fins, head, and tail attached (can be bled and gutted if tail is still attached).

Table 2 List of species that are small coastal sharks, including those that are prohibited.

Common name	**Species name**
Atlantic sharpnose	*Rhizoprionodon terraenovae*
Finetooth	*Carcharhinus isodon*
Blacknose	*Carcharhinus acronotus*
Bonnethead	*Sphryna tiburo*
Prohibited Species	
Caribbean sharpnose	*Rhizoprionodon porosus*
Smalltail	*Carcharhinus porosus*
Atlantic Angel	*Squatina dumerili*

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Small Coastal Shark Complex, Atlantic Sharpnose, Blacknose, Bonnethead, and Finetooth Shark

Section II: Data Workshop Report

SEDAR 13

SMALL COASTAL SHARKS

DATA WORKSHOP REPORT

23 March 2007

Introduction:
The current assessment for the Small Coastal Shark (SCS) Complex was to be run following, as close as possible, the procedures of the Southeast Data, Assessment, and Review (SEDAR) process. The process involves three meeting Workshops: Data, Assessment, and Review. The Data Workshop for the SCS complex was held in Panama City, FL February 5 through 9, 2007. Participants are listed in Appendix 1. Initial data compilations and exploratory analyses for SEDAR assessments were requested from participants in the form of "working documents" to be submitted in advance and evaluated over the course of the workshop. A full list of papers submitted is presented in Appendix 2.

Three working groups were established to address the quality and suitability of available data for stock assessment. The working groups were: 1) life history, 2) catch histories, and 3) indices of relative abundance. Participants were initially assigned to one of the groups based on their expertise and the type of documents they were submitting however participants were allowed to participate in any working group they wished. Group rapporteurs reported issues and progress to Data Workshop plenary sessions several times during the week. Written reports from the life history working group were substantially complete by week's end, whereas the catch and indices group reports were in the draft stages. There was some subsequent editing, and some further analyses sketched out during the Data Workshop have been completed. Some additional analyses recommended at the Data Workshop were too extensive to allow completion prior to circulation of the Data Workshop report.

This report is divided into three sections, paralleling the choice to establish three working groups. Structure within each section was determined by each working group, following some general guidelines derived from SEDARs for other species. The SCS complex was assessed in 2002 for National Marine Fisheries Service by a single individual, but has never before undergone the current SEDAR process. Figures and tables remain within the individual sections, and are numbered in "Section number.figure number" sequence. Lists of references to the general literature (i.e. papers other than the working documents submitted to this Workshop) also remain with the individual sections. Citations to papers submitted to this workshop as "working documents" are made in the text using the identifying numbers assigned by the Shark SEDAR Coordinator (in the form SEDAR 13-DW-XX), and refer to the list in Appendix 2.

As is customary for Data Workshop reports, several of the sections contain recommendations for future research efforts. Many of these recommendations are intended to be considered over the next several years, and are not recommendations for work to be completed prior to the Stock Assessment Workshop portion of the SCS SEDAR in May 2007.

This report is a complete and final documentation of the activities, decisions, and recommendations of the Data Workshop. It will also serve as one of 4 components of the final SEDAR Assessment Report. The final SEDAR Assessment Report will be completed following the last workshop in the cycle, the Review Workshop, and will consist of the following sections: I) Introduction; II) Data Workshop Report; III) Assessment Workshop Report; and IV) Review Workshop Report.

SEDAR 13 Small Coastal Sharks Data Workshop Terms of Reference

1. Characterize stock structure and develop a unit stock definition.

2. Tabulate available life history information (e.g., age, growth, natural mortality, reproductive characteristics). Provide models to describe growth, maturation, and fecundity by age, sex, or length as appropriate; recommend life history parameters (or ranges of parameters) for use in population modeling; evaluate the adequacy of life-history information for conducting stock assessments.

3. Provide indices of population abundance. Consider fishery dependent and independent data sources; develop index values for appropriate strata (e.g., age, size, area, and fishery); provide measures of precision; conduct analyses evaluating the degree to which available indices adequately represent fishery and population conditions. Document all programs used to develop indices, addressing program objectives, methods, coverage, sampling intensity, and other relevant characteristics.

4. Characterize commercial and recreational catches, including both landings and discard removals, in weight and numbers. Evaluate the adequacy of available data for accurately characterizing harvest and discard by species and fishery sector. Provide length and age distributions if feasible.

5. Evaluate the adequacy of available data for estimating the impacts of current management actions.

6. Recommend assessment methods and models that are appropriate given the quality and scope of the data sets reviewed and management requirements.

7. Provide recommendations for future research in areas such as sampling, fishery monitoring, and stock assessment. Include specific guidance on sampling intensity and coverage where possible.

8. Prepare complete documentation of workshop actions and decisions

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3. Indices

Appendices

1. Life History

Life History Working Group Summary Report
John Carlson (Chair), NOAA Fisheries Service-Panama City Laboratory
Dana Bethea, NOAA Fisheries Service-Panama City Laboratory
George Burgess, University of Florida
William Driggers III, NOAA Fisheries Service-Mississippi Laboratory
Mark Grace, NOAA Fisheries Service-Mississippi Laboratory
Terry Henwood, NOAA Fisheries Service-Mississippi Laboratory
John Tyminski, Mote Marine Laboratory

1.1 Summary of Life History Documents

SEDAR 13-DW-03:
Preliminary tag and recapture data of small coastal sharks (Atlantic sharpnose shark, *Rhizoprionodon terraenovae*, blacknose shark, *Carcharhinus acronotus*, bonnethead shark, *Sphyrna tiburo*, and finetooth shark, *C. isodon*) in the northeastern Gulf of Mexico
Bethea, D.M., L. Hollensead, and J.K. Carlson

Tag and recapture information from the NOAA Fisheries Cooperative Gulf of Mexico States Shark Pupping and Nursery (GULFSPAN) survey at the Panama City Laboratory from 1994 to 2006 are summarized for the Atlantic sharpnose, blacknose, bonnethead, and finetooth sharks in the northeastern Gulf of Mexico. A total of 1425 Atlantic sharpnose sharks were tagged. Recapture data was collected for 50 Atlantic sharpnose sharks for an overall recapture rate of 3.5 %. Majority of Atlantic sharpnose (34 of 50) were recaptured within the same bay system where they were tagged; however, the longest distance traveled was 399.6 km by a juvenile female tagged in Crooked Island Sound, FL, and recaptured 50 mi south of Venice, LA. For blacknose, 89 sharks were tagged and 6 were recaptured for an overall recapture rate of 6.7 %. All recapture locations of blacknose sharks were <35 km from tagging locations. A total of 481 bonnethead sharks were tagged. Eight bonnethead sharks were recaptured for an overall recapture rate of 1.7 %. The bonnethead shark at liberty the longest was also the shark the moved the greatest distance; it was tagged on the gulf-side of St. Vincent Island, FL, on October 11, 1993, and traveled 342.6 km to be recaptured 617 days later on June 21, 1995 south of Cedar Key, FL. For finetooth sharks, 333 sharks were tagged and 9 were recaptured for an overall recapture rate of 2.7 %. Recaptured finetooth sharks traveled longer distances to different locations than any other small coastal shark tagged by this survey. The longest distance traveled was 333.4 km by an adult male finetooth tagged on the gulf-side of St. Vincent Island, FL, and recaptured offshore of Venice, FL. All sharks were recaptured in U.S. Gulf of Mexico waters.

SEDAR 13-DW-08
Life history parameters for Atlantic sharpnose sharks, *Rhizoprionodon terraenovae*, from the United States South Atlantic Ocean and northern Gulf of Mexico
Carlson, J.K. and J. Loefer

Life history information for Atlantic sharpnose shark was summarized from information from two published studies and provides combined estimates of the life history for populations within the northern Gulf of Mexico and South Atlantic Ocean and Gulf of Mexico. Von Bertalanffy growth parameters were significantly differences between sharks in the US South Atlantic and Gulf of Mexico for females (log-likelihood ratio=149.2; p<0.0001) and males (log-likelihood ratio=138.8; p<0.0001). The maximum observed ages based on vertebral band counts were 6.5 and 9.8 years for male sharks from the Gulf of Mexico and US South Atlantic, respectively. For females, the oldest aged sharks were 9.5 and 11.4 years from the Gulf of Mexico and US South Atlantic, respectively. Estimates of size and age-at-maturity for male and female sharks from the Gulf of Mexico were different from those in the US South Atlantic. Fork length at which 50% of the population reached maturity is 60.5 cm in the US South Atlantic and 64.2 mm for females in the Gulf of Mexico. Median fork length at maturity for males is 66.8 cm and 61.4 cm for the US South Atlantic and Gulf of Mexico, respectively. Median age-at-maturity was 2.0 and 1.6 years for females, and 2.6 and 1.3 years for males for sharks in the US South Atlantic and Gulf of Mexico, respectively. Reproductive cycle for Atlantic sharpnose sharks is annual and a significant exponential relationship between maternal total length and number of embryos was found.

SEDAR 13-DW-11
Life history parameters for finetooth sharks, *Carcharhinus isodon*, from the United States South Atlantic Ocean and northern Gulf of Mexico.
Carlson, J.K., M. Drymon, and J.A. Neer

Life history parameters for finetooth sharks, *Carcharhinus isodon*, from the United States South Atlantic Ocean and northern Gulf of Mexico was summarized from studies by Castro (1996), Carlson et al. (2003), Neer and Thompson (2004), and Drymon et al. (in press). Significant differences between von Bertalanffy growth curves were found between sharks in the US South Atlantic and Gulf of Mexico for females (log-likelihood ratio=13.20; p=0.004) but not males (log-likelihood ratio=6.45; p=0.092). The maximum observed ages based on vertebral band counts were 8.2 and 10.3 years for male sharks from the Gulf of Mexico and US South Atlantic, respectively. For females, the oldest aged sharks were 8.1 and 12.3 years from the Gulf of Mexico and US South Atlantic, respectively. Estimates of size and age-at-maturity for male and female sharks from the Gulf of Mexico were different from those in the US South Atlantic. Fork length at which 50% of the population reached maturity is 1022 mm in the US South Atlantic and 990 mm for females in the Gulf of Mexico and was found to be significantly different (p<0.01). Median fork length at maturity for males is 988 mm and 935 mm for the US South Atlantic and Gulf of Mexico, respectively. Median age-at-maturity was 6.2 and 4.2 years for females, and 4.9 and 3.5 years for males for sharks in the US South Atlantic and Gulf of Mexico, respectively. The mean number of 4.036 pups year^{-1}. Although information on blacknose sharks from the Gulf of Mexico suggests a one-year reproductive cycle (Sulikowski et al. in press), reproductive cycle of 2 yr is assumed for finetooth shark from both areas.

SEDAR 13-DW-17
Life history and population genetics of blacknose sharks, *Carcharhinus acronotus*, in the South Atlantic Bight and the northern Gulf of Mexico

Driggers III, W.B., G.W. Ingram, Jr., M.A. Grace, J.K. Carlson, G.F. Ulrich, J.A. Sulikowski, and J.M. Quattro

The purpose of this document was to summarize the results of several studies on the life history of blacknose sharks in the South Atlantic Bight (SAB) and the northern Gulf of Mexico (GOM), compare important life history parameters reported in these studies and examine the population structure this species within the territorial waters of the United States. Von Bertalanffy growth function (VBGF) parameter estimates indicated that female blacknose sharks have a higher asymptotic length, lower growth constant and lower theoretical size at age zero than males in both the SAB and GOM. There were significant differences in VBGF parameter estimates between the sexes and sexes combined by region when comparing growth models generated for the SAB and GOM. In the SAB there was a significant difference in the size at 50% maturity ogives between females and males but not between the age at 50% maturity ogives. In the GOM no differences existed in age or size at 50% maturity ogives between the sexes. When treating the SAB and GOM as a single region there was a difference in size at 50% maturity ogives for females and males but not in the age at 50% maturity ogives. Female blacknose sharks were determined to reproduce biennially in the SAB and annually in the GOM. There was no difference in the mean number of pups per liter between areas (mean = 3.29). The population structure of blacknose sharks from the SAB and GOM was examined by direct sequencing of the mitochondrial DNA control region. While the analysis of molecular variance indicated there is no genetic difference in blacknose sharks between the SAB and the GOM ($p = 0.08$) the exact test of sample differentiation indicated that there is ($p < 0.01$).

SEDAR 13-DW-23
Preliminary Mark/Recapture Data for Four Species of Small Coastal Sharks in the Western North Atlantic
Kohler, N. and P. Turner

Mark/recapture information from the National Marine Fisheries Service (NMFS) Cooperative Shark Tagging Program (CSTP) covering the period from 1965 through 2005 are summarized for five species of small coastal shark-Atlantic sharpnose shark (*Rhizoprionodon terranovae*), bonnethead (*Sphyrna tiburo*), finetooth shark (*Carcharhinus isodon*), blacknose shark (*C. acronotus*), and Atlantic angel sharks (*Squatina dumeril*) 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 and to examine any regional trends in size. Only data with information on size and mark/recapture location were included in the regional analyses. Overall, there was no movement between the Atlantic and Gulf of Mexico and limited exchange between the US and the Mexican-managed portion of the Gulf of Mexico. This exchange was shown for Atlantic sharpnose sharks (8) and bonnethead (1). The true extent of this movement is unclear due to the possibility of under-reporting of recaptures.

SEDAR 13-DW-24
Life history traits of bonnethead sharks, *Sphyrna tiburo*, from the eastern Gulf of Mexico
Lombardi-Carlson, L.A.

Life-history traits (size at age, growth rates, size and age at maturity, and fecundity estimates) of bonnethead sharks, *Sphyrna tiburo*, were analyzed for sharks collected along Florida's Gulf of Mexico coastline between March 1998 and September 2000. A total of 539 sharks were collected. Females obtained a larger predicted asymptotic size (1139 mm and 907 mm TL, respectively) at a slower rate (0.22 mm yr^{-1} and .36 mm yr^{-1}, respectively) than males for areas combined. Males reached median size at a smaller size (721 mm TL and 821 mm TL, respectively) and at a younger age than females (2.0+ yrs and 3.0+ yrs, respectively). A fecundity estimate of 10 (std. ± 3) pups per year was determined from 50 litters.

SEDAR 13-DW-36
Tag-recapture results of small coastal sharks (*Carcharhinus acronotus, C. isodon, Rhizoprionodon terraenovae,* and *Sphyrna tiburo*) in the Gulf of Mexico
Tyminski, J., R.E. Hueter, A. J. Ubeda

Tag-recapture data from Mote Marine Laboratory's Center for Shark Research were summarized for the Atlantic sharpnose, *Rhizoprionodon terraenovae*, blacknose, *Carcharhinus acronotus*, bonnethead, *Sphyrna tiburo*, and finetooth, *Carcharhinus isodon*, sharks. Of the 7,871 sharks tagged from these species, there were 267 reported recaptures (3.4 %). 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 sharks moving from the Gulf of Mexico into the Atlantic or cross Gulf movements.

SEDAR 13-DW-39
Range extension: occurrence of the finetooth shark (*Carcharhinus isodon*) in Florida Bay
Wiley, T. and C.A. Simpfendorfer

Carcharhinus isodon (finetooth shark) is a migratory shark found in coastal waters of the southeastern United States and is well documented in the waters of north Florida in both the Gulf of Mexico and the Atlantic Ocean. The southernmost reports along Florida's Gulf coast are from Lemon Bay (27° N), just north of Charlotte Harbor, and from Port Salerno (27° N) on Florida's Atlantic coast. Four *C. isodon* were captured on bottom set longlines in Florida Bay, just north of 25° N latitude, during routine sampling for *Pristis pectinata* (smalltooth sawfish). These captures extend the southern range of *C. isodon* in Florida to approximately 25ºN and increase the likelihood of exchange between the Atlantic and Gulf.

LIFE HISTORY INFORMATION SUMMARY AND CONCENSUS

1.2 Atlantic sharpnose shark

<u>1.2.1 Stock definition</u>
After considering the available data, the working group decided that there should be two defined stocks for the Atlantic sharpnose shark: 1) an Atlantic stock, defined from North Carolina to the Straits of Florida and 2) a Gulf of Mexico stock, defined from the Florida Keys throughout the Gulf of Mexico. Even though animals in the Atlantic Ocean are not genetically different than animals in the Gulf of Mexico (Heist et. al 1996), the life history parameters are different enough

to suggest that two stocks exist. Additionally, tagging studies (SEDAR 13-DW-03, SEDAR 13-DW-23, SEDAR 13-DW-36) show no mixing of stocks.

An alternative hypothesis was offered in plenary; the observed life history pattern comes from a single stock and the variation is due to the amount of time that a given shark spends in a location/temperature cline. Another reason to use a single working stock is the pattern of fishery landings, which predominately come from the east coast of Florida. The majority of samples from the life history study in the Atlantic Ocean came from cooler waters (~50% from South Carolina, W. Driggers, pers. comm.) than where the landings occurred. The entire group agreed to compromise on the single stock hypothesis because of the underlying biology and modeling the life history reflected in the catches. However, the entire group agreed that a sensitivity analysis run would be based on the two-stock hypothesis. Research recommendations are given below to help resolve this issue.

1.2.2 Age and growth

Age and growth of the Atlantic sharpnose shark has been extensively studied in the Atlantic Ocean and Gulf of Mexico (Parsons 1983, Branstetter 1987, Leofer and Sedberry 2003, Carlson and Baremore 2003). These studies use vertebral centra for determining age at size for this shark. Leofer and Sedberry (2003) suggested a maximum age of 11 years; however, based on tag recapture data longevity was increased to 12 years (B. Fraiser, pers com). Carlson and Loefer (SEDAR 13-DW-08) used these studies to produce population estimates within the northern Gulf of Mexico, the southwest Atlantic Ocean, and the two areas combined. The group chose to adopt the separate growth models based on area provided in document SEDAR 13-DW-08.

1.2.3 Maturity and reproduction

The group chose to adopt the separate ogive schedules provided in document SEDAR 13-DW-08. Reproductive periodicity is annual regardless of area. A combined relationship of maternal size and litter size was produced and adopted for estimates of fecundity.

1.2.4 Mortality

There are no natural mortality estimates for small coastal sharks currently available based on empirical data. After consultation with the stock assessment analysts, the Working Group decided survivorship of age 0 (first-year survivorship) and age-1+ individuals should be based on the maximum estimate from values obtained using the methods of Hoenig (1983), Chen and Watanabe (1989), Pauly (1980), Peterson and Wroblewski (1984), and Lorenzen (1996). More details about the application of these indirect methods to estimate mortality can be found in Cortés (2004), Simpfendorfer et al. (2004), and Cortés et al. (2006). The rationale for using the maximum estimate from the multiple methods was to attempt to emulate a density-dependent response since the stock assessment methods are all based on density-dependent theory.

1.2.5 Population dynamics parameters

A life table/matrix model approach was used to generate values of several population parameters for use in stock assessment. The model is age-structured, based on a prebreeding census, a yearly time step, applied to females, and incorporates some considerations on density dependence (see Mortality section). Population parameters of interest are R_0 (net reproductive rate), r (intrinsic rate of increase), α (maximum lifetime reproductive rate), and z (steepness of the Beverton-Holt stock-recruit relationship; Myers et al. 1999).

1.3 Blacknose shark

1.3.1 Stock definition

After considering the available data, the working group decided that there should one defined stock for the blacknose shark. Existing genetic data is conflicting; however, the reproductive cycles differ by basin and tagging data shows no mixing (SEDAR 13-DW-03, SEDAR 13-DW-23, SEDAR 13-DW-36).

1.3.2 Age and growth

Age and growth of the blacknose shark has been studied in the Atlantic Ocean and Gulf of Mexico (Carlson et al. 1999, Driggers et al. 2004, Middlemiss et al. in review). These studies use vertebral centra for determining age at size for this shark. Driggers et. al (SEDAR 13-DW-17) used these studies to produce population estimates within the eastern Gulf of Mexico, South Carolina, and the two areas combined. Due to the lack of younger individuals in the growth model from South Carolina and the lack of larger animals from the eastern Gulf of Mexico, the working group chose to adopt a combined growth model to describe both areas (SEDAR 13-DW-17).

1.3.3 Maturity and reproduction

Because the working group adopted combined growth models, combined ogive schedules were also adopted as provided in SEDAR 13-DW-17. The reproductive periodicity in the Gulf of Mexico is considered to be annual while the periodicity is considered biennial in the south Atlantic. Average litter size from SEDAR 13-DW-17 is about 3 pups/litter for both areas. When these values are applied to a demographic model, estimates of intrinsic rate of increase (r) under a maximum compensatory response are not biologically feasible for the south Atlantic population. An alternate scenario was introduced in which fecundity was increased to 5 pups/litter based on the median observed value in Castro (1993). With this value, estimates of intrinsic rates of increase were 0.099/year. This rate is still unlikely. During plenary, the entire group decided that for the purposes of stock assessment a combined model for both areas should be adopted with fecundity representing the average of the two areas.

1.3.4 Mortality

There are no natural mortality estimates for small coastal sharks currently available based on empirical data. After consultation with the stock assessment analysts, the Working Group decided survivorship of age 0 (first-year survivorship) and age-1+ individuals should be based on the maximum estimate from values obtained using the methods of Hoenig (1983), Chen and Watanabe (1989), Pauly (1980), Peterson and Wroblewski (1984), and Lorenzen (1996). More details about the application of these indirect methods to estimate mortality can be found in Cortés (2004), Simpfendorfer et al. (2004), and Cortés et al. (2006). The rationale for using the maximum estimate from the multiple methods was to attempt to emulate a density-dependent response since the stock assessment methods are all based on density-dependent theory.

1.3.5 Population dynamics parameters

A life table/matrix model approach was used to generate values of several population parameters for use in stock assessment. The model is age-structured, based on a prebreeding census, a yearly time step, applied to females, and incorporates some considerations on density dependence (see Mortality section). Population parameters of interest are R_0 (net reproductive rate), r (intrinsic rate of increase), α (maximum lifetime reproductive rate), and z (steepness of the Beverton-Holt stock-recruit relationship; Myers et al. 1999).

1.4 Bonnethead shark

1.4.1 Stock definition

Because of the lack of available data for bonnetheads in the Atlantic Ocean, the working group decided that the stock definition should be from North Carolina through the Straits of Florida and Gulf of Mexico.

1.4.2 Age and growth

Age and growth of bonnetheads has only been studied in the eastern Gulf of Mexico (Parsons 1993, Carlson and Parsons 1997, Lombardi-Carlson et. al 2003). Lombardi-Carlson (SEDAR 13-DW-24) used these studies to produce three estimates along a latitudinal gradient in the eastern Gulf of Mexico. Due to the difficulty in modeling separate clines and the lack of data in the Atlantic Ocean, the working group chose to adopt the combined growth model provided in document SEDAR 13-DW-24. SEDAR 13-DW-24 documented maximum age to be 7.5 years based on vertebral age analysis. The working group decided to increase this value to a conservative estimate ate of 12 years based on 3 tag recaptures (time-at-liberty=6.2 years, 5.9 years, 5.6 years) on bonnetheads from the Tampa Bay, FL, area (J. Tyminski pers com).

1.4.3 Maturity and reproduction

Reproduction of bonnetheads has only been studied in the eastern Gulf of Mexico (Parsons 1993, Carlson and Parsons 1997, Lombardi-Carlson et. al 2003). Lombardi-Carlson (SEDAR 13-DW-24) used these studies to produce three estimates along a latitudinal gradient in the eastern Gulf of Mexico. Due to the difficulty in modeling separate clines and the lack of data in the Atlantic Ocean, the working group chose to adopt the combined reproductive values provided in document SEDAR 13-DW-24.

1.4.4 Mortality

There are no natural mortality estimates for small coastal sharks currently available based on empirical data. After consultation with the stock assessment analysts, the Working Group decided survivorship of age 0 (first-year survivorship) and age-1+ individuals should be based on the maximum estimate from values obtained using the methods of Hoenig (1983), Chen and Watanabe (1989), Pauly (1980), Peterson and Wroblewski (1984), and Lorenzen (1996). More details about the application of these indirect methods to estimate mortality can be found in Cortés (2004), Simpfendorfer et al. (2004), and Cortés et al. (2006). The rationale for using the maximum estimate from the multiple methods was to attempt to emulate a density-dependent response since the stock assessment methods are all based on density-dependent theory.

1.4.5 Population dynamics parameters

A life table/matrix model approach was used to generate values of several population parameters for use in stock assessment. The model is age-structured, based on a prebreeding census, a yearly time step, applied to females, and incorporates some considerations on density dependence (see Mortality section). Population parameters of interest are R_0 (net reproductive rate), r (intrinsic rate of increase), α (maximum lifetime reproductive rate), and z (steepness of the Beverton-Holt stock-recruit relationship; Myers et al. 1999).

1.5 Finetooth shark

1.5.1 Stock definition

Because of the similarities in life history estimates summarized in SEDAR 13-DW-11, low exchange of individual based on tagging data (SEDAR 13-DW-03, SEDAR 13-DW-23, SEDAR 13-DW-36), and lack of genetic differences (W. Driggers pers com), the Working Group decided that the stock definition for finetooth should be North Carolina through the Straits of Florida and into Gulf of Mexico.

1.5.2 Age and growth

SEDAR 13-DW-11 summarized several age and growth studies for the finetooth shark in the Atlantic Ocean and Gulf of Mexico and provided a combined growth model for both areas. These studies use vertebral centra for determining age at size for this shark. Because of the similarities in growth estimates for both areas, the Working Group adopted a combined growth model.

1.5.3 Maturity and reproduction

Because the Working Group adopted combined growth models, combined ogive schedules were also adopted as provided in SEDAR 13-DW-11. The reproductive periodicity in both areas is considered to be biennial although no information is available for the Gulf of Mexico. Average litter size from SEDAR 13-DW-11 is about 4 pups/litter for both areas. Very limited litter size information (n = 3) for the Gulf of Mexico agrees with this average (Neer and Thompson 2004). When these values are applied to a demographic model, estimates of intrinsic rate of increase (r) under a maximum compensatory response are negative. After discussion in plenary, the DW Panel decided that a stock assessment based on current life history information would be inappropriate. Thus, the Panel recommended that only a surplus production model be applied to this species.

1.5.4 Mortality

There are no natural mortality estimates for small coastal sharks currently available based on empirical data. After consultation with the stock assessment analysts, the Working Group decided survivorship of age 0 (first-year survivorship) and age-1+ individuals should be based on the maximum estimate from values obtained using the methods of Hoenig (1983), Chen and Watanabe (1989), Pauly (1980), Peterson and Wroblewski (1984), and Lorenzen (1996). More details about the application of these indirect methods to estimate mortality can be found in Cortés (2004), Simpfendorfer et al. (2004), and Cortés et al. (2006). The rationale for using the maximum estimate from the multiple methods was to attempt to emulate a density-dependent response since the stock assessment methods are all based on density-dependent theory.

1.5.5 Population dynamics parameters

A life table/matrix model approach was used to generate values of several population parameters for use in stock assessment. The model is age-structured, based on a prebreeding census, a yearly time step, applied to females, and incorporates some considerations on density dependence (see Mortality section). Population parameters of interest are R_0 (net reproductive rate), r (intrinsic rate of increase), α (maximum lifetime reproductive rate), and z (steepness of the Beverton-Holt stock-recruit relationship; Myers et al. 1999).

1.6 Summary of Recommended Life History Parameters

1.6.1 Atlantic Sharpnose Shark

1st year Survivorship (yr^{-1})	0.70
Adult Survivorship (yr^{-1})	0.72-0.79
S-R parameters, priors	
steepness or alpha	0.31/1.79
R_0	2.54
r	0.165
S-R function	Beverton Holt
Growth parameters	Male | Female | Combined sexes
L_{inf} (cm FL)	79.3 | 80.2 | 79.8
K	0.66 | 0.61 | 0.64
t_0	-0.76 | -0.84 | -0.80
Maximum observed age	12 years based tag-recapture
Length-Weight relationship	Weight (kg)=$(5.55519 * 10^{-6})$ Length (FL cm)$^{3.07395}$
Length-Length relationship	TL (cm)=(1.158)FL+1.476
Reproductive cycle	Annual
Fecundity	average=4.1 pups; $y = 0.0534e^{0.0544FL}$
Pupping Month	June
Sex-ratio	1:1
Stock structure	1 stock

Recommended Atlantic sharpnose shark maturity ogive (1 stock):

Age	Males	Females	Sexes Combined
0.00	0.02	0.01	0.01
0.50	0.05	0.03	0.04
1.50	0.28	0.32	0.30
2.50	0.76	0.87	0.81
3.50	0.96	0.99	0.98
4.50	1.00	1.00	1.00
5.50	1.00	1.00	1.00
6.50	1.00	1.00	1.00
7.50	1.00	1.00	1.00
8.50	1.00	1.00	1.00
9.50	1.00	1.00	1.00
10.50	1.00	1.00	1.00
11.50	1.00	1.00	1.00

1.6.1 Atlantic Sharpnose Shark (continued)

	Atlantic Ocean	**Gulf of Mexico**
1st year Survivorship (yr^{-1})	0.7	0.66
Adult Survivorship (yr^{-1})	0.72-0.79	0.73-0.79
S-R parameters priors		
Steepness or alpha	0.28/1.59	0.30/1.69
R_0	2.25	2.58
r	0.134	0.189
S-R function	Beverton Holt	Beverton Holt
Growth parameters	Male | Female | Combined sexes	Male | Female | Combined sexes
L_{inf} (cm FL)	81.3 | 81.9 | 81.6	77.8 | 80.8 | 79.5
K	0.50 | 0.48 | 0.49	0.86 | 0.63 | 0.73
t_0	-0.94 | -0.99 | -0.97	-0.72 | -1.01 | -0.86
Maximum observed age	2 tag recaptures (B. Frasier pers. comm.)~12 years;	9.5 years based vertebral band counts
	11.4 years based vertebral band counts	
Length-Weight relationship	Weight (kg)=($5.55519 * 10^{-6}$) Length (FL cm)$^{3.07395}$	Weight (kg)=($5.55519 * 10^{-6}$) Length (FL cm)$^{3.07395}$
Length-Length relationship	TL (cm)=(1.158)FL+1.476	TL (cm)=(1.158)FL+1.476
Maturity Ogive	see table from DW-08 for separate areas	see table from DW-08 for separate areas
Reproductive cycle	Annual	Annual
Fecundity	average=4.1 pups; $y = 0.0534e^{0.0544FL}$	average=4.1 pups; $y = 0.0534e^{0.0544FL}$
Pupping Month	June	June
Sex-ratio	1:1	1:1
Stock structure	2 stocks (sensitivity)	2 stocks (sensitivity)

Recommended Atlantic sharpnose shark maturity ogive (2 stocks):

Gulf of Mexico

Age	Males	Females	Combined
0.00	0.01	0.00	0.00
0.50	0.05	0.00	0.03
1.50	0.67	0.34	0.58
2.50	0.99	0.99	0.98
3.50	1.00	1.00	1.00
4.50	1.00	1.00	1.00
5.50	1.00	1.00	1.00
6.50	1.00	1.00	0.99
7.50	1.00	1.00	0.99
8.50	1.00	1.00	0.99
9.50	1.00	1.00	0.99

South Atlantic

Age	Males	Females	Combined
0.00	0.00	0.01	0.00
0.50	0.00	0.04	0.01
1.50	0.01	0.25	0.12
2.50	0.35	0.73	0.59
3.50	0.97	0.96	0.94
4.50	1.00	0.99	0.99
5.50	1.00	1.00	1.00
6.50	1.00	1.00	1.00
7.50	1.00	1.00	1.00
8.50	1.00	1.00	1.00
9.50	1.00	1.00	1.00
10.50	1.00	1.00	1.00
11.50	1.00	1.00	1.00

1.6.2 Blacknose Shark

1st year Survivorship (yr^{-1})	0.72
Adult Survivorship (yr^{-1})	0.76-0.83
S-R parameters, priors	
Steepness or alpha	0.24/1.27
R_0	1.76
r	0.084
S-R function	Beverton Holt
Growth parameters	Male | Female | Combined sexes
L_{inf} (cm FL)	979 | 1043 | 1012
K	0.36 | 0.30 | 0.32
t_0	-1.62 | -1.71 | -1.70
Maximum observed age	12.5
Length-Weight parameters	Weight (kg)=e(-1.6493+ 0.00336578*TL)
Length-Length parameters	TL (mm)=(97.7298+1.07623*FL)
Reproductive cycle	1.5
Fecundity	3.33
Pupping Month	June
Sex-ratio	1:1
Stock structure	1 stock

Recommended blacknose shark maturity ogive:

	Proportion mature		
Age (years)	Female	Male	Combined
0	0.00	0.00	0.00
0.5	0.00	0.00	0.00
1.5	0.00	0.00	0.00
2.5	0.00	0.01	0.01
3.5	0.04	0.07	0.07
4.5	0.50	0.47	0.48
5.5	0.95	0.91	0.92
6.5	1.00	0.99	0.99
7.5	1.00	1.00	1.00
8.5	1.00	1.00	1.00
9.5	1.00	1.00	1.00
10.5	1.00	1.00	1.00
11.5	1.00	1.00	1.00
12.5	1.00	1.00	1.00

1.6.3 Bonnethead Shark

1st year Survivorship (yr^{-1})	0.66
Adult Survivorship (yr^{-1})	0.66-0.81
S-R parameters, priors	
Steepness or alpha	0.32/1.88
R_0	2.83
r	0.205
S-R function	Beverton Holt
Growth parameters	Male | Female | Combined sexes
L_{inf} (cm TL)	907 | 1139 | 1155
K	0.36 | 0.22 | 0.20
t_0	-0.99 | -1.25 | -1.68
Maximum observed age	7.5 years based on vertebral band counts
	12 based on tag recaptures (J. Tyminski, pers. com.)
Length-Weight parameters	Weight (kg)=(9.52 * 10^{-11}) Total Length (mm)$^{3.59}$
Length-Length parameters	TL (mm)=(1.18)FL-23.34
Reproductive cycle	Annual
Fecundity	10.0 (3.0 S.D.)
Pupping Month	August
Sex-ratio	1:1
Stock structure	1 stock.

Recommended bonnethead shark maturity ogive:

Age (yr)	Males	Females	Combined
0.0	0.05	0.00	0.03
1.0	0.18	0.02	0.11
2.0	0.48	0.12	0.33
3.0	0.80	0.48	0.67
4.0	0.95	0.86	0.89
5.0	0.99	0.98	0.97
6.0	1.00	1.00	0.99
7.0	1.00	1.00	1.00

1.6.4. Finetooth Shark

r	-0.056
Growth parameters	Male | Female | Combined sexes
L_{inf} (cm FL)	1136 | 1267 | 1206
K	0.32 | 0.23 | 0.27
t_0	-1.64 | -1.95 | -1.83
Maximum observed age	12
Length-Weight parameters	Weight (kg)=(4.0834 * 10-9) STL (mm)$^{3.0346}$
Length-Length parameters	TL (mm)=(1.23)FL+20.34
	STL=1.1(TL)+11.25
Reproductive cycle	Biennial
Fecundity	4.036 (SD=0.793)
Pupping Month	June
Sex-ratio	1:1
Stock structure	1 stock.

Recommended finetooth shark maturity ogive:

Age	Males	Females	Combined
0.00	0.01	0.00	0.01
0.50	0.02	0.00	0.01
1.50	0.06	0.01	0.04
2.50	0.20	0.03	0.13
3.50	0.48	0.14	0.34
4.50	0.77	0.43	0.64
5.50	0.92	0.78	0.84
6.50	0.98	0.94	0.92
7.50	0.99	0.99	0.94
8.50	1.00	1.00	0.95
9.50	1.00	1.00	0.95
10.50	1.00	1.00	0.95
11.50	1.00	1.00	0.95
12.50	1.00	1.00	0.95

1.7 Research Recommendations

- Bonnethead life history in Atlantic Ocean, spanning the range of the stock.
- Re-evaluate finetooth life history in the Atlantic Ocean in order to validate fecundity and reproductive periodicity.
- Determine reproduction for finetooth in the Gulf of Mexico.
- Re-evaluate blacknose life history in Atlantic Ocean, spanning the range of the stock.
- Expand research efforts directed towards tagging of individuals in south Florida and Texas/Mexico border to get better data discerning potential stock mixing.
- Develop empirically based estimates of natural mortality.
- Coordinate a biological study for Atlantic sharpnose so that samples are made *at least* monthly, and within each month samples would be made consistently at distinct geographic locations. For example, sampling locations would be defined in the northern Gulf, west coast of Florida, the Florida Keys (where temperature is expected to be fairly constant over all seasons), and also several locations in the South Atlantic, including the east coast of Florida, South Carolina, and North Carolina. This same sampling design could be applied to all small coastal sharks.
- Population level genetic studies are needed that could lend support to arguments for stock discriminations using new loci and/or methodology that has increased levels of sensitivity.

1.8 Literature Cited

Branstetter, S. 1987. Age and growth validation of newborn sharks held in laboratory aquaria, and comments on the life history of the Atlantic sharpnose shark, *Rhizoprionodon terraenovae*. Copeia 1987:291-300.

Carlson, J.K. and I.E. Baremore. 2003. Changes in biological parameters of Atlantic sharpnose shark *Rhizoprionodon terraenovae* in the Gulf of Mexico: evidence for density-dependent growth and maturity? Marine and Freshwater Research 54:227-234.

Carlson, J.K., E. Cortés & D. Bethea. 2003. Life history and population dynamics of the finetooth shark, *Carcharhinus isodon*, in the northeast Gulf of Mexico. Fishery Bulletin 101:281-292.

Carlson, J. K., Cortés, E. & Johnson, A. G. (1999). Age and growth of the blacknose shark, Carcharhinus acronotus, in the Eastern Gulf of Mexico. Copeia, 684–691.

Carlson, J. K. and G. R. Parsons. 1997. Age and growth of the bonnethead shark, *Sphyrna tiburo*, from northwest Florida, with comments on clinal variation. Env. Bio. Fish. 50: 331-341.

Castro, J.I. 1993. The biology of the finetooth shark, *Carcharhinus isodon*. Environmental Biology of Fishes 36: 219-232.

Chen, S.B. and S. Watanabe. 1989. Age dependence of natural mortality coefficient in fish population dynamics. Nip. Suisan Gak. 55:205-208.

Cortés, E. 2004. Life history patterns, demography, and population dynamics. In 'Biology of Sharks and Their Relatives'. (Eds J. C. Carrier, J. A. Musick and M. R. Heithaus.) pp. 449-469. (CRC Press: Boca Raton, FL.)

Cortés, E., E. Brooks, P. Apostolaki, and C.A. Brown. 2006. Stock assessment of dusky shark in the U.S. Atlantic and Gulf of Mexico. Sustainable Fisheries Division Contribution SFD-2006-014.

Drymon, J.M.,W.B. Driggers, D. Oakley & G.F. Ulrich. In press. Investigating life history differences between finetooth sharks, *Carcharhinus isodon*, in the northern Gulf of Mexico and the western North Atlantic Ocean. Gulf of Mexico Science.

Driggers, W.B,. Oakley, D. A., Ulrich, G., Carlson, J.K., Cullum, B.J., & Dean, J.M. 2004. Reproductive biology of *Carcharhinus acronotus* in the coastal waters of South Carolina. Journal of Fish Biology 64:1540–1551.

Heist, E. J., J. A. Musick, and J. E. Graves. 1996. Mitochondrial DNA diversity and divergence among sharpnose sharks, Rhizoprionodon terraenovae, from the Gulf of Mexico and Mid-Atlantic Bight. Fishery Bulletin 94:664-668.

Hoenig, J. M. 1983. Empirical use of longevity data to estimate mortality rates. Fishery Bulletin 81:898–903

Lombardi-Carlson, L. A., Cortés, E., Parsons, G. R., and C. A. Manire. 2003. Latitudinal variation in life-history traits of bonnethead sharks, *Sphyrna tiburo,* (Carcharhiniformes: Sphyrnidae) from the eastern Gulf of Mexico. Mar. Fresh. Res. 54: 875-883.

Loefer J.K. and G.R. Sedberry. 2003. Life history of the Atlantic sharpnose shark (*Rhizoprionodon terraenovae*) (Richardson, 1836) off the southeastern United States. Fishery Bulletin 101:57- 88.

Lorenzen, K. 1996. The relationship between body weight and natural mortality in juvenile and adult fish: a comparison of natural ecosystems and aquaculture. J. Fish Biol. 49:627-647.

Middlemiss, A.M, J.K. Carlson and J.A Neer. In review. A revised age and growth model for the blacknose shark, *Carcharhinus acronotus*, from the eastern Gulf of Mexico using x-radiographs. Gulf of Mexico Science.

Myers, R.A., Bowen, K.G., and Barrowman, N. J. 1999. Maximum reproductive rate of fish at low population sizes. Canadian Journal of Fisheries and Aquatic Sciences 56, 2404-2419.

Neer, J.A. & B.A. Thompson. 2004. Aspects of the biology of the finetooth shark, *Carcharhinus isodon,* in Louisiana waters. Gulf of Mexico Science 2004(1):108-113

Parsons, G. R. 1983. The reproductive biology of the Atlantic sharpnose shark, *Rhizoprionodon terraenovae* (Richardson). Fishery Bulletin U.S. 81:61-73.

Parsons, G. R. 1993. Geographic variation in reproduction between two populations of the bonnethead shark, *Sphyrna tiburo*. Env. Bio. Fish. 38: 25-35.

Pauly, D. 1980. On the interrelationship between natural mortality, growth parameters, and mean environmental temperature in 175 fish stocks. J. Cons. Int. Explor. Mer 39:175-192.

Peterson, I., and J.S. Wroblewski. 1984. Mortality rates of fishes in the pelagic ecosystem. Can. J. Fish. Aquat. Sci. 41:1117-1120.

Simpfendorfer, C.A., R. Bonfil, and R.J. Latour. 2004. Mortality estimation. In 'Elasmobranch Fisheries Management Techniques'. (Eds J.A. Musick and R. Bonfil) pp. 165-186. APEC Fisheries Working Group, Singapore.

Sulikowski, J.A., W.B. Driggers, T.S. Ford, R. Boonstra and J.K. Carlson. In press. Reproductive cycle of the blacknose shark, *Carcharhinus acronotus*, in the Gulf of Mexico. Journal of Fish Biology

2. Catch Histories

<u>Catch Working Group Summary Report</u>
Enric Cortés – Chair, NMFS Panama City (NMFS-PC)
Loraine Hale – Rapporteur, NMFS Panama City (NMFS-PC)
Michael Clark – Highly Migratory Species (HMS)
Alan Bianchi – North Carolina Division of Marine Fisheries (NCMF)
Chris Vonderweidt – Atlantic States Marine Fisheries Commission (ASMFC)
Geoff White – Atlantic Coastal Cooperative Statistics Program (ACCSP)
Rusty Hudson – Directed Shark Fisheries (DSF)
Katie Siegfried – NMFS Panama City (NMFS-PC)

<u>2.1 Summary of Catch Documents</u>

SEDAR 13-DW-07
Gillnet selectivity of small coastal sharks off the southeastern United States
J.K. Carlson and E. Cortés

Gillnet selectivity parameters for the Atlantic sharpnose, *Rhizoprionodon terraenovae*, blacknose, *Carcharhinus acronotus*, finetooth, *Carcharhinus isodon*, and bonnethead, *Sphyrna tiburo*, sharks were estimated from fishery-independent catches in multi-panel gillnets with stretched mesh sizes ranging from 8.9 to 14.0 cm in steps of 1.3 cm, with an additional size of

20.3 cm. Mesh selectivities were estimated using a maximum-likelihood model, which fits a gamma distribution to length data for each mesh size using the log-likelihood function. The Atlantic sharpnose and finetooth shark exhibited the broadest selection curves. Peak selectivities for the Atlantic sharpnose were reached from 750 mm FL for the 8.9 cm mesh to 1150 mm FL for the 14.0 cm mesh in 50 mm FL increments per mesh. Peak selectivity for the finetooth shark was reached at 550 mm FL for the 8.9 and 10.2 cm meshes, increased to 650mm FL for the 11.4 mesh, and 750 mm FL for the 12.7 and 14.0 cm meshes. Selectivity was highest at 1150 mm FL for the 20.3 cm mesh. The bonnethead and blacknose shark exhibited narrower selection curves, with peak selectivity occurring at 450 mm FL for the 8.9 cm mesh, 750 mm for the 12.7 cm mesh in 100 mm FL increments per mesh. Maximum selectivity for the 20.3 cm mesh was 950 and 1050 mm FL for bonnethead and blacknose shark, respectively. The $\theta 1$ values for blacknose and finetooth shark were most similar (140.58 and 141.25), whereas the value calculated for Atlantic sharpnose was the highest (211.95) and that for the bonnethead (131.77) was the lowest. Values calculated for $\theta 2$, a parameter that describes the variance of sizes by mesh, ranged from 27,259 for the bonnethead to 189,873 for the finetooth shark. Although gillnets used in this study were not directly constructed for use in estimation of gillnet selectivities, information on mesh selectivities estimated herein has direct applicability to commercial gillnets with meshes of similar sizes.

SEDAR 13-DW-15
Updated catches of Atlantic small coastal sharks
E. Cortés and J.A. Neer

This document presents updated commercial and recreational landings of Atlantic small coastal sharks up to 2005. Species-specific information on the geographical distribution of commercial landings and recreational catches is presented along with the different gear types used in the commercial fisheries. Length-frequency information and average weights of the catches in three separate recreational surveys and in the directed shark bottom-longline observer program are also included.

SEDAR 13-DW-20
Bottom Longline Observer Program: Small Coastal Shark Catch and Bycatch 1994 to 2005
L. Hale, I. Baremore, J. Carlson, A. Morgan, and G. Burgess

This document presents observed catch and bycatch of small coastal sharks from the shark bottom longline observer program from 1994 through 2005. Catch is broken up by region and by year, into categories based upon disposition of the catch. Estimates of discarded dead catch (kept as bait, discarded dead, kept for samples) were presented in percentage of total SCS/species catch, by year and area for the small coastal shark complex combined and the Atlantic sharpnose shark, blacknose shark, finetooth shark, and bonnethead shark separately.

SEDAR 13-DW-32
Bycatch of small coastal sharks in the offshore shrimp fishery
S. Nichols

Estimates of offshore shrimp fleet bycatch for Atlantic sharpnose, bonnethead, blacknose, and small coastal sharks combined are provided using procedures used in previous SEDARs. Finetooth was too rare for the standard analysis.

SEDAR 13-DW-35
Estimation of bycatch of small coastal sharks in the shrimp trawl fishery in the US South Atlantic
K.I. Siegfried

Estimates of bycatch of the small coastal shark complex, *C. isodon*, *C. acronotus*, *S. tiburo*, and *R. terraenovae*, are required for the 2007 stock assessment. The regions of interest for the assessment are the Gulf of Mexico (GOM, statistical zones 1-21) and the South Atlantic (SA, 24-35), however this report focuses on the South Atlantic. For the purposes of this report, we focus on the shark bycatch in the shrimp trawl fishery. See Nichols (2007; SEDAR 13-DW-32) for the analysis of data from the GOM.

SEDAR 13-DW-40
Small Coastal Sharks Collected Under the Exempted Fishing Program Managed by the Highly Migratory Species Management Division
J. Wilson and M. Clark

The Highly Migratory Species Management Division provided small coastal shark landings data attained from their Exempted Fishing Permit program. This program authorizes the collection of sharks for public display and research from vessels deploying rod and reel, trawl, and longline gear. Because of the limited duration (2000-2005) and extent of the small coastal shark landings, data that were originally submitted were further broken down at the data workshop by species, year, region landed (South Atlantic, Gulf of Mexico, and Unknown), and gear type for possible integration into other relevant data sources. Furthermore, length (FL, cm) frequency graphs were created for the four species and the small coastal shark complex.

2.2. Landings and Discard Estimates

The Catch Working Group reviewed catch information for the Small Coastal Shark (SCS) complex (consisting of Atlantic sharpnose, bonnethead, blacknose and finetooth sharks), and the four individual species. Catch data for species that were originally included in the SCS complex and later designated as prohibited (smalltail, Caribbean sharpnose and Atlantic angel shark; **Table 2.1**) were not examined, but these species make up an insignificant portion of the SCS catches.

2.2.1. Commercial landings

U.S. commercial landings of Atlantic sharks for 1995-2005 (complete data for 2006 were not yet available) were compiled based on Northeast Regional and Southeast Regional general canvass landings data, and the SEFSC quota monitoring data based on southeastern region permitted shark dealer reports. The general canvass landings data are housed in the Accumulated Landings

System (ALS). The Quota Monitoring System (QMS) is now known as the Pelagic Dealer Compliance program (PDC). Data from this program are summarized by the SEFSC into monthly reports and sent to the Highly Migratory Species Management Division of the NMFS. This summary is used to monitor the respective fishery quotas for sharks.

Landings reported in the general canvass and quota monitoring data files from southeastern states (North Carolina to Texas) were combined to define the species composition and volume of landings. In general, the quota monitoring data provide a more diverse species listing than the general canvass data SE, whereas the general canvass data SE apportion a higher volume of shark landings as unclassified. The larger reported landing of a given species in the two data sets was taken as the actual landed volume for that species. Additionally, as is done for large coastal sharks, for the state of North Carolina (NC), it was assumed that some “dogfish” might also have been assigned to the unclassified shark category. To adjust for this possibility, the NC unclassified sharks were apportioned between the large coastal, small coastal, pelagic, prohibited, and dogfish categories based on the reported distribution of landings by species and gear for that state. This typically resulted in small amounts of unclassified sharks being categorized as SCS. Finally, the values reported from the NE general canvass landings data (Virginia north) were added to produce the final commercial landings values. Landings from the northeastern states were of very small magnitude and generally reported as unclassified SCS. Landings prior to 1995 only included data from the general canvass data for both regions as the quota monitoring system was not yet established. These landings were insignificant (262 and 3,308 SCS for 1993-1994; **Table 2.2**).

The landings data are collected in landed or dressed weight. Landed weights were expressed as numbers by dividing them by average weights obtained from the shark bottom longline fishery observer program for 1995-2005, which were obtained by predicting weight from length of those sharks measured in the observer program. A more detailed description of the sources of commercial landings, recreational catches and the bottom longline observer program as well as the methods used to arrive at estimates can be found in document SEDAR 13-DW-15.

Based on information provided in document SEDAR 13-DW-15, commercial landings were split into three groups according to the predominant gear types: (1) longlines, (2) nets (including drift gillnets and all gillnet types), and (3) lines (including troll lines, hook and line, and bandit gear). These three gear groups accounted for the vast majority of the volume of commercial landings reported (>99% in any year for 1995-2005). Note also that some landings reported in the general canvass data that had originally been assigned to an “unknown” region in document SEDAR-13-DW-15, were later determined to have been Georgia landings and re-designated as such. Gear-specific commercial landings of the SCS complex and the four individual species are presented in **Tables 2.2-2.6** and **Figures 2.1-2.5**.

2.2.2 Recreational catches

Recreational catches for 1981-2005 were taken from document SEDAR 13-DW-15, and correspond to the sum of the estimates from the Marine Recreational Fishery Statistics Survey (MRFSS; 1981-2005), the NMFS Headboat Survey (1986-2005), and the Texas Parks and Wildlife Department (TXPWD; 1983-2005) data sets. The MRFSS estimates included type A (retained) and B1 (discarded dead) estimates and were obtained based on the now adopted For Hire Survey (FHS) estimation method, which includes charterboats.

Catch-frequency information on the number of sharks caught by species, geographical area and year, and species-specific effort information (number of directed trips) by geographical area and year were provided by staff from the Atlantic Coastal Cooperative Statistics Program (ACCSP) and may be of value for management purposes.

2.2.3 Bottom longline discards

Discard estimates for 1994-2005 were obtained by multiplying the commercial landings column attributed to longlines by the annual dead discard rate obtained from the shark bottom longline fishery observer program. Dead discard rates from the observed bottom longline fishery were calculated as percentages (total number discarded dead divided by total number caught in that year) for the SCS complex and for Atlantic sharpnose, blacknose, bonnethead, and finetooth shark separately. The total number discarded dead was the sum of sharks kept for bait, discarded dead, and those kept for samples or for museum specimens. Sharks kept for carcass or lost on the line were not included in the calculation.

2.2.4 Mexican catches

The Working Group recommended not including Mexican catches of SCS in the catch tables because of the limited data available on migration rates between the two countries and the lack of species-specific information for Mexican catches.

2.2.5 Shrimp trawl fishery bycatch

Estimates of SCS bycatch in the shrimp trawl fishery in the Gulf of Mexico for 1972-2005 were provided in document SEDAR 13-DW-32 and subsequent information provided to the Working Group. Although document SEDAR 13-DW-35 and previously Cortés (2002) provided SCS bycatch estimates for the South Atlantic for the periods 1999-2005 and 1992-1997, the Working Group decided to reject these estimates because of extreme interannual variability and the fact that the CPUE portion of the estimate was based on very small sample sizes (sometimes n=1), which when expanded by total effort produced exceedingly high estimates. The Working Group felt that the estimates provided for the Gulf of Mexico (GOM) were more statistically robust and based on a methodology that has been used for other marine fishes, such as red snapper, and extensively reviewed. It was thus decided to produce estimates for the South Atlantic (SA) by comparing the observed trips in the GOM to those from the SA. There were 637 observed trips in the GOM with an average of 17.5 days per trip and 668 observed trips in the SA with an average of 2.2 days per trip. Based on these data, there are approximately 12.6% of the observed bycatch events in the SA compared to the GOM. Estimates of SCS bycatch in the SA were thus obtained by multiplying the GOM estimates by 0.126.

2.2.6 Exempted Fishing Permit catches

Numbers of SCS taken under HMS-issued Exempted Fishing Permits (EFPs) were small, but the Working Group recommended that they be included in the catch tables. Information on area of capture (Gulf of Mexico vs. South Atlantic) and gear of capture was available, and estimates were provided for 2000 and 2003-2005 (document SEDAR 13-DW-40). Prior to 1999, catches were not reported to HMS in the same way and were not included. EFP catches, shown as a separate column in all tables to illustrate magnitude, were added to the commercial landings or bycatch columns based on gear used and thus should not counted be towards the total landings column.

2.2.7 Catch reconstruction for Age-Structured model

In anticipation of the application of an age-structured surplus production model (Porch 2002), the catch series presented in Tables 2.2-2.6 had to be expanded back in time (**Tables 2.7-2.11**; **Figures 2.6-2.10**). This age-structured model requires that 1) a year where the stock was considered to be virgin be identified, 2) a starting year for each fishery included in the model, and 3) a catch series be provided for the period spanning between the initial year of the fishery identified in (2) and the first year for which catch data for SCS are available for the given fishery. The Working Group identified the following dates:

Year	Longline fisheries	Net fisheries	Line fisheries	Recreational fisheries	Shrimp trawl (GOM)	Shrimp trawl (SA)
Fishery start	1981	1987	1950	1950	1950	1950
Fishery catch data available	1995	1995	1995	1981	1972	1972

The Working Group decided that the year of virgin condition of the stocks was 1950. For the longline fishery, the Working Group assumed a linear increase from the year immediately preceding the start of the fishery in 1981 to the year when catch data first become available (1995). The same rationale was applied to the net fishery (linear increase from 1986 to 1995) and the line fishery (linear increase from 1950 to 1995). For bottom longline discards, we multiplied the average discard rate observed for 1994-2005 by the back-calculated annual longline catch for 1981-1994 to obtain discard estimates for that period.

For the recreational rod and reel fishery, it was assumed that the fishery started in 1950 and catch data are first available in 1981. Similar to the method used in the Gulf of Mexico gag grouper SEDAR (SEDAR 10), we decided to scale catches for which we have data using the trends in human population in the coastal counties of the South Atlantic and Gulf of Mexico. We gathered National Census Bureau data for the coastal counties in the South Atlantic and Gulf of Mexico states (www.census.gov, see Table below). Based on the trends in population growth, from decade to decade in relation to 1980 (**Figure a** below), we back-calculated the catches for each species in each region from 1950 to 1980. For the SCS complex, Atlantic sharpnose, and bonnethead, we averaged the first five years for which we have data and applied the trend of human population growth. For the blacknose and finetooth sharks, we averaged the first 10 years of data available because the data were sparser for these species. For the Gulf of Mexico, the trend was that 1950, 1960, and 1970 were 39%, 69%, and 75% of the 1980 values, respectively. For the Atlantic, the trend was that 1950, 1960, and 1970 were 17%, 54%, and 74% of the 1980 values, respectively (see **Figures b and c** below).

Population censuses for coastal communities in the Gulf of Mexico and the Atlantic (numbers).

Decade	Gulf of Mexico	Western Atlantic Ocean
1950	2335548	957730
1960	3566661	3113857
1970	4437028	4205833
1980	5937234	5721161
1990	7100383	7362099

Figure a.

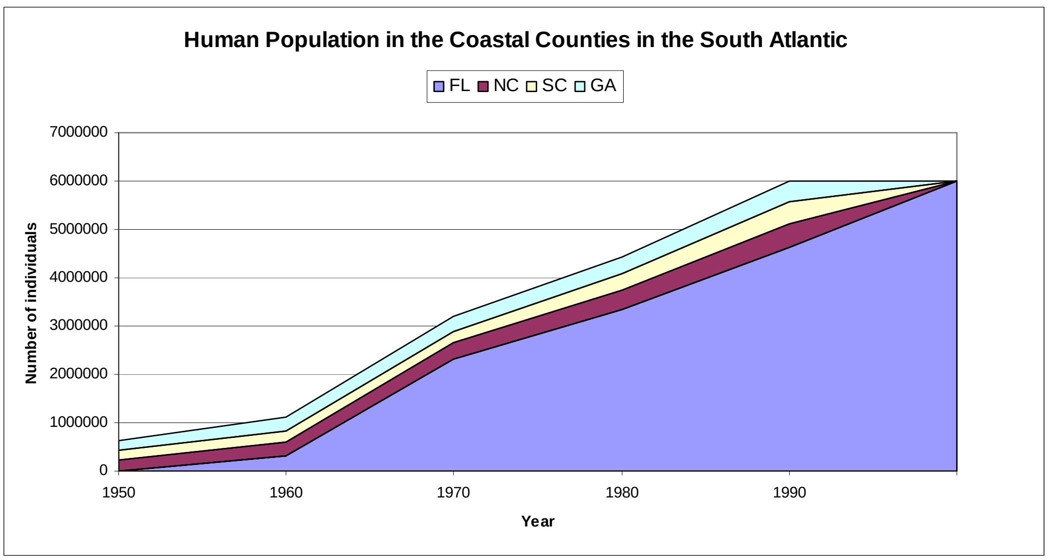


Figure b.

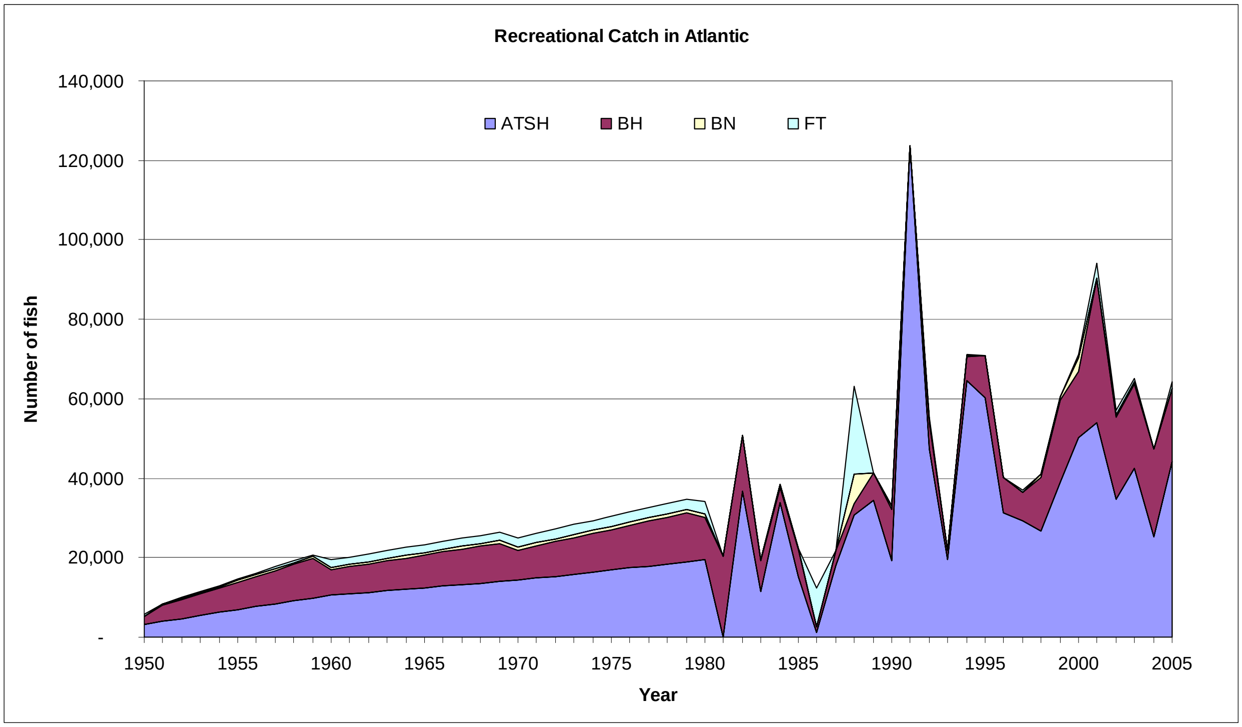
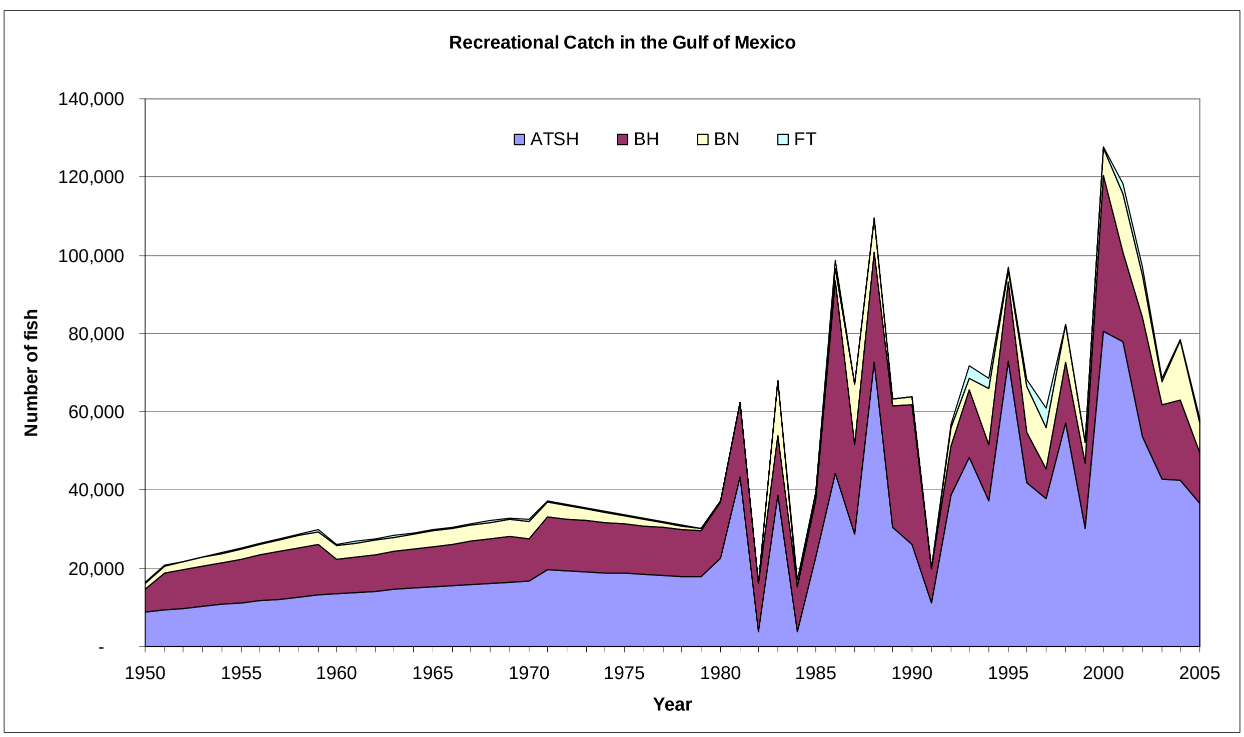


Figure c.



For the shrimp trawl fisheries, historic landings data were obtained from the NMFS Office of Science and Technology (NMFS ST) commercial fisheries data website (http://www.st.nmfs.gov/st1/commercial/). The database was queried for shrimp landings (shrimp) by region (Gulf of Mexico and Atlantic) and gear (all gears), between 1950 and 1960. All the non-trawl landings (cast nets and bag nets) were assumed to not have any SCS bycatch and all landings from Atlantic states north of North Carolina (i.e., New Jersey, Maine, etc), which were assumed to be outside the core range of small coastal sharks, were deleted. The pounds of shrimp reported in that database were "whole", and were converted to “heads off” by dividing by a conversion factor of 0.55, found by comparing landings of “heads off” from the NMFS Galveston Laboratory (see below) to landings of “whole” shrimp from the NMFS ST database in 1960, a year in which estimates from the two sources overlapped. This conversion factor from “heads off” to “whole” (1.82 = 1/0.55) is close to the conversion factors used by the NC Division of Marine Fisheries (1.54-1.61). Shrimp trawl landings for the South Atlantic for the period 1962-2005 were supplied by the SEFSC and those for the Gulf of Mexico for 1960-2005 by Jim Nance of the NMFS Galveston Laboratory. SCS bycatch estimates for 1950-1971 were then obtained by applying the mean ratio of shrimp caught to sharks caught by year for 1972-2005 (obtained as described above).

2.3. Suggested Sensitivity Analyses

Based on the recommendation of the Life History Working Group that Atlantic sharpnose shark be assessed as two separate stocks in a sensitivity analysis, two catch histories were developed for that species (Gulf of Mexico and Atlantic Ocean; **Table 2.12a & b**). Additionally, the two catch histories were also back-calculated to 1950 (**Tables 2.13-2.14**).

2.4. Species-specific selectivities

In estimating selectivity, the age of full selectivity must be determined. This age can be evaluated by plotting a histogram of age frequencies. With natural mortality operating alone, one would expect to see a decline at each age in the histogram. With both natural and fishing mortality operating, what is observed instead is an increase in the age frequency that reflects the increase in selectivity with age. Beyond the “fully selected” age, all subsequent ages are expected to consistently decline because they are all assumed to experience the same fishing and natural mortality. Thus, the fully selected age is determined by looking at the age frequency distribution and identifying the “fulcrum” age class, where younger ages show an increasing frequency and all subsequent ages decrease in frequency.

We will obtain age frequencies by back-transformation of lengths into ages through growth curves or through age-length keys based on the multiple length frequencies provided by the Life History and Indices Working Groups at the Data Workshop. For age-length keys, the procedure consists of determining the proportion of sharks at each age within a series of equal length classes covering the full range of lengths in the original ageing study for each species. The sample of interest is then divided into the same length classes and the number of sharks within each length class is assigned to ages based on the proportion of each age in that length class in the age-length key. The final step is to sum the number of sharks of each age across all the length classes. This approach captures variation in age-at-length that is not captured when back-transforming lengths into ages through a growth curve.

The following assumptions are generally made about selectivities:

Longlines: logistic **Gillnets**: dome-shaped

Hook and line: logistic **Trawl nets**: dome-shaped

We present the species-specific length-frequency distributions from the multiple fishery-dependent and fishery-independent sources presented at the Data Workshop in **Figures 2.11-2.14**.

2.5 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.

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 23 pp.

Table 2.1. List of species that were originally part of the Small Coastal Shark complex, including those that are currently prohibited.

Common name	Species name
Atlantic Sharpnose Shark	*Rhizoprionodon terraenovae*
Blacknose Shark	*Carcharhinus acronotus*
Bonnethead Shark	*Sphyrna tiburo*
Finetooth Shark	*Carcharhinus isodon*
Prohibited Species	
Caribbean sharpnose shark	*Rhizoprionodon porosus*
Atlantic angel shark	*Squatina dumeril*
Smalltail shark	*Carcharhinus porosus*

Table 2.2. Catch history for the Small Coastal Shark complex (numbers of fish).

CATCHES OF SMALL COASTAL SHARKS: 4 species (in numbers)

Year	Commercial				Recreational catches	Bottom longline discards	Shrimp bycatch (GOM)	Shrimp bycatch (SA)	EFP	Total
	Total	Longline	Nets	Lines						
1972							840,633	105,680		946,313
1973							233,634	29,371		263,005
1974							411,643	51,749		463,392
1975							872,930	109,740		982,670
1976							292,878	36,819		329,697
1977							946,230	118,955		1,065,185
1978							635,527	79,895		715,422
1979							933,737	117,384		1,051,121
1980							1,738,982	218,615		1,957,597
1981					82,759		1,736,376	218,287		2,037,422
1982					67,647		409,794	51,517		528,958
1983					87,399		674,421	84,784		846,604
1984					57,342		377,532	47,461		482,335
1985					62,885		476,828	59,944		599,657
1986					111,425		485,197	60,996		657,618
1987					98,947		1,040,738	130,836		1,270,521
1988					172,684		580,306	72,953		825,943
1989					104,757		603,506	75,869		784,132
1990					96,977		614,590	77,263		788,830
1991					143,845		891,723	112,102		1,147,670
1992					111,829		1,172,572	147,409		1,431,810
1993	262				93,562		509,360	64,034		666,956
1994	3,308				140,473		443,215	55,718		639,406
1995	139,569	57,819	80,791	627	164,884	32,494	1,051,681	132,211		1,520,508
1996	118,425	39,967	75,317	3,134	114,007	15,627	920,627	115,736		1,284,416
1997	214,221	29,527	181,922	1,723	99,382	9,035	703,350	88,421		1,113,361
1998	187,931	22,044	163,396	2,397	123,593	9,038	806,300	101,363		1,228,131
1999	222,715	18,064	198,804	4,601	112,715	14,379	641,017	80,585		1,070,164
2000	168,544	24,689	141,425	2,377	199,043	22,196	796,602	100,144	11	1,286,476
2001	219,962	14,643	201,777	1,535	212,442	14,365	641,786	80,682		1,167,231
2002	173,847	25,133	146,719	1,949	153,810	24,906	1,104,353	138,833		1,595,703
2003	147,313	36,678	90,411	20,120	133,738	26,518	544,058	68,396	5	919,918
2004	133,937	35,741	97,080	1,374	125,711	30,165	797,000	101,330	1872	1,188,402
2005	138,792	34,964	100,874	1,349	122,688	29,020	530,943	66,893	484	886,732

Table 2.3. Catch history for the Atlantic sharpnose shark (numbers of fish).

CATCHES OF ATLANTIC SHARPNOSE SHARKS (in numbers)										
Year	Commercial				Recreational catches	Bottom longline discards	Shrimp bycatch (GOM)	Shrimp bycatch (SA)	EFP	Total
	Total	Longline	Nets	Lines						
1972							485,780	61,069		546,849
1973							102,900	12,936		115,836
1974							185,074	23,266		208,340
1975							192,627	24,216		216,843
1976							141,282	17,761		159,043
1977							497,629	62,559		560,188
1978							578,336	72,705		651,041
1979							470,857	59,194		530,051
1980							757,373	95,213		852,586
1981					43,490		1,492,272	187,600		1,723,362
1982					40,656		208,879	26,259		275,794
1983					50,170		343,009	43,121		436,300
1984					37,539		193,399	24,313		255,251
1985					37,994		293,171	36,856		368,021
1986					45,392		202,706	25,483		273,581
1987					46,792		568,133	71,422		686,347
1988					103,375		322,388	40,529		466,292
1989					65,058		270,901	34,056		370,015
1990					45,233		303,917	38,207		387,357
1991					134,905		460,335	57,871		653,111
1992					85,972		860,192	108,138		1,054,302
1993					67,719		385,082	48,410		501,211
1994					101,774		230,386	28,963		361,123
1995	27,437	20,359	6,533	545	128,478	16,938	567,054	71,287		811,194
1996	49,113	12,074	35,721	1,318	73,114	5,011	446,999	56,194		630,430
1997	78,777	6,925	70,619	854	67,675	2,631	292,293	36,745		477,742
1998	72,977	6,580	64,506	1,794	83,748	2,711	455,072	57,209		671,619
1999	76,808	5,248	69,727	1,576	69,153	4,561	276,374	34,744		461,383
2000	40,762	3,951	35,610	1,146	130,727	3,564	478,883	60,202	1	714,082
2001	60,136	4,787	53,890	1,190	131,912	4,782	283,371	35,624		515,556
2002	71,568	11,635	59,098	819	88,297	11,531	567,679	71,365		810,424
2003	61,481	19,786	15,855	25,773	85,299	15,671	262,108	32,951	3	457,443
2004	74,024	26,183	47,693	644	67,870	25,136	153,970	20,253	1,568	341,748
2005	107,156	24,924	80,539	1,159	80,761	21,410	289,384	36,458	332	534,635

Table 2.4. Catch history for the Bonnethead shark (numbers of fish).

CATCHES OF BONNETHEAD SHARKS (in numbers)

Year	Commercial				Recreational catches	Bottom longline discards	Shrimp bycatch (GOM)	Shrimp bycatch (SA)	EFP	Total
	Total	Longline	Nets	Lines						
1972							230,616	28,992		259,608
1973							168,133	21,137		189,270
1974							227,183	28,560		255,743
1975							337,902	42,479		380,381
1976							152,590	19,183		171,773
1977							295,526	37,152		332,678
1978							72,078	9,061		81,139
1979							282,239	35,482		317,721
1980							749,312	94,199		843,511
1981					39,269		97,393	12,244		148,906
1982					26,115		168,807	21,221		216,143
1983					22,925		81,431	10,237		114,593
1984					15,418		91,813	11,542		118,773
1985					22,607		89,457	11,246		123,310
1986					50,474		287,078	36,090		373,642
1987					26,527		181,772	22,851		231,150
1988					30,986		161,864	20,349		213,199
1989					37,901		106,352	13,370		157,623
1990					48,317		241,231	30,326		319,874
1991					8,837		92,551	11,635		113,023
1992					18,692		137,106	17,236		173,034
1993					19,798		126,692	15,927		162,417
1994					20,524		108,176	13,599		142,299
1995	68,964	19,009	49,461	285	32,112	19,009	215,025	27,032		361,933
1996	12,796	7,324	5,259	209	22,519	6,350	425,538	53,496		520,695
1997	15,752	377	14,963	190	14,995	34	370,649	46,596		447,804
1998	2,650	957	1,468	225	29,065	957	146,460	18,412		197,545
1999	11,471	633	9,995	832	37,341	0	241,472	30,357		320,631
2000	17,452	899	16,500	52	56,436	899	121,846	15,318	10	211,950
2001	20,337	554	19,705	70	59,017	0	234,102	29,430		342,877
2002	39,779	2,344	36,840	578	51,048	2,344	271,715	34,159		399,028
2003	10,408	3,756	6,514	109	40,066	3,756	192,434	24,192	0	270,829
2004	8,062	924	7,063	58	42,295	0	403,209	50,925	236	504,474
2005	12,275	2,113	9,942	224	31,215	1,760	99,659	12,595	73	157,508

Table 2.5. Catch history for the Blacknose shark (numbers of fish).

CATCHES OF BLACKNOSE SHARKS (in numbers)

Year	Commercial				Recreational catches	Bottom longline discards	Shrimp bycatch (GOM)	Shrimp bycatch (SA)	EFP	Total
	Total	Longline	Nets	Lines						
1972							14,921	1,876		16,797
1973							15,177	1,908		17,085
1974							7,743	973		8,716
1975							20,404	2,565		22,969
1976							13,287	1,670		14,957
1977							100,259	12,604		112,863
1978							21,472	2,699		24,171
1979							13,168	1,655		14,823
1980							8,669	1,090		9,759
1981					0		10,194	1,281		11,475
1982					0		7,963	1,001		8,964
1983					14,233		9,533	1,198		24,964
1984					844		7,285	916		9,045
1985					1,918		9,794	1,231		12,943
1986					3,308		20,222	2,542		26,072
1987					15,382		12,131	1,525		29,038
1988					15,971		10,900	1,370		28,241
1989					1,793		26,649	3,350		31,792
1990					3,345		20,081	2,524		25,950
1991					8		37,291	4,688		41,987
1992					5,199		38,197	4,802		48,198
1993					2,875		15,514	1,950		20,339
1994					14,464		27,351	3,438		45,253
1995	15,672	15,652	0	20	2,954	5,181	40,316	5,068		69,191
1996	23,981	8,641	14,573	768	12,414	2,195	35,295	4,437		78,322
1997	43,792	17,628	26,004	88	11,079	1,869	58,309	7,330		122,306
1998	23,345	7,689	15,613	43	10,523	2,622	34,082	4,285		74,856
1999	29,057	5,968	21,812	539	6,139	901	27,461	3,452		66,273
2000	46,603	13,493	32,154	956	10,410	11,321	31,556	3,967	0	103,856
2001	35,568	5,732	28,549	29	15,445	3,456	45,593	5,732		104,537
2002	28,681	6,877	21,280	522	11,438	6,623	25,400	3,193		75,333
2003	22,995	10,387	12,498	90	6,615	5,131	54,258	6,821	2	95,801
2004	13,945	5,932	7,942	114	15,261	1,999	65,546	8,243	68	105,038
2005	18,326	8,248	9,055	212	7,548	5,617	20,568	2,586	77	53,835

Table 2.6. Catch history for the Finetooth shark (numbers of fish).

CATCHES OF FINETOOTH SHARKS (in numbers)

Year	Commercial				Recreational catches	Bottom longline discards	Shrimp bycatch (GOM)	Shrimp bycatch (SA)	EFP		Total
	Total	Longline	Nets	Lines							
1972											0
1973											0
1974											0
1975											0
1976											0
1977											0
1978											0
1979											0
1980											0
1981					0						0
1982					0						0
1983					71						71
1984					1,572						1,572
1985					366						366
1986					11,845						11,845
1987					17						17
1988					22,352						22,352
1989					5						5
1990					82						82
1991					95						95
1992					1,944						1,944
1993					3,170						3,170
1994					3,103						3,103
1995	3,508	3,197	0	312	847	0					4,355
1996	8,240	1,336	6,768	136	1,584	445					10,269
1997	13,143	1,233	11,798	69	5,633	411					19,144
1998	20,692	961	19,663	68	147	0					20,839
1999	22,086	1,161	20,603	319	78	0					22,161
2000	15,686	1,359	14,278	50	1,390	0				0	17,076
2001	23,476	412	22,990	73	6,628	0					30,103
2002	12,681	674	11,949	51	3,027	0					15,701
2003	14,515	1,062	13,412	40	1,758	0				0	16,272
2004	14,804	865	13,715	221	285	0				0	15,086
2005	7,506	887	6,608	2	3,164	0		2	2		10,663

Table 2.7. Retrospective catch history for the Small Coastal Shark (numbers of fish).

CATCHES OF SMALL COASTAL SHARKS: 4 species (in numbers)

Year	Commercial				Recreational catches	Bottom longline discards	Shrimp bycatch (GOM)	Shrimp bycatch (SA)	EFP	Total
	Total	Longline	Nets	Lines						
1950		0	0	0	11,951	0	363,834	48,826		424,610
1951		0	0	14	14,641	0	464,287	65,842		544,784
1952		0	0	28	17,332	0	475,356	61,153		553,869
1953		0	0	42	20,022	0	538,255	78,760		637,079
1954		0	0	56	22,713	0	568,585	68,504		659,857
1955		0	0	70	25,403	0	509,243	68,224		602,940
1956		0	0	84	28,094	0	464,206	60,711		553,095
1957		0	0	98	30,784	0	403,874	68,168		502,924
1958		0	0	111	33,474	0	415,624	53,086		502,296
1959		0	0	125	36,165	0	463,932	61,883		562,105
1960		0	0	139	38,855	0	489,272	74,053		602,319
1961		0	0	153	40,218	0	235,536	47,228		323,136
1962		0	0	167	41,581	0	308,355	62,363		412,466
1963		0	0	181	42,943	0	509,299	48,241		600,664
1964		0	0	195	44,306	0	446,029	52,786		543,316
1965		0	0	209	45,668	0	459,186	77,299		582,362
1966		0	0	223	47,031	0	441,789	64,385		553,428
1967		0	0	237	48,393	0	559,263	62,054		669,947
1968		0	0	251	49,756	0	495,528	71,359		616,893
1969		0	0	265	51,119	0	513,562	79,927		644,873
1970		0	0	279	52,481	0	591,956	61,497		706,212
1971		0	0	293	55,509	0	582,004	87,757		725,563
1972		0	0	307	58,537	0	840,633	105,680		1,005,156
1973		0	0	321	61,565	0	233,634	29,371		324,890
1974		0	0	334	64,592	0	411,643	51,749		528,318
1975		0	0	348	67,620	0	872,930	109,740		1,050,638
1976		0	0	362	70,648	0	292,878	36,819		400,707
1977		0	0	376	73,676	0	946,230	118,955		1,139,237
1978		0	0	390	76,703	0	635,527	79,895		792,516
1979		0	0	404	79,731	0	933,737	117,384		1,131,257
1980		0	0	418	71,390	0	1,738,982	218,615		2,029,405
1981		3,855	0	432	82,759	2,643	1,736,376	218,287		2,044,351
1982		7,709	0	446	67,647	5,286	409,794	51,517		542,399
1983		11,564	0	460	87,399	7,929	674,421	84,784		866,557
1984		15,418	0	474	57,342	10,572	377,532	47,461		508,799
1985		19,273	0	488	62,885	13,215	476,828	59,944		632,633
1986		23,128	0	502	111,425	15,858	485,197	60,996		697,105
1987		26,982	8,977	516	98,947	18,501	1,040,738	130,836		1,325,497
1988		30,837	17,953	530	172,684	21,144	580,306	72,953		896,407
1989		34,692	26,930	544	104,757	23,787	603,506	75,869		870,084
1990		38,546	35,907	557	96,977	26,430	614,590	77,263		890,270
1991		42,401	44,884	571	143,845	29,073	891,723	112,102		1,264,598
1992		46,255	53,860	585	111,829	31,716	1,172,572	147,409		1,564,227
1993		50,110	62,837	599	93,562	34,359	509,360	64,034		814,861
1994		53,965	71,814	613	140,473	37,002	443,215	55,718		802,800
1995	139,569	57,819	80,791	627	164,884	32,494	1,051,681	132,211		1,520,508
1996	118,425	39,967	75,317	3,134	114,007	15,627	920,627	115,736		1,284,416
1997	214,221	29,527	181,922	1,723	99,382	9,035	703,350	88,421		1,113,361
1998	187,931	22,044	163,396	2,397	123,593	9,038	806,300	101,363		1,228,131
1999	222,715	18,064	198,804	4,601	112,715	14,379	641,017	80,585		1,070,164
2000	168,544	24,689	141,425	2,366	199,043	22,196	796,602	100,144	11	1,286,465
2001	219,962	14,643	201,777	1,535	212,442	14,365	641,786	80,682		1,167,231
2002	173,847	25,133	146,719	1,949	153,810	24,906	1,104,353	138,833		1,595,703
2003	147,313	36,673	90,411	20,120	133,738	26,518	544,058	68,396	5	919,913
2004	133,937	35,415	97,080	1,374	125,711	30,165	797,000	100,194	1872	1,186,940
2005	138,792	34,842	100,874	1,349	122,688	29,020	530,943	66,747	484	886,464

Table 2.8. Retrospective catch history for the Atlantic sharpnose shark (numbers of fish).

CATCHES OF ATLANTIC SHARPNOSE SHARKS (in numbers)

Year	Commercial				Recreational catches	Bottom longline discards	Shrimp bycatch (GOM)	Shrimp bycatch (SA)	EFP	Total
	Total	Longline	Nets	Lines						
1950		0	0	0	12,114	0	175,722	23,435		211,271
1951		0	0	12	13,314	0	224,238	31,603		269,167
1952		0	0	24	14,514	0	229,584	29,353		273,475
1953		0	0	36	15,714	0	259,963	37,803		313,516
1954		0	0	48	16,914	0	274,611	32,881		324,454
1955		0	0	61	18,114	0	245,951	32,746		296,871
1956		0	0	73	19,314	0	224,199	29,140		272,726
1957		0	0	85	20,514	0	195,061	32,719		248,379
1958		0	0	97	21,714	0	200,735	25,481		248,027
1959		0	0	109	22,914	0	224,067	29,703		276,792
1960		0	0	121	24,114	0	236,305	35,544		296,084
1961		0	0	133	24,815	0	113,758	22,669		161,375
1962		0	0	145	25,517	0	148,927	29,933		204,523
1963		0	0	157	26,218	0	245,978	23,155		295,508
1964		0	0	169	26,920	0	215,420	25,337		267,846
1965		0	0	182	27,621	0	221,774	37,102		286,679
1966		0	0	194	28,322	0	213,372	30,904		272,792
1967		0	0	206	29,024	0	270,109	29,785		329,123
1968		0	0	218	29,725	0	239,327	34,251		303,521
1969		0	0	230	30,427	0	248,037	38,364		317,057
1970		0	0	242	31,128	0	285,899	29,517		346,786
1971		0	0	254	34,310	0	281,092	42,122		357,778
1972		0	0	266	34,613	0	485,780	61,069		581,728
1973		0	0	278	34,916	0	102,900	12,936		151,031
1974		0	0	291	35,220	0	185,074	23,266		243,850
1975		0	0	303	35,523	0	192,627	24,216		252,669
1976		0	0	315	35,827	0	141,282	17,761		195,184
1977		0	0	327	36,130	0	497,629	62,559		596,645
1978		0	0	339	36,434	0	578,336	72,705		687,814
1979		0	0	351	36,737	0	470,857	59,194		567,140
1980		0	0	363	41,970	0	757,373	95,213		894,919
1981		1,357	0	375	43,490	1,054	1,492,272	187,600		1,726,149
1982		2,714	0	387	40,656	2,108	208,879	26,259		281,003
1983		4,072	0	399	50,170	3,161	343,009	43,121		443,932
1984		5,429	0	412	37,539	4,215	193,399	24,313		265,307
1985		6,786	0	424	37,994	5,269	293,171	36,856		380,500
1986		8,143	0	436	45,392	6,323	202,706	25,483		288,483
1987		9,501	726	448	46,792	7,377	568,133	71,422		704,398
1988		10,858	1,452	460	103,375	8,430	322,388	40,529		487,492
1989		12,215	2,178	472	65,058	9,484	270,901	34,056		394,365
1990		13,572	2,904	484	45,233	10,538	303,917	38,207		414,855
1991		14,930	3,630	496	134,905	11,592	460,335	57,871		683,759
1992		16,287	4,355	508	85,972	12,645	860,192	108,138		1,088,098
1993		17,644	5,081	521	67,719	13,699	385,082	48,410		538,156
1994		19,001	5,807	533	101,774	14,753	230,386	28,963		401,217
1995	27,437	20,359	6,533	545	128,478	16,938	567,054	71,287		811,194
1996	49,113	12,074	35,721	1,318	73,114	5,011	446,999	56,194		630,430
1997	78,777	6,925	70,619	854	67,675	2,631	292,293	36,745		477,742
1998	72,977	6,580	64,506	1,794	83,748	2,711	455,072	57,209		671,619
1999	76,808	5,248	69,727	1,576	69,153	4,561	276,374	34,744		461,383
2000	40,762	3,951	35,610	1,145	130,727	3,564	478,883	60,202	1	714,081
2001	60,136	4,787	53,890	1,190	131,912	4,782	283,371	35,624		515,556
2002	71,568	11,635	59,098	819	88,297	11,531	567,679	71,365		810,424
2003	61,481	19,783	15,855	25,773	85,299	15,668	262,108	32,951	3	457,438
2004	74,024	25,639	47,693	644	67,870	24,613	153,970	19,356	1568	339,785
2005	107,156	24,876	80,539	1,159	80,761	21,369	289,384	36,380	332	534,468

Table 2.9. Retrospective catch history for the Bonnethead shark (numbers of fish).

CATCHES OF BONNETHEAD SHARKS (in numbers)

Year	Commercial				Recreational catches	Bottom longline discards	Shrimp bycatch (GOM)	Shrimp bycatch (SA)	EFP	Total
	Total	Longline	Nets	Lines						
1950		0	0	0	7,469	0	90,488	12,518		110,474
1951		0	0	6	13,314	0	115,471	16,880		145,671
1952		0	0	13	14,514	0	118,224	15,678		148,429
1953		0	0	19	15,714	0	133,867	20,192		169,792
1954		0	0	25	16,914	0	141,410	17,563		175,912
1955		0	0	32	18,114	0	126,652	17,491		162,288
1956		0	0	38	19,314	0	115,451	15,565		150,368
1957		0	0	44	20,514	0	100,446	17,477		138,481
1958		0	0	51	21,714	0	103,368	13,610		138,743
1959		0	0	57	22,914	0	115,383	15,865		154,219
1960		0	0	63	15,058	0	121,685	18,985		155,792
1961		0	0	70	15,760	0	58,579	12,108		86,517
1962		0	0	76	16,461	0	76,690	15,988		109,215
1963		0	0	82	17,162	0	126,666	12,368		156,278
1964		0	0	89	17,864	0	110,930	13,533		142,416
1965		0	0	95	18,565	0	114,202	19,818		152,680
1966		0	0	101	19,267	0	109,876	16,507		145,750
1967		0	0	108	19,968	0	139,092	15,909		175,077
1968		0	0	114	20,669	0	123,241	18,295		162,319
1969		0	0	120	21,371	0	127,726	20,491		169,708
1970		0	0	127	18,450	0	147,223	15,766		181,566
1971		0	0	133	21,632	0	144,748	22,499		189,012
1972		0	0	139	21,935	0	230,616	28,992		281,683
1973		0	0	146	22,239	0	168,133	21,137		211,654
1974		0	0	152	22,542	0	227,183	28,560		278,437
1975		0	0	158	22,846	0	337,902	42,479		403,385
1976		0	0	164	23,149	0	152,590	19,183		195,087
1977		0	0	171	23,453	0	295,526	37,152		356,301
1978		0	0	177	23,756	0	72,078	9,061		105,073
1979		0	0	183	24,060	0	282,239	35,482		341,965
1980		0	0	190	25,067	0	749,312	94,199		868,767
1981		1,267	0	196	39,269	745	97,393	12,244		151,114
1982		2,535	0	202	26,115	1,489	168,807	21,221		220,369
1983		3,802	0	209	22,925	2,234	81,431	10,237		120,837
1984		5,069	0	215	15,418	2,978	91,813	11,542		127,035
1985		6,336	0	221	22,607	3,723	89,457	11,246		133,590
1986		7,604	0	228	50,474	4,467	287,078	36,090		385,941
1987		8,871	5,496	234	26,527	5,212	181,772	22,851		250,963
1988		10,138	10,991	240	30,986	5,956	161,864	20,349		240,525
1989		11,405	16,487	247	37,901	6,701	106,352	13,370		192,463
1990		12,673	21,983	253	48,317	7,445	241,231	30,326		362,228
1991		13,940	27,478	259	8,837	8,190	92,551	11,635		162,890
1992		15,207	32,974	266	18,692	8,934	137,106	17,236		230,415
1993		16,475	38,470	272	19,798	9,679	126,692	15,927		227,312
1994		17,742	43,965	278	20,524	10,423	108,176	13,599		214,708
1995	68,964	19,009	49,461	285	32,112	19,009	215,025	27,032		361,933
1996	12,796	7,324	5,259	209	22,519	6,350	425,538	53,496		520,695
1997	15,752	377	14,963	190	14,995	34	370,649	46,596		447,804
1998	2,650	957	1,468	225	29,065	957	146,460	18,412		197,545
1999	11,471	633	9,995	832	37,341	0	241,472	30,357		320,631
2000	17,452	899	16,500	42	56,436	899	121,846	15,318	10	211,940
2001	20,337	554	19,705	70	59,017	0	234,102	29,430		342,877
2002	39,779	2,344	36,840	578	51,048	2,344	271,715	34,159		399,028
2003	10,408	3,756	6,514	109	40,066	3,756	192,434	24,192	0	270,829
2004	8,062	924	7,063	58	42,295	0	403,209	50,689	236	504,238
2005	12,275	2,109	9,942	224	31,215	1,757	99,659	12,529	73	157,434

Table 2.10. Retrospective catch history for the Blacknose shark (numbers of fish).

CATCHES OF BLACKNOSE SHARKS (in numbers)

Year	Commercial				Recreational catches	Bottom longline discards	Shrimp bycatch (GOM)	Shrimp bycatch (SA)	EFP	Total
	Total	Longline	Nets	Lines						
1950		0	0	0	1,826	0	10,173	1,336		13,335
1951		0	0	0	2,051	0	12,982	1,801		16,834
1952		0	0	1	2,276	0	13,291	1,673		17,241
1953		0	0	1	2,501	0	15,050	2,154		19,706
1954		0	0	2	2,725	0	15,898	1,874		20,499
1955		0	0	2	2,950	0	14,239	1,866		19,057
1956		0	0	3	3,175	0	12,979	1,661		17,818
1957		0	0	3	3,400	0	11,293	1,865		16,560
1958		0	0	4	3,625	0	11,621	1,452		16,701
1959		0	0	4	3,849	0	12,972	1,693		18,518
1960		0	0	4	4,074	0	13,680	2,026		19,785
1961		0	0	5	4,174	0	6,586	1,292		12,056
1962		0	0	5	4,273	0	8,622	1,706		14,606
1963		0	0	6	4,372	0	14,240	1,320		19,938
1964		0	0	6	4,472	0	12,471	1,444		18,393
1965		0	0	7	4,571	0	12,839	2,114		19,531
1966		0	0	7	4,671	0	12,353	1,761		18,792
1967		0	0	8	4,770	0	15,637	1,697		22,112
1968		0	0	8	4,870	0	13,855	1,952		20,685
1969		0	0	8	4,969	0	14,359	2,186		21,523
1970		0	0	9	5,068	0	16,551	1,682		23,311
1971		0	0	9	4,658	0	16,273	2,400		23,340
1972		0	0	10	4,247	0	14,921	1,876		21,053
1973		0	0	10	3,836	0	15,177	1,908		20,931
1974		0	0	11	3,425	0	7,743	973		12,151
1975		0	0	11	3,014	0	20,404	2,565		25,995
1976		0	0	12	2,603	0	13,287	1,670		17,572
1977		0	0	12	2,193	0	100,259	12,604		115,067
1978		0	0	12	1,782	0	21,472	2,699		25,965
1979		0	0	13	1,371	0	13,168	1,655		16,206
1980		0	0	13	1,183	0	8,669	1,090		10,956
1981		1,043	0	14	0	470	10,194	1,281		13,002
1982		2,087	0	14	0	941	7,963	1,001		12,006
1983		3,130	0	15	14,233	1,411	9,533	1,198		29,520
1984		4,174	0	15	844	1,882	7,285	916		15,115
1985		5,217	0	16	1,918	2,352	9,794	1,231		20,528
1986		6,261	0	16	3,308	2,822	20,222	2,542		35,171
1987		7,304	1,457	16	15,382	3,293	12,131	1,525		41,109
1988		8,347	2,915	17	15,971	3,763	10,900	1,370		43,283
1989		9,391	4,372	17	1,793	4,234	26,649	3,350		49,806
1990		10,434	5,829	18	3,345	4,704	20,081	2,524		46,935
1991		11,478	7,286	18	8	5,175	37,291	4,688		65,944
1992		12,521	8,744	19	5,199	5,645	38,197	4,802		75,127
1993		13,565	10,201	19	2,875	6,115	15,514	1,950		50,239
1994		14,608	11,658	20	14,464	6,586	27,351	3,438		78,125
1995	15,672	15,652	13,116	20	2,954	5,181	40,316	5,068		82,306
1996	23,981	8,641	14,573	768	12,414	2,195	35,295	4,437		78,322
1997	43,792	17,628	26,004	88	11,079	1,869	58,309	7,330		122,306
1998	23,345	7,689	15,613	43	10,523	2,622	34,082	4,285		74,856
1999	29,057	5,968	21,812	539	6,139	901	27,461	3,452		66,273
2000	46,603	13,493	32,154	956	10,410	11,321	31,556	3,967	0	103,856
2001	35,568	5,732	28,549	29	15,445	3,456	45,593	5,732		104,537
2002	28,681	6,877	21,280	522	11,438	6,623	25,400	3,193		75,333
2003	22,995	10,385	12,498	90	6,615	5,130	54,258	6,821	2	95,798
2004	13,945	5,889	7,942	114	15,261	1,985	65,546	8,240	68	104,977
2005	18,326	8,178	9,055	212	7,548	5,569	20,568	2,586	77	53,717

Table 2.11. Retrospective catch history for the Finetooth shark (numbers of fish).

CATCHES OF FINETOOTH SHARKS (in numbers)

Year	Commercial				Recreational catches	Bottom longline discards	Shrimp bycatch (GOM)	Shrimp bycatch (SA)	EFP	Total
	Total	Longline	Nets	Lines						
1950		0	0	0	696	0				696
1951		0	0	7	382	0				389
1952		0	0	14	441	0				455
1953		0	0	21	500	0				520
1954		0	0	28	558	0				586
1955		0	0	35	617	0				652
1956		0	0	42	676	0				717
1957		0	0	49	735	0				783
1958		0	0	55	793	0				849
1959		0	0	62	852	0				915
1960		0	0	69	2,250	0				2,319
1961		0	0	76	2,272	0				2,348
1962		0	0	83	2,294	0				2,378
1963		0	0	90	2,317	0				2,407
1964		0	0	97	2,339	0				2,436
1965		0	0	104	2,361	0				2,465
1966		0	0	111	2,383	0				2,494
1967		0	0	118	2,406	0				2,523
1968		0	0	125	2,428	0				2,553
1969		0	0	132	2,450	0				2,582
1970		0	0	139	2,799	0				2,938
1971		0	0	146	2,782	0				2,927
1972		0	0	152	2,764	0				2,917
1973		0	0	159	2,747	0				2,906
1974		0	0	166	2,730	0				2,896
1975		0	0	173	2,712	0				2,886
1976		0	0	180	2,695	0				2,875
1977		0	0	187	2,678	0				2,865
1978		0	0	194	2,660	0				2,854
1979		0	0	201	2,643	0				2,844
1980		0	0	208	3,189	0				3,397
1981		213	0	215	0	12				440
1982		426	0	222	0	24				672
1983		639	0	229	71	36				975
1984		852	0	236	1,572	48				2,708
1985		1,066	0	243	366	60				1,734
1986		1,279	0	249	11,845	72				13,446
1987		1,492	677	256	17	85				2,527
1988		1,705	1,354	263	22,352	97				25,770
1989		1,918	2,030	270	5	109				4,332
1990		2,131	2,707	277	82	121				5,318
1991		2,344	3,384	284	95	133				6,240
1992		2,557	4,061	291	1,944	145				8,998
1993		2,770	4,738	298	3,170	157				11,133
1994		2,984	5,414	305	3,103	169				11,975
1995	3,508	3,197	6,091	312	847	0				10,447
1996	8,240	1,336	6,768	136	1,584	445				10,269
1997	13,143	1,233	11,798	69	5,633	411				19,144
1998	20,692	961	19,663	68	147	0				20,839
1999	22,086	1,161	20,603	319	78	0				22,161
2000	15,686	1,359	14,278	50	1,390	0			0	17,076
2001	23,476	412	22,990	73	6,628	0				30,103
2002	12,681	674	11,949	51	3,027	0				15,701
2003	14,515	1,062	13,412	40	1,758	0			0	16,272
2004	14,804	865	13,715	221	285	0			0	15,086
2005	7,506	887	6,608	2	3,164	0			2	10,661

Table 2.12a. Catch histories for the Atlantic sharpnose shark for the Gulf of Mexico (numbers of fish).

CATCHES OF ATLANTIC SHARPNOSE SHARKS (in numbers): Gulf of Mexico									
Year	Commercial				Recreational catches	Bottom longline discards	Shrimp bycatch	EFP	Total
	Total	Longline	Nets	Lines					
1972							485780		485780
1973							102900		102900
1974							185074		185074
1975							192627		192627
1976							141282		141282
1977							497629		497629
1978							578336		578336
1979							470857		470857
1980							757373		757373
1981					43490		1492272		1535762
1982					3880		208879		212759
1983					38632		343009		381641
1984					3784		193399		197183
1985					22793		293171		315964
1986					44354		202706		247060
1987					28696		568133		596829
1988					72681		322388		395069
1989					30570		270901		301471
1990					25940		303917		329857
1991					11175		460335		471510
1992					38697		860192		898889
1993					48301		385082		433383
1994					37158		230386		267544
1995	1003	978	0	25	72934	978	567054		641969
1996	0	0	0	0	41746	0	446999		488745
1997	166	166	0	0	37872	166	292293		330497
1998	628	395	212	21	57044	394	455072		513137
1999	681	668	0	13	30238	656	276374		307949
2000	827	826	0	1	80471	822	478883	0	561002
2001	85	85	0	0	77892	0	283371		361348
2002	7282	7237	31	15	53551	7237	567679		635749
2003	35714	10117	906	24691	42775	7279	262108	0	347876
2004	17731	16913	664	154	42602	15746	153970	0	230049
2005	24069	10568	13489	11	36510	10258	289384	0	360220

Table 2.12b. Catch histories for the Atlantic sharpnose shark for the South Atlantic (numbers of fish).

CATCHES OF ATLANTIC SHARPNOSE SHARKS (in numbers): South Atlantic

Year	Commercial				Recreational catches	Bottom longline discards	Shrimp bycatch	EFP	Total
	Total	Longline	Nets	Lines					
1972							61069		61069
1973							12936		12936
1974							23266		23266
1975							24216		24216
1976							17761		17761
1977							62559		62559
1978							72705		72705
1979							59194		59194
1980							95213		95213
1981					0		187600		187600
1982					36776		26259		63035
1983					11538		43121		54659
1984					33755		24313		58068
1985					15201		36856		52057
1986					1038		25483		26521
1987					18096		71422		89518
1988					30693		40529		71222
1989					34489		34056		68545
1990					19293		38207		57500
1991					123730		57871		181601
1992					47276		108138		155414
1993					19417		48410		67827
1994					64616		28963		93579
1995	26434	19381	6533	520	60209	16098	71287		174028
1996	49113	12074	35721	1318	31259	4960	56194		141525
1997	78232	6759	70619	854	29197	2518	36745		146692
1998	72252	6185	64294	1773	26704	1812	57209		157977
1999	75870	4580	69727	1563	38914	3909	34744		153436
2000	39881	3125	35610	1145	50256	2785	60202	1	153124
2001	59782	4702	53890	1190	54020	4699	35624		154126
2002	64270	4399	59067	804	34746	4358	71365		174739
2003	25701	9669	14949	1082	42524	8316	32951	3	109492
2004	56267	8748	47029	490	25268	8646	20253	919	110434
2005	82554	14356	67049	1148	44251	10797	36458	126	174060

Table 2.13. Retrospective catch history for Atlantic sharpnose shark in the GOM (numbers of fish).

Year	Commercial				Recreational catches	Bottom longline	Shrimp bycatch	EFP	Total
	Total	Longline	Nets	Lines					
1950		0	0	0		0	175,722		175,722
1951		0	0	0		0	224,238		224,238
1952		0	0	0		0	229,584		229,584
1953		0	0	0		0	259,963		259,963
1954		0	0	0		0	274,611		274,611
1955		0	0	0		0	245,951		245,951
1956		0	0	0		0	224,199		224,199
1957		0	0	0		0	195,061		195,061
1958		0	0	0		0	200,735		200,735
1959		0	0	0		0	224,067		224,067
1960		0	0	0		0	236,305		236,305
1961		0	0	0		0	113,758		113,758
1962		0	0	0		0	148,927		148,927
1963		0	0	0		0	245,978		245,978
1964		0	0	0		0	215,420		215,420
1965		0	0	0		0	221,774		221,774
1966		0	0	0		0	213,372		213,372
1967		0	0	0		0	270,109		270,109
1968		0	0	0		0	239,327		239,327
1969		0	0	0		0	248,037		248,037
1970		0	0	0		0	285,899		285,899
1971		0	0	0		0	281,092		281,092
1972		0	0	0		0	485,780		485,780
1973		0	0	0		0	102,900		102,900
1974		0	0	0		0	185,074		185,074
1975		0	0	0		0	192,627		192,627
1976		0	0	0		0	141,282		141,282
1977		0	0	0		0	497,629		497,629
1978		0	0	0		0	578,336		578,336
1979		0	0	0		0	470,857		470,857
1980		0	0	0		0	757,373		757,373
1981		0	0	0	43,490	0	1,492,272		1,535,762
1982		0	0	0	3,880	0	208,879		212,759
1983		0	0	0	38,632	0	343,009		381,641
1984		0	0	0	3,784	0	193,399		197,183
1985		0	0	0	22,793	0	293,171		315,964
1986		0	0	0	44,354	0	202,706		247,060
1987		0	0	0	28,696	0	568,133		596,829
1988		0	0	0	72,681	0	322,388		395,069
1989		0	0	0	30,570	0	270,901		301,471
1990		0	0	0	25,940	0	303,917		329,857
1991		0	0	0	11,175	0	460,335		471,510
1992		0	0	0	38,697	0	860,192		898,889
1993		0	0	0	48,301	0	385,082		433,383
1994		0	0	0	37,158	0	230,386		267,544
1995	1003	978	0	25	72,934	978	567,054		641,969
1996	0	0	0	0	41,746	0	446,999		488,745
1997	166	166	0	0	37,872	166	292,293		330,497
1998	628	395	212	21	57,044	394	455,072		513,137
1999	681	668	0	13	30,238	656	276,374		307,949
2000	827	826	0	1	80,471	822	478,883	0	561,002
2001	85	85	0	0	77,892	0	283,371		361,348
2002	7282	7,237	31	15	53,551	7,237	567,679		635,749
2003	35714	10,117	906	24,691	42,775	7,279	262,108	0	347,876
2004	17731	16,913	664	154	42,602	15,746	153,970	0	230,049
2005	24069	10,568	13,489	11	36,510	10,258	289,384	0	360,220

Table 2.14. Retrospective catch history for the Atlantic sharpnose shark in the SA (numbers of fish).

Year	Commercial				Recreational catches	Bottom longline	Shrimp bycatch (ATL)	EFP	Total
	Total	Longline	Nets	Lines					
1950		0	0	0		0	23,435		23,435
1951		0	0	0		0	31,603		31,603
1952		0	0	0		0	29,353		29,353
1953		0	0	0		0	37,803		37,803
1954		0	0	0		0	32,881		32,881
1955		0	0	0		0	32,746		32,746
1956		0	0	0		0	29,140		29,140
1957		0	0	0		0	32,719		32,719
1958		0	0	0		0	25,481		25,481
1959		0	0	0		0	29,703		29,703
1960		0	0	0		0	35,544		35,544
1961		0	0	0		0	22,669		22,669
1962		0	0	0		0	29,933		29,933
1963		0	0	0		0	23,155		23,155
1964		0	0	0		0	25,337		25,337
1965		0	0	0		0	37,102		37,102
1966		0	0	0		0	30,904		30,904
1967		0	0	0		0	29,785		29,785
1968		0	0	0		0	34,251		34,251
1969		0	0	0		0	38,364		38,364
1970		0	0	0		0	29,517		29,517
1971		0	0	0		0	42,122		42,122
1972		0	0	0		0	61,069		61,069
1973		0	0	0		0	12,936		12,936
1974		0	0	0		0	23,266		23,266
1975		0	0	0		0	24,216		24,216
1976		0	0	0		0	17,761		17,761
1977		0	0	0		0	62,559		62,559
1978		0	0	0		0	72,705		72,705
1979		0	0	0		0	59,194		59,194
1980		0	0	0		0	95,213		95,213
1981		0	0	0	0	0	187,600		187,600
1982		0	0	0	36,776	0	26,259		63,035
1983		0	0	0	11,538	0	43,121		54,659
1984		0	0	0	33,755	0	24,313		58,068
1985		0	0	0	15,201	0	36,856		52,057
1986		0	0	0	1,038	0	25,483		26,521
1987		0	0	0	18,096	0	71,422		89,518
1988		0	0	0	30,693	0	40,529		71,222
1989		0	0	0	34,489	0	34,056		68,545
1990		0	0	0	19,293	0	38,207		57,500
1991		0	0	0	123,730	0	57,871		181,601
1992		0	0	0	47,276	0	108,138		155,414
1993		0	0	0	19,417	0	48,410		67,827
1994		0	0	0	64,616	0	28,963		93,579
1995	26434	19,381	6,533	520	60,209	16,098	71,287		174,028
1996	49113	12,074	35,721	1,318	31,259	4,960	56,194		141,525
1997	78232	6,759	70,619	854	29,197	2,518	36,745		146,692
1998	72252	6,185	64,294	1,773	26,704	1,812	57,209		157,977
1999	75870	4,580	69,727	1,563	38,914	3,909	34,744		153,436
2000	39881	3,125	35,610	1,145	50,256	2,785	60,202	1	153,124
2001	59782	4,702	53,890	1,190	54,020	4,699	35,624		154,126
2002	64270	4,399	59,067	804	34,746	4,358	71,365		174,739
2003	25701	9,669	14,949	1,082	42,524	8,316	32,951	3	109,492
2004	56267	8,748	47,029	490	25,268	8,646	19,356	919	109,537
2005	82554	14,356	67,049	1,148	44,251	10,797	36,380	126	173,982

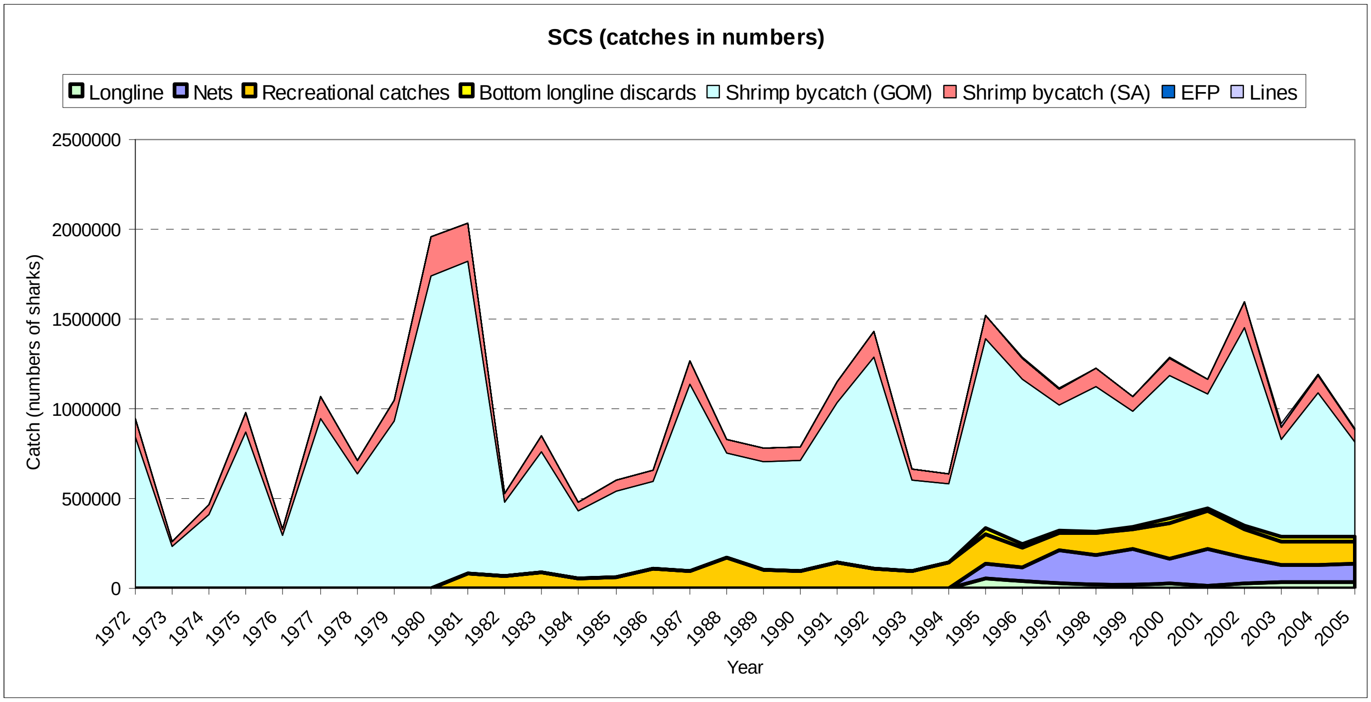


Figure 2.1. Total catches of Small Coastal Sharks by sector.

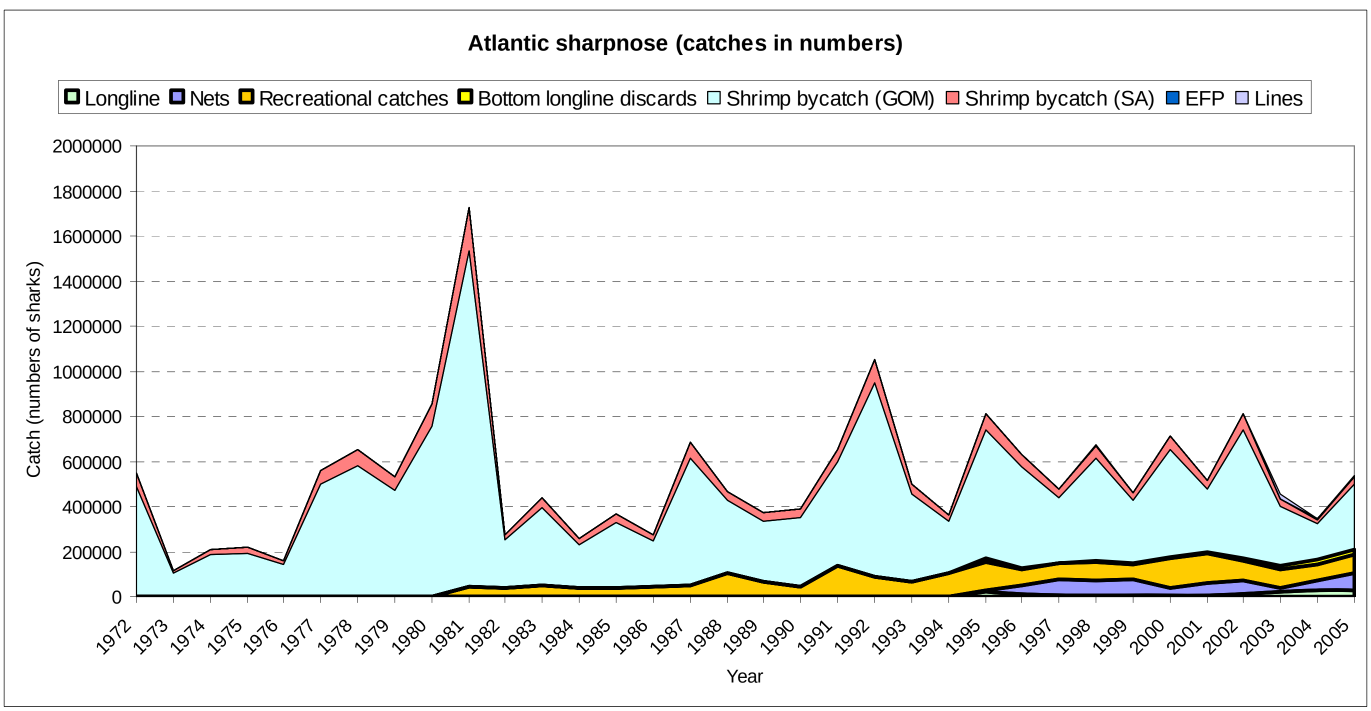


Figure 2.2. Total catches of Atlantic sharpnose sharks by sector.

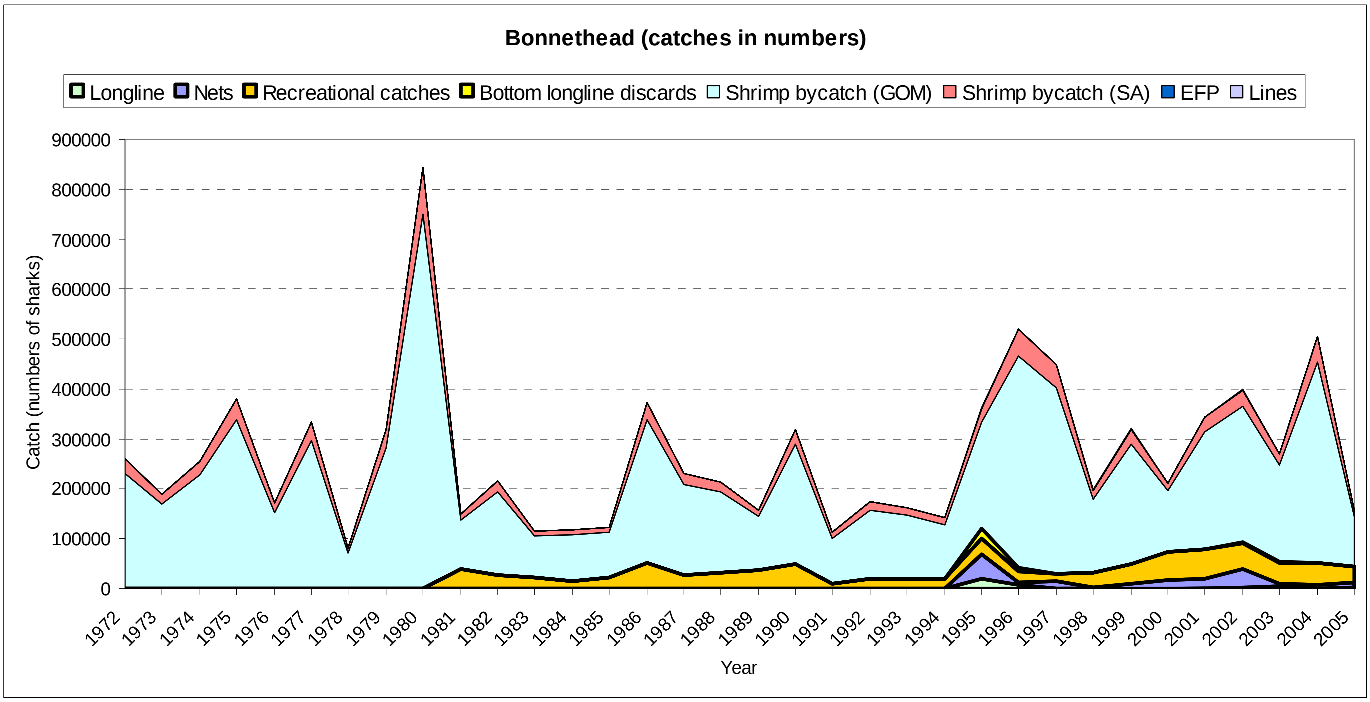


Figure 2.3. Total catches of bonnethead sharks by sector.

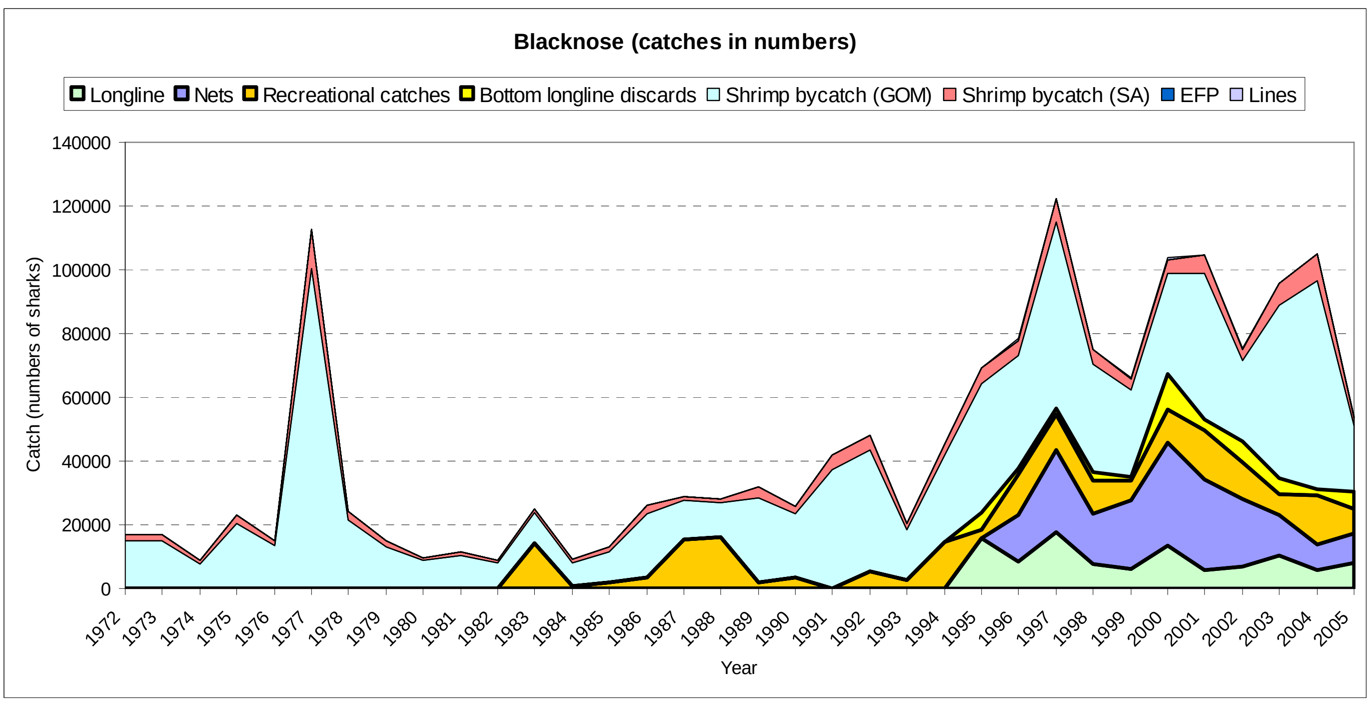


Figure 2.4. Total catches of blacknose sharks by sector.

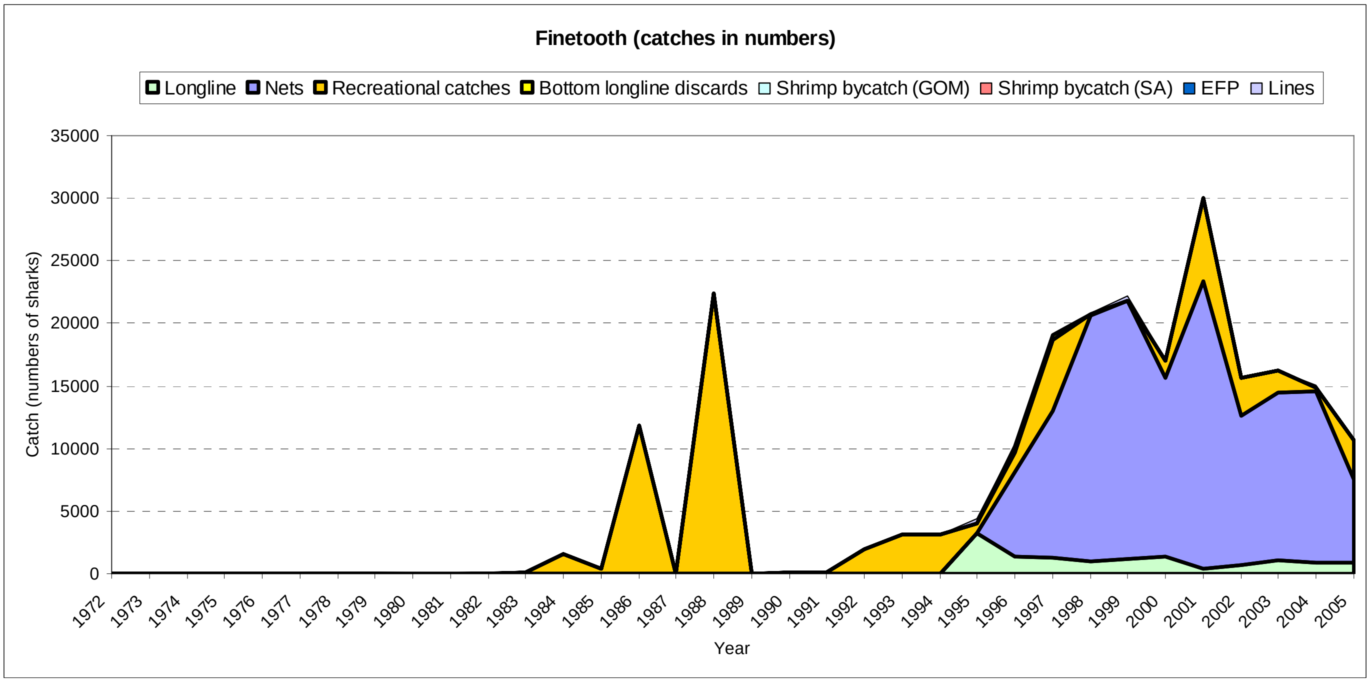


Figure 2.5. Total catches of finetooth sharks by sector.

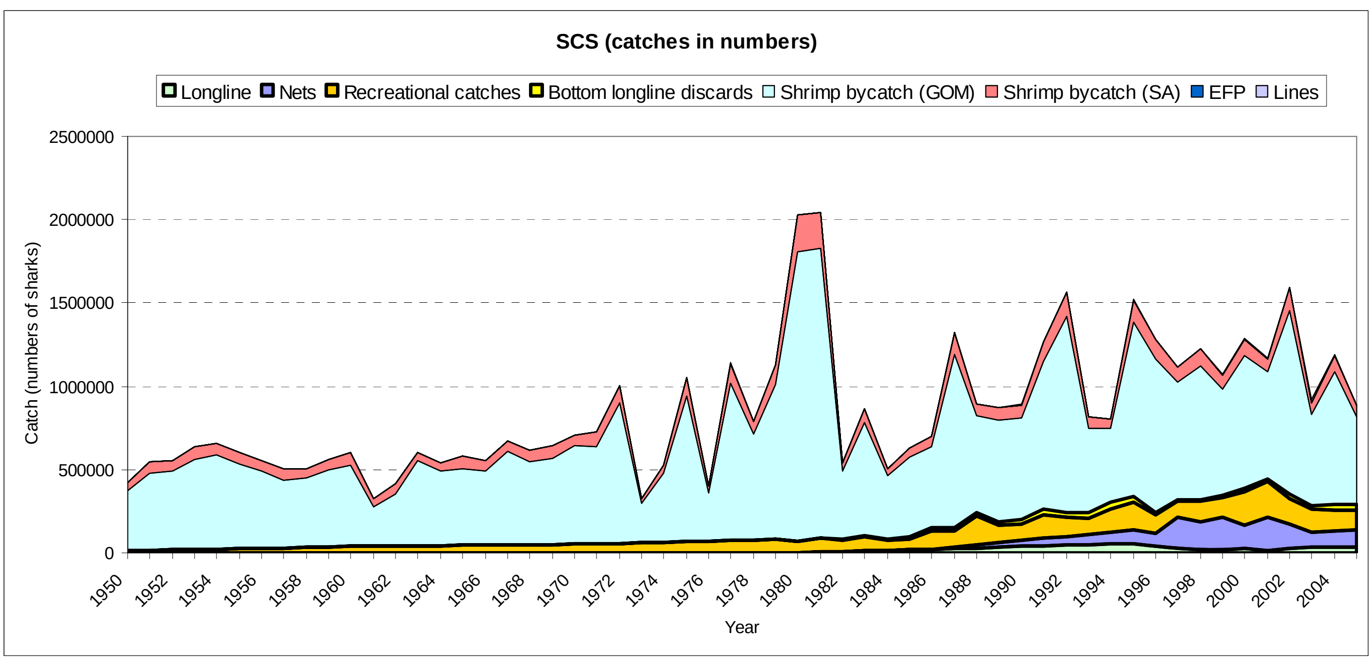


Figure 2.6. Total reconstructed catches of SCS by sector.

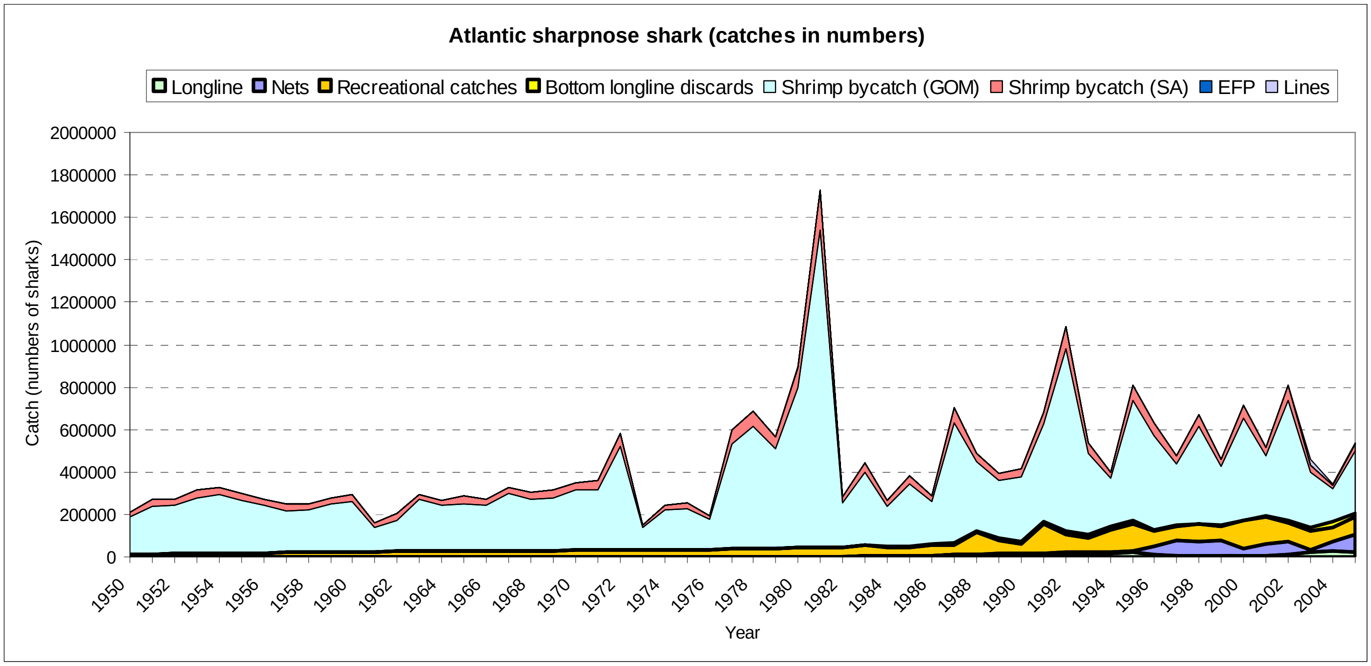


Figure 2.7. Total reconstructed catches of Atlantic sharpnose sharks by sector.

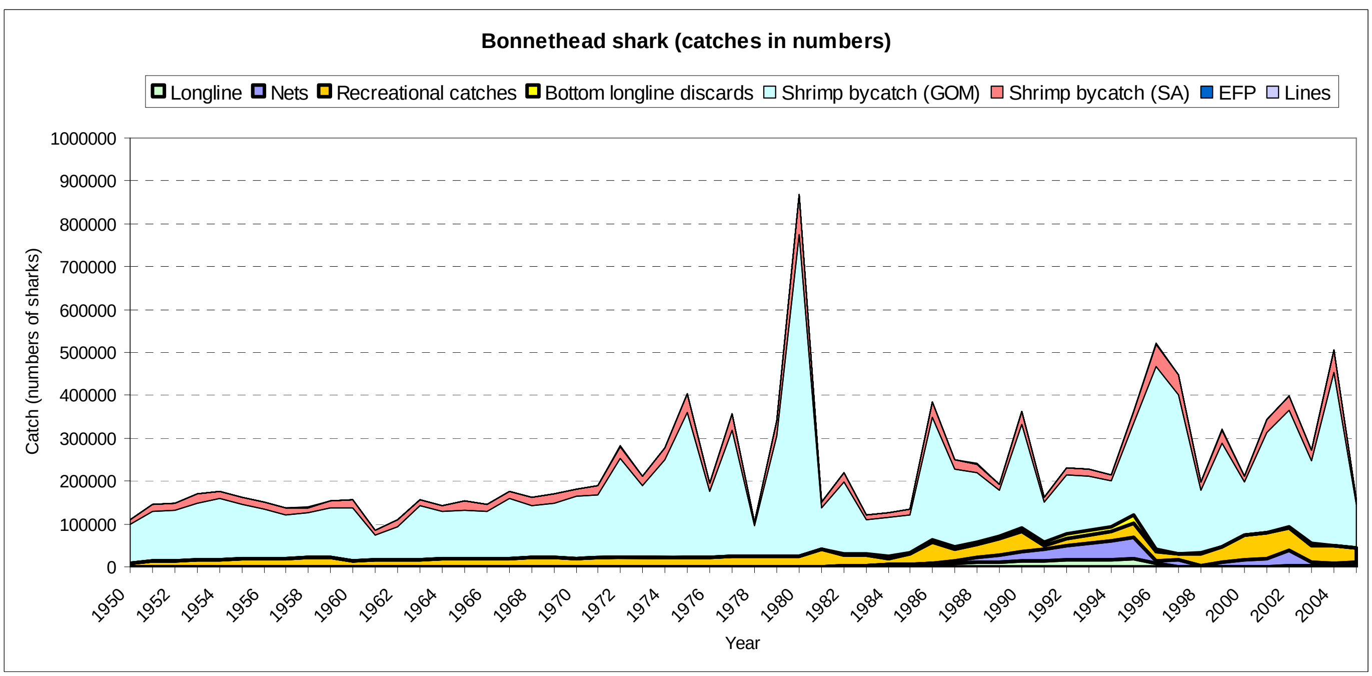


Figure 2.8. Total reconstructed catches of bonnethead sharks by sector.

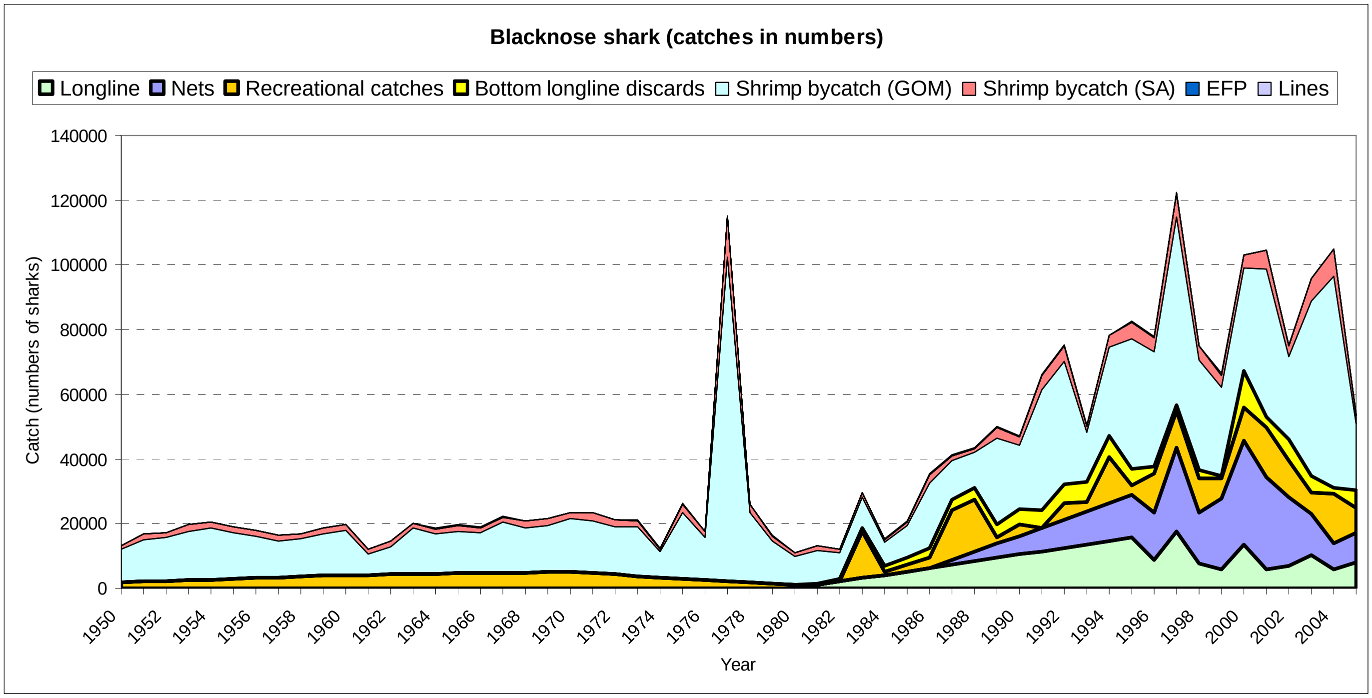


Figure 2.9. Total reconstructed catches of blacknose sharks by sector.

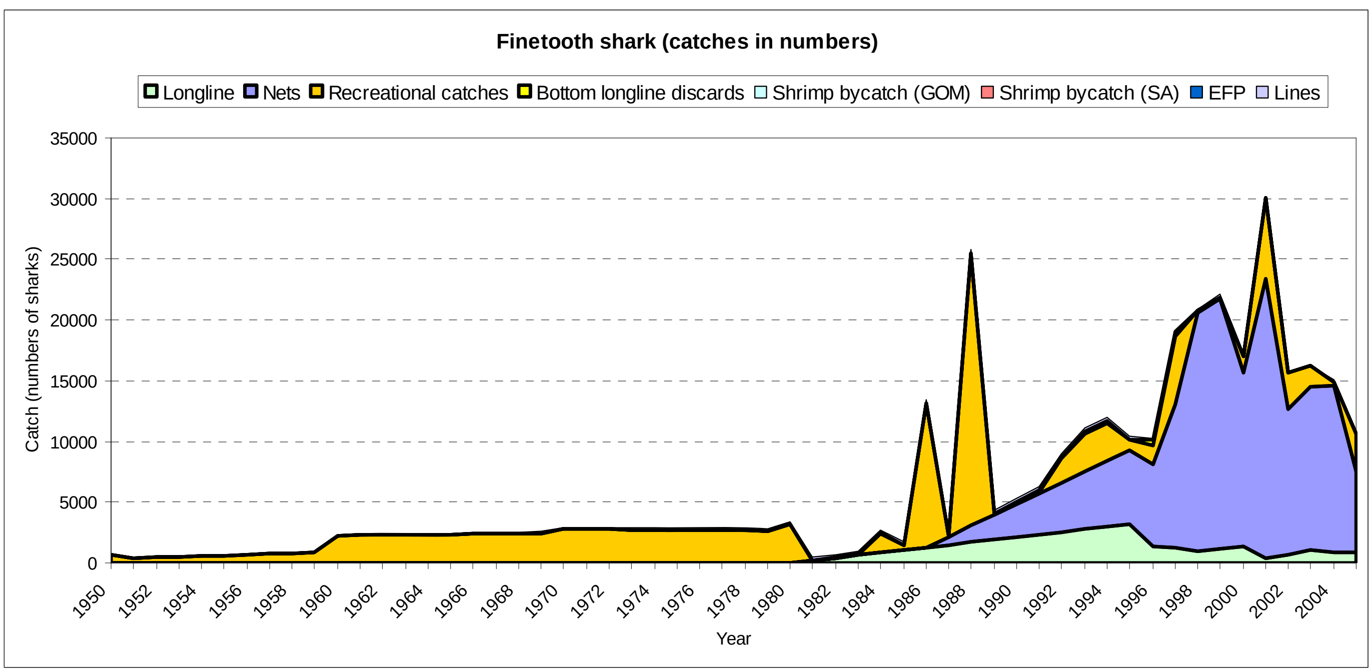


Figure 2.10. Total reconstructed catches of finetooth sharks by sector.

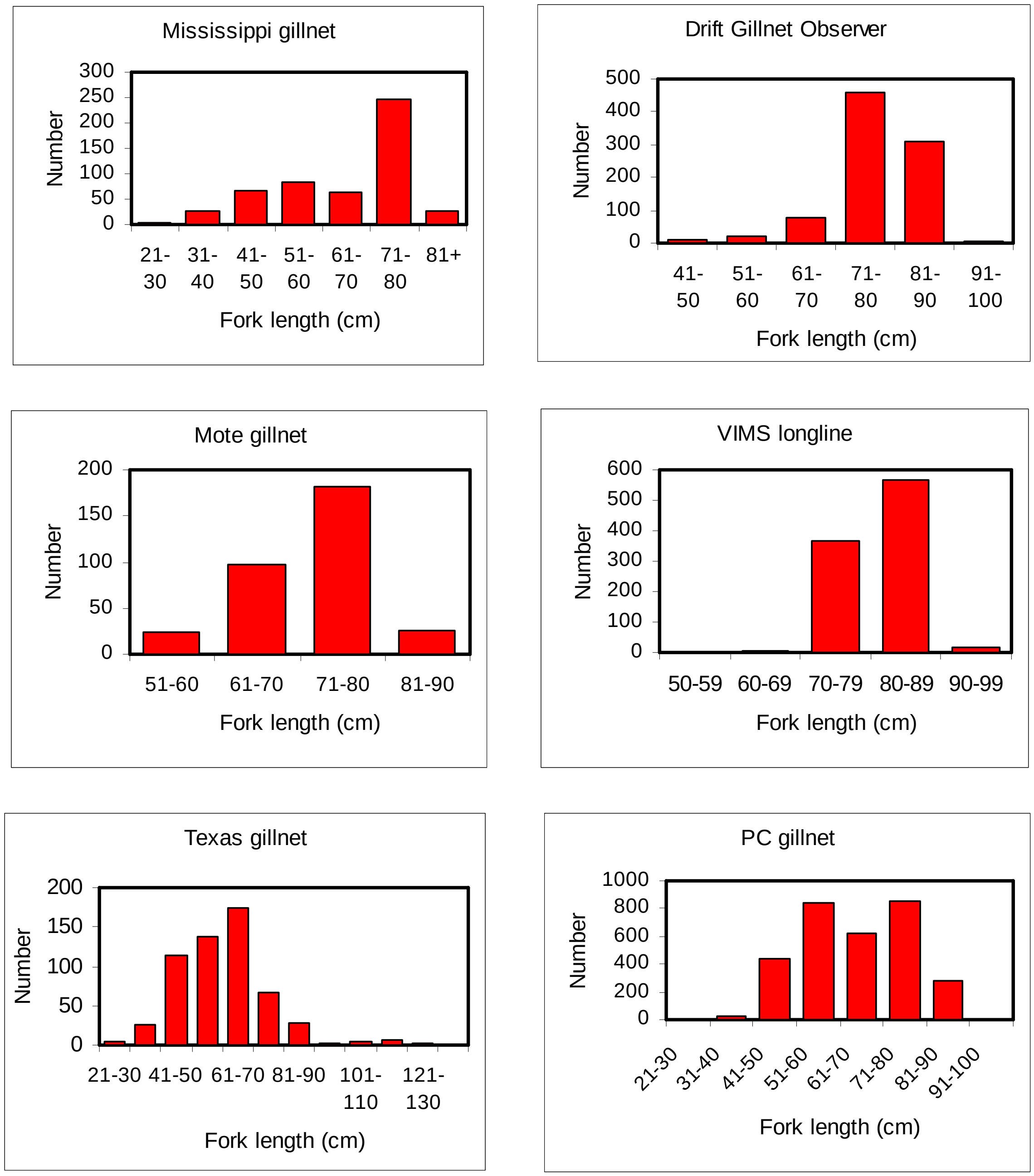


Figure 2.11. Length-frequency distributions for Atlantic sharpnose shark from various sources.

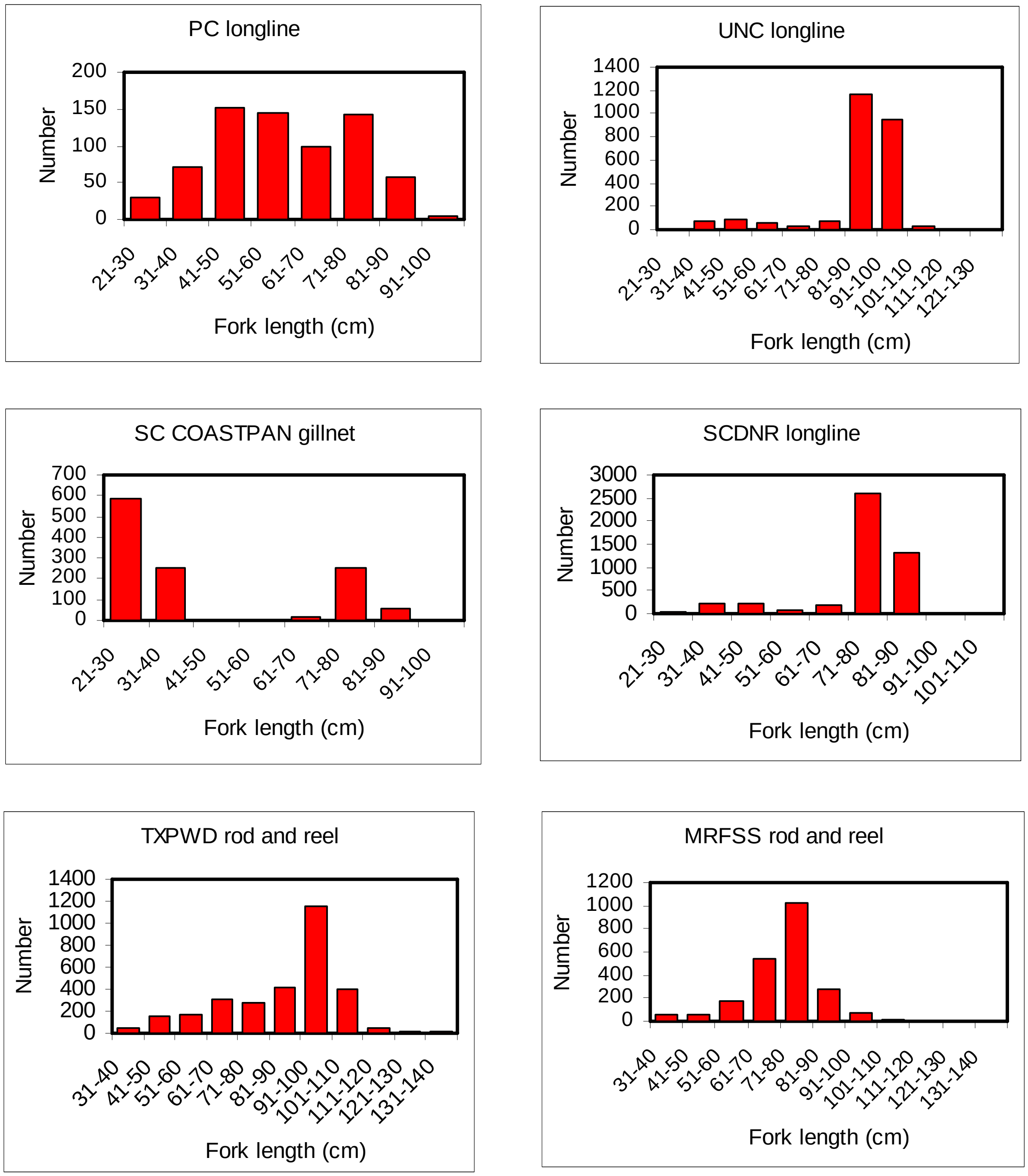


Figure 2.11. (continued)

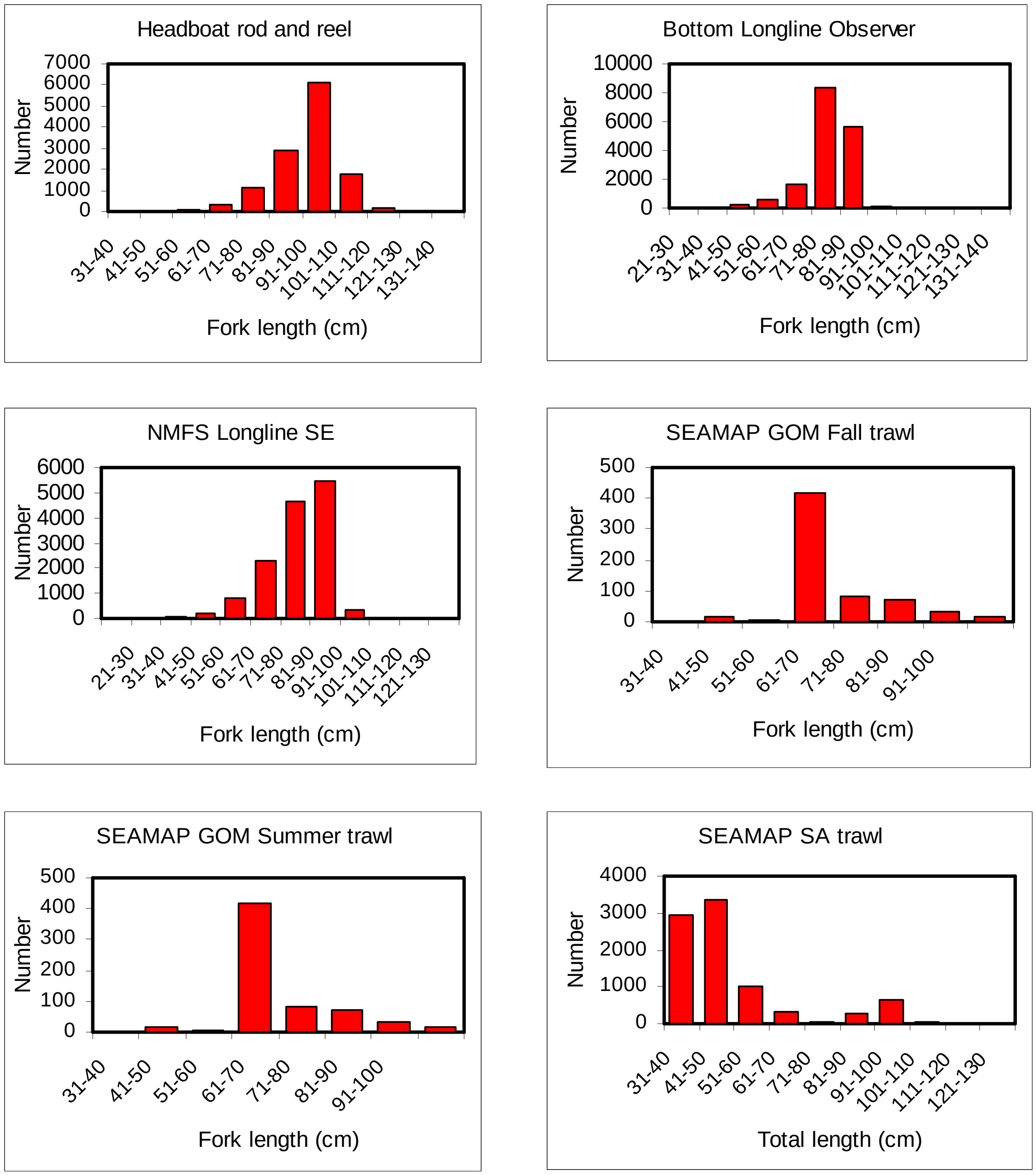


Figure 2.11. (continued)

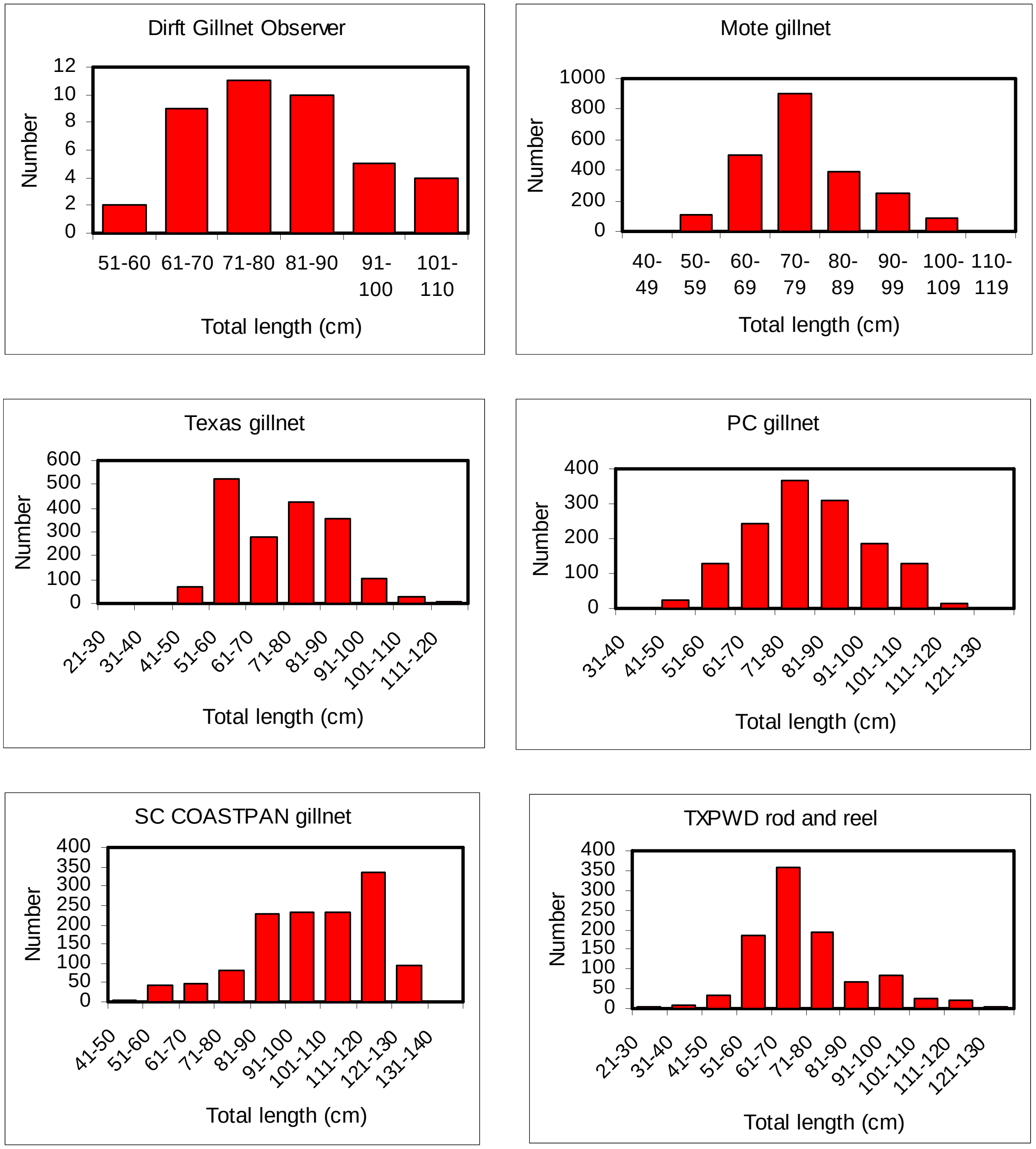


Figure 2.12. Length-frequency distributions for bonnethead shark from various sources.

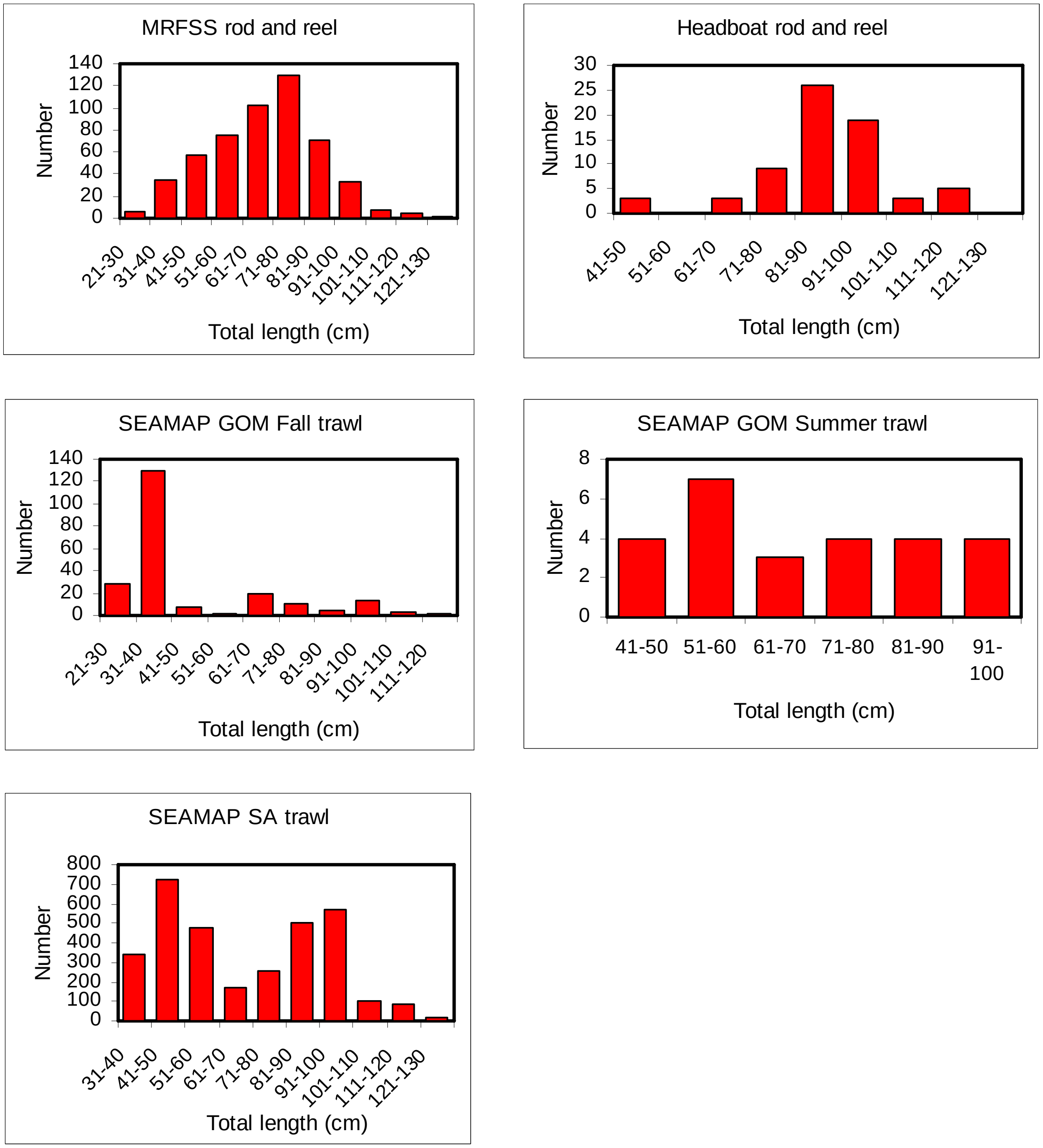


Figure 2.12. (continued)

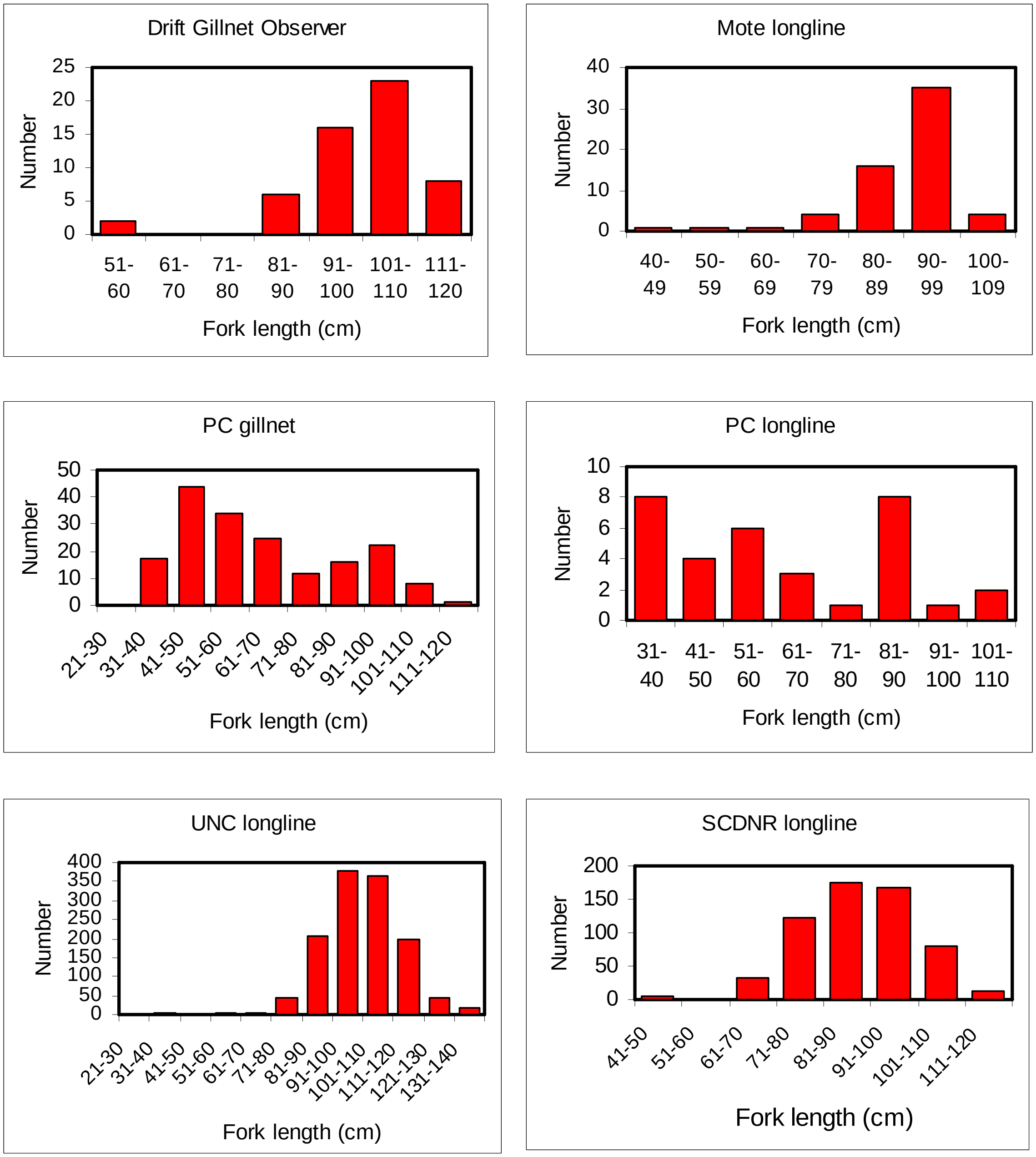
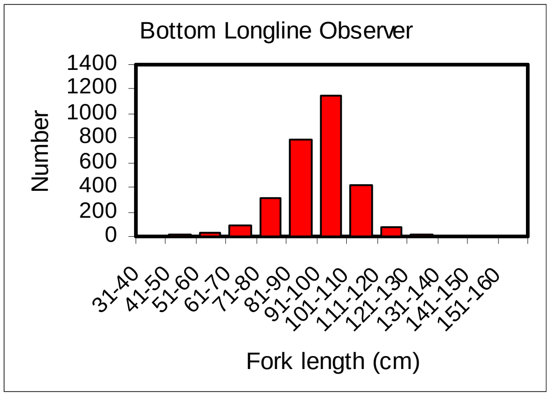


Figure 2.13. Length-frequency distributions for blacknose shark from various sources.



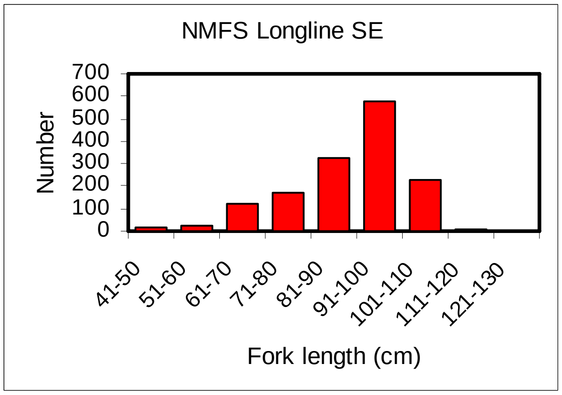


Figure 2.13. (continued)

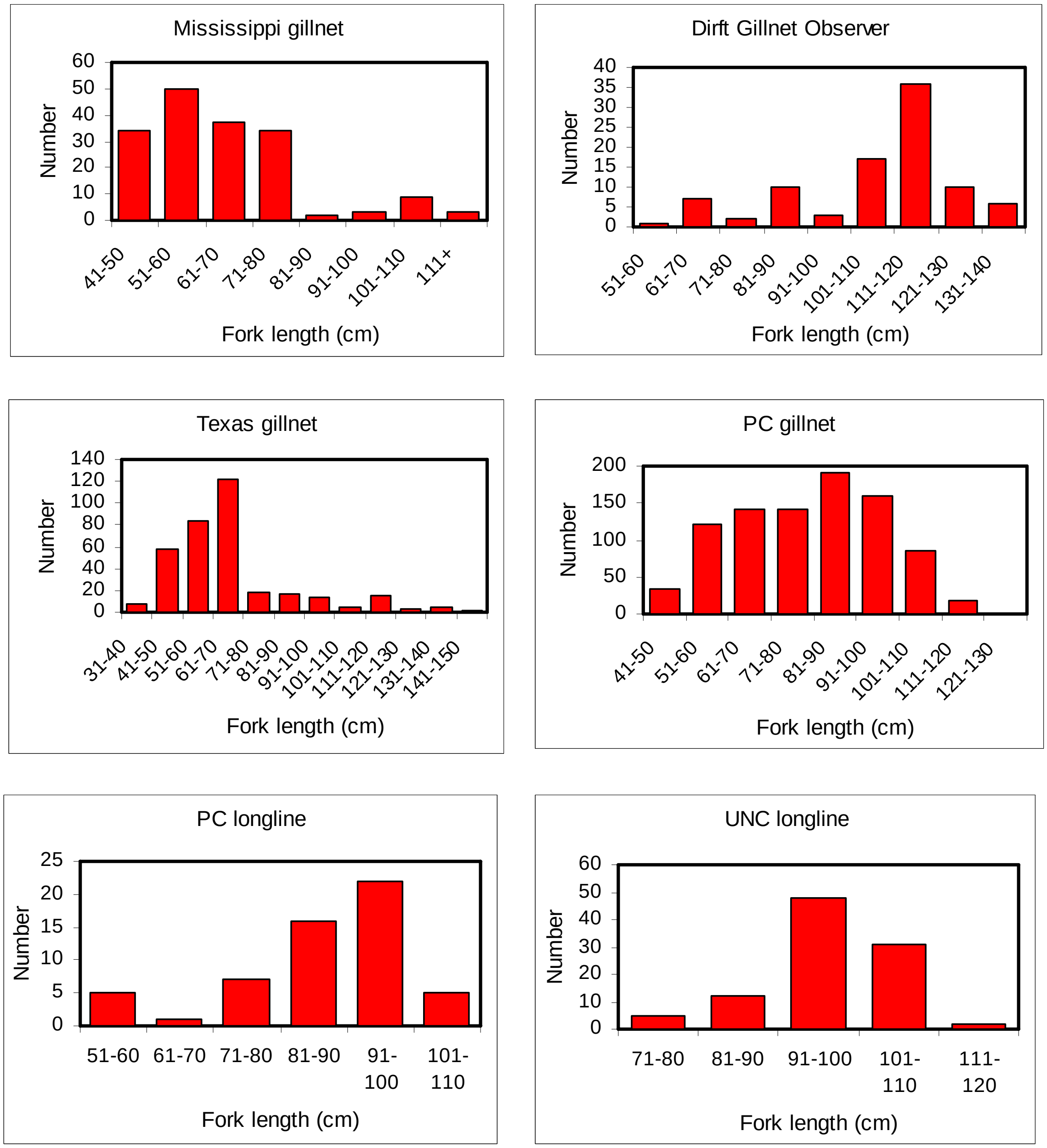


Figure 2.14. Length-frequency distributions for finetooth shark from various sources.

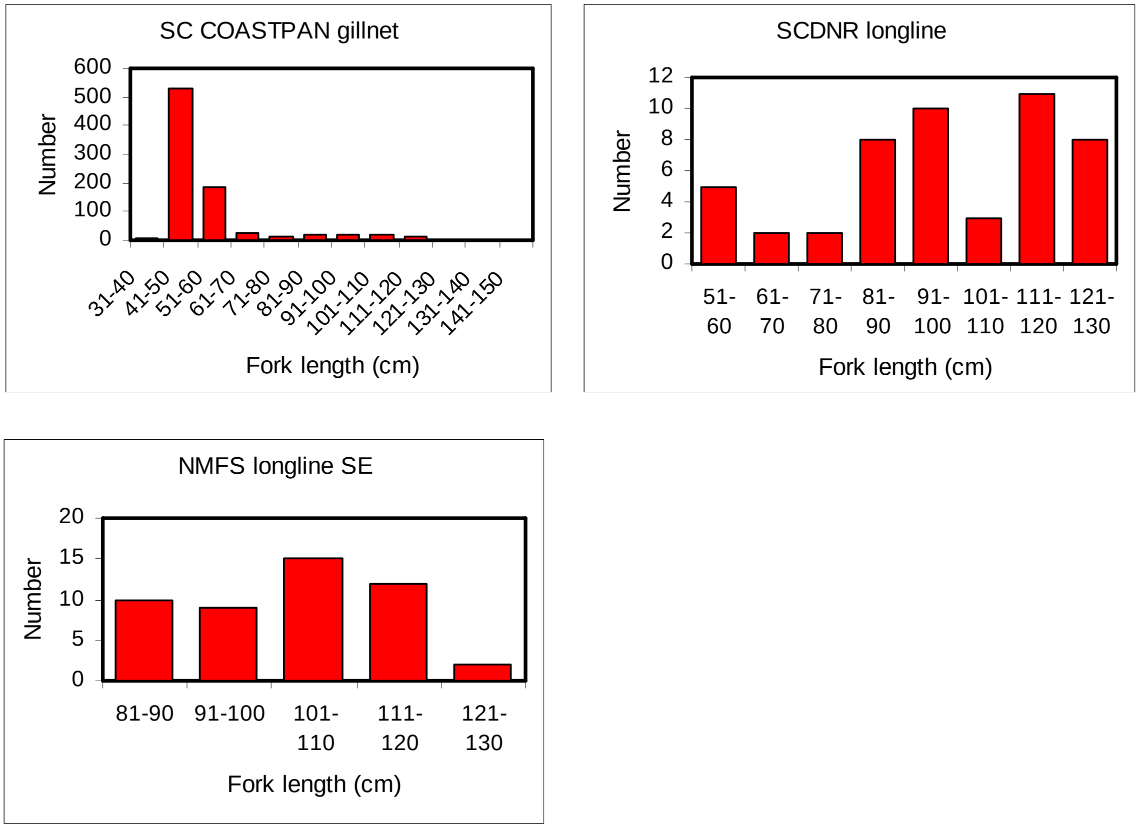


Figure 2.14. (continued)

3. Indices

Abundance Indices Working Group Summary Report
Walter Ingram (Chair), NOAA Fisheries Service, Pascagoula
Liz Brooks, NOAA Fisheries Service, Miami
Eric Hoffmayer, Gulf Coast Research Laboratory
Kevin McCarthy, NOAA Fisheries Service, Miami
Cami McCandless, NOAA Fisheries Service, Narragansett
John Carlson, NOAA Fisheries Service, Panama City
Mark Fisher, Texas Parks and Wildlife
John Tyminski, Mote Marine Laboratory
Armando Ubeda, Mote Marine Laboratory
Bryan Frazier, South Carolina Department of Natural Resources
Ginny Nesslage, Atlantic States Marine Fisheries Commission
Ivy Baremore, NOAA Fisheries Service, Panama City

3.1 SUMMARY OF ABUNDANCE INDEX ESTIMATE DOCUMENTS

Fishery-Independent Indices:

SEDAR 13-DW-05

Standardized catch rates of small coastal sharks from a fishery-independent longline survey in northwest Florida

Carlson, J.

A fishery-independent survey of large and small coastal shark populations in coastal areas of the northeast Gulf of Mexico was conducted using longlines from 1993-2000. Fishery-independent catch rates were standardized using a lognormal generalized linear model analysis. Standardized indices were developed for the small coastal species-aggregate, and Atlantic sharpnose, blacknose, finetooth shark, and bonnethead. Depending on species, the final models varied with factors area, season, year. Although factors such as area and month were significant in most models, results from this study indicate any bias associated with these aspects did not significantly change the trends between nominal and standardized data.

SEDAR 13-DW-06

Standardized catch rates of small coastal sharks from a fishery-independent gillnet survey in northwest Florida

Carlson, J. and Bethea, D.

Fishery-independent catch rates were standardized using a two-part generalized linear model analysis. One part modeled the proportion of sets that caught any sharks (at least one shark was caught) assuming a binomial distribution with a logit link function while the other part modeled the catch rates of sets with positive catches assuming a Poisson distribution with a log link function. Standardized indices were developed for the small coastal species-aggregate, and Atlantic sharpnose, blacknose, finetooth shark, and bonnethead. Additional catch rate series are also developed by life stage juvenile (age 1+) and adult. Depending on species, the final models varied with factors area, season, year. Although factors such as area and month were significant in most models, results from this study indicate any bias associated with these aspects did not significantly change the trends between nominal and standardized data. Overall, trends were not significant.

SEDAR 13-DW-14

Standardized catch rates of small coastal sharks from the SEAMAP-South Atlantic shallow water trawl survey

Cortés, E. and Boylan, J.

This document presents an updated analysis of the relative abundance of small coastal sharks, Atlantic sharpnose shark, and bonnethead from the SEAMAP-SA Shallow Water Trawl Survey for 1989-2006. Time series data from this survey were standardized with Generalized Linear Model (GLM) procedures. All series showed increasing trends. Examination of lengths of Atlantic sharpnose shark and bonnethead 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.

SEDAR 13-DW-18
Fishery-Independent Catch of Small Coastal Sharks in Texas Bays, 1975-2006
Fisher, M.

The Texas Parks and Wildlife Department's long-term fishery-independent monitoring program provides sound scientific information on catch rates, sizes, and distribution of small coastal sharks. A total of 21,310 gill net samples resulted in 1,787 bonnetheads, 559 Atlantic sharpnose, 342 finetooth and one blacknose shark. Catch rates of the small coastal shark complex have been increasing over time, mostly due to the increase in bonnetheads. Atlantic sharpnose and finetooth shark CPUE show no overall trend. Lengths indicate no change in the size composition over time, most likely because of low recreational landings, no directed commercial fishery and little bycatch as entangling nets were banned in 1988. Spatial distribution of catches indicates small coastal sharks are most commonly found in areas with salinities between 20 and 35‰ and particularly along the middle Texas coast. Trend analysis reveals CPUE to be significantly related to salinity.

SEDAR 13-DW-19
Occurrence of small coastal sharks and standardized catch rates of Atlantic sharpnose sharks in the VIMS Longline Survey: 1974-2005
Grubbs, R., Romine, J., and Musick, J.

The Virginia Institute of Marine Science has conducted a fishery-independent longline survey during summer months since 1974. Data for Atlantic sharpnose sharks captured in the survey between 1974 and 2005 are presented. In most years, abundance and catch rates of Atlantic sharpnose sharks are second only to sandbar sharks in Virginia coastal waters. Length frequency data indicate that nearly all sharpnose sharks caught in Virginia are mature and most are males. Nominal and standardized catch rates are presented. In general, CPUE increased between 1986 and 1999, declined through 2002, and again increased through 2005.

SEDAR 13-DW-21
Catch rates and size composition of small coastal sharks collected during a gillnet survey of Mississippi coastal waters during 2001-2006
Hoffmayer, E. and Ingram, W.

This document examines a catch rate series for the small coastal shark (SCS) complex (four species), Atlantic sharpnose, finetooth, and bonnethead sharks, calculated from a gillnet survey which was conducted in Mississippi coastal waters from 2001 to 2006. During 53 sampling events, 240 net sets and 210 hours of effort, 509 Atlantic sharpnose, 184 finetooth, and 27 bonnethead sharks were collected. Because the work was conducted in a known nursery area, shark catch was further divided into young-of-the-young (YOY, age-0), juvenile, and adult catch. Standardized catch rates were estimated using a Generalized Linear Mixed modeling approach assuming a delta-lognormal error distribution and negative binomial regression. Atlantic sharpnose shark exhibited a positive trend, finetooth sharks and the SCS complex exhibited a slightly negative trend in relative standardized catch rates from 2001 to 2006. Due to the fact that this is still a short-term time series, this data set may be best used for a sensitivity analysis.

SEDAR 13-DW-22
Catch rates, distribution and size composition of small coastal sharks collected during NOAA Fisheries Bottom Longline Surveys from the U.S. Gulf of Mexico and U.S. Atlantic Ocean.
Ingram, W., Driggers, W., Grace, M., Henwood, T., Jones, L., and Mitchell, K.

The Southeast Fisheries Science Center (SEFSC) Mississippi Laboratories has conducted standardized bottom longline surveys in the Gulf of Mexico (GOM), Caribbean, and Southern North Atlantic (Atlantic) since 1995. This document describes the development of nine indices using a delta-lognormal methodology with year, area, hook-type, depth, salinity and temperature being tested for inclusion as variables in each model. The models developed were as follows: blacknose shark for GOM; blacknose shark for Atlantic south of 37° north latitude; blacknose shark for both areas combined; Atlantic sharpnose shark for GOM; Atlantic sharpnose shark for Atlantic south of 37° north latitude; Atlantic sharpnose shark for both areas combined; small coastal shark complex for GOM; small coastal shark complex for Atlantic south of 37° north latitude; and small coastal shark complex for both areas combined. The impact of Hurricane Katrina on the survey was noticeable in 2005, and the model could not completely compensate for the resulting lack of effort. The blacknose and finetooth data from the GOM and Atlantic were found to be insufficient, but all other species in both the GOM and Atlantic were considered viable for base case because of the long time series.

SEDAR 13-DW-27
Standardized catch rates of small coastal sharks from the Georgia COASTSPAN and GADNR penaeid shrimp and blue crab assessment surveys
McCandless, C. and Belcher, C.

Prior to 1998, Georgia's only sources of data relative to shark species were anecdotal accounts from fishermen, the State's recreation fishing records, and any incidental bycatch reports that identified sharks captured during various projects conducted by Georgia's Department of Natural Resources. In 1998 the NMFS Apex Predators Investigation began the Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) program funded through the Highly Migratory Species Management Division's Office of Sustainable Fisheries. This program funded a pilot study through Savannah State University to determine the presence/absence of juvenile sharks in Georgia's estuarine waters. In 2000, the University of Georgia in cooperation with the Georgia Department of Natural Resources (GADNR) developed a coastal shark survey in Georgia's estuarine waters as part of the COASTSPAN program. Data from the first six years of this survey (2000 to 2005) and supplemental shark bycatch data from the GADNR penaeid shrimp and blue crab assessment surveys (2003 to 2005) were used to look at the trends in relative abundance of small coastal sharks in Georgia's coastal waters. Catch per unit effort (CPUE) in number of sharks per hook hour for longline sets and in number of sharks per tow hour for trawl sets were examined from mid April through September. The CPUE was standardized using a modified two-step approach originally proposed by Lo et al (1992) that models the zero catch separately from the positive catch.

SEDAR 13-DW-28
Standardized catch rates for Atlantic sharpnose sharks *Rhizoprionodon terraenovae* from exploratory longline surveys conducted by the Sandy Hook, NJ and Narragansett, RI labs: 1961-1991
McCandless, C. and Hoey, J.

The United States National Marine Fisheries Service (NMFS), and its predecessor agencies; the Bureau of Commercial Fisheries (BCF) and the Bureau of Sport Fish and Wildlife (BSFW), have conducted periodic longline surveys for swordfish, tuna, and sharks off the east coast of the United States since the early 1950's. While the BCF surveys focused on the development of a tuna fishery, the initiation of shark surveys in1961 at the Sandy Hook Marine Lab (SHML) responded to concerns about shark attacks off the coast of New Jersey and resort owner demands for legislation that would require sport and commercial fishermen to fish further offshore. Surveys predominantly relied on longline gear, although early sampling also used chain bottom gear, gillnets, and sport fishing gear. In subsequent years, monitoring of sport fishing tournaments during summer months complimented dedicated surveys on research vessels and opportunistic trips aboard commercial and sport fishing vessels. Early experimentation with different tag types, ultimately lead to the establishment of the ongoing Cooperative Shark Tagging Program. After the initial coastal surveys were conducted between 1961 and 1965, there was a gradual transition from coastal work to offshore effort along the edge of the continental shelf and associated Gulf Stream waters. The shark research program moved from the Sandy Hook to the Narragansett Lab in the early 1970s.

Catch per set data obtained from the exploratory longline surveys conducted within the U.S. EEZ by the Sandy Hook, NJ and Narragansett, RI labs from 1961-1991 were used to develop standardized indices of abundance for Atlantic sharpnose sharks *Rhizoprionodon terraenovae* for the 2007 Small Coastal Shark SEDAR Data Workshop. Atlantic sharpnose shark catch per unit effort (CPUE) by set in number of sharks/hour were examined. The CPUE was standardized using a modified two-step approach originally proposed by Lo et al (1992) that models the zero catch separately from the positive catch. Standardizing the CPUE data reduced some of the peaks seen in the nominal CPUE data revealing a more stable trend in relative abundance for the Atlantic sharpnose sharks caught during these exploratory longline surveys.

SEDAR 13-DW-29
Standardized catch rates for Atlantic sharpnose sharks from the NMFS northeast longline survey
McCandless, C. and Natanson, L.

This document details Atlantic sharpnose shark *Rhizoprionodon terraenovae* catch from the Northeast Fisheries Science Center (NEFSC) Coastal Shark Survey, conducted by the Apex Predators Investigation, Narragansett Laboratory, Narragansett, RI from 1996-2004. The primary objective of this survey is to conduct a standardized, systematic survey of the shark populations off the US Atlantic coast to provide unbiased indices of the relative abundance for species inhabiting the waters from Florida to the Mid-Atlantic. It also provides an opportunity to tag sharks as part of the NEFSC Cooperative Shark Tagging Program and to collect biological samples and data used in analyses of life history characteristics (age, growth, reproductive biology, trophic ecology, etc.) and other research of sharks in US coastal waters. Data from this survey were used to look at the trends in relative abundance of Atlantic sharpnose sharks in the waters off the east coast the United States. Atlantic sharpnose shark catch per unit effort (CPUE) by set in number of sharks/(hooks*soak time) were examined for each year of the bottom longline survey, 1996, 1998, 2001 and 2004. The CPUE was standardized using a modified two-step approach originally proposed by Lo et al (1992) that models the zero catch separately from the positive catch. Nominal and standardized CPUE results from this survey indicate an increasing trend in Atlantic sharpnose shark relative abundance across the survey years.

SEDAR 13-DW-30
Standardized catch rates of small coastal sharks from the South Carolina COASTSPAN and SCDNR red drum surveys
McCandless, C., Ulrich, G., Hendrix, C., and Frazier, B.

In an effort to examine the use of South Carolina's estuarine waters as nursery areas for coastal shark species the South Carolina Department of Natural Resources SCDNR) Marine Resources Division, in collaboration with the National Marine Fisheries Service's (NMFS) Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) Survey began sampling for sharks using longline and gillnet methods in several estuaries within South Carolina. In addition to the estuarine areas sampled specifically for sharks, the SCDNR also samples the shark bycatch from a long-term longline survey designed to monitor adult red drum *Sciaenops ocellatus* in the coastal waters of South Carolina. Data from these surveys were used to look at the trends in small coastal shark abundance in South Carolina's estuarine and nearshore waters from 1998 to 2005. Catch per unit effort (CPUE) in number of sharks per hook hour for longline sets and in number of sharks per hour for gillnet sets were examined from March through December. The CPUE was standardized using a modified two-step approach originally proposed by Lo et al (1992) that models the zero catch separately from the positive catch.

SEDAR 13-DW-31
Indexes of abundance for small coastal sharks from the SEAMAP trawl surveys
Nichols, S.

Simple abundance indexes ('Base Indexes') are reported for four of the time series in the Resource Surveys / SEAMAP trawl surveys database, for Atlantic sharpnose, bonnethead, and blacknose. Finetooth appeared in the surveys only twice, so no meaningful indexes could be calculated for that species. Extended indexes for fall and summer ('Bayesian Indexes') were calculated for sharpnose and bonnethead based on the Bayesian calibration procedures used in SEDAR7 and SEDAR9. An extended sharpnose index for fall is viable for 1972-2006, and for summer 1982-2006. An extended bonnethead index is viable for fall 1972-2006. The summer index for bonnethead may be a bit less useful, but one is available for 1982-2006. Blacknose was too rare to be a candidate for the extended index analysis. Indexes for the 4 small coastal species combined are also reported. Size frequency histograms are submitted in an accompanying file, so the DW can evaluate whether developing additional indexes for specific sizes or sized-based ages are worth attempting.

SEDAR 13-DW-34
Trends in relative abundance of shark species caught during a University of North Carolina longline survey between 1972 and 2005 in Onslow Bay, NC

Schwartz, F., McCandless, C., and Hoey, J.

Early information about shark abundances, species composition and life history characteristics in near-shore coastal areas along the Gulf and Atlantic coasts of the US was very limited. In the early 1960's, the Bureau of Sport Fish and Wildlife (BSFW) initiated a coastal shark survey (1961 and 1965) in response to shark attacks in New Jersey and concerns raised by resort owners. This early survey indicated high seasonal abundances and species diversity in near-shore waters from Cape Henry, VA to Long Island, NY. The BSFW survey was re-directed to deeper offshore strata in the mid 1960's, but questions about the importance of coastal habitats for shark life-history remained. In North Carolina waters information about sharks was limited prior to 1972. This led to the establishment of a bi-weekly longline survey (April- November, 1972-2005) to study the sharks found in Onslow Bay, North Carolina by the University of North Carolina Institute of Marine Sciences. Sampling was conducted at shallow east-west (13 m deep) and deeper north-south (22 m) stations, 1 to 3.5 km south of Shackleford Banks. The surveys objective was to define what sharks occurred in the area, their sizes, life stages, relative abundances and seasonal occurrences. While other surveys and sampling programs have been initiated, the 34 year UNC time series described here is particularly consistent in terms of fixed sampling stations and the gear that was used.

A total of 7,993 sharks were captured between 1972 and 2005 during 798 sets on 450 sampling days. Shark catch was dominated by six species, including Atlantic sharpnose *Rhizoprionodon terraenovae*, blacknose *Carcharhinus acronotus*, dusky *C. obscurus*, blacktip *C. limbatus*, smooth dogfish *Mustelus canis* and scalloped hammerhead *Sphyrna lewini* sharks (descending order), which accounted for 88% of the total shark catch. Sandbar *C. plumbeus*, spinner *C.* brevipinna, silky *C. falciformis* and finetooth *C. isodon* sharks were the next most abundant species, with 310, 228, 164 and 99 individuals, respectively. Blacknose, dusky, blacktip, smooth dogfish, scalloped hammerhead, and sandbar sharks all appear to have a decreasing trend of relative abundance during the survey years. The Atlantic sharpnose shark and the small coastal shark complex, which is driven by the Atlantic sharpnose shark, are the only ones that appear to have an increasing trend in relative abundance during the survey years from 1972-2005. Total shark relative abundance appears to be stable in Onslow Bay and is likely a balance between the increasing trend in the abundant Atlantic sharpnose shark and the decreasing trends in the majority of other species. The data from 2005 also indicate that the smooth dogfish may be beginning an upwards trend in relative abundance.

SEDAR 13-DW-37
Relative abundances of blacknose sharks, *Carcharhinus acronotus,* from coastal shark surveys in the eastern Gulf of Mexico, 2001-2006
Tyminski, J., Ubeda, A., Hueter, R., and Morris, J.

Coastal shark surveys conducted by the Center for Shark Research using drumlines and longlines off the eastern Gulf of Mexico captured 76 blacknose sharks, *Carcharhinus acronotus*, from 2001-06. The catch comprised mostly mature sharks with a relatively equal ratio of male to females. Preliminary analysis of the catch per unit effort data from these fishery-independent efforts revealed that there was no significant difference in catch rate from year to year in either gear type.

SEDAR 13-DW-38
Relative abundance of bonnethead, Sphyrna tiburo, and Atlantic sharpnose sharks, *Rhizoprionodon terraenovae*, in two Florida Gulf estuaries, 1995-2004
Ubeda, A., Tyminski, J., and Hueter, R.

This document examines catch rate series of two small coastal species of sharks, bonnetheads and Atlantic sharpnose sharks. The data is a fishery-independent gillnet survey conducted by the Center for Shark Research - Mote Marine Laboratory from 1995 to 2004 in two Florida gulf estuaries (Yankeetown and Charlotte Harbor). Analyses for this paper were separated by the stage of maturity of the sharks. The numbers of immature and mature sharks for both species caught on each set were converted to CPUE. CPUE was calculated by dividing the number of animals caught by the soak time of the net (the time from the first float entering the water to the time that the last float came out of the water). CPUE data were standardized using the natural logarithm of the CPUE + 1 before being analyzed. Standardized catch rates from both stages of maturity were calculated using a General Linear Model (GLM) with month, year, area, grid (nested with area) as factors. The GLM also included an interaction term between year and area to investigate if the estuaries had a different pattern of catch rates. Only the summer months (June, July and August) were including in these analyses. Results of our studies indicate that there has been an increase in number of mature bonnetheads in both areas between 1995 and 2004. There has been also a slight increase in the number of immature bonnetheads for the Charlotte Harbor area, but there is no clear evidence of decline or increase in the number of immature sharks in the Yankeetown area. There appears to be increase in the number of mature and immature Atlantic sharpnose sharks between 1995 and 2004 for the Yankeetown area; however, the low number of catch rates for the Charlotte Harbor area for both maturity stage groups made it difficult to make solid conclusions about the status of this population.

<u>Fishery-Dependent Indices:</u>

SEDAR 13-DW-09
The directed shark drift gillnet fishery: Characterization of the small coastal shark catch, average size and standardization of catch rates from observer data
Carlson, J., Bethea, D., and Baremore, I.

A summary of the catch of small coastal sharks and a standardization of catch rate series from the directed shark drift gillnet fishery was developed based on observer programs from 1993-1995 and 1998-2005. Depending on season and area, small coastal species (primarily Atlantic sharpnose shark) are targeted and harvested. Catch rates were standardized for a small coastal aggregate and Atlantic sharpnose, blacknose, finetooth shark, and bonnethead using a two-part generalized linear model analysis. Depending on species, the final models varied with factors area, season, mesh size, vessel and year. Results from this study indicate that the use of the two-step modeling approach was appropriate for standardizing catch rates for large coastal sharks.

SEDAR 13-DW-10
Standardized catch rates of bonnetheads from the Everglades National Park creel survey, 1978-2004.
Carlson, J., Osborne, J., and Schmidt, T.

The Everglades National Park was established in 1947 and a fisheries monitoring program by the National Park Service based on sport fisher dock-side interviews began in 1972. Interviewers record landings and releases. Using this data, a standardized index of abundance was created for bonnetheads. We examined the utilization of modeling catch rates for other small coastal sharks but due to small sample sizes, catch rates were not constructed. The delta-lognormal index was constructed by combining two general linear models, a binomial model fit to the proportion of positive trips, and a lognormal model fit to positive catches. The standardized abundance index is similar to the nominal CPUE series.

SEDAR 13-DW-12
Standardized catch rates of small coastal sharks from the commercial shark fishery longline observer program, 1994-2005
Carlson, J., Cortés, E., Morgan, A., Hale, L., Bethea, D., Baremore, I., and Burgess, G.

Catch rate series were developed from the Commercial Shark Fishery Observer Program (CSFOP) for the period 1994-2005 for all species in small coastal shark (SCS) complex and Atlantic sharpnose, and blacknose shark. We examined the utilization of modeling catch rates for finetooth sharks and bonnethead but due to small sample sizes, catch rates were not constructed. All series were subjected to a Generalized Linear Model (GLM) standardization technique that treats separately the proportion of sets with positive catches (i.e., where at least one shark was caught) assuming a binomial error distribution with a logit link function, and the catch rates of sets with positive catches assuming a lognormal error distribution with a log link function. Because observations of the fishery have been conducted using two different non-overlapping sampling strategies (i.e. voluntary and mandatory), catch rates were modeled independently for two time series representing periods of 1994-2001 (voluntary) and 2002-2005 (mandatory). Catch rates were also modeled assuming separate stocks of sharks from the Atlantic Ocean and Gulf of Mexico.

SEDAR 13-DW-16
Standardized catch rates of bonnethead, Atlantic sharpnose shark, and the small coastal shark complex from the Marine Recreational Fishery Statistics Survey (MRFSS)
Cortés, E.

This document presents an analysis of the relative abundance of bonnethead, Atlantic sharpnose shark, and the small coastal shark complex (bonnethead, Atlantic sharpnose, blacknose, and finetooth) using catch and effort data from MRFSS for 1981-2005. Time series data from this survey were standardized using a Generalized Linear Mixed Model approach assuming a delta-lognormal error distribution. The explanatory variables considered for standardization included geographical region, seasonal trimesters, fishing mode (a factor that classifies recreational fishing into shore, headboat, charter, or private/rental boat), area of fishing (according to distance from shore), and fishing target (based on ecological and habitat groups target species were classified into "guilds"). All series showed markedly increasing trends.

SEDAR 13-DW-25
Standardized catch rates of Atlantic sharpnose sharks, *Rhizoprionodon terraenovae*, observed by the Northeast Fisheries Observer Program in the gillnet fishery from 1995-2005
Mello, J., Gervelis, B., and McCandless, C.

The Atlantic sharpnose shark, *Rhizoprionodon terraenovae*, is a common small coastal shark species of the southern US and Gulf of Mexico waters. The Northeast Fisheries Observer Program has deployed observers on commercial fishing vessels from Maine to North Carolina since 1989. This analysis incorporated data from 1995-2005. Prior to 1995, no Atlantic sharpnose sharks were reported on observed trips. Catch per unit effort (CPUE) in number of sharks per gillnet soak hour was used to estimate the relative abundance of Atlantic sharpnose sharks from observed trips. The CPUE was standardized using the modified two-step approach originally used by Lo et al. (1992). This approach is based on a delta-log-normal model that models the zero catch separately from the positive catch.

SEDAR 13-DW-26
Standardized catch rates for small coastal sharks from the Untied States Gulf of Mexico and south Atlantic gillnet fishery, 1998-2005
McCarthy, K.

Gillnet landings and fishing effort data from commercial vessels operating in the Gulf of Mexico and the Atlantic Ocean south of Virginia were used to construct indices of abundance for small coastal sharks during the period 1998-2005. CPUE was calculated as pounds landed/(net area x hours fished). Type of gillnet is not recorded in the coastal logbook data. Upon examination of the available data, analyses included landings from trips in the Atlantic Ocean only. Indices could not be constructed for the Gulf of Mexico because few trips and landings were reported from the Gulf. The cpue series for the small coastal complex as a whole had no obvious trend over time. Confidence intervals for the index were large. Indices for finetooth and sharpnose sharks also showed no trend over time. The indices for blacknose and bonnethead sharks had generally increasing CPUEs over time, although the confidence intervals for the bonnethead shark index were very large.

SEDAR 13-DW-41
Standardized catch rates for small coastal sharks from the United States Gulf of Mexico and South Atlantic bottom longline fishery, 1996-2005
McCarthy, K.

Landings and fishing effort data from commercial longline vessels operating in the Gulf of Mexico and the Atlantic Ocean south of Virginia were used to construct indices of abundance for small coastal sharks during the period 1996-2005. CPUE was calculated as pounds landed/hook hours. The index developed for the complex as a whole had low CPUEs in the first half of the time series and higher values beginning in 2001. No trend was apparent during either period, however, and confidence intervals were large. The sharpnose shark index was similar to the small coastal shark complex index with CPUEs low prior to 2001, but with no apparent trend before or after that year. The index developed from blacknose shark data had generally increasing CPUEs from 1999. No indices were developed for finetooth or bonnethead sharks using commercial longline data due to inadequate sample sizes. The coastal logbook longline data were collected from the same fishery as the NMFS bottom longline survey.

3.2 DISCUSSION OF ABUNDANCE INDICES

Each document was presented to the working group by its author or other representative. The group discussed each index with respect to data quality and completeness, analysis methodology and results, as well as index importance and potential utility. Factors considered in determining importance and utility were spatial coverage, years spanned, whether any other indices better represented those years/areas, and whether the sampling design was likely to have encountered small coastal sharks and therefore be reflective of population abundance trends. The indices presented to the group are listed in Table 3.1. The group formulated research recommendations for selected index analyses to be implemented, if possible, prior to the assessment being carried out. It was understood that some of the research recommendations might not be completed due to time constraints. The working group also compiled a list of indices recommended for use with each base case, based upon importance of each index and degree of confidence that it is reflective of abundance.

After discussing each index, the group proposed specific modifications to some of the analyses in order to improve the applicability of the indices for the assessment. Also, as a result of differences in data available for each of the four small coastal species, it was suggested that the species composition (%) be reported by all authors who calculated indices of the overall small coastal complex.

The data for **SEDAR 13-DW-05** (PC LL) were spatially restricted, but fairly long term. It was determined that the catch rates for Atlantic sharpnose and the SCS Complex would be valid for the base case, and that finetooth and blacknose be included in sensitivity analyses.

All species were represented by **SEDAR 13-DW-06** (PC Gillnet) which is a long-term, although spatially restricted, fishery-independent survey. Separate indices were provided for juveniles and adults for each species. All indices (SCS Complex, Atlantic sharpnose, finetooth, bonnethead, and blacknose sharks) were recommended for the base models.

There were low sample sizes for **SEDAR 13-DW-09** (Gillnet Obs) however this was a long term survey and it is one of the very few fishery-dependent data sets for small coastal sharks. It was requested that the measure of effort presented (sharks/net area*hour) be recalculated as (sharks/10^{-7} net area * hour) and re-standardized. This series was recommended as a Base index for the complex and all four species (sharpnose, bonnethead, blacknose, and finetooth sharks).

There was some concern for the increasing trend seen in **SEDAR 13-DW-10** (ENP) being due to increasing training/efficiency of the creel personnel however because only bonnetheads were included in the index and they are a fairly distinguishable species, this was considered to be a minimal problem. This indexwas recommended as a base model index.

There were high CV values for **SEDAR 13-DW-12** (BLLOP), and it was suggested that this may be due to low sample size in some cells. It was also discussed that the observer program changed in 2001 from voluntary to mandatory. The authors had conducted the analysis on the voluntary (1994-2001) and mandatory (2001-2005) portions of the database separately. It was suggested that if there were vessels that were sampled in both time periods, then combining the data would be justified. There was also some concern over the measure of effort presented in the original document. The series was reanalyzed to address all concerns and was recommended for use as a base case index for Atlantic sharpnose and blacknose sharks, and for the SCS complex.

SEDAR 13-DW-14 (SEAMAP SA): This document provided catch rate series for the SCS complex, Atlantic sharpnose, and bonnethead sharks. There was some concern about the addition of new stations in 2001, but after further investigation, it was determined that was not the case. All indices were recommended for use in the Base model.

Concern was raised about species identification issues for **SEDAR 13-DW-16** (MRFSS) as well as several other data issues. However, the large area and temporal coverage made the data potentially useful pending reanalysis. The recommendation was for the data to be reanalyzed and re-examined. The data were not able to be reanalyzed in an appropriate timeframe so the series was not recommended for inclusion.

In the case of **SEDAR 13-DW-18** (Texas), it was suggested that the data be standardized because it was a statistically designed survey, but only nominal values were presented. The data were standardized using zero-inflated delta-lognormal (ZIDL) and zero-inflated binomial (ZIB) methodology as described in SEDAR 10-DW-12. This standardization was completed during the workshop. For bonnethead sharks, both submodels were used, whereas only the ZIB submodel was used for Atlantic sharpnose and finetooth sharks, along with the SCS Complex. The CVs were high early on for bonnethead sharks, but better in the later years so it was recommended for base case use. CV values of the Atlantic sharpnose shark index followed similar a trend to that of bonnethead sharks and the series was recommended for base case use. The finetooth shark index was highly recommended for base case due to paucity of data for finetooth. Finally, CV values were very good (low) for the SCS Complex and recommended as a base index.

There was a question regarding the confidence intervals and/or CV values presented in **SEDAR 13-DW-19** (VA LL). The Group felt that the confidence intervals were too wide for the reported CVs and that the reported CVs seemed too tight, given the small sample size in some years. It was recommended that the data needed to be reanalyzed. As the authors were not present, the original data were retrieved and the reanalysis completed by W. Ingram during the workshop. The CVs were determined to be incorrect. The values after reanalysis were still high, but were considered unreasonable. Considering that this series represented the northern range of Atlantic sharpnose sharks, it was recommended for the base model.

The standardized indices of **SEDAR 13-DW-21** (MS Gillnet) presented were outside of the confidence intervals and the author agreed to check his values. This was done and it was concluded that a graphing error had occurred and it was corrected. There were questions about its utility because of the short time span of the survey, but the length-frequency data were considered valuable. It was decided that the series for the SCS Complex, Atlantic sharpnose, and finetooth sharks were viable for sensitivity analyses.

The impact of Hurricane Katrina on **SEDAR 13-DW-22** (NMFS LL SE) was noticeable in 2005 and the author mentioned that the model could not completely compensate for the lack of effort that year. The blacknose and finetooth data from the Gulf and Atlantic were found to be insufficient, but all other species in both the Gulf and southern Atlantic were considered viable for the base case because of the long time series.

The increasing trend for Atlantic sharpnose seen in **SEDAR 13-DW-25** (NE Observer) was thought to be due to observers becoming better trained, and the fact that Atlantic sharpnose sharks were not reported before 1995. Because there were three types of net in the fishery and net type was not used as a factor in the model, it was suggested that the data be reanalyzed and the utility assessed later. After reanalysis, it was recommended that the series not be used for assessment purposes since it still had very high CV values, probably due to low sample size, and was missing years of a relatively short time series. Also, it represents the northern portion of the species range so it may not track changes in abundance.

Concerns with the data from **SEDAR 13-DW-26** (Gillnet Logs) included the fact that only landings, not catch, could be assessed. Additionally, increased reporting over time could also account for the observed increasing trend seen. The confidence interval range was very large, and it was suggested that because area was highly significant as a variable, the model could be trying to compensate for the variability and was giving the large range. One other major issue was that the gear category “gillnet” contains many types of net gear lumped together with no way to account for the different gears. Despite these issues, this series was recommended for use as a sensitivity index since it documents portions of the net fleet for which information is lacking prior to 2005.

The dip in 2005 observed for all series presented in **SEDAR 13-DW-27** (GA COASTSPAN LL and GADNR Trawl) was noted, and the author thought it might have been associated with rainfall. It was suggested that archival rainfall data be accessed, and the author agreed. Because of the short time series and spatial coverage represented by the data, it was determined that the GADNR trawl data would not be useful at this time, but may be valuable for the next assessment. The utility of the COASTSPAN longline index in the age-structured models for Atlantic sharpnose and bonnethead would be reassessed after the young-of-the-year data were removed however after further discussion it was decided that the COASTSPAN LL index was not suitable for use given that the authors shifted sampling locations over time, so the observed trend may be due to spatial differences rather than abundance.

Despite not recommending the index, the length-frequency information of Atlantic sharpnose sharks from the GA COASTSPAN LL was used to estimate a mortality rate for that species. This work will be presented at the assessment workshop.

The data from **SEDAR 13-DW-28** (NE Exp LL) were from exploratory surveys and did not include length-frequencies, but itis a long-term data set. Concern was voiced at the fact that the survey was designed to target large coastal and pelagic sharks, but the consensus was that there was the same probability of catching all small coastal sharks incidentally over the survey period. It was recommended for sensitivity analysis for Atlantic sharpnose.

There was a small sample size for Atlantic sharpnose from **SEDAR 13-DW-29** (NMFS LL NE), mainly because the survey targets large coastal sharks. Additionally, the survey did not take place in consecutive years and there are only four years of data. The recommendation was to reanalyze the data removing the most northern stations, as they are out of the normal range for the species of interest. There was very little improvement after the reanalysis and so the series was not recommended for use.

There were a few recommendations for **SEDAR 13-DW-30** (SC COASTSPAN LL, SC COASTSPAN Gillnet, and SCDNR LL). Firstly it was suggested that annual length-frequencies be generated for sharpnose, which the author agreed to do. The SC COASTSPAN LL was not recommended because there was a change in set locations within areas to target large coastal sharks in 2002. It may be a useful time series in the future, starting in 2002. The SC COASTSPAN Gillnet indices for Atlantic sharpnose, bonnethead, and finetooth sharks, as well as the SCS Complex, were recommended for base case use. The Atlantic sharpnose data produced a series including young-of-the-year (YOY) individuals for use in a surplus production model, and one without YOYs for an age-structured model. It was recommended that bonnethead and finetooth data from the SCDNR red drum survey not be used due to high CV values. The blacknose and Atlantic sharpnose shark series (both with and without YOY individuals) were recommended for base case use, as was the SCS Complex.

Four data sets were available for use in producing catch rate series in **SEDAR 13-DW-31** (SEAMAP GoM). There were basically two time series, early and late for both summer and fall, split due to methodological changes within the surveys. Standardized series were produced for each of the time periods (4 series possible for each species and the SCS complex), as well as two “extended” series (Fall and Summer) which used Bayesian methods to link and standardize the series. The extended series were available for Atlantic sharpnose and bonnethead sharks, as well as the SCS complex and were recommended as base indices. The short, individual series were not recommended for use.

There was limited spatial coverage for **SEDAR 13-DW-34** (UNC), but it covered a long time series and standardized sampling methods. Atlantic sharpnose made up the vast majority of the catch, and it was suggested that if Atlantic sharpnose are increasing, the other species might be under-represented. Base models were recommended for Atlantic sharpnose and blacknose sharks as well as the SCS complex, but not for finetooth sharks.

The survey for **SEDAR 13-DW-37** (MML LL and MML Drumline) was set up to target large coastal sharks using both drumline and longline gear, and the hook size and leaders were changed within the first few years. It was decided that the available blacknose data should be standardized, if possible, and be used in the sensitivity run. The sample size was low, but corresponded to low effort, so it was deemed potentially usable in a second version of the document.

The drumline data could not be standardized, so not recommended for use. The longline data for blacknose was standardized using a negative binomial regression for 4 years of data. Given the lack of blacknose data, it was recommended as a Base index.

It was suggested that the data for the two sampling areas of **SEDAR 13-DW-38** (MML Gillnet) be combined, and then area used as a factor in the model with maturity state separated for Atlantic sharpnose, bonnethead, and the SCS Complex. It was also recommended that any environmental variables that could, should be incorporated into the model. The areas were combined, using AREA as a variable, and an index for the SCS complex was produced. The recommendations were to use the juvenile and mature bonnethead indices as base case indices, as well as both juvenile and mature Atlantic sharpnose indices, although it was noted that the juvenile Atlantic sharpnose index had higher CVs than for bonnethead sharks. The SCS Complex series was also recommended for base case use.

Concerns with the data from **SEDAR 13-DW-41** (BLL Logs) include the fact that only landings, not catch, can be assessed. Increased reporting over time could also account for the trend seen. The confidence interval range was very large possibly due to low frequency of occurrence. Given that there were a variety of problems with the logbook data, and that the same sampling universe is covered by the BLLOP, these series were not recommended for use.

The available index values, including those updated following the recommendations described above, are shown in Table 3.2 and Figures 3.1 - 3.10. Maps displaying the geographic coverage of the indices are shown in Figure 3.11.

3.3 INDEX WEIGHTING RECOMMENDATIONS

The working group recommended equal weighting for the base case, and inverse CV weighting for a sensitivity run. The motivation for this recommendation was that most of the base indices were standardized and of relatively equal precision, whereas many of the sensitivity indices had larger CVs.

3.4 RESEACH RECOMMENDATIONS

The following recommendations provided in no particular order, deal with the collection of catch rate series data.

- Continuation of the fishery-independent surveys reviewed is encouraged. Some series that were not useful at this time may prove useful in the future with the inclusion of more data and series that were recommended for use at this time may improve with the additional information.

- If significant methodological changes are planned, it would be wise to have an overlap period between the gear, design, or vessel changes to all for calibration and quantification of those changes. This will allow for the time series to be maintained as one entity.

Table 3.1. A summary of catch series available for review at the SEDAR 13 Data Workshop.

Species	Series	Author	Reference	Data Source	Area	Years	Season	Biomass/ Number	Fishery Type	Standardized	Selectivity Info	Age Range	Positive Aspects	Negative Aspects	Utility for Assessment
AS	PCLL	Carlson	DW-05	Panama City data set	NW FL	93-00	Spr-Fall	No./10 hook hr	Independent	Log-normal	Length Frequencies	NA	Good temporal coverage, moderate length	Restricted geographic area	Base model set
BN	PCLL	Carlson	DW-05	Panama City data set	NW FL	93-00	Spr-Fall	No./10 hook hr	Independent	Log-normal	Length Frequencies	NA	Good temporal coverage, moderate length	Restricted geographic area	Sensitivity set
FT	PCLL	Carlson	DW-05	Panama City data set	NW FL	93-00	Spr-Fall	No./10 hook hr	Independent	Log-normal	Length Frequencies	NA	Good temporal coverage, moderate length	Restricted geographic area	Sensitivity set
SCS	PCLL	Carlson	DW-05	Panama City data set	NW FL	93-00	Spr-Fall	No./10 hook hr	Independent	Log-normal	Length Frequencies	NA	Good temporal coverage, moderate length	Restricted geographic area	Base model set
AS	PC Gillnet	Carlson	DW-06	Panama City data set	NW FL	96-06	Spr-Fall	No./net hr	Independent	Lo Method	Length Frequencies	NA	Good temporal coverage, moderate length	Restricted geographic area	Base model Set
AS	PC Gillnet-juvi	Carlson	DW-06	Panama City data set	NW FL	96-06	Spr-Fall	No./net hr	Independent	Lo Method	Length Frequencies	NA	Good temporal coverage, moderate length	Restricted geographic area	Base model Set
AS	PC Gillnet - adult	Carlson	DW-06	Panama City data set	NW FL	96-06	Spr-Fall	No./net hr	Independent	Lo Method	Length Frequencies	NA	Good temporal coverage, moderate length	Restricted geographic area	Base model Set
BH	PC Gillnet-	Carlson	DW-06	Panama City data set	NW FL	96-06	Spr-Fall	No./net hr	Independent	Lo Method	Length Frequencies	NA	Good temporal coverage, moderate length	Restricted geographic area	Base model Set
BH	PC Gillnet-juvi	Carlson	DW-06	Panama City data set	NW FL	96-06	Spr-Fall	No./net hr	Independent	Lo Method	Length Frequencies	NA	Good temporal coverage, moderate length	Restricted geographic area	Base model Set
BH	PC Gillnet - adult	Carlson	DW-06	Panama City data set	NW FL	96-06	Spr-Fall	No./net hr	Independent	Lo Method	Length Frequencies	NA	Good temporal coverage, moderate length	Restricted geographic area	Base model Set
BN	PC Gillnet-	Carlson	DW-06	Panama City data set	NW FL	96-06	Spr-Fall	No./net hr	Independent	Lo Method	Length Frequencies	NA	Good temporal coverage, moderate length	Restricted geographic area	Base model Set
BN	PC Gillnet-juvi	Carlson	DW-06	Panama City data set	NW FL	96-06	Spr-Fall	No./net hr	Independent	Lo Method	Length Frequencies	NA	Good temporal coverage, moderate length	Restricted geographic area	Base model Set
BN	PC Gillnet - adult	Carlson	DW-06	Panama City data set	NW FL	96-06	Spr-Fall	No./net hr	Independent	Lo Method	Length Frequencies	NA	Good temporal coverage, moderate length	Restricted geographic area	Base model Set
FT	PC Gillnet-	Carlson	DW-06	Panama City data set	NW FL	96-06	Spr-Fall	No./net hr	Independent	Lo Method	Length Frequencies	NA	Good temporal coverage, moderate length	Restricted geographic area	Base model Set
FT	PC Gillnet-juvi	Carlson	DW-06	Panama City data set	NW FL	96-06	Spr-Fall	No./net hr	Independent	Lo Method	Length Frequencies	NA	Good temporal coverage, moderate length	Restricted geographic area	Base model Set

Species	Series	Author	Reference	Data Source	Area	Years	Season	Biomass/ Number	Fishery Type	Standardized	Selectivity Info	Age Range	Positive Aspects	Negative Aspects	Utility for Assessment
FT	PC Gillnet - adult	Carlson	DW-06	Panama City data set	NW FL	96-06	Spr-Fall	No./net hr	Independent	Lo Method	Length Frequencies	NA	Good temporal coverage, moderate length	Restricted geographic area	Base model Set
SCS	PC Gillnet	Carlson	DW-06	Panama City data set	NW FL	96-06	Spr-Fall	No./net hr	Independent	Lo Method	Length Frequencies	NA	Good temporal coverage, moderate length	Restricted geographic area	Base model Set
AS	Gillnet-Obs	Carlson	DW-09	Gillnet observer program	NW-Key West to GA	93-95, 98-05	Year round	No./net area hr	Dependent-comm	Lo Method	Length Frequencies	NA	Good area coverage, moderately long series	Two missing years, lack of length frequencies in early years, small sample size in some years	Base model Set after reanalysis with new effort measure
AS	Gillnet-Obs	Carlson	DW-09-V2	Gillnet observer program	NW-Key West to GA	93-95, 98-05	Year round	No./10^{-7} net area hr	Dependent-comm	Lo Method	Length Frequencies	NA	Good area coverage, moderately long series	Two missing years, lack of length frequencies in early years, small sample size in some years	Base model Set
AS	Gillnet-Obs	Carlson	DW-09-V2	Gillnet observer program	Atl	93-95, 98-05	Year round	No./10^{-7} net area hr	Dependent-comm	Lo Method	Length Frequencies	NA	Good area coverage, moderately long series	Two missing years, lack of length frequencies in early years, small sample size in some years	Base model Set e
BH	Gillnet-Obs	Carlson	DW-09	Gillnet observer program	NW-Key West to GA	93-95, 98-05	Year round	No./net area hr	Dependent-comm	Lo Method	Length Frequencies	NA	Good area coverage, moderately long series	Two missing years, lack of length frequencies in early years, small sample size in some years	Base model Set after reanalysis with new effort measure
BH	Gillnet-Obs	Carlson	DW-09-V2	Gillnet observer program	NW-Key West to GA	93-95, 98-05	Year round	No./10^{-7} net area hr	Dependent-comm	Lo Method	Length Frequencies	NA	Good area coverage, moderately long series	Two missing years, lack of length frequencies in early years, small sample size in some years	Base model Set
BN	Gillnet Obs	Carlson	DW-09	Gillnet observer program	NW-Key West to GA	93-95, 98-05	Year round	No./net area hr	Dependent-comm	Lo Method	Length Frequencies	NA	Good area coverage, moderately long series	Two missing years, lack of length frequencies in early years, small sample size in some years	Base model Set after reanalysis with new effort measure
BN	Gillnet Obs	Carlson	DW-09-V2	Gillnet observer program	NW-Key West to GA	93-95, 98-05	Year round	No./10^{-7} net area hr	Dependent-comm	Lo Method	Length Frequencies	NA	Good area coverage, moderately long series	Two missing years, lack of length frequencies in early years, small sample size in some years	Base model Set
FT	Gillnet Obs	Carlson	DW-09	Gillnet observer program	NW-Key West to GA	93-95, 98-05	Year round	No./net area hr	Dependent-comm	Lo Method	Length Frequencies	NA	Good area coverage, moderately long series	Two missing years, lack of length frequencies in early years, small sample size in some years	Base model Set after reanalysis with new effort measure
FT	Gillnet Obs	Carlson	DW-09-V2	Gillnet observer program	NW-Key West to GA	93-95, 98-05	Year round	No./10^{-7} net area hr	Dependent-comm	Lo Method	Length Frequencies	NA	Good area coverage, moderately long series	Two missing years, lack of length frequencies in early years, small sample size in some years	Base model Set
SCS(year dependent)	Gillnet Obs	Carlson	DW-09	Gillnet observer program	NW-Key West to GA	93-95, 98-05	Year round	No./net area hr	Dependent-comm	Lo Method	Length Frequencies	NA	Good area coverage, moderately long series	Two missing years, lack of length frequencies in early years, small sample size in some years	Base model Set
BH	ENP	Carlson	DW-10	NPS	Everglades, South FL	78-04	Year Round	No./trip	Dependent-rec	Lo Method	NA	NA	Long-term, good temporal coverage	No selectivity, small spatial coverage	Base model set

Species	Series	Author	Reference	Data Source	Area	Years	Season	Biomass/ Number	Fishery Type	Standardized	Selectivity Info	Age Range	Positive Aspects	Negative Aspects	Utility for Assessment
AS	BLLOP	Carlson	DW-12	Shark LL observer program	NC-LA	94-05	Year Round	No./haul	Dependent-rec	Lo Method	Length Frequencies	NA	Length frequencies	Series analyzed separately after 2001.	Reanalyze and revisit
AS	BLLOP	Carlson	DW-12-V2	Shark LL observer program	NC-LA	94-05	Year Round	No./haul	Dependent-rec	Lo Method	Length Frequencies	NA	Length frequencies	Series combined	Base case
AS	BLLOP	Carlson	DW-12-V2	Shark LL observer program	GoM	94-05	Year Round	No./haul	Dependent-rec	Lo Method	Length Frequencies	NA	Length frequencies	Series combined	Base case
AS	BLLOP	Carlson	DW-12-V2	Shark LL observer program	A. Atlantic	94-05	Year Round	No./haul	Dependent-rec	Lo Method	Length Frequencies	NA	Length frequencies	Series combined	Base case
BN	BLLOP	Carlson	DW-12	Shark LL observer program	NC-LA	94-05	Year Round	No./haul	Dependent-rec	Lo Method	Length Frequencies	NA	Length frequencies	Series analyzed separately after 2001.	Reanalysis and revisit
BN	BLLOP	Carlson	DW-12-V2	Shark LL observer program	NC-LA	94-05	Year Round	No./haul	Dependent-rec	Lo Method	Length Frequencies	NA	Length frequencies	One time series combined.	Base index
SCS (year dependent)	BLLOP	Carlson	DW-12	Shark LL observer program	NC-LA	94-05	Year Round	No./haul	Dependent-rec	Lo Method	Length Frequencies	NA	Length frequencies	Series analyzed separately after 2001.	Base index
AS	SEAMAP-ATL	Cortes	DW-14	SEAMAP	NC-FL	89-06	Spr/Sum/Fall	No./trawl hr	Independent	Lo Method	Length frequencies	NA	Long-term, standardized methods, good spatial and temporal coverage	Increased effort on stations with higher variability	Base index
BH	SEAMAP-ATL	Cortes	DW-14	SEAMAP	NC-FL	89-06	Spr/Sum/Fall	No./trawl hr	Independent	Lo Method	Length frequencies	NA	Long-term, standardized methods, good spatial and temporal coverage	Increased effort on stations with higher variability	Base index
SCS (AS 71%, BH 28%)	SEAMAP-ATL	Cortes	DW-14	SEAMAP	NC-FL	89-06	Spr/Sum/Fall	No./trawl hr	Independent	Lo Method	Length frequencies	NA	Long-term, standardized methods, good spatial and temporal coverage	Increased effort on stations with higher variability	Base index
AS	MRFSS	Cortes	DW-16	MRFSS	ME-LA	81-05	Year round	No./1000 angler hrs	Dependent Rec	Lo Method	Length frequencies	NA	Large spatial and temporal coverage, long-term set	Low proportion positive, trend in residuals,	Could not be reanalyzed in time; Not recommended
BH	MRFSS	Cortes	DW-16	MRFSS	ME-LA	81-05	Year round	No./1000 angler hrs	Dependent Rec	Lo Method	Length frequencies	NA	Large spatial and temporal coverage, long-term set	Low proportion positive, trend in residuals,	Could not be reanalyzed in time; Not recommended
SCS (?)	MRFSS	Cortes	DW-16	MRFSS	ME-LA	81-05	Year round	No./1000 angler hrs	Dependent Rec	Lo Method	Length frequencies	NA	Large spatial and temporal coverage, long-term set	Low proportion positive, trend in residuals,	Could not be reanalyzed in time; Not recommneded

Species	Series	Author	Reference	Data Source	Area	Years	Season	Biomass/ Number	Fishery Type	Standardized	Selectivity Info	Age Range	Positive Aspects	Negative Aspects	Utility for Assessment
AS	Texas	Fisher	DW-18	Texas Parks & Wild.	TX (In)	75-06	Spr-Fall	Number/hr	Independent	Nominal	Length Frequency	NA	Long-term, no gear change, statistical sampling,	Not standardized with Lo Method.	If standardized, great base data set.
BH	Texas	Fisher	DW-18	Texas Parks & Wild.	TX(In)	75-06	Spr-Fall	Number/hr	Independent	Nominal	Length Frequency	NA	Long-term, no gear change, statistical sampling,	Not standardized with Lo Method.	If standardized, great data set.
FT	Texas	Fisher	DW-18	Texas Parks & Wild.	TX(In)	75-06	Spr-Fall	Number/hr	Independent	Nominal	Length Frequency	NA	Long-term, no gear change, statistical sampling,	Not standardized with Lo Method.	If standardized, great data set.
SCS(BH 67%, AS 20%, FT 13%)	Texas	Fisher	DW-18	Texas Parks & Wild.	TX (In)	75-06	Spr-Fall	Number/hr	Independent	Nominal	Length Frequency	NA	Long-term, no gear change, statistical sampling,	Not standardized with Lo Method.	If standardized, great base data set.
AS	Texas	Fisher	DW-18-V2	Texas Parks & Wild.	TX(In)	75-06	Spr-Fall	Number/hr	Independent	Zero-inflated binomial	Length Frequency	NA	Long-term, no gear change, statistical sampling,	Not standardized with Lo Method.	Base
BH	Texas	Fisher	DW-18-V2	Texas Parks & Wild.	TX(In)	75-06	Spr-Fall	Number/hr	Independent	Zero-inflated delta-lognormal, Zero-inflated binomial	Length Frequency	NA	Long-term, no gear change, statistical sampling,	Not standardized with Lo Method.	Base
FT	Texas	Fisher	DW-18-V2	Texas Parks & Wild.	TX(In)	75-06	Spr-Fall	Number/hr	Independent	Zero-inflated binomial	Length Frequency	NA	Long-term, no gear change, statistical sampling,	Not standardized with Lo Method.	Base
SCS(BH 67%, AS 20%, FT 13%)	Texas	Fisher	DW-18-V2	Texas Parks & Wild.	TX(In)	75-06	Spr-Fall	Number/hr	Independent	Zero-inflated binomial	Length Frequency	NA	Long-term, no gear change, statistical sampling,	Not standardized with Lo Method.	Base
AS	VA-LL	Grubbs	DW-19	VIMS	VA	74-05	Sum	No./100 hooks	Independent	Lo Method	Length Frequencies	NA	Long-term, standardized, length frequencies	CV's need to be recalculated, no time effort, small spatial scale	Reanalyze and revisit
AS	VA-LL	Grubbs	DW-19-V2	VIMS	VA	74-05	Sum	No./100 hooks	Independent	Lo Method	Length Frequencies	NA	Long-term, standardized, length frequencies	Small spatial scale	Base model
AS	MS-gillnet	Hoffmayer	DW-21	GCRL data set	MS (In)	01-06	Spr-Fall	Number/net hr	Independent	Negative Binomial	Length Frequency	NA	Length frequencies	Short data set, lower effort in early years.	Useful sensitivity set, may be more useful in future
FT	MS-gillnet	Hoffmayer	DW-21	GCRL data set	MS (In)	01-06	Spr-Fall	Number/net hr	Independent	Negative Binomial	Length Frequency	NA	Length frequencies	Short data set, lower effort in early years.	Useful sensitivity set, may be more useful in future
SCS (AS 71%, FT 26%)	MS-gillnet	Hoffmayer	DW-21	GCRL data set	MS (In)	01-06	Spr-Fall	Number/net hr	Independent	Negative Binomial	Length Frequency	NA	Length frequencies	Short data set, lower effort in early years.	Useful sensitivity set, may be more useful in future
AS	NMFS LL SE	Ingram	DW-22	NMFS data set	Gulf (Off)	95-06	Sum/Fall	No./100 hook hrs.	Independent	Lo Method	Length Frequency	NA	Long-term, length frequencies, statistical sampling	Not equal coverage in Atl. and Gulf over time.	Base model set
AS	NMFS LL SE	Ingram	DW-22	NMFS data set	Atl. (Off)	95-06	Sum/Fall	No./100 hook hrs.	Independent	Lo Method	Length Frequency	NA	Long-term, length frequencies, statistical sampling	Not equal coverage in Atl. and Gulf over time.	Base model set
AS	NMFS LL SE	Ingram	DW-22	NMFS data set	Gulf +Atl. (Off)	95-06	Sum/Fall	No./100 hook hrs.	Independent	Lo Method	Length Frequency	NA	Long-term, length frequencies, statistical sampling	Not equal coverage in Atl. and Gulf over time.	Base model set

Species	Series	Author	Reference	Data Source	Area	Years	Season	Biomass/ Number	Fishery Type	Standardized	Selectivity Info	Age Range	Positive Aspects	Negative Aspects	Utility for Assessment
BN	NMFS LL SE	Ingram	DW-22	NMFS data set	Gulf (Off)	95-06	Sum/Fall	No./100 hook hrs.	Independent	Lo Method	Length Frequency	NA	Long-term, length frequencies, statistical sampling	Not equal coverage in Atl. and Gulf over time.	Base model set
BN	NMFS LL SE	Ingram	DW-22	NMFS data set	Atl. (Off)	95-06	Sum/Fall	No./100 hook hrs.	Independent	Lo Method	Length Frequency	NA	Long-term, length frequencies, statistical sampling	Not equal coverage in Atl. and Gulf over time.	Not useful due to infrequent catch
BN	NMFS LL SE	Ingram	DW-22	NMFS data set	Gulf +Atl. (Off)	95-06	Sum/Fall	No./100 hook hrs.	Independent	Lo Method	Length Frequency	NA	Long-term, length frequencies, statistical sampling	Not equal coverage in Atl. and Gulf over time.	Despite concerns about infrequent catch in Atl., base model set for single stock
SCS(AS %, BN %)	NMFS LL SE	Ingram	DW-22	NMFS data set	Gulf +Atl.	95-06	Sum/Fall	No./100 hook hrs.	Independent	Lo Method	Length Frequency	NA	Long-term, length frequencies, statistical sampling	Not equal coverage in Atl. and Gulf over time.	Base model set
SCS(AS 84%, BN15%)	NMFS LL SE	Ingram	DW-22	NMFS data set	Gulf	95-06	Sum/Fall	No./100 hook hrs.	Independent	Lo Method	Length Frequency	NA	Long-term, length frequencies, statistical sampling	Not equal coverage in Atl. and Gulf over time.	Base model set
SCS(AS 98.5%, BN 1.5%)	NMFS LL SE	Ingram	DW-22	NMFS data set	Atl.	95-06	Sum/Fall	No./100 hook hrs.	Independent	Lo Method	Length Frequency	NA	Long-term, length frequencies, statistical sampling	Not equal coverage in Atl. and Gulf over time.	Base model set
AS	NE Observer	Mello	DW-25	NE-OBS	ME-NC	95-05	Year Round	No./set hr	Dependent-comm	Lo Method	Length Frequencies	NA	Good spatial and temporal coverage, length frequencies	Combined different gear types; net size not taken into consideration	Reanalyze and revisit
AS	NE Observer	Mello	DW-25-V2	NE-OBS	ME-NC	95-05	Year Round	No./set hr	Dependent-comm	Lo Method	Length Frequencies	NA	Good spatial and temporal coverage, length frequencies	Very high CV values; missing years	Not recommended
AS	Gillnet Logs	McCarthy	DW-26	Coastal Fisheries Logbooks	Cen. Fl-NC	95-05	Year Round	Lbs/sq. yard net hr	Dependent-comm	Lo Method	NA	NA	Covers gillnet gears not examined elsewhere	No gear differentiation, many unknown variables, no selectivity	Sensitivity set
BH	Gillnet Logs	McCarthy	DW-26	Coastal Fisheries Logbooks	Cen. Fl-NC	95-05	Year Round	Lbs/sq. yard net hr	Dependent-comm	Lo Method	NA	NA	Covers gillnet gears not examined elsewhere	No gear differentiation, many unknown variables, no selectivity	Sensitivity set
BN	Gillnet Logs	McCarthy	DW-26	Coastal Fisheries Logbooks	Cen. Fl-NC	95-05	Year Round	Lbs/sq. yard net hr	Dependent-comm	Lo Method	NA	NA	Covers gillnet gears not examined elsewhere	No gear differentiation, many unknown variables, no selectivity	Sensitivity set
FT	Gillnet Logs	McCarthy	DW-26	Coastal Fisheries Logbooks	Cen. Fl-NC	95-05	Year Round	Lbs/sq. yard net hr	Dependent-comm	Lo Method	NA	NA	Covers gillnet gears not examined elsewhere	No gear differentiation, many unknown variables, no selectivity	Sensitivity set
SCS	Gillnet Logs	McCarthy	DW-26	Coastal Fisheries Logbooks	Cen. Fl-NC	95-05	Year Round	Lbs/sq. yard net hr	Dependent-comm	Lo Method	NA	NA	Covers gillnet gears not examined elsewhere	No gear differentiation, many unknown variables, no selectivity	Sensitivity set
AS	GA Coastspan	McCandless	DW-27	Coastspan	GA	2000-05	Sum	No./50 hook hrs.	Independent	Lo Method	Length Frequency	NA	Length frequencies,	Short time series, unequal area coverage in some years, short spatial coverage	Not enough data without YOY, not recommended
AS	GADNR	McCandless	DW-27	GADNR	GA	03-05	Sum	No./tow hr	Independent	Lo Method	Length Frequency	NA	All areas covered, standardize methods	Short time series, short spatial coverage	Not useful now, maybe in future.

Species	Series	Author	Reference	Data Source	Area	Years	Season	Biomass/ Number	Fishery Type	Standardized	Selectivity Info	Age Range	Positive Aspects	Negative Aspects	Utility for Assessment
BH	GA Coastspan	McCandless	DW-27	Coastspan	GA	2000-05	Sum	No./50 hook hrs.	Independent	Lo Method	Length Frequency	NA	Length frequencies,	Short time series, unequal area coverage in some years, short spatial coverage	Not enough data without YOY, not recommended
BH	GADNR	McCandless	DW-27	GADNR	GA	03-05	Sum	No./tow hr	Independent	Lo Method	Length Frequency	NA	All areas covered, standardized methods	Short time series, short spatial coverage	Not useful now, maybe in future.
SCS (AS 68%, BH 31%, FT 1%)	GA Coastspan	McCandless	DW-27	Coastspan	GA (In)	2000-05	Sum	No./50 hook hrs.	Independent	Lo Method	Length Frequency	NA	Length frequencies,	Short time series, unequal area coverage in some years, short spatial coverage	Not recommended
SCS (AS 71%, BH 29%, BN <1%)	GADNR	McCandless	DW-27	GADNR	GA	03-05	Sum	No./tow hr	Independent	Lo Method	Length Frequency	NA	All areas covered, standardize methods	Short time series, short spatial coverage	Not useful now, maybe in future.
AS	NE Exp LL	McCandless	DW-28	Narrangansett	FL-MA	61-91	All	No./set	Independent	Lo Method	NA	NA	Long-term, good area coverage	No time effort, incidental catch data, no size selectivity	Sensitivity set
AS	NMFS LL NE	McCandless	DW-29	NMFS NE	FL - DE	96-04	Spr	No./hook hr	Independent	Lo Method	Length Frequency	NA	Good area coverage, standardized methods	Not all years (not concurrent years)	Reanalyze and revisit after removing northern sampling region
AS	NMFS LL NE	McCandless	DW-29-V2	NMFS NE	FL - NC	96-04	Spr	No./hook hr	Independent	Lo Method	Length Frequency	NA	Good area coverage, standardized methods	Not all years (not concurrent years) , incidental catch	Not recommended, may be useful in future
AS	SC Coastspan GN	McCandless	DW-30	Coastspan SC	SC	98-05	Spr-Fall	No./ hr	Independent	Lo Method	Length Frequency	NA	Standardized methods, length frequencies, consistent areas	Limited to SC	Base model set - SPM
AS	SC Coastspan GN	McCandless	DW-30-V3	Coastspan SC	SC	98-05	Spr-Fall	No./ hr	Independent	Lo Method	Length Frequency	NA	Standardized methods, length frequencies, consistent areas	Limited to SC	Base model set for ASM – removed YOY individuals
AS	SC Coastspan LL	McCandless	DW-30	Coastspan SC	SC	98-05	Spr-Fall	No./hook hr	Independent	Lo Method	Length Frequency	NA	Standardized methods, length frequencies, consistent areas	Shift in sampling area	Not currently recommended, may be useful in future start with 2002
AS	SCDNR	McCandless	DW-30	SCDNR	SC	98-05	Fall	No./hook hr	Independent	Lo Method	Length Frequency	NA	Standardized methods, length frequencies, consistent areas	Small spatial coverage	Base model set - SPM
AS	SCDNR	McCandless	DW-30-V3	SCDNR	SC	98-05	Fall	No./hook hr	Independent	Lo Method	Length Frequency	NA	Standardized methods, length frequencies, consistent areas; excludes YOYs	Small spatial coverage	Base model set - ASM
BH	SC Coastspan GN	McCandless	DW-30	Coastspan SC	SC	98-05	Spr-Fall	No./ hr	Independent	Lo Method	Length Frequency	NA	Standardized methods, length frequencies, consistent areas	Limited to SC	Base model set

Species	Series	Author	Reference	Data Source	Area	Years	Season	Biomass/ Number	Fishery Type	Standardized	Selectivity Info	Age Range	Positive Aspects	Negative Aspects	Utility for Assessment
BH	SC Coastspan LL	McCandless	DW-30	Coastspan SC	SC	98-05	Spr-Fall	No./hook hr	Independent	Lo Method	Length Frequency	NA	Standardized methods, length frequencies, consistent areas	Shift in sampling area	Not currently recommended, may be useful in future start with 2002
BH	SCDNR	McCandless	DW-30	SCDNR	SC	98-05	Fall	No./hook hr	Independent	Lo Method	Length Frequency	NA	Standardized methods, length frequencies, consistent areas	Small spatial coverage	Not recommended infrequent catch
BN	SCDNR	McCandless	DW-30	SCDNR	SC	98-05	Fall	No./hook hr	Independent	Lo Method	Length Frequencies	NA	Standardized methods, length frequencies, consistent areas	Small spatial coverage	Base model set
FT	SC Coastspan GN	McCandless	DW-30	Coastspan SC	SC	98-05	Spr-Fall	No./ hr	Independent	Lo Method	Length Frequency	NA	Standardized methods, length frequencies, consistent areas	Limited to SC	Base model set
FT	SC Coastspan LL	McCandless	DW-30	Coastspan SC	SC	98-05	Spr-Fall	No./hook hr	Independent	Lo Method	Length Frequency	NA	Standardized methods, length frequencies, consistent areas	Shift in sampling area	Not currently recommended, may be useful in future start with 2002
FT	SCDNR	McCandless	DW-30	SCDNR	SC	98-05	Fall	No./hook hr	Independent	Lo Method	Length Frequency	NA	Standardized methods, length frequencies, consistent areas	Small spatial coverage	Not enough data Not recommended
SCS (AS 37%, BH 38%, FT 26%, BN 1%)	SC Coastspan GN	McCandless	DW-30	Coastspan SC	SC	98-05	Spr-Fall	No./ hr	Independent	Lo Method	Length Frequency	NA	Standardized methods, length frequencies, consistent areas	Limited to SC	Base model set
SCS (AS 78%, BH 4%, FT 17%, BN 1%)	SC Coastspan LL	McCandless	DW-30	Coastspan SC	SC	98-05	Spr-Fall	No./hook hr	Independent	Lo Method	Length Frequency	NA	Standardized methods, length frequencies, consistent areas	Shift in sampling area	Not currently recommended, may be useful in future start with 2002
SCS (AS 87%, BH 1%, FT 1%, BN 11%)	SCDNR	McCandless	DW-30	SCDNR	SC	98-05	Fall	No./hook hr	Independent	Lo Method	Length Frequency	NA	Standardized methods, length frequencies, consistent areas	Small spatial coverage	Base model set
AS	SEAMAP-GOM	Nichols	DW-31	SEAMAP (extended summer)	Gulf (Cen,West)	82-06	Sum	No./trawl hr	Independent	Bayesian Lo Method	Length Frequencies	NA	Long-term, standardized methods, length frequencies, consistent areas	Two time series combined, central and western Gulf only.	Base model set
AS	SEAMAP-GOM	Nichols	DW-31	SEAMAP (extended fall)	Gulf (Cen,West)	72-06	Fall	No./trawl hr	Independent	Bayesian Lo Method	Length Frequencies	NA	Long-term, standardized methods, length frequencies, consistent areas	Two time series combined, central and western Gulf only.	Base model set
AS	SEAMAP-GOM	Nichols	DW-31	SEAMAP (Fall Groundfish)	Gulf (Cen,West)	72-87	Fall	No./trawl hr	Independent	Lo Method	Length Frequencies	NA	standardized methods, length frequencies, consistent areas	Short time series compared to extended, central and western Gulf only.	Not recommended

Species	Series	Author	Reference	Data Source	Area	Years	Season	Biomass/ Number	Fishery Type	Standardized	Selectivity Info	Age Range	Positive Aspects	Negative Aspects	Utility for Assessment
AS	SEAMAP-GOM	Nichols	DW-31	SEAMAP (Fall SEAMAP)	Gulf (Cen,West)	87-06	Fall	No./trawl hr	Independent	Lo Method	Length Frequencies	NA	standardized methods, length frequencies, consistent areas	Short time series compared to extended, central and western Gulf only.	Not recommended
AS	SEAMAP-GOM	Nichols	DW-31	SEAMAP (Early SEAMAP)	Gulf (Cen,West)	82-86	Sum	No./trawl hr	Independent	Lo Method	Length Frequencies	NA	standardized methods, length frequencies, consistent areas	Short time series, central and western Gulf only.	Not recommended
BH	SEAMAP-GOM	Nichols	DW-31	SEAMAP (extended summer)	Gulf (Cen,West)	82-06	Sum	No./trawl hr	Independent	Bayesian Lo Method	Length Frequencies	NA	Long-term, standardized methods, length frequencies, consistent areas	Two time series combined, central and western Gulf only.	Base model set
BH	SEAMAP-GOM	Nichols	DW-31	SEAMAP (extended fall)	Gulf (Cen,West)	72-06	Fall	No./trawl hr	Independent	Bayesian Lo Method	Length Frequencies	NA	Long-term, standardized methods, length frequencies, consistent areas	Two time series combined, central and western Gulf only.	Base model set
BH	SEAMAP-GOM	Nichols	DW-31	SEAMAP (Fall Groundfish)	Gulf (Cen,West)	72-87	Fall	No./trawl hr	Independent	Lo Method	Length Frequencies	NA	standardized methods, length frequencies, consistent areas	Short time series compared to extended, central and western Gulf only.	Not recommended
BH	SEAMAP-GOM	Nichols	DW-31	SEAMAP (Fall SEAMAP)	Gulf (Cen,West)	87-06	Fall	No./trawl hr	Independent	Lo Method	Length Frequencies	NA	standardized methods, length frequencies, consistent areas	Short time series compared to extended, central and western Gulf only.	Not recommended
BH	SEAMAP-GOM	Nichols	DW-31	SEAMAP (Early SEAMAP)	Gulf (Cen,West)	82-86	Sum	No./trawl hr	Independent	Lo Method	Length Frequencies	NA	standardized methods, length frequencies, consistent areas	Short time series, central and western Gulf only.	Not recommended
BH	SEAMAP-GOM	Nichols	DW-31	SEAMAP (Summer SEAMAP)	Gulf (Cen,West)	87-06	Sum	No./trawl hr	Independent	Lo Method	Length Frequencies	NA	standardized methods, length frequencies, consistent areas	Short time series compared to extended, central and western Gulf only.	Not recommended
BN	SEAMAP-GOM	Nichols	DW-31	SEAMAP (Fall Groundfish)	Gulf (Cen,West)	73-82	Fall	No./trawl hr	Independent	Lo Method	Length Frequencies	NA	standardized methods, length frequencies, consistent areas	Short time series, missing years, central and western Gulf only.	Not recommended for use
BN	SEAMAP-GOM	Nichols	DW-31	SEAMAP (Fall SEAMAP)	Gulf (Cen,West)	90-06	Fall	No./trawl hr	Independent	Lo Method	Length Frequencies	NA	standardized methods, length frequencies, consistent areas	Central and western Gulf only.	Not recommended for use
BN	SEAMAP-GOM	Nichols	DW-31	SEAMAP (Summer SEAMAP)	Gulf (Cen,West)	89-06	Summer	No./trawl hr	Independent	Lo Method	Length Frequencies	NA	standardized methods, length frequencies, consistent areas	Missing years, central and western Gulf only.	Not recommended for use

Species	Series	Author	Reference	Data Source	Area	Years	Season	Biomass/ Number	Fishery Type	Standardized	Selectivity Info	Age Range	Positive Aspects	Negative Aspects	Utility for Assessment
SCS (AS 90%, BH 5%, BN 5%)	SEAMAP-GOM	Nichols	DW-31	SEAMAP	Gulf (Cen,West)	72-06	Sum	No./trawl hr	Independent	Bayesian Lo Method	Length Frequencies	NA	Long-term, standardized methods, length frequencies, consistent areas	Two time series combined, central and western Gulf only.	Base model set
SCS(AS 71%, BH 24.5%, BN 5%)	SEAMAP-GOM	Nichols	DW-31	SEAMAP	Gulf (Cen,West)	72-06	Fall	No./trawl hr	Independent	Bayesian Lo Method	Length Frequencies	NA	Long-term, standardized methods, length frequencies, consistent areas	Two time series combined, central and western Gulf only.	Base model set
SCS	SEAMAP-GOM	Nichols	DW-31	SEAMAP (Fall Groundfish)	Gulf (Cen,West)	72-86	Fall	No./trawl hr	Independent	Lo Method	Length Frequencies	NA	standardized methods, length frequencies, consistent areas	Short time series compared to extended, central and western Gulf only.	Not recommended
SCS	SEAMAP-GOM	Nichols	DW-31	SEAMAP (Fall SEAMAP)	Gulf (Cen,West)	87-06	Fall	No./trawl hr	Independent	Lo Method	Length Frequencies	NA	standardized methods, length frequencies, consistent areas	Short time series compared to extended, central and western Gulf only.	Not recommended
SCS	SEAMAP-GOM	Nichols	DW-31	SEAMAP (Early SEAMAP)	Gulf (Cen,West)	82-86	Sum	No./trawl hr	Independent	Lo Method	Length Frequencies	NA	standardized methods, length frequencies, consistent areas	Short time series, central and western Gulf only.	Not recommended
SCS	SEAMAP-GOM	Nichols	DW-31	SEAMAP (Summer SEAMAP)	Gulf (Cen,West)	89-06	Summer	No./trawl hr	Independent	Lo Method	Length Frequencies	NA	standardized methods, length frequencies, consistent areas	Short time series compared to extended, central and western Gulf only.	Not recommended for use
AS	UNC	Schwartz	DW-34	UNC	NC	72--05	Spr	No./hook hr	Independent	Lo Method	Length Frequencies	NA	Long-term, standardized methods, length frequencies	Small spatial coverage	Base model
AS	UNC	Schwartz	DW-34-V2	UNC	NC	72--05	Spr	No./hook hr	Independent	Lo Method	Length Frequencies	NA	Long-term, standardized methods, length frequencies	Small spatial coverage	Base model (includes additional information)
BN	UNC	Schwartz	DW-34	UNC	NC	72--05	Spr	No./hook hr	Independent	Lo Method	Length Frequencies	NA	Long-term, standardized methods, length frequencies	Small spatial coverage	Base model
BN	UNC	Schwartz	DW-34-V2	UNC	NC	72--05	Spr	No./hook hr	Independent	Lo Method	Length Frequencies	NA	Long-term, standardized methods, length frequencies	Small spatial coverage	Base model (includes additional information)
FT	UNC	Schwartz	DW-34	UNC	NC	72--05	Spr	No./hook hr	Independent	Lo Method	Length Frequencies	NA	Long-term, standardized methods, length frequencies	Small spatial coverage	Not recommended
SCS (AS 67%, BN 28%, FT 4%)	UNC	Schwartz	DW-34	UNC	NC	72--05	Spr	No./hook hr	Independent	Lo Method	Length Frequencies	NA	Long-term, standardized methods, length frequencies	Small spatial coverage	Base model

Species	Series	Author	Reference	Data Source	Area	Years	Season	Biomass/ Number	Fishery Type	Standardized	Selectivity Info	Age Range	Positive Aspects	Negative Aspects	Utility for Assessment
SCS (AS 67%, BN 28%, FT 4%)	UNC	Schwartz	DW-34-V2	UNC	NC	72--05	Spr	No./hook hr	Independent	Lo Method	Length Frequencies	NA	Long-term, standardized methods, length frequencies	Small spatial coverage	Base model (includes additional information)
BN	MML-DL	Tyminski	DW-37	Mote Marine Lab	FL	01-06	Year round	No./DL	Independent	Nominal	Length Frequencies	NA	Length frequencies	Changed hook type and size,	Could not standardize, not recommended for analysis
BN	MML-LL	Tyminski	DW-37	Mote Marine Lab	FL	01-06	Year round	No./hook hr	Independent	Nominal	Length Frequencies	NA	Length frequencies	Changed hook type and size, changed leader type	Reanalyze and may be useful as sensitivity set
BN	MML-DL	Tyminski	DW-37-V2	Mote Marine Lab	FL	01-06	Year round	No./DL	Independent	Nominal	Length Frequencies	NA	Length frequencies	Changed hook type and size, could not be standardized, nominal only	Not recommeneded
BN	MML-LL	Tyminski	DW-37-V2	Mote Marine Lab	FL	01-06	Year round	No./hook hr	Independent	Negative binomial	Length Frequencies	NA	Length frequencies	Changed hook type and size, changed leader type	Base model
AS	MML-GN-YT-imm	Ubeda	DW-38	Mote Marine Lab	FL	95-04	Sum	No./net hr	Independent	Nominal	Length frequencies	NA	Long-term, length frequencies, standardized methods	Two different areas, single size mesh, only summer sampling	Reanalyze and may be useful as base model set
AS	MML-GN-YT-mat	Ubeda	DW-38	Mote Marine Lab	FL	95-04	Sum	No./net hr	Independent	Nominal	Length frequencies	NA	Long term-length frequencies, standardized methods	Two different areas, single size mesh, only summer sampling	Reanalyze and may be useful as base model set
AS	MML-GN-CH-imm	Ubeda	DW-38	Mote Marine Lab	FL	95-04	Sum	No./net hr	Independent	Nominal	Length frequencies	NA	Long-term, length frequencies, standardizes methods	Two different areas, single size mesh, only summer sampling	Reanalyze and may be useful as base model set
AS	MML-GN-CH-mat	Ubeda	DW-38	Mote Marine Lab	FL	95-04	Sum	No./net hr	Independent	Nominal	Length frequencies	NA	Long-term, length frequencies, standardizes methods	Two different areas, single size mesh, only summer sampling	Reanalyze and may be useful as base model set
BH	MML-GN-YT-imm	Ubeda	DW-38	Mote Marine Lab	FL	95-04	Sum	No./net hr	Independent	Nominal	Length Frequencies	NA	Long-term, length frequencies, standardized methods	Two different areas, single size mesh, only summer sampling	Reanalyze and may be useful as base model set
BH	MML-GN-YT-mat	Ubeda	DW-38	Mote Marine Lab	FL	95-04	Sum	No./net hr	Independent	Nominal	Length Frequencies	NA	Long-term, length frequencies, standardized methods	Two different areas, single size mesh, only summer sampling	Reanalyze and may be useful as base model set
BH	MML-GN-CH-imm	Ubeda	DW-38	Mote Marine Lab	FL	95-04	Sum	No./net hr	Independent	Nominal	Length Frequencies	NA	Long-term, length frequencies, standardized methods	Two different areas, single size mesh, only summer sampling	Reanalyze and may be useful as base model set
BH	MML-GN-CH-mat	Ubeda	DW-38	Mote Marine Lab	FL	95-04	Sum	No./net hr	Independent	Nominal	Length Frequencies	NA	Long-term, length frequencies, standardizes methods	Two different areas, single size mesh, only summer sampling	Reanalyze and may be useful as base model set

Species	Series	Author	Reference	Data Source	Area	Years	Season	Biomass/ Number	Fishery Type	Standardized	Selectivity Info	Age Range	Positive Aspects	Negative Aspects	Utility for Assessment
AS	MML Gillnet - juvi	Ubeda	DW-38-V2	Mote Marine Lab	FL	95-04	Sum	No./net hr	Independent	Lo Method	Length Frequencies	NA	Long-term, length frequencies, standardized methods	Two different areas, single size mesh, only summer sampling	Base
AS	MML Gillnet - adult	Ubeda	DW-38-V2	Mote Marine Lab	FL	95-04	Sum	No./net hr	Independent	Lo Method	Length Frequencies	NA	Long-term, length frequencies, standardized methods	Two different areas, single size mesh, only summer sampling	Base
BH	MML Gillnet - juvi	Ubeda	DW-38-V2	Mote Marine Lab	FL	95-04	Sum	No./net hr	Independent	Lo Method	Length Frequencies	NA	Long-term, length frequencies, standardized methods	Two different areas, single size mesh, only summer sampling	Base
BH	MML Gillnet - adult	Ubeda	DW-38-V2	Mote Marine Lab	FL	95-04	Sum	No./net hr	Independent	Lo Method	Length Frequencies	NA	Long-term, length frequencies, standardized methods	Two different areas, single size mesh, only summer sampling	Base
SCS	MML Gillnet	Ubeda	DW-38-V2	Mote Marine Lab	FL	95-04	Sum	No./net hr	Independent	Lo Method	Length Frequencies	NA	Long-term, length frequencies, standardized methods	Two different areas, single size mesh, only summer sampling	Base
AS	BLL Logs	McCarthy	DW-41	Coastal Fisheries Logbooks	LA-NC	95-05	Year Round	Lbs landed/hook	Dependent-comm	Lo Method	NA	NA		Only landings information, very higher confidence intervals, increased reporting over time may effect series	Not recommended for use
BH	BLL Logs	McCarthy	DW-41	Coastal Fisheries Logbooks	LA-NC	95-05	Year Round	Lbs landed/hook	Dependent-comm	Lo Method	NA	NA		Only landings information, very higher confidence intervals, increased reporting over time may effect series	Not recommended for use
BN	BLL Logs	McCarthy	DW-41	Coastal Fisheries Logbooks	LA-NC	95-05	Year Round	Lbs landed/hook	Dependent-comm	Lo Method	NA	NA		Only landings information, very higher confidence intervals, increased reporting over time may effect series	Not recommended for use
FT	BLL Logs	McCarthy	DW-41	Coastal Fisheries Logbooks	LA-NC	95-05	Year Round	Lbs landed/hook	Dependent-comm	Lo Method	NA	NA		Only landings information, very higher confidence intervals, increased reporting over time may effect series	Not recommended for use
SCS	BLL Logs	McCarthy	DW-41	Coastal Fisheries Logbooks	LA-NC	95-05	Year Round	Lbs landed/hook	Dependent-comm	Lo Method	NA	NA		Only landings information, very higher confidence intervals, increased reporting over time may effect series	Not recommended for use

Table 3.2 Available catch rates series for the small coastal shark complex, Atlantic sharpnose, blacknose, bonnethead, and finetooth sharks. Absolute index is the absolute estimated mean CPUE, relative index is the estimated mean CPUE divided by the overall mean and the CV is the estimated precision of the mean value. Type refers to whether the index is fishery – independent (FI) or fishery-dependent (FD), recreational (R) or commercial (C). Recommendation refers to the recommendation by the Indices Working Group to include the particular index as a base index (Base), use it for sensitivity runs (Sensitivity) or not recommended for use in the assessment (NR); AS indicates the series is for an age-structured model (excludes young of the year individuals), SPM indicates a series useful for a surplus production approach. Series with no model indicated are useful for both approaches.

Small Coastal Shark Complex

					Index		
Document Number	Series Name	Type	Recommendation	Year	Absolute	Relative	CV
SEDAR 13-DW-05	PC LL	FI	Base	1993	0.517	0.843	0.507
				1994	0.235	0.383	0.544
				1995	0.343	0.559	0.483
				1996	1.073	1.750	0.092
				1997	0.594	0.969	0.185
				1998	0.439	0.716	0.378
				1999	1.170	1.908	0.116
				2000	0.534	0.871	0.296
SEDAR 13-DW-06	PC Gillnet	FI	Base	1996	5.091	1.817	0.238
				1997	14.715	5.251	0.144
				1998	1.121	0.400	1.436
				1999	1.174	0.419	1.253
				2000	0.697	0.249	1.294
				2001	1.327	0.474	0.732
				2002	1.167	0.416	1.013
				2003	1.454	0.519	0.531
				2004	0.668	0.238	0.896
				2005	0.611	0.218	0.645
SEDAR 13-DW-09	Gillnet Obs	FD-C	Base	1993	3.014	0.149	0.879
				1994	9.942	0.490	0.172
				1995	10.934	0.539	0.218
				1996			
				1997			
				1998	20.516	1.011	0.130
				1999	12.287	0.606	0.109
				2000	9.998	0.493	0.140
				2001	5.548	0.273	0.220
				2002	72.233	3.560	0.016
				2003	11.597	0.572	0.133
				2004	8.254	0.407	0.180
				2005	58.842	2.900	0.029

SEDAR 13-DW-12	BLLOP	FD-C	Base	1994	0.000	0.068	11.142
				1995	0.004	0.714	1.797
				1996	0.003	0.425	2.412
				1997	0.004	0.595	2.171
				1998	0.006	1.088	1.292
				1999	0.021	3.535	0.890
				2000	0.014	2.346	1.241
				2001	0.009	1.547	1.420
				2002	0.002	0.255	2.922
				2003	0.002	0.357	2.344
				2004	0.003	0.493	2.083
				2005	0.003	0.578	1.346
SEDAR 13-DW-14	SEAMAP - SA	FI	Base	1989	4.138	0.878	0.283
				1990	3.543	0.752	0.285
				1991	4.059	0.861	0.269
				1992	3.530	0.749	0.254
				1993	2.569	0.545	0.293
				1994	2.747	0.583	0.301
				1995	4.433	0.940	0.221
				1996	2.169	0.460	0.306
				1997	4.790	1.016	0.237
				1998	3.817	0.810	0.243
				1999	3.664	0.777	0.252
				2000	4.532	0.961	0.243
				2001	4.998	1.060	0.193
				2002	7.635	1.620	0.165
				2003	7.170	1.521	0.191
				2004	4.576	0.971	0.216
				2005	6.195	1.314	0.218
				2006	10.279	2.181	0.174
SEDAR 13-DW-16	MRFSS	FD-R	NR	1981	0.259	0.128	1.016
				1982	0.944	0.466	0.580
				1983	0.298	0.147	0.947
				1984	0.673	0.332	0.663
				1985	0.804	0.397	0.600
				1986	0.702	0.347	0.563
				1987	0.643	0.317	0.565
				1988	1.070	0.528	0.512
				1989	0.796	0.393	0.533
				1990	0.706	0.349	0.546
				1991	0.566	0.279	0.555
				1992	1.259	0.622	0.459
				1993	1.334	0.659	0.467
				1994	1.757	0.867	0.443
				1995	2.356	1.163	0.430
				1996	1.982	0.979	0.442
				1997	1.734	0.856	0.442

				1998	2.549	1.259	0.423
				1999	2.936	1.450	0.420
				2000	3.755	1.854	0.411
				2001	4.442	2.193	0.409
				2002	5.235	2.585	0.406
				2003	3.730	1.842	0.413
				2004	4.655	2.298	0.409
				2005	5.450	2.691	0.408
SEDAR 13-DW-18	Texas	FI	Base	1975	0.044	0.726	0.710
				1976	0.073	1.206	0.300
				1977	0.021	0.347	0.555
				1978	0.021	0.349	0.555
				1979	0.041	0.669	0.342
				1980	0.062	1.019	0.248
				1981	0.024	0.399	0.371
				1982	0.042	0.699	0.214
				1983	0.077	1.263	0.167
				1984	0.085	1.404	0.149
				1985	0.056	0.915	0.203
				1986	0.084	1.387	0.148
				1987	0.014	0.234	0.444
				1988	0.077	1.272	0.155
				1989	0.053	0.879	0.187
				1990	0.072	1.182	0.162
				1991	0.076	1.244	0.175
				1992	0.050	0.822	0.235
				1993	0.063	1.036	0.198
				1994	0.052	0.859	0.200
				1995	0.046	0.751	0.213
				1996	0.076	1.256	0.150
				1997	0.051	0.844	0.256
				1998	0.058	0.961	0.203
				1999	0.065	1.077	0.165
				2000	0.078	1.282	0.152
				2001	0.082	1.349	0.171
				2002	0.074	1.218	0.181
				2003	0.093	1.536	0.152
				2004	0.084	1.387	0.165
				2005	0.080	1.325	0.161
				2006	0.067	1.103	0.227
SEDAR 13-DW-21	MS Gillnet	FI	Sensitivity	2001	3.399	1.959	0.294
				2002			
				2003	1.401	0.807	0.509
				2004	1.176	0.678	0.298
				2005	1.465	0.844	0.277
				2006	1.235	0.712	0.232

SEDAR 13-DW-22	NMFS LL SE Atlantic	FI	Base	1995	1.977	0.210	0.310
				1996	1.839	0.195	0.335
				1997	2.481	0.263	0.321
				1998			
				1999	1.039	0.110	0.624
				2000	4.819	0.511	0.161
				2001			
				2002	14.822	1.571	0.128
				2003			
				2004	14.495	1.536	0.224
				2005	21.566	2.286	0.310
				2006	21.866	2.318	0.185
SEDAR 13-DW-22	NMFS LL SE GoM	FI	Base	1995	2.141	0.592	0.268
				1996	3.424	0.947	0.272
				1997	1.915	0.530	0.225
				1998		0.000	
				1999	1.799	0.498	0.174
				2000	3.765	1.042	0.162
				2001	2.996	0.829	0.188
				2002	3.723	1.030	0.175
				2003	5.410	1.497	0.146
				2004	5.542	1.533	0.157
				2005	4.330	1.198	0.301
				2006	4.715	1.305	0.183
SEDAR 13-DW-22	NMFS LL SE combined areas	FI	Base	1995	2.394	0.507	0.197
				1996	3.506	0.742	0.216
				1997	2.996	0.634	0.166
				1998			
				1999	1.962	0.415	0.171
				2000	4.133	0.875	0.114
				2001	3.707	0.785	0.176
				2002	5.251	1.111	0.132
				2003	6.868	1.454	0.133
				2004	7.157	1.515	0.132
				2005	7.582	1.605	0.236
				2006	6.414	1.358	0.154
SEDAR 13-DW-26	Gillnet Logs	FD-C	Sensitivity	1998	0.058	0.780	0.870
				1999	0.074	0.995	0.818
				2000	0.063	0.847	0.769
				2001	0.068	0.922	0.752
				2002	0.100	1.356	0.731
				2003	0.053	0.710	0.807
				2004	0.054	0.727	0.917
				2005	0.123	1.664	0.653
SEDAR 13-DW-27	GA Coastspan	FI	NR	2000	2.498	0.388	0.542
				2001	5.508	0.856	0.202

				2002	7.579	1.178	0.253
				2003	7.958	1.237	0.245
				2004	10.941	1.700	0.158
				2005	4.121	0.640	0.410
SEDAR 13-DW-27	GADNR Trawl	FI	NR	2003	648.908	1.124	0.153
				2004	580.957	1.006	0.164
				2005	502.532	0.870	0.174
SEDAR 13-DW-30	SC Coastspan GN	FI	Base	1998	19.412	0.671	0.365
				1999			
				2000	24.300	0.840	0.293
				2001	30.937	1.070	0.157
				2002	26.974	0.933	0.170
				2003	43.688	1.511	0.127
				2004	29.077	1.006	0.513
				2005	28.029	0.969	0.190
SEDAR 13-DW-30	SC Coastspan LL	FI	NR	1998	0.177	0.746	5.345
				1999	0.381	1.603	2.862
				2000	0.376	1.583	1.765
				2001	0.492	2.070	0.756
				2002	0.143	0.603	3.502
				2003	0.136	0.573	3.787
				2004	0.130	0.548	3.377
				2005	0.065	0.274	4.884
SEDAR 13-DW-30	SCDNR red drum	FI	Base	1998	0.156	0.968	0.726
				1999	0.093	0.576	1.115
				2000	0.149	0.921	1.049
				2001	0.240	1.488	0.797
				2002	0.249	1.538	0.866
				2003	0.197	1.219	0.827
				2004	0.071	0.437	2.644
				2005	0.138	0.852	3.029
SEDAR 13-DW-31	SEAMAP-GoM Extended Summer	FI	Base	1982	0.720	0.925	2.001
				1983	3.042	3.906	1.517
				1984	0.864	1.110	1.952
				1985	1.555	1.997	1.860
				1986	0.720	0.925	1.927
				1987	0.689	0.884	0.439
				1988	0.596	0.765	0.401
				1989	0.651	0.836	0.464
				1990	0.199	0.256	0.540
				1991	0.811	1.041	0.383
				1992	0.576	0.740	0.423
				1993	0.821	1.054	0.400
				1994	0.228	0.292	0.488
				1995	1.072	1.376	0.394

				1996	1.103	1.416	0.382
				1997	0.626	0.803	0.431
				1998	0.473	0.607	0.411
				1999	0.570	0.732	0.423
				2000	0.805	1.033	0.423
				2001	0.427	0.548	0.588
				2002	0.789	1.013	0.405
				2003	0.510	0.654	0.468
				2004	0.428	0.550	0.435
				2005	0.389	0.499	0.467
				2006	0.808	1.037	0.402
SEDAR 13-DW-31	SEAMAP-GoM Extended Fall	FI	Base	1972	0.814	0.956	0.525
				1973	1.229	1.443	0.428
				1974	2.116	2.485	0.417
				1975	1.871	2.197	0.421
				1976	2.046	2.402	0.415
				1977	1.164	1.367	0.430
				1978	0.928	1.089	0.438
				1979	1.192	1.399	0.431
				1980	1.709	2.007	0.429
				1981	1.094	1.285	0.438
				1982	1.215	1.426	0.426
				1983	1.044	1.225	0.463
				1984	0.782	0.918	0.457
				1985	1.268	1.488	0.509
				1986	0.651	0.764	0.846
				1987	0.854	1.002	0.299
				1988	0.518	0.608	0.285
				1989	0.364	0.427	0.316
				1990	0.585	0.687	0.297
				1991	0.355	0.417	0.285
				1992	0.323	0.380	0.304
				1993	0.513	0.603	0.282
				1994	0.629	0.739	0.283
				1995	0.448	0.526	0.293
				1996	0.692	0.812	0.272
				1997	0.556	0.652	0.279
				1998	0.369	0.434	0.315
				1999	0.535	0.628	0.275
				2000	0.590	0.693	0.291
				2001	0.455	0.534	0.284
				2002	0.499	0.585	0.288
				2003	0.610	0.716	0.265
				2004	0.488	0.573	0.290
				2005	0.847	0.994	0.274
				2006	0.457	0.536	0.293
SEDAR 13-DW-31	SEAMAP-GoM Fall Groundfish	FI	NR	1972	0.671	0.626	0.298
				1973	1.037	0.967	0.181

				1974	1.918	1.789	0.180
				1975	1.567	1.461	0.157
				1976	1.630	1.521	0.141
				1977	1.064	0.992	0.261
				1978	0.799	0.745	0.198
				1979	1.068	0.996	0.207
				1980	1.524	1.421	0.204
				1981	0.875	0.816	0.235
				1982	0.992	0.925	0.204
				1983	0.836	0.779	0.227
				1984	0.660	0.615	0.373
				1985	1.134	1.057	0.348
				1986	0.310	0.289	0.571
SEDAR 13-DW-31	SEAMAP-GoM Fall SEAMAP	FI	NR	1987	0.999	2.028	0.978
				1988	0.406	0.825	0.198
				1989	0.356	0.723	0.336
				1990	0.526	1.068	0.295
				1991	0.286	0.580	0.179
				1992	0.233	0.474	0.216
				1993	0.502	1.020	0.276
				1994	0.641	1.301	0.311
				1995	0.304	0.616	0.286
				1996	0.630	1.280	0.194
				1997	0.526	1.067	0.238
				1998	0.272	0.551	0.229
				1999	0.606	1.230	0.282
				2000	0.636	1.291	0.314
				2001	0.386	0.784	0.209
				2002	0.410	0.833	0.341
				2003	0.461	0.935	0.185
				2004	0.590	1.197	0.294
				2005	0.744	1.510	0.271
				2006	0.339	0.687	0.273
SEDAR 13-DW-31	SEAMAP-GoM Early SEAMAP	FI	NR	1982	0.052	0.173	0.629
				1983	0.626	2.092	0.475
				1984	0.131	0.437	0.835
				1985	0.546	1.821	0.439
				1986	0.143	0.477	0.838
SEDAR 13-DW-31	SEAMAP-GoM Summer SEAMAP	FI	NR	1987	0.704	1.307	0.381
				1988	0.455	0.845	0.349
				1989	0.327	0.607	0.485
				1990	0.123	0.228	0.479
				1991	1.439	2.672	0.594
				1992	0.373	0.692	0.258
				1993	1.546	2.871	0.546
				1994	0.110	0.205	0.458
				1995	0.952	1.767	0.323

				1996	1.057	1.963	0.319
				1997	0.354	0.658	0.393
				1998	0.459	0.852	0.343
				1999	0.342	0.634	0.355
				2000	0.385	0.716	0.223
				2001	0.157	0.292	0.597
				2002	0.554	1.029	0.392
				2003	0.306	0.568	0.410
				2004	0.376	0.698	0.447
				2005	0.235	0.437	0.394
				2006	0.518	0.961	0.272
SEDAR 13-DW-34	UNC	FI	Base	1972	3.163	0.856	1.549
				1973	4.983	1.348	0.530
				1974	1.497	0.405	1.608
				1975	2.893	0.782	0.687
				1976	2.183	0.590	0.879
				1977	5.669	1.533	0.359
				1978	4.574	1.237	0.386
				1979	3.865	1.046	0.430
				1980	2.579	0.697	0.484
				1981	1.143	0.309	1.039
				1982	1.538	0.416	0.645
				1983	2.145	0.580	0.462
				1984	2.383	0.644	0.469
				1985	2.116	0.572	0.571
				1986	1.426	0.386	0.958
				1987	2.638	0.713	0.566
				1988	4.012	1.085	0.362
				1989	2.050	0.555	0.733
				1990	2.206	0.597	0.576
				1991	4.629	1.252	0.319
				1992	8.752	2.367	0.246
				1993	4.138	1.119	0.552
				1994	3.981	1.077	0.414
				1995	6.372	1.724	0.234
				1996	4.272	1.156	0.371
				1997	3.443	0.931	0.477
				1998	3.795	1.026	0.382
				1999	3.029	0.819	0.468
				2000	4.197	1.135	0.341
				2001			
				2002	4.831	1.307	0.347
				2003	6.917	1.871	0.288
				2004	6.883	1.862	0.274
				2005			
SEDAR 13-DW-38	MML Gillnet	FI	Base	1995	1.559	0.464	0.171
				1996	1.242	0.370	0.336
				1997	2.793	0.831	0.148

				1998			
				1999	2.441	0.727	0.190
				2000	4.185	1.246	0.197
				2001	5.070	1.509	0.158
				2002	2.978	0.887	0.178
				2003	4.300	1.280	0.190
				2004	5.665	1.686	0.165
SEDAR 13-DW-41	BLL Logs	FD-C	NR	1996	0.004	0.028	4.996
				1997	0.023	0.160	2.086
				1998	0.110	0.765	1.069
				1999	0.058	0.403	1.298
				2000	0.053	0.369	1.429
				2001	0.244	1.697	0.815
				2002	0.208	1.446	0.814
				2003	0.192	1.335	0.812
				2004	0.208	1.446	0.818
				2005	0.338	2.350	0.773

Atlantic Sharpnose Shark

					Index		
Document Number	Series Name	Type	Recommendation	Year	Absolute	Relative	CV
SEDAR 13-DW-05	PC LL	FI	Base	1993	0.481	0.878	0.516
				1994	0.136	0.248	0.882
				1995	0.301	0.549	0.520
				1996	0.951	1.735	0.098
				1997	0.531	0.969	0.196
				1998	0.380	0.693	0.413
				1999	1.160	2.116	0.111
				2000	0.445	0.812	0.337
SEDAR 13-DW-06	PC Gillnet	FI	Base	1996	1.066	0.561	0.357
			(SPM)	1997	1.709	0.900	0.324
				1998	1.230	0.647	0.401
				1999	1.501	0.790	0.413
				2000	1.169	0.615	0.465
				2001	1.994	1.050	0.358
				2002	1.992	1.048	0.332
				2003	2.022	1.064	0.317
				2004	1.128	0.594	0.388
				2005	1.879	0.989	0.352
				2006	5.209	2.742	0.281
SEDAR 13-DW-06	PC Gillnet - Adult	FI	Base	1996	0.339	0.517	0.403
			(AS)	1997	0.679	1.036	0.296

				1998	0.408	0.623	0.429
				1999	0.361	0.551	0.518
				2000	0.616	0.940	0.468
				2001	0.706	1.078	0.382
				2002	1.037	1.583	0.322
				2003	1.091	1.665	0.287
				2004	0.659	1.006	0.382
SEDAR 13-DW-06	PC Gillnet - juvi	FI	Base (AS)	1996	1.166	1.103	0.356
				1997	1.401	1.325	0.335
				1998	1.039	0.983	0.430
				1999	1.514	1.432	0.465
				2000	0.852	0.806	0.505
				2001	1.442	1.364	0.399
				2002	1.036	0.980	0.405
				2003	1.117	1.056	0.393
				2004	0.667	0.631	0.449
				2005	0.339	0.321	0.517
SEDAR 13-DW-09	Gillnet Observer combined	FD-C	Base	1993	63.769	0.136	1.458
				1994	520.751	1.114	0.590
				1995	355.170	0.760	1.454
				1996			
				1997			
				1998			
				1999	165.327	0.354	0.484
				2000	27.340	0.058	0.915
				2001	634.326	1.356	0.427
				2002	831.673	1.778	0.420
				2003	814.365	1.741	0.586
				2004	278.853	0.596	0.672
				2005	984.790	2.106	0.670
SEDAR 13-DW-09	Gillnet Observer Atlantic	FD-C	Base	1993	131.934	0.170	1.286
				1994	853.410	1.103	0.434
				1995	639.344	0.826	1.263
				1996			
				1997			
				1998			
				1999	196.219	0.254	0.355
				2000	47.828	0.062	0.825
				2001	989.642	1.279	0.274
				2002	1190.888	1.539	0.279
				2003	1496.536	1.934	0.404
				2004	403.973	0.522	0.446
				2005	1789.160	2.312	0.431
SEDAR 13-DW-12	BLLOP combined	FD-C	Base	1994	10.534	0.039	0.654
				1995	118.473	0.438	0.561
				1996	107.619	0.398	0.558

				1997	157.065	0.581	0.563
				1998	245.823	0.909	0.543
				1999	760.861	2.815	0.547
				2000	828.94	3.067	0.567
				2001	292.945	1.084	0.551
				2002	272.197	1.007	0.548
				2003	167.911	0.621	0.547
				2004	133.011	0.492	0.558
				2005	148.218	0.548	0.558
SEDAR 13-DW-12	BLLOP Atlantic	FD-C	Base	1994	36.151	0.111	0.62
				1995	203.128	0.625	0.552
				1996	146.506	0.451	0.55
				1997	177.954	0.548	0.571
				1998	400.443	1.232	0.549
				1999	674.209	2.075	0.582
				2000	977.488	3.008	0.569
				2001	498.29	1.533	0.567
				2002	395.279	1.216	0.573
				2003	98.901	0.304	0.594
				2004	75.067	0.231	0.653
				2005	216.165	0.665	0.597
SEDAR 13-DW-12	BLLOP GoM	FD-C	Base	1994	0.036	0.000	4.355
				1995	1.533	0.016	0.909
				1996	6.081	0.062	0.828
				1997	167.41	1.695	0.575
				1998	82.08	0.831	0.617
				1999	102.412	1.037	0.526
				2000			
				2001	41.426	0.419	0.677
				2002	92.86	0.940	0.498
				2003	108.793	1.101	0.46
				2004	170.67	1.728	0.463
				2005	313.232	3.171	0.453
SEDAR 13-DW-14	SEAMAP - SA	FI	Base	1990	2.983	0.833	0.305
				1991	3.163	0.884	0.284
				1992	2.908	0.812	0.296
				1993	2.240	0.626	0.325
				1994	1.623	0.453	0.361
				1995	3.052	0.853	0.255
				1996	1.860	0.520	0.347
				1997	3.855	1.077	0.264
				1998	2.679	0.748	0.293
				1999	2.734	0.764	0.290
				2000	3.835	1.071	0.271
				2001	3.385	0.946	0.228
				2002	5.306	1.482	0.207
				2003	5.686	1.588	0.233

				2004	3.851	1.076	0.239
				2005	4.969	1.388	0.269
				2006	6.730	1.880	0.221
SEDAR 13-DW-16	MRFSS	FD-R	NR	1982	0.434	0.589	0.823
				1983	0.062	0.084	2.263
				1984	0.433	0.587	0.903
				1985	0.290	0.393	0.883
				1986	0.119	0.161	1.072
				1987	0.184	0.250	0.881
				1988	0.514	0.697	0.665
				1989	0.406	0.551	0.687
				1990	0.320	0.434	0.736
				1991	0.284	0.385	0.719
				1992	0.533	0.723	0.596
				1993	0.307	0.416	0.690
				1994	0.657	0.891	0.580
				1995	0.667	0.905	0.580
				1996	0.681	0.924	0.595
				1997	0.397	0.539	0.642
				1998	0.538	0.730	0.589
				1999	0.847	1.149	0.552
				2000	1.311	1.778	0.517
				2001	1.726	2.341	0.511
				2002	1.659	2.250	0.510
				2003	1.704	2.311	0.514
				2004	1.322	1.793	0.524
				2005	2.298	3.117	0.511
SEDAR 13-DW-18	Texas	FI	Base	1975	0.017	1.080	1.063
				1976	0.009	0.554	1.068
				1977	0.008	0.479	1.067
				1978			
				1979	0.016	0.983	0.577
				1980	0.005	0.329	1.058
				1981	0.004	0.278	1.056
				1982	0.003	0.167	1.044
				1983	0.007	0.463	0.576
				1984	0.021	1.316	0.312
				1985	0.017	1.068	0.374
				1986	0.040	2.560	0.218
				1987	0.007	0.474	0.744
				1988	0.034	2.177	0.238
				1989	0.014	0.875	0.376
				1990	0.010	0.653	0.442
				1991	0.017	1.101	0.375
				1992	0.009	0.578	0.577
				1993	0.008	0.531	0.575
				1994	0.011	0.703	0.441
				1995	0.007	0.439	0.575

				1996	0.030	1.891	0.246
				1997	0.011	0.717	0.575
				1998	0.010	0.654	0.497
				1999	0.032	2.035	0.239
				2000	0.025	1.612	0.275
				2001	0.003	0.216	1.047
				2002	0.026	1.658	0.312
				2003	0.029	1.867	0.277
				2004	0.022	1.365	0.333
				2005	0.018	1.140	0.351
				2006	0.016	1.039	0.371
SEDAR 13-DW-19	VA LL	FI	Base	1976	0.036	0.013	1.893
				1977	1.125	0.400	0.728
				1978			
				1979			
				1980	3.406	1.209	0.444
				1981	3.703	1.315	0.261
				1982			
				1983	3.114	1.106	1.049
				1984			
				1985			
				1986			
				1987	5.103	1.812	0.587
				1988	1.765	0.627	1.223
				1989	0.946	0.336	0.533
				1990	2.706	0.961	0.380
				1991	3.147	1.117	0.547
				1992	2.478	0.880	0.434
				1993	3.154	1.120	0.532
				1994			
				1995	2.715	0.964	0.392
				1996	3.201	1.137	0.402
				1997	2.048	0.727	0.471
				1998	3.247	1.153	0.288
				1999	6.057	2.151	0.274
				2000	1.156	0.411	0.382
				2001	2.550	0.905	0.430
				2002	1.850	0.657	0.444
				2003	1.557	0.553	0.939
				2004	1.833	0.651	0.469
				2005	7.879	2.798	0.616
SEDAR 13-DW-21	MS Gillnet	FI	Sensitivity (SPM)	2001	1.549	1.883	0.380
				2002			
				2003	0.311	0.378	0.859
				2004	0.397	0.483	0.443
				2005	0.663	0.806	0.331
				2006	1.192	1.449	0.278

SEDAR 13-DW-21	MS Gillnet - Adult	FI	Sensitivity (AS)	2001	1.412	2.335	0.392
				2002			
				2003	0.385	0.637	0.989
				2004	0.460	0.761	0.460
				2005	0.414	0.685	0.407
				2006	0.352	0.582	0.380
SEDAR 13-DW-21	MS Gillnet - juvi	FI	Sensitivity (AS)	2001	0.717	1.749	0.515
				2002			
				2003	0.153	0.374	1.307
				2004	0.109	0.266	0.763
				2005	0.199	0.485	0.556
				2006	0.872	2.127	0.303
SEDAR 13-DW-22	NMFS LL SE Atlantic	FI	Base	1995	1.982	0.212	0.304
				1996	1.820	0.194	0.326
				1997	2.426	0.259	0.320
				1998			
				1999	0.627	0.067	1.018
				2000	4.592	0.490	0.169
				2001			
				2002	14.949	1.596	0.130
				2003			
				2004	14.600	1.559	0.223
				2005	21.693	2.317	0.309
				2006	21.588	2.305	0.186
SEDAR 13-DW-22	NMFS LL SE GoM	FI	Base	1995	1.893	0.577	0.298
				1996	2.847	0.868	0.320
				1997	1.322	0.403	0.270
				1998			
				1999	1.376	0.420	0.207
				2000	3.515	1.072	0.175
				2001	2.982	0.909	0.200
				2002	3.940	1.201	0.173
				2003	4.902	1.494	0.151
				2004	5.084	1.550	0.173
				2005	4.063	1.239	0.313
				2006	4.155	1.267	0.205
SEDAR 13-DW-22	NMFS LL SE combined	FI	Base	1995	2.120	0.483	0.221
				1996	2.904	0.662	0.256
				1997	2.430	0.554	0.192
				1998			
				1999	1.438	0.328	0.228
				2000	3.837	0.875	0.123
				2001	3.693	0.842	0.196
				2002	5.229	1.192	0.136
				2003	6.258	1.427	0.141
				2004	6.679	1.523	0.147

				2005	7.840	1.788	0.244
				2006	5.811	1.325	0.171
SEDAR 13-DW-25	NE Observer	FD-C	NR	1995	0.005	0.210	30.450
				1996	0.088	4.093	7.003
				1997			
				1998	0.001	0.065	57.853
				1999	0.002	0.070	43.692
				2000	0.029	1.333	5.874
				2001			
				2002			
				2003	0.005	0.238	50.096
				2004	0.029	1.357	8.004
				2005	0.014	0.634	15.384
SEDAR 13-DW-26	Gillnet Logs	FD-C	Sensitivity	1998	0.016	0.873	0.261
				1999	0.023	1.216	0.237
				2000	0.018	0.956	0.236
				2001	0.017	0.922	0.243
				2002	0.013	0.721	0.284
				2003	0.015	0.832	0.265
				2004	0.016	0.871	0.259
				2005	0.030	1.610	0.253
SEDAR 13-DW-27	GA Coastspan	FI	NR	2000	2.234	0.486	0.544
				2001	5.103	1.111	0.195
				2002	5.693	1.239	0.308
				2003	6.480	1.410	0.258
				2004	5.316	1.157	0.287
				2005	2.744	0.597	0.543
SEDAR 13-DW-27	GADNR Trawl	FI	NR	2003	526.649	1.043	0.191
				2004	511.770	1.014	0.186
				2005	476.209	0.943	0.205
SEDAR 13-DW-28	NE Exp LL	FI	Sensitivity	1979	0.713	1.355	4.316
				1980			
				1981			
				1982			
				1983	1.086	2.064	3.781
				1984			
				1985	0.115	0.219	10.572
				1986	0.861	1.636	0.932
				1987			
				1988			
				1989	0.109	0.207	7.822
				1990			
				1991	0.273	0.519	3.069
SEDAR 13-DW-29	NMFS LL NE	FI	NR	1996	0.002	0.046	123.969

				1997			
				1998	0.017	0.393	22.607
				1999			
				2000			
				2001	0.046	1.064	9.113
				2002			
				2003			
				2004	0.108	2.497	4.852
SEDAR 13-DW-30	SC Coastspan GN	FI	Base (SPM)	1998	21.911	1.805	0.379
				1999	13.300	1.096	0.793
				2000	8.360	0.689	0.537
				2001	8.558	0.705	0.343
				2002	6.516	0.537	0.337
				2003	23.346	1.923	0.162
				2004	6.414	0.528	1.268
				2005	8.705	0.717	0.329
SEDAR 13-DW-30	SC Coastspan GN	FI	Base (AS)	1998	8.280	1.111	0.554
				1999	9.923	1.331	0.704
				2000	5.892	0.791	0.593
				2001	6.140	0.824	0.363
				2002	5.182	0.695	0.344
				2003	14.621	1.962	0.185
				2004	3.570	0.479	1.593
				2005	6.018	0.807	0.357
SEDAR 13-DW-30	SC Coastspan LL	FI	NR	1998	0.170	0.872	3.639
				1999	0.263	1.344	2.513
				2000	0.397	2.033	1.579
				2001	0.388	1.986	0.819
				2002	0.097	0.495	3.808
				2003	0.097	0.498	3.766
				2004	0.091	0.467	3.465
				2005	0.060	0.305	4.000
SEDAR 13-DW-30	SCDNR red drum	FI	Base (SPM)	1998	0.157	0.996	0.598
				1999	0.091	0.574	0.951
				2000	0.147	0.933	0.884
				2001	0.234	1.484	0.685
				2002	0.227	1.438	0.799
				2003	0.198	1.253	0.677
				2004	0.069	0.437	2.240
				2005	0.140	0.886	2.443
SEDAR 13-DW-30	SCDNR red drum	FI	Base (AS)	1998	0.154	0.983	0.747
				1999	0.090	0.573	1.170
				2000	0.148	0.939	1.070
				2001	0.230	1.463	0.863
				2002	0.227	1.442	0.967

				2003	0.195	1.243	0.826
				2004	0.075	0.479	2.642
				2005	0.138	0.878	3.001
SEDAR 13-DW-31	SEAMAP - GoM Extended Summer	FI	Base	1982	0.855	1.098	2.139
				1983	3.329	4.278	1.557
				1984	1.118	1.436	2.061
				1985	1.550	1.992	1.975
				1986	0.862	1.107	1.936
				1987	0.705	0.906	0.450
				1988	0.649	0.834	0.421
				1989	0.669	0.859	0.476
				1990	0.189	0.243	0.567
				1991	0.810	1.040	0.404
				1992	0.587	0.754	0.439
				1993	0.658	0.846	0.425
				1994	0.232	0.298	0.523
				1995	1.066	1.370	0.409
				1996	1.057	1.358	0.394
				1997	0.537	0.691	0.452
				1998	0.500	0.643	0.427
				1999	0.484	0.622	0.435
				2000	0.786	1.010	0.441
				2001	0.351	0.451	0.633
				2002	0.822	1.057	0.432
				2003	0.410	0.527	0.505
				2004	0.219	0.282	0.497
				2005	0.359	0.461	0.516
				2006	0.651	0.837	0.430
SEDAR 13-DW-31	SEAMAP - GoM Extended Fall	FI	Base	1972	0.424	0.725	0.731
				1973	0.455	0.777	0.656
				1974	1.380	2.357	0.618
				1975	1.193	2.038	0.622
				1976	1.296	2.213	0.619
				1977	0.710	1.212	0.632
				1978	0.661	1.129	0.629
				1979	0.764	1.305	0.628
				1980	1.263	2.156	0.621
				1981	0.836	1.428	0.624
				1982	0.896	1.529	0.624
				1983	0.776	1.324	0.658
				1984	0.623	1.064	0.642
				1985	0.941	1.607	0.688
				1986	0.533	0.909	1.004
				1987	0.781	1.334	0.327
				1988	0.443	0.756	0.334
				1989	0.324	0.554	0.375
				1990	0.474	0.810	0.335
				1991	0.244	0.417	0.368

				1992	0.237	0.404	0.398
				1993	0.417	0.712	0.348
				1994	0.500	0.854	0.340
				1995	0.340	0.581	0.346
				1996	0.565	0.965	0.312
				1997	0.386	0.659	0.336
				1998	0.315	0.538	0.382
				1999	0.406	0.694	0.352
				2000	0.489	0.834	0.371
				2001	0.288	0.492	0.370
				2002	0.286	0.488	0.363
				2003	0.404	0.690	0.333
				2004	0.199	0.340	0.411
				2005	0.380	0.649	0.336
				2006	0.267	0.456	0.401
SEDAR 13-DW-31	SEAMAP-GoM Fall Groundfish	FI	NR	1972	0.489	0.549	0.381
				1973	0.430	0.483	0.246
				1974	1.609	1.807	0.199
				1975	1.304	1.464	0.173
				1976	1.255	1.409	0.147
				1977	0.704	0.791	0.202
				1978	0.697	0.782	0.207
				1979	0.843	0.946	0.215
				1980	1.415	1.589	0.208
				1981	0.837	0.940	0.242
				1982	0.932	1.047	0.215
				1983	0.770	0.865	0.242
				1984	0.660	0.741	0.373
				1985	1.103	1.238	0.357
				1986	0.310	0.348	0.571
SEDAR 13-DW-31	SEAMAP-GoM Fall SEAMAP	FI	NR	1987	0.927	2.673	1.053
				1988	0.334	0.961	0.225
				1989	0.298	0.859	0.386
				1990	0.396	1.141	0.346
				1991	0.175	0.504	0.239
				1992	0.166	0.478	0.242
				1993	0.388	1.119	0.341
				1994	0.475	1.369	0.395
				1995	0.236	0.679	0.341
				1996	0.475	1.369	0.241
				1997	0.286	0.826	0.295
				1998	0.219	0.631	0.272
				1999	0.444	1.279	0.372
				2000	0.548	1.581	0.362
				2001	0.281	0.809	0.243
				2002	0.234	0.675	0.402
				2003	0.284	0.820	0.213
				2004	0.142	0.409	0.395

				2005	0.443	1.278	0.424
				2006	0.188	0.541	0.392
SEDAR 13-DW-31	SEAMAP-GoM Early SEAMAP	FI	NR	1982	0.052	0.187	0.629
				1983	0.584	2.116	0.509
				1984	0.131	0.474	0.835
				1985	0.470	1.704	0.493
				1986	0.143	0.518	0.838
SEDAR 13-DW-34	UNC	FI	Base	1973	0.861	0.328	4.135
				1974	0.313	0.119	9.764
				1975	0.653	0.249	3.486
				1976	0.372	0.142	6.784
				1977	0.739	0.282	3.328
				1978	1.366	0.521	1.736
				1979	1.166	0.444	1.862
				1980	1.139	0.434	1.530
				1981	0.594	0.226	2.643
				1982	0.340	0.130	4.363
				1983	1.353	0.516	1.210
				1984	0.922	0.352	1.675
				1985	1.322	0.504	1.312
				1986	1.150	0.438	1.918
				1987	1.735	0.661	1.149
				1988	2.299	0.876	0.761
				1989	1.265	0.482	1.604
				1990	1.750	0.667	1.028
				1991	3.526	1.344	0.593
				1992	6.286	2.397	0.447
				1993	3.141	1.198	0.964
				1994	2.164	0.825	1.096
				1995	5.698	2.172	0.527
				1996	3.101	1.182	0.634
				1997	2.898	1.105	0.773
				1998	3.780	1.441	0.539
				1999	2.865	1.092	0.678
				2000	4.001	1.526	0.544
				2001	.		.
				2002	4.872	1.858	0.463
				2003	6.899	2.630	0.364
				2004	6.449	2.459	0.462
				2005	8.917	3.400	0.246
SEDAR 13-DW-38	MML GN - Adult	FI	Base	1995	2.868	0.204	0.731
				1996	9.140	0.649	0.629
				1997	3.210	0.228	1.500
				1998			
				1999	6.522	0.463	0.677
				2000	5.041	0.358	0.707
				2001	32.431	2.302	0.521

				2002	13.662	0.970	0.574
				2003	35.560	2.524	0.527
				2004	18.350	1.303	0.535
				1995	0.070	0.111	1.837
SEDAR 13-DW-38	MML GN - juvi	FI	Base	1996	0.305	0.485	0.756
				1997	2.971	4.721	0.398
				1998			
				1999	0.423	0.672	0.588
				2000	0.161	0.255	0.765
				2001	0.505	0.803	0.896
				2002	0.897	1.426	0.456
				2003	0.254	0.404	0.757
				2004	0.078	0.124	0.831
SEDAR 13-DW-41	BLL Logs	FD-C	NR	1996	0.013	0.556	1.378
				1997	0.006	0.256	2.397
				1998	0.008	0.342	2.194
				1999	0.014	0.598	1.707
				2000	0.007	0.299	2.309
				2001	0.036	1.538	1.314
				2002	0.040	1.709	1.265
				2003	0.036	1.538	1.164
				2004	0.041	1.752	1.360
				2005	0.033	1.410	1.457

Bonnethead shark

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Document Number	Series Name	Type	Recommendation	Year	Absolute	Relative	CV
SEDAR 13-DW-06	PC Gillnet	FI	Base	1996	0.789	0.821	0.443
			(SPM)	1997	0.900	0.936	0.551
				1998	0.714	0.743	0.570
				1999	1.249	1.299	0.526
				2000	0.662	0.689	0.672
				2001	1.176	1.223	0.480
				2002	0.863	0.898	0.502
				2003	2.218	2.307	0.448
				2004	0.455	0.473	0.608
				2005	0.589	0.613	0.577
SEDAR 13-DW-06	PC Gillnet - Adult	FI	Base	1996	0.563	1.595	0.483
			(AS)	1997	0.204	0.578	0.728
				1998	0.165	0.467	0.814
				1999	0.374	1.059	0.687
				2000	0.046	0.130	2.407

				2001	0.619	1.754	0.470
				2002	0.504	1.428	0.452
				2003	0.692	1.960	0.381
				2004	0.296	0.839	0.557
				2005	0.067	0.190	1.047
SEDAR 13-DW-06	PC Gillnet - juvi	FI	Base (AS)	1996	0.602	1.705	0.554
				1997	0.827	2.343	0.575
				1998	0.622	1.762	0.481
				1999	0.710	2.011	0.598
				2000	0.304	0.861	0.779
				2001	0.390	1.105	0.617
				2002	0.435	1.232	0.590
				2003	0.292	0.827	0.624
				2004	0.166	0.470	0.778
				2005	0.046	0.130	1.536
SEDAR 13-DW-09	Gillnet Obs	FD-C	Base	1994	196.274	1.447	0.619
				1995	12.915	0.095	1.359
				1996			
				1997			
				1998	169.757	1.252	0.841
				1999	102.106	0.753	0.519
				2000	431.009	3.178	0.538
				2001	133.159	0.982	0.530
				2002	67.460	0.497	0.545
				2003	29.868	0.220	0.875
				2004	8.594	0.063	0.882
				2005	163.588	1.206	0.665
SEDAR 13-DW-10	ENP	FD-R	Base	1978	0.436	0.565	0.313
				1979	0.545	0.706	0.341
				1980	0.151	0.196	0.443
				1981	0.395	0.512	0.205
				1982	0.285	0.369	0.222
				1983	0.542	0.702	0.137
				1984	0.944	1.223	0.078
				1985	0.627	0.813	0.114
				1986	0.602	0.780	0.115
				1987	0.631	0.818	0.109
				1988	0.708	0.917	0.112
				1989	0.901	1.168	0.104
				1990	0.818	1.060	0.090
				1991	0.498	0.645	0.130
				1992	0.971	1.258	0.077
				1993	0.931	1.206	0.089
				1994	1.026	1.330	0.077
				1995	1.137	1.473	0.075
				1996	1.102	1.428	0.072
				1997	0.879	1.139	0.083

				1998	0.808	1.047	0.094
				1999	0.940	1.218	0.087
				2000	0.888	1.151	0.088
				2001	0.965	1.251	0.087
				2002	0.881	1.142	0.100
				2003	0.803	1.041	0.101
				2004	0.781	1.012	0.119
SEDAR 13-DW-14	SEAMAP - SA	FI	Base	1989	0.777	0.426	0.543
				1990	1.370	0.751	0.359
				1991	2.100	1.152	0.343
				1992	1.448	0.794	0.323
				1993	1.031	0.565	0.407
				1994	1.563	0.857	0.347
				1995	1.749	0.959	0.324
				1996	0.711	0.390	0.439
				1997	1.578	0.865	0.331
				1998	1.248	0.684	0.356
				1999	1.122	0.615	0.382
				2000	1.644	0.902	0.340
				2001	2.237	1.227	0.277
				2002	3.415	1.873	0.243
				2003	2.936	1.610	0.260
				2004	1.264	0.693	0.343
				2005	2.731	1.498	0.269
				2006	3.901	2.139	0.251
SEDAR 13-DW-16	MRFSS	FD-R	NR	1981	0.110	0.226	1.223
				1982	0.178	0.366	0.804
				1983	0.066	0.136	1.709
				1984	0.085	0.175	1.289
				1985	0.215	0.443	0.803
				1986	0.273	0.562	0.677
				1987	0.247	0.508	0.675
				1988	0.142	0.292	0.823
				1989	0.220	0.453	0.703
				1990	0.154	0.317	0.801
				1991	0.101	0.208	0.996
				1992	0.531	1.093	0.488
				1993	0.236	0.486	0.629
				1994	0.269	0.554	0.573
				1995	0.391	0.805	0.512
				1996	0.422	0.869	0.502
				1997	0.366	0.753	0.523
				1998	0.638	1.313	0.447
				1999	0.686	1.412	0.445
				2000	0.904	1.861	0.417
				2001	1.089	2.242	0.409
				2002	1.724	3.549	0.392
				2003	0.958	1.972	0.413

				2004	1.150	2.367	0.406
				2005	0.990	2.038	0.416
SEDAR 13-DW-18	Texas	FI	Base	1975	0.164	0.192	1.634
				1976	1.578	1.848	0.440
				1977	0.178	0.208	1.091
				1978	0.199	0.233	0.877
				1979	0.559	0.654	0.622
				1980	1.092	1.279	0.405
				1981	0.997	1.168	0.674
				1982	0.645	0.755	0.355
				1983	1.076	1.260	0.281
				1984	1.397	1.636	0.232
				1985	0.453	0.531	0.376
				1986	0.779	0.913	0.284
				1987	0.090	0.105	1.009
				1988	1.222	1.431	0.263
				1989	0.591	0.692	0.338
				1990	1.560	1.827	0.261
				1991	1.042	1.220	0.287
				1992	0.399	0.467	0.431
				1993	0.984	1.152	0.295
				1994	0.661	0.774	0.368
				1995	0.479	0.560	0.407
				1996	0.558	0.654	0.321
				1997	0.495	0.579	0.465
				1998	1.350	1.582	0.308
				1999	0.441	0.517	0.393
				2000	1.340	1.569	0.274
				2001	1.341	1.570	0.243
				2002	1.335	1.564	0.299
				2003	0.927	1.085	0.283
				2004	1.323	1.549	0.273
				2005	1.000	1.171	0.264
				2006	1.071	1.254	0.310
SEDAR 13-DW-21	MS Gillnet *nominal	FI	NR	2001	0.060		
				2002			
				2003	0.000		
				2004	0.000		
				2005	0.140		
				2006	0.150		
SEDAR 13-DW-26	Gillnet Logs	FD-C	Sensitivity	1998	0.001	0.307	5.975
				1999	0.001	0.261	7.179
				2000	0.002	0.426	5.128
				2001	0.003	0.598	4.448
				2002	0.003	0.698	5.102
				2003	0.004	0.838	5.547
				2004	0.014	3.067	2.233

				2005	0.007	1.560	3.061
SEDAR 13-DW-27	GA Coastspan	FI	NR	2000	0.602	0.280	1.955
				2001	0.804	0.374	1.279
				2002	2.398	1.115	0.709
				2003	2.024	0.941	0.765
				2004	5.412	2.517	0.270
				2005	1.660	0.772	0.921
SEDAR 13-DW-27	GADNR Trawl	FI	NR	2003	191.430	1.220	0.186
				2004	176.985	1.128	0.203
				2005	102.319	0.652	0.244
SEDAR 13-DW-30	SC Coastspan GN	FI	Base	1998	5.113	0.402	0.925
				1999	13.233	1.040	0.456
				2000	12.370	0.972	0.414
				2001	13.092	1.029	0.236
				2002	10.316	0.811	0.288
				2003	14.299	1.124	0.236
				2004	17.229	1.354	0.713
				2005	16.121	1.267	0.222
SEDAR 13-DW-30	SC Coastspan LL	FI	NR	1999	0.002	0.280	235.619
				2000	0.006	0.706	63.675
				2001	0.008	0.925	55.198
				2002	0.001	0.170	303.687
				2003	0.013	1.558	33.864
				2004	0.018	2.143	25.107
				2005	0.010	1.217	31.041
SEDAR 13-DW-30	SCDNR red drum	FI	NR	1998			
				1999	0.000	0.216	237.125
				2000			
				2001			
				2002	0.003	1.738	42.219
				2003	0.003	1.909	35.677
				2004	0.001	0.403	192.029
				2005	0.001	0.734	141.569
SEDAR 13-DW-31	SEAMAP - GoM Extended Summer	FI	Base	1982	0.037	1.075	1.863
				1983	0.055	1.585	1.162
				1984	0.050	1.449	1.752
				1985	0.077	2.231	1.093
				1986	0.040	1.150	1.698
				1987	0.028	0.817	1.194
				1988	0.013	0.364	1.855
				1989	0.016	0.453	1.825
				1990	0.027	0.786	1.035
				1991	0.013	0.375	1.717

				1992	0.023	0.672	1.128
				1993	0.031	0.903	0.849
				1994	0.013	0.372	1.723
				1995	0.065	1.874	0.681
				1996	0.045	1.313	0.708
				1997	0.038	1.094	0.849
				1998	0.010	0.294	1.799
				1999	0.048	1.392	0.802
				2000	0.012	0.350	1.578
				2001	0.038	1.093	1.326
				2002	0.014	0.400	1.690
				2003	0.028	0.820	1.227
				2004	0.038	1.104	0.810
				2005	0.039	1.140	0.930
				2006	0.065	1.894	0.638
SEDAR 13-DW-31	SEAMAP - GoM Extended Fall	FI	Base	1972	1.687	2.406	2.198
				1973	4.090	5.833	1.955
				1974	2.479	3.535	1.983
				1975	1.530	2.182	2.016
				1976	2.750	3.922	1.963
				1977	2.142	3.055	1.969
				1978	0.977	1.393	2.095
				1979	1.775	2.531	1.983
				1980	1.013	1.444	2.178
				1981	0.458	0.654	2.298
				1982	0.477	0.680	2.157
				1983	0.664	0.948	2.305
				1984	0.159	0.227	2.697
				1985	0.654	0.932	2.867
				1986	0.961	1.370	3.591
				1987	0.111	0.159	0.579
				1988	0.103	0.146	0.483
				1989	0.056	0.080	0.654
				1990	0.114	0.163	0.444
				1991	0.119	0.170	0.415
				1992	0.097	0.139	0.480
				1993	0.135	0.192	0.412
				1994	0.091	0.130	0.515
				1995	0.074	0.106	0.541
				1996	0.161	0.229	0.396
				1997	0.143	0.203	0.462
				1998	0.089	0.126	0.482
				1999	0.117	0.167	0.448
				2000	0.113	0.162	0.460
				2001	0.158	0.226	0.389
				2002	0.208	0.297	0.416
				2003	0.172	0.246	0.373
				2004	0.199	0.283	0.423
				2005	0.280	0.400	0.305

				2006	0.186	0.265	0.395
SEDAR 13-DW-31	SEAMAP-GoM Fall Groundfish	FI	NR	1972	0.182	0.944	0.419
				1973	0.558	2.892	0.258
				1974	0.308	1.599	0.275
				1975	0.164	0.849	0.433
				1976	0.321	1.667	0.254
				1977	0.360	1.864	0.651
				1978	0.102	0.530	0.405
				1979	0.225	1.167	0.556
				1980	0.108	0.561	0.543
				1981	0.038	0.195	0.496
				1982	0.045	0.235	0.404
				1983	0.065	0.339	0.568
				1984			
				1985	0.031	0.158	1.000
				1986			
SEDAR 13-DW-31	SEAMAP-GoM Fall SEAMAP	FI	NR	1987	0.072	0.560	0.466
				1988	0.073	0.566	0.412
				1989	0.058	0.451	0.594
				1990	0.107	0.836	0.456
				1991	0.090	0.700	0.324
				1992	0.054	0.419	0.471
				1993	0.112	0.870	0.343
				1994	0.156	1.215	0.462
				1995	0.035	0.270	0.635
				1996	0.148	1.151	0.318
				1997	0.232	1.805	0.412
				1998	0.048	0.373	0.376
				1999	0.139	1.082	0.359
				2000	0.070	0.545	0.336
				2001	0.093	0.723	0.417
				2002	0.165	1.287	0.633
				2003	0.126	0.984	0.452
				2004	0.430	3.354	0.385
				2005	0.215	1.678	0.244
				2006	0.145	1.130	0.400
SEDAR 13-DW-31	SEAMAP-GoM Early SEAMAP	FI	NR	1983	0.042	0.720	0.636
				1984			
				1985	0.075	1.280	0.876
SEDAR 13-DW-31	SEAMAP-GoM Summer SEAMAP	FI	NR	1987	0.054	1.453	0.717
				1988			
				1989			
				1990	0.022	0.608	0.666
				1991			
				1992	0.013	0.362	0.817
				1993	0.023	0.617	0.700

				1994			
				1995	0.140	3.800	0.607
				1996	0.035	0.962	0.681
				1997	0.037	0.995	0.792
				1998			
				1999	0.032	0.878	0.590
				2000			
				2001	0.006	0.150	1.668
				2002			
				2003	0.009	0.247	1.035
				2004	0.029	0.788	0.757
				2005	0.011	0.285	0.888
				2006	0.068	1.856	0.441
SEDAR 13-DW-38	MML GN - adult	FI	Base	1995	0.881	0.492	0.217
				1996	0.597	0.333	0.425
				1997	1.179	0.658	0.180
				1998			
				1999	1.409	0.786	0.207
				2000	2.479	1.383	0.192
				2001	2.728	1.523	0.170
				2002	1.695	0.946	0.207
				2003	2.346	1.309	0.226
				2004	2.811	1.569	0.213
SEDAR 13-DW-38	MML GN - juvi	FI	Base	1995	0.493	0.275	0.239
				1996	0.316	0.176	0.403
				1997	1.216	0.679	0.252
				1998			
				1999	0.607	0.339	0.287
				2000	1.350	0.753	0.283
				2001	1.204	0.672	0.180
				2002	0.581	0.324	0.242
				2003	1.110	0.620	0.233
				2004	1.867	1.042	0.246

Finetooth shark

					Index		
Document Number	Series Name	Type	Recommendation	Year	Absolute	Relative	CV
SEDAR 13-DW-05	PC LL	FI	Sensitivity	1993	0.014	0.41791	3.924
				1994	0.046	1.37313	0.61
				1995	0.012	0.35821	2.759
				1996	0.123	3.67164	0.182
				1997	0.057	1.70149	0.425
				1998	0.006	0.1791	6.8

				1999	0.01	0.29851	2.972
				2000	0	0	0
SEDAR 13-DW-06	PC Gillnet	FI	Base (SPM)	1996	0.479	0.763	0.391
				1997	1.363	2.174	0.291
				1998	0.051	0.081	0.915
				1999	0.840	1.339	0.465
				2000	0.252	0.401	0.833
				2001	0.589	0.940	0.519
				2002	0.451	0.719	0.504
				2003	1.147	1.828	0.361
				2004	0.447	0.712	0.551
				2005	0.654	1.043	0.476
SEDAR 13-DW-06	PC Gillnet - Adult	FI	Base (AS)	1996	0.174	1.15768	0.357
				1997	0.173	1.15103	0.396
				1998	0.034	0.22621	1.503
				1999	0.2	1.33067	0.525
				2000	0.022	0.14637	3.025
				2001	0.123	0.81836	0.614
				2002	0.161	1.07119	0.411
				2003	0.188	1.25083	0.378
				2004	0.209	1.39055	0.435
				2005	0.219	1.45709	0.524
SEDAR 13-DW-06	PC Gillnet - juvi	FI	Base (AS)	1996	0.377	2.50832	0.42
				1997	1.063	7.07252	0.321
				1998	0.017	0.11311	1.358
				1999	0.416	2.7678	0.672
				2000	0.208	1.3839	0.92
				2001	0.473	3.14704	0.681
				2002	0.235	1.56354	0.704
				2003	0.684	4.5509	0.496
				2004	0.178	1.1843	0.779
				2005	0.289	1.92282	0.681
SEDAR 13-DW-09	Gillnet Obs	FD-C	Base	1993	75.596	0.48257	1.024
				1994	44.255	0.2825	0.897
				1995	30.002	0.19152	1.546
				1996			
				1997			
				1998	0.926	0.00591	0.999
				1999	44.518	0.28418	0.764
				2000	945.377	6.03485	0.707
				2001	68.73	0.43874	0.718
				2002	77.065	0.49195	0.888
				2003	57.723	0.36848	1.096
				2004	8.28	0.05286	1.115
				2005	370.709	2.36644	0.766

SEDAR 13-DW-18	Texas	FI	Base	1976	0.007	0.624	1.069
				1977			
				1978			
				1979	0.005	0.484	1.067
				1980	0.012	1.058	0.579
				1981	0.008	0.704	0.752
				1982	0.012	1.037	0.407
				1983	0.018	1.555	0.354
				1984	0.012	1.093	0.406
				1985	0.010	0.848	0.499
				1986	0.016	1.399	0.351
				1987			
				1988	0.005	0.451	0.752
				1989	0.006	0.556	0.584
				1990	0.024	2.116	0.286
				1991	0.012	1.074	0.445
				1992	0.011	0.974	0.502
				1993	0.003	0.279	1.066
				1994	0.013	1.123	0.407
				1995	0.015	1.293	0.378
				1996	0.026	2.323	0.264
				1997	0.008	0.748	0.752
				1998			
				1999	0.008	0.668	0.499
				2000	0.018	1.584	0.332
				2001	0.003	0.282	1.066
				2002	0.010	0.915	0.499
				2003	0.020	1.730	0.336
				2004	0.012	1.024	0.449
				2005	0.009	0.801	0.499
				2006	0.003	0.255	0.500
SEDAR 13-DW-21	MS Gillnet	FI	Sensitivity (SPM)	2001	0.180	0.435	0.842
				2002			
				2003	0.562	1.360	0.656
				2004	0.481	1.162	0.626
				2005	0.398	0.962	0.502
				2006	0.447	1.080	0.447
SEDAR 13-DW-21	MS Gillnet - YOY	FI	Sensitivity	2001	0.311	1.470	1.062
				2002			
				2003	0.228	1.081	0.760
				2004			
				2005	0.089	0.371	0.840
				2006	0.228	1.078	0.489
SEDAR 13-DW-21	MS Gillnet - juvi	FI	Sensitivity (AS)	2003	0.293	1.530	1.206
				2004	0.560	1.338	0.636
				2005	0.136	0.712	0.705
				2006	0.081	0.421	0.817

SEDAR 13-DW-26	Gillnet Logs	FD - C	Sensitivity	1998	0.002	0.842	5.796
				1999	0.000	0.141	12.628
				2000	0.001	0.410	5.755
				2001	0.001	0.674	4.470
				2002	0.001	0.413	9.181
				2003	0.003	1.193	4.535
				2004	0.002	0.844	9.364
				2005	0.008	3.483	2.823
SEDAR 13-DW-30	SC Coastspan GN	FI	Base	1998	6.303	0.766	0.851
				1999	4.878	0.593	1.267
				2000	6.423	0.780	0.783
				2001	13.024	1.582	0.284
				2002	12.751	1.549	0.344
				2003	13.754	1.671	0.312
				2004	2.864	0.348	1.994
				2005	5.858	0.712	0.503
SEDAR 13-DW-30	SC Coastspan LL	FI	NR	2000	0.074	1.413	5.992
				2001	0.090	1.728	4.672
				2002	0.056	1.074	8.468
				2003	0.047	0.903	11.748
				2004	0.039	0.746	12.274
				2005	0.007	0.136	36.534
SEDAR 13-DW-30	SCDNR red drum	FI	NR	1998	0.000	0.059	346.846
				1999	0.002	1.008	28.167
				2000	0.001	0.831	42.958
				2001	0.002	1.246	30.216
				2002	0.005	3.025	13.707
				2003	0.001	0.653	56.316
				2004	0.000	0.178	242.517
SEDAR 13-DW-34	UNC	FI	NR	1972			
				1973			
				1974			
				1975			
				1976			
				1977	0.039	0.190	18.502
				1978	0.039	0.186	18.678
				1979	0.097	0.466	6.776
				1980			
				1981	0.119	0.577	9.485
				1982	0.128	0.616	9.175
				1983	0.038	0.182	14.100
				1984			
				1985			
				1986			
				1987	0.045	0.217	12.265

1988	0.070	0.337	6.917
1989	0.542	2.620	2.041
1990			
1991			
1992	0.144	0.695	6.877
1993	0.118	0.570	8.334
1994	1.271	6.145	0.869
1995	0.027	0.132	21.866
1996			
1997	0.194	0.939	4.466
1998			
1999			
2000			
2001			
2002			
2003			
2004			
2005	0.233	1.127	4.129

Blacknose shark

					Index		
Document Number	Series Name	Type	Recommendation	Year	Absolute	Relative	CV
SEDAR 13-DW-05	PC LL	FI	Sensitivity	1993	0.008	0.212	6.171
				1994	0.076	2.013	0.282
				1995	0.021	0.556	1.332
				1996			
				1997	0.017	0.450	1.201
				1998	0.032	0.848	0.981
				1999	0.052	1.377	0.493
				2000	0.096	2.543	0.294
SEDAR 13-DW-06	PC Gillnet	FI	Base	1996	0.446	2.164	0.269
			(SPM)	1997	0.161	0.781	0.710
				1998	0.156	0.757	0.724
				1999	0.308	1.494	0.833
				2000	0.025	0.121	5.613
				2001	0.157	0.762	0.971
				2002	0.242	1.174	0.741
				2003	0.216	1.048	0.759
				2004	0.232	1.126	0.763
				2005	0.118	0.573	1.159
SEDAR 13-DW-06	PC Gillnet - Adult	FI	Base	1996	0.446	2.164	0.269
			(AS)	1997	0.161	0.781	0.710
				1998	0.156	0.757	0.724

				1999	0.308	1.494	0.833
				2000	0.025	0.121	5.613
				2001	0.157	0.762	0.971
				2002	0.242	1.174	0.741
				2003	0.216	1.048	0.759
				2004	0.232	1.126	0.763
				2005	0.118	0.573	1.159
SEDAR 13-DW-06	PC Gillnet - juvi	FI	Base (AS)	1996	0.168	1.507	0.356
				1997	0.082	0.735	0.351
				1998	0.069	0.619	0.250
				1999	0.086	0.771	0.268
				2000	0.105	0.942	0.282
				2001	0.114	1.022	0.289
				2002	0.124	1.112	0.300
				2003	0.117	1.049	0.296
				2004	0.131	1.175	0.309
				2005	0.119	1.067	0.294
SEDAR 13-DW-09	Gillnet Obs	FD-C	Base	1993	12.832	0.143	1.321
				1994	110.912	1.234	0.801
				1995	14.734	0.164	1.166
				1996			
				1997			
				1998	39.207	0.436	0.991
				1999	55.567	0.618	0.646
				2000	96.643	1.075	0.680
				2001	40.011	0.445	0.639
				2002	143.840	1.601	0.578
				2003	63.992	0.712	0.675
				2004	46.179	0.514	0.658
				2005	251.732	2.801	0.747
SEDAR 13-DW-12	BLLOP	FD-C	Base	1994	17.126	0.305915	0.615
				1995	41.156	0.735152	0.45
				1996	35.776	0.639052	0.459
				1997	13.373	0.238876	0.6
				1998	37.706	0.673526	0.465
				1999	44.055	0.786936	0.582
				2000	130.194	2.325601	0.522
				2001	14.477	0.258597	0.649
				2002	67.202	1.200401	0.368
				2003	34.63	0.618581	0.407
				2004	28.78	0.514085	0.501
				2005	130.604	2.332924	0.468
SEDAR 13-DW-22	NMFS LL SE Atlantic	FI	NR (two stocks)	1995	0.000	0.000	
				1996	0.000	0.000	
				1997	0.01101	0.106	0.619

				1998			
				1999	0.28056	2.709	0.422
				2000	0.04009	0.387	0.447
				2001			
				2002	0.1006	0.972	0.260
				2003			
				2004	0.02776	0.268	0.579
				2005		0.000	
				2006	0.16128	1.558	0.579
SEDAR 13-DW-22	NMFS LL SE GoM	FI	Base (two stocks)	1995	0.123	0.433	0.453
				1996	0.316	1.114	0.374
				1997	0.223	0.787	0.349
				1998			
				1999	0.161	0.567	0.263
				2000	0.174	0.615	0.255
				2001	0.274	0.967	0.248
				2002	0.189	0.666	0.261
				2003	0.521	1.838	0.213
				2004	0.435	1.535	0.213
				2005	0.270	0.954	0.492
				2006	0.432	1.523	0.251
SEDAR 13-DW-22	NMFS LL SE Combined	FI	Base (one stock)	1995	0.066	0.287	0.511
				1996	0.177	0.773	0.399
				1997	0.129	0.564	0.317
				1998			
				1999	0.139	0.606	0.307
				2000	0.139	0.606	0.260
				2001	0.251	1.093	0.271
				2002	0.215	0.937	0.248
				2003	0.483	2.105	0.227
				2004	0.347	1.513	0.225
				2005	0.204	0.888	0.540
				2006	0.374	1.628	0.257
SEDAR 13-DW-26	Gillnet Logs	FD-C	Sensitivity	1998	0.001	0.110	2.524
				1999	0.001	0.128	3.298
				2000	0.001	0.123	1.293
				2001	0.004	0.355	1.210
				2002	0.011	1.065	0.850
				2003	0.015	1.430	0.963
				2004	0.014	1.328	1.301
				2005	0.026	2.547	0.981
SEDAR 13-DW-30	SCDNR red drum	FI	Base	1998	0.016	0.690	3.017
				1999	0.008	0.343	5.552
				2000	0.033	1.488	1.803
				2001	0.016	0.722	4.303
				2002	0.035	1.546	1.962

				2003	0.023	1.007	2.136
				2004	0.015	0.677	4.236
				2005	0.034	1.528	3.598
SEDAR 13-DW-31	SEAMAP-GoM Fall Groundfish	FI	NR	1973	0.049	0.903	0.619
				1974			
				1975	0.099	1.831	0.424
				1976	0.054	0.996	0.718
				1977			
				1978			
				1979			
				1980			
				1981			
				1982	0.015	0.270	0.704
SEDAR 13-DW-31	SEAMAP-GoM Fall SEAMAP	FI	NR	1990	0.023	1.177	0.690
				1991	0.021	1.082	0.465
				1992	0.014	0.706	0.785
				1993	0.002	0.127	0.803
				1994	0.010	0.516	0.671
				1995	0.033	1.713	0.727
				1996	0.008	0.407	0.838
				1997	0.008	0.402	0.862
				1998	0.005	0.250	1.047
				1999	0.024	1.213	0.660
				2000	0.018	0.906	0.576
				2001	0.013	0.654	0.598
				2002	0.011	0.554	0.609
				2003	0.039	2.025	0.354
				2004	0.011	0.576	1.167
				2005	0.085	4.391	0.558
				2006	0.006	0.300	1.101
SEDAR 13-DW-31	SEAMAP-GoM Summer SEAMAP	FI	NR	1989	0.033	1.115	1.043
				1990			
				1991	0.008	0.264	1.082
				1992			
				1993	0.021	0.692	0.568
				1994	0.008	0.273	0.754
				1995			
				1996	0.024	0.805	0.957
				1997	0.069	2.306	0.839
				1998	0.005	0.170	0.988
				1999	0.004	0.150	1.693
				2000	0.027	0.917	0.725
				2001	0.050	1.668	0.876
				2002	0.015	0.520	0.942
				2003	0.030	1.005	0.521
				2004	0.109	3.659	0.978
				2005	0.014	0.485	0.747

				2006	0.029	0.971	1.011
SEDAR 13-DW-34	UNC	FI	Base	1972	3.967	2.564	1.594
				1973	4.233	2.736	0.936
				1974	1.600	1.034	2.293
				1975	3.326	2.149	0.996
				1976	2.490	1.609	1.113
				1977	6.276	4.056	0.344
				1978	4.048	2.616	0.605
				1979	3.115	2.013	0.666
				1980	1.866	1.206	0.859
				1981	0.728	0.470	2.338
				1982	1.503	0.971	0.832
				1983	0.849	0.548	1.670
				1984	1.814	1.172	0.852
				1985	0.953	0.616	1.787
				1986	0.595	0.384	2.992
				1987	1.099	0.710	1.686
				1988	2.135	1.380	1.136
				1989	0.812	0.525	2.507
				1990	0.565	0.365	4.043
				1991	1.052	0.680	2.063
				1992	2.315	1.496	1.385
				1993	1.381	0.893	1.903
				1994	0.819	0.529	2.557
				1995	1.012	0.654	2.286
				1996	1.396	0.902	1.966
				1997	0.419	0.271	4.255
				1998	0.189	0.122	8.969
				1999	0.131	0.085	14.208
				2000	0.194	0.125	9.467
				2001	0.597	0.386	4.604
				2002	0.243	0.157	7.470
				2003	0.100	0.065	16.434
				2004	0.387	0.250	6.553
				2005	0.405	0.262	5.506
SEDAR 13-DW-37	MML drumline	FI	NR	2001			
	*nominal			2002			
	(values not provided)			2003			
				2004			
				2005			
				2006			
SEDAR 13-DW-37	MML LL	FI	Base	2003	0.988	0.624	0.473
				2004	2.548	1.610	0.424
				2005	1.717	1.085	0.473
				2006	1.077	0.680	0.459
SEDAR 13-DW-41	BLL Logs	FD-C	NR	1996	0.014	0.308	1.062

1997	0.015	0.330	1.016
1998	0.023	0.507	0.902
1999	0.018	0.396	0.937
2000	0.024	0.529	1.052
2001	0.043	0.947	0.886
2002	0.035	0.771	0.989
2003	0.062	1.366	0.762
2004	0.139	3.062	0.682
2005	0.081	1.784	0.817

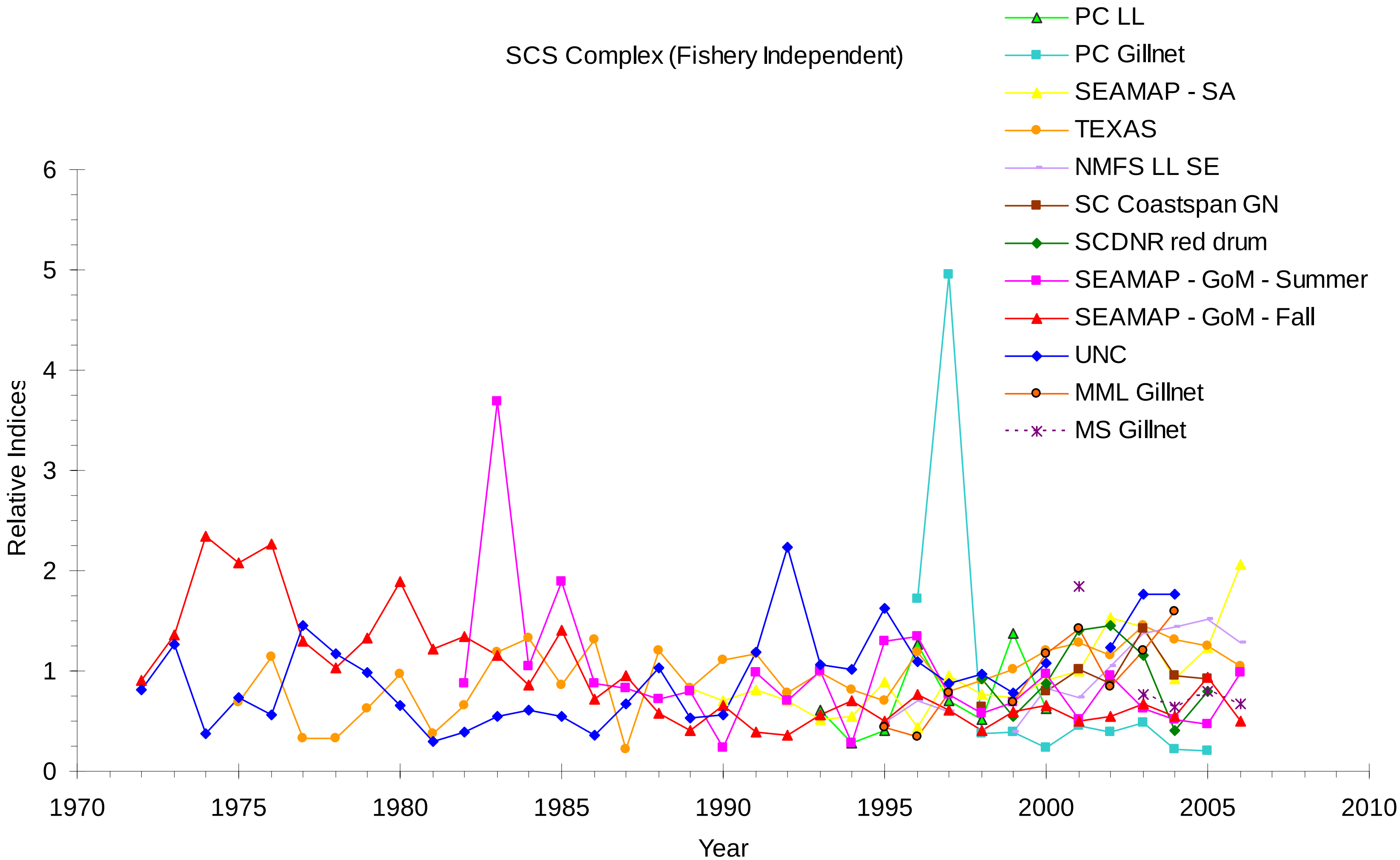


Figure 3.1. Fishery-independent catch rate series for the **Small Coastal Shark complex**. Solid lines indicate base case indices while dashed lines are for series to be used in sensitivity analysis. Series are scaled (each series is divided by the mean of the years within that series which overlap between all series) to appear on a common scale.

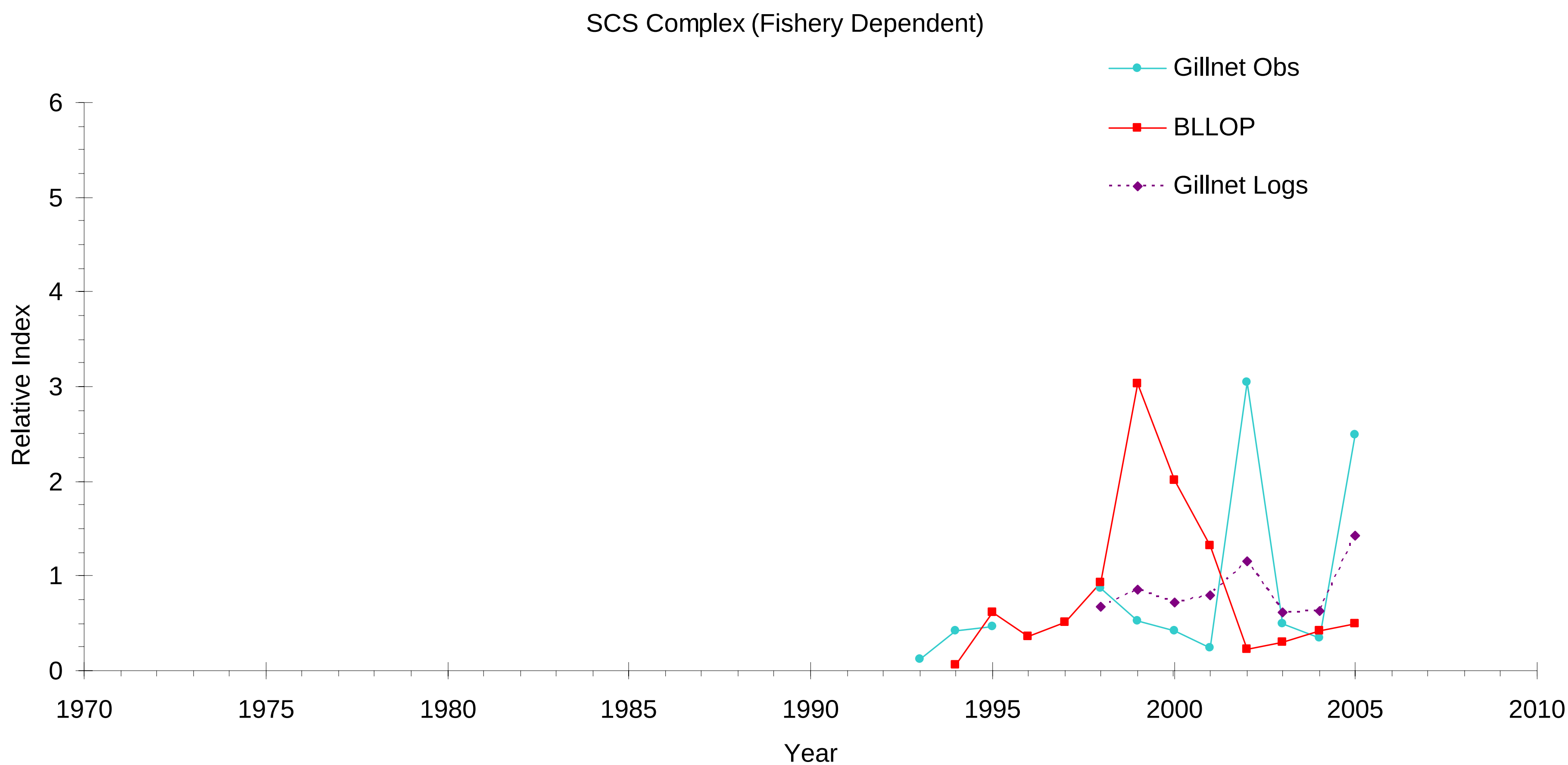


Figure 3.2. Fishery-dependent catch rate series for the **Small Coastal Shark complex**. Solid lines indicate base case indices while dashed lines are for series to be used in sensitivity analysis. Series are scaled (each series is divided by the mean of the years within that series which overlap between all series) to appear on a common scale.

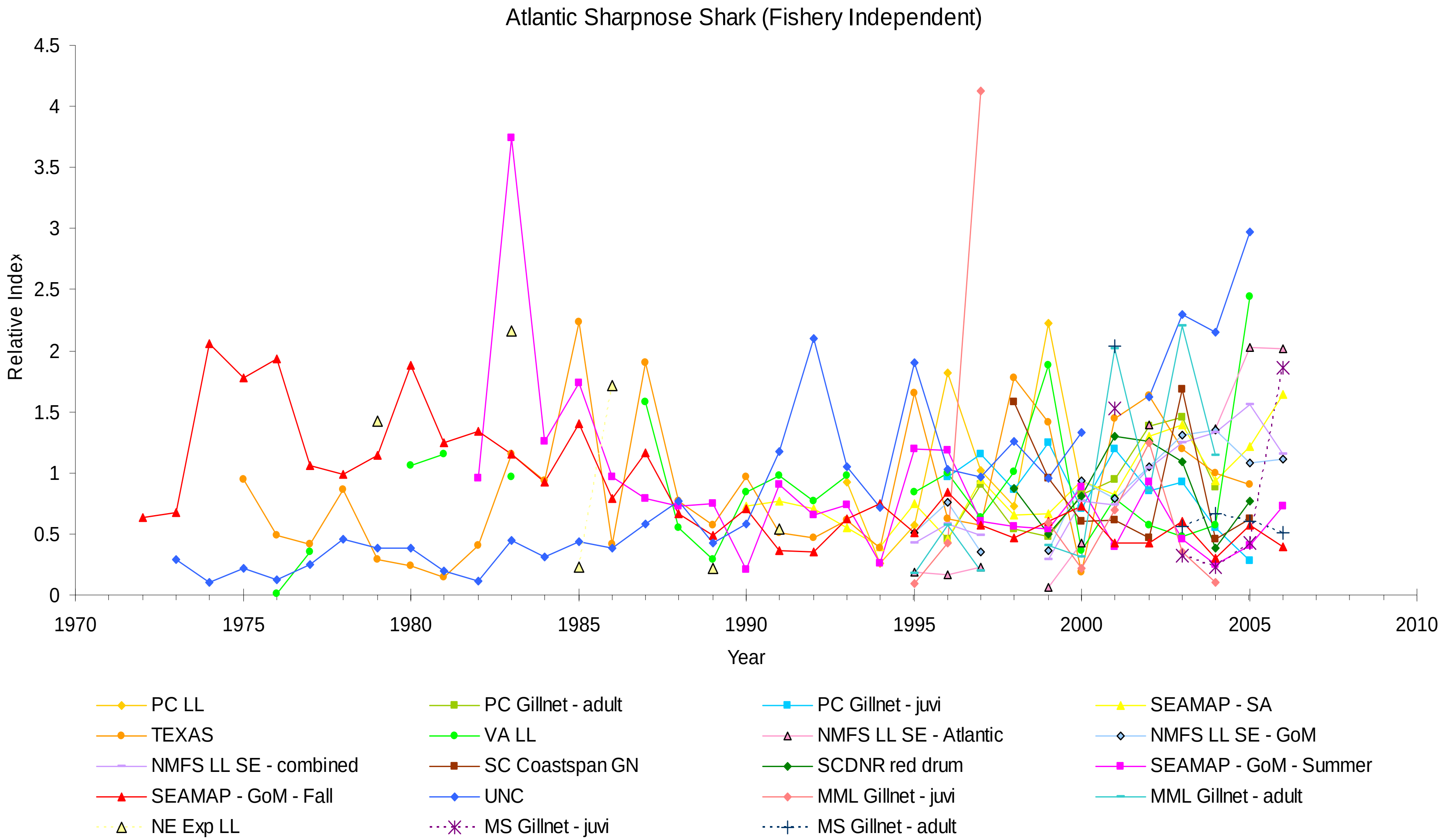


Figure 3.3. Fishery-independent catch rate series for **Atlantic sharpnose sharks**. Solid lines indicate base case indices while dashed lines are for series to be used in sensitivity analysis. Series are scaled (each series is divided by the mean of the years within that series which overlap between all series) to appear on a common scale.

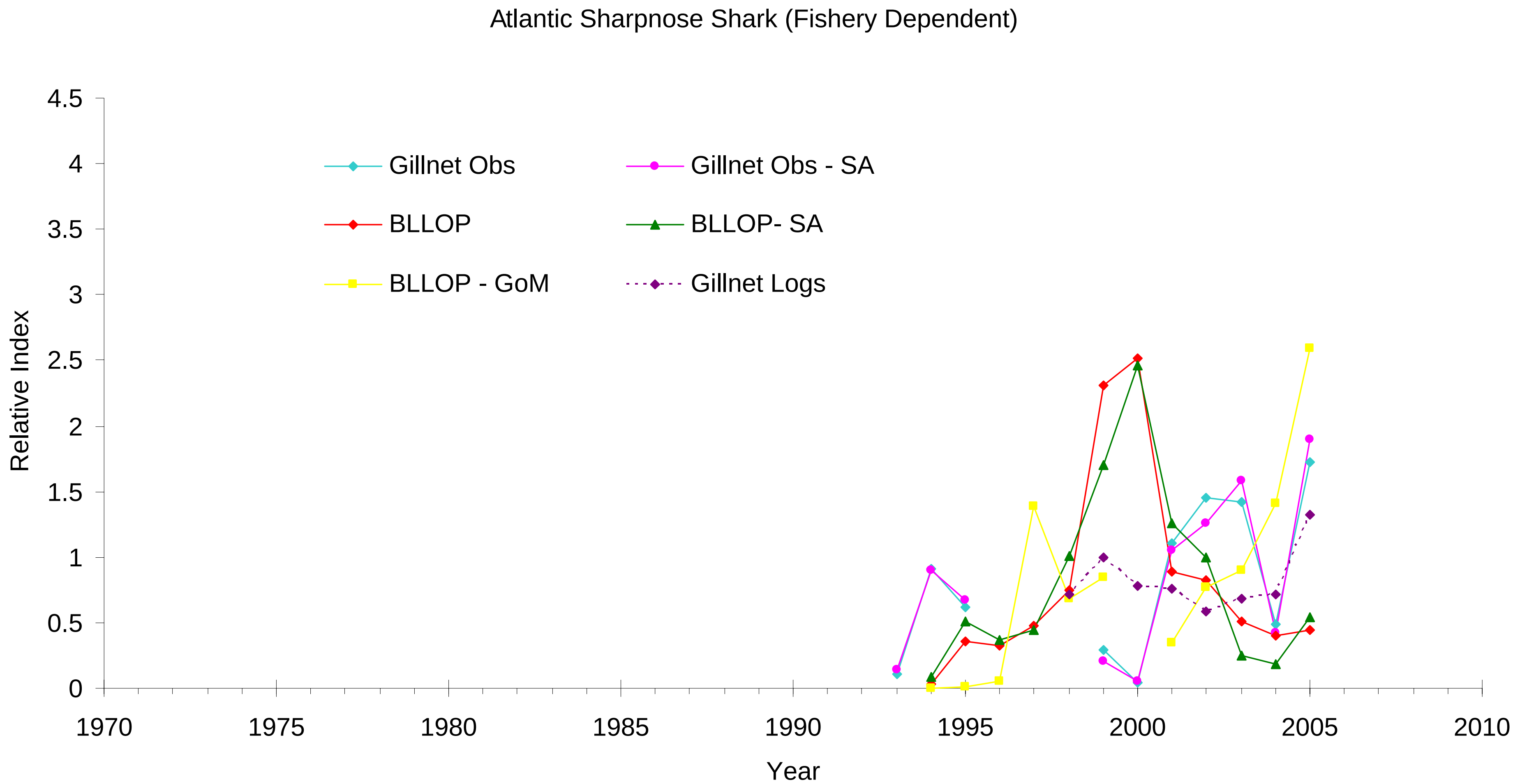


Figure 3.4. Fishery-dependent catch rate series for **Atlantic sharpnose sharks**. Solid lines indicate base case indices while dashed lines are for series to be used in sensitivity analysis. Series are scaled (each series is divided by the mean of the years within that series which overlap between all series) to appear on a common scale.

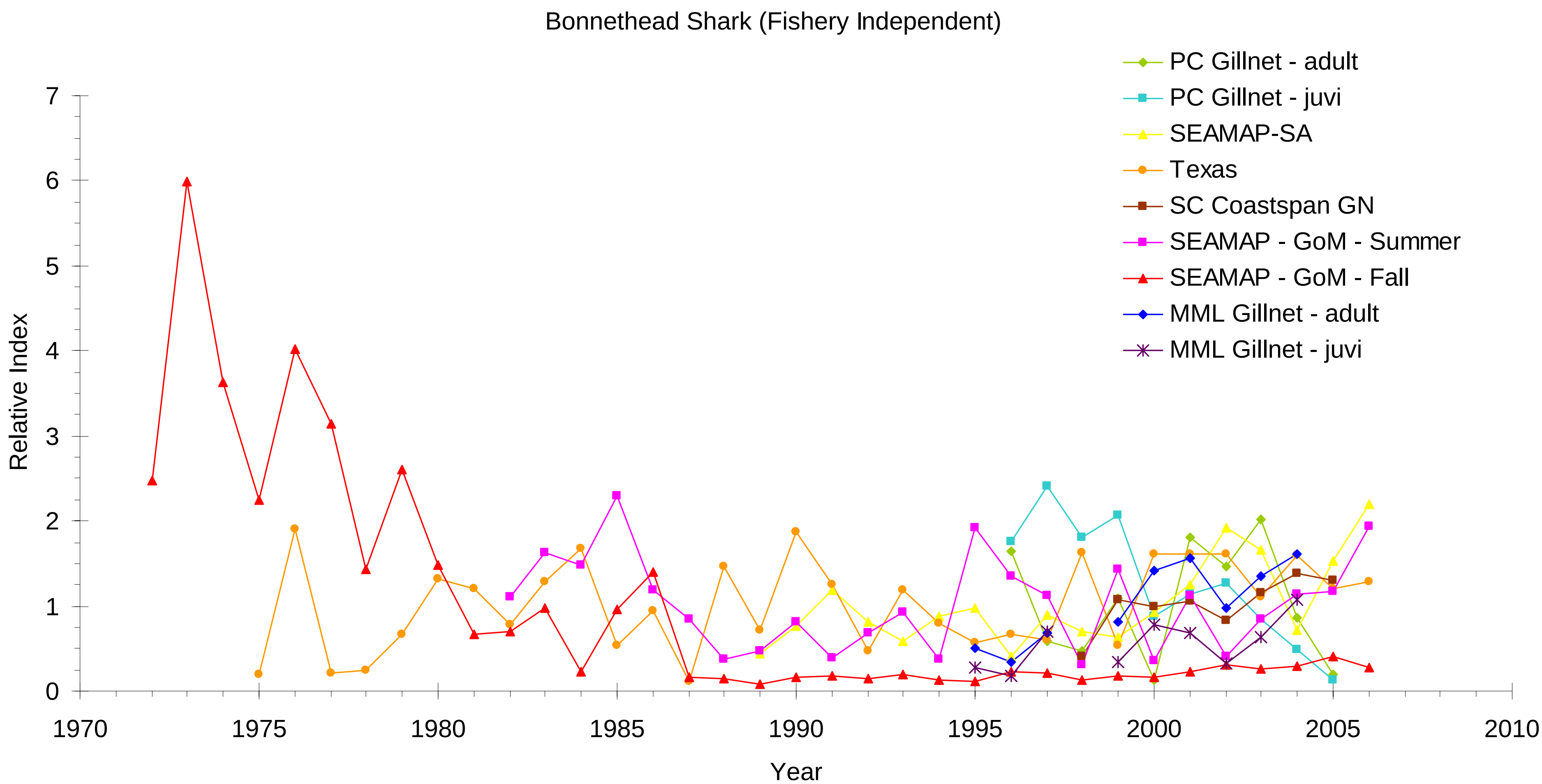


Figure 3.5. Fishery-independent catch rate series for **bonnethead sharks**. Solid lines indicate base case indices while dashed lines are for series to be used in sensitivity analysis. Series are scaled (each series is divided by the mean of the years within that series which overlap between all series) to appear on a common scale.

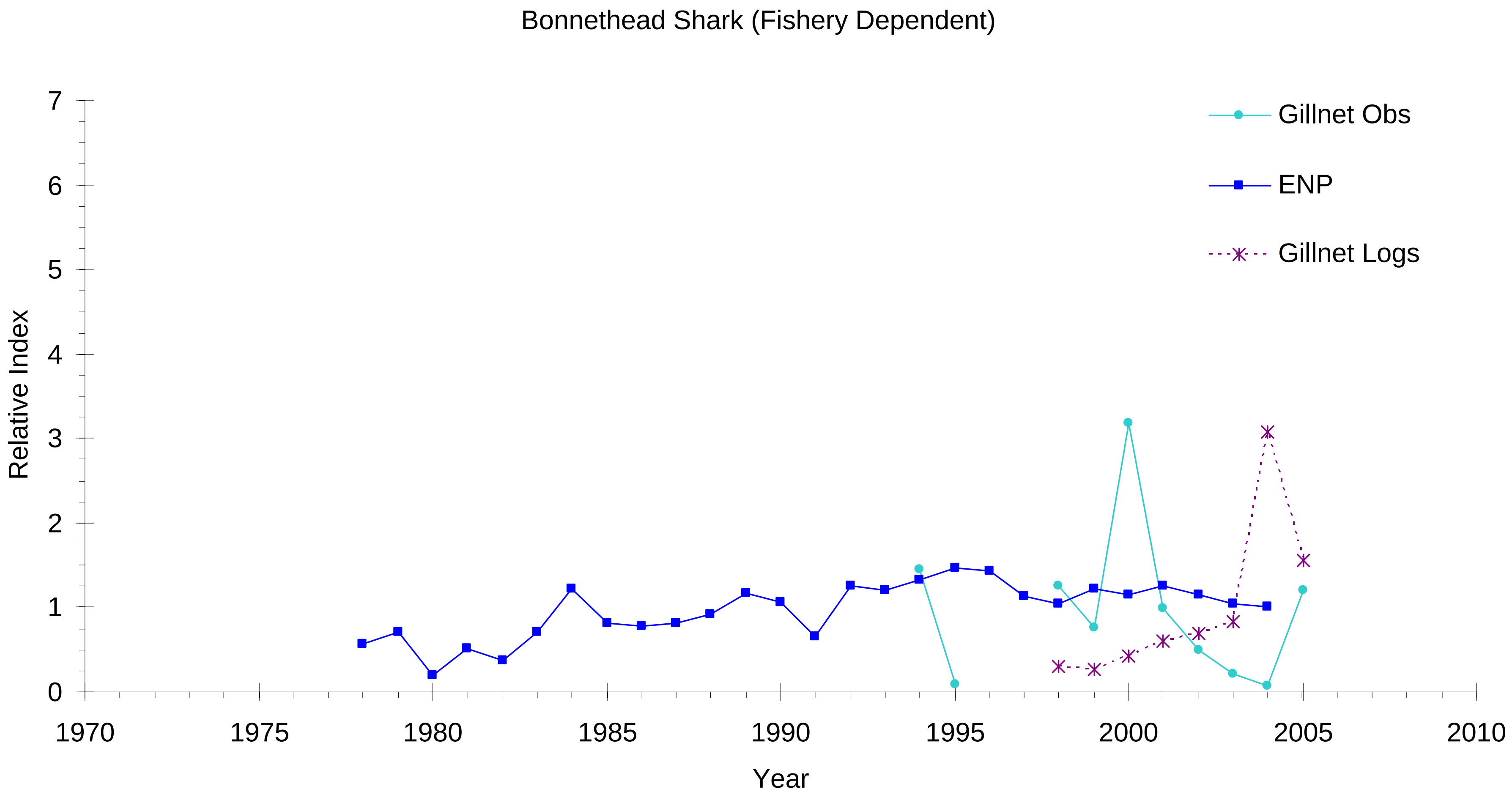


Figure 3.6. Fishery-dependent catch rate series for **bonnethead sharks**. Solid lines indicate base case indices while dashed lines are for series to be used in sensitivity analysis. Series are scaled (each series is divided by the mean of the years within that series which overlap between all series) to appear on a common scale.

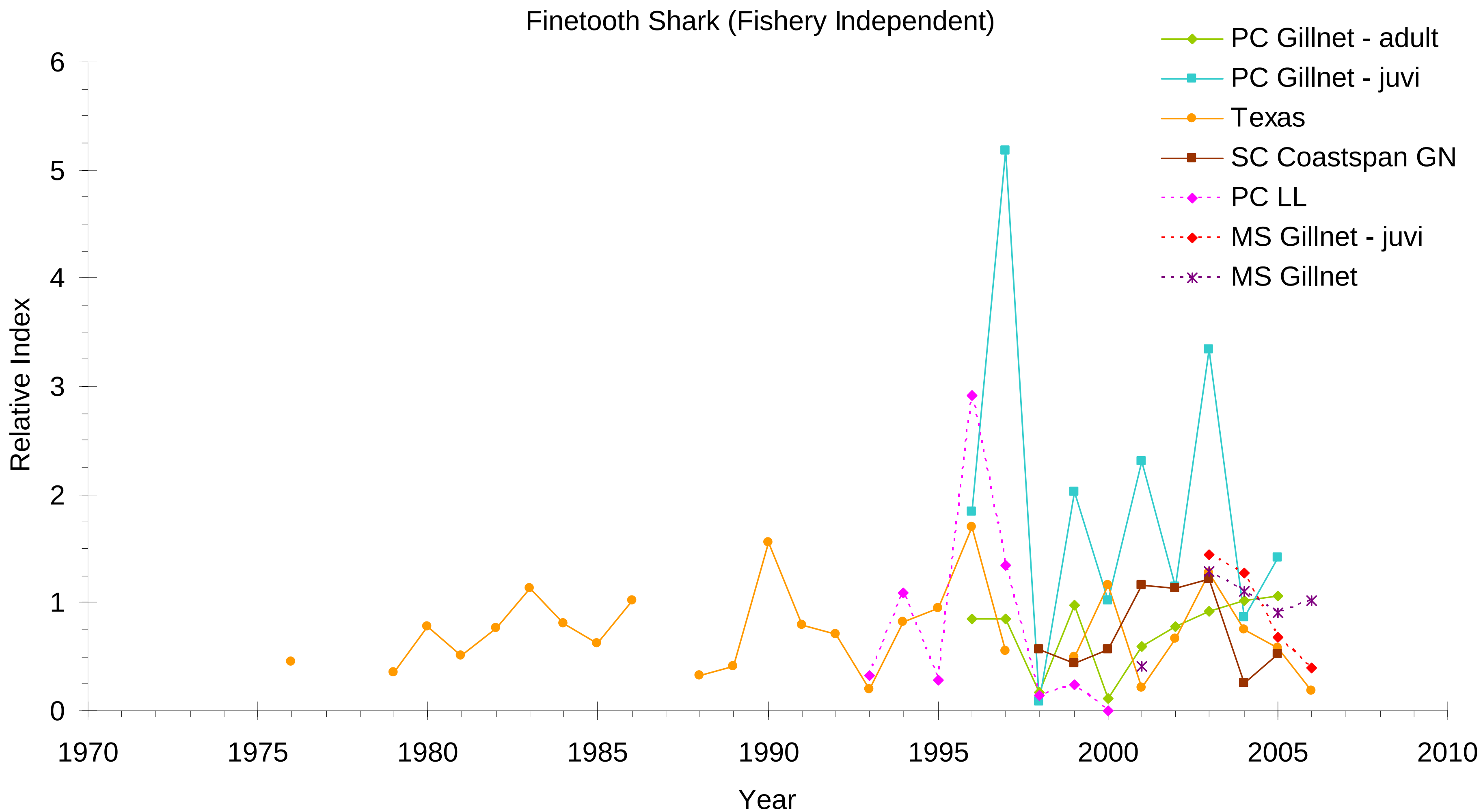


Figure 3.7. Fishery-independent catch rate series for **finetooth sharks**. Solid lines indicate base case indices while dashed lines are for series to be used in sensitivity analysis. Series are scaled (each series is divided by the mean of the years within that series which overlap between all series) to appear on a common scale.

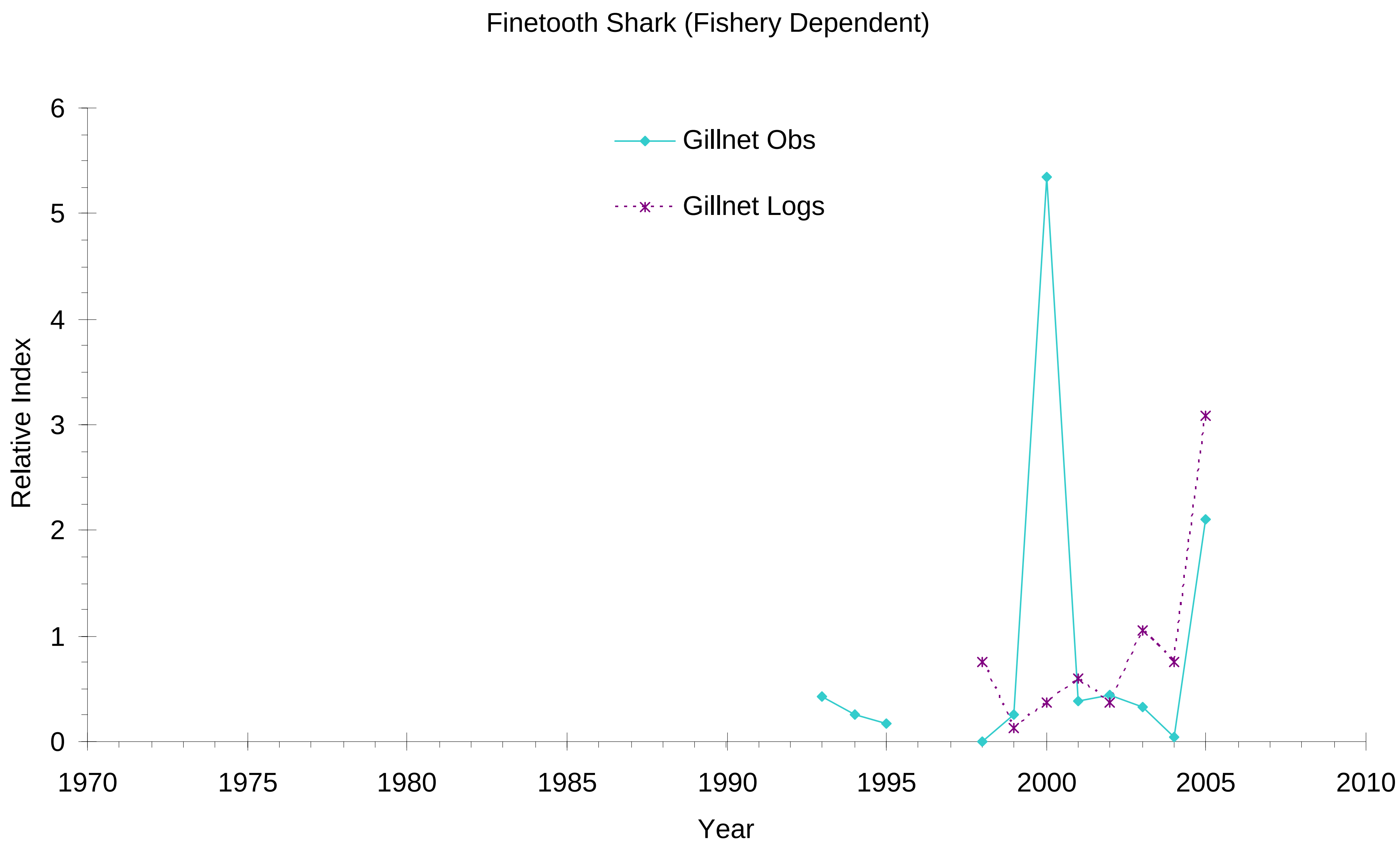


Figure 3.8. Fishery-dependent catch rate series for **finetooth sharks**. Solid lines indicate base case indices while dashed lines are for series to be used in sensitivity analysis. Series are scaled (each series is divided by the mean of the years within that series which overlap between all series) to appear on a common scale.

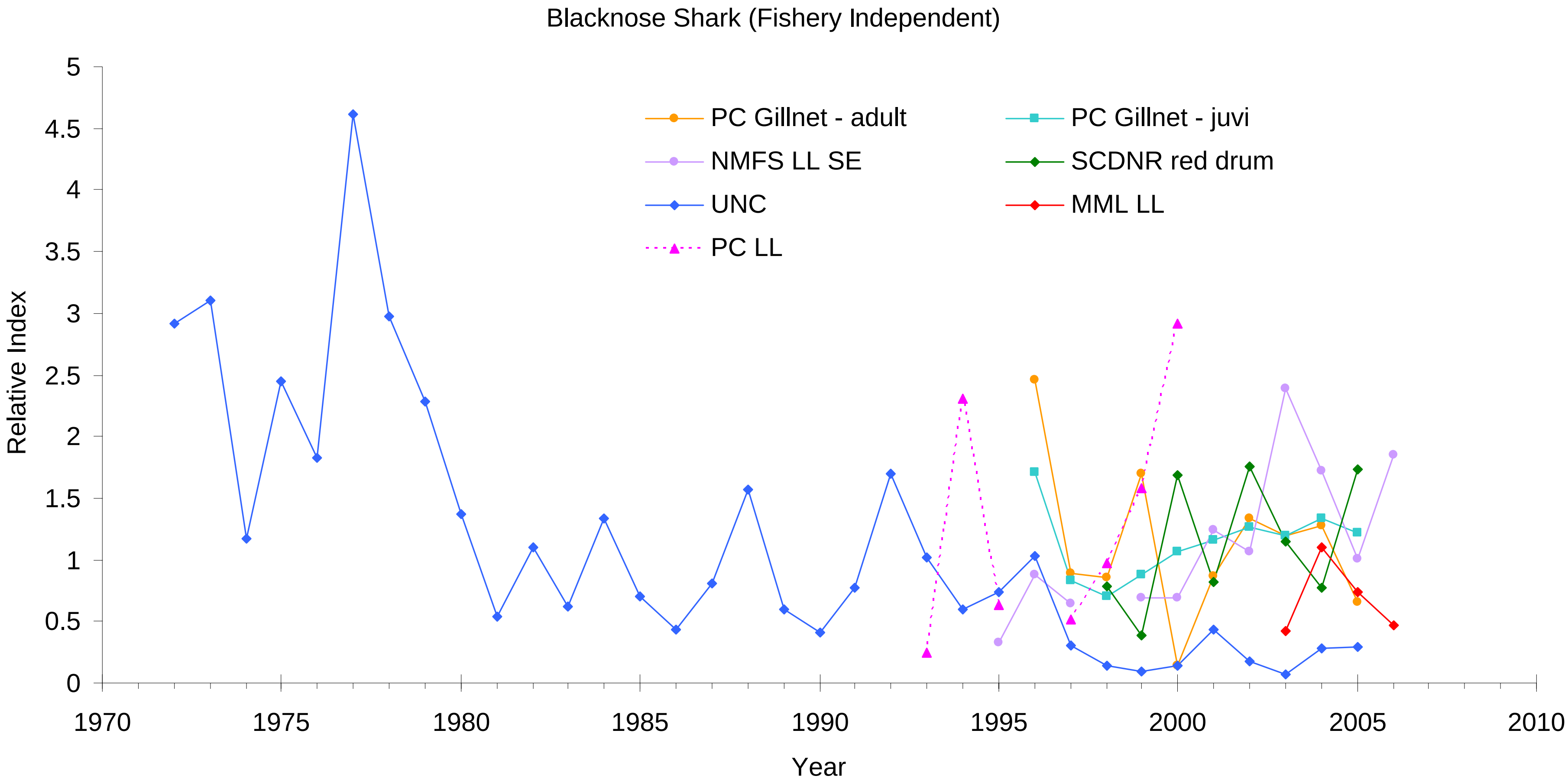


Figure 3.9. Fishery-independent catch rate series for **blacknose sharks**. Solid lines indicate base case indices while dashed lines are for series to be used in sensitivity analysis. Series are scaled (each series is divided by the mean of the years within that series which overlap between all series) to appear on a common scale.

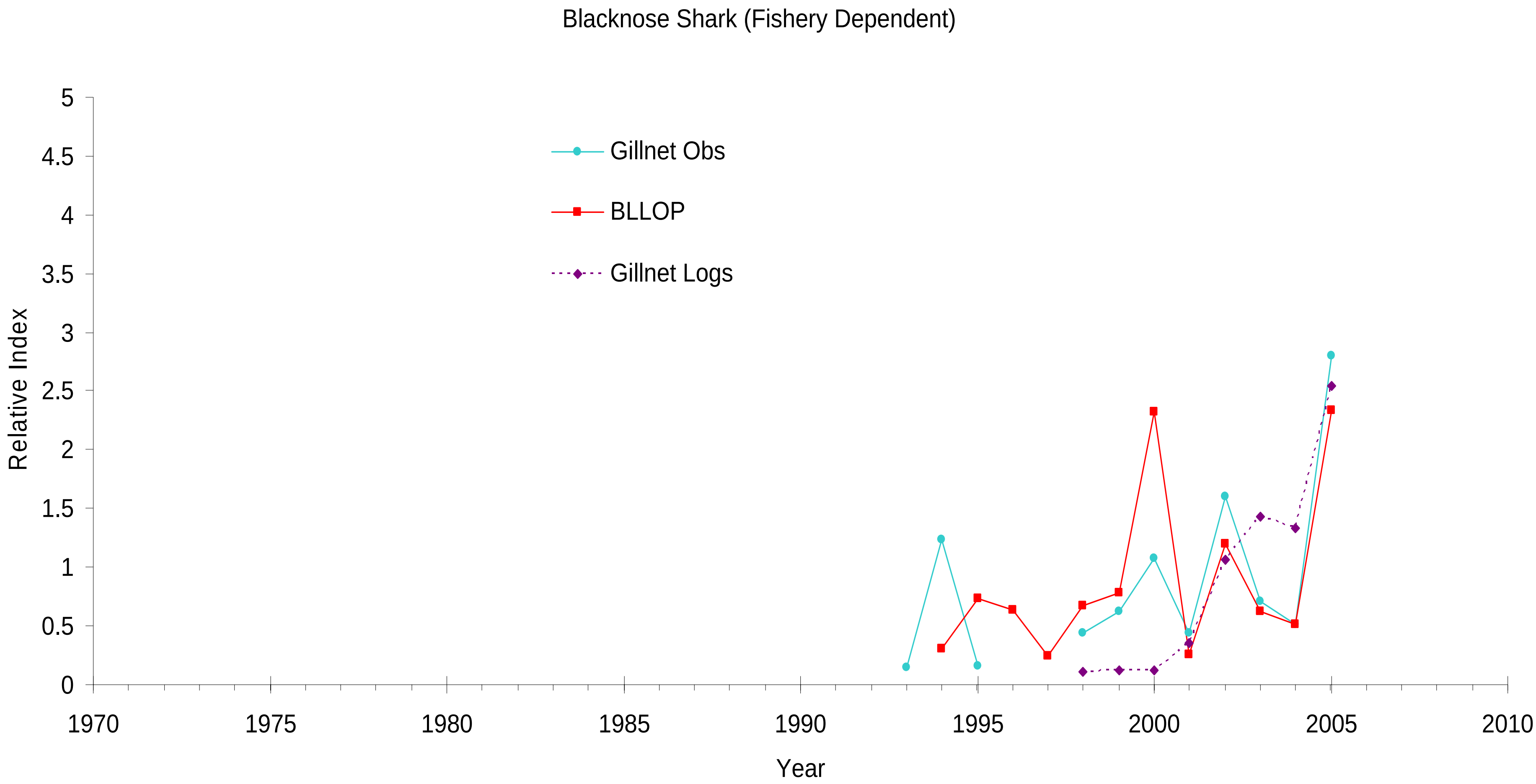
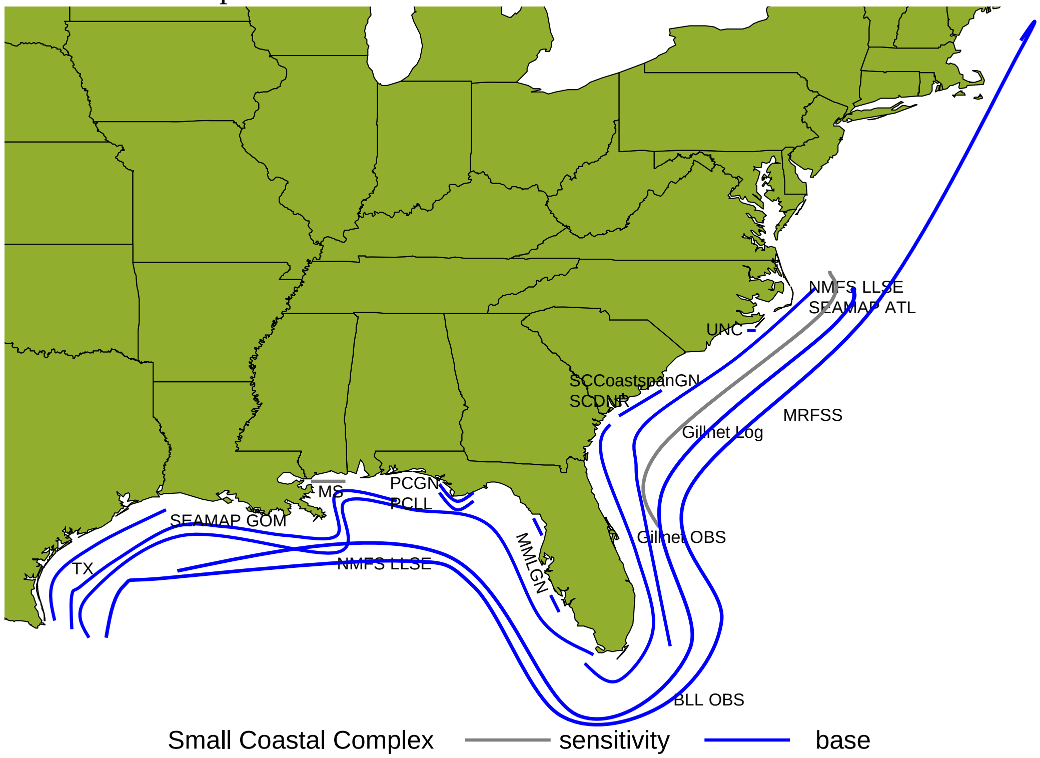


Figure 3.10. Fishery-dependent catch rate series for **blacknose sharks**. Solid lines indicate base case indices while dashed lines are for series to be used in sensitivity analysis. Series are scaled (each series is divided by the mean of the years within that series which overlap between all series) to appear on a common scale.

A. Small Coastal Complex



B. Atlantic Sharpnose Shark

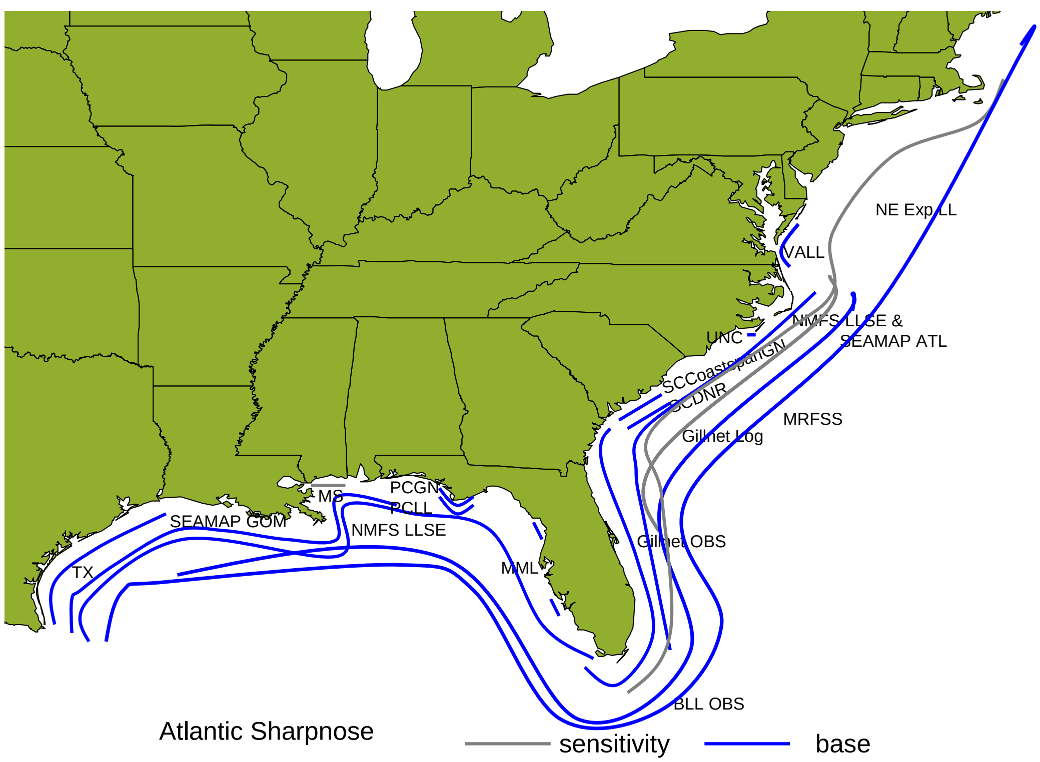
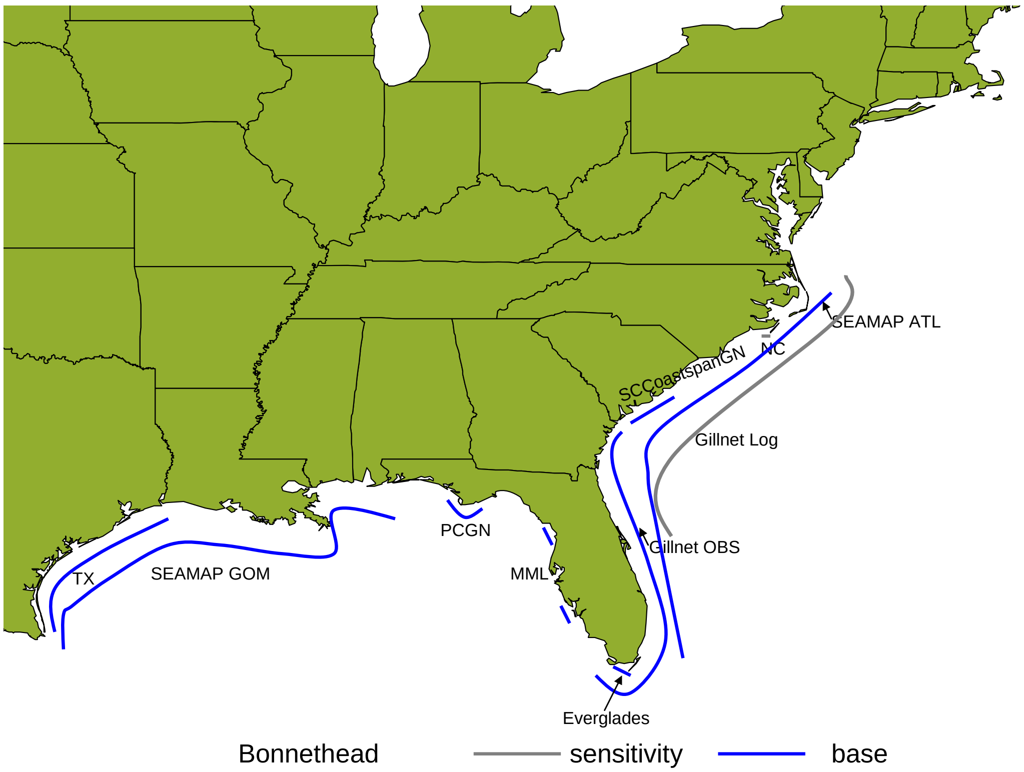


Figure 3.11. General geographic coverage of relative abundance indices reviewed at the Data Workshop.

C. Bonnethead Shark



D. Finetooth Shark

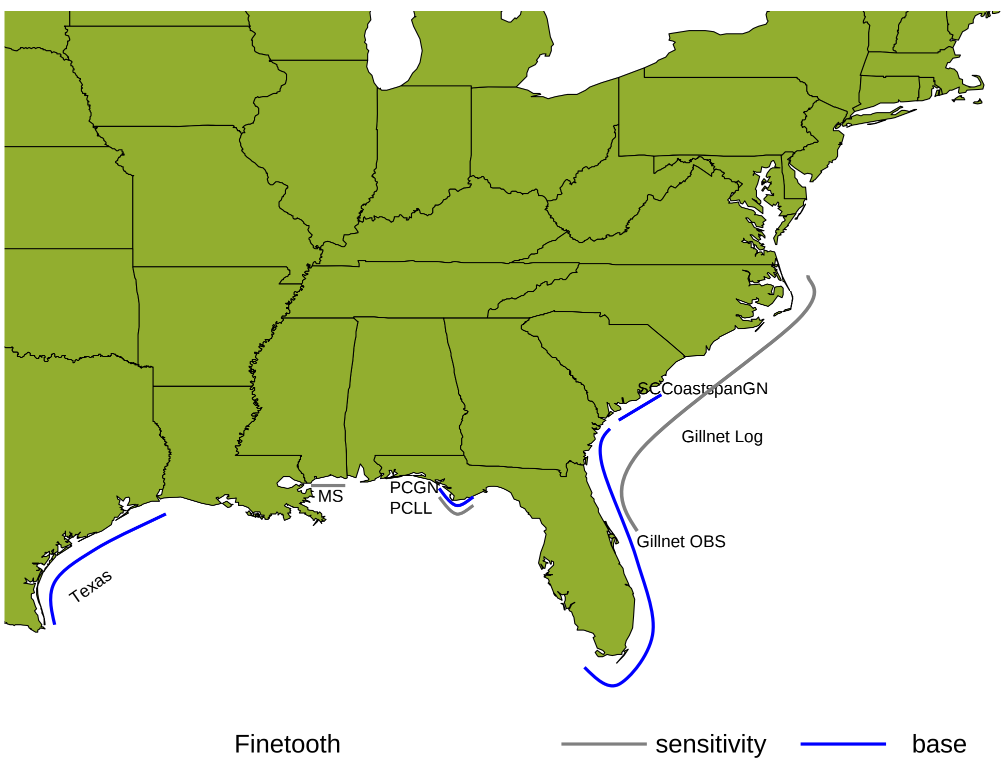


Figure 3.11. (continuted)

E. Blacknose Shark

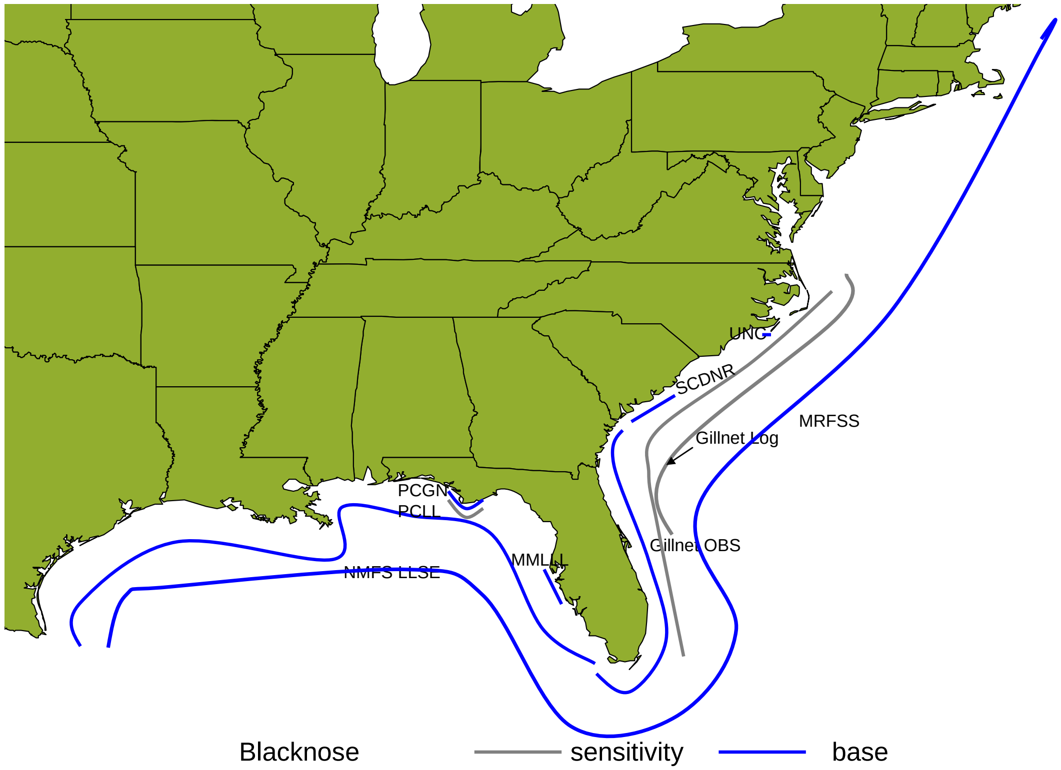


Figure 3.11 (continued)

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Appendix 2: List of SEDAR 13 DW Working Documents

SEDAR 13-DW-01: Anonymous: SEAMAP-SA shallow water trawl survey – Materials and methods

SEDAR 13-DW-02: Balchowsky and Poffenberger: Description of the databases that contain landings of shark species from the Atlantic Ocean and Gulf of Mexico

SEDAR 13-DW-03: Bethea et al.: Preliminary tag and recapture data of small coastal sharks (Atlantic sharpnose shark, *Rhizoprionodon terraenovae*, blacknose shark, *Carcharhinus acronotus*, bonnethead shark, *Sphyrna tiburo*, and finetooth shark, *C. isodon*) in the northeastern Gulf of Mexico

SEDAR 13-DW-04: Brewster-Geisz**:** A summary of the management of Atlantic small coastal sharks

SEDAR 13-DW-05: Carlson: Standardized catch rates of small coastal sharks from a fishery-independent longline survey in northwest Florida

SEDAR 13-DW-06: Carlson and Bethea: Standardized catch rates of small coastal sharks from a fishery-independent gillnet survey in northwest Florida

SEDAR 13-DW-07: Carlson and Cortés: Gillnet selectivity of small coastal sharks off the southeastern United States

SEDAR 13-DW-08: Carlson and Loefer: Life history parameters for Atlantic sharpnose sharks, *Rhizoprionodon terraenovae*, from the United States South Atlantic Ocean and northern Gulf of Mexico

SEDAR 13-DW-09: Carlson et al.: The Directed Shark Drift Gillnet Fishery: Characterization of the Small Coastal Shark Catch, Average Size and Standardization of Catch Rates from Observer Data

SEDAR 13-DW-10: Carlson et al: Standardized catch rates of bonnetheads from the Everglades National Park creel survey, 1978-2004

SEDAR 13–DW-11: Carlson et al.: Life history parameters for finetooth sharks, *Carcharhinus isodon*, from the United States South Atlantic Ocean and northern Gulf of Mexico

SEDAR 13-DW-12: Carlson et al.: Standardized catch rates of small coastal sharks from the Commercial Shark Fishery Longline Observer Program, 1994-2005

SEDAR 13-DW-13: Cortés: 2002 Stock assessment of small coastal sharks in the U.S. Atlantic and Gulf of Mexico

SEDAR 13-DW-14: Cortés and Boylan: Standardized catch rates of Small Coastal Sharks from the SEAMAP-South Atlantic Shallow Water Trawl Survey

SEDAR 13-DW-15: Cortés and Neer: Updated catches for Atlantic small coastal sharks

SEDAR 13-DW-16: Cortés: Standardized catch rates of bonnethead, Atlantic sharpnose shark, and the small coastal shark complex from the Marine Recreational Fishery Statistics Survey (MRFSS)

SEDAR 13-DW-17: Driggers et al.: Life history and population genetics of blacknose sharks, *Carcharhinus acronotus*, in the western North Atlantic Ocean and the northern Gulf of Mexico

SEDAR 13-DW-18: Fisher: Fishery-Independent Catch of Small Coastal Sharks in Texas Bays, 1975-2006

SEDAR 13-DW-19: Grubbs et al.: Occurrence of small coastal sharks and standardized catch rates of Atlantic sharpnose sharks in the VIMS Longline Survey: 1974-2005

SEDAR 13-DW-20: Hale et al.: Bottom Longline Observer Program: small coastal shark catch and bycatch 1994 to 2005

SEDAR 13-DW-21: Hoffmayer and Ingram: Catch Rates and Size Composition of Small Coastal Sharks Collected During a Gillnet Survey of Mississippi Coastal Waters During 2001–2006

SEDAR 13-DW-22: Ingram et al.: Catch rates, distribution and size composition of small coastal sharks collected during NOAA Fisheries Bottom Longline Surveys from the U.S. Gulf of Mexico and U.S. Atlantic Ocean

SEDAR 13-DW-23: Kohler & Turner: Preliminary mark/recapture data for four species of small coastal sharks in the western North Atlantic

SEDAR 13-DW-24: Lombardi-Carlson: Life history traits of bonnethead sharks, *Sphyrna tiburo*, from the eastern Gulf of Mexico

SEDAR 13-DW-25: Mello et al.: Standardized catch rates of Atlantic sharpnose, *Rhizoprionodon terraenovae*, observed by the Northeast Fisheries Observer Program in the gillnet fishery from 1995-2005

SEDAR 13-DW-26: McCarthy: Standardized catch rates for small coastal sharks from the United States Gulf of Mexico and south Atlantic gillnet fishery, 1998-2005

SEDAR 13-DW-27: McCandless and Belcher: Standardized catch rates of small coastal sharks from the Georgia COASTSPAN and GADNR penaeid shrimp and blue crab assessment surveys

SEDAR 13-DW-28: McCandless and Hoey: Standardized catch rates for Atlantic sharpnose sharks from exploratory longline surveys conducted by the Sandy Hook, NJ and Narragansett, RI labs: 1961-1991

SEDAR 13-DW-29: McCandless and Natanson: Standardized catch rates for Atlantic sharpnose sharks from the NMFS Northeast Longline Survey

SEDAR 13-DW-30: McCandless et al.: Standardized catch rates of small coastal sharks from the South Carolina COASTSPAN and SCDNR red drum surveys

SEDAR 13-DW-31: Nichols: Indexes of abundance for small coastal sharks from the SEAMAP trawl surveys

SEDAR 13-DW-32: Nichols: Bycatch of small coastal sharks in the offshore shrimp fishery

SEDAR 13-DW-33: Risenhoover: Memo regarding Management Needs for Upcoming Small Coastal Shark (SCS) Stock Assessment

SEDAR 13-DW-34: Schwartz et al.: Trends in relative abundance of shark species caught during a University of North Carolina longline survey between 1972 and 2005 in Onslow Bay, NC

SEDAR 13-DW-35: Siegfried: The estimation of small coastal shark bycatch in the shrimp trawl fishery of the south Atlantic

SEDAR 13-DW-36: Tyminski et al.: Tag-recapture results of small coastal sharks (*Carcharhinus acronotus, C. isodon, Rhizoprionodon terraenovae*, and *Sphyrna tiburo*) in the Gulf of Mexico

SEDAR 13-DW-37: Tyminski et al.: Relative abundance of blacknose sharks, *Carcharhinus acronotus,* from coastal shark surveys in the eastern Gulf of Mexico, 2001–2006

SEDAR 13-DW-38: Ubeda et al.: Relative abundance of bonnethead, *Sphyrna tiburo*, and Atlantic sharpnose sharks, *Rhizoprionodon terraenovae*, in two Florida Gulf estuaries, 1995-2004

SEDAR 13-DW-39: Wiley and Simpfendorfer: Range extension: occurrence of the finetooth shark (*Carcharhinus isodon*) in Florida Bay

SEDAR 13-DW-40: Wilson and Clark: Small coastal sharks collected under the exempted fishing program managed by the Highly Migratory Species Management Division

SEDAR 13-DW-41: McCarthy: Standardized catch rates for small coastal sharks from the United States Gulf of Mexico and south Atlantic bottom longline fishery, 1996-2005

SEDAR 13

Stock Assessment Report

Small Coastal Shark Complex, Atlantic Sharpnose, Blacknose, Bonnethead, and Finetooth Shark

Section III: Assessment Workshop Report

SEDAR 13

SMALL COASTAL SHARKS

ASSESSMENT WORKSHOP REPORT

Prepared by the
SEDAR 13 Stock Assessment Panel
9 July 2007

Contents:

1. Introduction

The current assessment for the Small Coastal Shark (SCS) Complex was to be run following, as close as possible, the procedures of the Southeast Data, Assessment, and Review (SEDAR) process. The process involves three meeting Workshops: Data, Assessment, and Review. The Data Workshop (DW) for the SCS complex was held in Panama City, FL February 5-9 2007. The Assessment Workshop (AW) was also held in Panama City, FL May 7 – 11 2007. Initial data compilations and exploratory analyses for SEDAR assessments were requested from participants in the form of "working documents" to be submitted in advance and evaluated over the course of the workshop.

This Report represents the discussions, analyses, and stock status determinations for five separate assessments: 1) SCS complex, 2) finetooth shark, 3) blacknose shark, 4) Atlantic sharpnose shark and 5) bonnethead shark. These assessments are being reported in one Report as many of the indices, data, and issues overlap among assessments. All discussions were conducted in a plenary format, with analysts conducting requested sensitivities and modifications and reporting back to the panel throughout the week.

This report is divided into four main sections, paralleling the separate assessments conducted. Structure within each section was determined by the lead analyst, following some general guidelines derived from SEDARs for other species and the content previously reported from Shark Evaluation Workshops (SEWs). The SCS complex, and the individual species have been assessed in 2002 by NOAA Fisheries. Figures and tables remain within the individual sections, and are numbered in "Section number.figure number" sequence. Lists of references to the general literature (i.e. papers other than the working documents submitted to this Workshop) also remain with the individual sections. Citations to papers submitted to this workshop as "working documents" are made in the text using the identifying numbers assigned by the Shark SEDAR Coordinator (in the form SEDAR13-AW-xx).

This report is a complete and final documentation of the activities, decisions, and recommendations of the Assessment Workshop. It will also serve as one of 4 components of the final SEDAR Assessment Report. The final SEDAR Assessment Report will be completed following the last workshop in the cycle, the Review Workshop, and will consist of the following sections: I) Introduction; II) Data Workshop Report; III) Assessment Workshop Report; and IV) Review Workshop Report.

1.1 SEDAR 13 Assessment Workshop Terms of Reference

1. Select several modeling approaches based on available data sources, parameters and values required to manage the stock, and recommendations of the data workshop.
2. Provide justification for the chosen data sources and for any deviations from data workshop recommendations.
3. Provide estimates of stock parameters (fishing mortality, abundance, biomass, selectivity, stock-recruitment relationship, etc); include appropriate and representative measures of precision for parameter estimates and measures of model ‘goodness of fit’.
4. Characterize uncertainty in the assessment, considering components such as input data, modeling approach, and model configuration.
5. Provide complete SFA criteria. This may include evaluating existing SFA benchmarks or estimating alternative SFA benchmarks (SFA benchmarks include MSY, Fmsy, Bmsy, MSST, and MFMT); recommend proxy values where necessary; provide stock control rules.
6. Provide declarations of stock status relative to SFA benchmarks: MSY, Fmsy, Bmsy, MSST, MFMT. Project future stock conditions (biomass, abundance, and exploitation) and develop rebuilding schedules if warranted; include estimated generation time. Stock projections will be based on constant quotas or various F criteria.
7. Evaluate the results of past management actions and probable impacts of current management actions with emphasis on determining progress toward stated management goals.
8. Provide recommendations for future research and data collection (field and assessment); be as specific as practicable in describing sampling design and sampling intensity.
9. Provide the Assessment Workshop Report (Section III of the SEDAR Stock Assessment Report) including tables of estimated values within 5 weeks of workshop conclusion. SEE NOTE.

REPORT COMPLETION NOTE: The final Assessment Workshop report is due no later than Monday, June 18 2007. If final assessment results are not available for review by workshop panelists during the workshop, the panel shall determine deadlines and methods for distribution and review of the final results and completion of the workshop report.

1.2 SEDAR 13 AW Participants

Workshop participants:

Liz Brooks	NMFS/ SEFSC Miami, FL
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Enric Cortés	NMFS/ SEFSC Panama City, FL
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1.3 SEDAR 13 Assessment Workshop Documents

SEDAR 13-AW-01	Cortés: Assessment of Small Coastal Sharks, Atlantic sharpnose, Bonnethead, Blacknose and Finetooth Sharks using Surplus Production Methods
SEDAR 13-AW-02	Siegfried et al: Determining Selectivities for Small Coastal Shark Species for Assessment Purposes
SEDAR 13-AW-03	Siegfried and Brooks: Assessment of Blacknose, Bonnethead, and Atlantic Sharpnose Sharks with a State-Space, Age-Structured Production Model

SMALL COASTAL SHARK COMPLEX ASSESSMENT

2. SMALL COASTAL SHARK COMPLEX ASSESSMENT

2.1 Summary of SCS Complex Working Documents

SEDAR13-AW-01
Assessment of Small Coastal Sharks, Atlantic sharpnose, Bonnethead, Blacknose and Finetooth Sharks using Surplus Production Methods
We used two complementary surplus production models (BSP and WinBUGS) to assess the status of the Small Coastal Shark (SCS) complex and four individual species (Atlantic sharpnose, bonnethead, blacknose, and finetooth sharks) identified as baseline scenarios in the SCS Data Workshop report. Both methodologies use Bayesian inference to estimate stock status, and the BSP further performs Bayesian decision analysis to examine the sustainability of various levels of future catch. Extensive sensitivity analyses were performed with the BSP model to assess the effect of different assumptions on CPUE indices and weighting methods, catches, intrinsic rate of increase, and importance function on results. Baseline scenarios predicted that the stock status is not overfished and overfishing is not occurring in all cases. Using the inverse variance method to weight the CPUE data was problematic because of the nature of the CPUE time series and must be regarded with great caution, although predictions on stock status did not change, except for blacknose sharks. The alternative surplus production model implemented in WinBUGS supported the results from the BSP model, with the exception of blacknose sharks, which became overfished. None of the other sensitivity analyses examined had a large impact on results and did not affect conclusions on stock status in any case. Only blacknose sharks with the alternative catch scenario approached an overfishing condition.

2.2 Background

The Small Coastal Shark (SCS) complex was assessed in 2002 (Cortés 2002) using a variety of surplus production methods and a form of delay-difference model (lagged recruitment, survival and growth model). The SCS SEDAR Data Workshop (DW) panel and report recommended that the SCS complex and the finetooth shark be assessed with surplus production methods alone because of the nature of the complex (composed of the sum of four individual species with different life histories) and the lack of adequate biological data to conduct an age-structured assessment for the finetooth shark.

1.3 Available Models

Two surplus production modeling approaches were available for discussion (SEDAR13-AW-01):

1) Bayesian surplus production model (BSP)
2) WinBUGS state-space Bayesian surplus production model

The Bayesian Surplus Production (BSP) model program fits a Schaefer model to CPUE and catch data using the SIR algorithm. The BSP software is available, for example, in the ICCAT catalog of methods (McAllister and Babcock 2004) and has been used as the base model in previous assessments of large and small coastal sharks as well as pelagic sharks.

The WinBUGS implementation of the Schaefer surplus production model uses Gibbs sampling, an MCMC method of numerical integration, to sample from the posterior distribution (Spiegelhalter et al. 2000). The model was originally developed by Meyer and Millar (1999a) and modified by Cortés (2002) and Cortés et al. (2002) to apply it to small and large coastal sharks, respectively.

The BSP was selected as the final baseline model because it generally provides a more flexible framework for examining the effects of various modeling issues (e.g., type of importance function used for Bayesian estimation, multiple CPUE weighting methods) and conducts Bayesian decision analysis to project population status into the future and estimate performance indicators under various management policies.

2.4 Model Scenarios

The Assessment Workshop (AW) panel recommended that surplus production models be used to assess the status of the SCS complex and finetooth sharks. Surplus production models were the only type of model presented for the SCS complex and finetooth sharks following the recommendations of the Data Workshop (DW) panel and report. Additionally, surplus production models were also used to assess the status of Atlantic sharpnose, bonnethead and blacknose sharks in document SEDAR13-AW-01, but those results are not presented herein. In the present document we thus assessed the status of the SCS complex (consisting of four species).

2.5. Discussion of weighting methods

The Data Workshop Panel recommended that *equal weighting* for assigning weights to the different CPUE time series available during model fitting should be used for the baseline runs. The panel discussed the advantages and disadvantages of the *equal weighting* vs. the *inverse CV weighting* methods:

Equal weighting ignores the better quality of some data (smaller CVs) but is more stable between assessments because yearly changes on CVs in a given CPUE series do not affect the importance of that time series for the overall fit.

Inverse CV weighting can provide better precision as it tracks individual indices however, it could be less stable between assessments due to changes on the relative ‘noise’ of each time series. This method may also not be appropriate in cases in which different standardization techniques have been used for the standardization of the series and therefore, the same value of CV might reflect different levels of error depending on the CPUE it corresponds to.

The Assessment Workshop Panel further discussed the issue for weighting indices. It was noted that there are a variety of ways to weight indices in addition to equal and inverse CV weighting, however how to determine which weighting method is most appropriate is a discussion topic that is still without satisfying resolution. Given that fact, the Assessment Workshop Panel decided that equal weighting would be the base weighting method for the current assessment but noted that, as there is at present no objective way to decide which method is superior other than comparing model convergence diagnostics, future assessments may need to re-examine this issue.

2.6 Methods

2.6.1 Bayesian Surplus Production (BSP) Model description

The Bayesian Surplus Production (BSP) model program fits a Schaefer model to CPUE and catch data using the SIR algorithm. The BSP software is available, for example, in the ICCAT catalog of methods (McAllister and Babcock 2004) and has been used as the base model in previous assessments of large and small coastal sharks. Herein we used the discrete-time version of the model (although the continuous form is also implemented by the software), so that:

$$B_{t+1} = B_t + rB_t - \frac{r}{K} B_t^2 - C_t$$

where B_t= biomass at the beginning of year t, r is the intrinsic rate of increase, K is carrying capacity and C_t is the catch in year t.

The expected catch rate (CPUE) for each of the available time series j in year t is given by:

$$\hat{I}_{j,t} = q_j B_t e^{\varepsilon_t}$$

where q_j is the catchability coefficient for CPUE series j, and ε_t is the residual error, which is assumed to be lognormally distributed. The program allows for a variety of methods to weight CPUE data points. As recommended in the DW report, we used equal weighting (or no weighting) in all baseline scenarios. The model log-likelihood is given by:

$$\ln L = -\sum_j \sum_y \frac{\left[\ln(I_{j,y}) - \ln(\hat{q}_j \hat{B}_y)\right]^2}{2\sigma_{j,y}^{2}}$$

where $I_{j,y}$ is the CPUE in year y for series j, $\hat{q}_j$ is the constant of proportionality for series j, $\hat{B}_y$ is the estimated biomass in year y, and $\sigma_{j,y}^{2}$ is the variance (=1/weight; in this case weight=1) applied to series j in year y.

In the inverse variance method, the annual observations are proportional to the annual CV^2 (if available) and the average variance for each series is equal to the MLE estimate. The log likelihood function is expressed as:

$$\ln L = -\sum_{j=1}^{j=s}\sum_{t=1}^{t=y} \left\{ \frac{0.5}{c_j CV_{j,t}{}^2 \Box \sigma_j{}^2} \left[\ln\left(\frac{I_{j,t}}{q_j N_t} \right) \right]^2 - 0.5\ln(c_j CV_{j,t}{}^2 \Box \sigma_j^2 \ ) \right\}$$

where s is the number of CPUE series, y is the number of years in each CPUE series, $CV_{j,t}^2$ is the coefficient of variation for series j in year t, c_j is a constant of proportionality for each series j chosen such that the average variance for each series equals its estimated average variance, σ_j^2 (the MLE estimate). The catchability coefficient for each time series (q_j) is also estimated as the MLE such that:

$$\hat{q}_j = e^{\left(\frac{\sum_{t=1}^{t=y} \left(\ln(I_{j,t}) - \ln(B\Box_t) \right) / c_j CV_{j,t}{}^2 \Box \sigma_j{}^2}{\sum_{t=1}^{t=y} 1/(c_j CV_{j,t}{}^2 \Box \sigma_j{}^2)} \right)}$$

2.6.2 WinBUGS State-Space Bayesian Surplus Production Model description

This implementation of the Schaefer surplus production model uses Gibbs sampling, an MCMC method of numerical integration, to sample from the posterior distribution using WinBUGS (Spiegelhalter et al. 2000). The model was originally developed by Meyer and Millar (1999a) and modified by Cortés (2002) and Cortés et al. (2002) to apply it to small and large coastal sharks, respectively. To minimize correlations between model parameters and speed mixing of the Gibbs sampler, the surplus production model is reparameterized by expressing the annual biomass as a proportion of carrying capacity:

$$P_t = P_{t-1} + rP_{t-1}(1 - P_{t-1}) - \frac{C_{t-1}}{K} e^{P_t}$$

where $P_t = B_t/K$. The model is a state-space model, which relates the observed catch rates (I_t) to unobserved states (B_t) through a stochastic observation model for I_t given Bt (Millar and Meyer 1999, Meyer and Millar 1999b):

$$I_t = qKP_t e^{O_t}$$

The model thus assumes lognormal error structures for both process and observation errors (e^P and e^O), with $P_t \sim N(0,\sigma^2)$ and $O_t \sim N(0,\tau^2)$. In the present implementation, the catchability coefficient for each CPUE series is taken as the MLE.

The crucial equation for Bayesian inference is the joint posterior distribution of the unobservable states given the data, which is equal to the product of the joint prior distribution and the sampling distribution (likelihood):

$$
\begin{aligned}
&p(K, r, q, C_0, P_{72}, \sigma^2, \tau^2, P_1, ..., P_n, I_1, ..., I_n) = \\
&p(K)\,p(r)\,p(q)\,p(C_0)\,p(P_{72})\,p(\sigma^2)\,p(\tau^2)\,p(P_1 \mid \sigma^2) \\
&\times \prod_{i=2}^{i=m+1} p(P_t \mid P_{t-1}, K, r, C_0, P_{72}\sigma^2) \prod_{i=m+2}^{i=n} p(P_t \mid P_{t-1}, K, r, P_{72}, \sigma^2) \prod_{t=1}^{t=n} p(I_t \mid P_t, q, \tau^2)
\end{aligned}
$$

where $P_{72}=N_{72}/K$ and m is the number of years of unobserved catches, if applicable (C_0).

2.6.3 Data inputs, prior probability distributions, and performance indicators

Catch data (in numbers) were available from 1972 to 2005 (**Table 2.1**) and CPUE data, also from 1972 to 2005, as provided in the DW report. Thirteen CPUE series identified as "base" in the DW report were used in the baseline scenario. All CPUE series are listed in Appendix 1. The fishery was assumed to begin in 1972, the first year for which CPUE data were available. Estimated parameters were r, K, and the abundance (in numbers) in 1972 relative to K (N_{72}/K). The constant of proportionality between each abundance index and the biomass trend was calculated using the numerical shortcut of Walters and Ludwig (1994). The prior for K was uniform on log (K), weakly favoring smaller values, and was allowed to vary between 10^4 and 10^8 individuals. Informative, lognormally distributed priors were used for N_{72}/K and r. For N_{72}/K, the mean was set equal to 0.9 to reflect some depletion with respect to virgin levels, and the log-SD was 0.2. For r, there was no specific value recommended in the DW report; the mean was thus taken as the average of the values for the four individual species, weighted by their percent contribution to the total catch (0.17 yr^{-1}). For SD, we used a value of 0.32, which corresponds to a log-variance of 0.10 (the BSP uses variance as an input) and which is approximately of the same magnitude with respect to the mean as the value used for SCS in the 2002 assessment. Input values are listed in **Table 2.2**.

The input parameters and priors described above are those used in the BSP model. Model inputs and priors used with WinBUGS were almost exactly the same. Additionally, priors for the observation error variance (τ^2) and process error variance (σ^2) in the WinBUGS model were inverse gamma distributions as used in previous stock assessments (Millar and Meyer 1999, Cortés et al. 2002), i.e., the 10% and 90% quantiles were set at approximately 0.05 and 0.15, and 0.04 and 0.08, respectively.

Performance indicators for the BSP model included the maximum sustainable yield (MSY=rK/4), the stock abundance in the last year of data (N_{2005}), the ratio of stock abundance in the last year of data to carrying capacity and MSY (N_{2005}/K and N_{2005}/MSY), the fishing mortality rate in the last year of data as a proportion of the fishing mortality rate at MSY (F_{2005}/F_{MSY}), the catch in the last year of data as a proportion of the replacement yield (C_{2005}/R_y) and MSY (C_{2005}/MSY), the stock abundance in the first year of the model (N_{init}), and the ratio of stock abundance in the last and first years of the model (N_{2005}/N_{init}). The same metrics, except for those containing replacement yield, were calculated for the WinBUGS model. Additionally, the relative abundance (N_i/N_{MSY}) and fishing mortality (F_i/F_{MSY}) trajectories, as well as the predicted abundance trend, were obtained and plotted for the time period considered in each scenario.

2.6.4 Methods of numerical integration, convergence diagnostics, and decision analysis

For the BSP model, numerical integration was carried out using the SIR algorithm (Berger 1985, McAllister and Kirkwood 1998, McAllister et al. 2001) built in the BSP software. The marginal posterior distributions for each of the population parameters of interest were obtained by integrating the joint probability with respect to all the other parameters. Posterior CVs for each population parameter estimate were computed by dividing the posterior SD by the posterior expected value (mean) of the parameter of interest. Two importance functions were used in the SIR algorithm (depending on which function produced better convergence diagnostics): the multivariate Student t distribution and the priors. For the multivariate Student t distribution, the mean is based on the posterior mode of θ (vector of parameter estimates K, r, B_{init}/K, and C_0 if applicable), and the covariance of θ is based on the Hessian estimate of the covariance at the mode (see McAllister and Kirkwood [1998] and references therein for full details). A variance expansion factor of at least 2 was generally used to make the importance function more diffuse (wider) and ensure that the variance of the parameters was not underestimated when using the multivariate Student t distribution.

WinBUGS uses an MCMC method called Gibbs sampling (Gilks et al. 1996) to sample from the joint posterior distribution. All runs were based on two chains of initial values (where the P_t values were set equal to 0.5 and 1.0, respectively) to account for over-dispersed initial values (Spiegelhalter et al. 2000), and included a 5,000 sample burn-in phase followed by a 100,000 iteration phase with a thinning rate of 2.

Convergence diagnostics for the BSP model included the ratio of the CV of the weights to the CV of the product of the likelihood function and the priors, with values <1 indicating convergence and values >10 indicating likely convergence failure, and the maximum weight of any draw as a fraction of the total importance weight, which should be less than 0.5% (SB-02-25; McAllister and Babcock 2004).

In the WinBUGS analyses, convergence of the MCMC algorithm for the two chains was tested by examining the time series history of the two MCMC chains to determine whether mixing was good, parameter autocorrelations, and the convergence diagnostic of Gelman and Rubin (Gelman and Rubin 1992).

For the BSP model, posterior expected values for several indices of policy performance were calculated using the resampling portion of the SIR algorithm built in the BSP software, which involves randomly drawing 5,000 values of θ with replacement from the discrete approximation to the posterior distribution of θ, with the probability of drawing each value of θ being proportional to the posterior probability calculated during the importance sampling phase. Details of this procedure can be found in McAllister and Kirkwood (1998) and McAllister et al. (2001), and references therein. Once a value of θ was drawn, the model was projected from the initial year of the model to 2005, and then forward in time up to 30 years to evaluate the potential consequences of future management actions. The exploratory policies considered included setting the total allowable catch (TAC) equal to 0, to the catch in 2005, and doubling the 2005 catch. The projections included calculating the following reference points, among others: expected value of N_{fin}/K (with fin=2015, 2025, and 2035) and the probabilities that N_{fin} were $< 0.2K$ and $N_{fin} > N_{msy}$.

2.6.5 Sensitivity analyses

We conducted sensitivity analyses to explore the influence of multiple factors (sources of uncertainty) on results by changing the following items with respect to those in the baseline scenario one at a time. All sensitivities were implemented with the BSP model.

W—Sensitivity to model, sources of error and method of numerical integration used: this involved using a complementary surplus production model (in WinBUGS) that also takes into account process error (vs. observation error only in the BSP), and uses MCMC for numerical integration (vs. the SIR algorithm in the BSP)

WM—Sensitivity to weighting scheme used: this involved changing the method for weighting the CPUE series from equal weighting in the baseline scenario to inverse variance weighting

IF—Sensitivity to importance function used: this involved changing the importance function from the priors to a multivariate t distribution. Only results obtained using the importance function that produced the best convergence diagnostics are reported

AC—Sensitivity to extending the catch series back to 1950 to mimic the catch stream used with the age-structured model (for Atlantic sharpnose, bonnethead, and blacknose sharks)

ALL—Adding the CPUE series identified as "sensitivity" in Table 3.2 of the DW report to those in the baseline scenario

2.7 Results

2.7.1 Baseline scenarios

Figure 2.1 shows the relative contribution of the four individual species to the small coastal shark complex catches. Except for 1995, when bonnetheads were more important, commercial landings were dominated by Atlantic sharpnose, finetooth, and blacknose sharks. Atlantic sharpnose sharks were the dominant species caught recreationally, followed by bonnethead and blacknose sharks, whereas finetooth sharks are rarely reported caught. Bycatch in the shrimp trawl fishery also consists mostly of Atlantic sharpnose and bonnethead sharks, with blacknose sharks also caught, but to a much lesser degree. Estimates for finetooth sharks could not be produced (see DW report) because they are rarely caught. In all, the majority of the catches correspond to shrimp bycatch in the Gulf of Mexico (**Fig. 2.2A,B**).

The abundance trajectory at the mode of the posterior distribution showed a trend that only decreased slightly with respect to virgin levels in the early 1970s (**Fig. 2.3**). Two of the four longest CPUE series (UNC and TEXAS) showed a generally increasing trend, whereas the other two series (SEAMAP-GOM-Fall and SEAMAP-GOM-Summer) showed a flatter or slightly declining trend. Most of the other series showed increasing or fluctuating trends. The model interpreted these trends with rather flat fits (**Fig. 2.4**). The median relative biomass and fishing mortality trajectories indicated that the complex did not approach an overfished status or overfishing, respectively, in any year (**Fig. 2.5A,B**). The complete time series of median estimates of stock abundance (N_i), relative stock abundance (N_i/N_{MSY}), fishing mortality rate (F_i), and relative fishing mortality rate (F_i/F_{MSY}) are given in **Table 2.3**.

Current status of the population was accordingly above N_{MSY} and no overfishing was occurring (**Table 2.4**). The priors were used as an importance function for importance sampling. The SIR algorithm converged with good diagnostics of convergence (maximum weight of any draw <<0.5%, CV(weights) / CV(likelihood * priors) <1). The posterior distributions of K and r showed that the data supported much higher values of K and relatively higher values of r, respectively (**Fig. 2.6A,B**). The joint posterior distribution of K and r showed a large area of probability for K and a much more confined probability for r (**Fig. 2.6C**). Population projections showed that the population would be expected to remain above N_{MSY} for at least 30 years even when doubling the current level of total catch (**Table 2.5**; **Fig. 2.7**).

2.7.2 Sensitivity analyses

W: Considering an alternative model, sources of error and method of numerical integration—This involved using WinBUGS as an alternative surplus production model methodology. The median relative abundance trajectory for the WinBUGS model showed an increasing trend that never approached an overfished status. The median relative fishing mortality trajectory was very similar to that obtained with the BSP, with the only exception that the 97.5th quantile (vs. 80th quantile in the BSP) reached overfishing in a number of years. In all, current status of the population was above N_{MSY} and no overfishing was occurring (**Table 2.6**). WinBUGS model fits to the CPUE series were all increasing, with the exception of the fit to the SEAMAP-GOM-Fall series, which was decreasing and was fitted exactly to the observed data. The UNC and MML Gillnet series also showed exact, but increasing fits. Convergence diagnostics for the WinBUGS model showed that there was good mixing of the two chains for all parameters. Autocorrelations for all parameters also decreased after an initial lag, but remained high for some parameters. The Gelman-Rubin diagnostic indicated good convergence for the main parameters of interest (the ratio of the width of the central 80% interval of the pooled runs and the average width of the 80% intervals within the individual runs converged to 1 and both the pooled and within interval widths stabilized).

WM: Changing the CPUE weighting method—This involved changing the CPUE weighting method from equal weighting to inverse variance weighting. The model did not converge (**Table 2.7**). We observed that the likelihood of the fit for multiple parameter combinations attempted was very low probably because the CVs of some CPUE values were very small (<0.1) so that if those points were not fitted exactly the likelihood became very small. In general, when data are noisy and contradictory and the CVs differ by several orders of magnitude, as is the case for the SCS complex, using inverse variance methods is problematic.

AC: Extending the catch series back to 1950—This involved using the alternative catch series (Table 2.7 of the DW) to mimic the catch stream used in the age-structured models for Atlantic sharpnose, bonnethead, and blacknose sharks. This change had little impact on results (**Table 2.7**). Convergence diagnostics were good.

ALL: Adding the CPUE series identified as "sensitivity" in the DW to those from the baseline scenario—This involved adding the MS Gillnet and Gillnet Logs series. This change had little impact on results (**Table 2.7**). Convergence diagnostics were also good.

2.8 Discussion and Conclusions

The baseline scenario for the SCS complex predicted that the stock status is not overfished nor overfishing is occurring and very little depletion in numbers with respect to virgin levels (15%). The inverse variance weighting scenario did not converge. In general, when data are noisy and contradictory and the CVs differ substantially in magnitude, as was notably the case for the SCS complex, using inverse variance methods is problematic.

Other technical issues, such as the type of surplus production model, types of error and method of numerical integration, all tested by using a model developed in WinBUGS, supported the results of the baseline scenario using the BSP software. Depletions were of the same magnitude (10%) as found in the baseline scenario (15%) and the stock did not approach an overfishing condition.

The other two sensitivity analyses conducted (extending the catch series available back to 1950 and adding all the "sensitivity" CPUE series to the baseline) had essentially no effect on stock status.

The baseline scenario assumed that the stock had experienced a depletion of about 10% with respect to virgin levels at the beginning of the model, when data were first available (1972). The catch reconstruction (to 1950) scenario was an attempt to account for some historical level of exploitation, but nevertheless resulted in the same conclusions on stock status as the baseline scenario.

Figure 2.8 is a phase plot summarizing the results on stock status found in the baseline scenario and sensitivity analyses in the present assessment of the SCS complex. The plot also shows the baseline results of the 2002 SCS stock assessment using the surplus production model implemented in WinBUGS (Cortés 2002) for comparison and to have a historical perspective. It is important to note, however, that the current assessment does not represent any form of continuity analysis of the 2002 assessment because the inputs (catch stream, CPUE series considered, and life history parameters) are different. In all, the current assessment using surplus production methods indicated that when considering small coastal sharks as a complex, they are not overfished and overfishing is not occurring. It is important to remember, however, that the vast majority of the total catches of SCS corresponded to Atlantic sharpnose (almost 2/3) and bonnethead (1/3) sharks, respectively.

2.9 References

Berger, J. O. 1985. Statistical decision theory and Bayesian analysis. 2nd ed. Springer-Verlag, New York.

Cortés, E. 2002. Stock assessment of small coastal sharks in the U.S. Atlantic and Gulf of Mexico. March, 2002. NOAA/NMFS/Panama City Laboratory. Sustainable Fisheries Division Contribution SFD-01/02-152.

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

Gelman, A. and D. B. Rubin. 1992. Inference from iterative simulation using multiple sequences. Stat. Sci. 7:457-511.

Gilks, W. R., S. Richardson, and D. J. Spiegelhalter. 1996. Markov chain Monte Carlo in practice. Chapman and Hall, London, U.K.

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

McAllister, M. K. and G. P. Kirkwood. 1998. Bayesian stock assessment: a review and example application using the logistic model. ICES J. Mar. Sci. 55:1031-1060.

McAllister, M. K., E. K. Pikitch, and E. A. Babcock. 2001. Using demographic methods to construct Bayesian priors for the intrinsic rate of increase in the Schaefer model and implications for stock rebuilding. Can. J. Fish. Aquat. Sci. 58: 1871–1890.

Meyer, R. and R. B. Millar. 1999a. BUGS in Bayesian stock assessments. Can. J. Fish. Aquat. Sci. 56:1078-1086.

Meyer, R. and R. B. Millar. 1999b. Bayesian stock assessment using a state-space implementation of the delay difference model. Can. J. Fish. Aquat. Sci. 56:37-52.

Millar, R. B. and R. Meyer. 1999. Nonlinear state-space modeling of fisheries biomass dynamics using Metropolis-Hastings within Gibbs sampling. Tech. Rep. STAT9901. Department of Statistics, University of Auckland, Auckland, New Zealand.

Simpfendorfer, C.A. and G. H. Burgess. 2002. Assessment of the status of the small coastal sharks in US waters using an age-structured model. Mote Marine Laboratory Tech. Rep. 386, Sarasota, FL.

Spiegelhalter D., A. Thomas, and N. Best. 2000. WinBUGS User Manual Version 1.4. August 2002.

Walters, C.J. and D. Ludwig. 1994. Calculation of Bayes posterior probability distributions for key population parameters: a simplified approach. Can. J. Fish. Aquat. Sci. 51:713-722.

Table 2.1. Catch history for the **Small Coastal Shark complex** (numbers of fish).

CATCHES OF SMALL COASTAL SHARKS: 4 species (in numbers)

Year	Commercial				Recreational catches	Bottom longline discards	Shrimp bycatch (GOM)	Shrimp bycatch (SA)	EFP	Total
	Total	Longline	Nets	Lines						
1972							840,633	105,680		946,313
1973							233,634	29,371		263,005
1974							411,643	51,749		463,392
1975							872,930	109,740		982,670
1976							292,878	36,819		329,697
1977							946,230	118,955		1,065,185
1978							635,527	79,895		715,422
1979							933,737	117,384		1,051,121
1980							1,738,982	218,615		1,957,597
1981					82,759		1,736,376	218,287		2,037,422
1982					67,647		409,794	51,517		528,958
1983					87,399		674,421	84,784		846,604
1984					57,342		377,532	47,461		482,335
1985					62,885		476,828	59,944		599,657
1986					111,425		485,197	60,996		657,618
1987					98,947		1,040,738	130,836		1,270,521
1988					172,684		580,306	72,953		825,943
1989					104,757		603,506	75,869		784,132
1990					96,977		614,590	77,263		788,830
1991					143,845		891,723	112,102		1,147,670
1992					111,829		1,172,572	147,409		1,431,810
1993	262				93,562		509,360	64,034		666,956
1994	3,308				140,473		443,215	55,718		639,406
1995	139,569	57,819	80,791	627	164,884	32,494	1,051,681	132,211		1,520,508
1996	118,425	39,967	75,317	3,134	114,007	15,627	920,627	115,736		1,284,416
1997	214,221	29,527	181,922	1,723	99,382	9,035	703,350	88,421		1,113,361
1998	187,931	22,044	163,396	2,397	123,593	9,038	806,300	101,363		1,228,131
1999	222,715	18,064	198,804	4,601	112,715	14,379	641,017	80,585		1,070,164
2000	168,544	24,689	141,425	2,377	199,043	22,196	796,602	100,144	11	1,286,476
2001	219,962	14,643	201,777	1,535	212,442	14,365	641,786	80,682		1,167,231
2002	173,847	25,133	146,719	1,949	153,810	24,906	1,104,353	138,833		1,595,703
2003	147,313	36,678	90,411	20,120	133,738	26,518	544,058	68,396	5	919,918
2004	133,937	35,741	97,080	1,374	125,711	30,165	797,000	101,330	1872	1,188,402
2005	138,792	34,964	100,874	1,349	122,688	29,020	530,943	66,893	484	886,732

Table 2.2. Prior probability distributions of parameters used in the baseline scenario (Bayesian Surplus Production Model [BSP] with the SIR algorithm) and the sensitivity analysis with WinBUGS (Bayesian state-space surplus production model with the MCMC algorithm) for the **SCS complex**. K is carrying capacity (in numbers), r is the intrinsic rate of population increase, N_{1972}/K is the ratio of abundance in 1972 to carrying capacity, q is the catchability coefficient, σ^2 is the observation error variance in the BSP model (but process error variance in WinBUGS), and τ^2 is observation error variance in WinBUGS.

Grouping/ Model	**K**	**r**	**C_0**	**N_{1972}/K**	**q**	**σ^2**	**τ^2**
BSP (SIR)							
SCS complex	Uniform on log K[1] (10^4-10^8)	Lognormal (0.17,0.32,0.001,2.0)	n/a	Lognormal (0.9,0.2,0.2,1.1)	Uniform on log[2]	Uniform on log	N/A
WinBUGS (MCMC)							
SCS complex	Uniform on log K (10^4-10^8)	Lognormal (0.17,0.32,0.01,0.5)	n/a	Lognormal (0.9,0.2,0.2,1.1)	MLE[3]	Inverse gamma (0.04-0.08)	Inverse gamma (0.05-0.15)

[1] Values in parentheses are lower and upper bounds (uniform distribution), mean, log-SD, lower bound, and upper bound (lognormal distribution), 10% and 90% quantiles (inverse gamma distribution); [2] Priors for q and σ^2 were given a uniform distribution on a log scale, but were integrated from the joint posterior distribution using the method described by Walters and Ludwig (1994); [3] The maximum likelihood estimate of q for each CPUE series was used instead of a prior for q.

Table 2.3. Time series of estimates of stock abundance (N_i), relative stock abundance ((N_i/N_{MSY}), fishing mortality rate (F_i), and relative fishing mortality rate (F_i/F_{MSY}) for the BSP model baseline scenario for the **SCS complex**. Values listed are medians.

Year	N_i	N_i/N_{MSY}	F_i	F_i/F_{MSY}
1972	50410989	1.79	0.019	0.22
1973	51211717	1.83	0.005	0.06
1974	51785881	1.85	0.009	0.11
1975	51951240	1.84	0.019	0.23
1976	52192325	1.86	0.006	0.08
1977	52345438	1.84	0.020	0.24
1978	52140884	1.84	0.014	0.16
1979	52040414	1.82	0.020	0.24
1980	51377381	1.77	0.038	0.45
1981	50350696	1.73	0.040	0.49
1982	50185314	1.76	0.011	0.13
1983	50659681	1.77	0.017	0.20
1984	51064590	1.79	0.009	0.11
1985	51424884	1.80	0.012	0.14
1986	51675748	1.81	0.013	0.15
1987	51432235	1.79	0.025	0.29
1988	51252483	1.79	0.016	0.19
1989	51381837	1.80	0.015	0.18
1990	51475609	1.80	0.015	0.18
1991	51326530	1.79	0.022	0.27
1992	50930729	1.76	0.028	0.34
1993	50821827	1.78	0.013	0.16
1994	51081583	1.79	0.013	0.15
1995	50880786	1.76	0.030	0.35
1996	50415234	1.75	0.025	0.30
1997	50136046	1.75	0.022	0.27
1998	49945417	1.74	0.025	0.29
1999	49796955	1.75	0.021	0.26
2000	49634759	1.74	0.026	0.31
2001	49440693	1.73	0.024	0.28
2002	49111864	1.71	0.032	0.38
2003	48979623	1.73	0.019	0.22
2004	49016160	1.73	0.024	0.29
2005	49087650	1.74	0.018	0.21

Table 2.4. Expected values (EV) of the mean and coefficients of variation (CV) of marginal posterior distributions for output parameters from the Bayesian SPM using the SIR algorithm. Results for the **SCS complex** (baseline scenario) using equal weighting. Abundances are in thousands of fish.

	SCS complex	
	EV	CV
Importance function	priors	
K	59566	0.35
r	0.181	0.32
MSY	2623	0.45
N_{2005}	51605	0.40
N_{2005}/K	**0.85**	0.09
N_{init}	53057	0.38
N_{2005}/N_{init}	0.97	0.13
C_{2005}/MSY	0.40	0.42
F_{2005}/F_{MSY}	**0.25**	0.55
N_{2005}/N_{MSY}	**1.69**	0.09
$C_{2005}/repy$	0.79	0.05
N_{MSY}	29783	0.35
F_{MSY}	0.091	
repy	1125	0.05
Diagnostics		
CW (Wt)	0.786	
CV (L*prior)	0.902	
CV (Wt) / CV (L*p)	0.87	
%maxpWt	0.002	

N_{init} is the initial abundance (for the first year of the model), repy is replacement yield

Table 2.5. Decision analysis table for the **SCS complex** corresponding to the results in Table 2.4.

SCS complex

Horizon	Policy	$E(N_{fin}/K)$	$E(N_{fin}/N_{msy})$	$P(N_{fin}<0.2K)$	$P(N_{fin}>N_{msy})$	$P(N_{fin}>N_{cur})$	$P(F_{fin}<F_{cur})$	$P(N_{cur}>N_{ref})$	$P(N_{fin}<0.01K)$
10 -year	TAC=0	1.29	1.93	0	1	1	1	1	0
	$TAC=1C_{2005}$	1.18	1.74	0	1	1	1	1	0
	$TAC=2C_{2005}$	1.06	1.52	0.01	0.95	0	0	0	0
20 -year	TAC=0	1.33	1.98	0	1	1	1	1	0
	$TAC=1C_{2005}$	1.19	1.75	0	1	1	1	1	0
	$TAC=2C_{2005}$	1.02	1.43	0.05	0.89	0	0	0	0.02
30 -year	TAC=0	1.33	2	0	1	1	1	1	0
	$TAC=1C_{2005}$	1.19	1.76	0	1	1	1	1	0
	$TAC=2C_{2005}$	0.99	1.36	0.08	0.84	0	0	0	0.05

Table 2.6. Expected values (EV) of the mean and coefficients of variation (CV) of marginal posterior distributions for output parameters for the **SCS complex** using WinBUGS as an alternative model formulation. Abundances are in thousands of fish.

	SCS complex	
	EV	CV
K	59700	0.36
r	0.150	0.38
MSY	2124	0.42
N_{2005}	54000	0.39
N_{2005}/K	**0.90**	0.12
N_{init}	44393	
N_{2005}/N_{init}	1.22	
C_{2005}/MSY	0.42	
F_{2005}/F_{MSY}	**0.28**	0.48
N_{2005}/N_{MSY}	**1.82**	0.11
N_{MSY}	29850	
F_{MSY}	0.075	
C_0	n/a	
N_{init}/K	0.74	0.17
Diagnostics		
Chain mixing	good	
Autocorrelations	high	
Gelman-Rubin	good	

N_{init} is initial abundance (for the first year of the model)

Table 2.7. Expected values (EV) of the mean and coefficients of variation (CV) of marginal posterior distributions for output parameters from the Bayesian SPM using the SIR algorithm. Results for the **SCS complex** using an alternative catch series starting in 1950, and all the CPUE series identified as "sensitivity" in the Data Workshop report. The run using inverse CV weighting did not converge. Abundances are in thousands of fish.

	Alternative catch		All CPUE series	
	EV	CV	EV	CV
Importance function	priors		priors	
K	60082	0.35	59511	0.35
r	0.184	0.32	0.181	0.32
MSY	2695	0.44	2621	0.45
N_{2005}	52193	0.40	51548	0.41
N_{2005}/K	**0.85**	0.09	**0.85**	0.09
N_{init}	51785	0.38	53006	0.38
N_{2005}/N_{init}	1.00	0.17	0.97	0.13
C_{2005}/MSY	0.39	0.41	0.41	0.42
F_{2005}/F_{MSY}	**0.24**	0.54	**0.25**	0.55
N_{2005}/N_{MSY}	**1.70**	0.09	**1.69**	0.09
C_{2005}/repy	0.77	0.04	0.79	0.05
N_{MSY}	30041	0.35	29756	0.35
F_{MSY}	0.092		0.090	
repy	1146	0.04	1125	0.05
C_0				
Diagnostics				
CW (Wt)	0.635		0.785	
CV (L*prior)	0.797		0.902	
CV (Wt) / CV (L*p)	0.80		0.87	
%maxpWt	0.001		0.002	

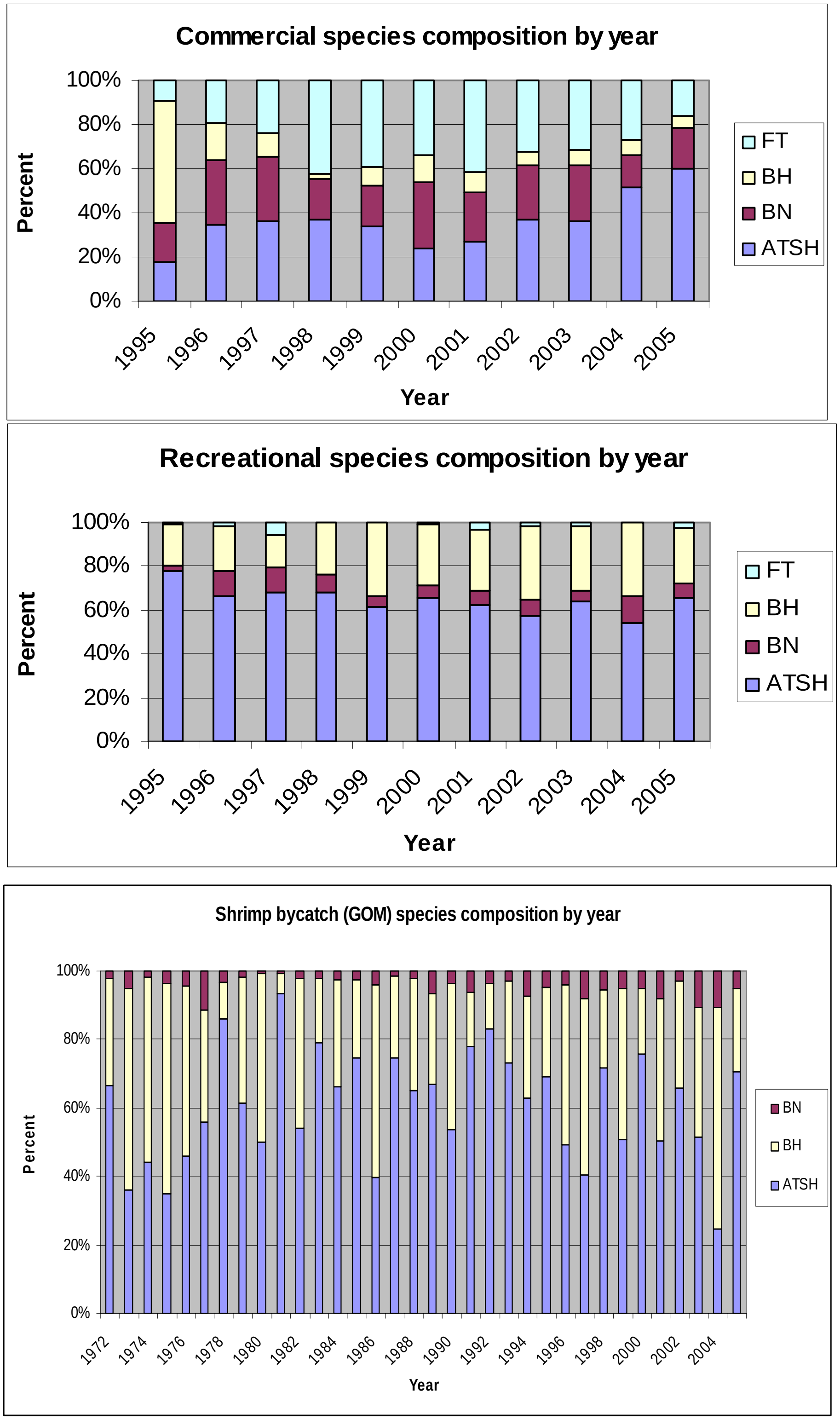
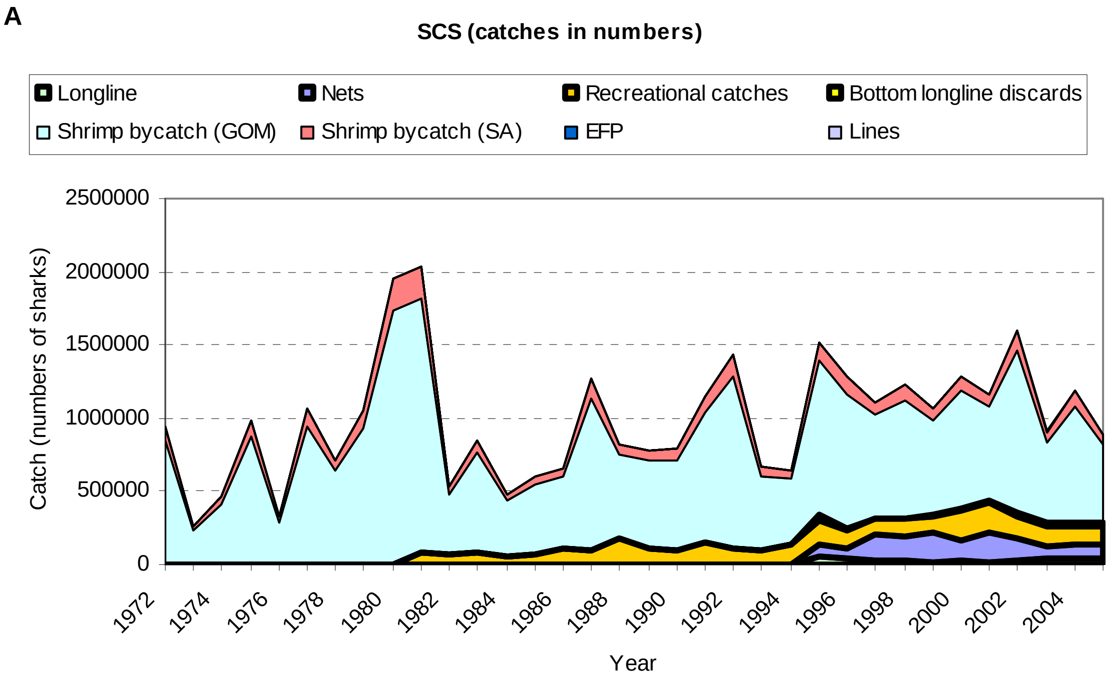


Figure 2.1. Relative species composition of commercial landings, recreational catches, and dead discards from the shrimp trawl fishery for the **SCS complex**.



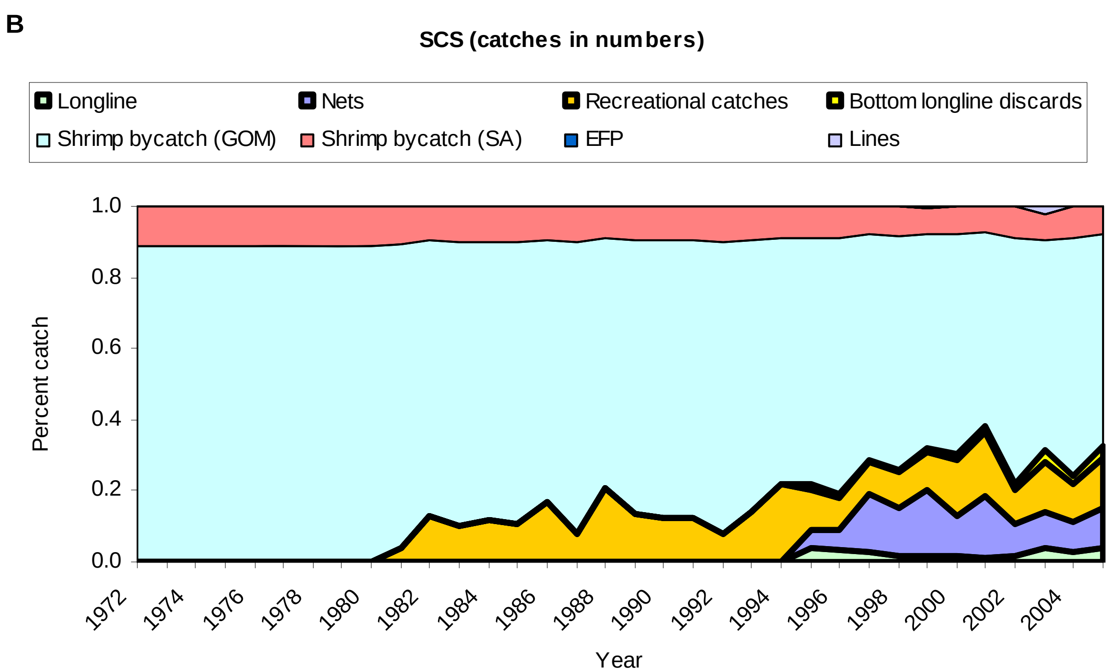


Figure 2.2. Total catches of the SCS complex by sector in (A) absolute and (B) relative terms.

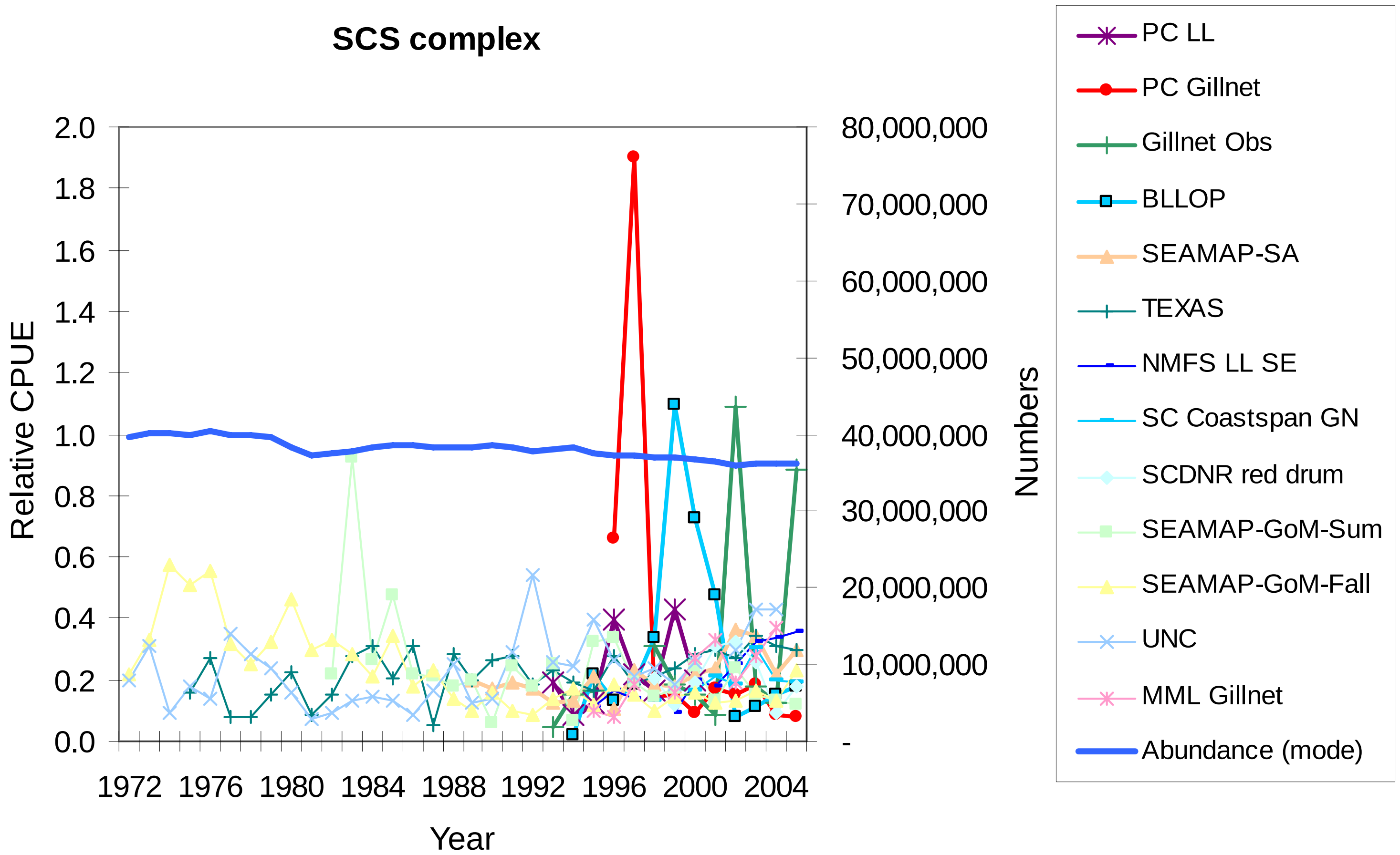


Figure 2.3. Predicted abundance trend of the BSP model fitted to the catch and CPUE data for the **SCS complex**. CPUE series shown are scaled (divided by the catchability coefficient for each series, the mean of the overlapping years, and the overall mean for all series).

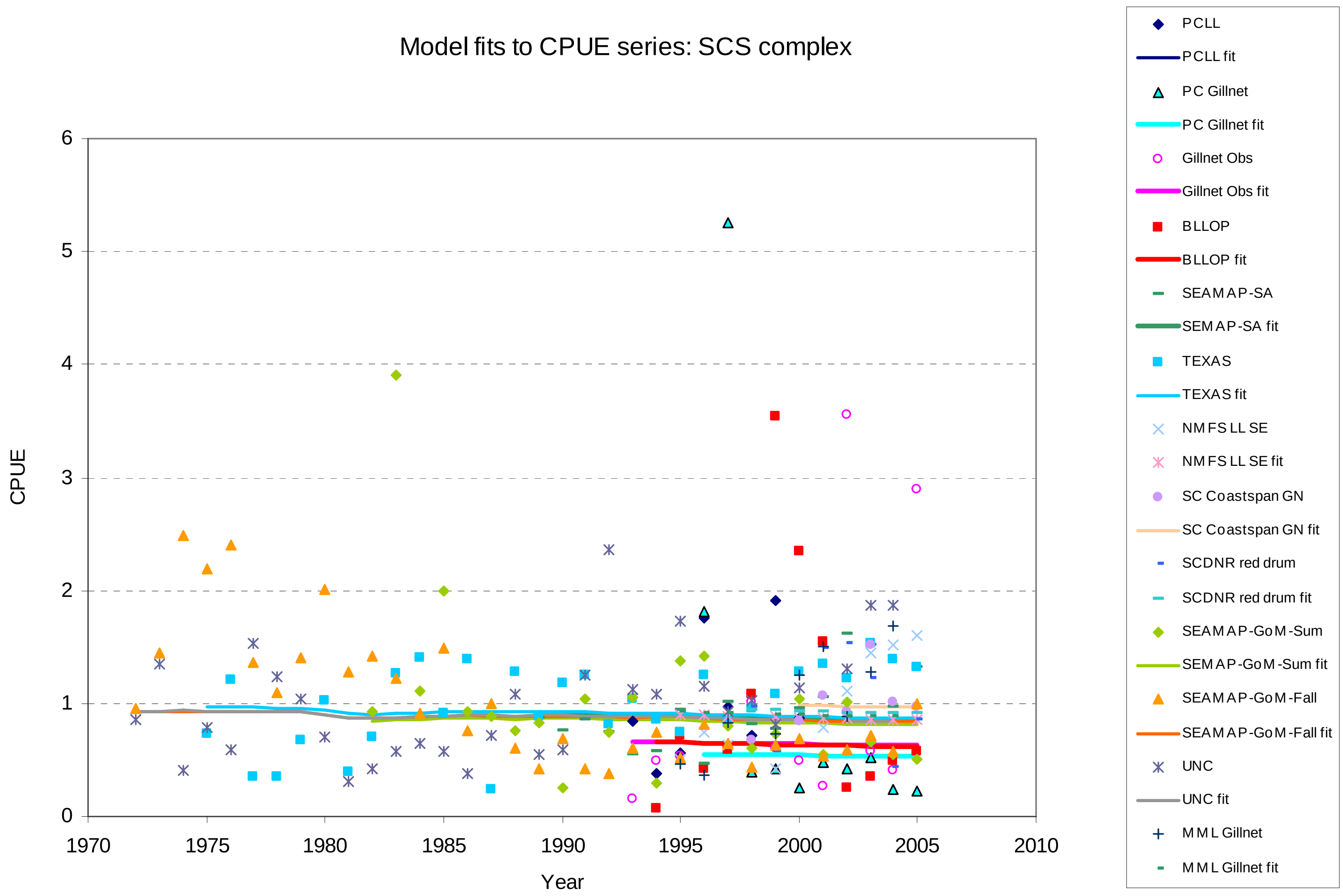
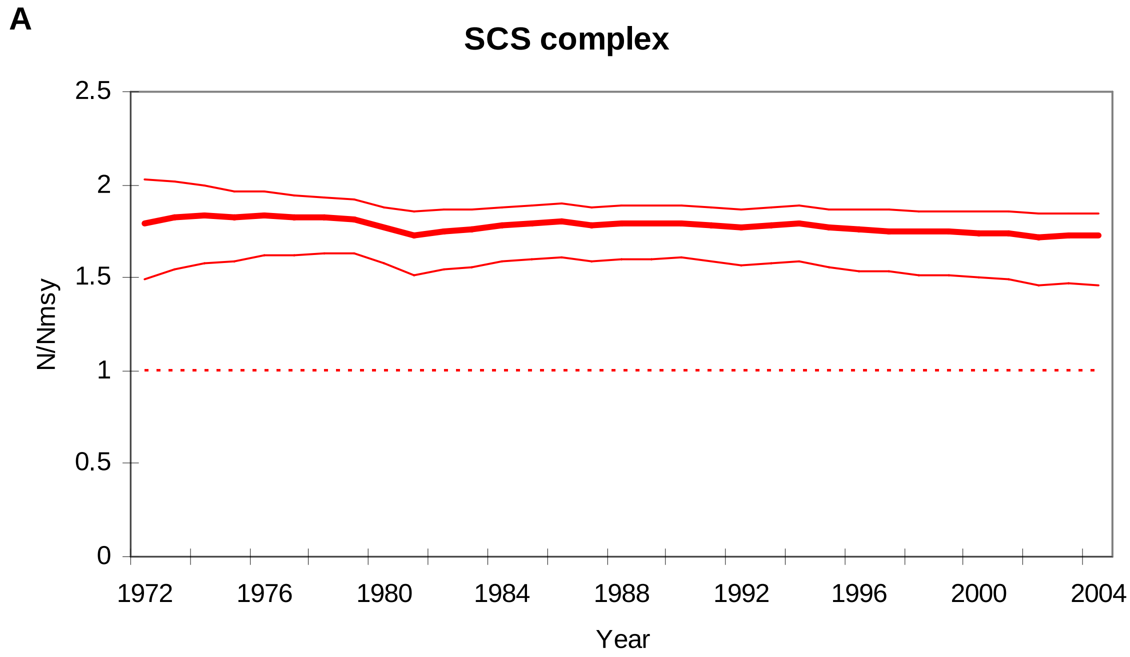


Figure 2.4. BSP model fits to the individual CPUE series for the **SCS complex**.



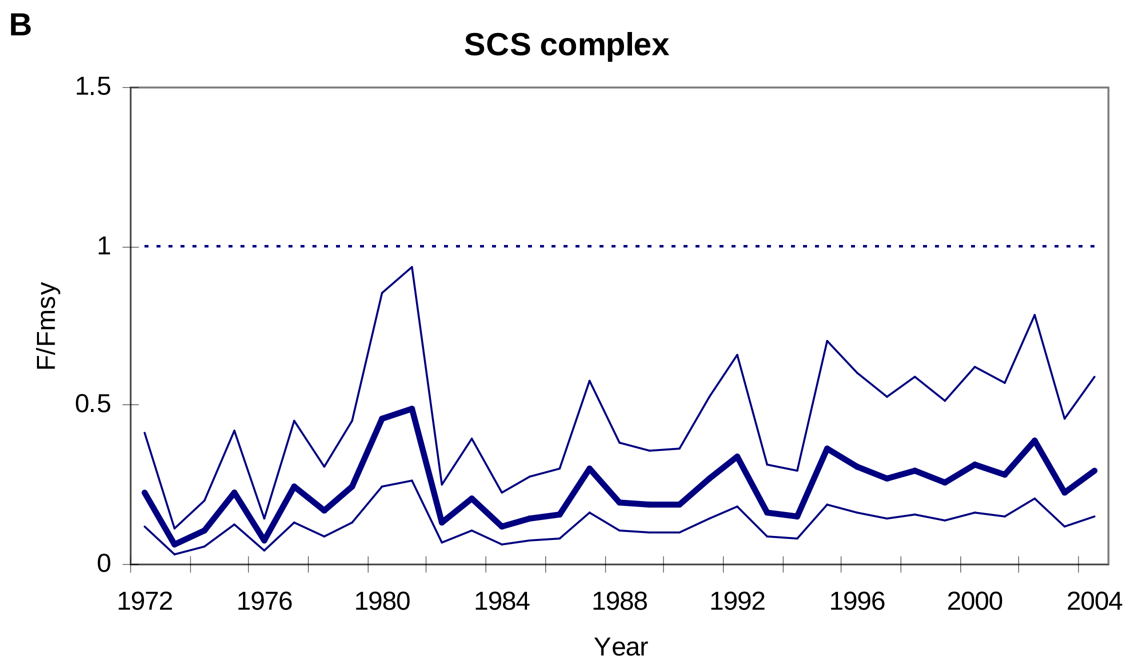


Figure 2.5. Predicted median relative abundance (A) and fishing mortality rate (B) trajectories for the **SCS complex** with the BSP model. Values shown are medians with 80% probability intervals; horizontal lines at 1 denote MSY levels.

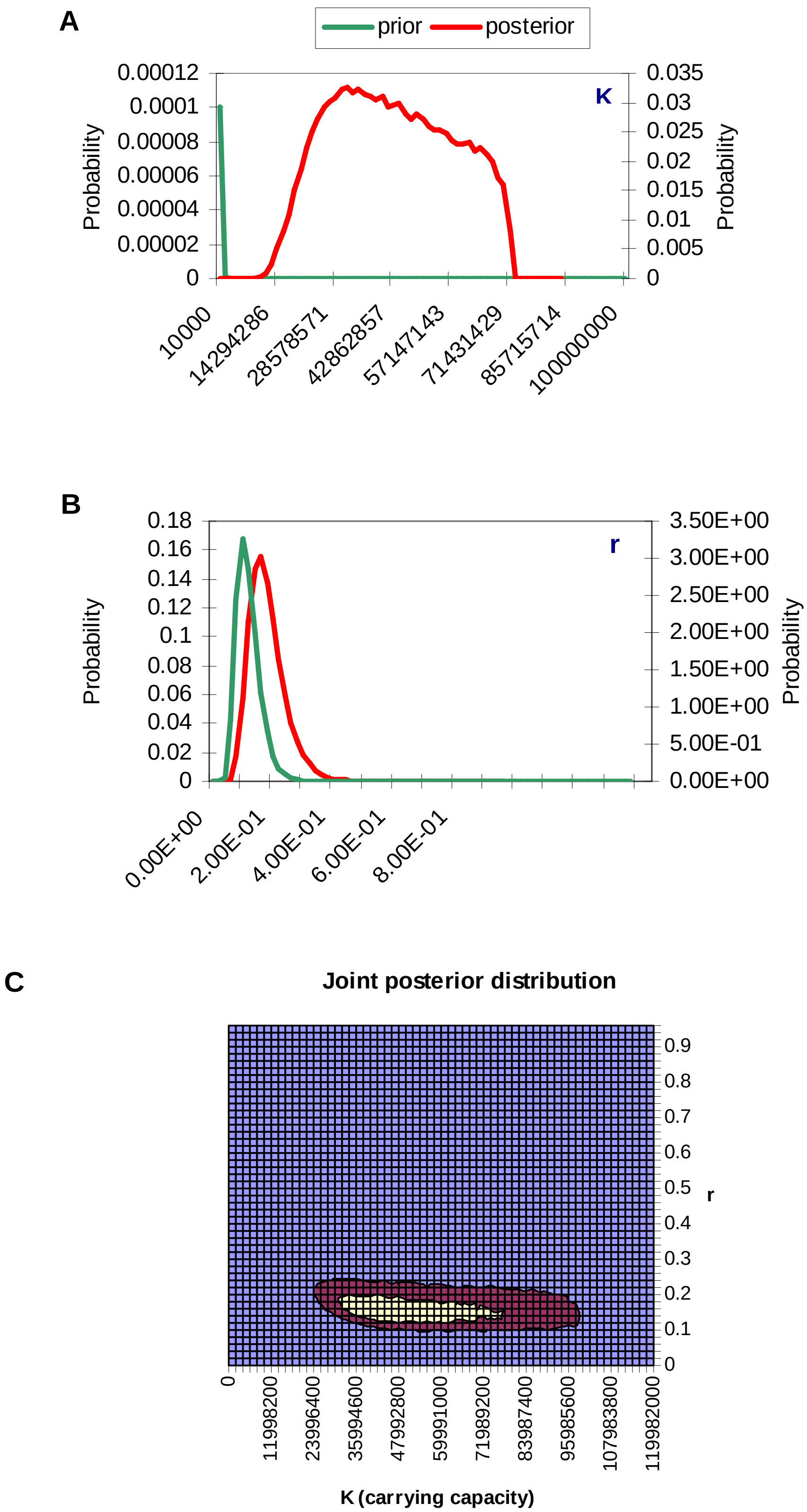


Figure 2.6. Prior (green) and posterior (red) probability distributions for (A) K and (B) r for the **SCS complex** from the BSP model. Also shown (C) is the joint posterior probability distribution for r and K.

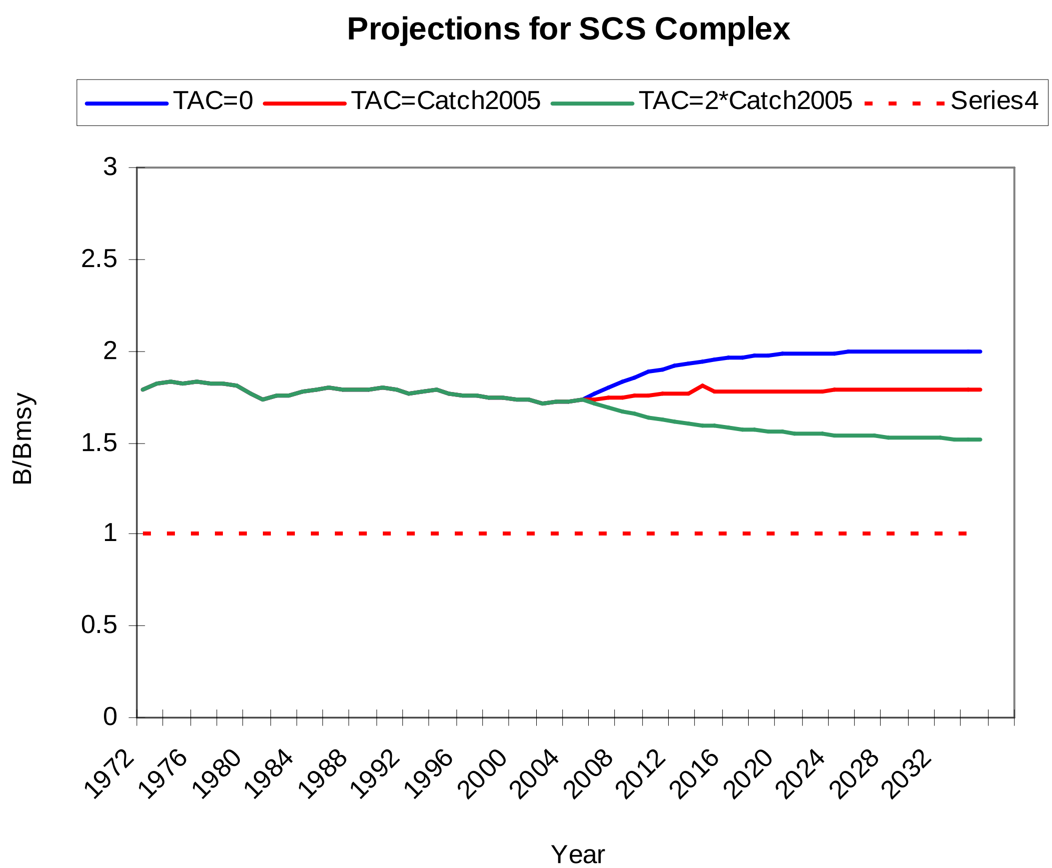


Figure 2.7. Estimated median relative abundance trajectory and projections (from 2006 to 2035) for alternative TAC-based harvesting policies (0, 1, and 2 times the 2005 TAC) for the **SCS complex** baseline scenario. The dashed horizontal line at 1 denotes the MSY level.

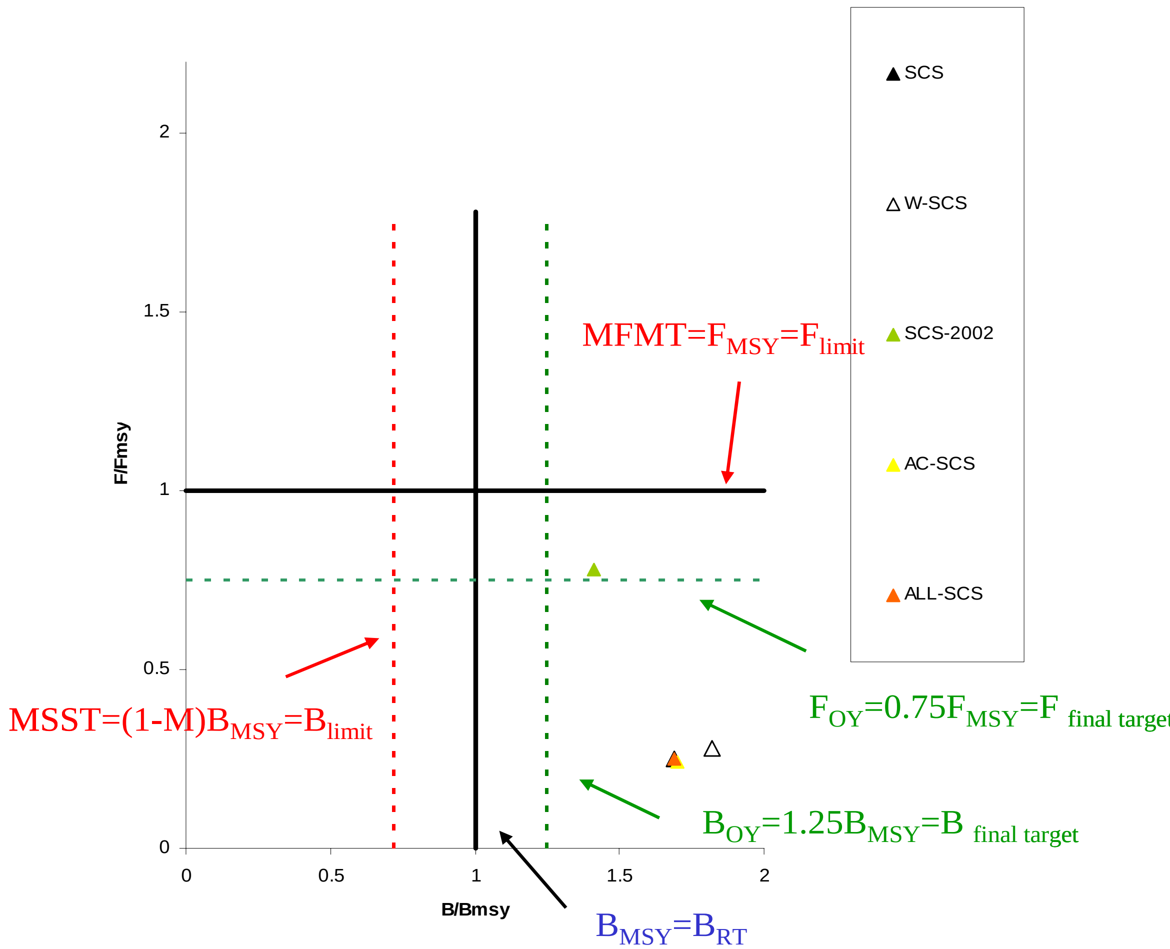


Figure 2.8. Phase plot for the **SCS complex** showing values of N_{2005}/N_{MSY} and F_{2005}/F_{MSY} obtained in the baseline scenario using the BSP model and various sensitivity analyses. The models include: SCS (baseline), W (WinBUGS surplus production model), AC-SCS (alternative catch starting in 1950), ALL-SCS (all CPUE series), and SCS-2002 (results of the 2002 SCS assessment using WinBUGS). See text for full details. Several control rules are illustrated: the solid horizontal line indicates the MFMT (Maximum Fishing Mortality Threshold), the solid vertical line denotes the target biomass (biomass or number at MSY), the dashed horizontal line indicates the F at optimum yield (final F target for rebuilding), and the dashed vertical lines denote the MSST (Minimum Stock Size Threshold or limit biomass) and B_{OY} (biomass at optimum yield or final B target for rebuilding).

FINETOOTH SHARK ASSESSMENT

3. FINETOOTH SHARK (*Carcharhinus isodon*) ASSESSMENT

3.1 Summary of Finetooth shark Working Documents

SEDAR13-AW-01
Assessment of Small Coastal Sharks, Atlantic sharpnose, Bonnethead, Blacknose and Finetooth Sharks using Surplus Production Methods
We used two complementary surplus production models (BSP and WinBUGS) to assess the status of the Small Coastal Shark (SCS) complex and four individual species (Atlantic sharpnose, bonnethead, blacknose, and finetooth sharks) identified as baseline scenarios in the SCS Data Workshop report. Both methodologies use Bayesian inference to estimate stock status, and the BSP further performs Bayesian decision analysis to examine the sustainability of various levels of future catch. Extensive sensitivity analyses were performed with the BSP model to assess the effect of different assumptions on CPUE indices and weighting methods, catches, intrinsic rate of increase, and importance function on results. Baseline scenarios predicted that the stock status is not overfished and overfishing is not occurring in all cases. Using the inverse variance method to weight the CPUE data was problematic because of the nature of the CPUE time series and must be regarded with great caution, although predictions on stock status did not change, except for blacknose sharks. The alternative surplus production model implemented in WinBUGS supported the results from the BSP model, with the exception of blacknose sharks, which became overfished. None of the other sensitivity analyses examined had a large impact on results and did not affect conclusions on stock status in any case. Only blacknose sharks with the alternative catch scenario approached an overfishing condition.

3.2 Background

The finetooth shark, a component of the Small Coastal Shark (SCS) complex, was assessed in 2002 (Cortés 2002) using a variety of surplus production methods and a form of delay-difference model (lagged recruitment, survival and growth model). Additionally, an age-structured model was used in a parallel assessment (Simpfendorfer and Burgess 2002). The SCS SEDAR Data Workshop (DW) panel and report recommended that the SCS complex and the finetooth shark be assessed with surplus production methods alone because of the nature of the complex (composed of the sum of four individual species with different life histories) and the lack of adequate biological data to conduct an age-structured assessment for the finetooth shark.

3.3 Available Models

Two surplus production modeling approaches were available for discussion (SEDAR13-AW-01):

2) Bayesian surplus production model (BSP)
2) WinBUGS state-space Bayesian surplus production model

The Bayesian Surplus Production (BSP) model program fits a Schaefer model to CPUE and catch data using the SIR algorithm. The BSP software is available, for example, in the ICCAT catalog of methods (McAllister and Babcock 2004) and has been used as the base model in previous assessments of large and small coastal sharks as well as pelagic sharks.

The WinBUGS implementation of the Schaefer surplus production model uses Gibbs sampling, an MCMC method of numerical integration, to sample from the posterior distribution (Spiegelhalter et al. 2000). The model was originally developed by Meyer and Millar (1999a) and modified by Cortés (2002) and Cortés et al. (2002) to apply it to small and large coastal sharks, respectively.

The BSP was selected as the final baseline model because it generally provides a more flexible framework for examining the effects of various modeling issues (e.g., type of importance function used for Bayesian estimation, multiple CPUE weighting methods) and conducts Bayesian decision analysis to project population status into the future and estimate performance indicators under various management policies.

3.4 Model Scenarios

The Assessment Workshop (AW) panel recommended that surplus production models be used to assess the status of the SCS complex and finetooth sharks. Surplus production models were the only type of model presented for the SCS complex and finetooth sharks following the recommendations of the Data Workshop (DW) panel and report. Additionally, surplus production models were also used to assess the status of Atlantic sharpnose, bonnethead and blacknose sharks in document SEDAR13-AW-01, but those results are not presented herein. In the present document we thus assessed the status of the finetooth shark.

3.5 Discussion of weighting methods

The Data Workshop Panel recommended that *equal weighting* for assigning weights to the different CPUE time series available during model fitting should be used for the baseline runs. The panel discussed the advantages and disadvantages of the *equal weighting* vs. the *inverse CV weighting* methods:

Equal weighting ignores the better quality of some data (smaller CVs) but is more stable between assessments because yearly changes on CVs in a given CPUE series do not affect the importance of that time series for the overall fit.

Inverse CV weighting can provide better precision as it tracks individual indices however, it could be less stable between assessments due to changes on the relative ‘noise’ of each time series. This method may also not be appropriate in cases in which different standardization techniques have been used for the standardization of the series and therefore, the same value of CV might reflect different levels of error depending on the CPUE it corresponds to.

The Assessment Workshop Panel further discussed the issue for weighting indices. It was noted that there are a variety of ways to weight indices in addition to equal and inverse CV weighting, however how to determine which weighting method is most appropriate is a discussion topic that is still without satisfying resolution. Given that fact, the Assessment Workshop Panel decided that equal weighting would be the base weighting method for the current assessment but noted that, as there is at present no objective way to decide which method is superior other than comparing model convergence diagnostics, future assessments may need to re-examine this issue.

3.6 Methods

3.6.1 Bayesian Surplus Production (BSP) Model description

The Bayesian Surplus Production (BSP) model program fits a Schaefer model to CPUE and catch data using the SIR algorithm. The BSP software is available, for example, in the ICCAT catalog of methods (McAllister and Babcock 2004) and has been used as the base model in previous assessments of large and small coastal sharks. Herein we used the discrete-time version of the model (although the continuous form is also implemented by the software), so that:

$$B_{t+1} = B_t + rB_t - \frac{r}{K} B_t^2 - C_t$$

where B_t= biomass at the beginning of year t, r is the intrinsic rate of increase, K is carrying capacity and C_t is the catch in year t.

The expected catch rate (CPUE) for each of the available time series j in year t is given by:

$$\hat{I}_{j,t} = q_j B_t e^{\varepsilon_t}$$

where q_j is the catchability coefficient for CPUE series j, and ε_t is the residual error, which is assumed to be lognormally distributed. The program allows for a variety of methods to weight CPUE data points. As recommended in the DW report, we used equal weighting (or no weighting) in all baseline scenarios. The model log-likelihood is given by:

$$\ln L = -\sum_j \sum_y \frac{\left[\ln(I_{j,y}) - \ln(\hat{q}_j \hat{B}_y)\right]^2}{2\sigma_{j,y}^{\ 2}}$$

where $I_{j,y}$ is the CPUE in year y for series j, $\hat{q}_j$ is the constant of proportionality for series j, $\hat{B}_y$ is the estimated biomass in year y, and $\sigma_{j,y}^{\ 2}$ is the variance (=1/weight; in this case weight=1) applied to series j in year y.

In the inverse variance method, the annual observations are proportional to the annual CV^2 (if available) and the average variance for each series is equal to the MLE estimate. The log likelihood function is expressed as:

$$\ln L = -\sum_{j=1}^{j=s}\sum_{t=1}^{t=y}\left\{\frac{0.5}{c_j CV_{j,t}^{2}\sigma_j^{2}}\left[\ln\left(\frac{I_{j,t}}{q_j N_t}\right)\right]^2 - 0.5\ln(c_j CV_{j,t}^{2}\sigma_j^{2})\right\}$$

where s is the number of CPUE series, y is the number of years in each CPUE series, $CV_{j,t}^2$ is the coefficient of variation for series j in year t, c_j is a constant of proportionality for each series j chosen such that the average variance for each series equals its estimated average variance, σ_j^2 (the MLE estimate). The catchability coefficient for each time series (q_j) is also estimated as the MLE such that:

$$\hat{q}_j = e^{\left(\frac{\sum_{t=1}^{t=y}\left(\ln(I_{j,t})-\ln(B_t)\right)/c_j CV_{j,t}^{2}\sigma_j^{2}}{\sum_{t=1}^{t=y}1/(c_j CV_{j,t}^{2}\sigma_j^{2})}\right)}$$

3.6.2 WinBUGS State-Space Bayesian Surplus Production Model description

This implementation of the Schaefer surplus production model uses Gibbs sampling, an MCMC method of numerical integration, to sample from the posterior distribution using WinBUGS (Spiegelhalter et al. 2000). The model was originally developed by Meyer and Millar (1999a) and modified by Cortés (2002) and Cortés et al. (2002) to apply it to small and large coastal sharks, respectively. To minimize correlations between model parameters and speed mixing of the Gibbs sampler, the surplus production model is reparameterized by expressing the annual biomass as a proportion of carrying capacity:

$$P_t = P_{t-1} + rP_{t-1}(1-P_{t-1}) - \frac{C_{t-1}}{K}e^{P_t}$$

where $P_t=B_t/K$. The model is a state-space model, which relates the observed catch rates (I_t) to unobserved states (B_t) through a stochastic observation model for I_t given Bt (Millar and Meyer 1999, Meyer and Millar 1999b):

$$I_t = qKP_t e^{O_t}$$

The model thus assumes lognormal error structures for both process and observation errors (e^P and e^O), with $P_t \sim N(0,\sigma^2)$ and $O_t \sim N(0,\tau^2)$. In the present implementation, the catchability coefficient for each CPUE series is taken as the MLE.

The crucial equation for Bayesian inference is the joint posterior distribution of the unobservable states given the data, which is equal to the product of the joint prior distribution and the sampling distribution (likelihood):

$$p(K,r,q,C_0,P_{72},\sigma^2,\tau^2,P_1,...,P_n,I_1,...,I_n) =$$
$$p(K)\,p(r)\,p(q)\,p(C_0)\,p(P_{72})\,p(\sigma^2)\,p(\tau^2)\,p(P_1\,|\,\sigma^2)$$
$$\times\prod_{i=2}^{i=m+1} p(P_t\,|\,P_{t-1},K,r,C_0,P_{72},\sigma^2)\prod_{i=m+2}^{i=n} p(P_t\,|\,P_{t-1},K,r,P_{72},\sigma^2)\prod_{t=1}^{t=n} p(I_t\,|\,P_t,q,\tau^2)$$

where $P_{72}=N_{72}/K$ and m is the number of years of unobserved catches, if applicable (C_0).

3.6.3 Data inputs, prior probability distributions, and performance indicators

Catch data (in numbers) were available from 1983 to 2005 (**Table 3.1**) and CPUE data, from 1976 to 2005, as provided in the DW report. Four CPUE series identified as "base" in the DW report were used in the baseline scenario. All CPUE series are listed in Appendix 1. The fishery was assumed to begin in 1976, the first year for which CPUE data were available. Estimated parameters were r, K, and the abundance (in numbers) in 1976 relative to K (N_{76}/K). Additionally, the catches in the years 1976-1982 were assumed to be constant and equal to the model-estimated parameter C_0. The constant of proportionality between each abundance index and the biomass trend was calculated using the numerical shortcut of Walters and Ludwig (1994). The prior for K was uniform on log (K), weakly favoring smaller values, and was allowed to vary between 10^4 and $2x10^7$ individuals. Informative, lognormally distributed priors were used for N_{76}/K, r, and C_0. For N_{76}/K, the mean was set equal to 0.9 to reflect some depletion with respect to virgin levels, and the log-SD was 0.2. Since the value of r listed in the DW report was negative (-0.056 yr^{-1}), we opted to use the value from the 2002 assessment (0.060 yr^{-1}) as the mean of r and a log-variance of 0.04 (log-SD=0.2 also from the 2002 assessment). For C_0, the mean was set equal to the average catch during 1983-1988 (2,774 individuals) and the log-SD was 1, implying a wide distribution. Input values are listed in **Table 3.2**.

The input parameters and priors described above are those used in the BSP model. Model inputs and priors used with WinBUGS were almost exactly the same. Additionally, priors for the observation error variance (τ^2) and process error variance (σ^2) in the WinBUGS model were inverse gamma distributions as used in previous stock assessments (Millar and Meyer 1999, Cortés et al. 2002), i.e., the 10% and 90% quantiles were set at approximately 0.05 and 0.15, and 0.04 and 0.08, respectively.

Performance indicators for the BSP model included the maximum sustainable yield (MSY=rK/4), the stock abundance in the last year of data (N_{2005}), the ratio of stock abundance in the last year of data to carrying capacity and MSY (N_{2005}/K and N_{2005}/MSY), the fishing mortality rate in the last year of data as a proportion of the fishing mortality rate at MSY (F_{2005}/F_{MSY}), the catch in the last year of data as a proportion of the replacement yield (C_{2005}/R_y) and MSY (C_{2005}/MSY), the stock abundance in the first year of the model (N_{init}), and the ratio of stock abundance in the last and first years of the model (N_{2005}/N_{init}). The same metrics, except for those containing replacement yield, were calculated for the WinBUGS model. Additionally, the relative abundance (N_i/N_{MSY}) and fishing mortality (F_i/F_{MSY}) trajectories, as well as the predicted abundance trend, were obtained and plotted for the time period considered in each scenario.

3.6.4 Methods of numerical integration, convergence diagnostics, and decision analysis

For the BSP model, numerical integration was carried out using the SIR algorithm (Berger 1985, McAllister and Kirkwood 1998, McAllister et al. 2001) built in the BSP software. The marginal posterior distributions for each of the population parameters of interest were obtained by integrating the joint probability with respect to all the other parameters. Posterior CVs for each population parameter estimate were computed by dividing the posterior SD by the posterior expected value (mean) of the parameter of interest. Two importance functions were used in the SIR algorithm (depending on which function produced better convergence diagnostics): the multivariate Student t distribution and the priors. For the multivariate Student t distribution, the mean is based on the posterior mode of θ (vector of parameter estimates K, r, B_{init}/K, and C_0 if applicable), and the covariance of θ is based on the Hessian estimate of the covariance at the mode (see McAllister and Kirkwood [1998] and references therein for full details). A variance expansion factor of at least 2 was generally used to make the importance function more diffuse (wider) and ensure that the variance of the parameters was not underestimated when using the multivariate Student t distribution.

WinBUGS uses an MCMC method called Gibbs sampling (Gilks et al. 1996) to sample from the joint posterior distribution. All runs were based on two chains of initial values (where the P_t values were set equal to 0.5 and 1.0, respectively) to account for over-dispersed initial values (Spiegelhalter et al. 2000), and included a 5,000 sample burn-in phase followed by a 100,000 iteration phase with a thinning rate of 2.

Convergence diagnostics for the BSP model included the ratio of the CV of the weights to the CV of the product of the likelihood function and the priors, with values <1 indicating convergence and values >10 indicating likely convergence failure, and the maximum weight of any draw as a fraction of the total importance weight, which should be less than 0.5% (SB-02-25; McAllister and Babcock 2004).

In the WinBUGS analyses, convergence of the MCMC algorithm for the two chains was tested by examining the time series history of the two MCMC chains to determine whether mixing was good, parameter autocorrelations, and the convergence diagnostic of Gelman and Rubin (Gelman and Rubin 1992).

For the BSP model, posterior expected values for several indices of policy performance were calculated using the resampling portion of the SIR algorithm built in the BSP software, which involves randomly drawing 5,000 values of θ with replacement from the discrete approximation to the posterior distribution of θ, with the probability of drawing each value of θ being proportional to the posterior probability calculated during the importance sampling phase. Details of this procedure can be found in McAllister and Kirkwood (1998) and McAllister et al. (2001), and references therein. Once a value of θ was drawn, the model was projected from the initial year of the model to 2005, and then forward in time up to 30 years to evaluate the potential consequences of future management actions. The exploratory policies considered included setting the total allowable catch (TAC) equal to 0, to the catch in 2005, and doubling the 2005 catch. The projections included calculating the following reference points, among others: expected value of N_{fin}/K (with fin=2015, 2025, and 2035) and the probabilities that N_{fin} were < 0.2K and $N_{fin} > N_{msy}$.

3.6.5 Sensitivity analyses

We conducted sensitivity analyses to explore the influence of multiple factors (sources of uncertainty) on results by changing the following items with respect to those in the baseline scenario one at a time. All sensitivities were implemented with the BSP model.

W—Sensitivity to model, sources of error and method of numerical integration used: this involved using a complementary surplus production model (in WinBUGS) that also takes into account process error (vs. observation error only in the BSP), and uses MCMC for numerical integration (vs. the SIR algorithm in the BSP)

WM—Sensitivity to weighting scheme used: this involved changing the method for weighting the CPUE series from equal weighting in the baseline scenario to inverse variance weighting

IF—Sensitivity to importance function used: this involved changing the importance function from the priors to a multivariate t distribution. Only results obtained using the importance function that produced the best convergence diagnostics are reported

AC—Sensitivity to extending the catch series back to 1950 to mimic the catch stream used with the age-structured model (for Atlantic sharpnose, bonnethead, and blacknose sharks)

ALL—Adding the CPUE series identified as "sensitivity" in Table 3.2 of the DW report to those in the baseline scenario

LOWr—Using a lower value of intrinsic rate of increase (0.02 yr^{-1})

3.7 Results

3.7.1 Baseline scenarios

Figure 3.1 shows the relative contribution of the four individual species to the small coastal shark complex catches. Except for 1995, when bonnetheads were more important, commercial landings were dominated by Atlantic sharpnose, finetooth, and blacknose sharks. Atlantic sharpnose sharks were the dominant species caught recreationally, followed by bonnethead and blacknose sharks, whereas finetooth sharks are rarely reported caught. Bycatch in the shrimp trawl fishery also consists mostly of Atlantic sharpnose and bonnethead sharks, with blacknose sharks also caught, but to a much lesser degree. Estimates for finetooth sharks could not be produced (see DW report) because they are rarely caught. The majority of the catches of finetooth sharks since the mid-1990s correspond to gillnets (**Fig. 3.2A,B** and see also SEDAR 13-DW-15).

The abundance trajectory at the mode of the posterior distribution showed a rather flat trend (**Fig. 3.3**). This trend in estimated abundance was reflective of the lack of signal from the four CPUE series available, which showed fluctuation but no clear trend. The model fits to the CPUE series were accordingly rather flat (**Fig. 3.4**). The median relative biomass and fishing mortality trajectories indicated that the stock did not approach an overfished status or overfishing, respectively, in any year (**Fig. 3.5A,B**). The complete time series of median estimates of stock abundance (N_i), relative stock abundance (N_i/N_{MSY}), fishing mortality rate (F_i), and relative fishing mortality rate (F_i/F_{MSY}) are given in **Table 3.3**.

Current status of the population was above N_{MSY} and no overfishing was occurring (**Table 3.4**). The priors were used as an importance function for importance sampling. The SIR algorithm converged with good diagnostics of convergence (maximum weight of any draw <<0.5%, CV(weights) / CV(likelihood * priors) <1). The posterior distributions of K and r showed that the data supported relatively higher values of these two parameters (**Fig. 3.6A,B**). The joint posterior distribution of K and r showed a restricted area of probability for r (**Fig. 3.6C**). Population projections indicated that the population would be expected to remain above N_{MSY} for at least 30 years even when doubling the current level of total catch (**Table 3.5**; **Fig. 3.7**).

3.7.2 Sensitivity analyses

W: Considering an alternative model, sources of error and method of numerical integration—This involved using WinBUGS as an alternative surplus production model methodology. The median relative abundance trajectory was very similar to that estimated by the BSP, with the stock never being overfished. The median relative fishing mortality trajectory was also very similar to that obtained with the BSP, but showing wider credibility intervals. In all, the stock was not currently overfished and overfishing was not occurring (**Table 3.6**). WinBUGS model fits to the four CPUE series were all essentially flat. Convergence diagnostics for the WinBUGS model showed that there was good mixing of the two chains for all parameters. Autocorrelations for all parameters also decreased after an initial lag, but remained high for some parameters. The Gelman-Rubin diagnostic indicated good convergence for the main parameters of interest (the ratio of the width of the central 80% interval of the pooled runs and the average width of the 80% intervals within the individual runs converged to 1 and both the pooled and within interval widths stabilized).

WM: Changing the CPUE weighting method—This involved changing the CPUE weighting method from equal weighting to inverse variance weighting. Only those results obtained with the importance function (prior vs. multivariate t) that produced the best convergence diagnostics are reported (**Table 2.7**). Stock status did not change with respect to the baseline scenario and convergence diagnostics were satisfactory.

AC: Extending the catch series back to 1950—This involved using the alternative catch series identified in Table 2.11 of the DW report. This change had very little impact on results (**Table 3.7**). Convergence diagnostics were good.

ALL: Adding the CPUE series identified as "sensitivity" in the DW to those from the baseline scenario—This involved adding the PC LL, MS gillnet and Gillnet Logs series. This change also had very little impact on results (**Table 3.7**). Convergence diagnostics were also good.

LOWr: Using a lower value of intrinsic rate of increase for finetooth sharks—This involved lowering the value of intrinsic rate of increase from 0.06 yr^{-1} to 0.02 yr^{-1}. Stock status was a little less optimistic than in the baseline scenario, but conclusions were not altered: no overfished status nor overfishing (**Table 3.7**). Convergence diagnostics were satisfactory.

3.8. Discussion and Conclusions

The baseline scenario for the finetooth shark predicted that the stock status is not overfished nor overfishing is occurring and very little depletion in numbers with respect to virgin levels (10%). None of the sensitivities explored (inverse CV weighting of the CPUE series, alternative surplus production model, types of error and method of numerical integration considered, considering alternative catches or CPUE series, or a lower productivity) affected results, and supported the outcome of the baseline scenario. Depletions were of the same magnitude (8-17%) as found in the baseline scenario (10%) and the stock did not approach an overfishing condition.

The baseline scenario assumed that the stock had experienced a depletion of about 10% with respect to virgin levels at the beginning of the model, when data were first available (1976). The catch reconstruction (to 1950) scenario was an attempt to account for some historical level of exploitation, but nevertheless resulted in the same conclusions on stock status as the baseline scenario.

Figure 3.8 is a phase plot summarizing the results on stock status found in the baseline scenario and sensitivity analyses in the present assessment of the finetooth shark. The plot also shows the baseline results of the 2002 SCS stock assessment using the surplus production model implemented in WinBUGS (Cortés 2002) for comparison and to have a historical perspective. It is important to note, however, that the current assessment does not represent any form of continuity analysis of the 2002 assessment because the inputs (catch stream and CPUE series considered) are different. In all, the current assessment using surplus production methods indicated that finetooth sharks are not overfished and overfishing is not occurring.

Unlike the other species of small coastal sharks (especially the Atlantic sharpnose and bonnethead sharks), which are mostly caught in shrimp trawl gear, the finetooth shark is predominantly caught in gillnets. In all, the magnitude of finetooth shark catches is much smaller compared to that of the other SCS species. Additionally, only 4 baseline CPUE series were available for this species, and none showed a clear trend. This was interpreted by the model as indicative of little depletion. Finetooth sharks appear to be much less naturally abundant than Atlantic sharpnose and bonnethead sharks. In light of the uncertain life history information and sketchy data on catches and catch rates, the results of the present assessment must be viewed cautiously.

3.9. References

Berger, J. O. 1985. Statistical decision theory and Bayesian analysis. 2nd ed. Springer-Verlag, New York.

Cortés, E. 2002. Stock assessment of small coastal sharks in the U.S. Atlantic and Gulf of Mexico. March, 2002. NOAA/NMFS/Panama City Laboratory. Sustainable Fisheries Division Contribution SFD-01/02-152.

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

Gelman, A. and D. B. Rubin. 1992. Inference from iterative simulation using multiple sequences. Stat. Sci. 7:457-511.

Gilks, W. R., S. Richardson, and D. J. Spiegelhalter. 1996. Markov chain Monte Carlo in practice. Chapman and Hall, London, U.K.

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

McAllister, M. K. and G. P. Kirkwood. 1998. Bayesian stock assessment: a review and example application using the logistic model. ICES J. Mar. Sci. 55:1031-1060.

McAllister, M. K., E. K. Pikitch, and E. A. Babcock. 2001. Using demographic methods to construct Bayesian priors for the intrinsic rate of increase in the Schaefer model and implications for stock rebuilding. Can. J. Fish. Aquat. Sci. 58: 1871–1890.

Meyer, R. and R. B. Millar. 1999a. BUGS in Bayesian stock assessments. Can. J. Fish. Aquat. Sci. 56:1078-1086.

Meyer, R. and R. B. Millar. 1999b. Bayesian stock assessment using a state-space implementation of the delay difference model. Can. J. Fish. Aquat. Sci. 56:37-52.

Millar, R. B. and R. Meyer. 1999. Nonlinear state-space modeling of fisheries biomass dynamics using Metropolis-Hastings within Gibbs sampling. Tech. Rep. STAT9901. Department of Statistics, University of Auckland, Auckland, New Zealand.

Simpfendorfer, C.A. and G. H. Burgess. 2002. Assessment of the status of the small coastal sharks in US waters using an age-structured model. Mote Marine Laboratory Tech. Rep. 386, Sarasota, FL.

Spiegelhalter D., A. Thomas, and N. Best. 2000. WinBUGS User Manual Version 1.4. August 2002.

Walters, C.J. and D. Ludwig. 1994. Calculation of Bayes posterior probability distributions for key population parameters: a simplified approach. Can. J. Fish. Aquat. Sci. 51:713-722.

Table 3.1. Catch history for the **finetooth shark** (numbers of fish).

CATCHES OF FINETOOTH SHARKS (in numbers)

Year	Commercial				Recreational catches	Bottom longline discards	Shrimp bycatch (GOM)	Shrimp bycatch (SA)	EFP	Total
	Total	Longline	Nets	Lines						
1972										0
1973										0
1974										0
1975										0
1976										0
1977										0
1978										0
1979										0
1980										0
1981					0					0
1982					0					0
1983					71					71
1984					1,572					1,572
1985					366					366
1986					11,845					11,845
1987					17					17
1988					22,352					22,352
1989					5					5
1990					82					82
1991					95					95
1992					1,944					1,944
1993					3,170					3,170
1994					3,103					3,103
1995	3,508	3,197	0	312	847	0				4,355
1996	8,240	1,336	6,768	136	1,584	445				10,269
1997	13,143	1,233	11,798	69	5,633	411				19,144
1998	20,692	961	19,663	68	147	0				20,839
1999	22,086	1,161	20,603	319	78	0				22,161
2000	15,686	1,359	14,278	50	1,390	0			0	17,076
2001	23,476	412	22,990	73	6,628	0				30,103
2002	12,681	674	11,949	51	3,027	0				15,701
2003	14,515	1,062	13,412	40	1,758	0			0	16,272
2004	14,804	865	13,715	221	285	0			0	15,086
2005	7,506	887	6,608	2	3,164	0		2	2	10,663

Table 3.2. Prior probability distributions of parameters used in the baseline scenario (Bayesian Surplus Production Model [BSP] with the SIR algorithm) and the sensitivity analysis with WinBUGS (Bayesian state-space surplus production model with the MCMC algorithm) for **finetooth shark**. K is carrying capacity (in numbers), r is the intrinsic rate of population increase, C_0 is the annual catch from 1976 to 1982 (in thousands of individuals), N_{1976}/K is the ratio of abundance in 1976 to carrying capacity, q is the catchability coefficient, σ^2 is the observation error variance in the BSP model (but process error variance in WinBUGS), and τ^2 is observation error variance in WinBUGS.

Grouping/ Model	**K**	**r**	**C_0**	**N_{1976}/K**	**q**	**σ^2**	**τ^2**
BSP (SIR)							
Finetooth shark	Uniform on log K[1] (10^4-2x10^7)	Lognormal (0.06,0.20,0.001,2.0)	Lognormal (2774,1,10,5x10^3)	Lognormal (0.9,0.2,0.2,1.1)	Uniform on log[2]	Uniform on log	N/A
WinBUGS (MCMC)							
Finetooth shark	Uniform on log K (10^4-2x10^7)	Lognormal (0.06,0.20,0.01,0.5)	Normal (2774,1,10,5x10^3)	Lognormal (0.9,0.2,0.2,1.1)	MLE[3]	Inverse gamma (0.04-0.08)	Inverse gamma (0.05-0.15)

[1] Values in parentheses are lower and upper bounds (uniform distribution), mean, log-SD, lower bound, and upper bound (lognormal distribution), 10% and 90% quantiles (inverse gamma distribution); [2] Priors for q and σ^2 were given a uniform distribution on a log scale, but were integrated from the joint posterior distribution using the method described by Walters and Ludwig (1994); [3] The maximum likelihood estimate of q for each CPUE series was used instead of a prior for q.

Table 3.3. Time series of estimates of stock abundance (N_i), relative stock abundance ((N_i/N_{MSY}), fishing mortality rate (F_i), and relative fishing mortality rate (F_i/F_{MSY}) for the BSP model baseline scenario for the **finetooth shark**. Values listed are medians.

Year	N_i	N_i/N_{MSY}	F_i	F_i/F_{MSY}
1976	3715591	1.69	0.00037	0.013
1977	3746419	1.70	0.00037	0.013
1978	3782939	1.71	0.00036	0.012
1979	3804648	1.73	0.00036	0.012
1980	3853028	1.74	0.00036	0.012
1981	3886461	1.75	0.00036	0.012
1982	3914178	1.76	0.00035	0.012
1983	3947929	1.78	0.00002	0.001
1984	3973650	1.79	0.00040	0.014
1985	4007561	1.80	0.00009	0.003
1986	4029594	1.80	0.00294	0.101
1987	4050990	1.81	0.00000	0.000
1988	4060077	1.80	0.00550	0.188
1989	4067150	1.82	0.00000	0.000
1990	4086793	1.83	0.00002	0.001
1991	4101931	1.83	0.00002	0.001
1992	4125104	1.84	0.00047	0.016
1993	4134643	1.85	0.00077	0.026
1994	4149026	1.86	0.00075	0.026
1995	4160614	1.86	0.00105	0.036
1996	4165721	1.86	0.00246	0.084
1997	4168160	1.86	0.00458	0.156
1998	4162128	1.85	0.00500	0.171
1999	4159672	1.85	0.00532	0.182
2000	4158784	1.85	0.00411	0.140
2001	4147655	1.84	0.00724	0.247
2002	4144185	1.84	0.00379	0.129
2003	4146744	1.84	0.00392	0.134
2004	4152703	1.84	0.00364	0.124
2005	4157172	1.84	0.00257	0.088

Table 3.4. Expected values (EV) of the mean and coefficients of variation (CV) of marginal posterior distributions for output parameters from the Bayesian SPM using the SIR algorithm. Results for the **finetooth shark** (baseline scenario) using equal weighting and value of r (intrinsic rate of increase) from the 2002 stock assessment of small coastal sharks. Abundances are in thousands of fish.

	Finetooth shark	
	EV	CV
Importance function	priors	
K	6397	0.82
r	0.060	0.20
MSY	96	0.86
N_{2005}	6000	0.84
N_{2005}/K	**0.90**	0.08
N_{init}	5380	0.84
N_{2005}/N_{init}	1.09	0.14
C_{2005}/MSY	0.27	1.08
F_{2005}/F_{MSY}	**0.17**	1.32
N_{2005}/N_{MSY}	**1.80**	0.09
C_{2005}/repy	0.78	81.34
N_{MSY}	3199	0.82
F_{MSY}	0.030	
repy	21	0.83
C_0	2	0.69
Diagnostics		
CW (Wt)	0.609	
CV (L*prior)	1.163	
CV (Wt) / CV (L*p)	0.52	
%maxpWt	0.0004	

N_{init} is initial abundance (for the first year of the model), repy is replacement yield

Table 3.5. Decision analysis table for the **finetooth shark** corresponding to the results in Table 3.4.

Finetooth shark

Horizon	Policy	$E(N_{fin}/K)$	$E(N_{fin}/N_{msy})$	$P(N_{fin}<0.2K)$	$P(N_{fin}>N_{msy})$	$P(N_{fin}>N_{cur})$	$P(F_{fin}<F_{cur})$	$P(N_{cur}>N_{ref})$	$P(N_{fin}<0.01K)$
10 -year	TAC=0	6.08	1.88	0	1	1	1	0.99	0
	$TAC=1C_{2005}$	5.99	1.81	0	1	0.71	0.71	0.71	0
	$TAC=2C_{2005}$	5.91	1.74	0.01	0.97	0.31	0	0.33	0
20 -year	TAC=0	6.18	1.93	0	1	1	1	0.99	0
	$TAC=1C_{2005}$	6.04	1.82	0.01	0.99	0.71	0.71	0.71	0
	$TAC=2C_{2005}$	5.9	1.7	0.03	0.95	0.31	0	0.33	0.01
30 -year	TAC=0	6.23	1.96	0	1	1	1	0.99	0
	$TAC=1C_{2005}$	6.07	1.82	0.01	0.99	0.71	0.71	0.71	0
	$TAC=2C_{2005}$	5.89	1.67	0.04	0.92	0.31	0	0.32	0.02

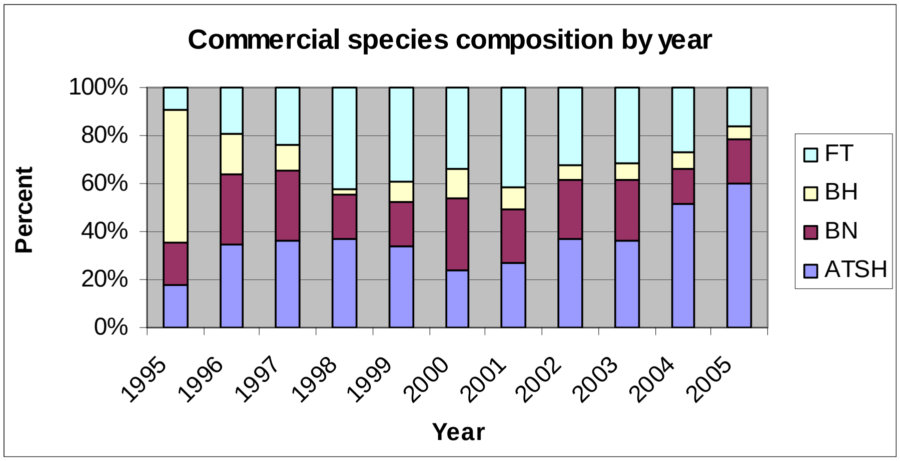
Table 3.6. Expected values (EV) of the mean and coefficients of variation (CV) of marginal posterior distributions for output parameters for the **finetooth shark** using WinBUGS as an alternative model formulation. Abundances are in thousands of fish.

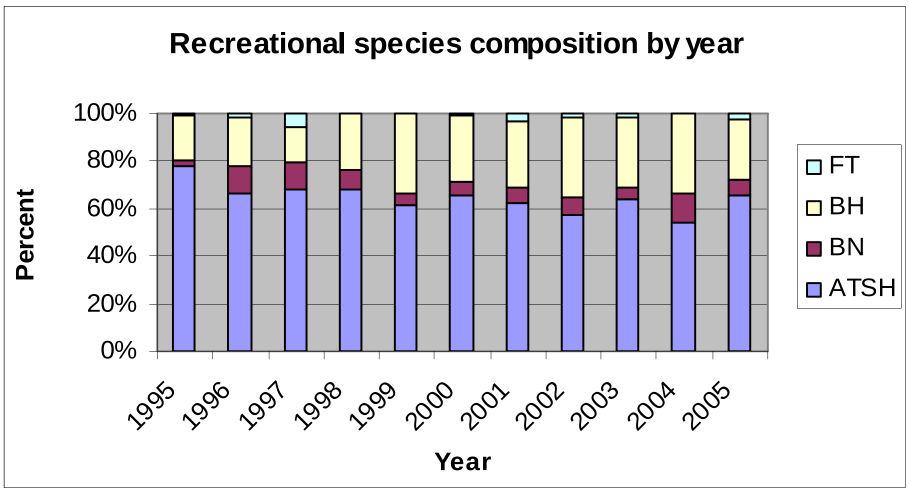
	Finetooth shark	
	EV	CV
K	5357	0.95
r	0.071	0.53
MSY	91	0.12
N_{2005}	4731	0.99
N_{2005}/K	**0.85**	0.15
N_{init}	4232	
N_{2005}/N_{init}	1.12	
C_{2005}/MSY	0.12	
F_{2005}/F_{MSY}	**0.26**	1.44
N_{2005}/N_{MSY}	**1.70**	1.45
N_{MSY}	2679	
F_{MSY}	0.036	
C_0	2	0.58
N_{init}/K	0.79	0.15
Diagnostics		
Chain mixing	good	
Autocorrelations	high	
Gelman-Rubin	good	

N_{init} is initial abundance (for the first year of the model)

Table 3.7. Expected values (EV) of the mean and coefficients of variation (CV) of marginal posterior distributions for output parameters from the Bayesian SPM using the SIR algorithm. Results for the **finetooth shark** using inverse CV weighting, an alternative catch series starting in 1950, all the CPUE series identified as "sensitivity" in the Data Workshop report, and a lower value of r. Abundances are in thousands of fish.

	Inverse CV weighting		Alternative catch		All CPUE series		Lower r	
	EV	CV	EV	CV	EV	CV	EV	CV
Importance function	priors		priors		priors		priors	
K	5950	0.88	6466	0.81	6518	0.81	6949	0.76
r	0.061	0.20	0.060	0.20	0.060	0.20	0.020	0.20
MSY	91	0.92	97	0.85	97	0.85	35	0.80
N_{2005}	5496	0.91	6217	0.84	6113	0.83	6031	0.79
N_{2005}/K	**0.87**	0.12	**0.92**	0.08	**0.90**	0.08	**0.83**	0.13
N_{init}	4692	0.91	5494	0.83	5469	0.83	5836	0.78
N_{2005}/N_{init}	1.13	0.17	1.11	0.17	1.10	0.14	1.00	0.10
C_{2005}/MSY	0.33	1.15	0.26	1.05	0.26	1.06	0.67	1.04
F_{2005}/F_{MSY}	**0.22**	1.60	**0.16**	1.29	**0.16**	1.27	**0.45**	1.26
N_{2005}/N_{MSY}	**1.75**	0.12	**1.84**	0.08	**1.81**	0.08	**1.67**	0.13
C_{2005}/repy	0.71	59.22	0.87	0.29	0.76	82.85	1.18	68.60
N_{MSY}	2974	0.88	3233	0.81	3259	0.81	3474	0.76
F_{MSY}	0.031		0.030		0.030		0.010	
repy	24	0.84	13	0.37	22	0.83	15	0.99
C_0	2	0.69			2	0.69	2	0.69
Diagnostics								
CW (Wt)	0.823		0.558		0.637		0.654	
CV (L*prior)	1.207		0.944		1.167		1.124	
CV (Wt) / CV (L*p)	0.68		0.59		0.55		0.58	
%maxpWt	0.002		0.0004		0.0005		0.0005	





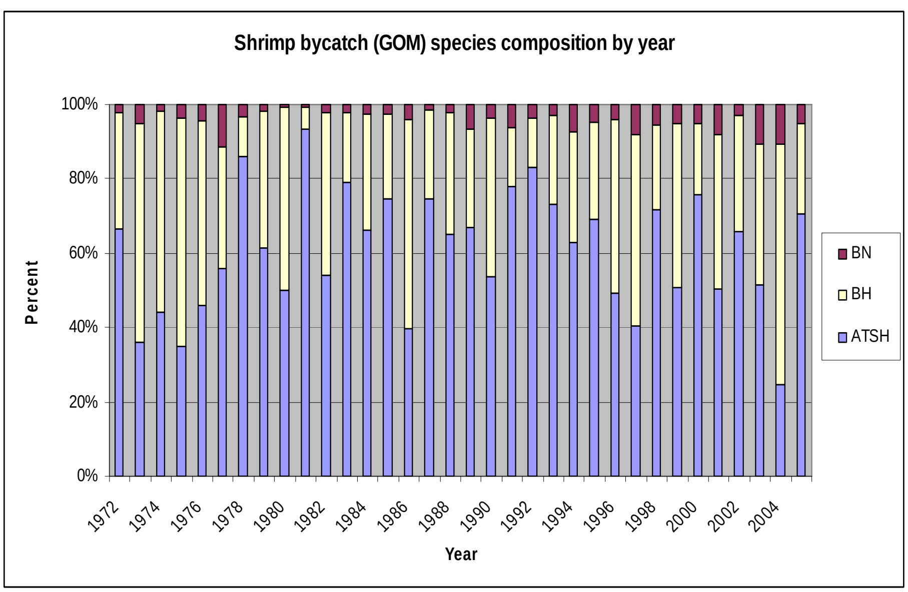
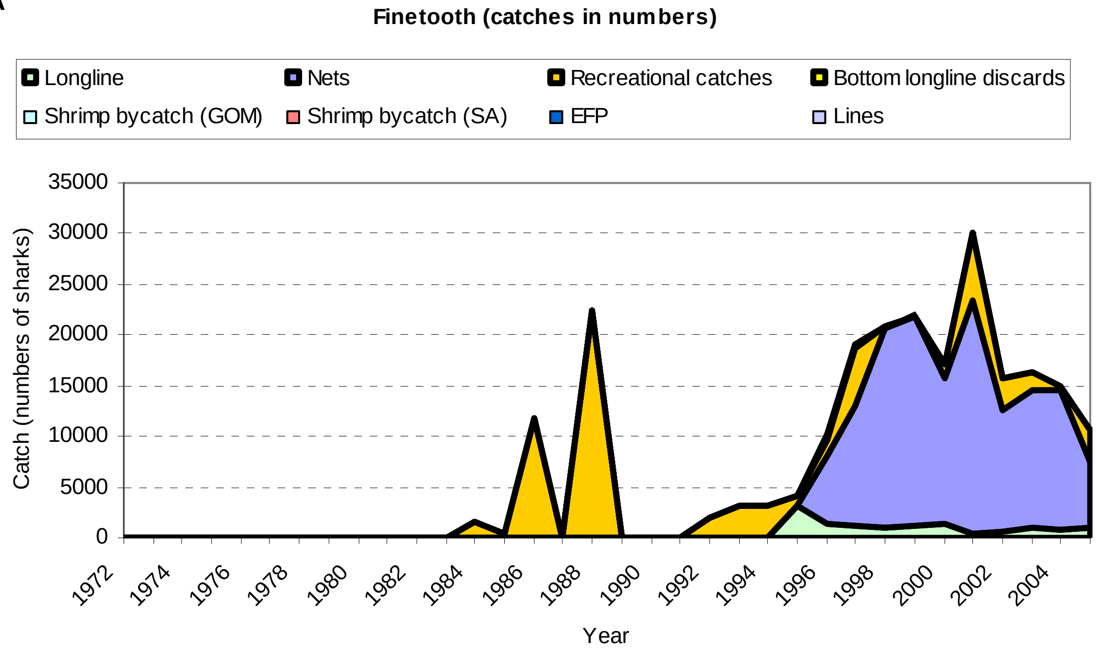


Figure 3.1. Relative species composition of commercial landings, recreational catches, and dead discards from the shrimp trawl fishery for the SCS complex.

A



B

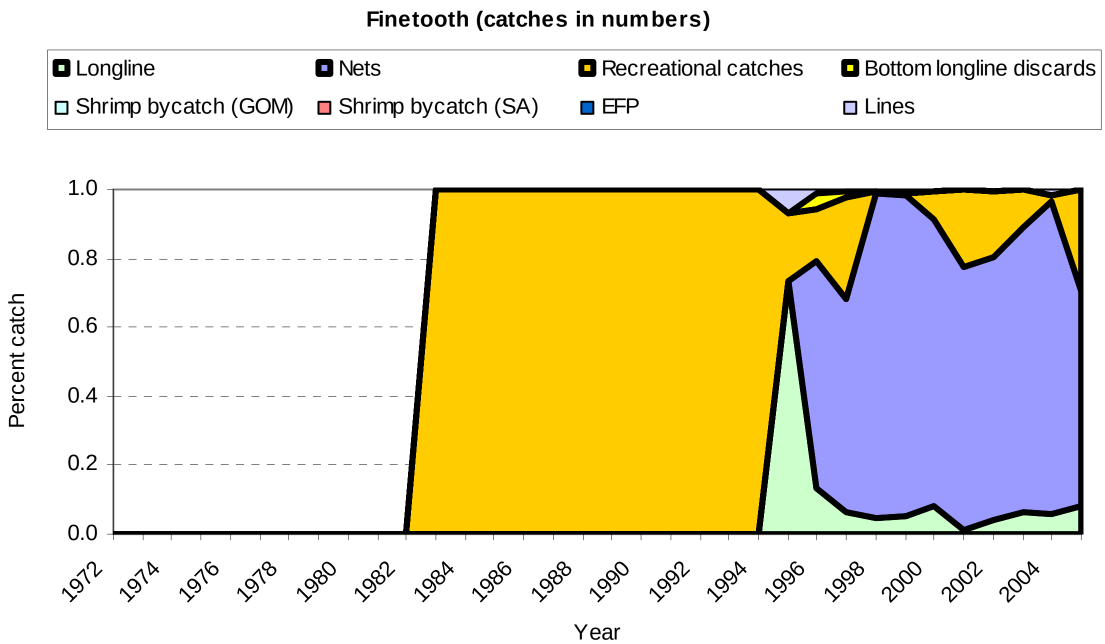


Figure 3.2. Total catches of the **finetooth shark** by sector in (A) absolute and (B) relative terms.

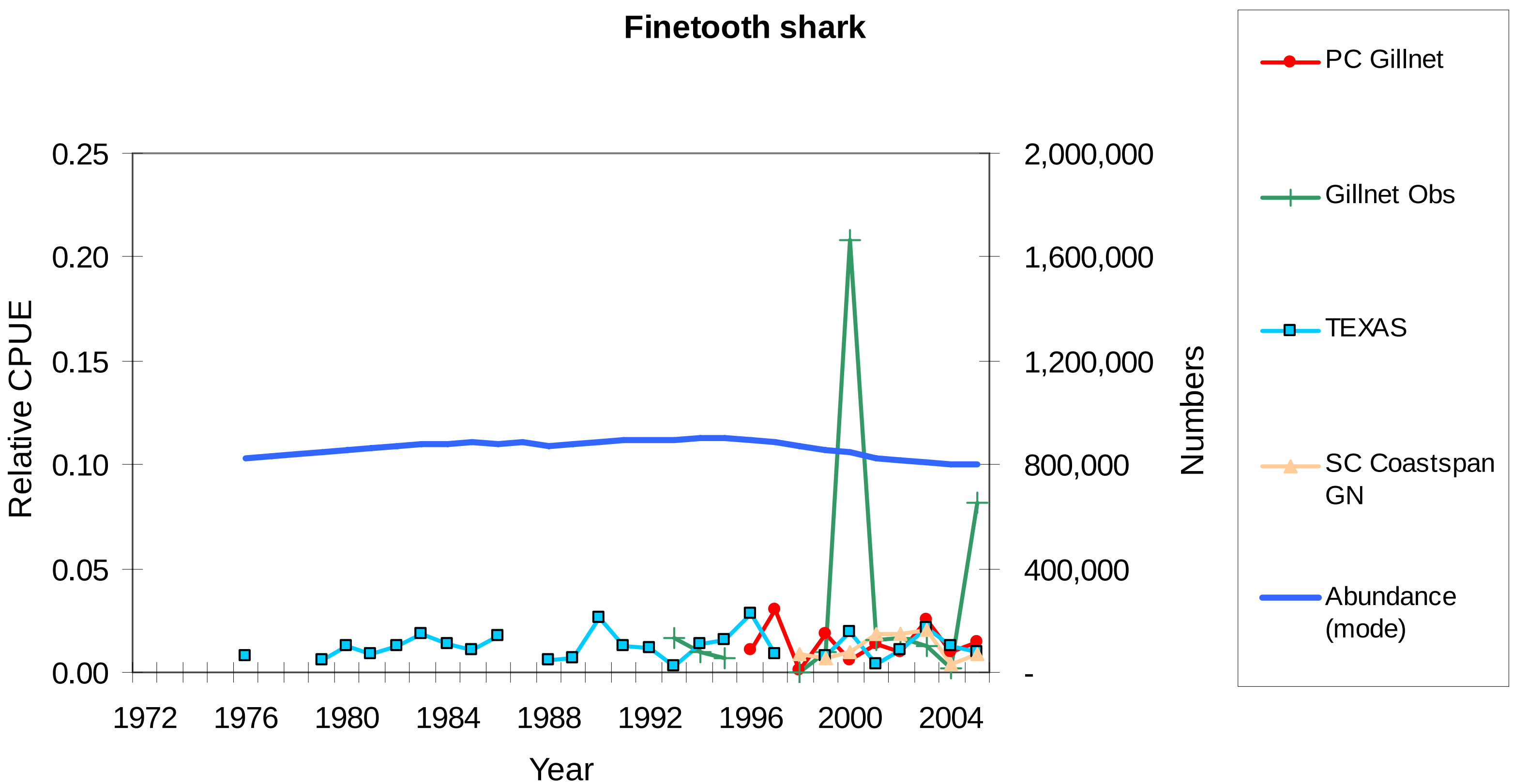


Figure 3.3. Predicted abundance trend of the BSP model fitted to the catch and CPUE data for **finetooth shark.** CPUE series shown are scaled (divided by the catchability coefficient for each series, the mean of the overlapping years, and the overall mean for all series).

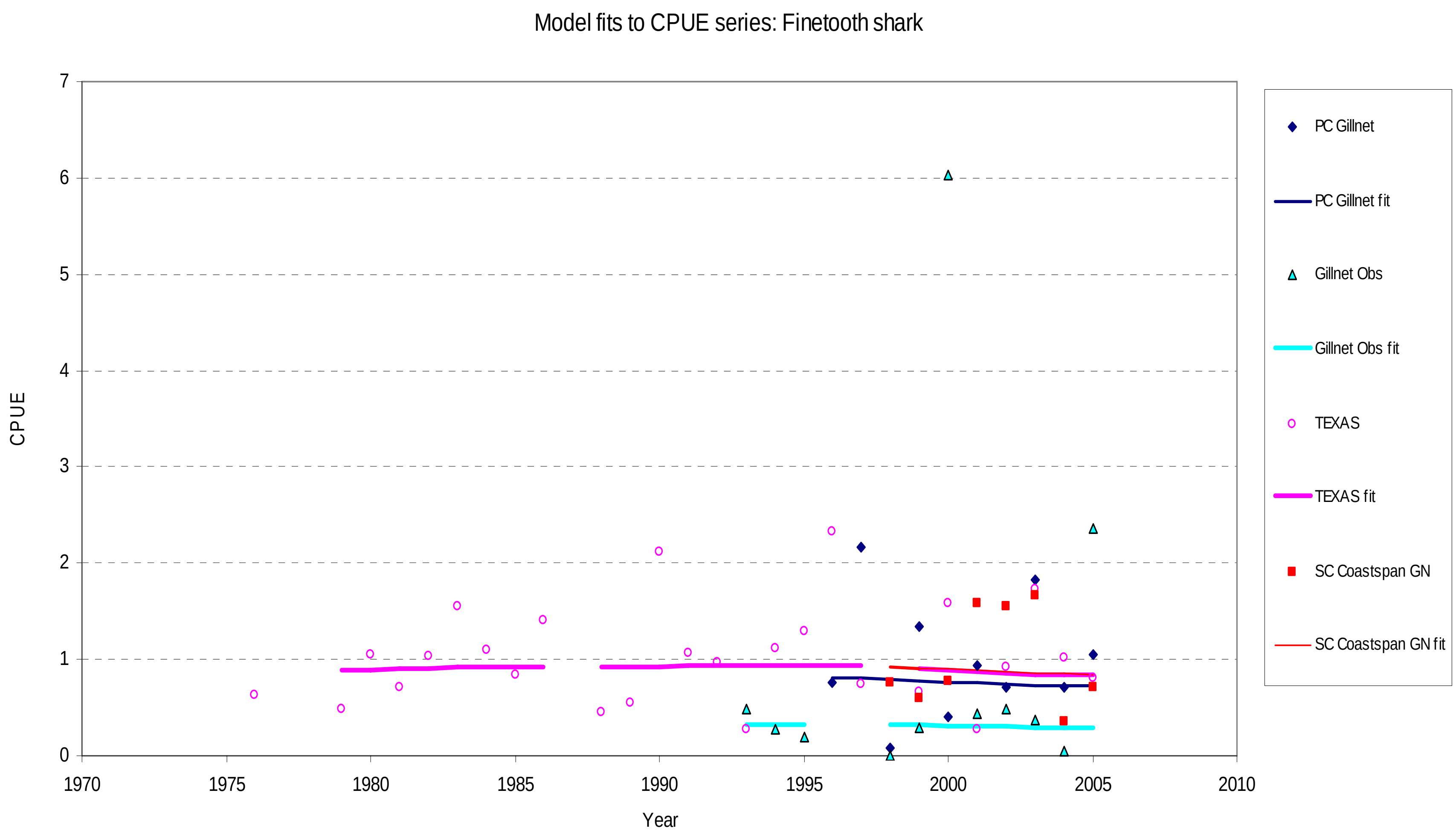
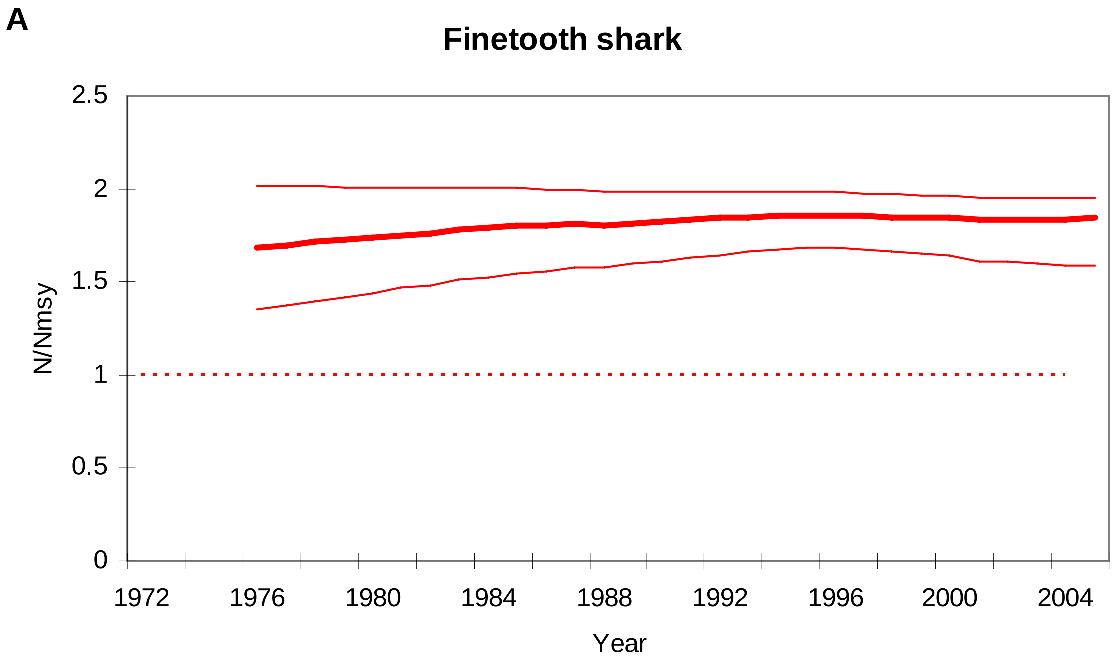


Figure 3.4. BSP model fits to the individual CPUE series for the **finetooth shark**.



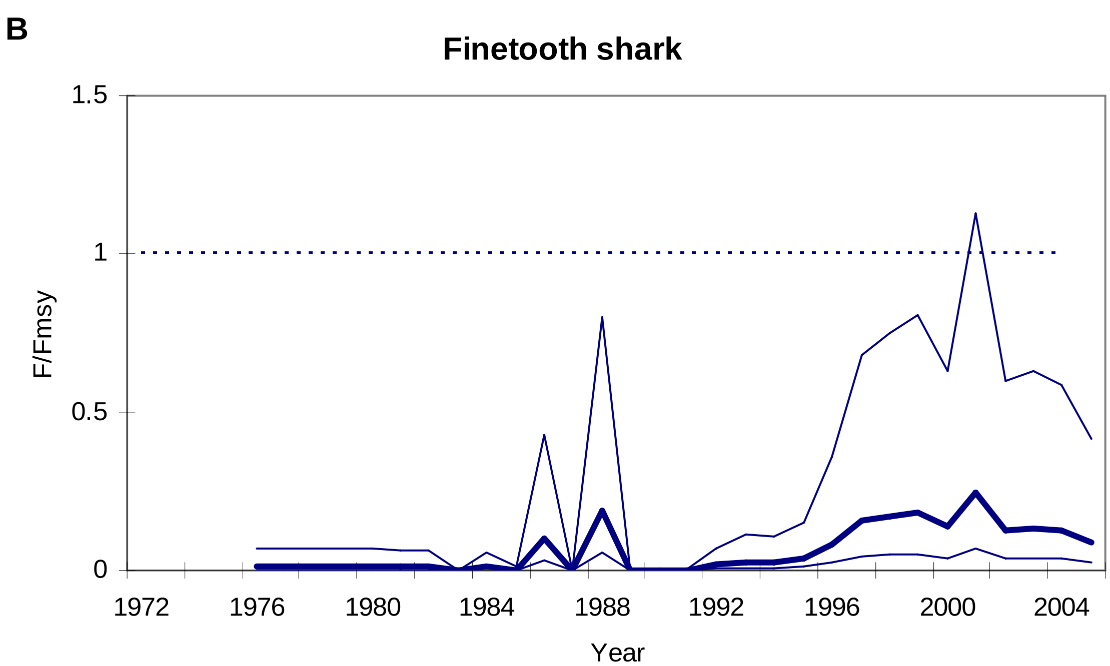


Figure 3.5. Predicted median relative abundance (A) and fishing mortality rate (B) trajectories for the **finetooth shark** with the BSP model. Values shown are medians with 80% probability intervals; horizontal lines at 1 denote MSY levels.

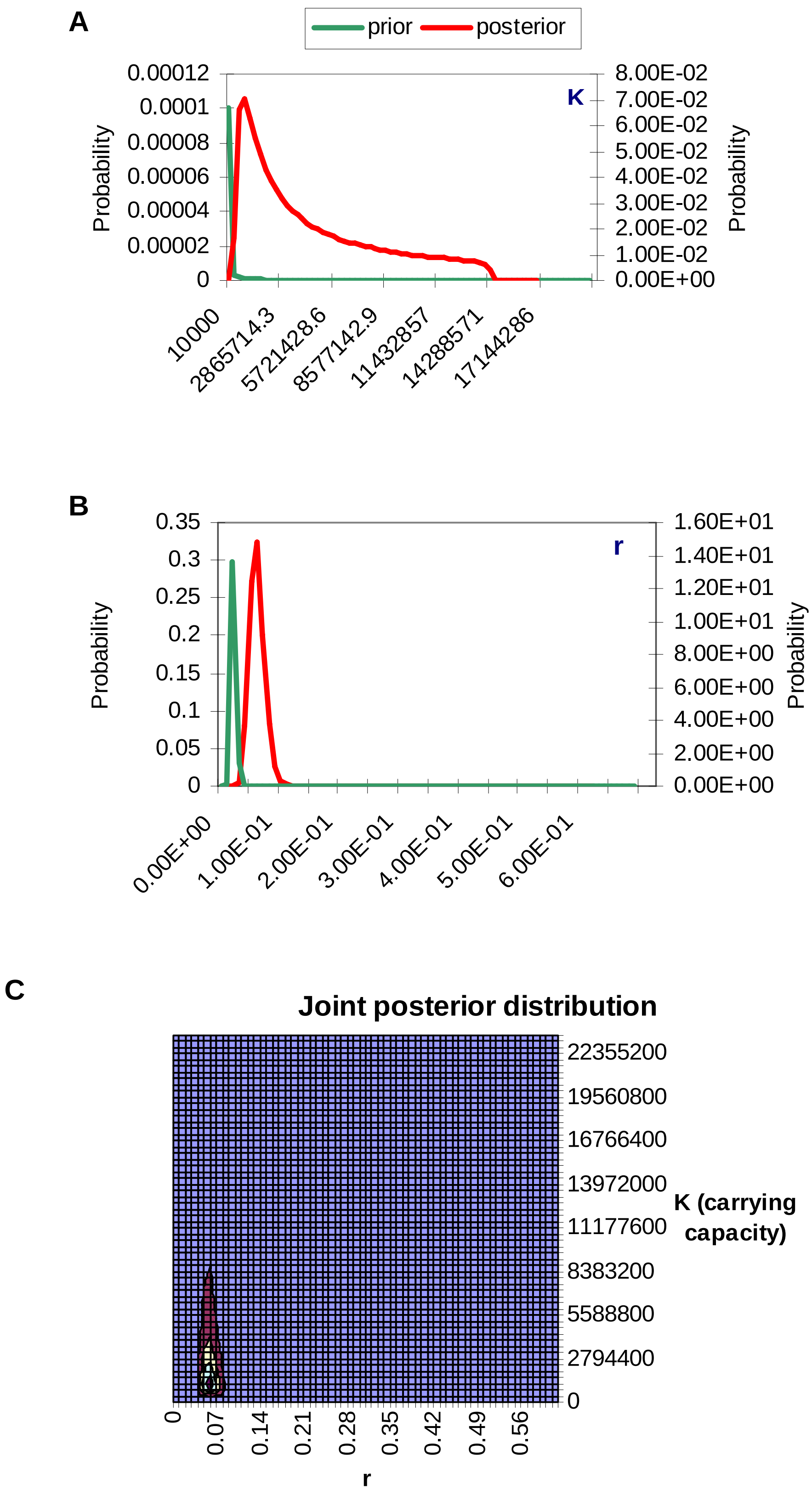


Figure 3.6. Prior (green) and posterior (red) probability distributions for (A) K and (B) r for the SCS complex from the BSP model. Also shown (C) is the joint posterior probability distribution for r and K.

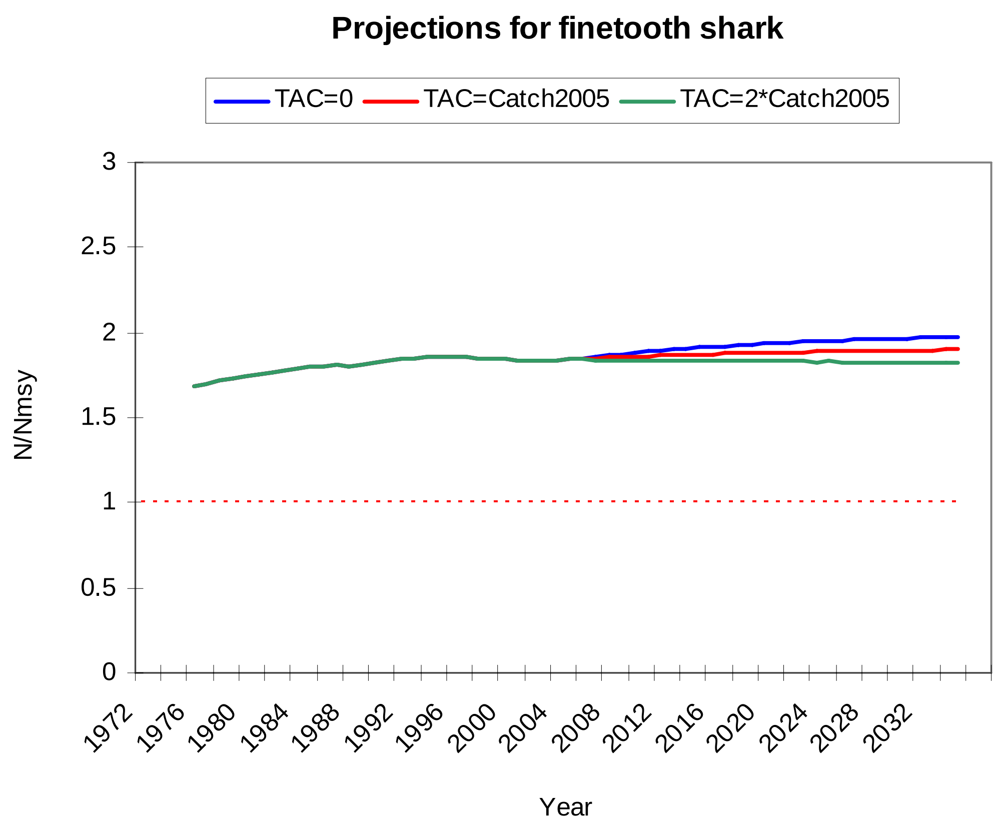


Figure 3.7. Estimated median relative abundance trajectory and projections (from 2006 to 2035) for alternative TAC-based harvesting policies (0, 1, and 2 times the 2005 TAC) for the **finetooth shark** baseline scenario. The dashed horizontal line at 1 denotes the MSY level.

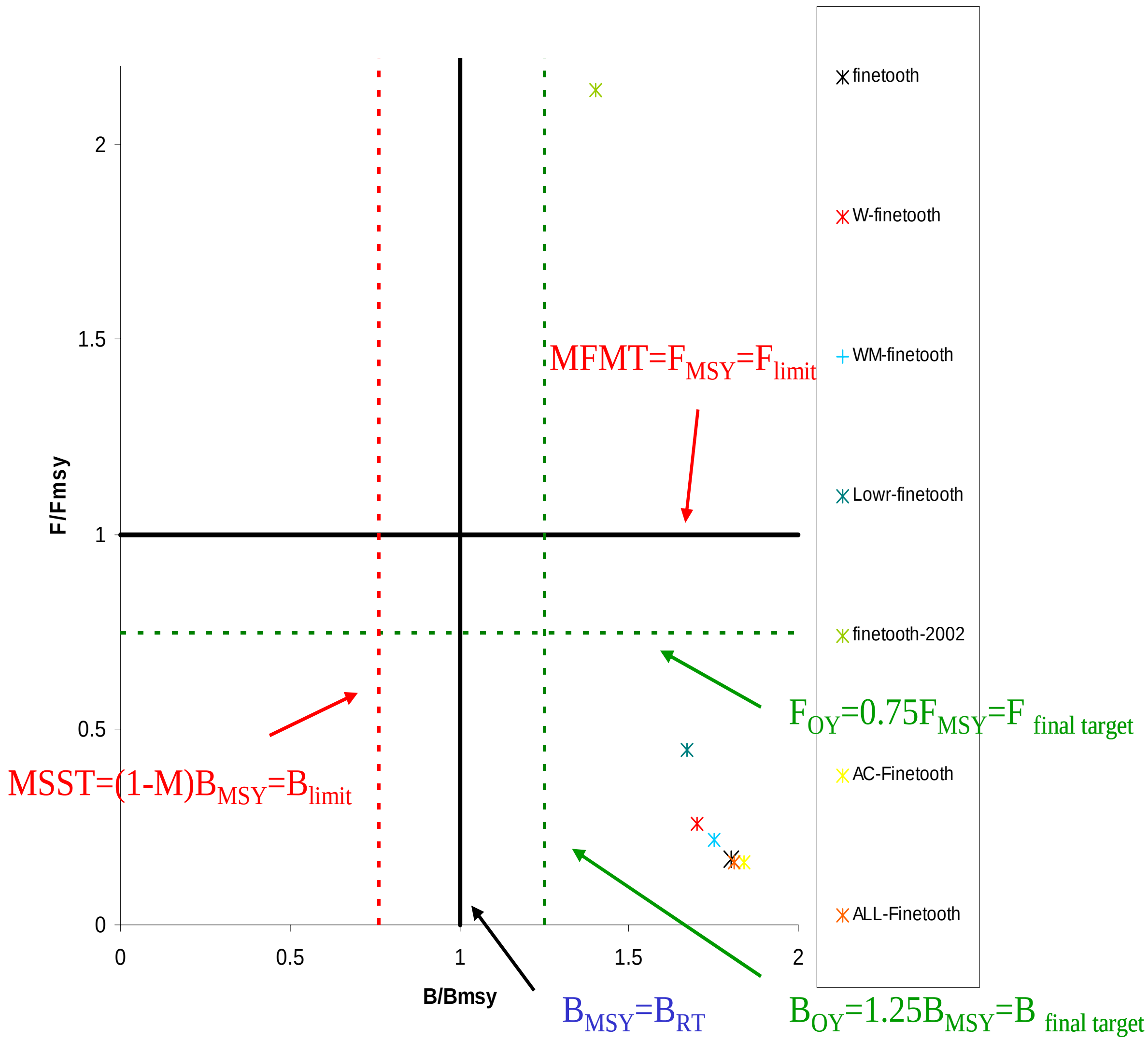


Figure 3.8. Phase plot for the **finetooth shark s**howing values of N_{2005}/N_{MSY} and F_{2005}/F_{MSY} obtained in the baseline scenario using the BSP model and various sensitivity analyses. The models include: Finetooth (baseline), W-finetooth (WinBUGS surplus production model), WM-finetooth (inverse CV weighting), AC-finetooth (alternative catch starting in 1950), ALL-finetooth (all CPUE series), and finetooth-2002 (results of the 2002 SCS assessment using WinBUGS). See text for full details. Several control rules are illustrated: the solid horizontal line indicates the MFMT (Maximum Fishing Mortality Threshold), the solid vertical line denotes the target biomass (biomass or number at MSY), the dashed horizontal line indicates the F at optimum yield (final F target for rebuilding), and the dashed vertical lines denote the MSST (Minimum Stock Size Threshold or limit biomass) and B_{OY} (biomass at optimum yield or final B target for rebuilding).

BLACKNOSE SHARK ASSESSMENT

4. BLACKNOSE SHARK (*Carcharhinus acronotus*) ASSESSMENT

4.1 Summary of Blacknose Shark Working Documents

SEDAR 13-AW-01
Cortés: Assessment of Small Coastal Sharks, Atlantic sharpnose, Bonnethead, Blacknose and Finetooth Sharks using Surplus Production Methods
We used two complementary surplus production models (BSP and WinBUGS) to assess the status of the Small Coastal Shark (SCS) complex and four individual species (Atlantic sharpnose, bonnethead, blacknose, and finetooth sharks) identified as baseline scenarios in the SCS Data Workshop report. Both methodologies use Bayesian inference to estimate stock status, and the BSP further performs Bayesian decision analysis to examine the sustainability of various levels of future catch. Extensive sensitivity analyses were performed with the BSP model to assess the effect of different assumptions on CPUE indices and weighting methods, catches, intrinsic rate of increase, and importance function on results. Baseline scenarios predicted that the stock status is not overfished and overfishing is not occurring in all cases. Using the inverse variance method to weight the CPUE data was problematic because of the nature of the CPUE time series and must be regarded with great caution, although predictions on stock status did not change, except for blacknose sharks. The alternative surplus production model implemented in WinBUGS supported the results from the BSP model, with the exception of blacknose sharks, which became overfished. None of the other sensitivity analyses examined had a large impact on results and did not affect conclusions on stock status in any case. Only blacknose sharks with the alternative catch scenario approached an overfishing condition.

SEDAR 13-AW-02
Siegfried, Cortés, and Brooks: Determining Selectivities for Small Coastal Shark Species for Assessment Purposes
Selectivities of catch series and indices had to be determined for sharpnose, blacknose, and bonnethead sharks for the 2007 small coastal shark stock assessment. Based on age frequencies, five selectivities were determined for sharpnose, four for blacknose, and two for bonnethead.

SEDAR 13-AW-03
Siegfried and Brooks: Assessment of Blacknose, Bonnethead, and Atlantic Sharpnose Sharks with a State-Space, Age-Structured Production Model
An age-structured production model was employed to assess the following small coastal sharks: Blacknose (*Carcharhinus acronotus*), Bonnethead (*Sphyrna tiburo*), and Atlantic Sharpnose (*Rhizoprionodon terraenovae*). All models assumed virgin conditions in 1950, and historically reconstructed catches were derived to inform the model on likely levels of removals for the years prior to the start of observed and recorded catches. The base models for all three species applied equal weight to all indices. Base model results for bonnethead shark indicate that the stock is overfished and that there is overfishing. The stock status appears to be quite sensitive to the reconstructed catches, particularly because of some extreme peaks in the bottom longline fishery reports and the shrimp bycatch reports. An initial sensitivity run indicates that the stock depletion decrease when less weight is given to the extreme peaks. Additional sensitivities will be performed at the assessment workshop. The base model results for blacknose suggest that the stock is overfished and that there is also overfishing. The base model for Atlantic sharpnose assumed a single stock, and results from this model indicate that the stock is not overfished nor is

overfishing occurring. A sensitivity analysis where inverse CV weights were applied to the base indices showed very little difference from the base model, and the stock status estimate was no overfishing and the stock is not overfished.

4.2 Background

In 2002, a stock assessment was conducted on the small coastal complex of sharks (finetooth (*Carcharhinus isodon*), blacknose (*Carcharhinus acronotus*), bonnethead (*Sphyrna tiburo*), and Atlantic sharpnose (*Rhizoprionodon terraenovae*), in the Gulf of Mexico and the Atlantic (Cortés 2002). The author used a variety of Bayesian statistical models, including a Schaefer biomass dynamic model, a Schaefer surplus production model (SPM), and a lagged-recruitment, survival and growth state-space model. There are more data available to assess the blacknose, bonnethead, and Atlantic sharpnose populations currently; therefore an age-structured model was applied in addition to the models used in the last assessment. This assessment report outlines the discussions and results of the current blacknose stock assessment

4.3 Available models

Three models were available for discussion for the blacknose shark assessment: two surplus production models, the BSP and WinBUGS models described previously, and one age-structured approach (Cortés 2002, SPASM, Porch 2002).

4.4 Details about surplus production model and age-structured model

A surplus production model simulates the dynamics of a population using total population biomass as the parameter that reflects changes in population size relative to its virgin condition. In comparison to more complicated models, the surplus production model is simpler in its formulation, takes less time to run and requires less input information. However, due to its formulation, the surplus production model does not describe changes that occur in subgroups of the population (adults, juveniles, etc). In addition, the sensitivity of model predictions to key stage-dependent biological parameters cannot be evaluated using a surplus production model. Finally, surplus production models are not able to incorporate a lag time into the results.

An age-structured population dynamics model describes the dynamics of each age class in the population separately and therefore, requires age-specific input information. Due to the higher complexity of these models, they usually take longer to run and require a higher volume of information relative to simpler models. However, they can account for age-dependent differences in biology, dynamics and exploitation of fish and provide an insight into the structure of the population and the processes that are more important at different life stages. They also allow for the incorporation of age-specific selectivity information.

With regard to management benchmarks, the surplus production model assumes that the population biomass that corresponds to MSY is always equal to half of the virgin population biomass, whereas the relative biomass at MSY calculated with an age-structured model (and other benchmarks associated to it) is species-specific and could be any fraction of virgin biomass.

The Assessment Panel decided to use the state-space, age-structured production model described in document SEDAR13-AW-03 for blacknose sharks. This model was selected as it allowed for the incorporation of age-specific biological and selectivity information, along with the ability to produce required management benchmarks.

4.5 Discussion of weighting methods

The Data Workshop Panel recommended that *equal weighting* for assigning weights to the different CPUE time series available during model fitting should be used for the baseline runs. The panel discussed the advantages and disadvantages of the *equal weighting* vs. the *inverse CV weighting* methods:

Equal weighting ignores the better quality of some data (smaller CVs) but is more stable between assessments because yearly changes on CVs in a given CPUE series do not affect the importance of that time series for the overall fit.

Inverse CV weighting can provide better precision as it tracks individual indices however, it could be less stable between assessments due to changes on the relative 'noise' of each time series. This method may also not be appropriate in cases in which different standardization techniques have been used for the standardization of the series and therefore, the same value of CV might reflect different levels of error depending on the CPUE it corresponds to.

The Assessment Workshop Panel further discussed the issue for weighting indices. It was noted that there are a variety of ways to weight indices in addition to equal and inverse CV weighting, however how to determine which weighting method is most appropriate is a discussion topic that is still without satisfying resolution. Given that fact, the Assessment Workshop Panel decided that equal weighting would be the base weighting method for the current assessment but noted that, as there is at present no objective way to decide which method is superior other than comparing model convergence diagnostics, future assessments may need to re-examine this issue.

4.6 Data issues and solutions derived during the assessment workshop

It was noted by that Assessment Workshop Panel that the estimate of blacknose bycatch in the shrimp fishery in 1977 seemed anomalously large (orders of magnitude) compared to the rest of the series. The anomalous peak in the shrimp bycatch data was investigated in the working document (SEDAR 13-DW-32) and found to be outside of the limits of confidence. Panelists agreed to take the geometric mean of the three years before and after the anomalous peak and replace it with that geometric mean.

Another issue that concerned Panelists was the method by which the catches were reconstructed for the longline fishery for the period between the starting year of the model (1981) and the first year of observed catch data (1995). The Catch Working Group at the Data Workshop Panel recommended the reconstruction follow a linear increase between 1981 and 1995. The Panelists at the Assessment Workshop, along with input for industry representatives present at the Workshop argued that this was not a realistic representation of the level of catch, especially in the earlier years of fishery expansion. Panelists agreed upon an exponential increase in fishing for the longline fleet reconstruction after much discussion. The new reconstructions were applied to the commercial bottom longline catch and the bottom longline discards.

4.7 Methods

4.7.1 State-space age-structured production model description

The age-structured production model (originally derived in Porch 2002) starts from a year when the stock can be considered to be at virgin conditions. Then, assuming that there is some basis for deriving historic removals, one can estimate a population trajectory from virgin conditions through a "historic era," where data are sparse, and a "modern era," where more data are available for model fitting. In all three model applications, virgin conditions were assumed in 1950. The earliest index of abundance (SEAMAP) and the earliest catch series (Shrimp trawl bycatch) begin in 1972, thus the historic model years spanned 1950-1971 (22 years) and the modern model years spanned 1972-2005 (34 years).

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

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

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

(2) $$R = \frac{R_0 S \alpha}{S_0 + (\alpha - 1)S} \quad .$$

In (2), R_0 and S_0 are virgin number of recruits (age-1 pups) and spawners (units are number of mature adult females times pup production at age), respectively. The parameter α is calculated as:

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

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

The time period from the first model year (y_1) to the last model year (y_T) is divided into a historic and a modern period, 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 less data compared to the modern period. The manner in which effort is estimated depends on the model period. 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. In the modern period, fleet-specific effort is estimated as a constant with annual deviations, which are assumed to follow a first-order lognormal autoregressive process:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

The term λ_g is a variable-specific multiplier of the overall model CV. For catch series and indices (eq 11b), the additional term, $\omega_{i,y}$, is the weight applied to individual points within those series. For instance, because the indices are standardized external to the model, the estimated variance of points within each series is available and could be used to weight the model fit. Given the data workshop decision to use equal weighting between indices for the base model run, all $\omega_{i,y}$ were fixed to 1.0 and the same λ_g was applied to all indices. To evaluate the sensitivity case where indices were weighted by the inverse of their CV, each $\omega_{i,y}$ was fixed to the estimated CV for point *y* in series *i*; an attempt was also made to estimate a separate λ_g for each series, however those multipliers were not estimable and so a single λ was applied to all indices.

4.7.2 Data inputs, prior probability distributions, and performance indicators

Baseline scenario (SPASM-BASE)
The base model represented the decisions made by the Data Workshop Panelists as well as any additional decisions or modifications made by the assessment workshop. Data inputted to the model included maturity at age, fecundity at age (pups per mature female), spawning season, catches, indices, and selectivity functions (Tables 4.1a and 4.1b, 4.2, and 4.3; Figures 4.1–4.3). Catches were made by the commercial sector and the recreational sector and we included a catch series for the discards in the bottom longline fishery. A total of ten indices were made available after the data workshop (Table 4.3, Figure 4.2), eight of which were recommended as base indices.

Individual selectivity functions to be applied to indices and catch series were identified based on length frequencies and biological information provided by the Life History Working Group at the Data Workshop. The selectivity determination methods and recommendations were presented in SEDAR 13 AW-02 and summarized here in Figure 4.3.

Catch data begin in 1981, while the earliest data for the indices is 1972 (UNC). Catches from 1981 were imputed back to 1950, when a virgin assumption was imposed. The catches for each fleet were imputed as follows: the commercial longline was reconstructed to increase at an exponential rate from 1981 to 1995 (the year of the first data point). The commercial gillnet fishery was reconstructed to increase linearly from 1981 to 1995. The longline reconstruction changed from linear (a Data Workshop recommendation) to an exponential increase following the assessment workshop recommendations.

Individual points within catch series and indices can be assigned different weights, based either on estimated precision or expert opinion. The base case model configuration was to treat all points Assessment Workshop to downweight any individual or group of points.

Estimated model parameters were pup survival, virgin recruitment (R_0), catchabilities associated with catches and indices, and fleet-specific effort. Natural mortality at ages 1+ was fixed at the values provided by the life history working group (Table 4.1a), and the priors for pup survival and virgin recruitment are listed in Table 4.1b.

In summary, the base model configuration assumed virgin conditions in 1950, used the reconstructed catch series as agreed upon (whether it was a linear or exponential increase, and used the new value for the shrimp bycatch in 1977. All inputs are given in Tables 4.1, 4.2, and 4.3. Base indices are in black font and sensitivity indices in red in Table 4.3.

Performance indicators included estimates of absolute population levels and fishing mortality for year 2005 (F_{2005}, SSF_{2005}, B_{2005}), population statistics at MSY (F_{MSY}, SSF_{MSY}, SPR_{MSY}), current status relative to MSY levels, and depletion estimates (current status relative to virgin levels). In addition, trajectories for F_{year}/F_{MSY} and SSF_{year}/SSF_{MSY} were plotted. SSF is spawning stock fecundity.

4.7.3 Methods of numerical integration, convergence diagnostics, and decision analysis

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. 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).

4.7.4 Sensitivity analyses

Four sensitivity runs to the base model were performed. The first sensitivity, recommended at the Data Workshop, was to include the indices labeled as “sensitivity indices” (PC-longline and GN logs) to the base model configuration. The second sensitivity, also recommended at the Data Workshop, was to use an inverse-CV weighting method for weighting the base indices.

The third and fourth sensitivities were requested at the Assessment Workshop. As is noted in the life history section of the Data Workshop Report, the blacknose shark has been observed to have both a one- and two-year reproductive cycle depending on the region. As the data were too sparse to conduct a region-specific analysis, it was agreed upon at the Data Workshop to use the average reproductive cycle of 1.5 years for the assessment. Sensitivities three and four were requested in order to assess the stock assuming a one- or two-year reproductive cycle.

No other sensitivities were requested at the assessment workshop.

4.8 Results

4.8.1 Baseline scenario

The base model estimated an overfished stock with overfishing (Tables 4.4 and 4.5; Figure 4.4). The stock has been experiencing an increasing level of overfishing since 1993 and became overfished in 1996. The model estimate of F by fleet is dominated by the shrimping fleet for the entire time period examined (1950-2005) (Figure 4.4). Model fits to catches are shown in Figure 4.5 and show very good agreement for all series. Model fits to the indices are shown in Figure 4.6. The UNC index is the longest time series, beginning in 1972, and its trend was fit well by the model, with the exception of the early years (Figure 4.6).

Likelihood profiling was performed in ADModel Builder (Otter Research Ltd. 2000) to obtain an approximation to the posterior distributions for several model parameters (Figures 4.7 and 4.8). The distributions for total biomass depletion or spawning stock fecundity depletion range from about 0.1-0.6 with a mode of 0.19 (Figure 4.7). The mode for the posterior of pup survival was estimated at a slightly higher value than the prior mode, while the mode of the posterior for virgin recruitment of pups was approximately 270,000 (Figure 4.8).

4.8.2 Sensitivity analyses

The results of the three sensitivity cases also estimated that the stock was overfished with overfishing (Table 4.4). For **S1** (where all indices were used) the results were very similar to the base case. Although the estimate of F_{2005}/F_{MSY} was similar to the base model, model **S2** (where the inverse-CV weighting method was used) estimated a slightly higher SSF_{2005}/SSF_{MSY}. However, the MSY and the pup survival are very similar. This sensitivity was requested by Panelists, but they agreed the results were not sufficiently different to make any changes to the base model. The results from the final two sensitivities, **S3** and **S4** (where we examined the way the model fit a one- and two-year reproductive cycle) were as expected. With a one-year reproductive cycle, the level of overfishing is reduced, as there is more production. For the two-year reproductive cycle used in **S4** the results show a more severe level of overfishing as well as a more overfished stock. Again, the Panelists requested S3 and S4 but agreed that the base case of a 1.5-year reproductive cycle was appropriate.

A phase plot of stock status for all available models shows very little agreement between the surplus production models and age structured models used in this assessment (Figure 4.9). Again, Panelists at the Assessment Workshop recommended the use of the age-structured model over that of the surplus production models. The estimate from the 2002 assessment (Cortés 2002) is shown for reference.

4.8.3 Comparison of model fits

The relative likelihood values by model source (catch, indices, effort, catchability, and recruitment) as well as a breakdown of likelihood by individual index and catch series are shown in Figures 4.10 and 4.11. These graphs show the relative contributions of each index, catch series and model source on the model's relative likelihood.

4.9 Projections of the base model

The base model was projected at F = 0 to determine the year when the stock could be declared recovered ($SSF/SSF_{MSY} > 1$). In making projections, the estimate of F in 2005 was applied for the following year (2006) and then reduced by 50% in 2007-2009 to account for an assumed reduction in the shrimping due to Hurricane Katrina. It is unlikely that any management actions could be realized until 2009.

Projections were done using Pro-2Box (Porch 2003). Projecting the stock at F = 0 we used $F = F_{2005}$ for 2006 and 50% of F_{2005} for 2007 through 2009. This projection was bootstrapped 500 times by allowing for process error in the spawner-recruit relationship. Lognormal recruitment deviations with CV = 0.4, with no autocorrelation, were assumed. No other variability was introduced into the projections. Under these assumptions, the year with 70% probability of recovering to SSF_{MSY} is **2019**, which is a **rebuilding time of 11 years** from 2009 (Figure 4.12).

Given that the rebuilding time is greater than 10 years, then management action should be implemented to rebuild the stock within the estimated **rebuild time + 1 generation time** (Restrepo et al. 1998). The estimate of generation time is about 8 years, which gives (**11 years) + (8 years) = 19 years** to rebuild, or the **year 2027**. Generation time was calculated as

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

where *i* is age, f_i is the product of (fecundity at age) x (maturity at age), and s_j is survival at age. The calculations were carried out to an age, A, such that the difference between performing the calculation to age A or A+1 was negligible. This calculation is consistent with the assessment model, which treats survival of the plus group as the sum of a geometric series (e.g. see third line in Equation 1). The 2005 maturity ogive was used, 1.65 pups per female was the fecundity for all ages, adjusted age-specific survival at age was used, and the mode of 0.72 for the prior on pup survival was used. Note that because pup-production is constant for all ages, it factors out of both numerator and denominator, and the resulting estimate of generation time is insensitive to that value.

A fixed TAC strategy was used to estimate a TAC that would attain rebuilding by the year 2027. Assumptions for these projections included the above process error in stock-recruitment, the selectivity vector was the geometric mean of the last 3 years (2003-2005), and it was assumed that any modification to a TAC would impact each fishery by the same proportion. A constant TAC of 19,200 individuals would lead to rebuilding with 70% probability by 2027(70% of the bootstraps have $SSF_{2027}/SSF_{MSY} > 1$; Figure 4.13). The constant TAC also allows for rebuilding with 50% confidence by 2024 (black line in Figure 4.13)

3.10 Discussion

The main issues, such as the anomalous shrimp peak and linear versus exponential reconstruction of the blacknose catch in the commercial longline fishery were debated and resolved agreeably. All models, including the sensitivities, that were agreed upon by the panelists show an overfished stock with overfishing occurring. The last assessment did not find an overfished stock or overfishing occurring; however, fewer data were available for the 2002 assessment. As shown in the phase plot in Figure 4.9, the SPMs gave far more optimistic scenarios for stock status than the age-structured models agreed upon by the Panelists. In the base model, total fishing mrtality from 1995-2005 averages 0.26, and for 2002-2005 it averages 0.32. These levels are 4-5 times the estimate of F_{MSY}. The combination of life-history parameters and the vulnerability of these sharks to the various gears long before they are mature suggest a population that cannot support more exploitation.

3.11 References

Cortés, E. (2002). Stock Assessment of Small Coastal Sharks in the U.S. Atlantic and Gulf of Mexico, NOAA-Fisheries Sustainable Fisheries Division
133.

Myers, R. A., K. G. Bowen, et al. 1999. Maximum reproductive rate of fish at low population sizes. *Canadian Journal of Fisheries and Aquatic Sciences* **56**: 2404-2419.

Otter Research Ltd. 2001. An introduction to AD MODEL BUILDER Version 6.0.2. Box 2040, Sidney, B. C. V8L 3S3, Canada.

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.

Porch, C.E. 2003. Pro-2Box v.2.01 User's guide.

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

Table 41a. Biological inputs for the **blacknose shark**

Age	M	Female Maturity	Pups-per-Female
1	0.33	0	1.65
2	0.28	0.07	1.65
3	0.26	0.10	1.65
4	0.25	0.48	1.65
5	0.25	0.92	1.65
6	0.24	0.99	1.65
7	0.24	1	1.65
8	0.24	1	1.65
9	0.24	1	1.65
10	0.24	1	1.65
11	0.24	1	1.65
12	0.24	1	1.65
13	0.22	1	1.65

Table 41b. Additional parameter specifications for the **blacknose shark**, where L_∞, K, and t_0 are von Bertalanffy parameters; a is the scalar coefficient of weight on length; and b is the power coefficient of weight on length. Weight units are kg.

Parameter	Value	Prior
L_∞	104.3 (cm FL)	*constant*
K	0.3	*constant*
t_0	-1.71	*constant*
a	1.65E-06	*constant*
b	3.34	*constant*
Pup Survival	0.72	~LN with CV=0.30
Virgin Recruitment (R_0)	[1.0E+4, 1.0E+10]	~N with CV=0.7

Table 4.. Catches of **blacknose shark** by fleet with reconstructed catches in blue. The last row lists the selectivity applied to each catch series.

Year	Longline	Nets	Lines	Recreational catches	Bottom longline discards	Shrimp bycatch
1950	0	0	0	1,826	0	11,509
1951	0	0	0	2,051	0	14,783
1952	0	0	0	2,276	0	14,964
1953	0	0	0	2,501	0	17,204
1954	0	0	0	2,725	0	17,772
1955	0	0	0	2,950	0	16,105
1956	0	0	0	3,175	0	14,640
1957	0	0	0	3,400	0	13,157
1958	0	0	0	3,625	0	13,073
1959	0	0	0	3,849	0	14,664
1960	0	0	0	4,074	0	15,706
1961	0	0	0	4,174	0	7,878
1962	0	0	0	4,273	0	10,328
1963	0	0	0	4,372	0	15,560
1964	0	0	0	4,472	0	13,915
1965	0	0	0	4,571	0	14,953
1966	0	0	0	4,671	0	14,114
1967	0	0	0	4,770	0	17,335
1968	0	0	0	4,870	0	15,807
1969	0	0	0	4,969	0	16,546
1970	0	0	0	5,068	0	18,233
1971	0	0	0	4,658	0	18,674
1972	0	0	0	4,247	0	16,797
1973	0	0	0	3,836	0	17,085
1974	0	0	0	3,425	0	8,716
1975	0	0	0	3,014	0	22,969
1976	0	0	0	2,603	0	14,957
1977	0	0	0	2,193	0	14,791
1978	0	0	0	1,782	0	24,171
1979	0	0	0	1,371	0	14,823
1980	0	0	0	1,183	0	9,759
1981	7	0	0	0	3	11,475
1982	19	0	0	0	8	8,964
1983	75	0	0	14,233	34	10,731
1984	126	0	0	844	57	8,201
1985	191	0	0	1,918	86	11,025
1986	299	0	0	3,308	135	22,764
1987	467	1,457	0	15,382	211	13,656

1988	673	2,915	0	15,971	303	12,270
1989	1,023	4,372	0	1,793	461	29,999
1990	1,300	5,829	0	3,345	586	22,605
1991	2,000	7,286	0	8	902	41,979
1992	4,000	8,744	0	5,199	1,803	42,999
1993	6,000	10,201	0	2,875	2,705	17,464
1994	8,500	11,658	0	14,464	3,832	30,789
1995	15,652	13,116	20	2,954	7,056	45,384
1996	8,641	14,573	768	12,414	3,895	39,732
1997	17,628	26,004	88	11,079	7,947	65,639
1998	7,689	15,613	43	10,523	3,466	38,367
1999	5,968	21,812	539	6,139	2,691	30,913
2000	13,493	32,154	956	10,410	6,083	35,523
2001	5,732	28,549	29	15,445	2,584	51,325
2002	6,877	21,280	522	11,438	3,101	28,593
2003	10,385	12,498	90	6,615	4,683	61,079
2004	5,889	7,942	114	15,261	2,674	73,786
2005	8,178	9,055	212	7,548	3,718	23,154
Selectivity	1	3	1	1	3	1

Table 4.3 Indices available for use in the current **blacknose shark** assessment. Sensitivity indices are in red. The last row lists the selectivity applied to each index.

PC-GN adult	PC-GN juvenile	GNOP	BLLOP	NMFS LL SE	SCDNR	UNC	MML	PC-LL	GN logs	Year
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1950
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1951
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1952
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1953
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1954
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1955
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1956
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1957
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1958
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1959
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1960
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1961
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1962
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1963
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1964
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1965
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1966
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1967
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1968
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1969
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1970
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1971
-1	-1	-1	-1	-1	-1	3.967	-1	-1	-1	1972
-1	-1	-1	-1	-1	-1	4.233	-1	-1	-1	1973
-1	-1	-1	-1	-1	-1	1.600	-1	-1	-1	1974
-1	-1	-1	-1	-1	-1	3.326	-1	-1	-1	1975
-1	-1	-1	-1	-1	-1	2.489	-1	-1	-1	1976
-1	-1	-1	-1	-1	-1	6.276	-1	-1	-1	1977
-1	-1	-1	-1	-1	-1	4.048	-1	-1	-1	1978

-1	-1	-1	-1	-1	-1	3.115	-1	-1	-1	1979
-1	-1	-1	-1	-1	-1	1.866	-1	-1	-1	1980
-1	-1	-1	-1	-1	-1	0.728	-1	-1	-1	1981
-1	-1	-1	-1	-1	-1	1.503	-1	-1	-1	1982
-1	-1	-1	-1	-1	-1	0.849	-1	-1	-1	1983
-1	-1	-1	-1	-1	-1	1.814	-1	-1	-1	1984
-1	-1	-1	-1	-1	-1	0.953	-1	-1	-1	1985
-1	-1	-1	-1	-1	-1	0.595	-1	-1	-1	1986
-1	-1	-1	-1	-1	-1	1.099	-1	-1	-1	1987
-1	-1	-1	-1	-1	-1	2.135	-1	-1	-1	1988
-1	-1	-1	-1	-1	-1	0.812	-1	-1	-1	1989
-1	-1	-1	-1	-1	-1	0.565	-1	-1	-1	1990
-1	-1	-1	-1	-1	-1	1.052	-1	-1	-1	1991
-1	-1	-1	-1	-1	-1	2.315	-1	-1	-1	1992
-1	-1	12.832	-1	-1	-1	1.381	-1	0.008	-1	1993
-1	-1	110.912	17.126	-1	-1	0.819	-1	0.076	-1	1994
-1	-1	14.734	41.156	0.066	-1	1.012	-1	0.021	-1	1995
0.446	0.168	-1	35.776	0.1774	-1	1.396	-1	-1	-1	1996
0.161	0.082	-1	13.373	0.129	-1	0.419	-1	0.017	-1	1997
0.156	0.069	39.207	37.706	-1	0.016	0.189	-1	0.032	0.001	1998
0.308	0.086	55.567	44.055	0.139	0.008	0.131	-1	0.052	0.001	1999
0.025	0.105	96.643	130.194	0.139	0.033	0.194	-1	0.096	0.001	2000
0.157	0.114	40.011	14.477	0.251	0.016	0.597	-1	-1	0.004	2001
0.242	0.124	143.84	67.202	0.215	0.035	0.243	-1	-1	0.011	2002
0.216	0.117	63.992	34.63	0.483	0.023	0.1	0.988	-1	0.015	2003
0.232	0.131	46.179	28.78	0.347	0.015	0.387	2.548	-1	0.014	2004
0.118	0.119	251.732	130.604	0.204	0.034	0.405	1.717	-1	0.026	2005
3	3	2	1	1	1	4	4	1	2	Selectivity

Table 4.4. Results for the BASE, S1, S2, S3 and S4 model runs for **blacknose shark** using the updated catches. Pups-virgin is the number of age 1 pups at virgin conditions. SSF is spawning stock fecundity, which is the sum of number mature at age times pup-production at age (rather than SSB, since biomass does not influence pup production in sharks).

Blacknose	BASE		S1		S2		S3		S4	
	Estimate	CV	Estimate	CV	Estimate	CV	Estimate	CV	Estimate	CV
SSF_{2005}/SSF_{MSY}	0.48	0.67	0.52	0.59	0.60	0.73	0.601	0.66	0.43	0.65
F_{2005}/F_{MSY}	3.77	0.83	3.48	0.81	3.49	0.76	2.12	0.80	5.68	0.85
N_{2005}/N_{MSY}	0.48	-	0.52	-	0.51	-	0.55	-	0.30	-
MSY	89,415	-	99,876	-	99,236	-	91,681	-	88,911	-
SPR_{MSY}	0.71	0.38	0.71	0.39	0.70	0.14	0.54	0.28	0.64	0.45
F_{MSY}	0.07	-	0.07	-	0.07	-	0.11	-	0.05	-
SSF_{MSY}	349,060	-	347,930	-	343,050	-	434,590	-	108,920	-
N_{MSY}	570,753	-	569,595	-	564,628	-	522,800	-	603,536	-
F_{2005}	0.24	0.83	0.23	0.16	0.23	0.76	0.23	0.80	0.26	0.85
SSF_{2005}	168,140	0.75	179,870	0.77	204,720	0.71	261,240	0.82	133,250	0.78
N_{2005}	349,308	-	293,540	-	286,486	-	290,138	-	180,370	-
SSF_{2005}/SSF_0	0.20	0.65	0.22	0.63	0.21	0.58	0.22	0.23	0.19	0.49
B_{2005}/B_0	0.17	0.68	0.19	0.66	0.18	0.55	0.21	0.63	0.15	0.61
R0	317,590	0.19	321,470	0.19	316,810	0.18	265,620	0.19	358,870	0.20
Pup-survival	0.78	0.23	0.78	0.23	0.79	0.23	0.75	0.24	0.81	0.22
alpha	2.02	-	2.02	-	2.05	-	3.43	-	1.58	-
steepness	0.336	-	0.34	-	0.339	-	0.46	-	0.28	-

Table 4.5. Estimates of total number, spawning stock fecundity, and fishing mortality by year for base model for **blacknose shark**.

Year	N	SSF	F
1950	1.34E+06	9.11E+05	0.012
1951	1.33E+06	9.06E+05	0.013
1952	1.32E+06	8.99E+05	0.014
1953	1.31E+06	8.92E+05	0.015
1954	1.30E+06	8.84E+05	0.016
1955	1.30E+06	8.77E+05	0.017
1956	1.29E+06	8.71E+05	0.018
1957	1.28E+06	8.64E+05	0.019
1958	1.27E+06	8.57E+05	0.020
1959	1.26E+06	8.50E+05	0.021
1960	1.26E+06	8.43E+05	0.022
1961	1.25E+06	8.37E+05	0.023
1962	1.24E+06	8.30E+05	0.024
1963	1.23E+06	8.23E+05	0.025
1964	1.23E+06	8.16E+05	0.026
1965	1.22E+06	8.10E+05	0.027
1966	1.21E+06	8.03E+05	0.028
1967	1.20E+06	7.96E+05	0.029
1968	1.19E+06	7.90E+05	0.030
1969	1.19E+06	7.83E+05	0.031
1970	1.18E+06	7.77E+05	0.032
1971	1.17E+06	7.70E+05	0.033
1972	1.16E+06	7.64E+05	0.034
1973	1.16E+06	7.57E+05	0.031
1974	1.15E+06	7.52E+05	0.017
1975	1.15E+06	7.52E+05	0.040
1976	1.14E+06	7.47E+05	0.027
1977	1.14E+06	7.45E+05	0.044
1978	1.13E+06	7.39E+05	0.041
1979	1.12E+06	7.32E+05	0.026
1980	1.12E+06	7.30E+05	0.017
1981	1.13E+06	7.32E+05	0.019
1982	1.13E+06	7.36E+05	0.014

1983	1.14E+06	7.42E+05	0.031
1984	1.13E+06	7.34E+05	0.014
1985	1.14E+06	7.38E+05	0.020
1986	1.14E+06	7.40E+05	0.041
1987	1.13E+06	7.36E+05	0.041
1988	1.11E+06	7.23E+05	0.042
1989	1.10E+06	7.09E+05	0.062
1990	1.08E+06	6.99E+05	0.055
1991	1.07E+06	6.90E+05	0.090
1992	1.04E+06	6.72E+05	0.107
1993	1.01E+06	6.44E+05	0.067
1994	9.92E+05	6.23E+05	0.116
1995	9.47E+05	5.88E+05	0.157
1996	8.89E+05	5.48E+05	0.154
1997	8.39E+05	5.10E+05	0.279
1998	7.46E+05	4.47E+05	0.176
1999	7.05E+05	4.11E+05	0.169
2000	6.70E+05	3.85E+05	0.259
2001	6.05E+05	3.44E+05	0.305
2002	5.41E+05	3.05E+05	0.229
2003	5.02E+05	2.75E+05	0.345
2004	4.41E+05	2.39E+05	0.445
2005	3.72E+05	2.00E+05	0.245

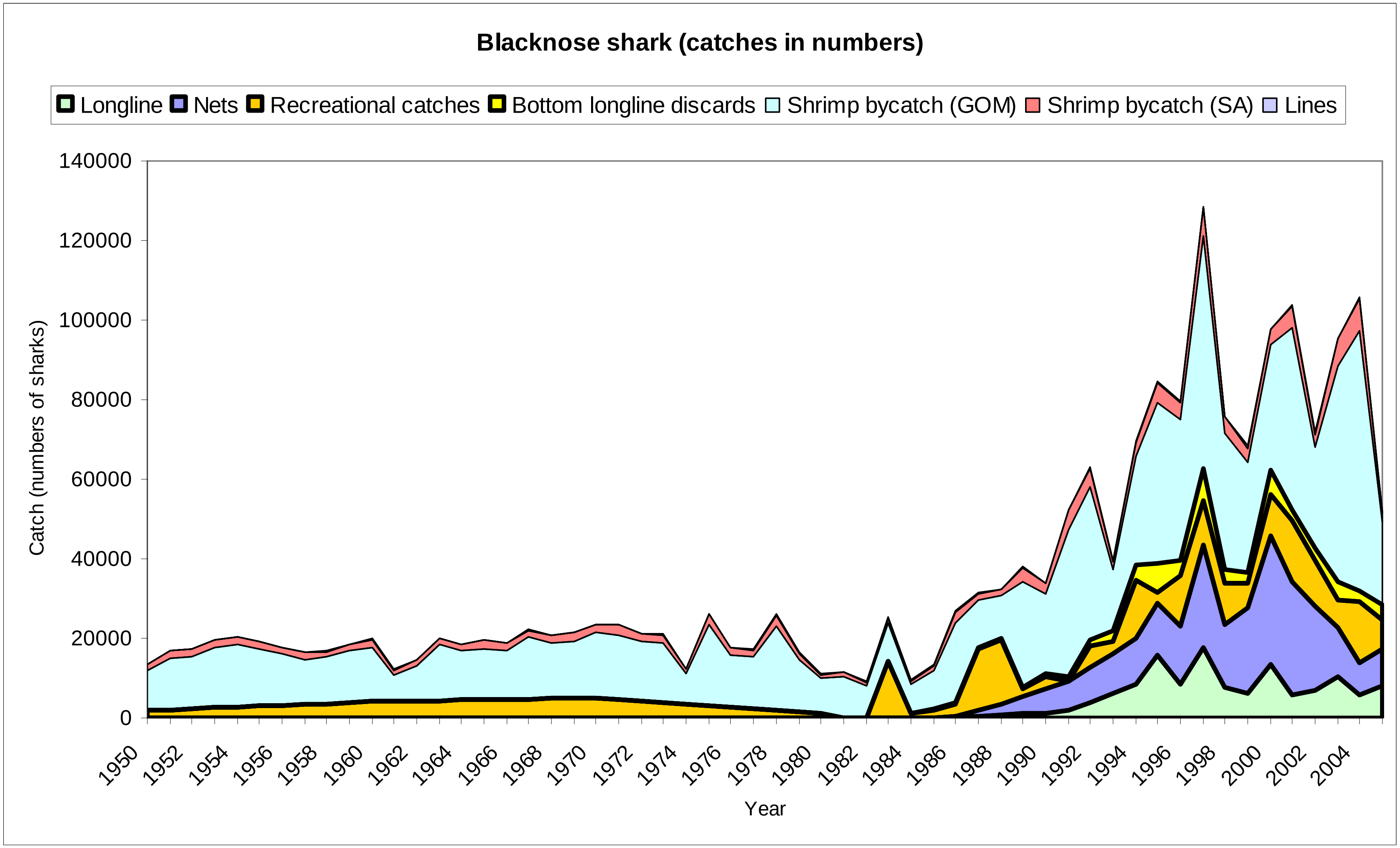


Figure 4.1. All catches by fleet for **blacknose shark** including reconstructed catches.

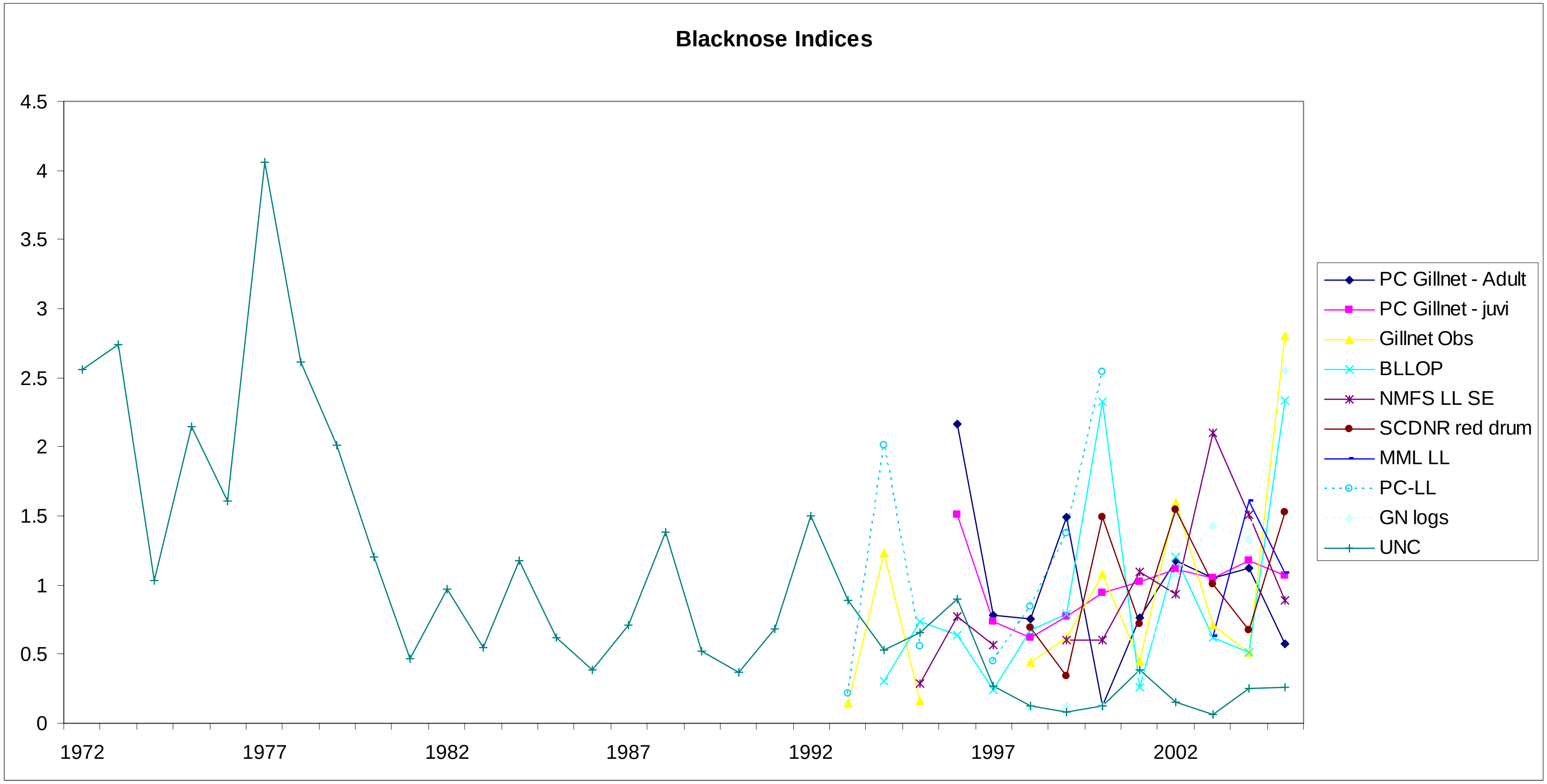


Figure 4.2. Indices available for the current **blacknose shark** assessment. The sensitivity indices are dashed lines.

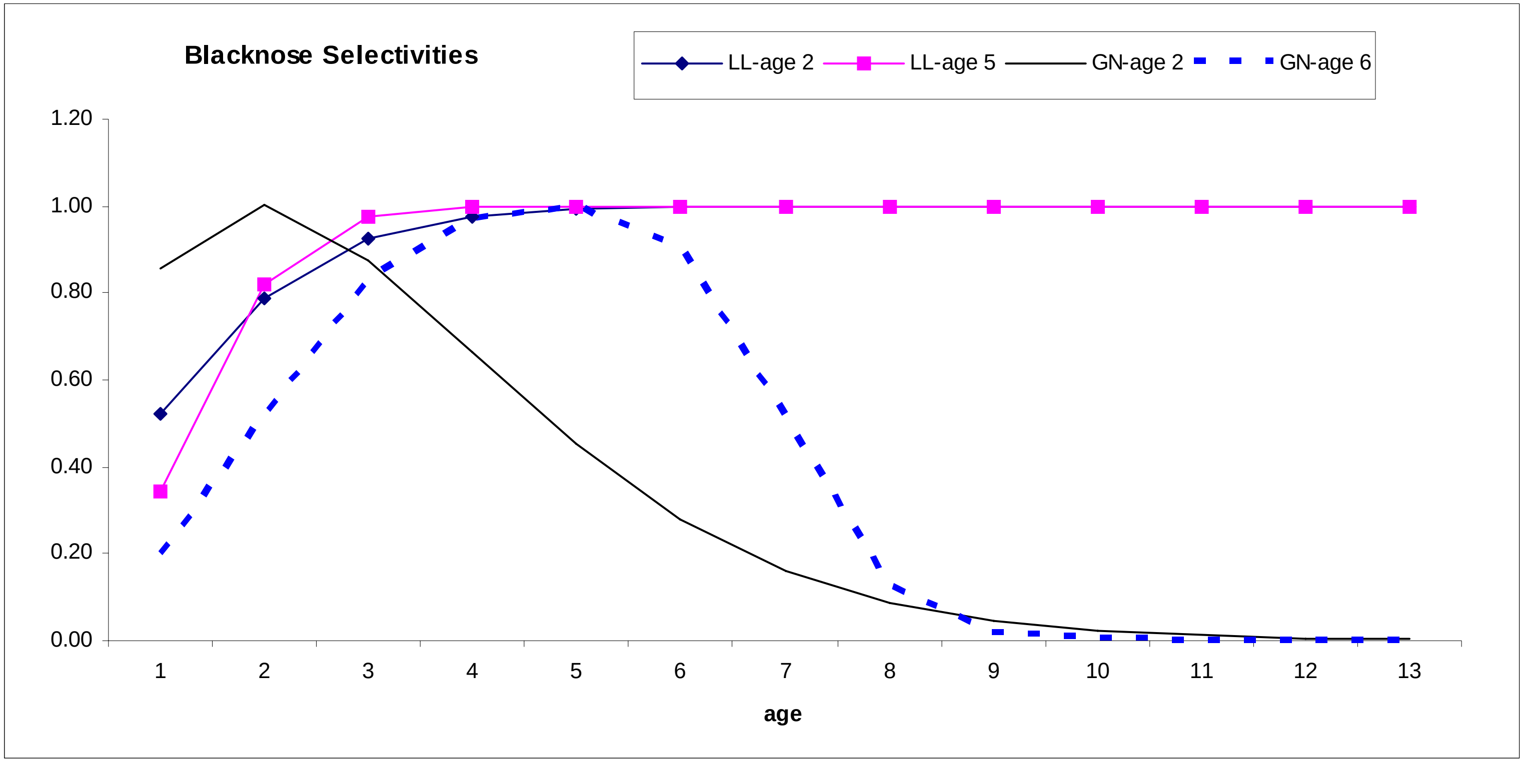


Figure 4.3. Selectivities used in **blacknose shark** assessment. In the text, they are reference as 1,2,3 and 4, which corresponds to the order in which they appear in the legend above.

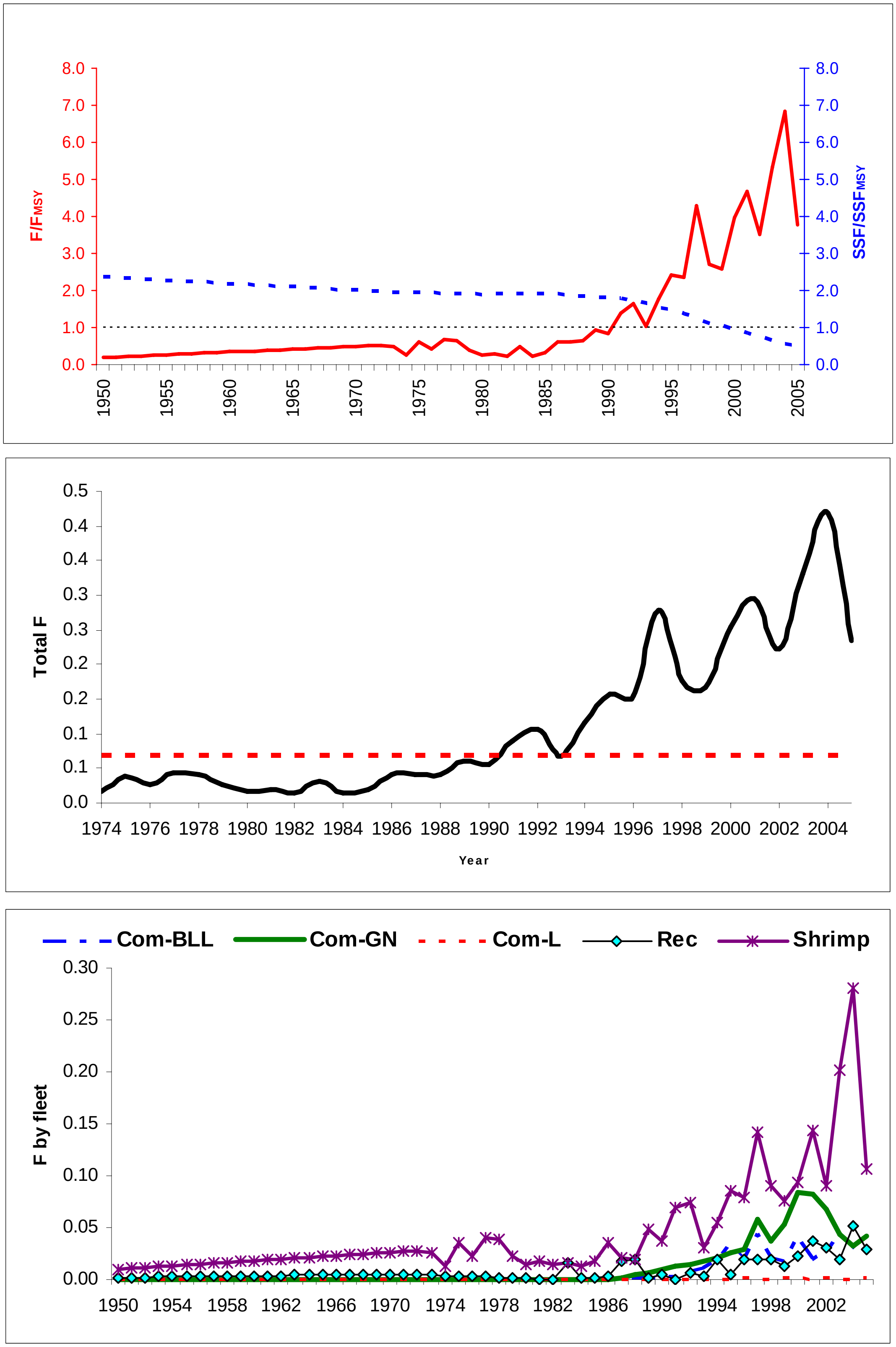


Figure 4.4. Estimated stock status (top), total fishing mortality (middle), and fleet-specific F (bottom) for **blacknose shark**. The dashed line in the middle panel indicates F_{MSY}.

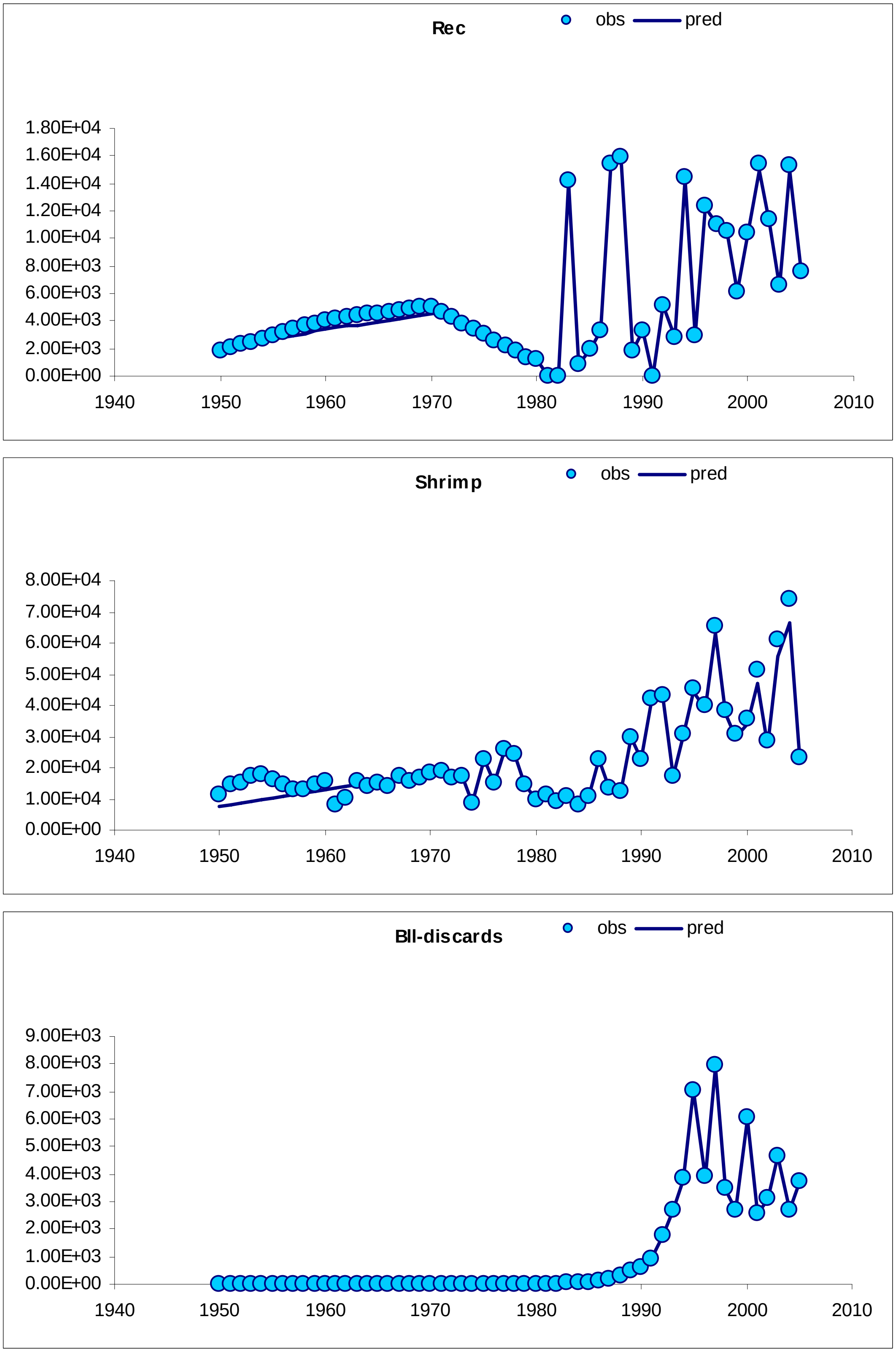
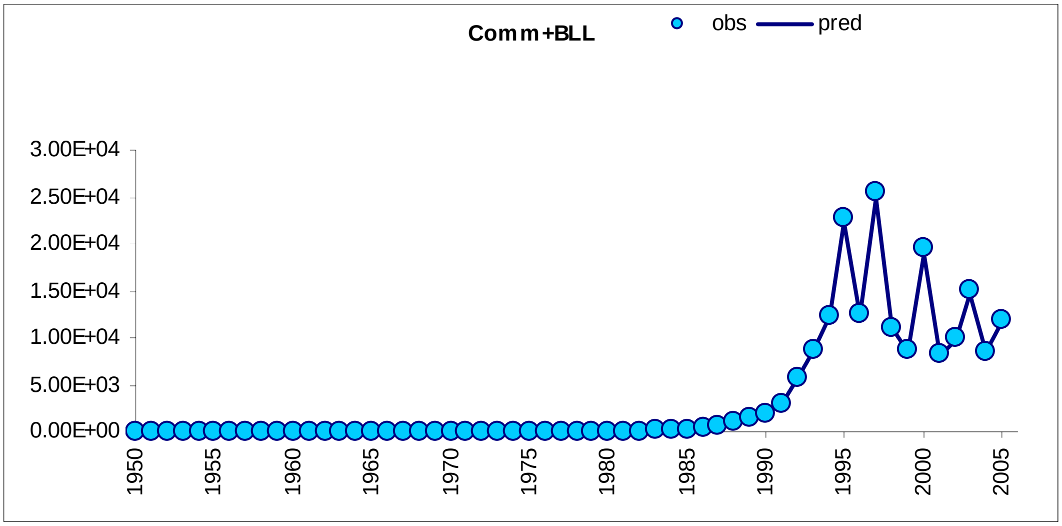


Figure 4.5. Model predicted fit to **blacknose shark** catch data. Circles represent observed data, solid line is predicted.



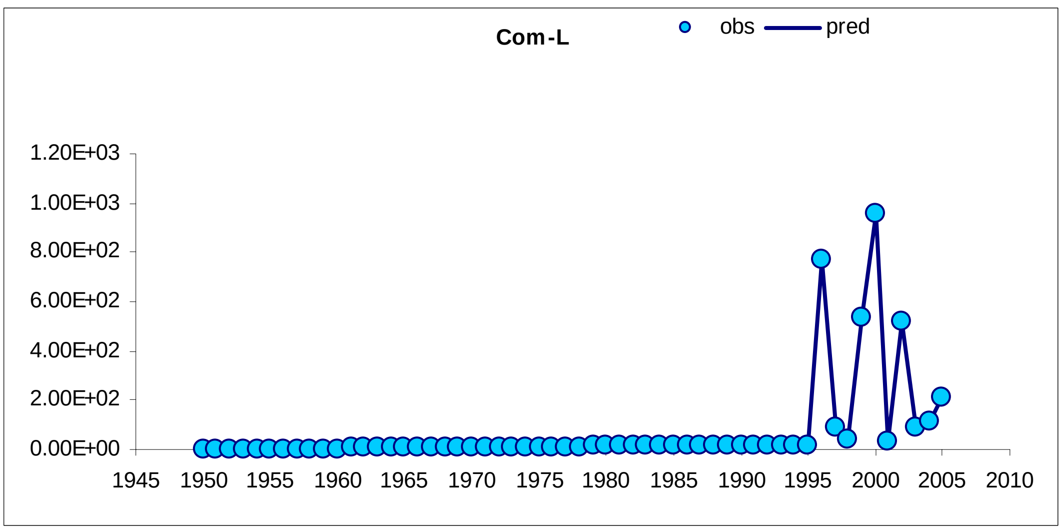


Figure 4.5. (continued).

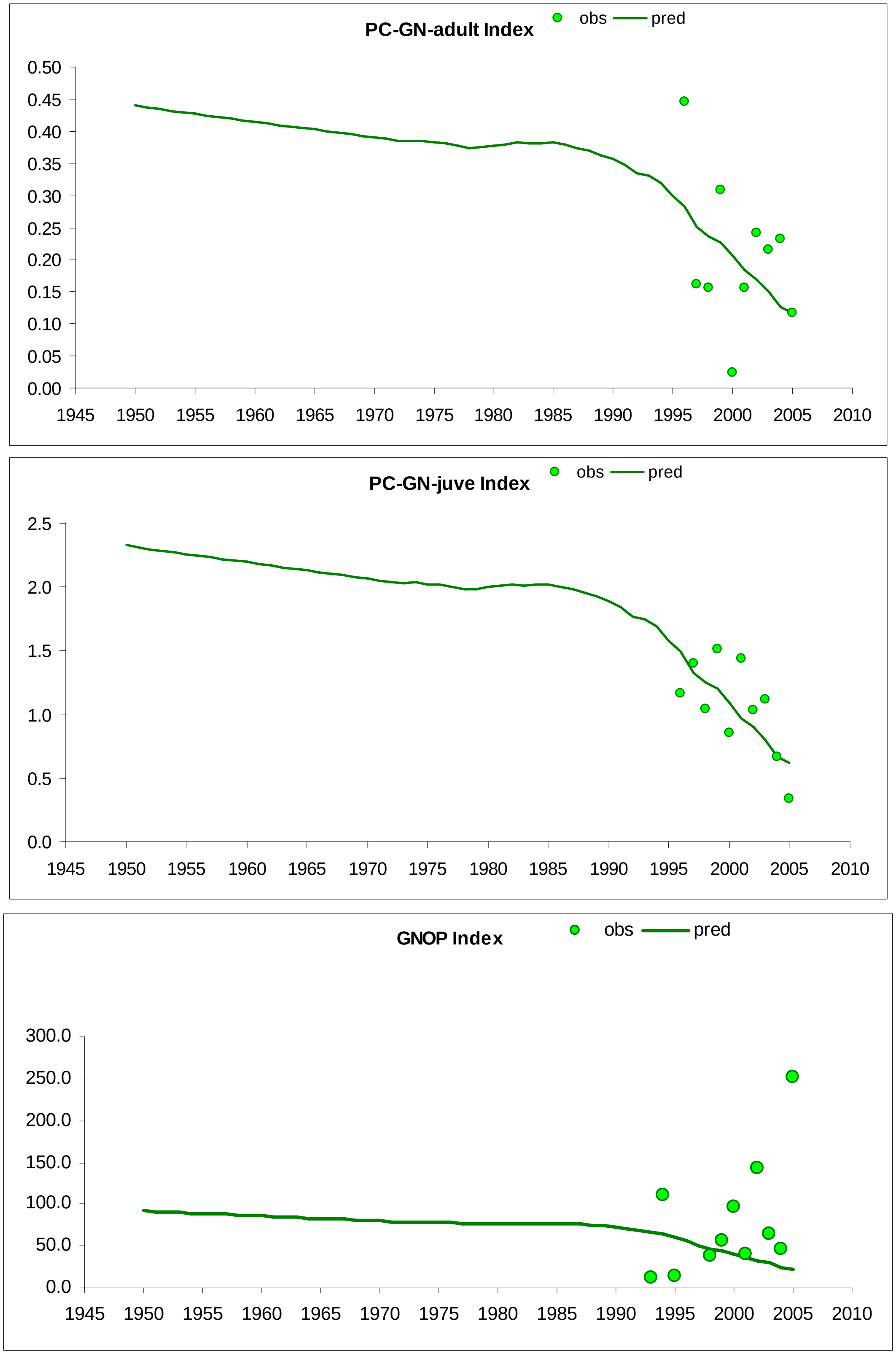


Figure 4.6. Model predicted fit to **blacknose shark** catch rate indices. Circles represent observed data, solid line is predicted.

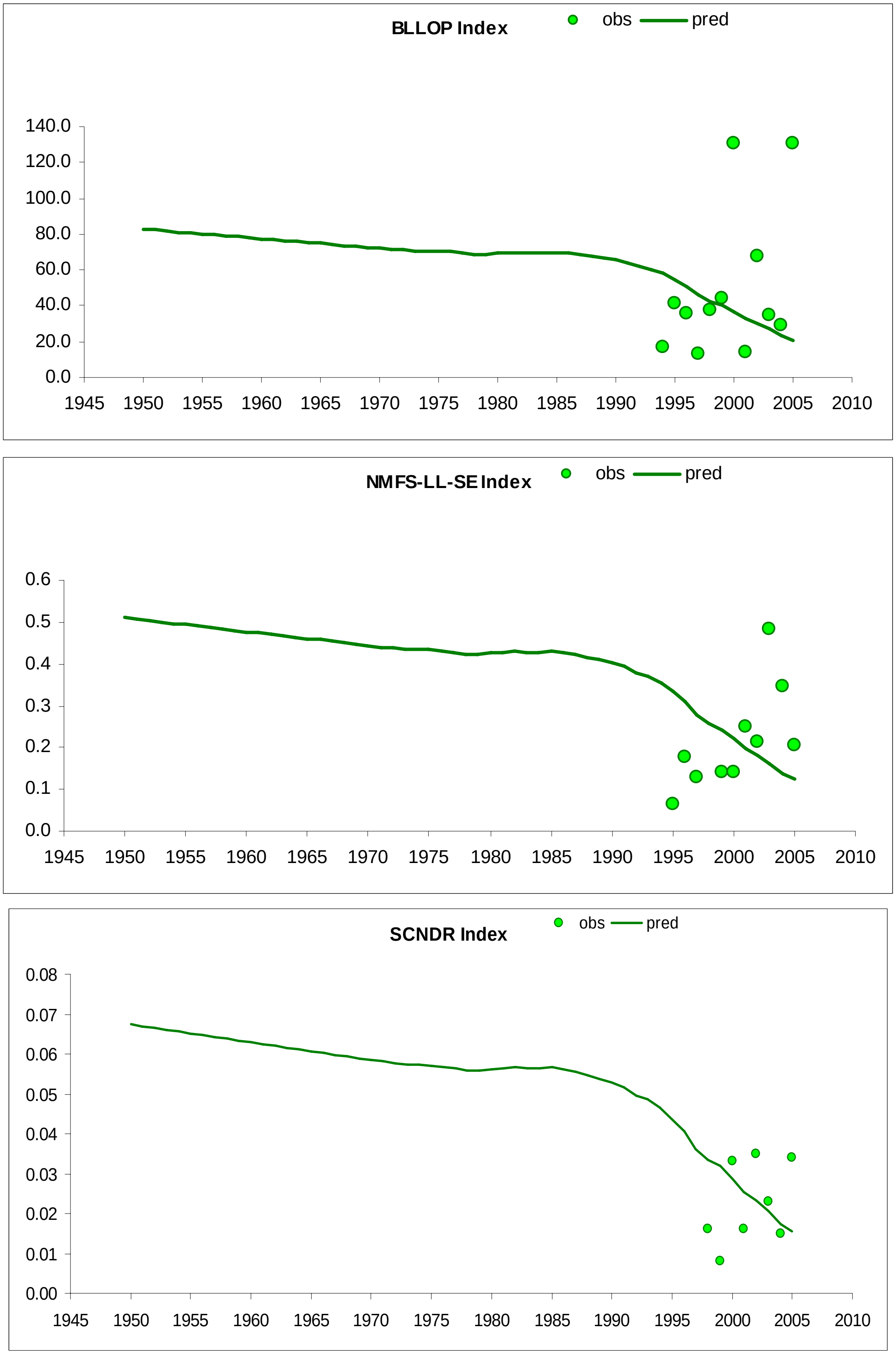


Figure 4.6. (Continued).

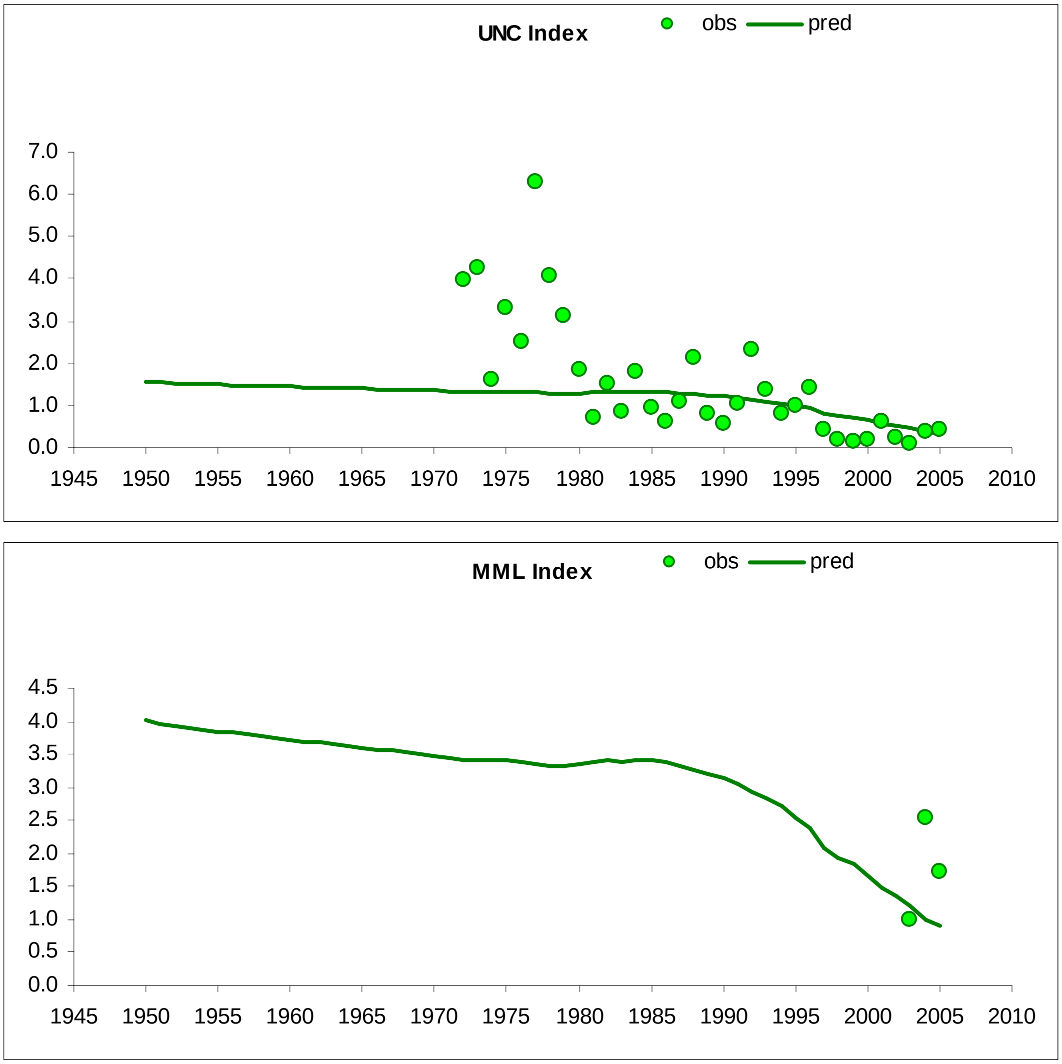


Figure 4.6. (Continued).

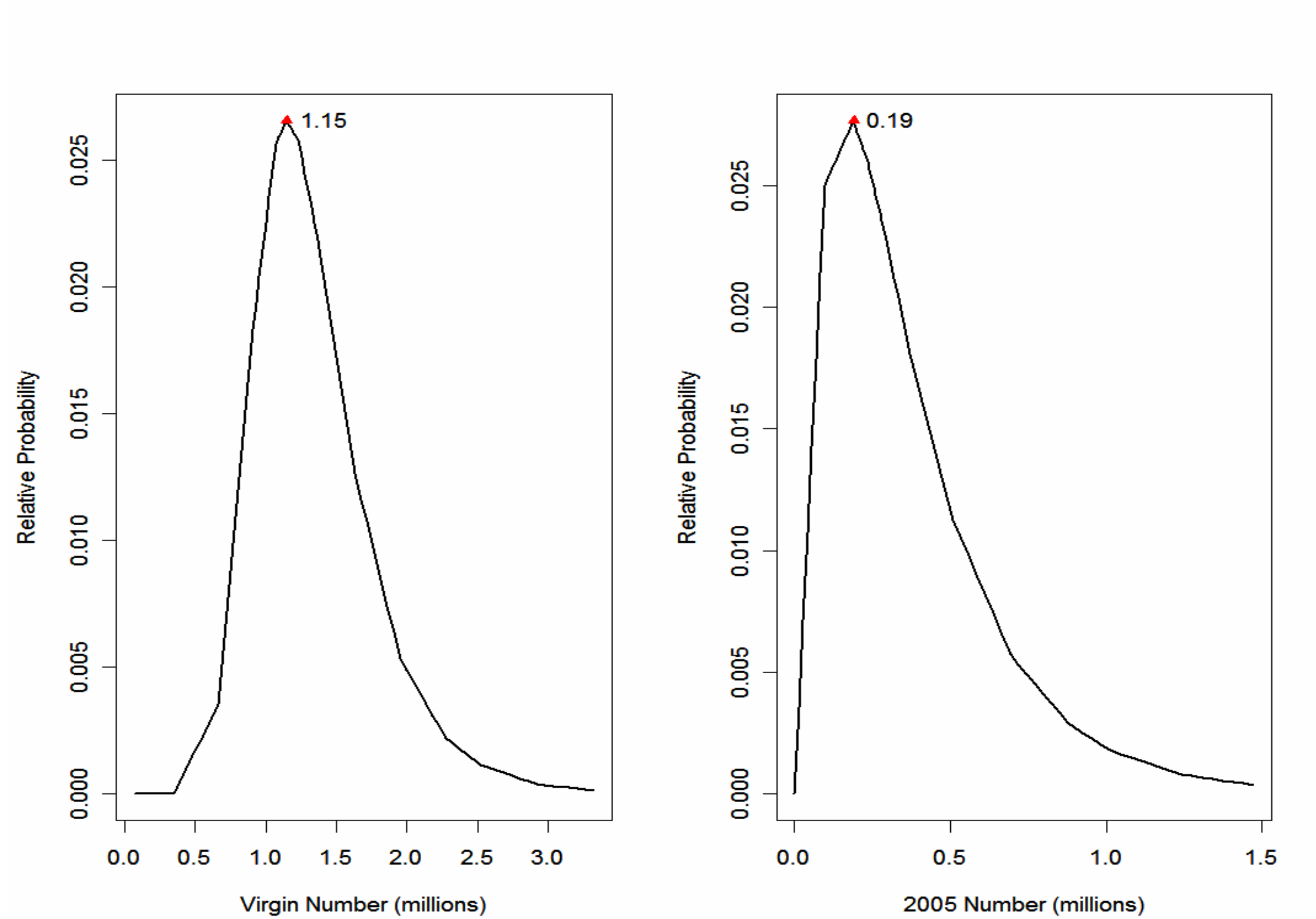


Figure 4.7. **Blacknose shark** profile likelihoods for virgin and current abundance (numbers), and virgin and current spawning stock fecundity, as well as depletion (current/MSY values) estimates of these parameters. The red triangles denote the modes of the distributions.

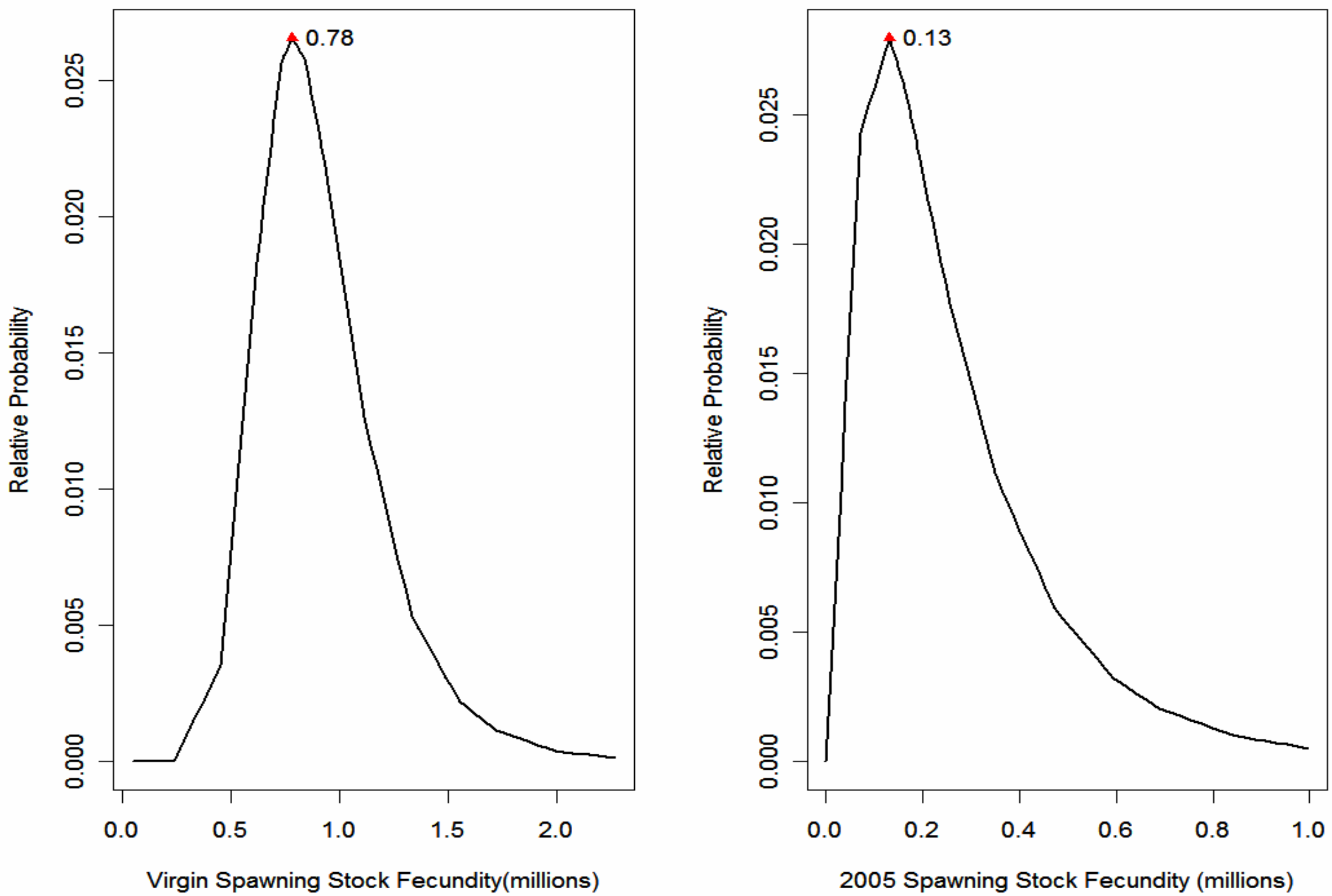


Figure 4.7. (continued)

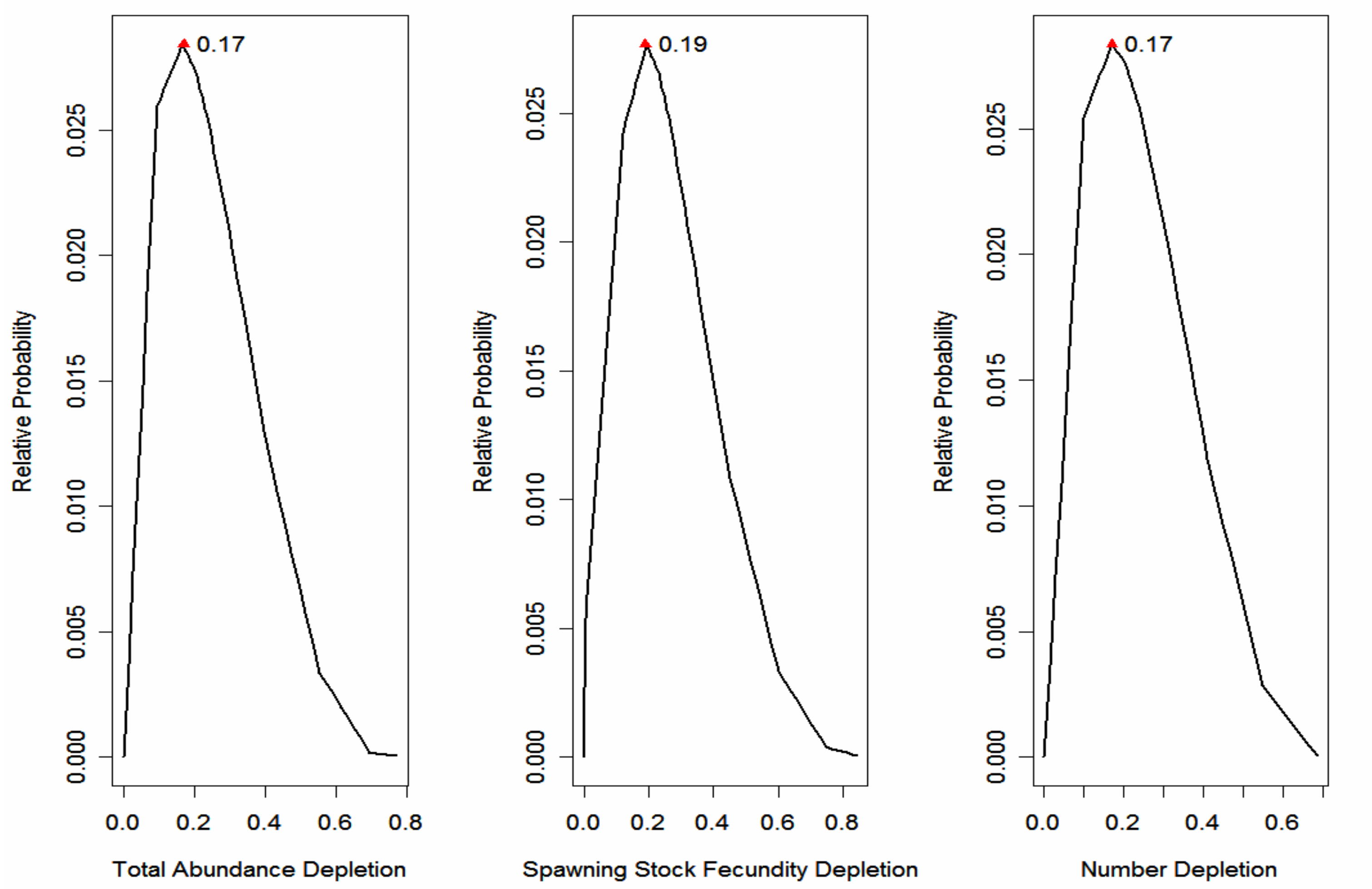


Figure 4.7. (continued)

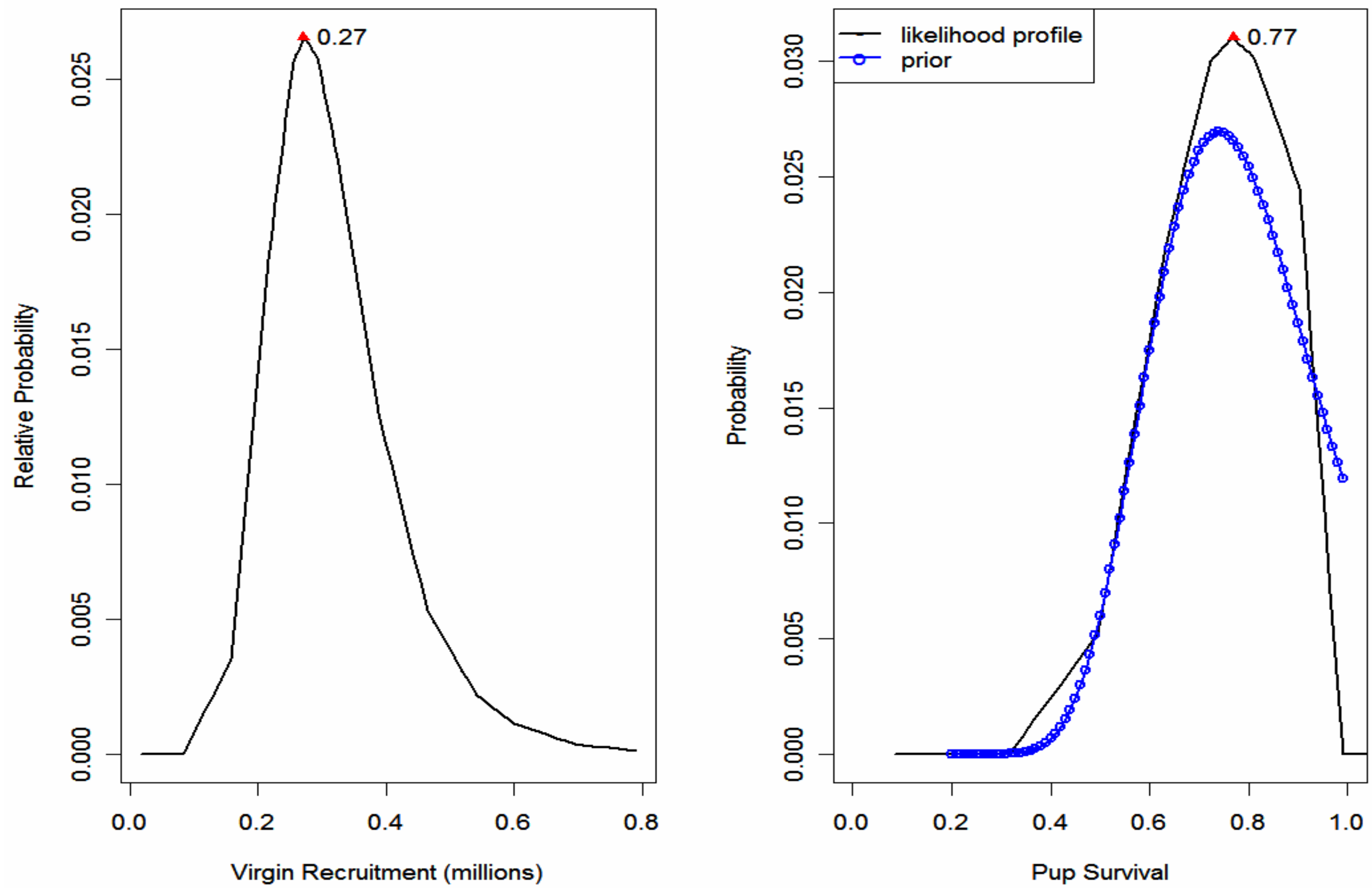


Figure 4.8. Profile likelihoods for pup survival and virgin recruitment, and for pup survival for **blacknose shark**. The prior is also plotted. The red triangles are the modes of the distributions.

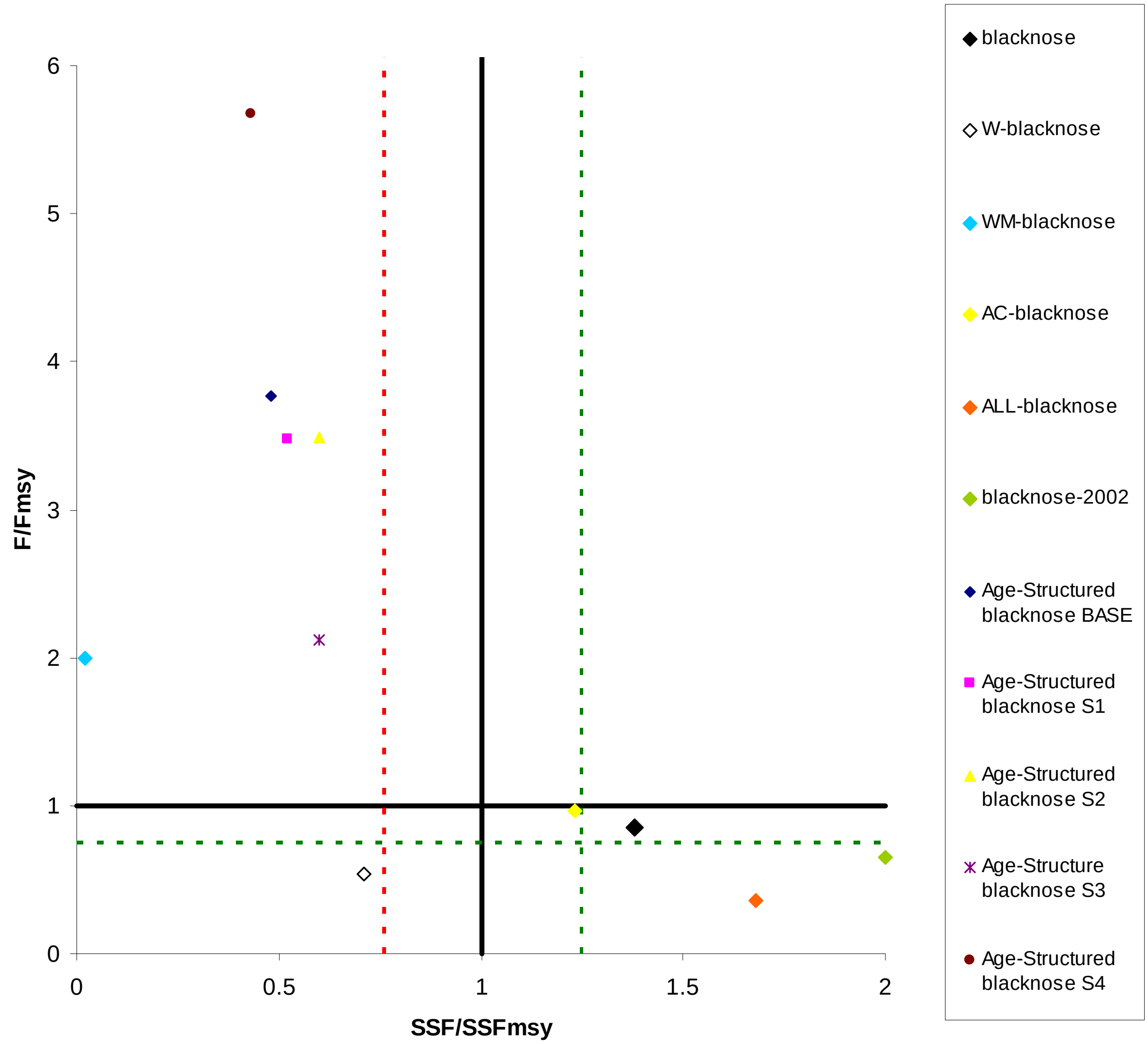


Figure 4.9. Phase-plot of **blacknose shark** stock status. Selected sensitivity analyses from the surplus production models (SPM) and the stock status from the 2002 assessment are included for reference. The age-structured models are in bold and include BASE, S1, S2, S3, S4. The SPM sensitivities are as follows: W— WinBUGS**,** complementary surplus production model. WM—SPM sensitivity to weighting scheme used: this involved changing the method for weighting the CPUE series from equal weighting in the baseline scenario to inverse variance weighting. IF—SPM sensitivity to importance function used: this involved changing the importance function from the priors to a multivariate t distribution. AC—SPM sensitivity to extending the catch series back to 1950. ALL—SPM sensitivity adding the CPUE series identified as "sensitivity" to those in the baseline scenario. Several control rules are illustrated: the dashed horizontal line indicates the MFMT (Maximum Fishing Mortality Threshold) and the dashed vertical line denotes the target biomass (biomass or number at MSY). SSF is spawning stock fecundity, which is the sum of number mature at age times pup-production at age (rather than SSB, since biomass does not influence pup production in sharks).

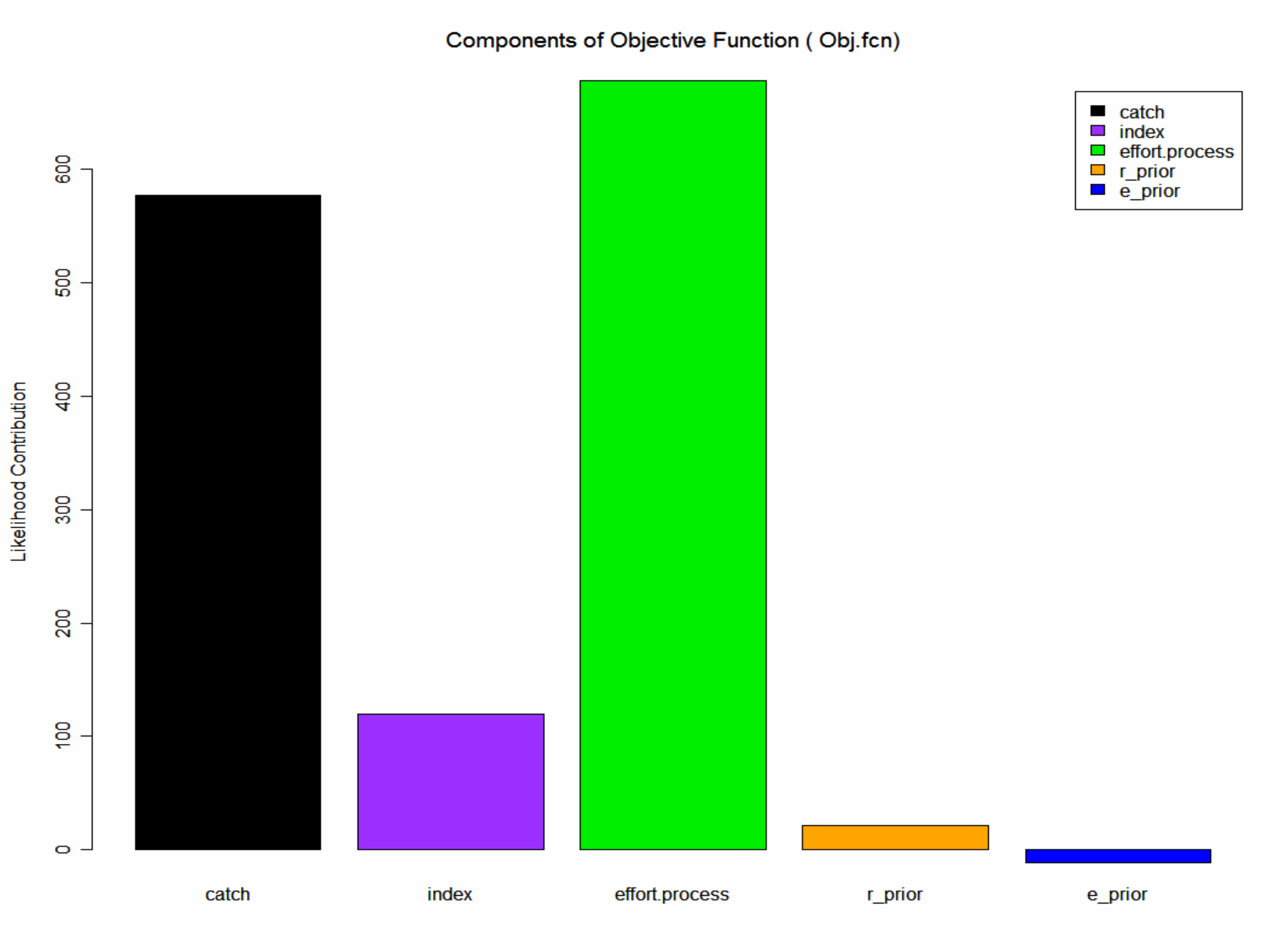


Figure 4.10. Contributions to the likelihood by model source for the **blacknose shark** base model.

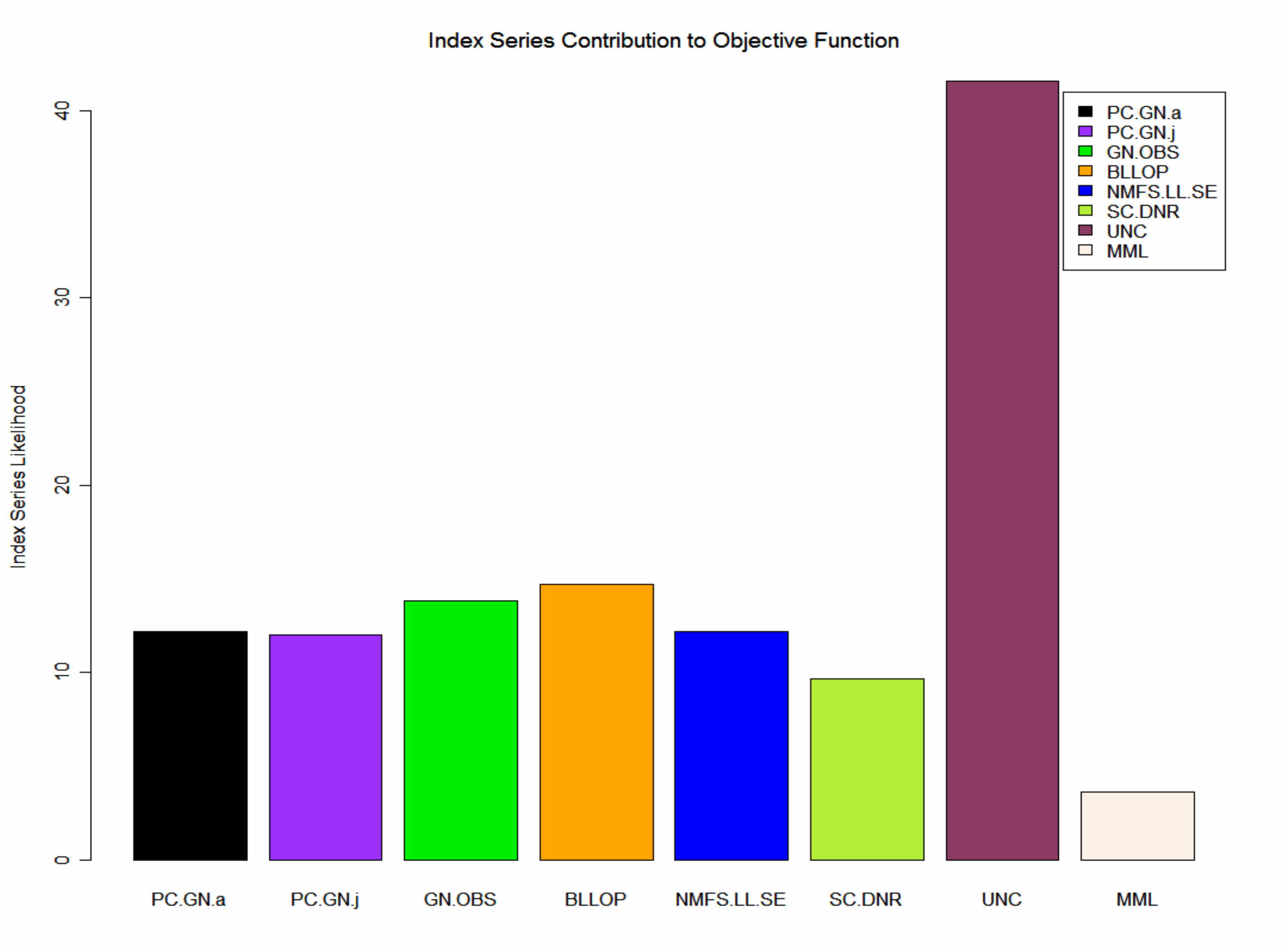


Figure 4.11. Contribution to relative likelihood by index series and catch series for the **blacknose shark** base model.

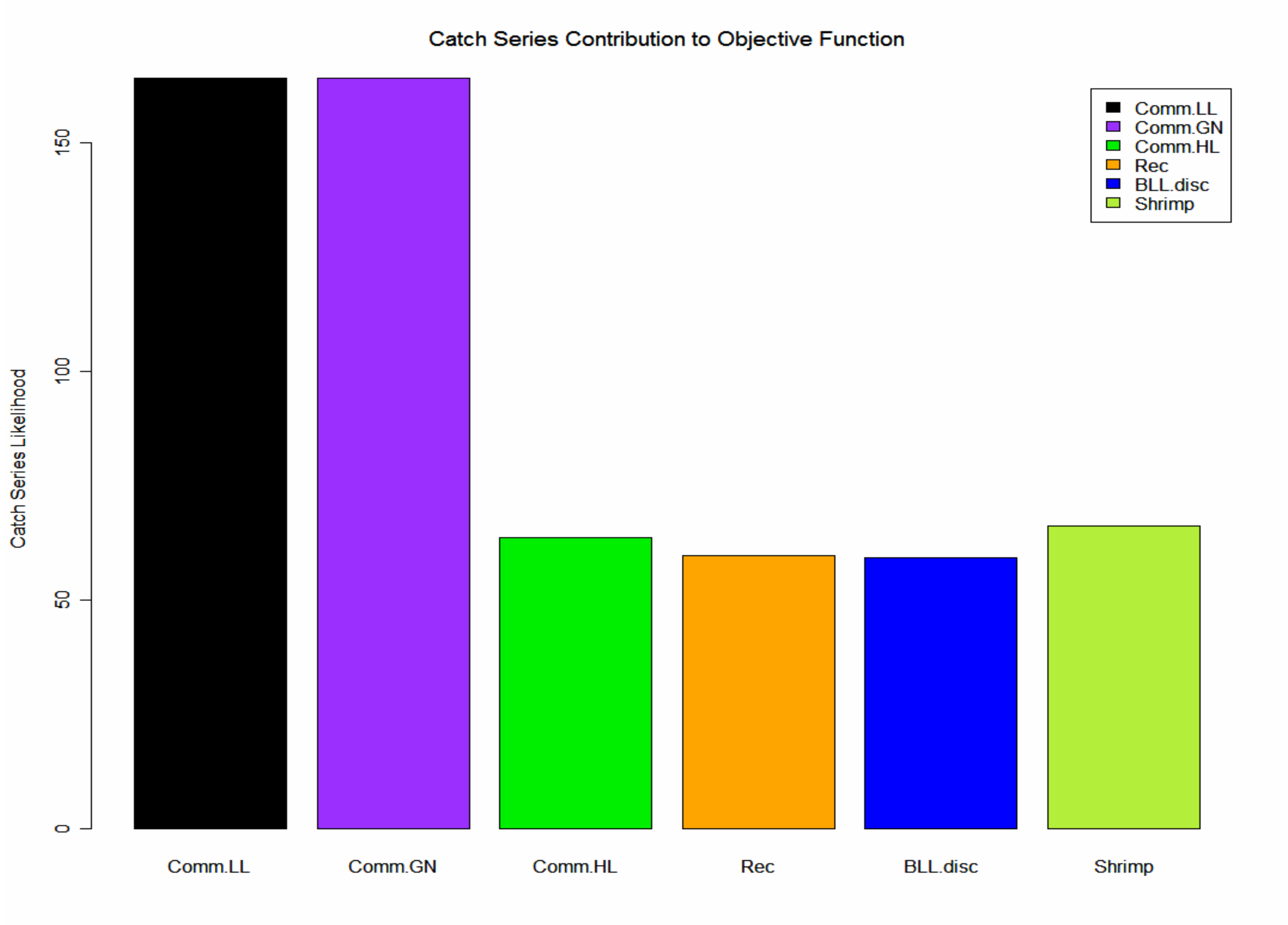


Figure 4.11. (Continued).

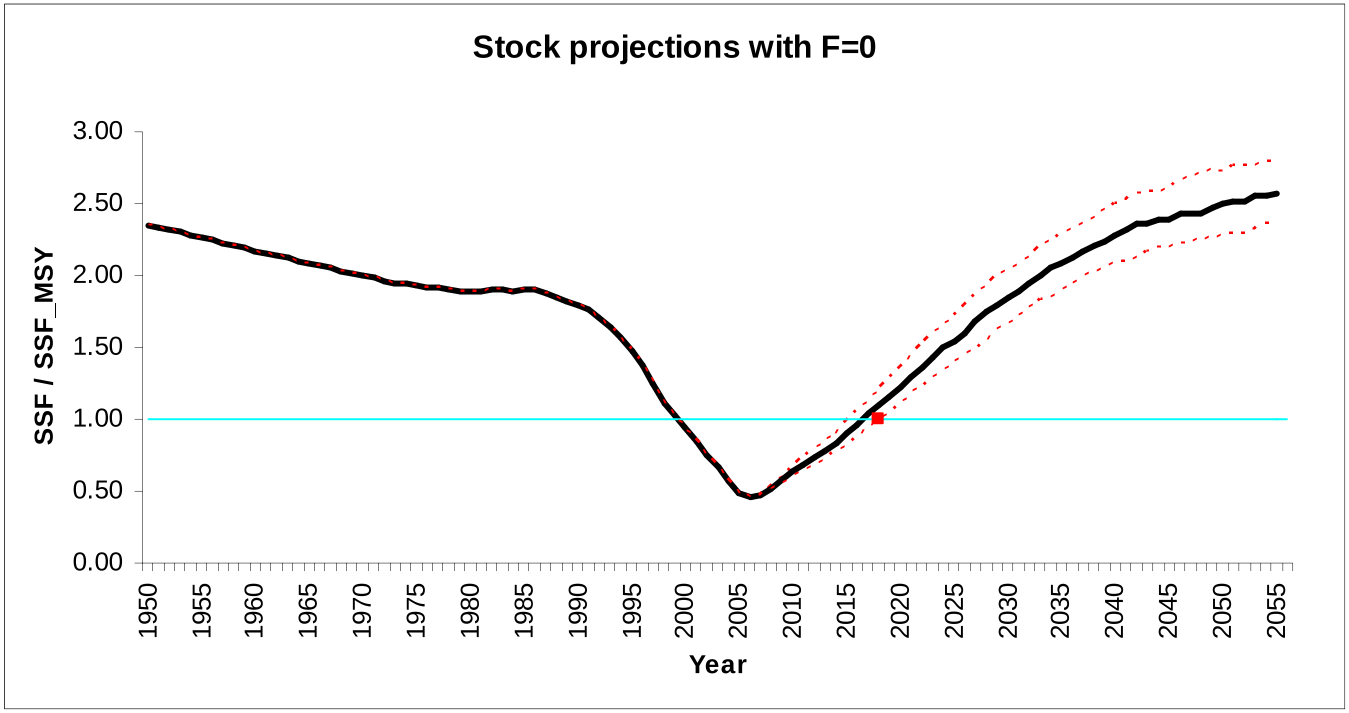


Figure 4.12. **Blacknose shark** stock projections with F=0 (solid black). The dashed red lines represent the 30th percentile (lower) and the 70th percentile (upper). Rebuilding under F = 0 with 70% probability is achieved in year 2019 (solid red square).

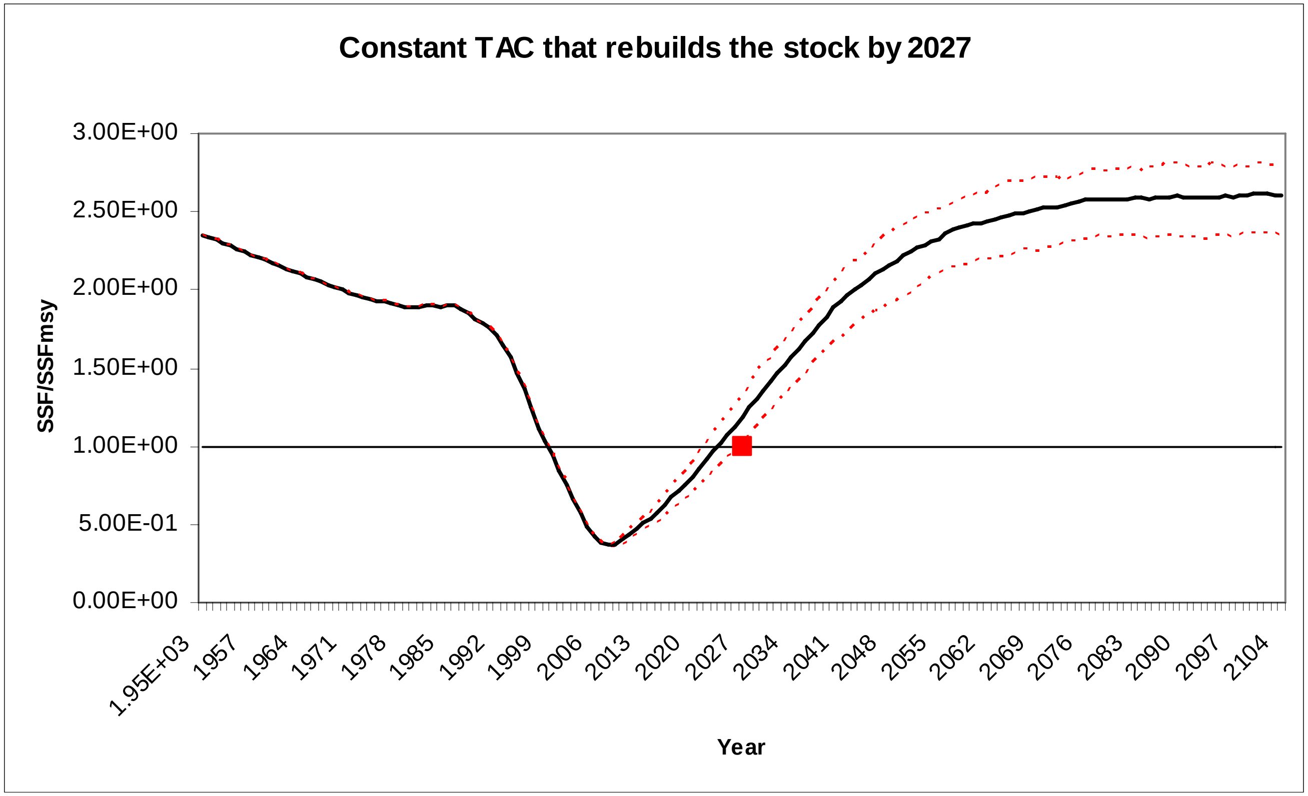


Figure 4.13. **Blacknose shark** stock projections with the constant TAC (19,200 individuals) required to rebuild the stock with 70% probability by 2027 (marked by the solid red square. The constant TAC allows the stock to rebuild with 50% confidence by 2024.

ATLANTIC SHARPNOSE SHARK

ASSESSMENT

5. ATLANTIC SHARPNOSE SHARK ASSESSMENT

5.1 Summary of Atlantic Sharpnose Shark Working Documents

SEDAR 13-AW-01
Assessment of Small Coastal Sharks, Atlantic sharpnose, Bonnethead, Blacknose and Finetooth Sharks using Surplus Production Methods
We used two complementary surplus production models (BSP and WinBUGS) to assess the status of the Small Coastal Shark (SCS) complex and four individual species (Atlantic sharpnose, bonnethead, blacknose, and finetooth sharks) identified as baseline scenarios in the SCS Data Workshop report. Both methodologies use Bayesian inference to estimate stock status, and the BSP further performs Bayesian decision analysis to examine the sustainability of various levels of future catch. Extensive sensitivity analyses were performed with the BSP model to assess the effect of different assumptions on CPUE indices and weighting methods, catches, intrinsic rate of increase, and importance function on results. Baseline scenarios predicted that the stock status is not overfished and overfishing is not occurring in all cases. Using the inverse variance method to weight the CPUE data was problematic because of the nature of the CPUE time series and must be regarded with great caution, although predictions on stock status did not change, except for blacknose sharks. The alternative surplus production model implemented in WinBUGS supported the results from the BSP model, with the exception of blacknose sharks, which became overfished. None of the other sensitivity analyses examined had a large impact on results and did not affect conclusions on stock status in any case. Only blacknose sharks with the alternative catch scenario approached an overfishing condition.

SEDAR 13-AW-02
Determining Selectivities for Small Coastal Shark Species for Assessment Purposes
Selectivities of catch series and indices had to be determined for sharpnose, blacknose, and bonnethead sharks for the 2007 small coastal shark stock assessment. Based on age frequencies, five selectivities were determined for sharpnose, four for blacknose, and two for bonnethead.

SEDAR 13-AW-03
Siegfried and Brooks: Assessment of Blacknose, Bonnethead, and Atlantic Sharpnose Sharks with a State-Space, Age-Structured Production Model
An age-structured production model was employed to assess the following small coastal sharks: Blacknose (*Carcharhinus acronotus*), Bonnethead (*Sphyrna tiburo*), and Atlantic Sharpnose (*Rhizoprionodon terraenovae*). All models assumed virgin conditions in 1950, and historically reconstructed catches were derived to inform the model on likely levels of removals for the years prior to the start of observed and recorded catches. The base models for all three species applied equal weight to all indices. Base model results for bonnethead shark indicate that the stock is overfished and that there is overfishing. The stock status appears to be quite sensitive to the reconstructed catches, particularly because of some extreme peaks in the bottom longline fishery reports and the shrimp bycatch reports. An initial sensitivity run indicates that the stock depletion decrease when less weight is given to the extreme peaks. Additional sensitivities will be performed at

the assessment workshop. The base model results for Blacknose suggest that the stock is overfished and that there is also overfishing. The base model for Atlantic sharpnose assumed a single stock, and results from this model indicate that the stock is not overfished nor is overfishing occurring. A sensitivity analysis where inverse CV weights were applied to the base indices showed very little difference from the base model, and the stock status estimate was no overfishing and the stock is not overfished.

5.2 Background

In 2002, a stock assessment was conducted on the small coastal complex of sharks (finetooth (*Carcharhinus isodon*), blacknose (*Carcharhinus acronotus*), bonnethead (*Sphyrna tiburo*), and Atlantic sharpnose (*Rhizoprionodon terraenovae*), in the Gulf of Mexico and the Atlantic (Cortés 2002). The author used a variety of Bayesian statistical models, including a Schaefer biomass dynamic model, a Schaefer surplus production model, and a lagged-recruitment, survival and growth state-space model. This assessment report outlines the discussions and results of the current Atlantic sharpnose shark stock assessment

5.3 Available models

Three models were available for discussion for the Atlantic sharpnose shark assessment: two surplus production models, the BSP and WinBUGS models described previously, and one age-structured production approach (Porch 2002).

5.4 Details about surplus production model and age-structured model

A surplus production model simulates the dynamics of a population using total population biomass as the parameter that reflects changes in population size relative to its virgin condition. In comparison to more complicated models, the surplus production model is simpler in its formulation, takes less time to run and requires less input information. However, due to its formulation, the surplus production model does not describe changes that occur in subgroups of the population (adults, juveniles, etc). In addition, the sensitivity of model predictions to key stage-dependent biological parameters cannot be evaluated using a surplus production model. Finally, surplus production models are not able to incorporate a lag time into the results.

An age-structured population dynamics model describes the dynamics of each age class in the population separately and therefore, requires age-specific input information. Due to the higher complexity of these models, they usually take longer to run and require a higher volume of information relative to simpler models. However, they can account for age-dependent differences in biology, dynamics and exploitation of fish and provide an insight into the structure of the population and the processes that are more important at different life stages. They also allow for the incorporation of age-specific selectivity information.

With regard to management benchmarks, the surplus production model assumes that the population biomass that corresponds to MSY is always equal to half of the virgin population biomass, whereas the relative biomass at MSY calculated with an age-structured model (and other benchmarks associated to it) is species-specific and could be any fraction of virgin biomass.

The Assessment Panel decided to use the state-space, age-structured production model described in document SEDAR13-AW-03 for sharpnose sharks. This model was selected as it allowed for the incorporation of age-specific biological and selectivity information, along with the ability to produce required management benchmarks.

5.5 Discussion of weighting methods

The Data Workshop recommended that *equal weighting* for assigning weights to the different CPUE time series available during model fitting should be used for the baseline runs. The panel discussed the advantages and disadvantages of the *equal weighting* vs. the *inverse CV weighting* methods:

Equal weighting gives the same weight to residuals for all indices (annual points, and overall between each index), regardless of estimates of precision. Arguments in the past have pointed out that indices derived from many sample points typically have high precision (for example, fisheries dependent data) while scientific surveys may have higher variability due to sample size. In this situation, one must consider both precision *and accuracy*—the mere fact that an index is precise does not address whether or not it accurately reflects population trend. An index derived from data where sampling methodology or gear changed, or where fish finding technology improved could bias the estimated trend. Giving equal weighting to all indices is a way to balance the question of accuracy and precision.

Inverse CV weighting emphasizes the indices with greater estimated precision, and allows the model to fit those indices more closely. A caveat for this method is that it may not be appropriate for cases in which the standardization techniques differed between indices. In that situation, the same value of CV might reflect different levels of error depending on the CPUE it corresponds to.

The Assessment Panel further discussed the issue for weighting indices. It was noted that there are a variety of ways to weight indices in addition to equal and inverse CV weighting, however the determination of which weighting method is most appropriate is a discussion topic that is still without satisfying resolution. Given that fact, the Assessment Panel decided that equal weighting would be the base weighting method for the current assessment but noted that, as there is at present no objective way to decide which method is superior other than comparing model convergence diagnostics, future assessments may need to re-examine this issue.

5.6 Data issues and decisions made during the Assessment Workshop

Several of the catch series, and specifically the reconstruction of historic catches, were revisited during the Assessment Workshop. For the commercial bottom longline series, the DW fit a linear trend from 0 catches in 1980 to the first data point in 1995. At the AW, a discussion on how the fishery developed led the group to decide that an exponential fit from 1980 to 1995 was more appropriate. The bottom long line discard estimation methodology was revisited, and it was decided that discards for the whole time period of 1980-2005 would be estimated based on the average rate of discarding observed in 1995-2005. For the commercial hand line fishery, an anomalously high catch was recorded in 2003. The major source of data contributing to that point was traced to a record identifying the catch as “trolling in Alabama.” However, no landings for that region/gear had been recorded in previous or in subsequent years. The AW discussed this issue and decided that this was likely misreported gear. Noting that the landings for gillnet in that same year were lower than surrounding years, it was decided to re-assign those catches reported as “trolling” to the gillnet catch series in 2003. Finally, in the shrimp bycatch series, there were landings estimates for which the entire credibility interval did not contain the series average. Those estimates were generally very imprecise, and consistently larger than the series mean. The AW discussed the nature of those estimates, and given that year specific CVs were not applied to the bycatch estimates in the assessment model (nor to any catch series, for that matter), a decision was made to smooth those points by replacing the estimate with a geometric mean of 3 years before and after the questionable estimate.

5.7 Methods

5.7.1 State-space age-structured production model description

The age-structured production model (originally derived in Porch 2002) starts from a year when the stock can be considered to be at virgin conditions. Then, assuming that there is some basis for deriving historic removals, one can estimate a population trajectory from virgin conditions through a “historic era,” where data are sparse, and a “modern era,” where more data are available for model fitting. In all three model applications, virgin conditions were assumed in 1950. The earliest index of abundance (SEAMAP) and the earliest catch series (Shrimp trawl bycatch) begin in 1972, thus the historic model years spanned 1950-1971 (22 years) and the modern model years spanned 1972-2005 (34 years).

Population Dynamics

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

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

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

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

$$(2) \qquad R = \frac{R_0 S \alpha}{S_0 + (\alpha - 1)S} .$$

In (2), R_0 and S_0 are virgin number of recruits (age-1 pups) and spawners (units are number of mature adult females times pup production at age), respectively. The parameter α is calculated as:

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

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).

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, where y_i for i<mod are historic years, and modern years are y_i for which mod $\le$ i $\le$ T. The historic period is characterized by having relatively less data compared to the modern period. The manner in which effort is estimated depends on the model period. In the historic period, effort is estimated as either a constant (4a) or a linear trend (4b)

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

or

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

where $f_{y,i}$ is annual fleet-specific effort, b_0 is the intercept, and $f_{y=\text{mod},i}$ is a fleet-specific constant. In the modern period, fleet-specific effort is estimated as a constant with annual deviations, which are assumed to follow a first-order lognormal autoregressive process:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

The term λ_g is a variable-specific multiplier of the overall model CV. For catch series and indices (eq 11b), the additional term, $\omega_{i,y}$, is the weight applied to individual points within those series. For instance, because the indices are standardized external to the model, the estimated variance of points within each series is available and could be used to weight the model fit. Given the data workshop decision to use equal weighting between indices for the base model run, all $\omega_{i,y}$ were fixed to 1.0 and the same λ_g was applied to all indices. To evaluate the sensitivity case where indices were weighted by the inverse of their CV, each $\omega_{i,y}$ was fixed to the estimated CV for point *y* in series *i*; an attempt was also made to estimate a separate λ_g for each series, however those multipliers were not estimable and so a single λ was applied to all indices.

5.7.2 Data inputs, prior probability distributions, and performance indicators

Baseline scenario (SPASM-BASE)
The base model represented the decisions made by the Data Workshop as well as any additional decisions or modifications made by the Assessment Workshop. Data inputted

to the model included maturity at age, fecundity at age (pups per mature female), spawning season, catches, indices, and selectivity functions (Tables 5.1 – 5.4; Figures 5.1 – 5.4). Catches were attributed to six different fleets: the commercial bottom longline, the commercial gillnet, the commercial handline, discards from the commercial bottom longline, the recreational sector, and bycatch from the shrimp trawl fishery. A comparison of the DW and the revised AW catch series are shown in Figures 5.2 (a-e). In addition to the catch series, a total of 13 indices were available from the Data Workshop.

Individual selectivity functions to be applied to catch and catch series were identified based on length frequencies and biological information provided by the Life History Working Group at the Data Workshop. The selectivity determination methods and recommendations were presented in SEDAR 13 AW-02 and summarized here in Figure 5.4.

Catch data begin in 1981, while the earliest data for the indices is 1972 (UNC). Catches from 1981 were imputed back to 1950, when a virgin assumption was imposed. The catches for each fleet were imputed as follows: the commercial longline was reconstructed to increase at an exponential rate from 1981 to 1995 (the year of the first data point). The commercial gillnet fishery was reconstructed to increase linearly from 1981 to 1995. The longline reconstruction changed from linear (a Data Workshop recommendation) to an exponential increase following the Assessment Workshop recommendations.

Individual points within catch and index series can be assigned different weights, based either on estimated precision or expert opinion. The base case model configuration was to treat all points as having an equal weight. There were no recommendations by either the Data Workshop or the Assessment Workshop to downweight any individual or group of points.

Estimated model parameters were pup survival, virgin recruitment (R_0), catchabilities associated with all indices, fleet-specific effort and effort deviations in the modern period. Natural mortality at ages 1+ was fixed at the values provided by the Life History Working Group (Table 5.3), and the priors for pup survival and virgin recruitment are listed in Table 5.4.

In summary, the base model configuration assumed virgin conditions in 1950, used the revised reconstructed catch series as agreed upon at the Assessment Workshop. All inputs are given in Tables 5.1 – 5.4.

Performance indicators included estimates of absolute population levels and fishing mortality for year 2005 (F_{2005}, SSF_{2005}, B_{2005}), population statistics at MSY (F_{MSY}, SSF_{MSY}, SPR_{MSY}), current status relative to MSY levels, and depletion estimates (current status relative to virgin levels). In addition, trajectories for F_{year}/F_{MSY} and SSF_{year}/SSF_{MSY} were plotted. SSF is spawning stock fecundity.

5.7.3 Methods of numerical integration, convergence diagnostics, and decision analysis

Numerical integration for the age-structured production 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 model parameters, and in a Bayesian context the posterior density, was examined with likelihood profiling. AD Model Builder calculates likelihood profiles by assuming that the posterior probability distribution is well approximated by a multivariate normal (Otter Research Ltd. 2001).

5.7.4 Description of Model Runs

The base model (described below) was the basis for management advice. Additional model runs (identified below with an S and a number) were explored to determine sensitivity of results to assumptions and the configuration of the base model. Each model configuration is described below.

BASE –base indices were used and given equal weighting; the revised AW catches were used;
S1 – base indices were used and given inverse CV weighting; the revised AW catches were used;
S2 – a separate assessment was conducted for the Gulf of Mexico and the Atlantic as an exploration of a “2-stock” hypothesis; base indices for the Gulf of Mexico and the Atlantic were used and given equal weighting; the revised AW catches were used;
S3 – all base and sensitivity indices were used and given equal weighting; the revised AW catches were used;
S4 – the SEAMAP extended fall index was split due to a change in sampling protocol; the extended summer SEAMAP index was dropped because the same sampling protocol change occurred but no data was available to estimate separate indices before and after the split; equal weighting applied to indices; the revised AW catches were used.

5.8 Results

5.8.1 Baseline scenario

The base model results (Table 5.5; Fig. 5.5) indicated that the stock was not overfished nor was overfishing occurring (SSF_{2005}/SSF_{MSY}=1.49 and F_{2005}/F_{MSY}=0.70). Although the level of fishing mortality exceeded F_{MSY} in several years, the last three years have all been less than F_{MSY} (Figure 5.5). Years where $F>F_{MSY}$ generally coincide with peaks in the shrimp landings (*cf.* Figures 5.1 and 5.6). Examining the pattern in estimated fishing mortality at age for the last decade, it appears that the highest F is occurring on ages 1-3

(Figure 5.7), i.e. fishing mortality is occurring on fish before they reach maturity (see maturity ogive plotted in Figure 5.4). The stock is estimated to be at 60-65% of virgin levels (for units of biomass or number, respectively; Figure 5.8). Catches were fit well in general, although the down-weighting of historically reconstructed catches caused them to be fit less closely than data in the modern period, defined as 1972-2005 (Figure 5.9). Indices were fit assuming lognormal error, and fits to these indices were acceptable (Figure 5.10).

The base model estimate of MSY is 1.21 million kg, or approximately 1.2 million sharks, given the selectivities derived for the various catch series. The virgin estimate of sharpnose sharks (in numbers) is about 11 million, while the 2005 population size is estimated to be close to 6 million.

Likelihood profiling was performed for the base model. Posterior distributions for several model parameters are plotted in Figures 5.11-5.15; where priors were specified, these are plotted with the estimated posterior.

The relative likelihood values by model source (catch, indices, effort, catchability, and recruitment) as well as a breakdown of likelihood by individual index and catch series are shown in Figure 5.16. These graphs show the relative contributions of each model source, catch series, and index on the model's relative likelihood. In general, the smaller the bar, the better a given component was fit. However, it is important to keep in mind that not all components have the same number of data points, nor do all model sources have the same assumed error structure.

5.8.2 Sensitivity analyses

Results for sensitivity model S1, which was configured exactly the same as the base model with the exception that indices were weighted by their inverse CV, were very similar to the base model (Table 5.5). For sensitivity model run S2, where assessments were run separately for a Gulf of Mexico and an Atlantic stock, only the Gulf of Mexico model converged. Results for the Gulf of Mexico stock support the base case results, in that the Gulf stock was also not estimated to be overfished, nor was overfishing occurring. MSY for the Gulf stock was 860,000 kg, or approximately 71% of the base model MSY estimate (single stock), while the estimate of virgin pup production (1.91 million pups) was about 61% of the base case model. Sensitivity model S3, where 4 additional sensitivity indices were inputted to the model, did not converge. Sensitivity model S4, with the fall SEAMAP index split, gave results that were very similar to the base model.

The estimated stock status for the base model and all converged sensitivity models is plotted in Figure 5.17. In addition, stock status estimates from the two production models (Bayesian Surplus Production and WinBUGS) and the result from the 2002 assessment are plotted. All results fall in the quadrant where $SSF_{2005}/SSF_{MSY}>1$ and $F_{2005}/F_{MSY}<1$, indicating that the stock is neither overfished nor is overfishing occurring.

5.9 Projections

As the base model results indicate that the stock status is not overfished and that no overfishing is taking place, no projections were made.

5.10 Discussions

While the estimated status of the Atlantic sharpnose stock is good, the selectivity pattern that indicates the highest selectivity occurring on immature or not fully mature age classes is a trend that could adversely the stock in the future. It is noted that much of the landings on smaller (younger) sharks comes in the form of bycatch in the shrimp fishery, and it is uncertain what level of effort to expect from that fleet in the future. Notwithstanding the shrimp bycatch, small sharpnose sharks are also caught by the recreational sector and the commercial gillnet fleet (SEDAR13-AW-02).

5.11 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.

Otter Research Ltd. 2001. An introduction to AD MODEL BUILDER Version 6.0.2. Box 2040, Sidney, B. C. V8L 3S3, Canada.

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.

Siegfried, K. I., E. Cortés, and E. Brooks. 2007. Determining selectivities for small coastal shark species for assessment purposes. SEDAR13-AW-02.

Table 5.1. Catches of **Atlantic sharpnose shark** by fleet, as updated by the AW. Values in italics were reconstructed or otherwise modified from the DW.

Year	Com-BLL	Com-GN	Com-Line	BLL-Discards	Recreational	Shrimp Bycatch
1950	*0*	*0*	*0*	*0*	*12,114*	*199,157*
1951	*0*	*0*	*12*	*0*	*13,314*	*255,841*
1952	*0*	*0*	*24*	*0*	*14,514*	*258,937*
1953	*0*	*0*	*36*	*0*	*15,714*	*297,766*
1954	*0*	*0*	*48*	*0*	*16,914*	*307,492*
1955	*0*	*0*	*61*	*0*	*18,114*	*278,697*
1956	*0*	*0*	*73*	*0*	*19,314*	*253,339*
1957	*0*	*0*	*85*	*0*	*20,514*	*227,780*
1958	*0*	*0*	*97*	*0*	*21,714*	*226,216*
1959	*0*	*0*	*109*	*0*	*22,914*	*253,769*
1960	*0*	*0*	*121*	*0*	*24,114*	*271,849*
1961	*0*	*0*	*133*	*0*	*24,815*	*136,426*
1962	*0*	*0*	*145*	*0*	*25,517*	*178,861*
1963	*0*	*0*	*157*	*0*	*26,218*	*269,133*
1964	*0*	*0*	*169*	*0*	*26,920*	*240,757*
1965	*0*	*0*	*182*	*0*	*27,621*	*258,877*
1966	*0*	*0*	*194*	*0*	*28,322*	*244,276*
1967	*0*	*0*	*206*	*0*	*29,024*	*299,894*
1968	*0*	*0*	*218*	*0*	*29,725*	*273,578*
1969	*0*	*0*	*230*	*0*	*30,427*	*286,401*
1970	*0*	*0*	*242*	*0*	*31,128*	*315,416*
1971	*0*	*0*	*254*	*0*	*34,310*	*323,214*
1972	*0*	*0*	*266*	*0*	*34,613*	546,849
1973	*0*	*0*	*278*	*0*	*34,916*	115,836
1974	*0*	*0*	*291*	*0*	*35,220*	208,340
1975	*0*	*0*	*303*	*0*	*35,523*	216,843
1976	*0*	*0*	*315*	*0*	*35,827*	159,043
1977	*0*	*0*	*327*	*0*	*36,130*	560,188
1978	*0*	*0*	*339*	*0*	*36,434*	651,041
1979	*0*	*0*	*351*	*0*	*36,737*	530,051
1980	*50*	*0*	*363*	*39*	41,970	852,586
1981	*75*	*0*	*375*	*58*	43,490	*424,066*
1982	*112*	*0*	*387*	*87*	40,656	235,138
1983	*168*	*0*	*399*	*130*	50,170	386,130
1984	*250*	*0*	*412*	*194*	37,539	217,712
1985	*373*	*0*	*424*	*289*	37,994	330,027
1986	*556*	*0*	*436*	*432*	45,392	228,189
1987	*830*	*726*	*448*	*644*	46,792	639,555
1988	*1,238*	*1,452*	*460*	*961*	103,375	362,917
1989	*1,847*	*2,178*	*472*	*1,433*	65,058	304,957
1990	*2,755*	*2,904*	*484*	*2,138*	45,233	342,124
1991	*4,110*	*3,630*	*496*	*3,190*	134,905	518,206
1992	*6,132*	*4,355*	*508*	*4,758*	85,972	968,330
1993	*9,148*	*5,081*	*521*	*7,099*	67,719	433,492

1994	*13,647*	*5,807*	*533*	*10,590*	101,774	259,349
1995	20,359	6,533	545	15,799	128,478	638,341
1996	12,074	35,721	1,318	9,369	73,114	503,193
1997	6,925	70,619	854	5,374	67,675	329,038
1998	6,580	64,506	1,794	5,106	83,748	512,281
1999	5,248	69,727	1,576	4,072	69,153	311,118
2000	3,951	35,610	1,145	3,066	130,727	539,085
2001	4,787	53,890	1,190	3,715	131,912	318,995
2002	11,635	59,098	819	9,029	88,297	639,044
2003	19,783	*40,159*	1,469	15,352	85,299	295,059
2004	25,639	47,693	644	19,896	67,870	173,326
2005	24,876	80,539	1,159	19,304	80,761	325,764

Table 5.2a. Base indices available for use in the 2006/2007 **Atlantic sharpnose shark** assessment. Selectivity series indicated in last row (see Figure 5.4).

Year	PC-LL	PC-GN.a	PC-GN.j	GNOP	BLLOP	SEAMAP-SA	Texas	VA-LL	NMFS-LL SE	SC-GN	SCDNR	SEAMAP-GOM ES	SEAMAP GOM-EF	UNC	MML-GN.a	MML-GN.j
1972	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0.424	-1	-1	-1
1973	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0.455	0.861	-1	-1
1974	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1.380	0.313	-1	-1
1975	-1	-1	-1	-1	-1	-1	1.7	-1	-1	-1	-1	-1	1.193	0.653	-1	-1
1976	-1	-1	-1	-1	-1	-1	0.9	0.036	-1	-1	-1	-1	1.296	0.372	-1	-1
1977	-1	-1	-1	-1	-1	-1	0.8	1.125	-1	-1	-1	-1	0.710	0.739	-1	-1
1978	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0.661	1.366	-1	-1
1979	-1	-1	-1	-1	-1	-1	1.6	-1	-1	-1	-1	-1	0.764	1.166	-1	-1
1980	-1	-1	-1	-1	-1	-1	0.5	3.406	-1	-1	-1	-1	1.263	1.139	-1	-1
1981	-1	-1	-1	-1	-1	-1	0.4	3.703	-1	-1	-1	-1	0.836	0.594	-1	-1
1982	-1	-1	-1	-1	-1	-1	0.3	-1	-1	-1	-1	0.855	0.896	0.34	-1	-1
1983	-1	-1	-1	-1	-1	-1	0.7	3.114	-1	-1	-1	3.329	0.776	1.353	-1	-1
1984	-1	-1	-1	-1	-1	-1	2.1	-1	-1	-1	-1	1.118	0.623	0.922	-1	-1
1985	-1	-1	-1	-1	-1	-1	1.7	-1	-1	-1	-1	1.550	0.941	1.322	-1	-1
1986	-1	-1	-1	-1	-1	-1	4	-1	-1	-1	-1	0.862	0.533	1.150	-1	-1
1987	-1	-1	-1	-1	-1	-1	0.7	5.103	-1	-1	-1	0.705	0.781	1.735	-1	-1
1988	-1	-1	-1	-1	-1	-1	3.4	1.765	-1	-1	-1	0.649	0.443	2.299	-1	-1
1989	-1	-1	-1	-1	-1	-1	1.4	0.946	-1	-1	-1	0.669	0.324	1.265	-1	-1
1990	-1	-1	-1	-1	-1	2.983	1	2.706	-1	-1	-1	0.189	0.474	1.750	-1	-1
1991	-1	-1	-1	-1	-1	3.163	1.7	3.147	-1	-1	-1	0.810	0.244	3.526	-1	-1
1992	-1	-1	-1	-1	-1	2.908	0.9	2.478	-1	-1	-1	0.587	0.237	6.286	-1	-1
1993	0.481	-1	-1	63.769	-1	2.24	0.8	3.154	-1	-1	-1	0.658	0.417	3.141	-1	-1
1994	0.136	-1	-1	520.751	10.534	1.623	1.1	-1	-1	-1	-1	0.232	0.500	2.164	-1	-1
1995	0.301	-1	-1	355.17	118.473	3.052	0.7	2.715	1.982	-1	-1	1.066	0.340	5.698	2.868	0.07
1996	0.951	0.339	1.166	-1	107.619	1.860	3	3.201	1.820	-1	-1	1.057	0.565	3.101	9.14	0.305
1997	0.531	0.679	1.401	-1	157.065	3.855	1.1	2.048	2.426	-1	-1	0.537	0.386	2.898	3.21	2.971
1998	0.38	0.408	1.039	-1	245.823	2.679	1	3.247	-1	8.28	0.154	0.500	0.315	3.780	-1	-1
1999	1.16	0.361	1.514	165.327	760.861	2.734	3.2	6.057	0.627	9.923	0.090	0.484	0.406	2.865	6.522	0.423
2000	0.445	0.616	0.852	27.34	828.94	3.835	2.5	1.156	4.592	5.892	0.148	0.786	0.489	4.001	5.041	0.161

2001	-1	0.706	1.442	634.326	292.945	3.385	0.3	2.55	-1	6.140	0.230	0.351	0.288	-1	32.431	0.505
2002	-1	1.037	1.036	831.673	272.197	5.306	2.6	1.85	14.949	5.182	0.227	0.822	0.286	4.872	13.662	0.897
2003	-1	1.091	1.117	814.365	167.911	5.686	2.9	1.557	-1	14.621	0.195	0.410	0.404	6.899	35.56	0.254
2004	-1	0.659	0.667	278.853	133.011	3.851	2.2	1.833	14.6	3.570	0.075	0.219	0.199	6.449	18.35	0.078
2005	-1	-1	0.339	984.79	148.218	4.969	1.8	7.879	21.693	6.018	0.138	0.359	0.380h	8.917	-1	-1
Selectivity series																
	3	5	3	4	1	3	3	2	1	3	2	3	3	2	5	3

Table 5.2b. Sensitivity indices available for use in the 2006/2007 **Atlantic sharpnose shark** assessment. Selectivity series indicated in last row (see Figure 5.4).

	MS.GN - a	MS.GN - j	Gillnet Logs	NE Exp LL
1979	-1	-1	-1	0.713
1980	-1	-1	-1	-1
1981	-1	-1	-1	-1
1982	-1	-1	-1	-1
1983	-1	-1	-1	1.086
1984	-1	-1	-1	-1
1985	-1	-1	-1	0.115
1986	-1	-1	-1	0.861
1987	-1	-1	-1	-1
1988	-1	-1	-1	-1
1989	-1	-1	-1	0.109
1990	-1	-1	-1	-1
1991	-1	-1	-1	0.273
1992	-1	-1	-1	-1
1993	-1	-1	-1	-1
1994	-1	-1	-1	-1
1995	-1	-1	-1	-1
1996	-1	-1	-1	-1
1997	-1	-1	-1	-1
1998	-1	-1	0.016	-1
1999	-1	-1	0.023	-1
2000	-1	-1	0.018	-1
2001	1.412	0.717	0.017	-1
2002	-1	-1	0.013	-1
2003	0.385	0.153	0.015	-1
2004	0.460	0.109	0.016	-1
2005	0.414	0.199	0.030	-1
Selectivity series				
	5	3	4	2

Table 5.3. **Atlantic sharpnose shark** biological inputs for natural mortality (M), maturity at age, and pups per female at age. ***Note that age 0 M is actually a survival rate for pups, not a natural mortality rate.

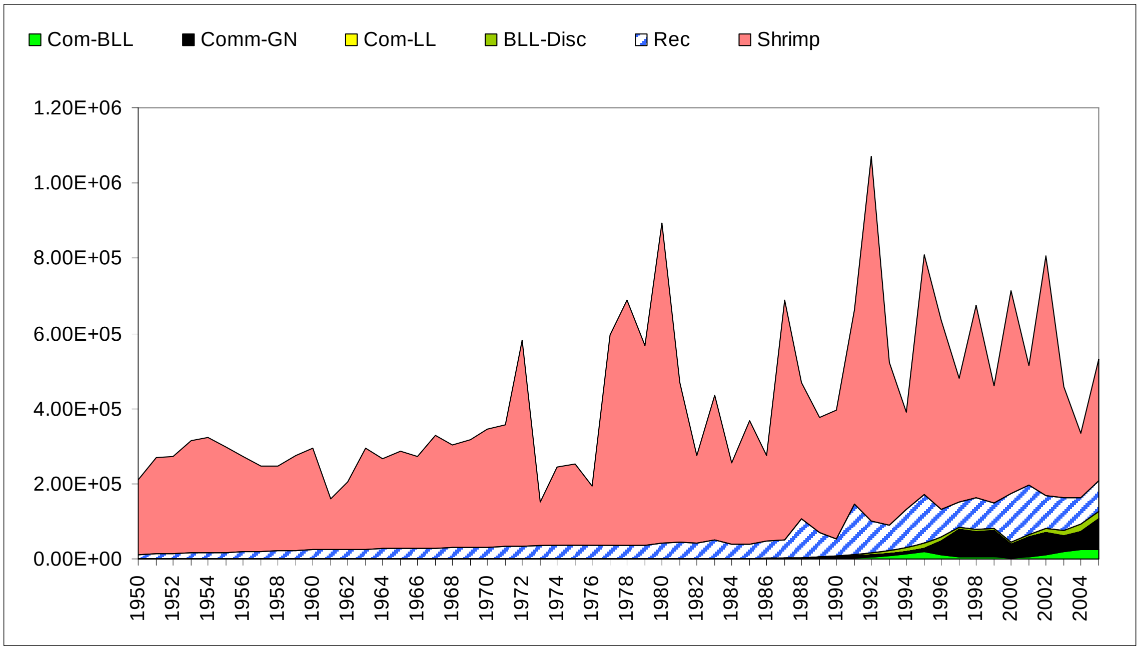
Age	M at age	Female Maturity	Pups per female
0	0.7*	0	0
1	0.36	0.01	2.05
2	0.34	0.28	2.05
3	0.33	0.92	2.05
4	0.31	1	2.05
5	0.31	1	2.05
6	0.30	1	2.05
7	0.29	1	2.05
8	0.27	1	2.05
9	0.27	1	2.05
10	0.26	1	2.05
11	0.25	1	2.05
12	0.24	1	2.05

Table 5.4. **Atlantic sharpnose shark** parameter specifications for vonBertalanffy length at age, length-weight parameters, pup survival, virgin recruitment, and the number of pups per female.

Parameter	Atlantic sharpnose
L_∞ (cm FL)	80.2
K	0.61
t0	-0.84
a (Kg/cm)	5.56E-06
b	3.074
Pup Survival	~ LN(0.7, CV=0.30)
Virgin Recruitment (R0)	[1.0E+3, 1.0E+10] no prior

Table 5.5. **Atlantic sharpnose shark** stock assessment results of the base case (Base Model, entries given in **bold** type) and sensitivity runs (S1 inverse CV weighting, S2 Gulf of Mexico Stock, and S4 split Fall SEAMAP). CVs of model estimates are given beside each model estimate. SSF is spawning stock fecundity (not spawning stock *biomass*) and is calculated as the sum of the number of mature females multiplied by the number of pups produced per mature female. Parameters N_{2005} and N_{MSY} are numbers in the population in 2005 and numbers at MSY, respectively, and are calculated mid-year.

Parameter	**Base Model Estimate**	**CV**	S1 (Inverse CV weight) Estimate	CV	S2 (Gulf of Mexico Stock) Estimate	CV	S4 (split Fall SEAMAP) Estimate	CV
SSF_{2005}/SSF_{MSY}	**1.49**	**0.45**	1.54	0.42	1.92	0.45	1.52	0.44
F_{2005}/F_{MSY}	**0.7**	**0.78**	0.66	0.76	0.35	0.78	0.71	0.78
N_{2005}/N_{MSY}	**1.35**	**--**	1.39	--	1.69	--	1.37	--
MSY	**1.27E+06**	**--**	1.32E+06	--	1.47E+06	--	1.24E+06	--
SPR_{MSY}	**0.59**	**0.11**	0.59	0.11	0.6	0.11	0.59	0.11
F_{MSY}	**0.19**	**--**	0.19	--	0.24	--	0.19	--
SSF_{MSY}	**4.59E+06**	**--**	4.77E+06	--	4.96E+06	--	4.43E+06	--
N_{MSY}	**4.62E+06**	**--**	4.80E+06	--	4.89E+06	--	4.47E+06	--
F_{2005}	**0.13**	**0.78**	0.12	0.76	0.08	0.78	0.13	0.78
SSF_{2005}	**6.81E+06**	**0.65**	7.35E+06	0.61	9.54E+06	0.65	6.72E+06	0.65
N_{2005}	**6.22E+06**	**--**	6.67E+06	--	8.27E+06	--	6.11E+06	--
SSF_{2005}/SSF_0	**0.56**	**0.32**	0.59	0.29	0.73	0.32	0.57	0.31
B_{2005}/B_0	**0.49**	**0.31**	0.5	0.27	0.61	0.31	0.49	0.29
R_0	**3.24E+06**	**0.35**	3.36E+06	0.35	3.50E+06	0.35	3.13E+06	0.36
Pup-survival	**0.76**	**0.28**	0.76	0.28	0.74	0.28	0.77	0.28
alpha	**2.85**	**--**	2.87	--	2.8	--	2.88	--
steepness	**0.42**	**--**	0.42	--	0.41	--	0.42	--



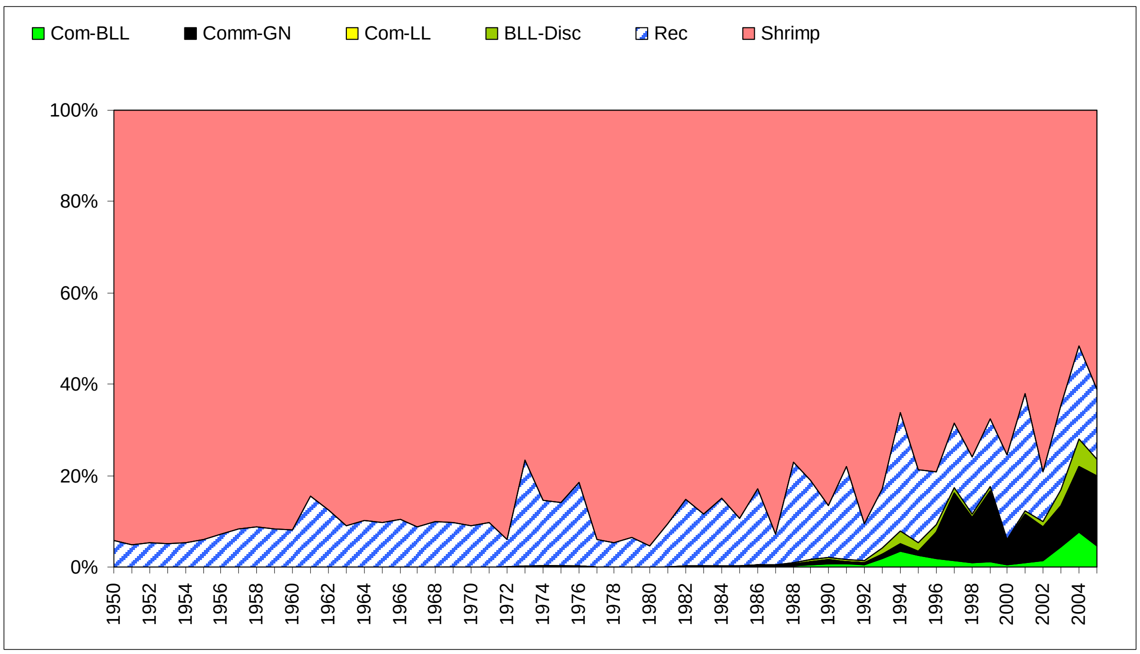
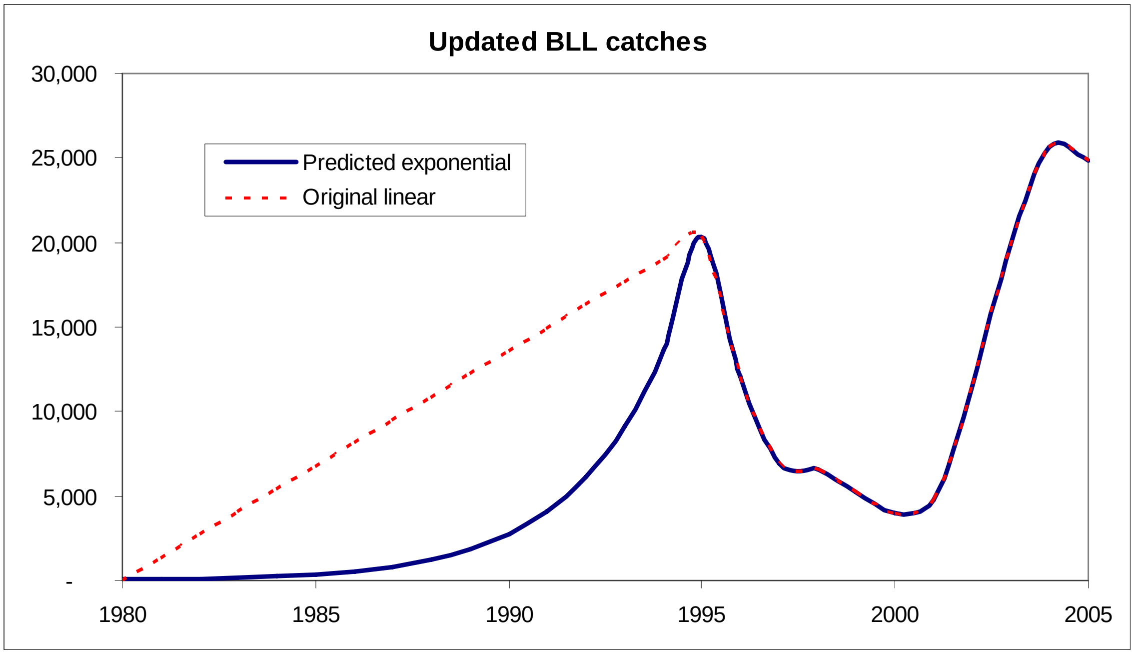


Figure 5.1. Catch of **Atlantic sharpnose shark** by fleet in numbers (top) and by proportion (bottom) from 1950-2005. Catches are the updated AW values.

a)



b)

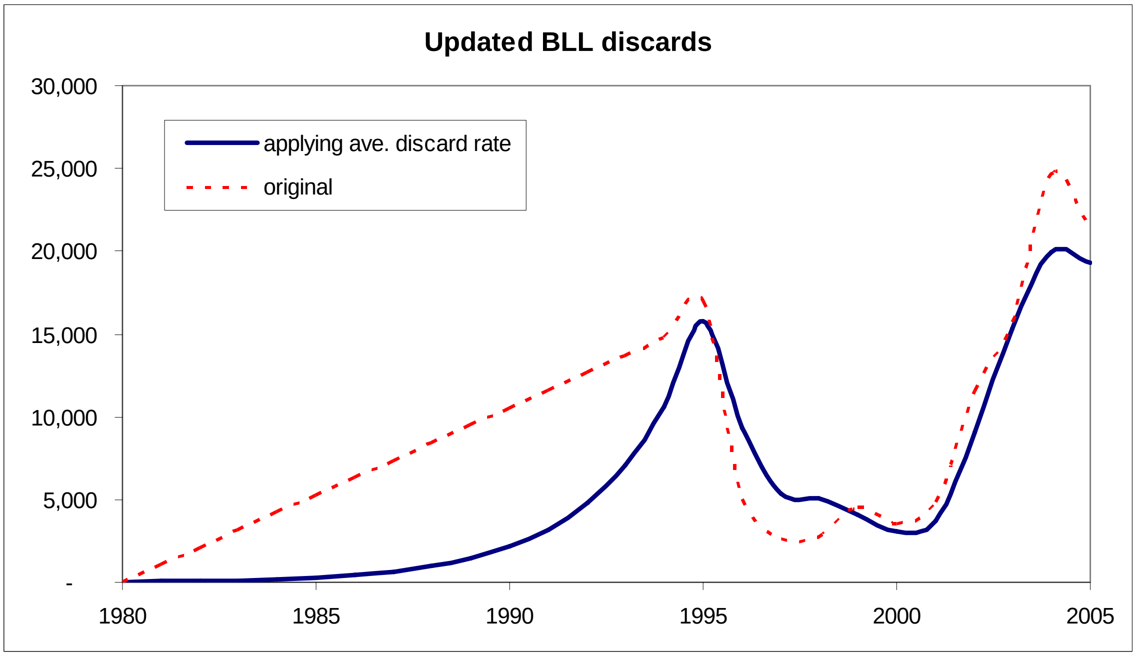
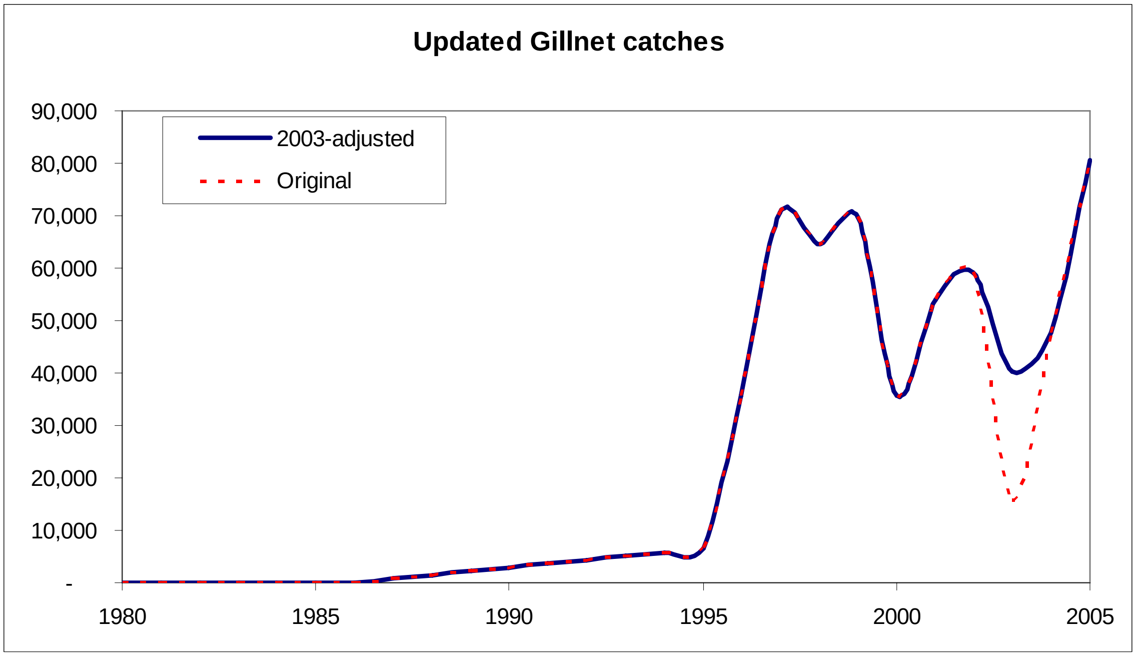


Figure 5.2. Series-specific updated catches for **Atlantic sharpnose shark** from the AW workshop for a) bottom long line; b) bottom long line discards; c) commercial hand line; d) commercial gill net; and e) shrimp bycatch.

c)



d)

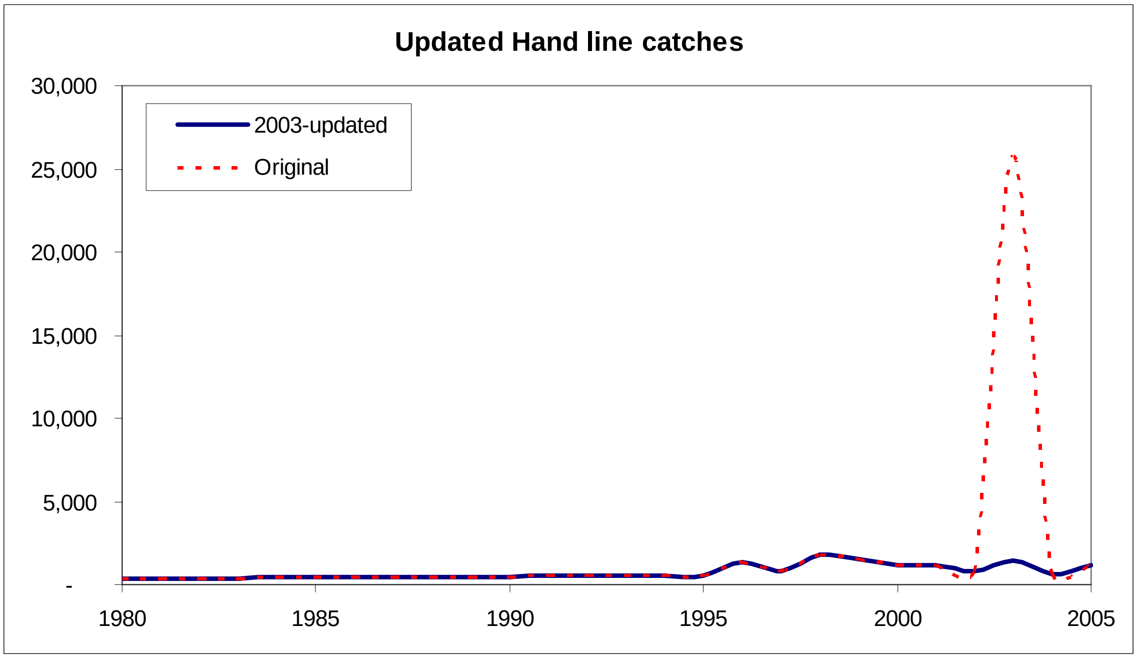


Figure 5.2 (cont.)

e)

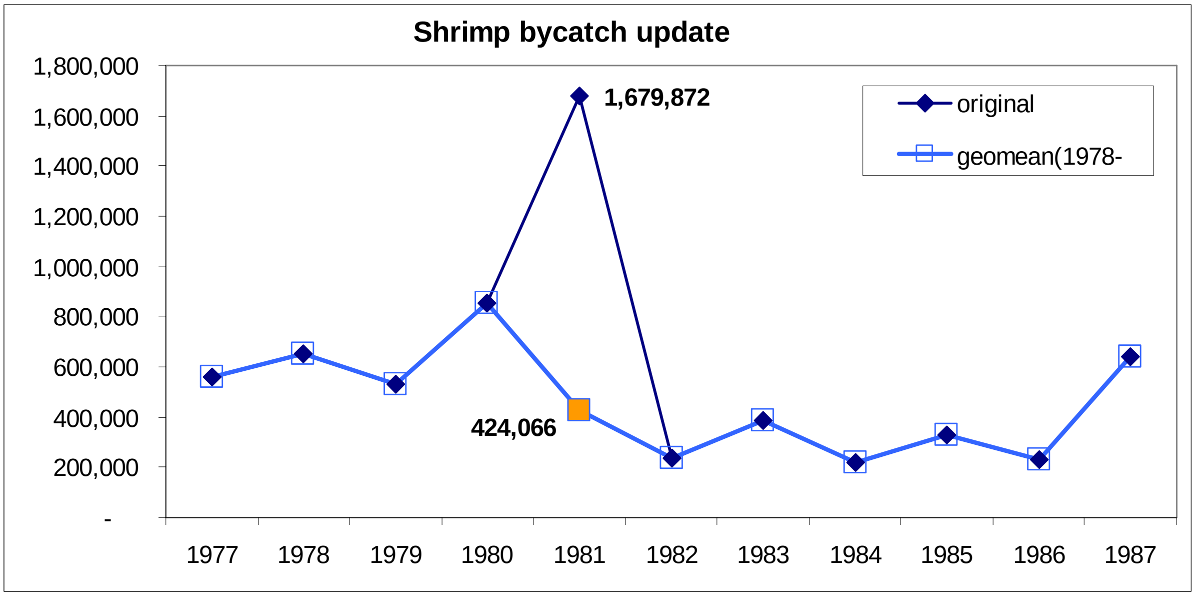
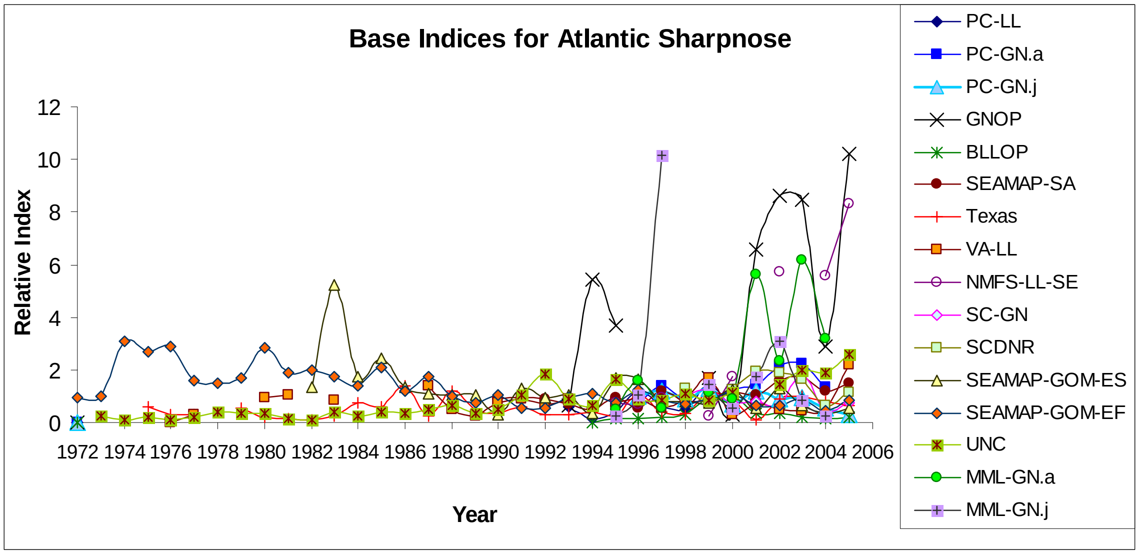


Figure 5.2 (cont.)



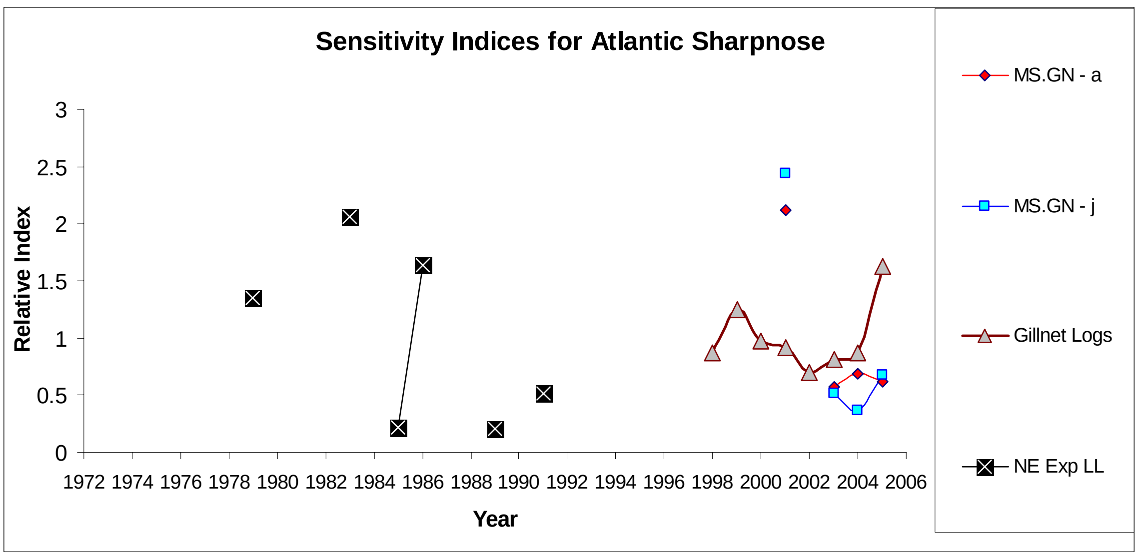


Figure 5.3. Indices for **Atlantic sharpnose shark**. The top panel shows the base indices, the bottom panel the sensitivity indices.

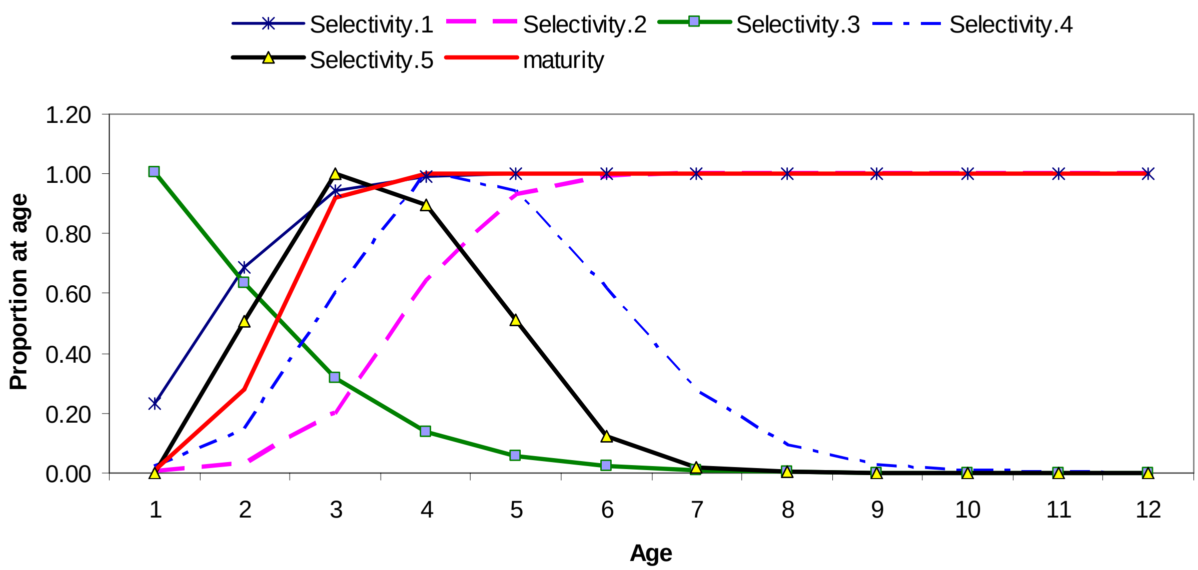


Figure 5.4. Selectivity at age and maturity at age (solid red line) for **Atlantic sharpnose shark**. The selectivity assigned to each index is given in the last row of the table of indices (Table 4.2).

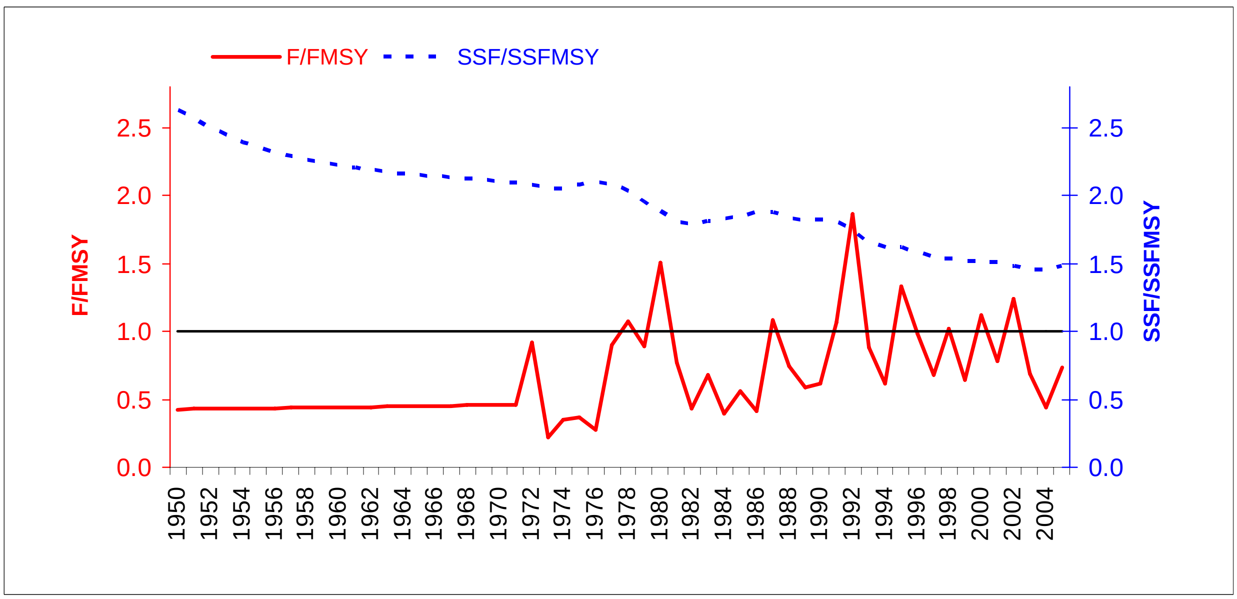
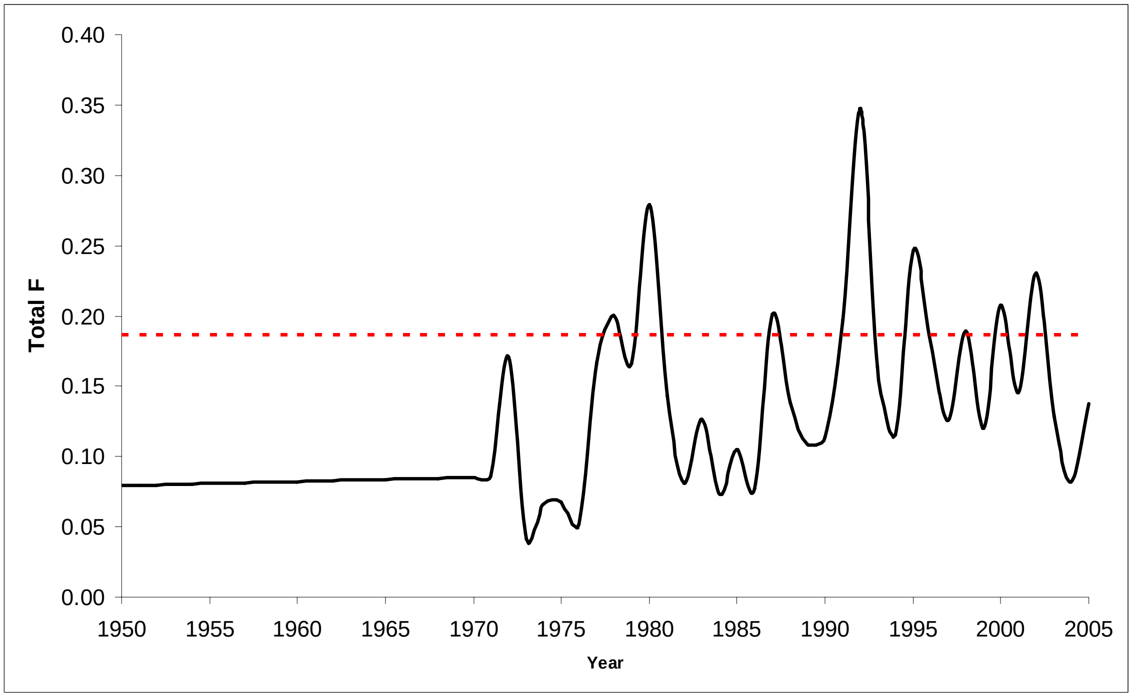


Figure 5.5. **Atlantic sharpnose shark** base model estimated relative fishing mortality (solid red) and spawning stock fecundity (dashed blue) for the base case with equal index weighting (top) and inverse CV weighting (bottom). The horizontal line at 1.0 is a reference line, such that F/F_{MSY} >1 implies overfishing, while B/B_{MSY} <1 implies an overfished stock.



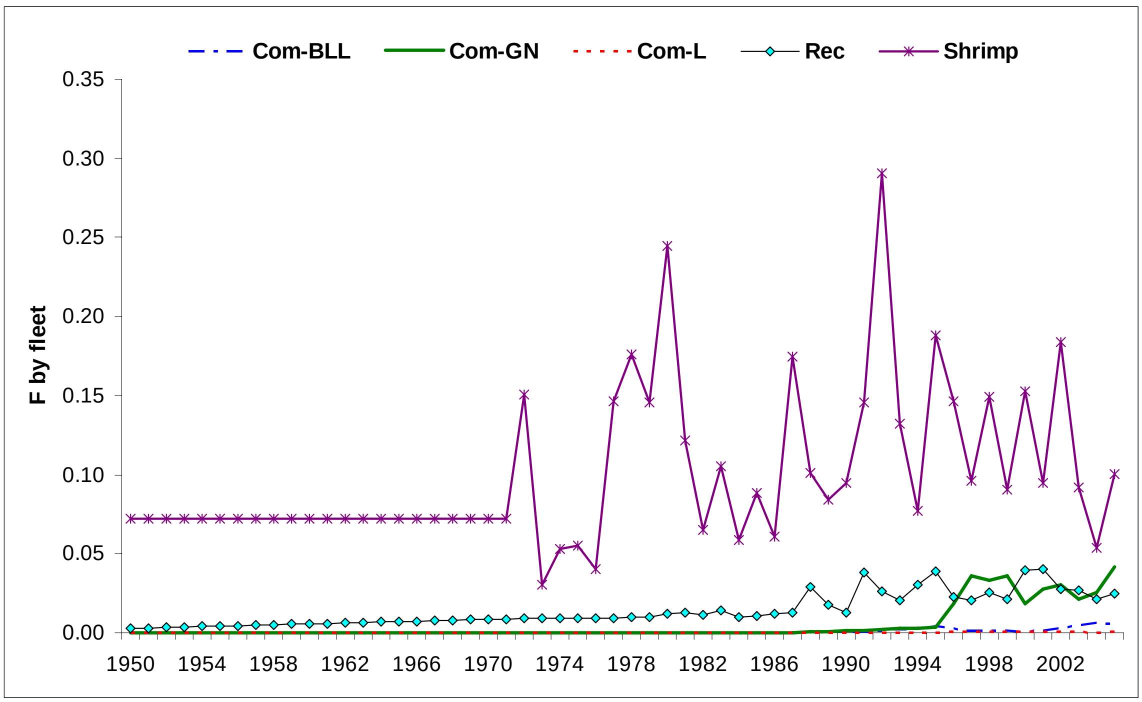


Figure 5.6. **Atlantic sharpnose shark** base model estimated total fishing mortality (solid black) and dashed reference line for F_{MSY} (top panel) and fishing mortality by fleet (bottom panel).

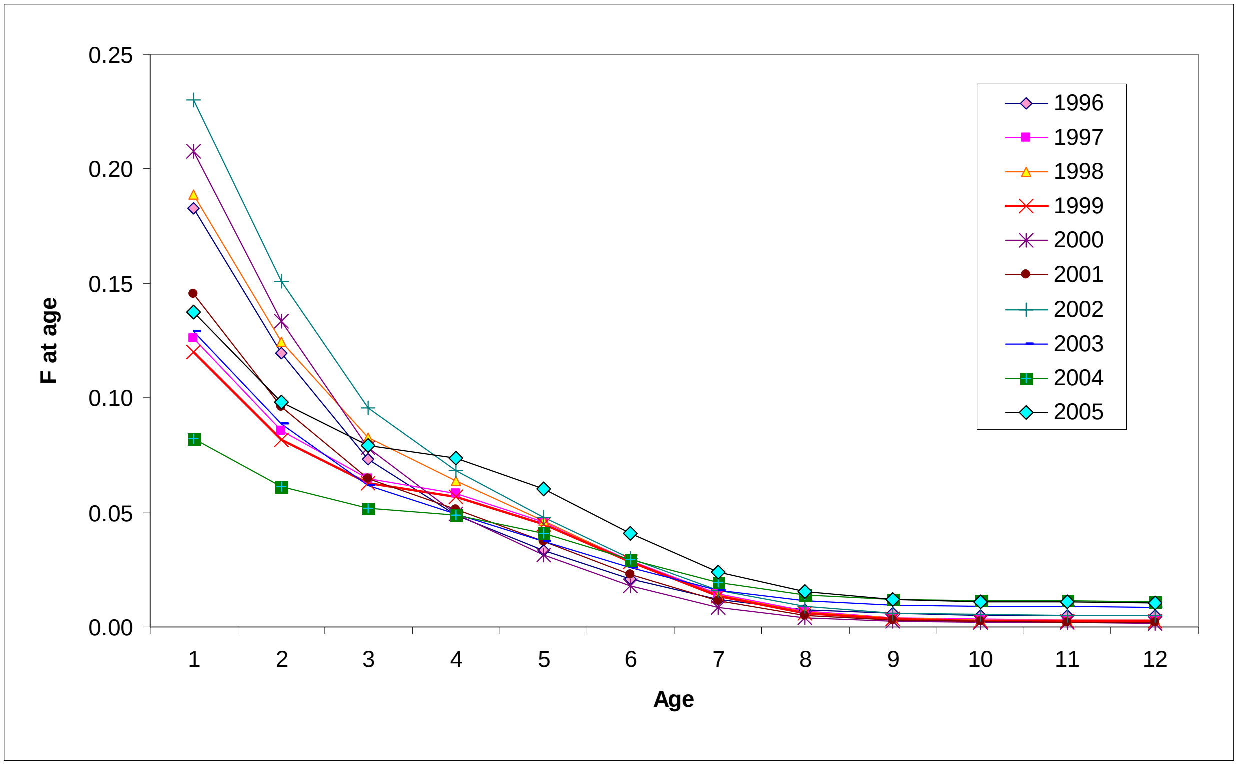


Figure 5.7. Base model estimated fishing mortality at age for **Atlantic sharpnose shark** for years 1996-2005.

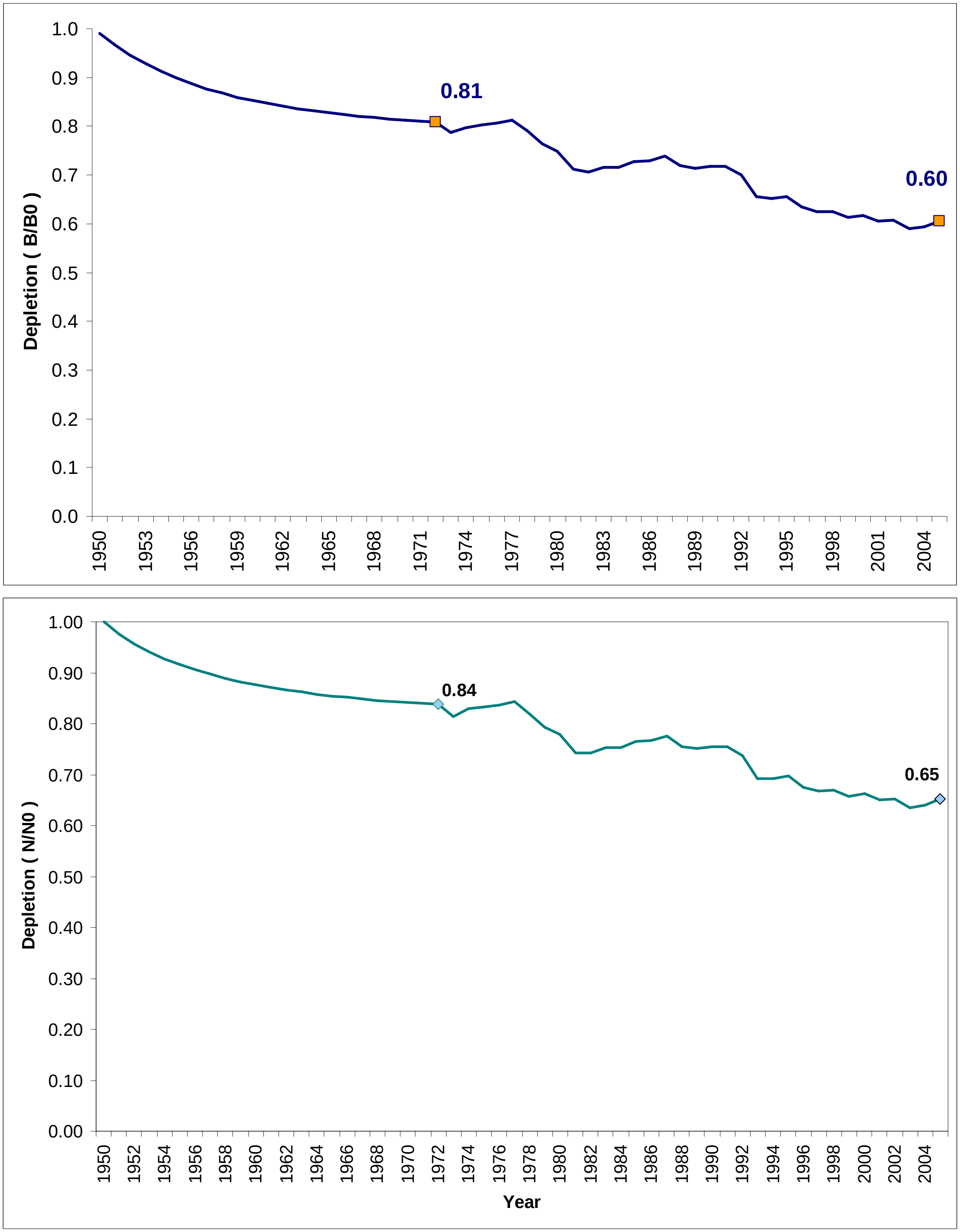


Figure 5.8. Base model estimated depletion of total biomass (top) and total number in the population (bottom) for **Atlantic sharpnose shark**. Labeled values correspond to the year 1972 (first year of 'modern period') and the final assessment year, 2005.

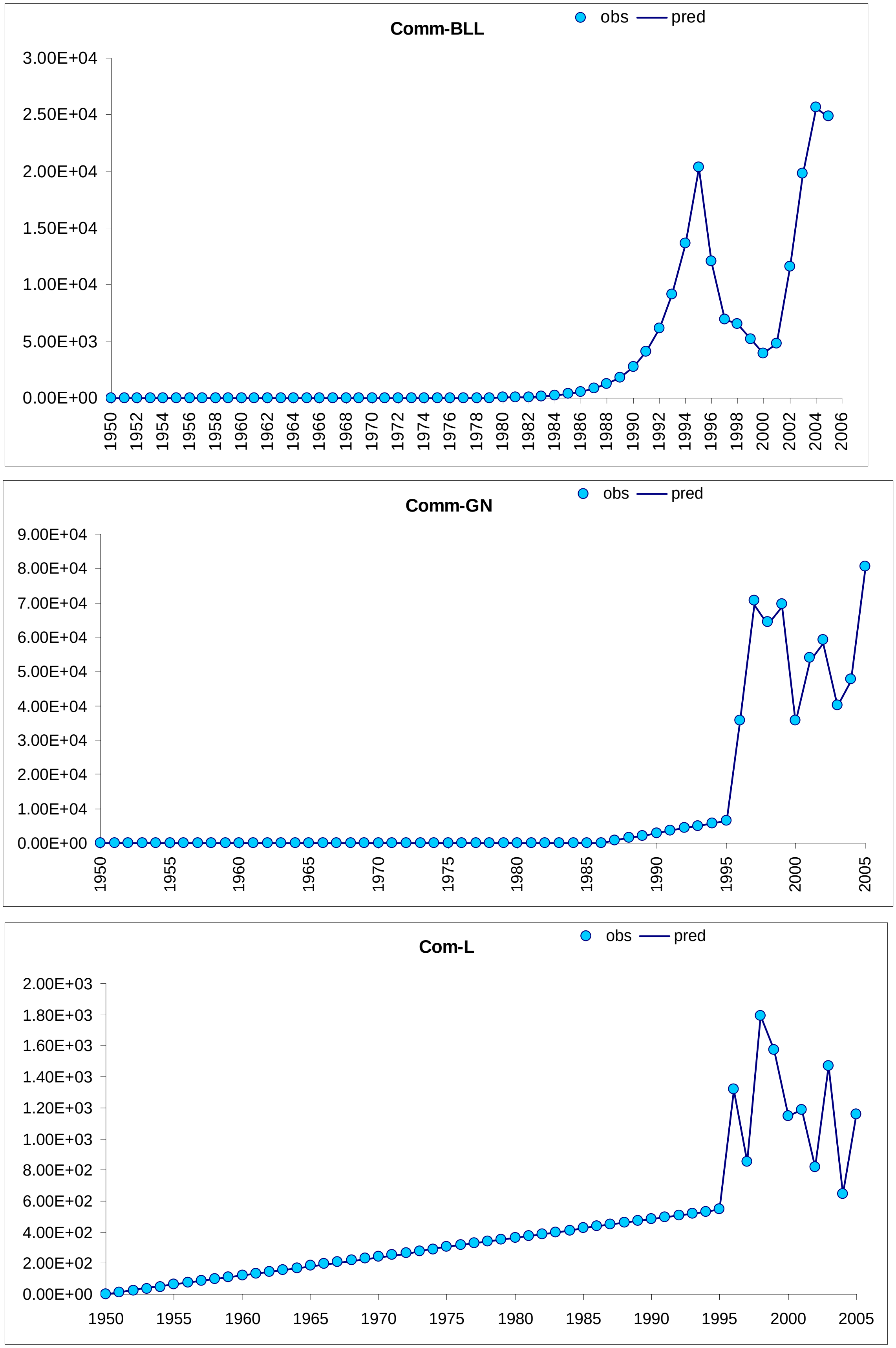


Figure 5.9. Base model fit to catch in number by fleet for **Atlantic sharpnose shark**.

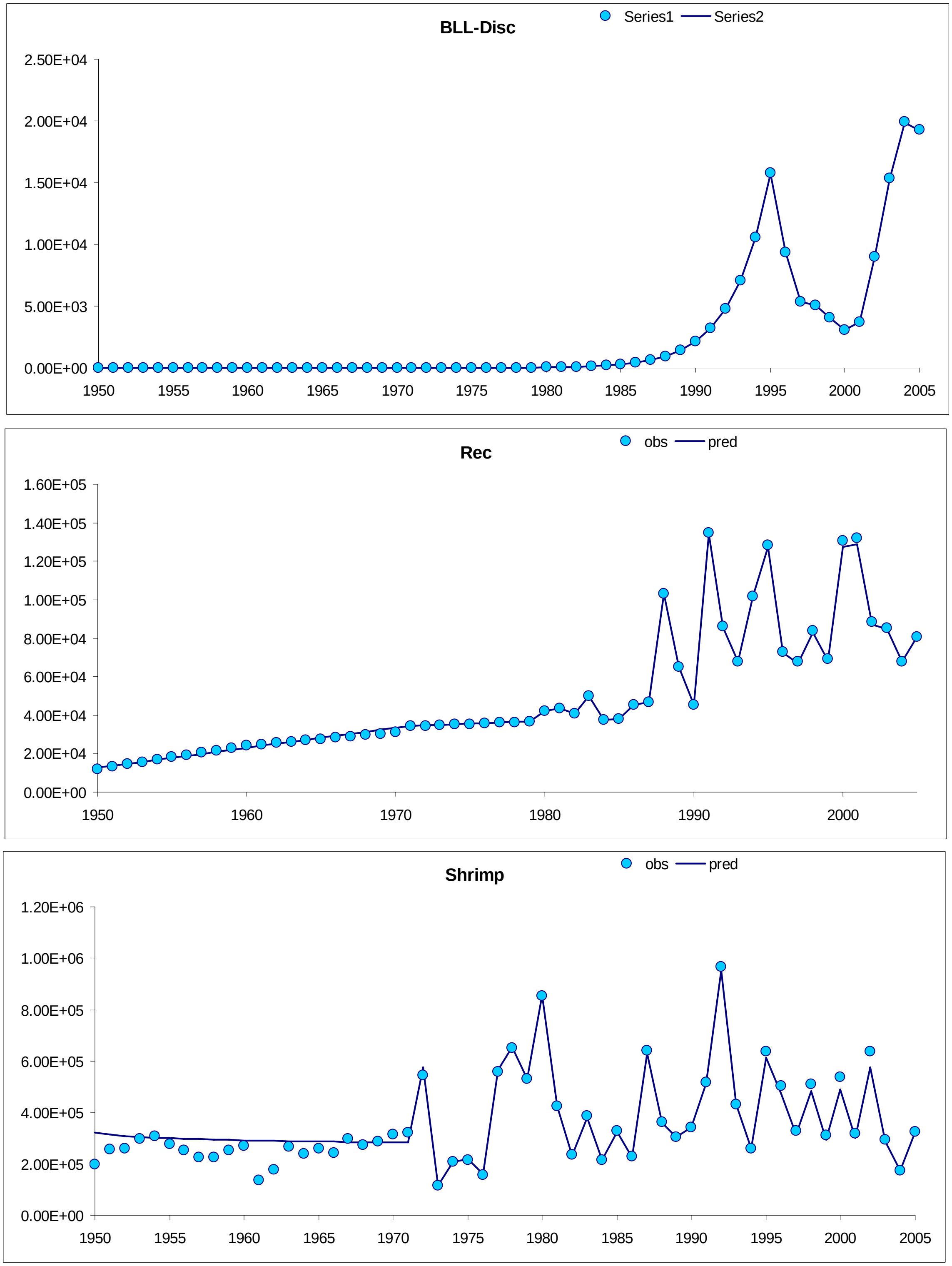


Figure 5.9 (cont.).

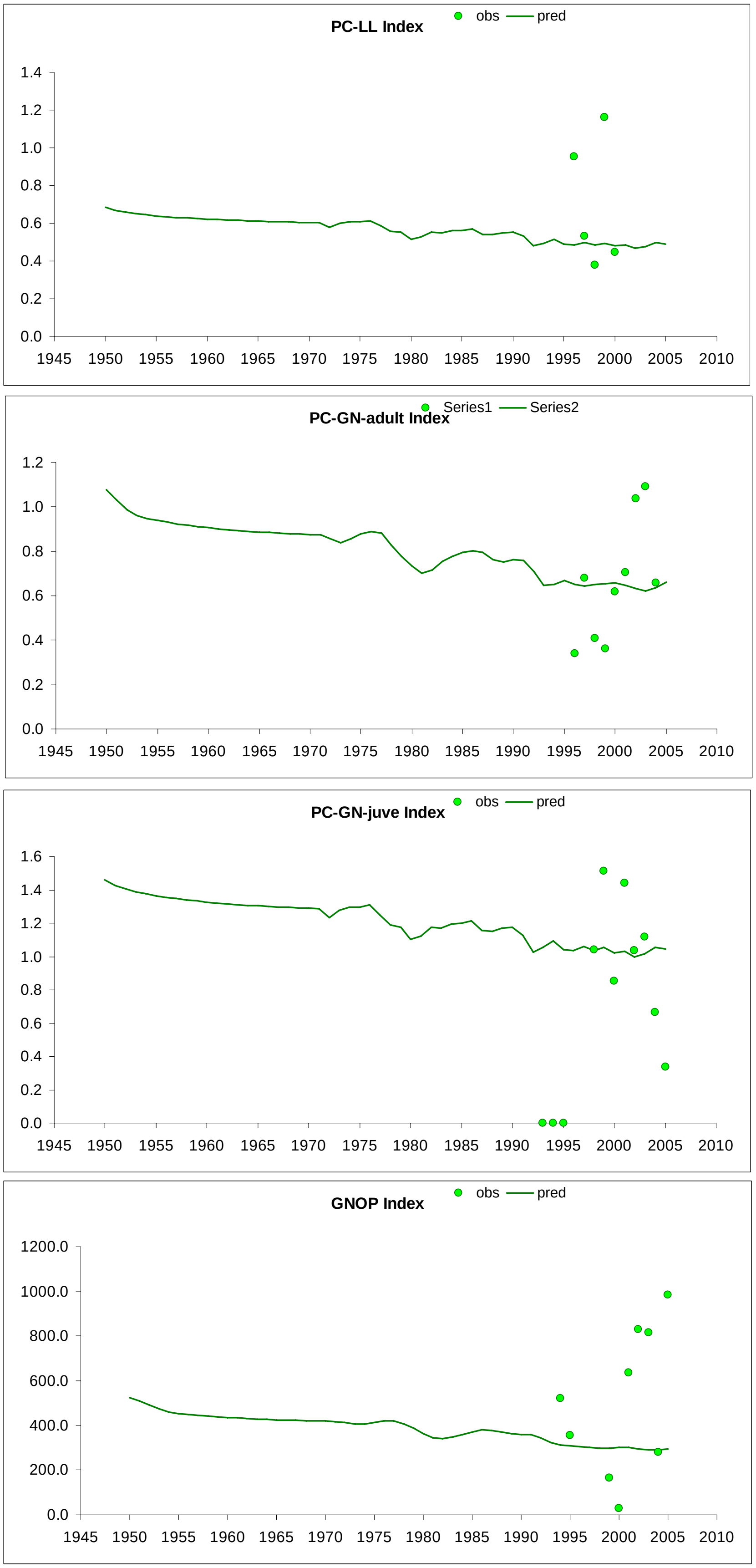
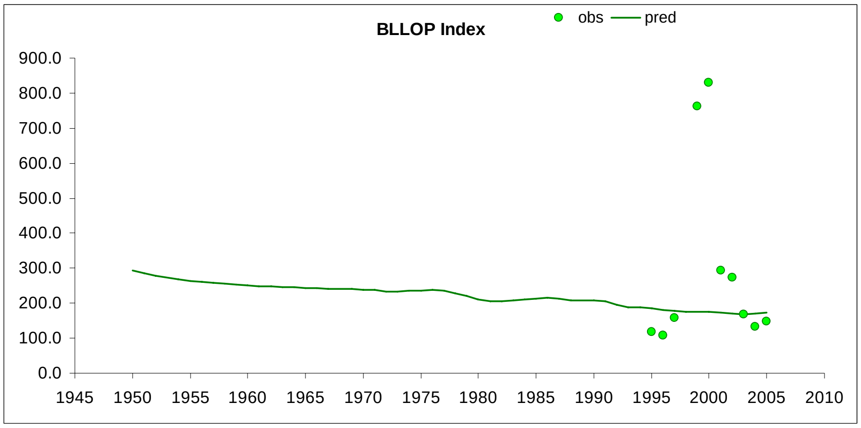
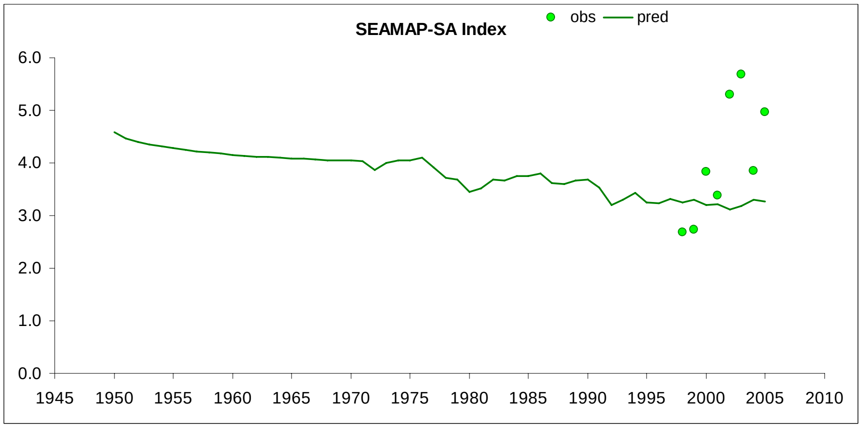
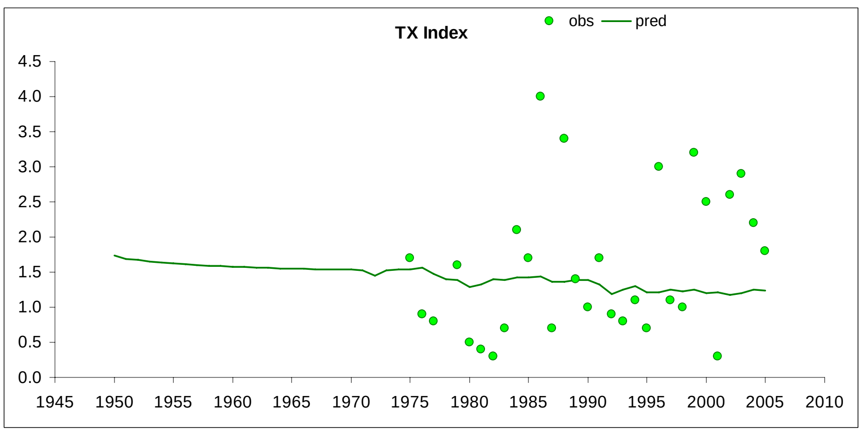


Figure 5.10. Base model estimated fits (solid line) to observed indices (circles) for **Atlantic sharpnose shark.**







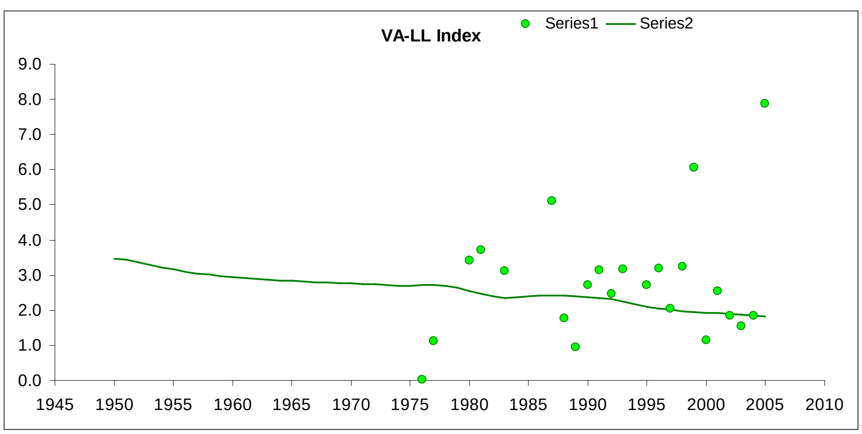


Figure 5.10. (cont).

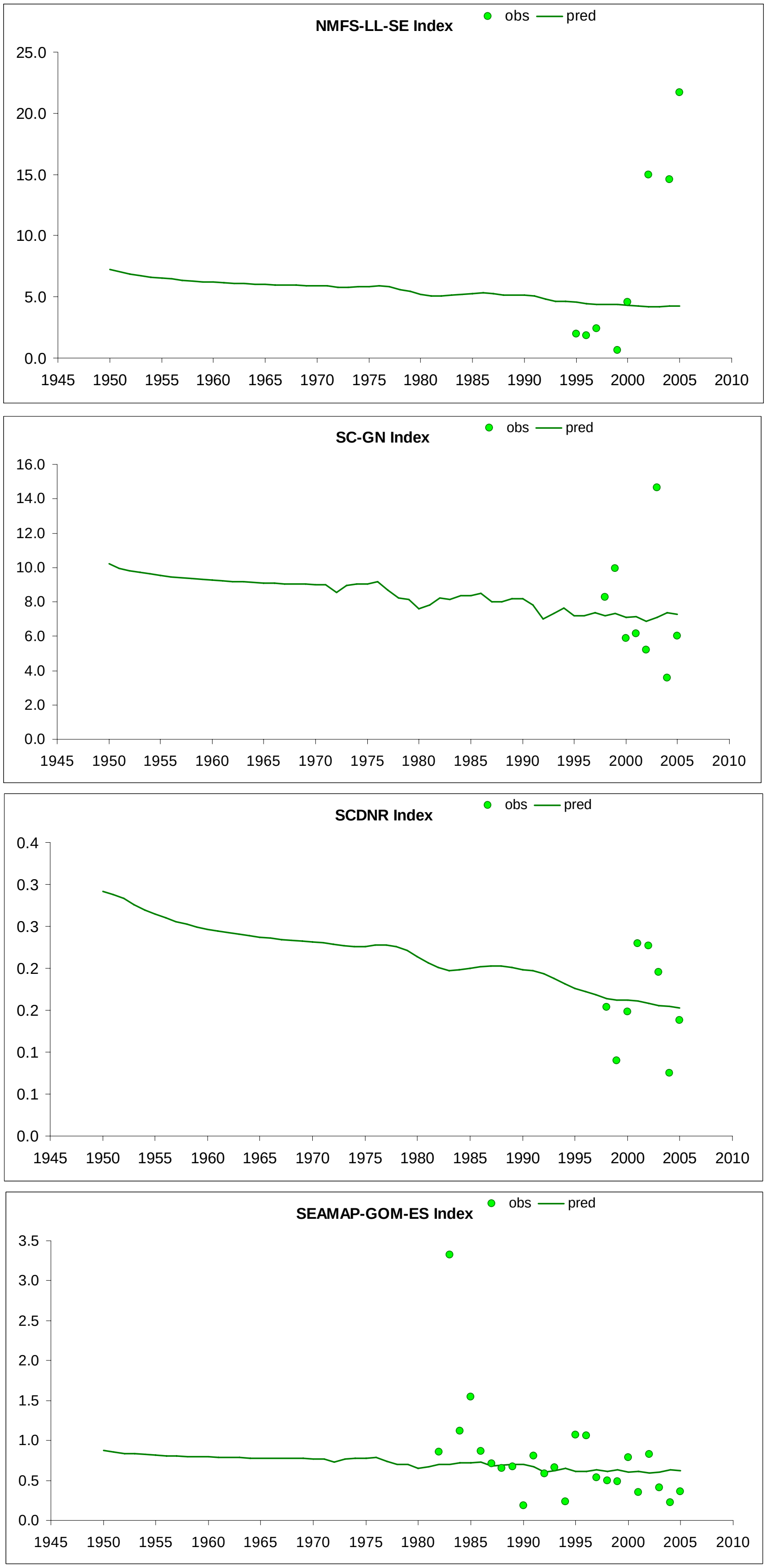


Figure 5.10. (cont).

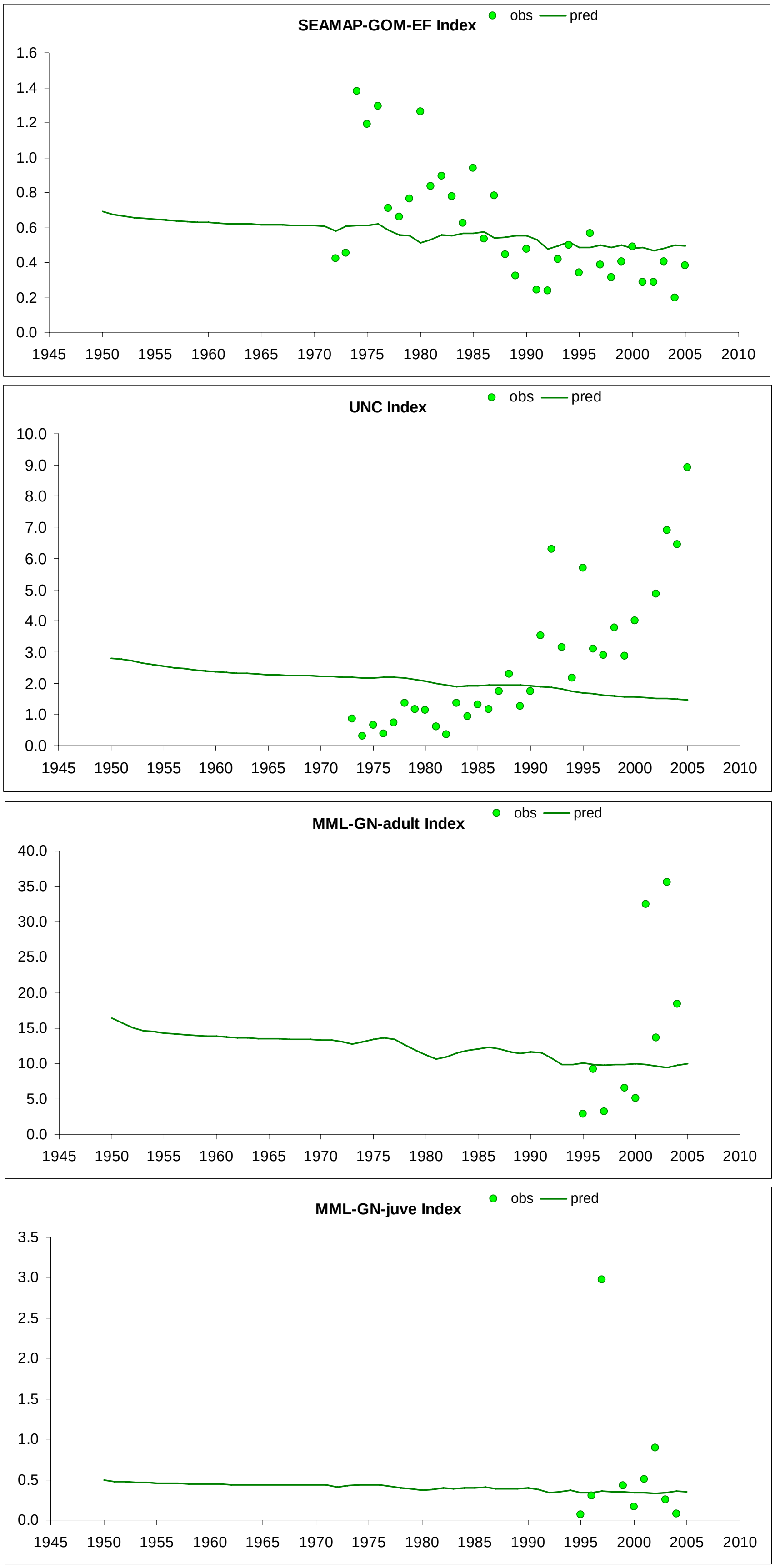


Figure 5.10. (cont).

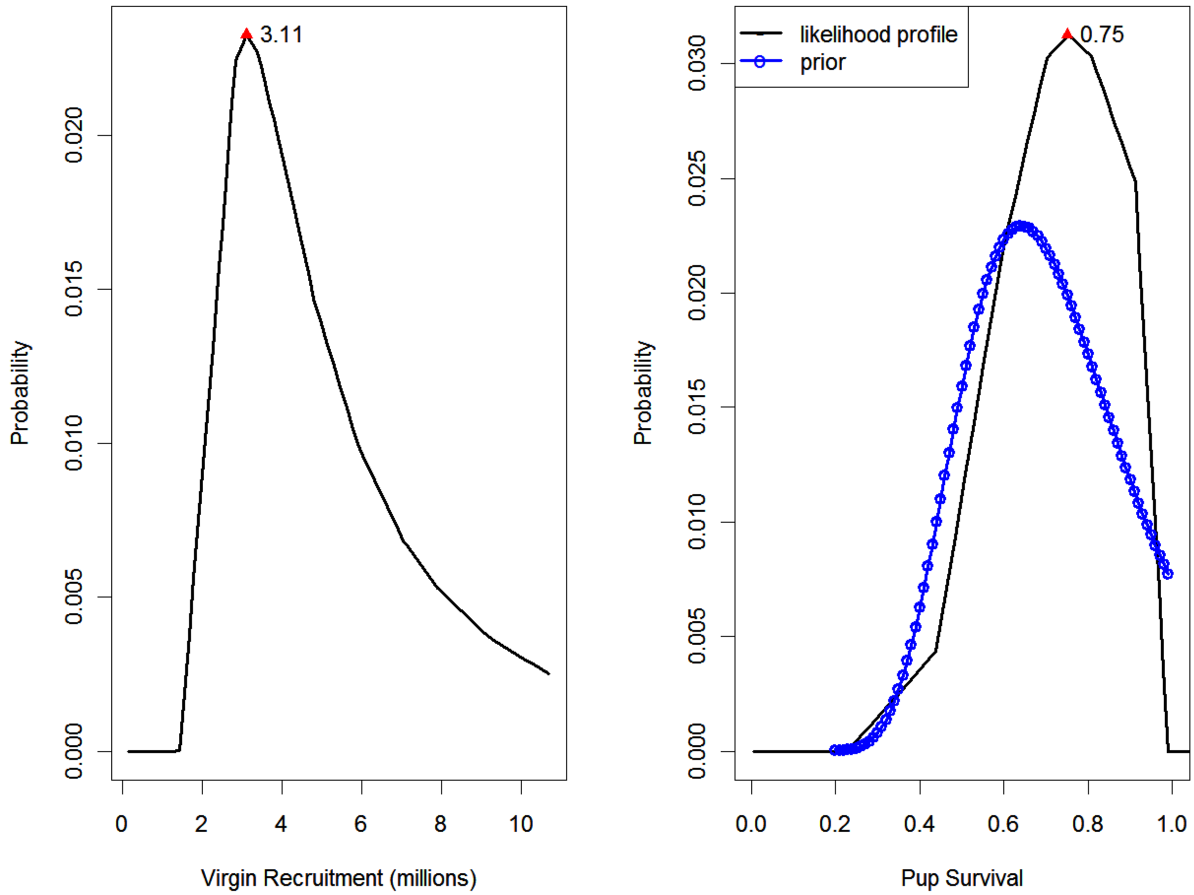


Figure 5.11. **Atlantic sharpnose shark** base model estimated likelihood profile for virgin recruitment (R_0, in millions) and pup-survival (prior plotted in blue with open circles). The mode of the posterior is indicated with a solid triangle, and the value is labeled.

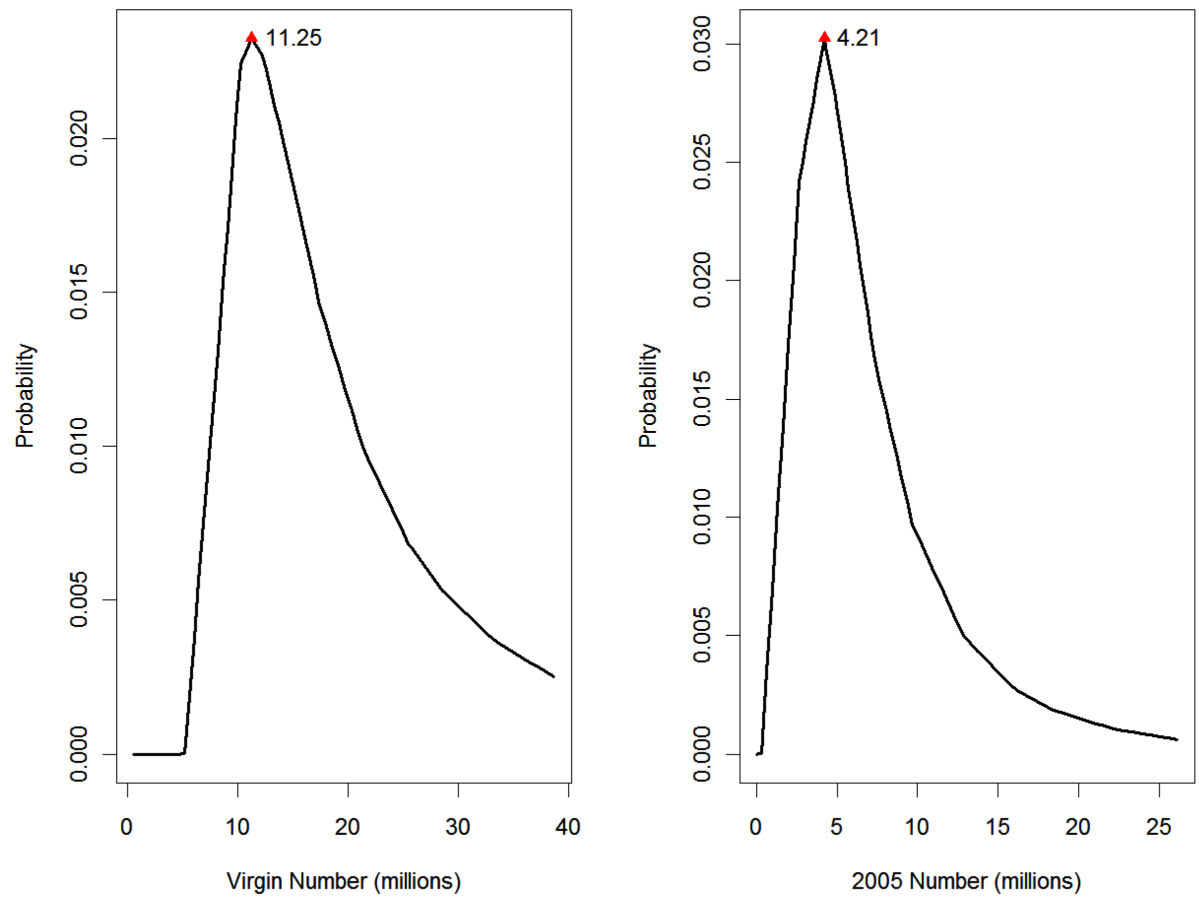


Figure 5.12. Base model estimated likelihood profile for total population size (in number) at virgin conditions, and current population size for **Atlantic sharpnose shark**. The mode of the posterior is indicated with a solid triangle, and the value is labeled.

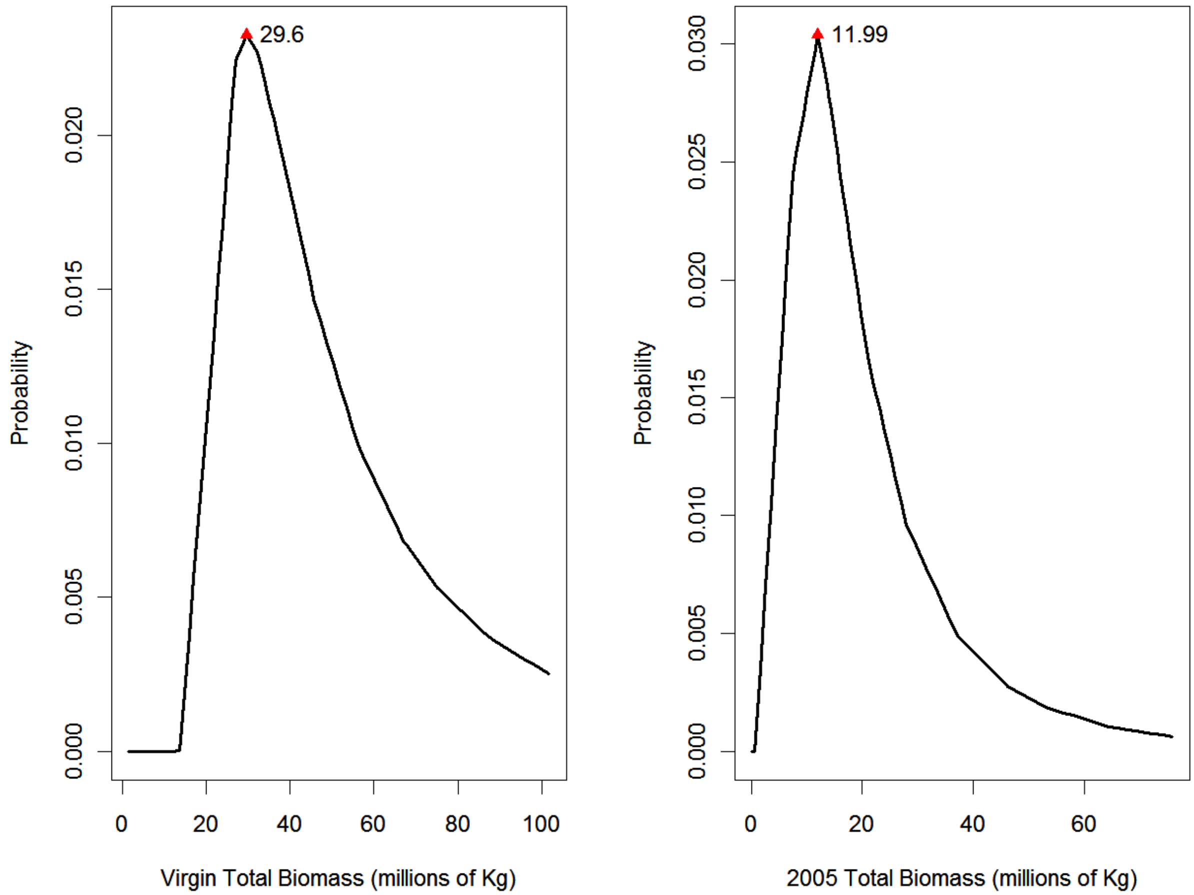


Figure 5.13. **Atlantic sharpnose shark** base model estimated likelihood profile for total population biomass (Kg.) at virgin conditions, and current population biomass (Kg.). The mode of the posterior is indicated with a solid triangle, and the value is labeled.

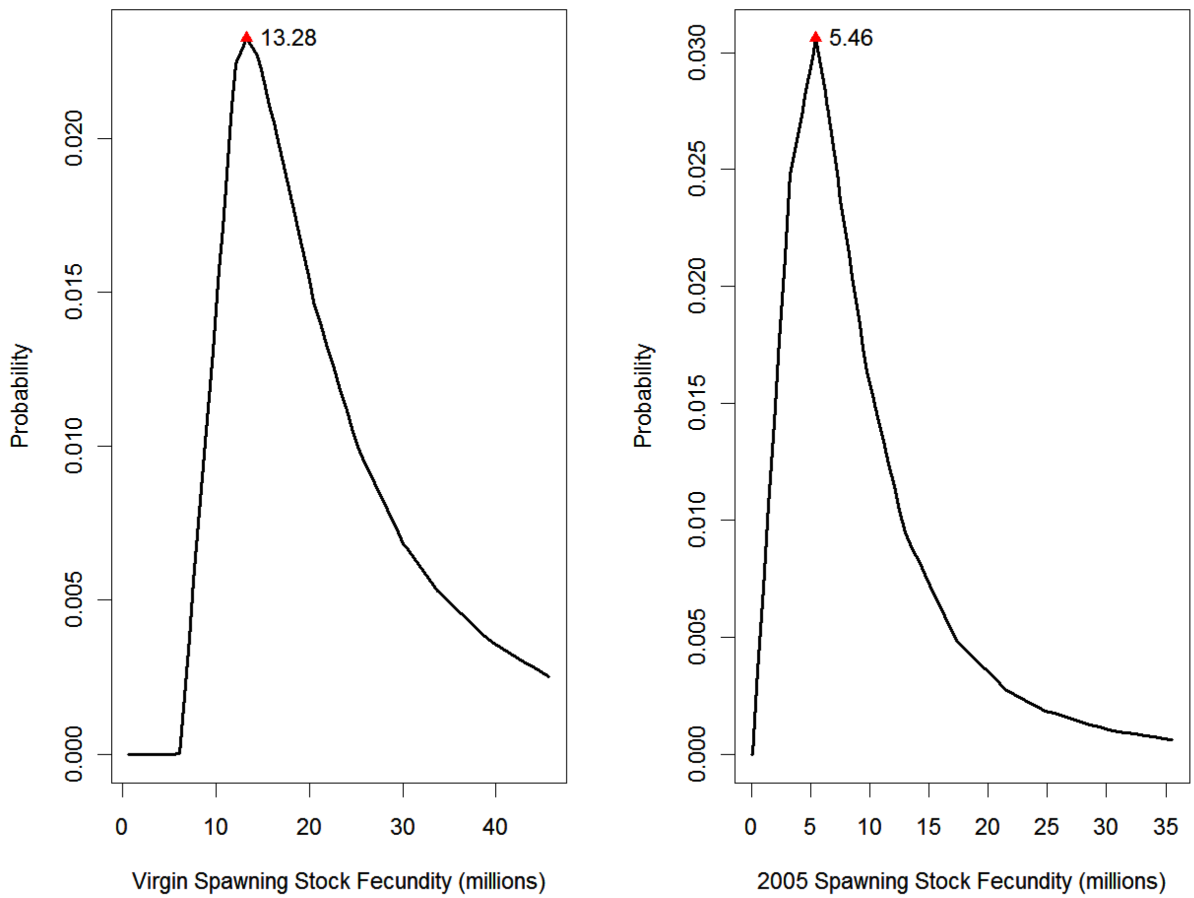


Figure 5.14. Base model estimated likelihood profile for spawning stock fecundity (SSF, millions of pups produced) at virgin conditions, and current spawning stock fecundity for **Atlantic sharpnose shark**. The mode of the posterior is indicated with a solid triangle, and the value is labeled.

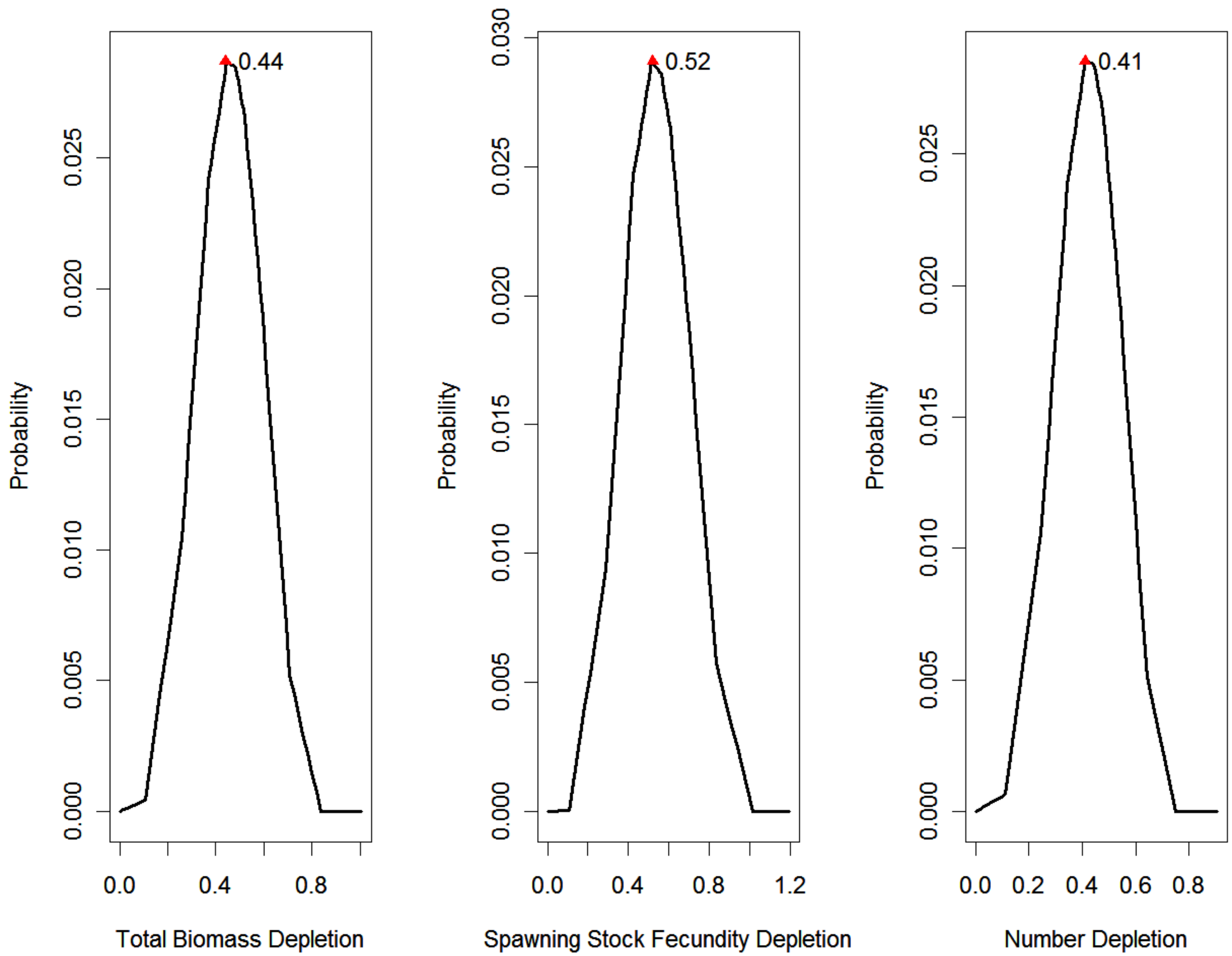


Figure 5.15. Base model estimated likelihood profile for depletion in biomass (B_{2005}/B_0), spawning stock fecundity (SSF_{2005}/SSF_0), and in number (N_{2005}/N_0) for **Atlantic sharpnose shark**. The mode of the posterior is indicated with a solid triangle, and the value is labeled.

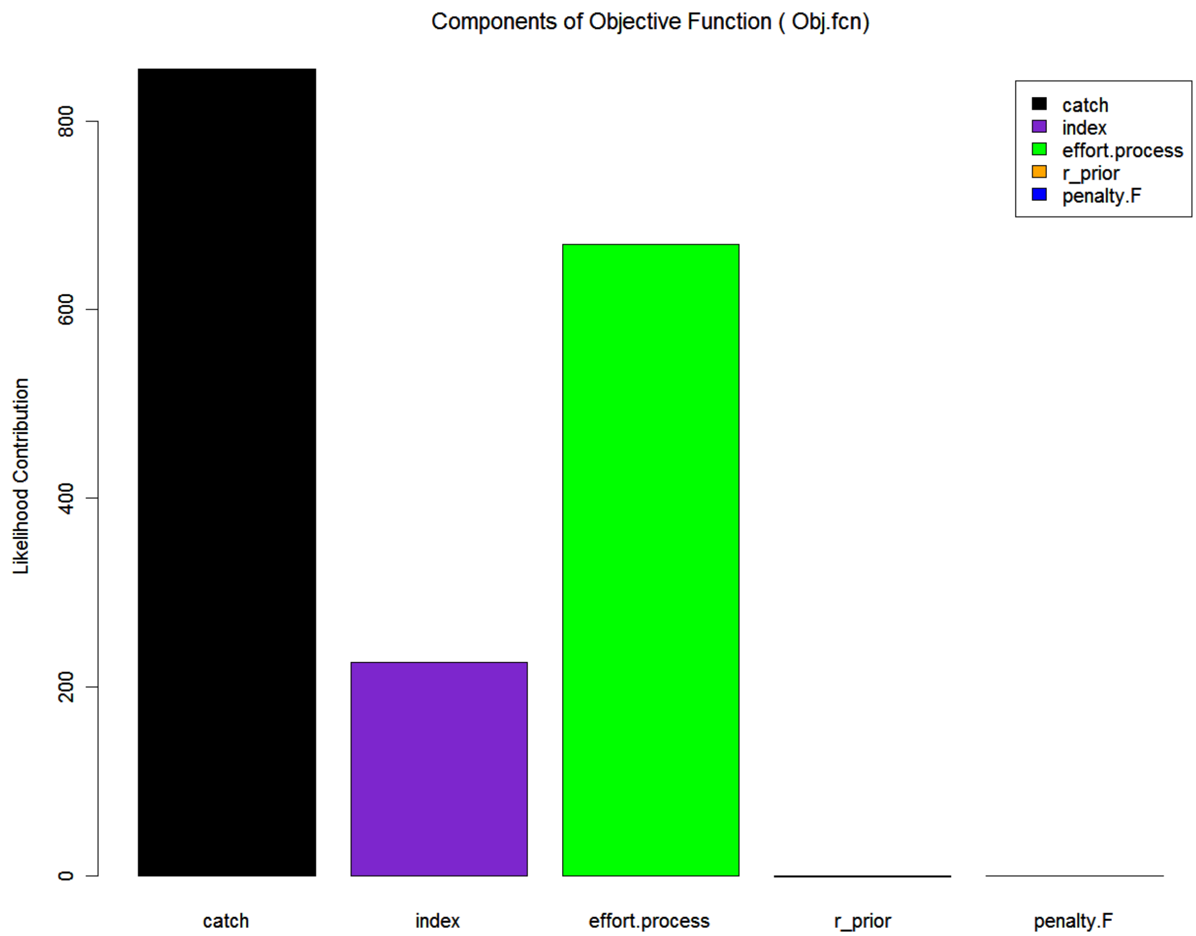


Figure 5.16. Contributions to the likelihood by model source for the **Atlantic sharpnose shark** base model.

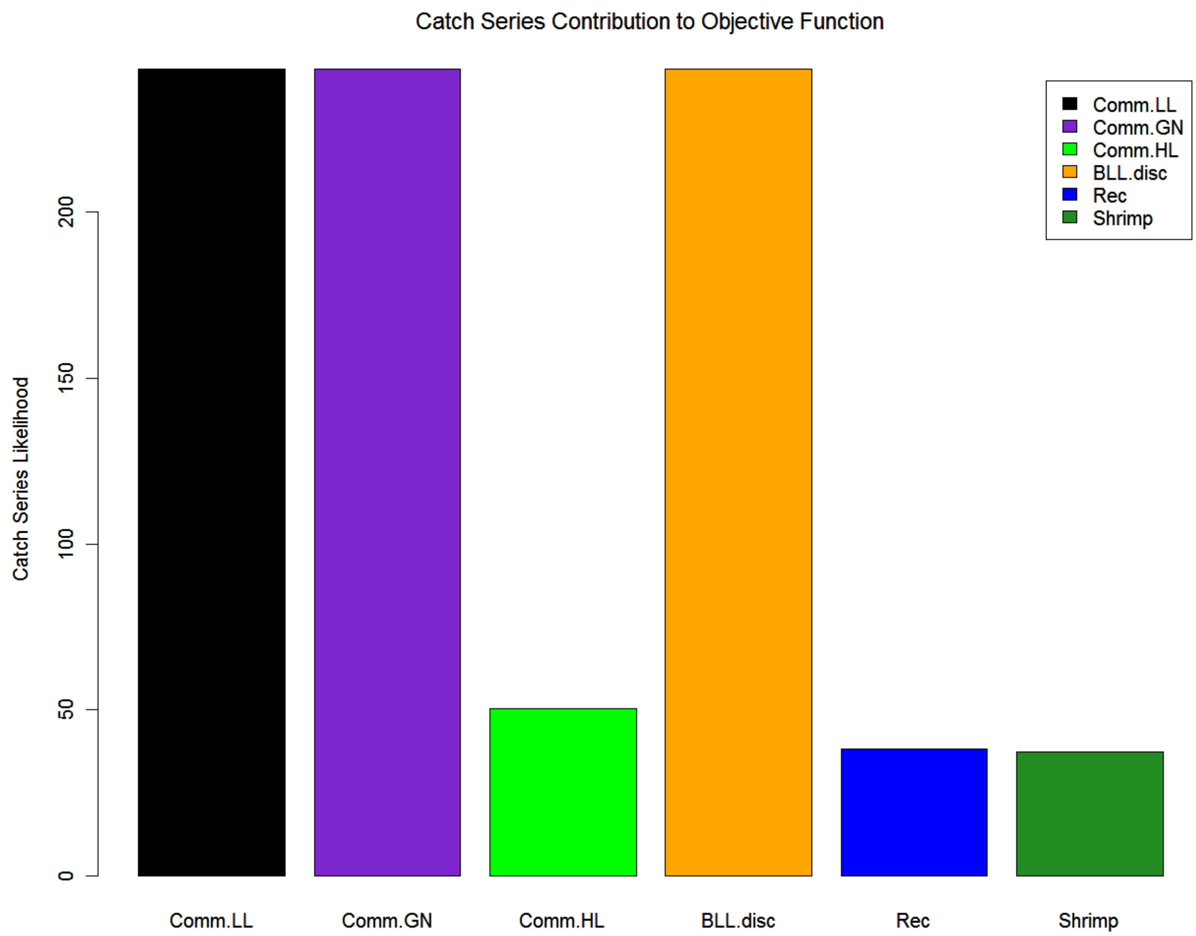


Figure 5.16 (cont.)

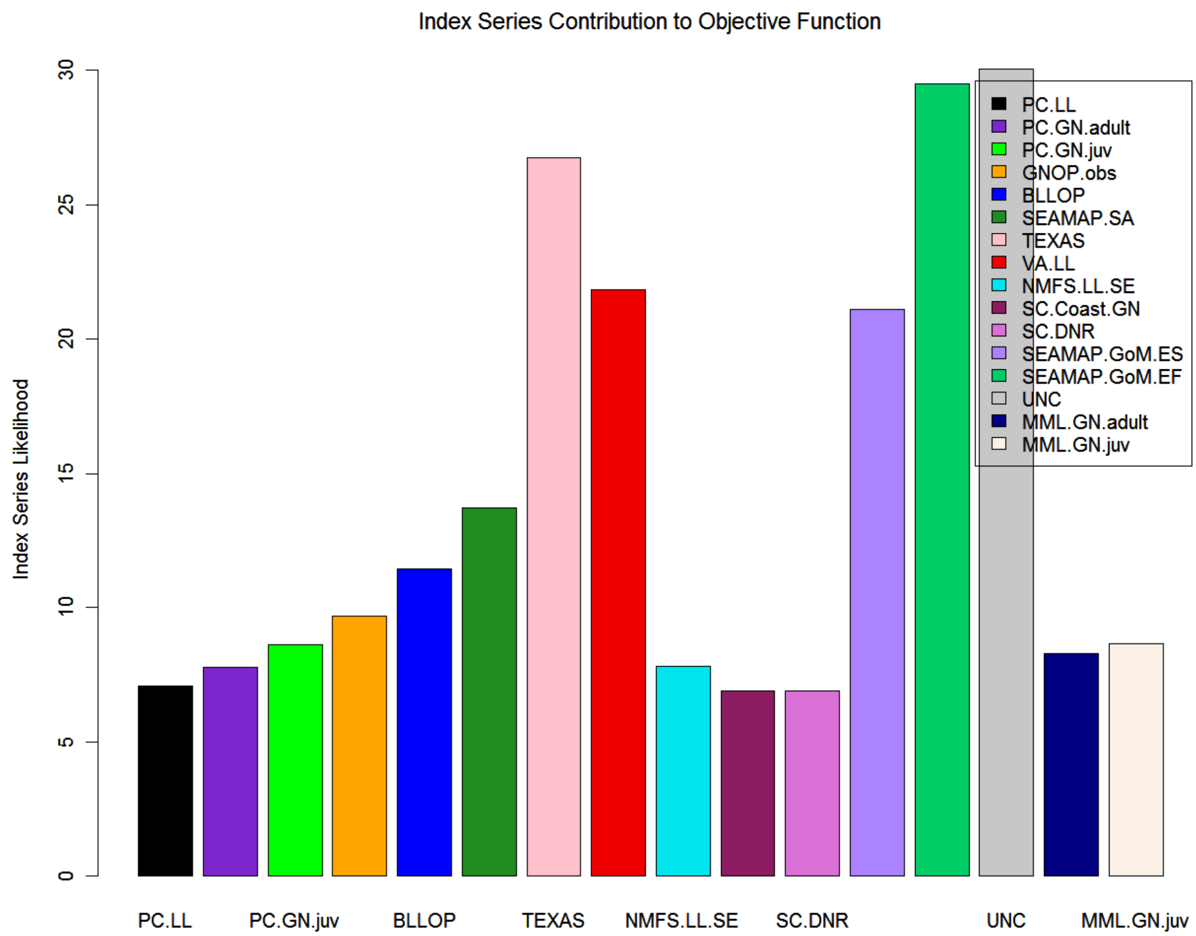


Figure 5.16 (cont.)

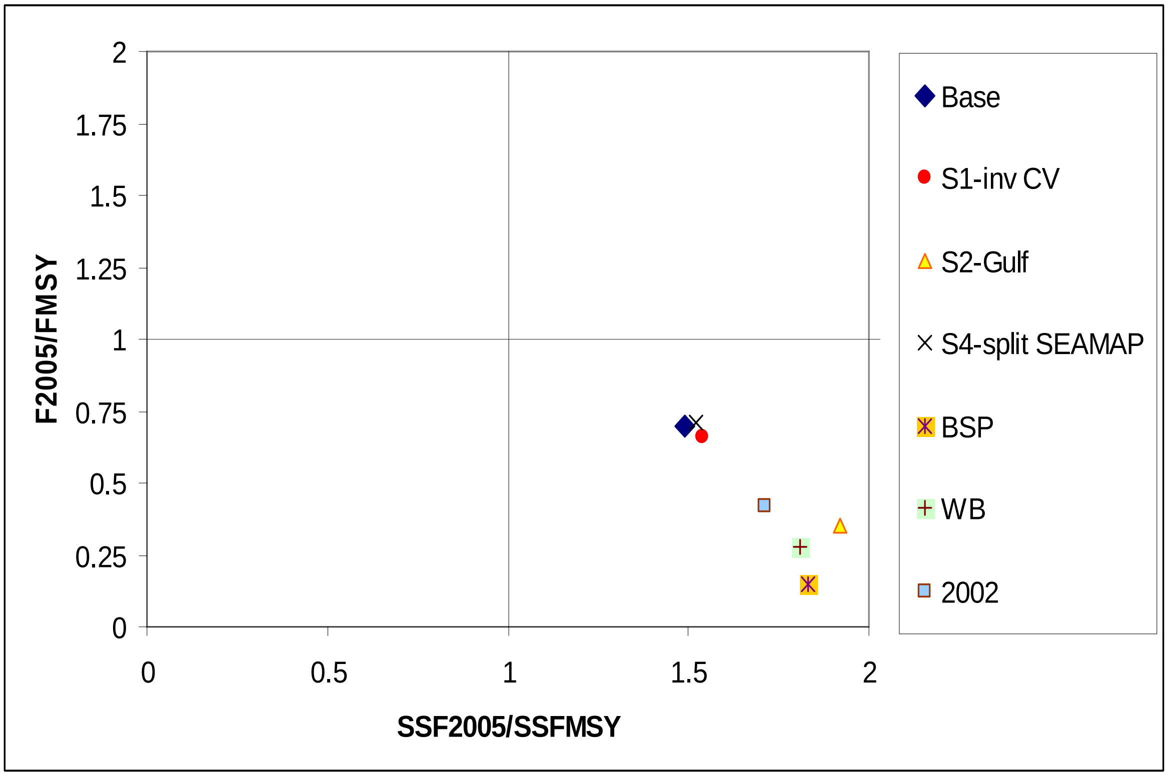


Figure 5.17. Phase plot of all model results for **Atlantic sharpnose shark.** The result from the 2002 assessment (labeled 2002) is included for comparison with 2006 assessment results. BSP and WB are the results from the Bayesian Surplus Production and the WinBUGS surplus production model, respectively.

BONNETHEAD SHARK STOCK ASSESSMENT

6. BONNETHEAD SHARK STOCK ASSESSMENT

6.1. Summary of Bonnethead Shark Working Documents

SEDAR 13-AW-01
Cortés: Assessment of Small Coastal Sharks, Atlantic sharpnose, Bonnethead, Blacknose and Finetooth Sharks using Surplus Production Methods
We used two complementary surplus production models (BSP and WinBUGS) to assess the status of the Small Coastal Shark (SCS) complex and four individual species (Atlantic sharpnose, bonnethead, blacknose, and finetooth sharks) identified as baseline scenarios in the SCS Data Workshop report. Both methodologies use Bayesian inference to estimate stock status, and the BSP further performs Bayesian decision analysis to examine the sustainability of various levels of future catch. Extensive sensitivity analyses were performed with the BSP model to assess the effect of different assumptions on CPUE indices and weighting methods, catches, intrinsic rate of increase, and importance function on results. Baseline scenarios predicted that the stock status is not overfished and overfishing is not occurring in all cases. Using the inverse variance method to weight the CPUE data was problematic because of the nature of the CPUE time series and must be regarded with great caution, although predictions on stock status did not change, except for blacknose sharks. The alternative surplus production model implemented in WinBUGS supported the results from the BSP model, with the exception of blacknose sharks, which became overfished. None of the other sensitivity analyses examined had a large impact on results and did not affect conclusions on stock status in any case. Only blacknose sharks with the alternative catch scenario approached an overfishing condition.

SEDAR 13-AW-02
Siegfried, Cortés, and Brooks: Determining Selectivities for Small Coastal Shark Species for Assessment Purposes
Selectivities of catch series and indices had to be determined for sharpnose, blacknose, and bonnethead sharks for the 2007 small coastal shark stock assessment. Based on age frequencies, five selectivities were determined for sharpnose, four for blacknose, and two for bonnethead.

SEDAR 13-AW-03
Siegfried and Brooks: Assessment of Blacknose, Bonnethead, and Atlantic Sharpnose Sharks with a State-Space, Age-Structured Production Model
An age-structured production model was employed to assess the following small coastal sharks: Blacknose (*Carcharhinus acronotus*), Bonnethead (*Sphyrna tiburo*), and Atlantic Sharpnose (*Rhizoprionodon terraenovae*). All models assumed virgin conditions in 1950, and historically reconstructed catches were derived to inform the model on likely levels of removals for the years prior to the start of observed and recorded catches. The base models for all three species applied equal weight to all indices. Base model results for bonnethead shark indicate that the stock is overfished and that there is overfishing. The stock status appears to be quite sensitive to the reconstructed catches, particularly because of some extreme peaks in the bottom longline fishery reports and the shrimp bycatch reports. An initial sensitivity run indicates that the stock depletion decrease when less weight is given to the extreme peaks. Additional sensitivities will be performed at the assessment workshop. The base model results for blacknose suggest that the

stock is overfished and that there is also overfishing. The base model for Atlantic sharpnose assumed a single stock, and results from this model indicate that the stock is not overfished nor is overfishing occurring. A sensitivity analysis where inverse CV weights were applied to the base indices showed very little difference from the base model, and the stock status estimate was no overfishing and the stock is not overfished.

6.2. Background

In 2002, a stock assessment was conducted on the small coastal complex of sharks (finetooth (*Carcharhinus isodon*), blacknose (*Carcharhinus acronotus*), bonnethead (*Sphyrna tiburo*), and Atlantic sharpnose (*Rhizoprionodon terraenovae*), in the Gulf of Mexico and the Atlantic (Cortés 2002). The author used a variety of Bayesian statistical models, including a Schaefer biomass dynamic model, a Schaefer surplus production model (SPM), and a lagged-recruitment, survival and growth state-space model. There are more data available to assess the blacknose, bonnethead, and Atlantic sharpnose populations currently; therefore an age-structured model was applied in addition to the models used in the last assessment. This assessment report outlines the results of the age-structured model applied to bonnethead shark data.

6.3 Available Models

Three models were available for discussion for the bonnethead shark assessment: two surplus production models (SPMs), the BSP and WinBUGS models described previously, and one age-structured production approach (Cortés 2002, SPASM, Porch 2002).

6.4 Details about surplus production model and age-structured model

A surplus production model simulates the dynamics of a population using total population biomass as the parameter that reflects changes in population size relative to its virgin condition. In comparison to more complicated models, the surplus production model is simpler in its formulation, takes less time to run and requires less input information. However, due to its formulation, the surplus production model does not describe changes that occur in subgroups of the population (adults, juveniles, etc). In addition, the sensitivity of model predictions to key stage-dependent biological parameters cannot be evaluated using a surplus production model. Finally, surplus production models are not able to incorporate a lag time into the results.

An age-structured population dynamics model describes the dynamics of each age class in the population separately and therefore, requires age-specific input information. Due to the higher complexity of these models, they usually take longer to run and require a higher volume of information relative to simpler models. However, they can account for age-dependent differences in biology, dynamics and exploitation of fish and provide an insight into the structure of the population and the processes that are more important at different life stages. They also allow for the incorporation of age-specific selectivity information.

With regard to management benchmarks, the surplus production model assumes that the population biomass that corresponds to MSY is always equal to half of the virgin population biomass, whereas the relative biomass at MSY calculated with an age-structured model (and other benchmarks associated to it) is species-specific and could be any fraction of virgin biomass.

The Assessment Workshop Panel decided to use the state-space, age-structured production model described in document SEDAR13-AW-03 for bonnethead sharks. This model was selected as it allowed for the incorporation of age-specific biological and selectivity information, along with the ability to produce required management benchmarks.

6.5 Discussion of weighting methods

The Data Workshop recommended that *equal weighting* for assigning weights to the different CPUE time series available during model fitting should be used for the baseline runs. The panel discussed the advantages and disadvantages of the *equal weighting* vs. the *inverse CV weighting* methods:

Equal weighting ignores the better quality of some data (smaller CVs) but is more stable between assessments because yearly changes on CVs in a given CPUE series do not affect the importance of that time series for the overall fit.

Inverse CV weighting can provide better precision as it tracks individual indices however, it could be less stable between assessments due to changes on the relative 'noise' of each time series. This method may also not be appropriate in cases in which different standardization techniques have been used for the standardization of the series and therefore, the same value of CV might reflect different levels of error depending on the CPUE it corresponds to.

The Assessment Workshop Panel further discussed the issue for weighting indices. It was noted that there are a variety of ways to weight indices in addition to equal and inverse CV weighting, however how to determine which weighting method is most appropriate is a discussion topic that is still without satisfying resolution. Given that fact, the Assessment Workshop Panel decided that equal weighting would be the base weighting method for the current assessment but noted that, as there is at present no objective way to decide which method is superior other than comparing model convergence diagnostics, future assessments may need to re-examine this issue.

6.6 Data issues and solutions derived during the assessment workshop

The estimate of bonnethead bycatch in the shrimp fishery in 1980 raised concern amongst the panelists. It was orders of magnitude larger than the points around it, and had no apparent explanation. The anomalous peak in the shrimp bycatch data was investigated in the working document (SEDAR 13-DW-32) and found to be outside of the limits of confidence. Panelists agreed to take the geometric mean of the three years before and after the anomalous peak and replace it with the geometric mean.

Another anomalous peak in the 1995 reports from the bottom longline fishery concerned panelists. The value, 19,009 sharks caught, was considered too high to be valid. It was argued that the point in question was larger than the total number of bonnetheads caught in the bottom longline in the last ten years. To resolve the issue, the panelists agreed to take the geometric mean of the observed points and replace the 1995 value with that mean.

An issue was brought up during the assessment workshop that involved the fit to the SEAMAP indices for bonnethead. The SEAMAP extended summer and extended fall indices covered a time period during which there was a sampling protocol change. Because of the low proportion positives of bonnethead (~1%), the panelists decided to replace the longer extended fall index with two new indices that cover the early years and late years of that sampling effort respectively. The SEAMAP extended summer index was also considered for replacement by two shorter time series, however two acceptable time series were not available. Therefore, it was excluded.

A final data issue that concerned panelists was the method by which the catches were reconstructed for the commercial longline fishery. It was agreed upon in the catch working group at the data workshop to start the reconstruction in 1981 with a linearly increasing trend ending at the first year of observed data (1995). The panelists at the assessment workshop argued that this was not a realistic representation of the level of catch, especially in the earlier years of fishery expansion. The panelists agreed upon an exponential increase in fishing for the longline fleet reconstruction after much discussion. The new reconstructions were applied to the commercial bottom longline catch and the bottom longline discards.

6.7 Methods

6.7.1 State-space age-structured production model description

The age-structured production model (originally derived in Porch 2002) starts from a year when the stock can be considered to be at virgin conditions. Then, assuming that there is some basis for deriving historic removals, one can estimate a population trajectory from virgin conditions through a “historic era,” where data are sparse, and a “modern era,” where more data are available for model fitting. In all three model applications, virgin conditions were assumed in 1950. The earliest index of abundance (SEAMAP) and the earliest catch series (Shrimp trawl bycatch) begin in 1972, thus the historic model years spanned 1950-1971 (22 years) and the modern model years spanned 1972-2005 (34 years).

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

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

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

(2) $$R = \frac{R_0 S\alpha}{S_0 + (\alpha-1)S} .$$

In (2), R_0 and S_0 are virgin number of recruits (age-1 pups) and spawners (units are number of mature adult females times pup production at age), respectively. The parameter α is calculated as:

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

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).

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, 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 less data compared to the modern period. The manner in which effort is estimated depends on the model period. In the historic period, effort is estimated as either a constant (4a) or a linear trend (4b)

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

or

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

where $f_{y,i}$ is annual fleet-specific effort, b_0 is the intercept, and $f_{y=mod,i}$ is a fleet-specific constant. In the modern period, fleet-specific effort is estimated as a constant with annual deviations, which are assumed to follow a first-order lognormal autoregressive process:

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

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

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

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

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

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

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

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

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

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

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

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

State space implementation

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

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

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

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

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

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

The term λ_g is a variable-specific multiplier of the overall model CV. For catch series and indices (eq 11b), the additional term, $\omega_{i,y}$, is the weight applied to individual points within those series. For instance, because the indices are standardized external to the model, the estimated variance of points within each series is available and could be used to weight the model fit. Given the data workshop decision to use equal weighting between indices for the base model run, all $\omega_{i,y}$ were fixed to 1.0 and the same λ_g was applied to all indices. To evaluate the sensitivity case where indices were weighted by the inverse of their CV, each $\omega_{i,y}$ was fixed to the estimated CV for point *y* in series *i*; an attempt was also made to estimate a separate λ_g for each series, however those multipliers were not estimable and so a single λ was applied to all indices.

6.7.2. Data inputs, prior probability distributions, and performance indicators

Baseline scenario (SPASM-BASE)

The base model represented the decisions made by the Data Workshop as well as any additional decisions or modifications made by the assessment workshop. Data inputted to the model included maturity at age, fecundity at age (pups per mature female), spawning season, catches, indices, and selectivity functions (Tables 6.1a and 6.1b, 6.2, and 6.3; Figures 6.1-6.3). Catches were made by the commercial sector and the recreational sector and we included a catch series for the discards in the bottom longline fishery. A total of twelve indices were made available after the data workshop (Table 6.3, Figure 6.2), eleven of which were recommended as base indices.

Individual selectivity functions to be applied to catch series were identified based on length frequencies and biological information provided by the Life History Working Group. The selectivity recommendations can be found in the Assessment Workshop report on determining selectivities (Table 6.2, Figure 6.3, and SEDAR 13 AW-02).

Catch data begin in 1981, while the earliest data for the indices is 1972 (SEAMAP). Catches from 1981 were imputed back to 1950, when a virgin assumption was imposed. The catches for each fleet were imputed as follows: the commercial longline was reconstructed to increase at an exponential rate from 1981 to 1995 (the year of the first data point). The commercial gillnet fishery was reconstructed to increase linearly from 1981 to 1995. The longline reconstruction changed from linear (a Data Workshop recommendation) to an exponential increase following the Assessment Workshop recommendations.

Individual points within catch and index series can be assigned different weights, based either on estimated precision or expert opinion. The base case model configuration was to treat all points as having an equal weight. There were no recommendations by either the data workshop or the assessment workshop to downweight any individual or group of points.

Estimated model parameters were pup survival, virgin recruitment (R_0), catchabilities associated with catches and indices, and fleet-specific effort. Natural mortality at ages 1+ was fixed at the values provided by the life history working group (Table 6.1a), and the priors for pup survival and virgin recruitment are listed in Table 6.1b.

In summary, the base model configuration assumed virgin conditions in 1950, used the reconstructed catch series as agreed upon (whether it was a linear or exponential increase) and used the new value for the shrimp bycatch in 1980. All inputs are given in Tables 6.1, 6.2, and 6.3. Base indices are in black font in Table 6.3.

Performance indicators included estimates of absolute population levels and fishing mortality for year 2005 (F_{2005}, SSF_{2005}, B_{2005}), population statistics at MSY (F_{MSY}, SSF_{MSY}, SPR_{MSY}), current status relative to MSY levels, and depletion estimates (current status relative to virgin levels). In addition, trajectories for F_{year}/F_{MSY} and SSF_{year}/SSF_{MSY} were plotted. SSF is spawning stock fecundity.

6.7.3 Methods of numerical integration, convergence diagnostics, and decision analysis

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. 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).

6.7.4 Sensitivity analyses

Two sensitivity runs were requested by Data Workshop. The first sensitivity recommended at the Data Workshop was to include the 12th index (GN logs) to the model run. The second sensitivity, also recommended at the Data Workshop, was to use an inverse-CV weighting method for weighting the indices. No additional sensitivities were requested.

6.8 Results

6.8.1 Baseline scenario

The base model estimated a stock that was not overfished with no overfishing occurring (Tables 6.4 and 6.5; Figure 6.4). The model estimate of F by fleet is dominated by the bycatch from the shrimp fleet (Figure 6.4). Model fits to catches are shown in Figure 6.5 and show very good agreement. The Texas index is the longest time series, beginning in 1975, and its trend was fit well by the model (Figure 6.6). The SEAMAP split series are fit well, especially through the late series and the ENP (beginning in 1978) is also well fit by the model. The South Carolina COASTSPAN gillnet survey is the index that is fit least well by the model.

Likelihood profiling was performed in ADModel Builder (Otter Research Ltd. 2000) to obtain posterior distributions for several model parameters (Figures 6.8 and 6.9). The distributions for total biomass depletion or spawning stock fecundity depletion (current/msy value for that parameter) range from about 0.1-0.8 with a mode of 0.36 (Figure 6.8). The mode for the posterior of pup survival was estimated at a higher value than the prior mode, while the mode of the posterior for virgin recruitment of pups was approximately 1,008,000 (Figure 6.9).

6.8.2 Sensitivity analyses

The first sensitivity (**S1**-inverse CV weighting method) is very slightly overfished, with a spawning stock fecundity ratio <1 (~0.99). **S1**, however, does not show any overfishing. Sensitivity 2 (**S2**, all indices are included) showed a status very similar to that of the base model. Panelists at the Data Workshop requested these sensitivities and Panelists at the Assessment Workshop agreed that the base model was most appropriate.

6.8.3 Comparison of model fits

A breakdown of the likelihood by individual catch and index series as well as the relative likelihood values by model source (catch, indices, effort, catchability, and recruitment) are shown in Figures 6.10-6.11. These graphs show the relative contributions of each index and catch series on the model objective function.

6.9 Projections of the base model

As the base model does not show an overfished stock or any overfishing in the current time period, projections were not calculated.

6.10 Discussion

The main issues, such as the anomalous shrimp peak and the linear versus exponential interpolation of catch data in the longline fishery were debated and resolved agreeably. The base SPASM model for bonnethead shows that the stock is not overfished and that there is no overfishing occurring. The first sensitivity, where the inverse-CV weighting method was used, shows a very negligible status of overfished, but there is not a history of an overfished status at any time for this stock. There have been years of overfishing (1975, 1980, 1997, etc. see Figure 6.4). The main contributor to population mortality is the recreational fleet followed more closely since 1990 by the commercial gillnet fleet. As shown in the phase plot in Figure 6.7, the SPMs gave more optimistic scenarios for stock status than the age-structured models agreed upon by the Assessment Workshop Panelists. In the base model, total fishing mortality from 1995-2005 averages 0.38, and for 2002-2005 it averages 0.4. These levels are 1.2-1.3 times the estimate of F_{MSY}.

5.11 References

Cortés, E. (2002). Stock Assessment of Small Coastal Sharks in the U.S. Atlantic and Gulf of Mexico, NOAA-Fisheries Sustainable Fisheries Division
133.

Myers, R. A., K. G. Bowen, et al. 1999. "Maximum reproductive rate of fish at low population sizes." *Canadian Journal of Fisheries and Aquatic Sciences* **56**: 2404-2419.

Otter Research Ltd. 2001. An introduction to AD MODEL BUILDER Version 6.0.2. Box 2040, Sidney, B. C. V8L 3S3, Canada.

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.

Table 6.1a. Biological inputs for **bonnethead shark** from the data workshop.

Age	M	Female Maturity	Pups-per-Female
1	0.42	0.02	5
2	0.40	0.12	5
3	0.39	0.48	5
4	0.37	0.86	5
5	0.33	0.98	5
6	0.29	1	5
7	0.27	1	5
8	0.26	1	5
9	0.25	1	5
10	0.24	1	5
11	0.22	1	5
12	0.21	1	5

Table 6.1b. Additional parameter specifications for **bonnethead shark** where L_∞, K, and t_0 are von Bertalanffy parameters; a is the scalar coefficient of weight on length; and b is the power coefficient of weight on length. Weight units are kg.

Parameter	**Value**	**Prior**
L_∞	113.9 (cm TL)	*constant*
K	0.22	*constant*
t_0	-1.25	*constant*
a	9.52E-11	*constant*
b	3.59	*constant*
Pup Survival	0.66	~LN with CV=0.30
Virgin Recruitment (R_0)	[1.0E+4, 1.0E+10]	~U on [1.0E+4, 1.0E+10]

Table 6.2. Catches of **bonnethead shark** by fleet. Units are numbers of sharks and the reconstructed catches are in blue. The last row lists which selectivity is assumed for the catch series.

Year	Longline	Nets	Lines	Recreational catches	Bottom longline discards	Shrimp bycatch
1950	0	0	0	7,469	0	103,005
1951	0	0	0	13,314	0	132,351
1952	0	0	0	14,514	0	133,902
1953	0	0	0	15,714	0	154,059
1954	0	0	0	16,914	0	158,973
1955	0	0	0	18,114	0	144,143
1956	0	0	0	19,314	0	131,016
1957	0	0	0	20,514	0	117,923
1958	0	0	0	21,714	0	116,978
1959	0	0	0	22,914	0	131,248
1960	0	0	0	15,058	0	140,670
1961	0	0	0	15,760	0	70,687
1962	0	0	0	16,461	0	92,678
1963	0	0	0	17,162	0	139,034
1964	0	0	0	17,864	0	124,463
1965	0	0	0	18,565	0	134,020
1966	0	0	0	19,267	0	126,382
1967	0	0	0	19,968	0	155,001
1968	0	0	0	20,669	0	141,535
1969	0	0	0	21,371	0	148,218
1970	0	0	0	18,450	0	162,989
1971	0	0	0	21,632	0	167,247
1972	0	0	0	21,935	0	259,608
1973	0	0	0	22,239	0	189,270
1974	0	0	0	22,542	0	255,743
1975	0	0	0	22,846	0	380,381
1976	0	0	0	23,149	0	171,773
1977	0	0	0	23,453	0	332,678
1978	0	0	0	23,756	0	81,139
1979	0	0	0	24,060	0	317,721
1980	0	0	0	25,067	0	235,763
1981	0	0	0	39,269	0	109,637
1982	1	0	0	26,115	0	190,028
1983	1	0	0	22,925	1	91,668
1984	3	0	0	15,418	2	103,355
1985	6	0	0	22,607	4	100,703

1986	10	0	0	50,474	6	323,168
1987	16	5,496	0	26,527	10	204,623
1988	24	10,991	0	30,986	14	182,213
1989	40	16,487	0	37,901	24	119,722
1990	74	21,983	0	48,317	44	271,557
1991	113	27,478	0	8,837	66	104,186
1992	190	32,974	0	18,692	112	154,342
1993	349	38,470	0	19,798	205	142,619
1994	680	43,965	0	20,524	400	121,775
1995	1,305	49,461	285	32,112	11,168	242,057
1996	7,324	5,259	209	22,519	4,303	479,034
1997	377	14,963	190	14,995	221	417,245
1998	957	1,468	225	29,065	562	164,872
1999	633	9,995	832	37,341	372	271,829
2000	899	16,500	42	56,436	528	137,164
2001	554	19,705	70	59,017	326	263,532
2002	2,344	36,840	578	51,048	1,377	305,874
2003	3,756	6,514	109	40,066	2,207	216,626
2004	924	7,063	58	42,295	543	453,898
2005	2,109	9,942	224	31,215	1,241	112,188
Selectivity	2	1	2	1	2	1

Table 6.3. Indices available for use in the current **bonnethead shark** assessment. Sensitivity index in green. The last row lists the sensitivity used for each index.

PC-GN a	PC-GN j	GN-obs	ENP	SEAMAP-SA	Texas	SC Coastspan GN	SEAMAP early	SEAMAP late	MML GN-adult	MML GN- juvi	GN Logs	Year
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1950
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1951
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1952
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1953
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1954
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1955
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1956
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1957
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1958
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1959
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1960
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1961
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1962
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1963
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1964
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1965
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1966
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1967
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1968
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1969
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1970
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1971
-1	-1	-1	-1	-1	-1	-1	0.182	-1	-1	-1	-1	1972
-1	-1	-1	-1	-1	-1	-1	0.558	-1	-1	-1	-1	1973
-1	-1	-1	-1	-1	-1	-1	0.308	-1	-1	-1	-1	1974
-1	-1	-1	-1	-1	0.164	-1	0.164	-1	-1	-1	-1	1975
-1	-1	-1	-1	-1	1.578	-1	0.321	-1	-1	-1	-1	1976
-1	-1	-1	-1	-1	0.178	-1	0.360	-1	-1	-1	-1	1977
-1	-1	-1	0.436	-1	0.199	-1	0.102	-1	-1	-1	-1	1978
-1	-1	-1	0.545	-1	0.559	-1	0.225	-1	-1	-1	-1	1979
-1	-1	-1	0.151	-1	1.092	-1	0.108	-1	-1	-1	-1	1980
-1	-1	-1	0.395	-1	0.997	-1	0.038	-1	-1	-1	-1	1981

-1	-1	-1	0.285	-1	0.645	-1	0.045	-1	-1	-1	-1	1982
-1	-1	-1	0.542	-1	1.076	-1	0.065	-1	-1	-1	-1	1983
-1	-1	-1	0.944	-1	1.397	-1	0.000	-1	-1	-1	-1	1984
-1	-1	-1	0.627	-1	0.453	-1	0.031	-1	-1	-1	-1	1985
-1	-1	-1	0.602	-1	0.779	-1	0.000	-1	-1	-1	-1	1986
-1	-1	-1	0.631	-1	0.090	-1	-1	0.072	-1	-1	-1	1987
-1	-1	-1	0.708	-1	1.222	-1	-1	0.073	-1	-1	-1	1988
-1	-1	-1	0.901	0.777	0.591	-1	-1	0.058	-1	-1	-1	1989
-1	-1	-1	0.818	1.37	1.560	-1	-1	0.107	-1	-1	-1	1990
-1	-1	-1	0.498	2.1	1.042	-1	-1	0.090	-1	-1	-1	1991
-1	-1	-1	0.971	1.448	0.399	-1	-1	0.054	-1	-1	-1	1992
-1	-1	-1	0.931	1.031	0.984	-1	-1	0.112	-1	-1	-1	1993
-1	-1	196.274	1.026	1.563	0.661	-1	-1	0.156	-1	-1	-1	1994
-1	-1	12.915	1.137	1.749	0.479	-1	-1	0.035	0.881	0.493	-1	1995
0.563	0.602	-1	1.102	0.711	0.558	-1	-1	0.148	0.597	0.316	-1	1996
0.204	0.827	-1	0.879	1.578	0.495	-1	-1	0.232	1.179	1.216	-1	1997
0.165	0.622	169.757	0.808	1.248	1.350	5.113	-1	0.048	-1	-1	0.001	1998
0.374	0.71	102.106	0.94	1.122	0.441	13.233	-1	0.139	1.409	0.607	0.001	1999
0.046	0.304	431.009	0.888	1.644	1.340	12.370	-1	0.070	2.479	1.350	0.002	2000
0.619	0.39	133.159	0.965	2.237	1.341	13.092	-1	0.093	2.728	1.204	0.003	2001
0.504	0.435	67.46	0.881	3.415	1.335	10.316	-1	0.165	1.695	0.581	0.003	2002
0.692	0.292	29.868	0.803	2.936	0.927	14.299	-1	0.126	2.346	1.110	0.004	2003
0.296	0.166	8.594	0.781	1.264	1.323	17.229	-1	0.430	2.811	1.867	0.014	2004
0.067	0.046	163.588	-1	2.731	0.999	16.121	-1	0.215	-1	-1	0.007	2005
2	1	1	1	2	1	1	1	1	2	1	1	Selectivity

Table 6.4. Results for the base model runs and two sensitivity analyses that converged using the updated biological parameters for **bonnethead shark**. Pups-virgin is the number of age 1 pups at virgin conditions. SSF is spawning stock fecundity, which is the sum of number mature at age times pup-production at age (rather than SSB, since biomass does not influence pup production in sharks).

	Base		S-1		S-2	
	Estimate	CV	Estimate	CV	Estimate	CV
SSF_{2005}/SSF_{MSY}	1.13	0.49	0.99	0.39	1.08	0.54
F_{2005}/F_{MSY}	0.61	0.82	0.64	0.68	0.61	0.54
N_{2005}/N_{MSY}	0.83	-	0.75	-	0.78	-
MSY	568,871	-	499,839	-	567,756	-
SPR_{MSY}	0.42	0.17	0.49	0.02	0.57	0.30
F_{MSY}	0.31	-	0.40	-	0.31	-
SSF_{MSY}	1.99E+06	-	1.99E+05	-	1.90E+06	-
N_{MSY}	1.92E+06	-	1.50E+06	-	1.93E+06	-
F_{2005}	0.19	0.82	0.25	0.68	0.19	1.84
SSF_{2005}	2.26E+06	0.72	1.97E+06	0.53	2.06E+06	0.67
N_{2005}	1.59E+06	-	1.13E+06	-	1.51E+06	-
SSF_{2005}/SSF_0	0.41	0.47	0.33	0.38	0.41	0.51
B_{2005}/B_0	0.41	0.47	0.34	0.34	0.39	0.50
R0	1.22E+06	0.29	9.8E+05	0.20	1.15E+06	0.32
Pup-survival	0.70	0.24	0.70	0.24	0.70	0.24
alpha	3.14	-	4.20	-	3.13	-
steepness	0.44	-	0.51	-	0.44	-

Table 6.5. Estimates of total number, spawning stock fecundity, and fishing mortality by year for base model for **bonnethead shark**.

Year	N	SSF	F
1950	3.99E+06	2.10E+06	0.085
1951	3.89E+06	2.09E+06	0.090
1952	3.82E+06	2.06E+06	0.096
1953	3.76E+06	2.01E+06	0.101
1954	3.71E+06	1.96E+06	0.106
1955	3.66E+06	1.92E+06	0.112
1956	3.61E+06	1.88E+06	0.117
1957	3.56E+06	1.84E+06	0.122
1958	3.51E+06	1.81E+06	0.127
1959	3.47E+06	1.78E+06	0.133
1960	3.42E+06	1.75E+06	0.138
1961	3.38E+06	1.72E+06	0.143
1962	3.34E+06	1.69E+06	0.149
1963	3.30E+06	1.66E+06	0.154
1964	3.26E+06	1.63E+06	0.159
1965	3.22E+06	1.60E+06	0.165
1966	3.19E+06	1.58E+06	0.170
1967	3.15E+06	1.55E+06	0.175
1968	3.11E+06	1.53E+06	0.181
1969	3.08E+06	1.50E+06	0.186
1970	3.04E+06	1.48E+06	0.191
1971	3.01E+06	1.46E+06	0.196
1972	2.97E+06	1.43E+06	0.202
1973	2.94E+06	1.41E+06	0.189
1974	2.92E+06	1.39E+06	0.259
1975	2.84E+06	1.37E+06	0.411
1976	2.68E+06	1.33E+06	0.189
1977	2.73E+06	1.28E+06	0.364
1978	2.61E+06	1.23E+06	0.100
1979	2.72E+06	1.21E+06	0.346
1980	2.58E+06	1.19E+06	0.276
1981	2.55E+06	1.18E+06	0.147
1982	2.62E+06	1.17E+06	0.213
1983	2.60E+06	1.15E+06	0.110
1984	2.67E+06	1.17E+06	0.112
1985	2.72E+06	1.19E+06	0.115
1986	2.76E+06	1.22E+06	0.410
1987	2.57E+06	1.24E+06	0.245
1988	2.58E+06	1.22E+06	0.220
1989	2.59E+06	1.18E+06	0.166
1990	2.63E+06	1.15E+06	0.341
1991	2.51E+06	1.15E+06	0.139
1992	2.59E+06	1.15E+06	0.199
1993	2.59E+06	1.14E+06	0.195
1994	2.59E+06	1.15E+06	0.182
1995	2.60E+06	1.16E+06	0.334

1996	2.50E+06	1.16E+06	0.557
1997	2.31E+06	1.12E+06	0.505
1998	2.22E+06	1.06E+06	0.210
1999	2.31E+06	9.91E+05	0.334
2000	2.25E+06	9.50E+05	0.225
2001	2.27E+06	9.54E+05	0.374
2002	2.19E+06	9.59E+05	0.468
2003	2.09E+06	9.45E+05	0.313
2004	2.11E+06	9.14E+05	0.635
2005	1.94E+06	8.68E+05	0.188

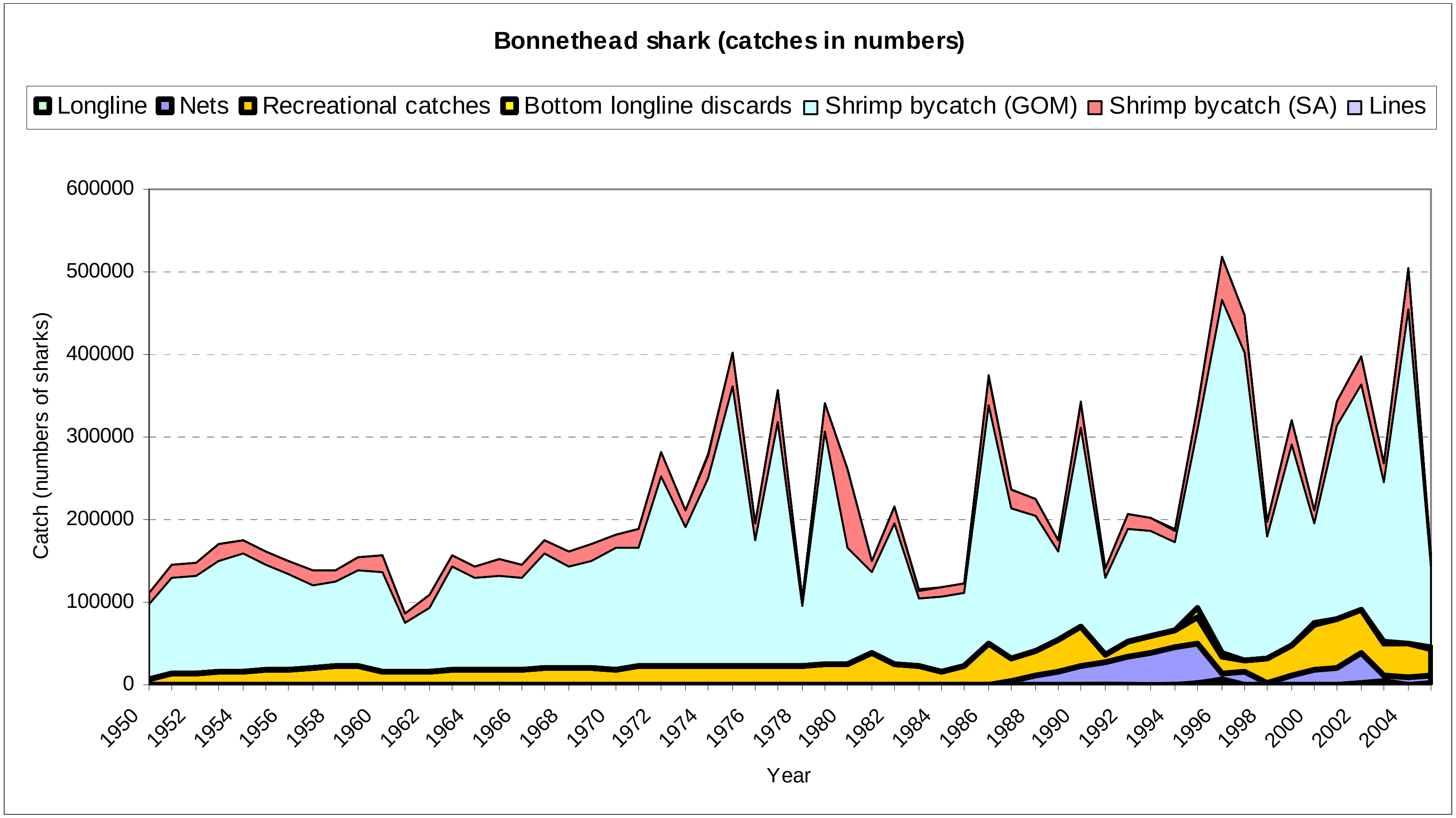


Figure 6.1. Catches of **bonnethead shark** by fleet.

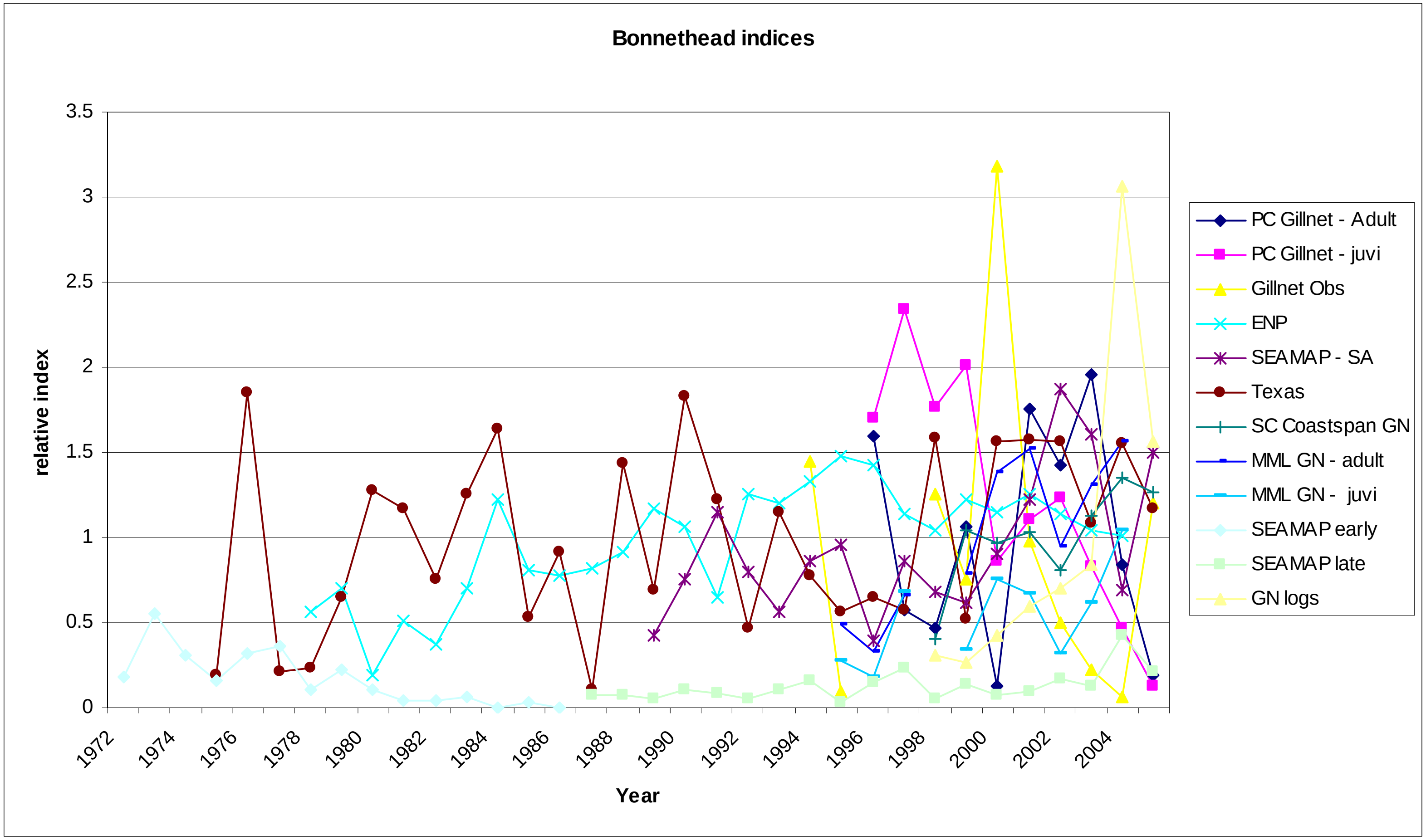


Figure 6.2 Indices available for the current **bonnethead shark** assessment.

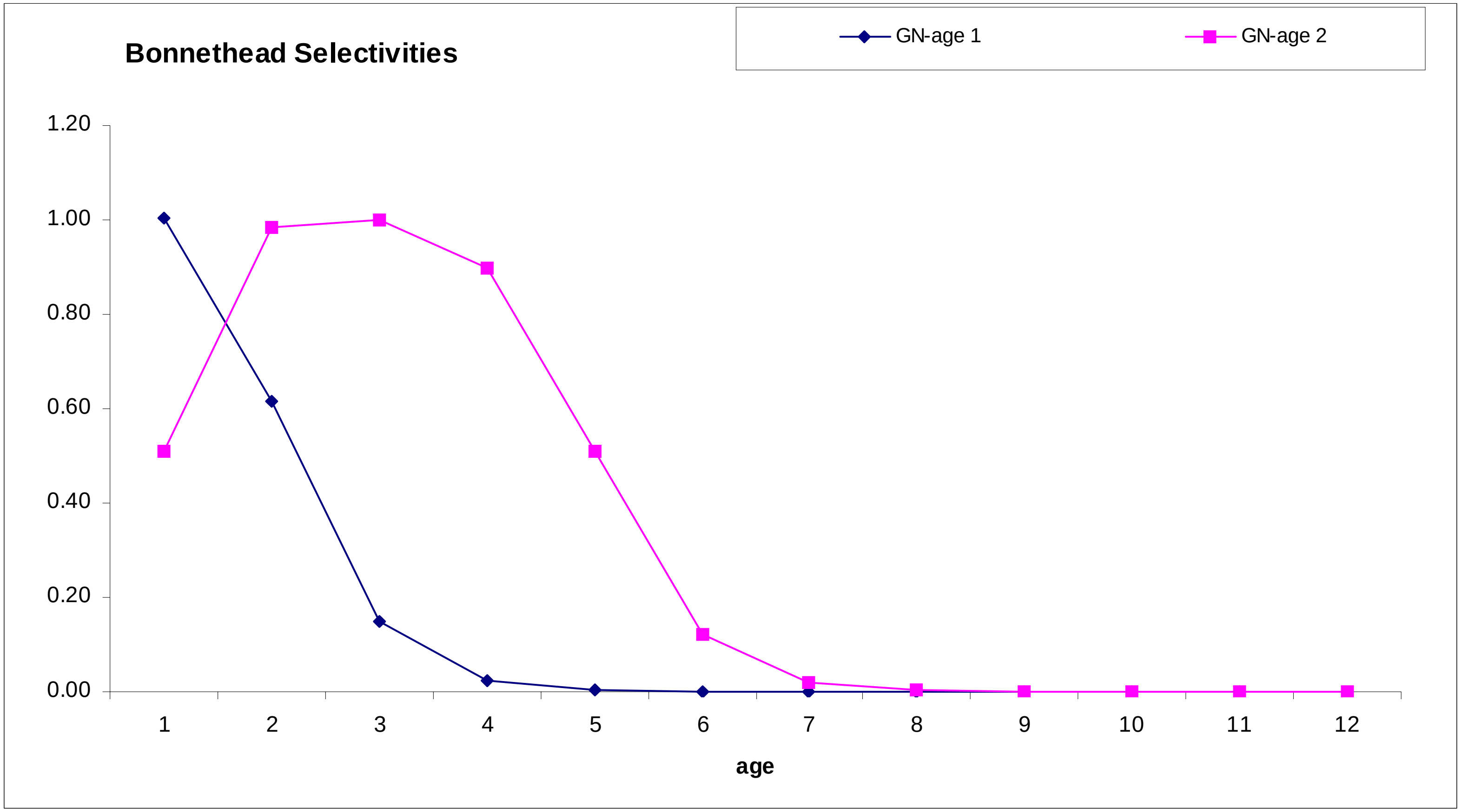


Figure 6.3 Selectivities used in **bonnethead shark** assessment.

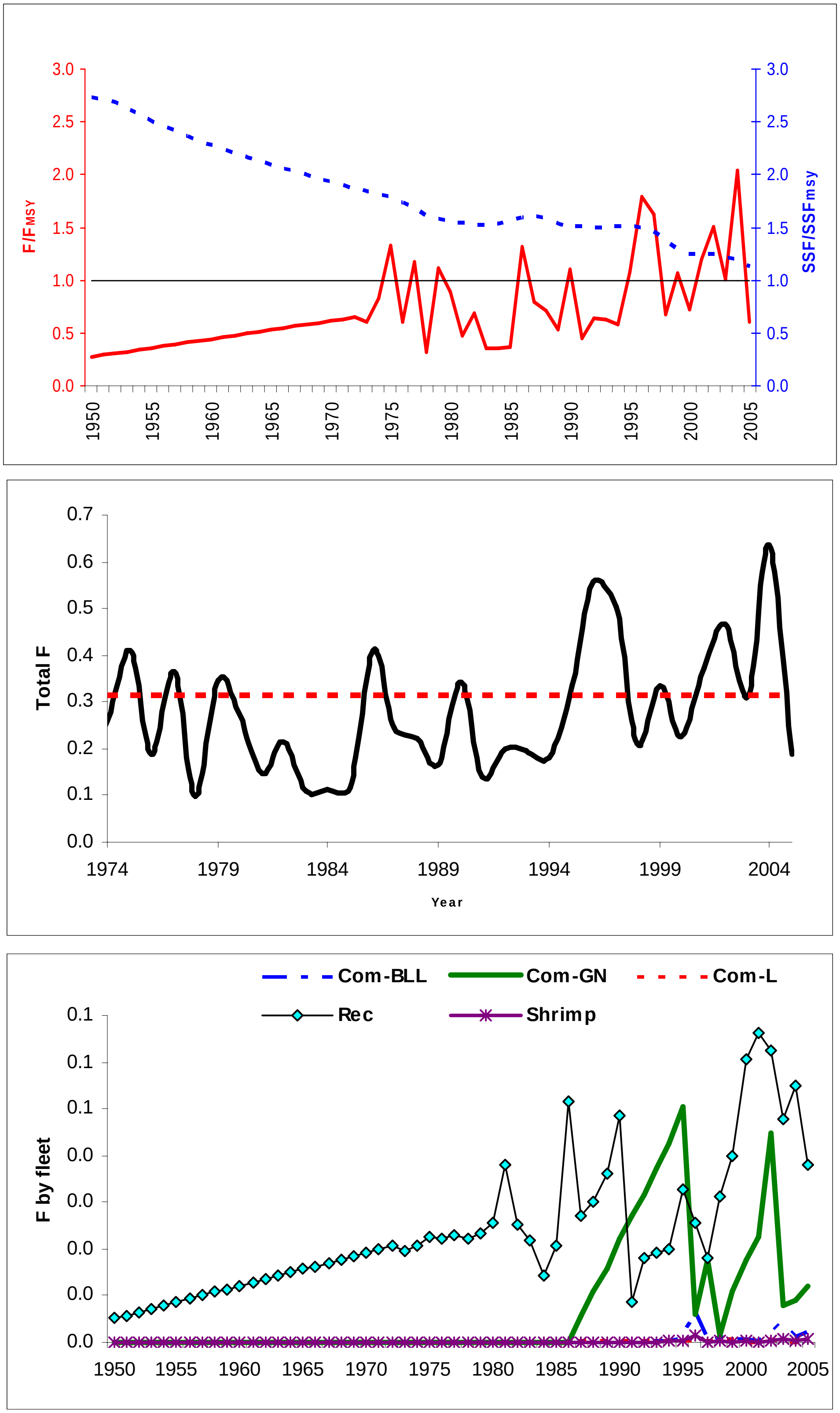


Figure 6.4. **Bonnethead shark** estimated stock status (top), total fishing mortality (middle), and fleet-specific F (bottom). The dashed line in the middle panel indicates F_{MSY} (0.311).

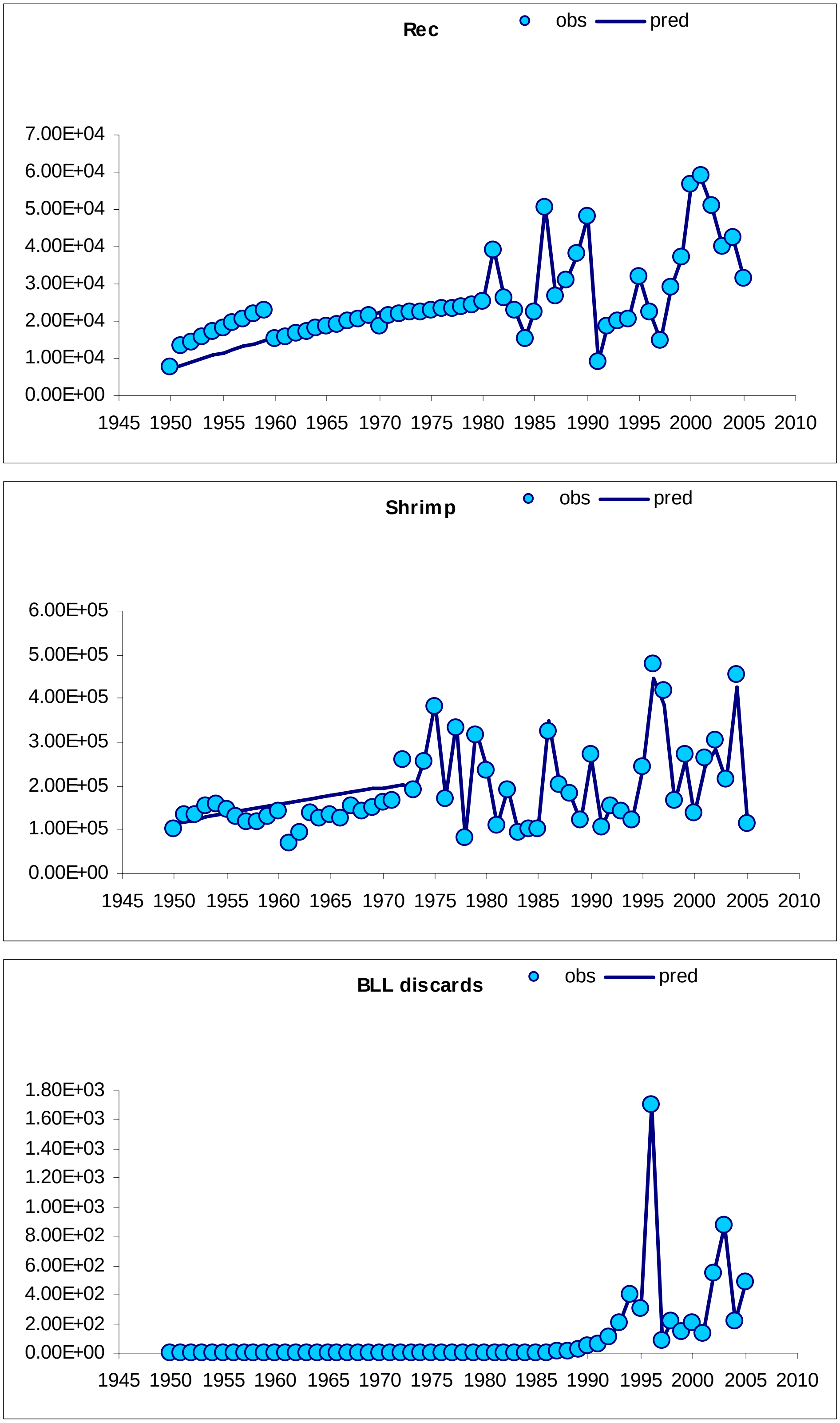


Figure 6.5. **Bonnethead shark** model predicted fit to catch data. Circles represent observed data, solid line is predicted.

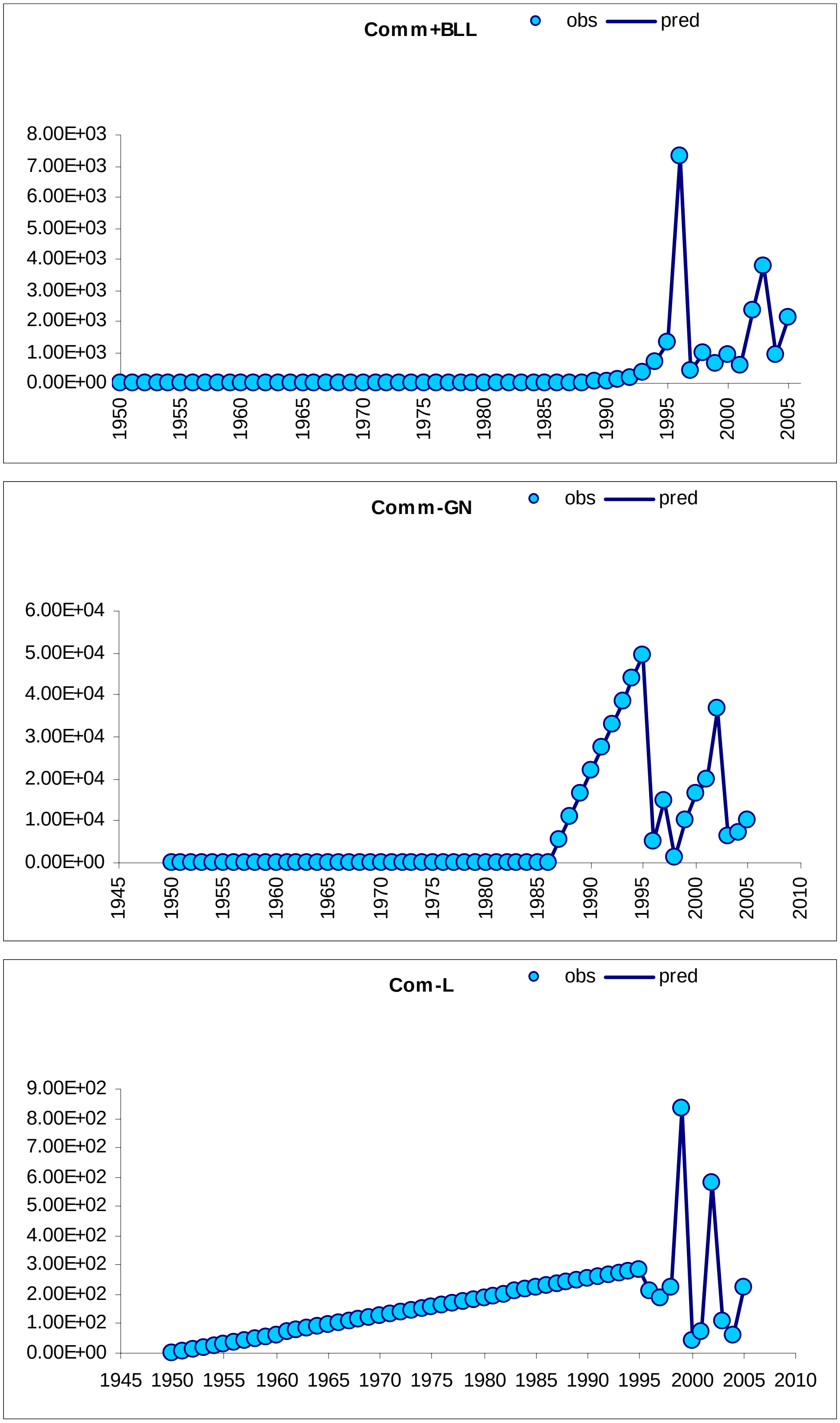


Figure 6.5 (Continued).

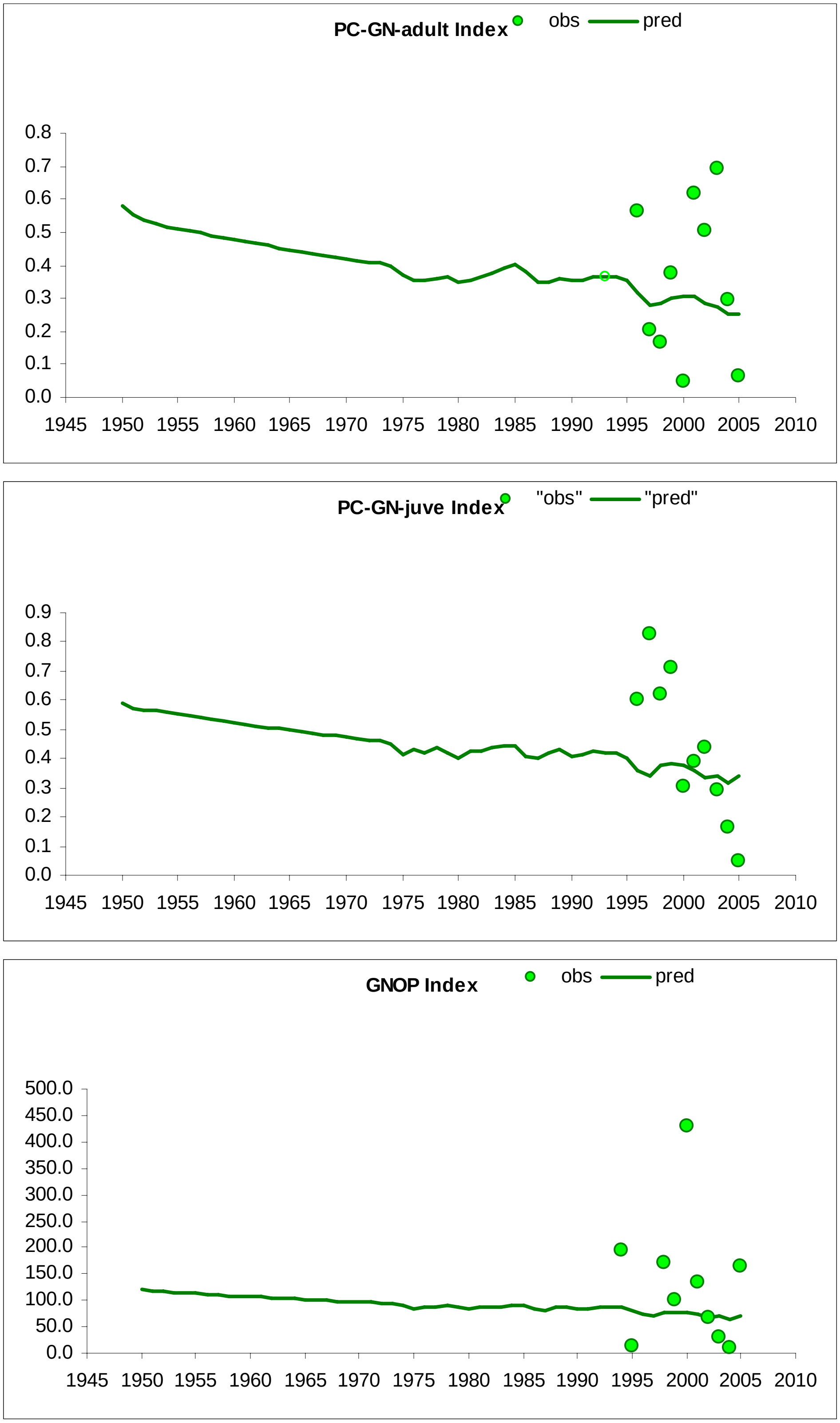
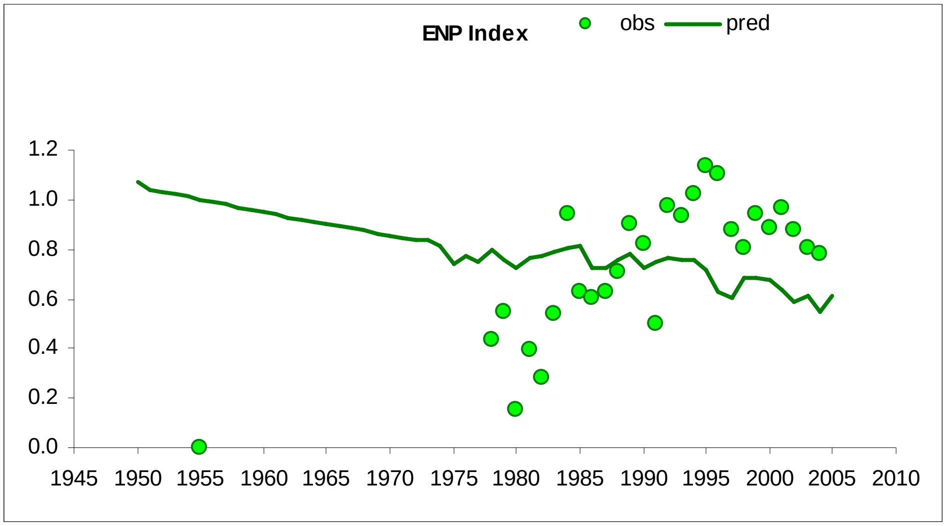


Figure 6.6. **Bonnethead shark** model predicted fit to indices. Circles represent observed data, solid line is predicted.



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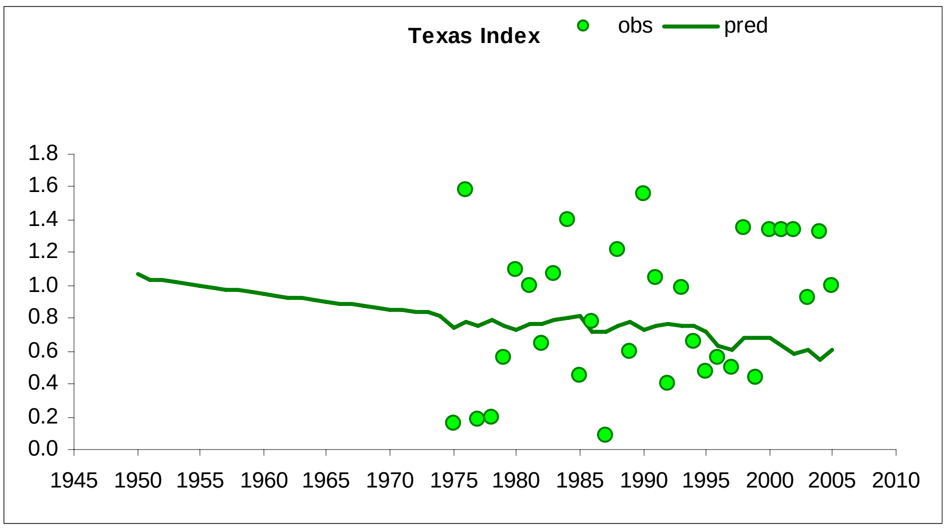


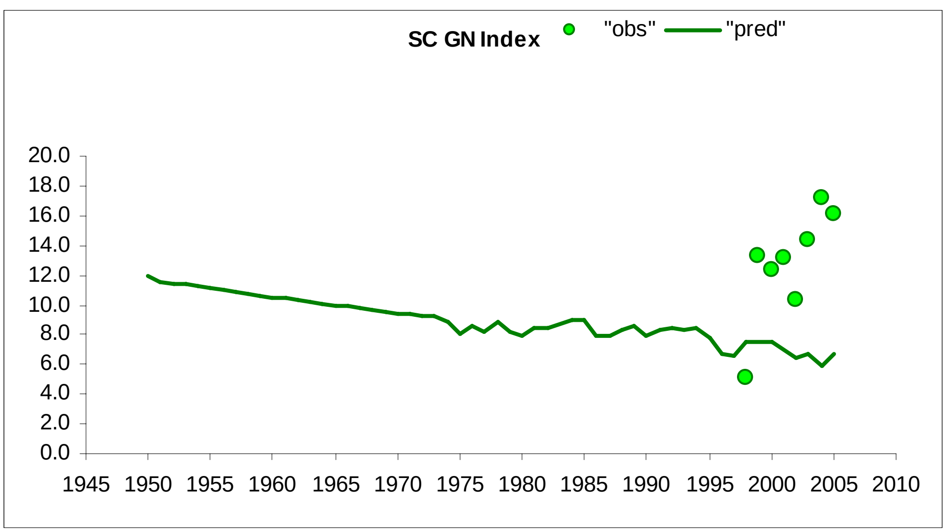


Figure 6.6. (Continued).

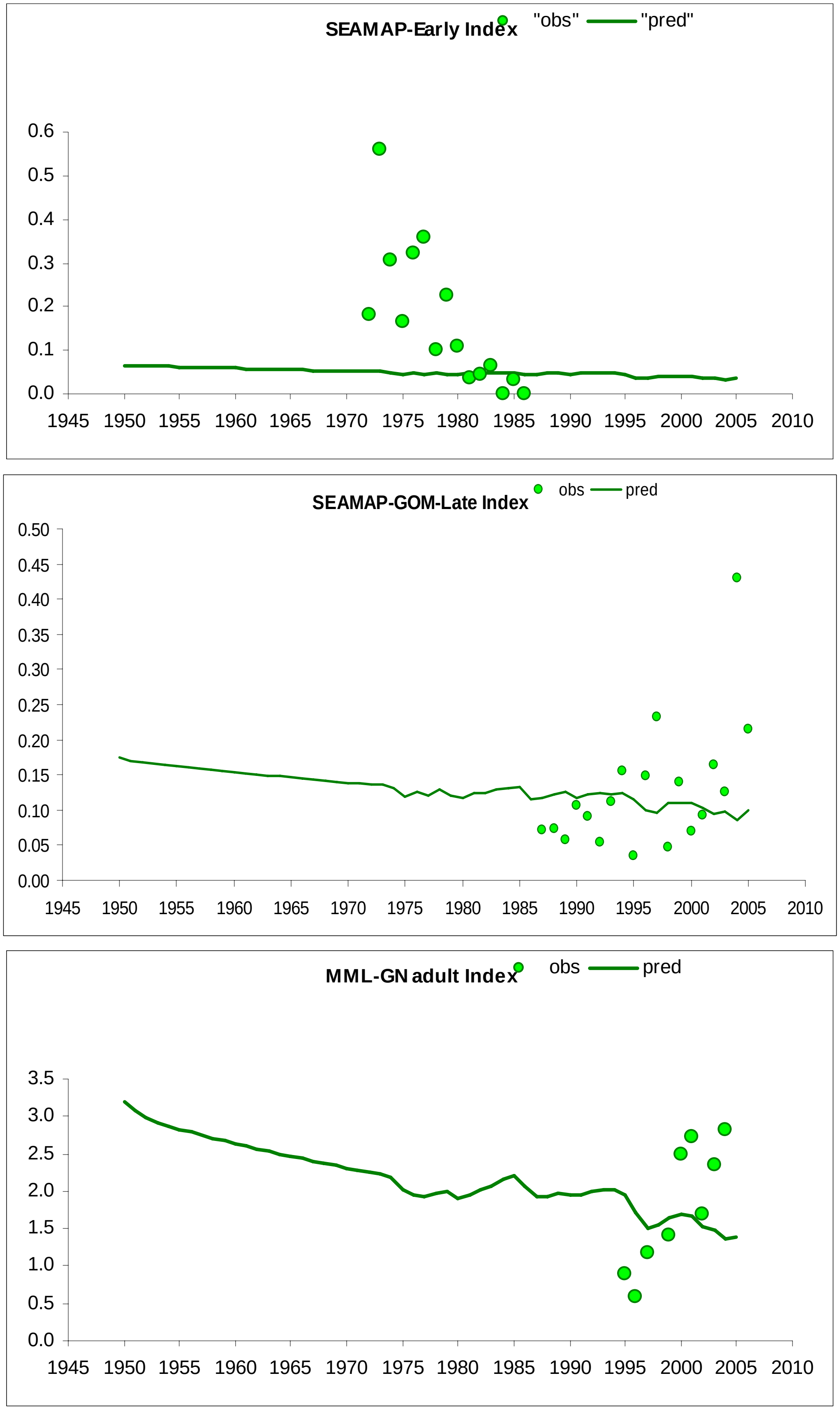
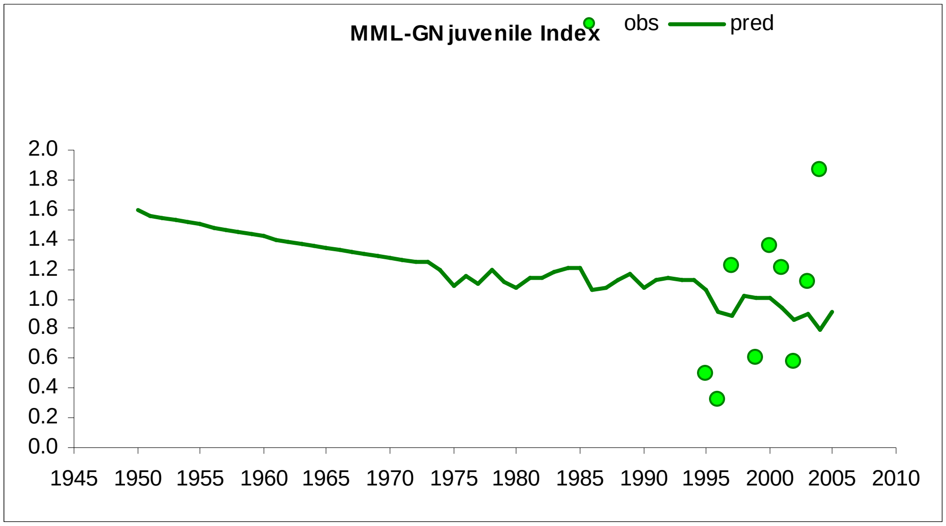


Figure 6.6. (Continued).



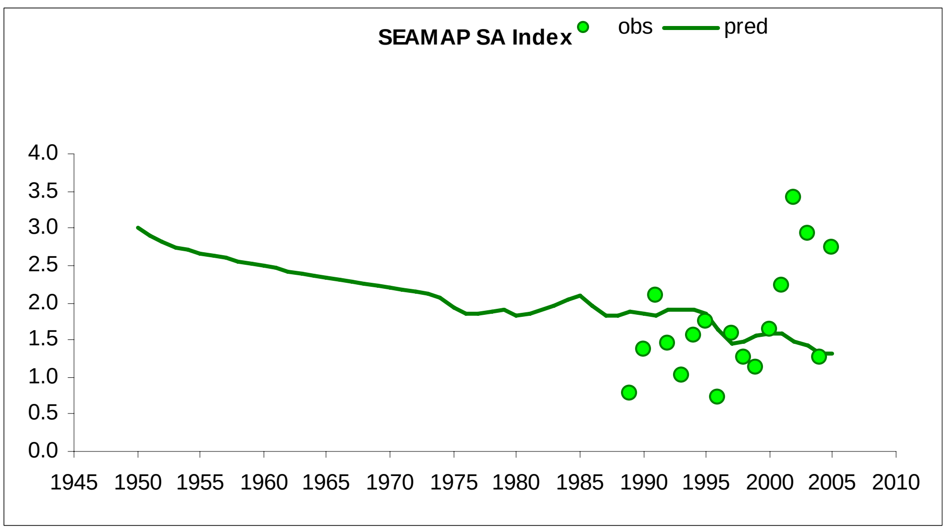


Figure 6.6. (Continued).

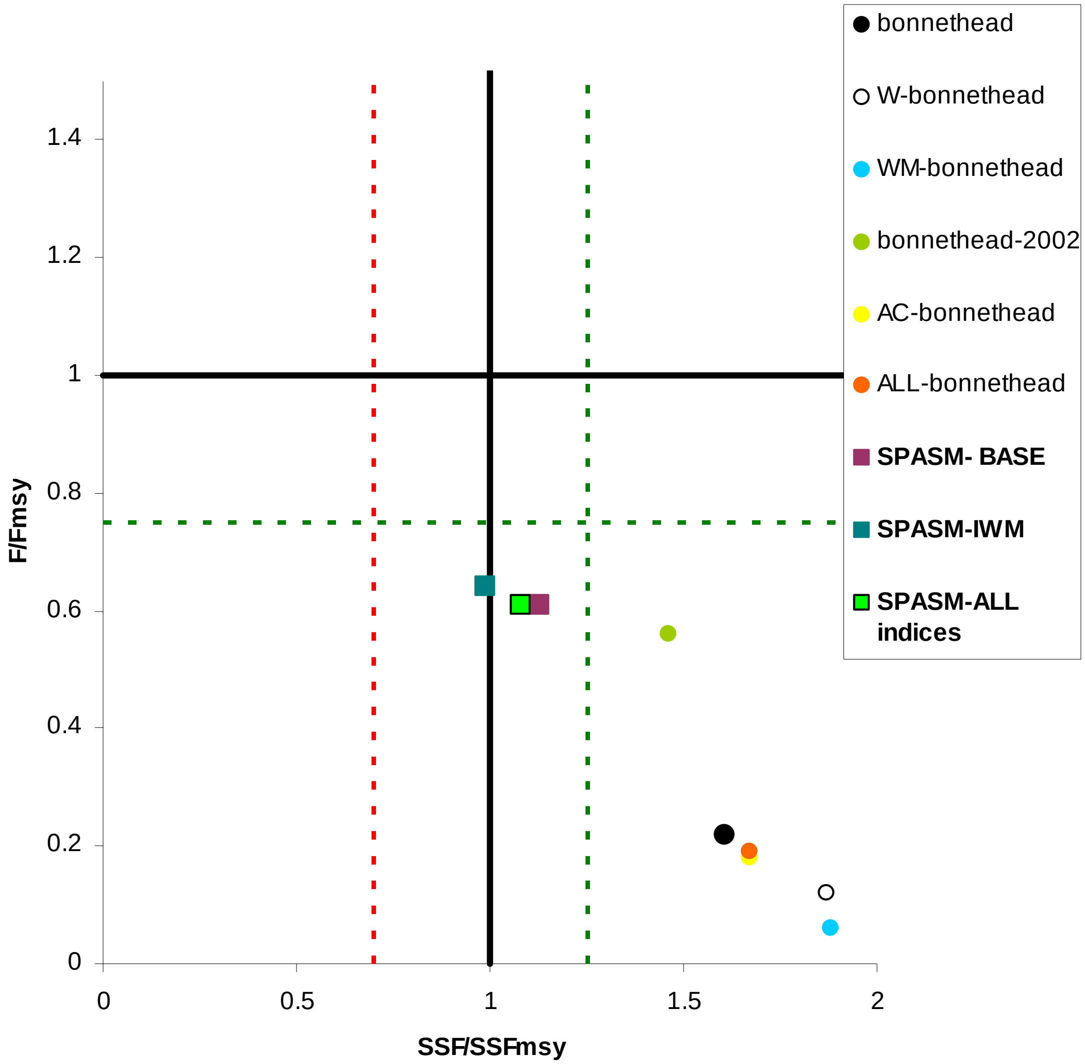


Figure 6.7. Phase-plot of **bonnethead shark** stock status. Baseline and selected sensitivity analyses from the surplus production models (SPM) and the stock status from the 2002 assessment are included for reference. The age-structured models are in bold and include BASE, S1 (IWM), and S2 (all indices). The SPM sensitivities are as follows: W— WinBUGS**,** complementary surplus production model. WM—SPM sensitivity to weighting scheme used: this involved changing the method for weighting the CPUE series from equal weighting in the baseline scenario to inverse variance weighting. IF—SPM sensitivity to importance function used: this involved changing the importance function from the priors to a multivariate t distribution. AC—SPM sensitivity to extending the catch series back to 1950. ALL—SPM sensitivity adding the CPUE series identified as “sensitivity” to those in the baseline scenario. Several control rules are illustrated: the dashed horizontal line indicates the MFMT (Maximum Fishing Mortality Threshold) and the dashed vertical line denotes the target biomass (biomass or number at MSY). SSF is spawning stock fecundity, which is the sum of number mature at age times pup-production at age (rather than SSB, since biomass does not influence pup production in sharks).

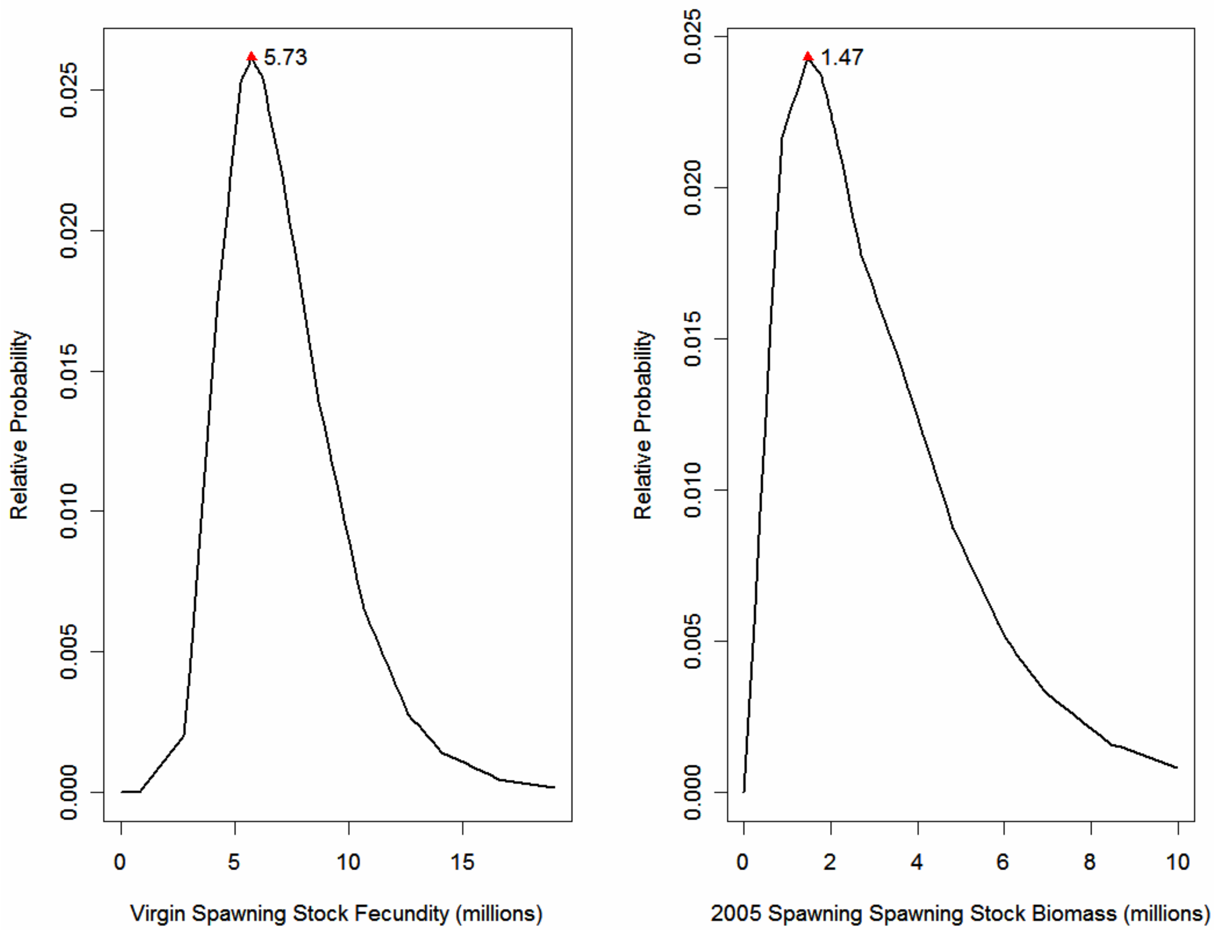


Figure 6.8. **Bonnethead shark** profile likelihoods for virgin number, current abundance, and spawning stock fecundity, as well as depletion estimates of these parameters. The red triangles are the modes of the distributions.

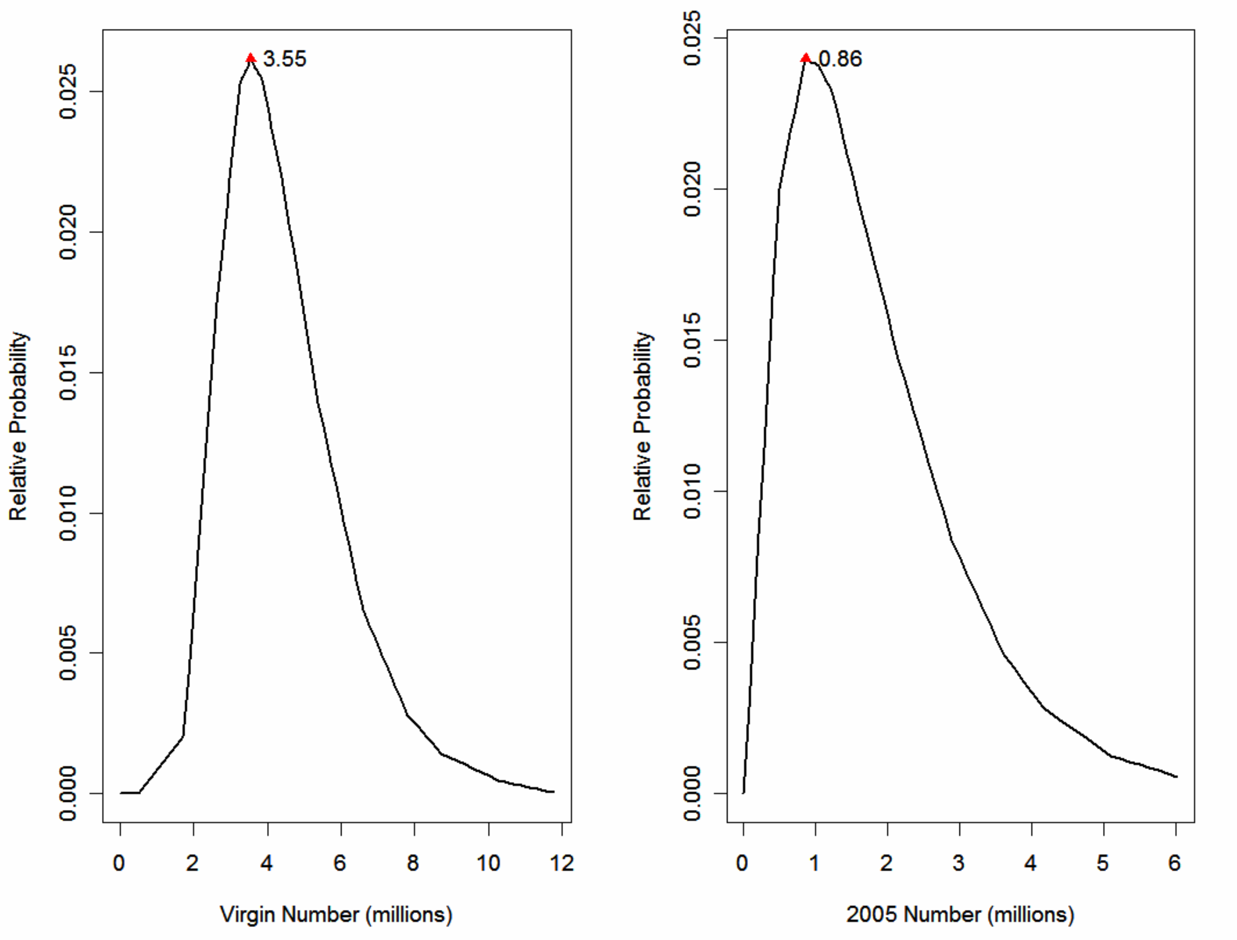


Figure 6.8 (Continued).

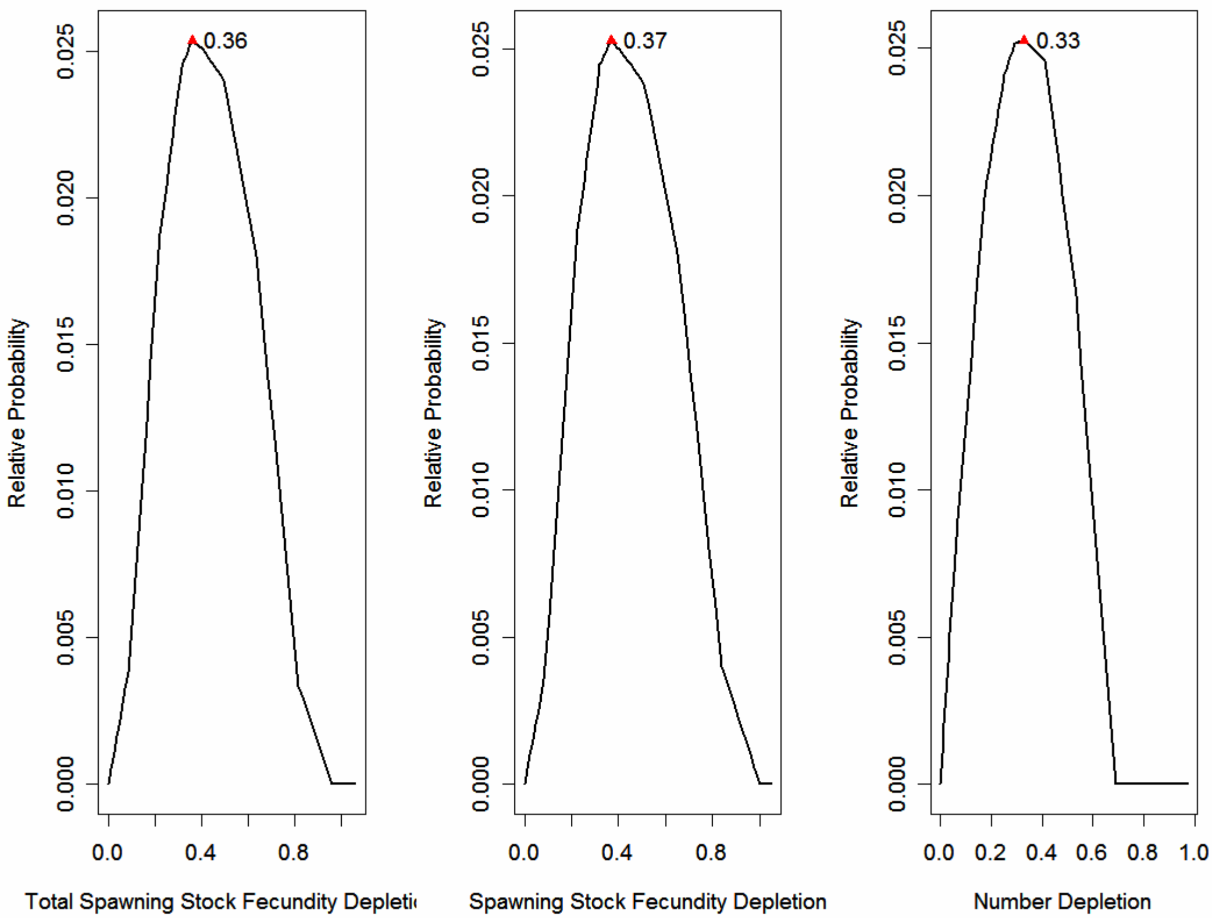


Figure 6.8 (Continued).

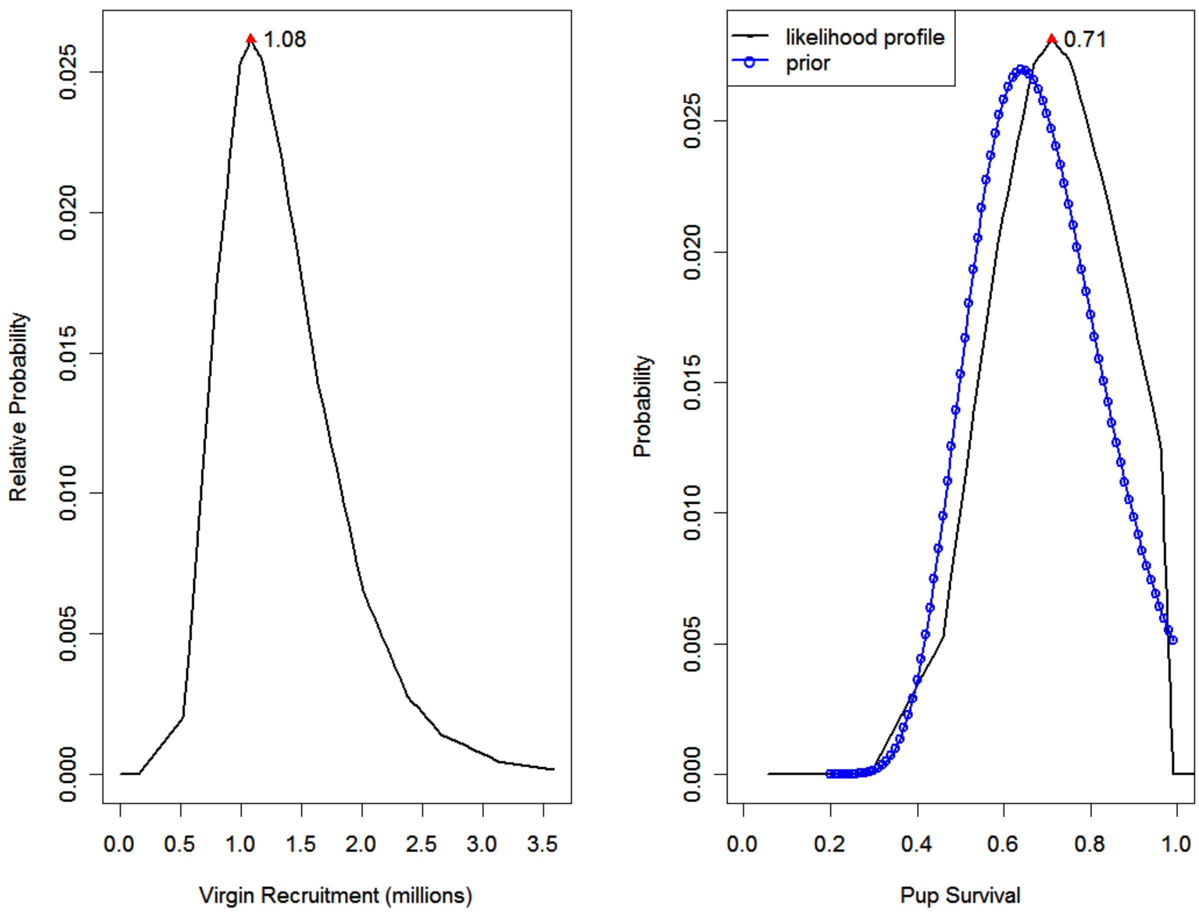


Figure 6.9. **Bonnethead shark** profile likelihoods for pup survival and virgin recruitment, and for pup survival, the prior is also plotted. The red triangles are the modes of the distributions.

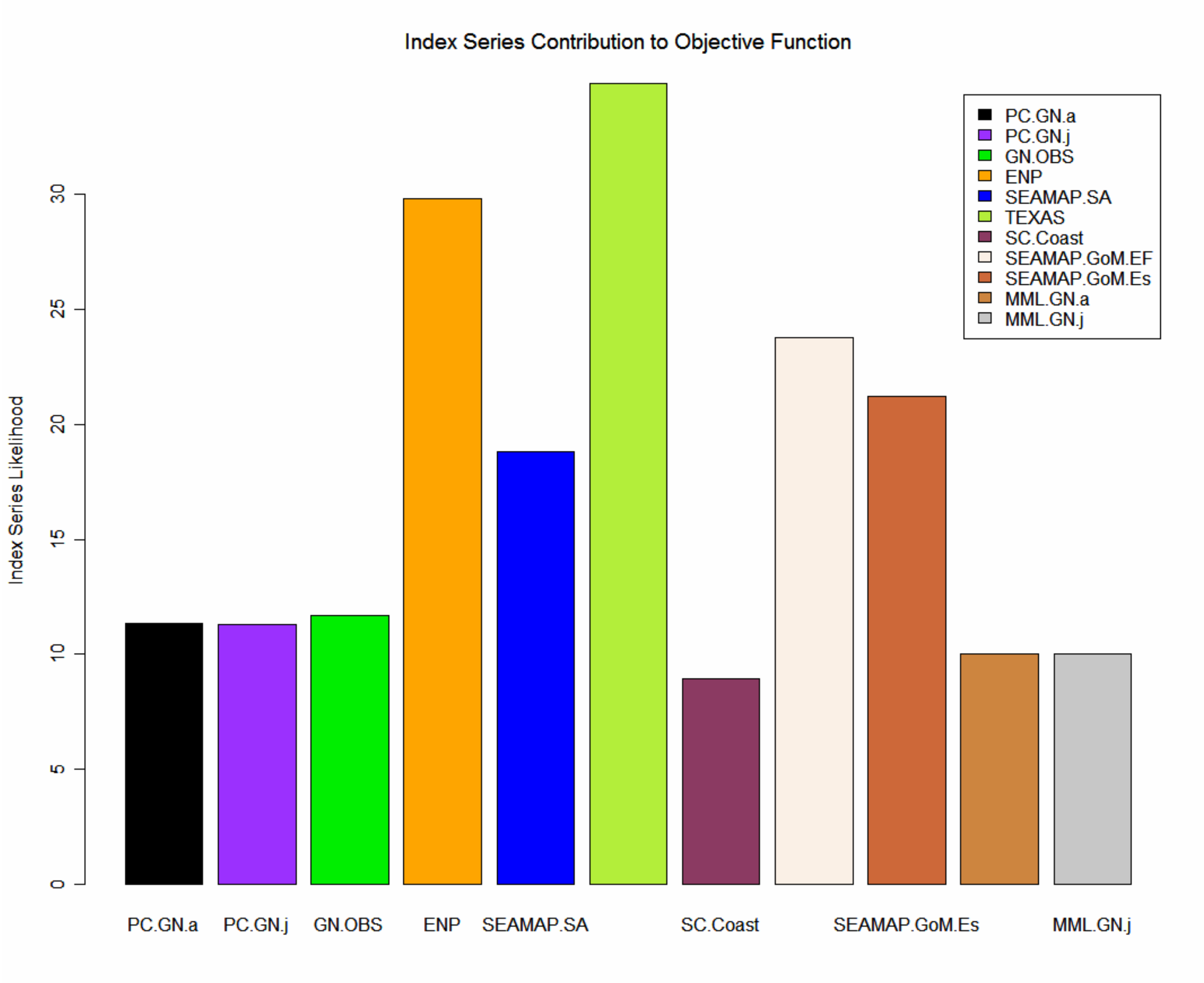


Figure 6.10. The contribution of the indices to the relative likelihood by category for **bonnethead sharks**.

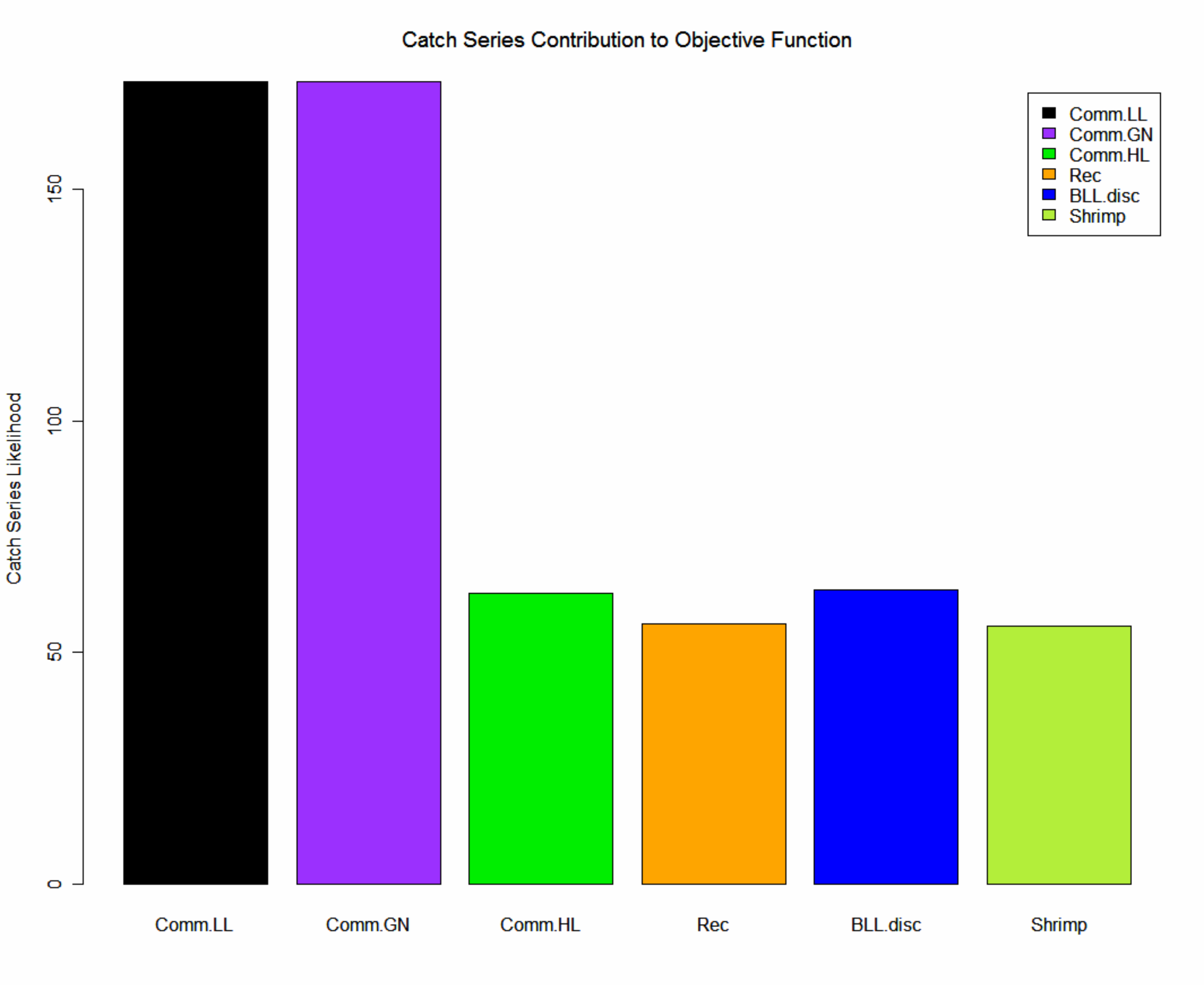


Figure 6.11. Catch series and model source contributions to relative likelihood by category for **bonnethead sharks**.

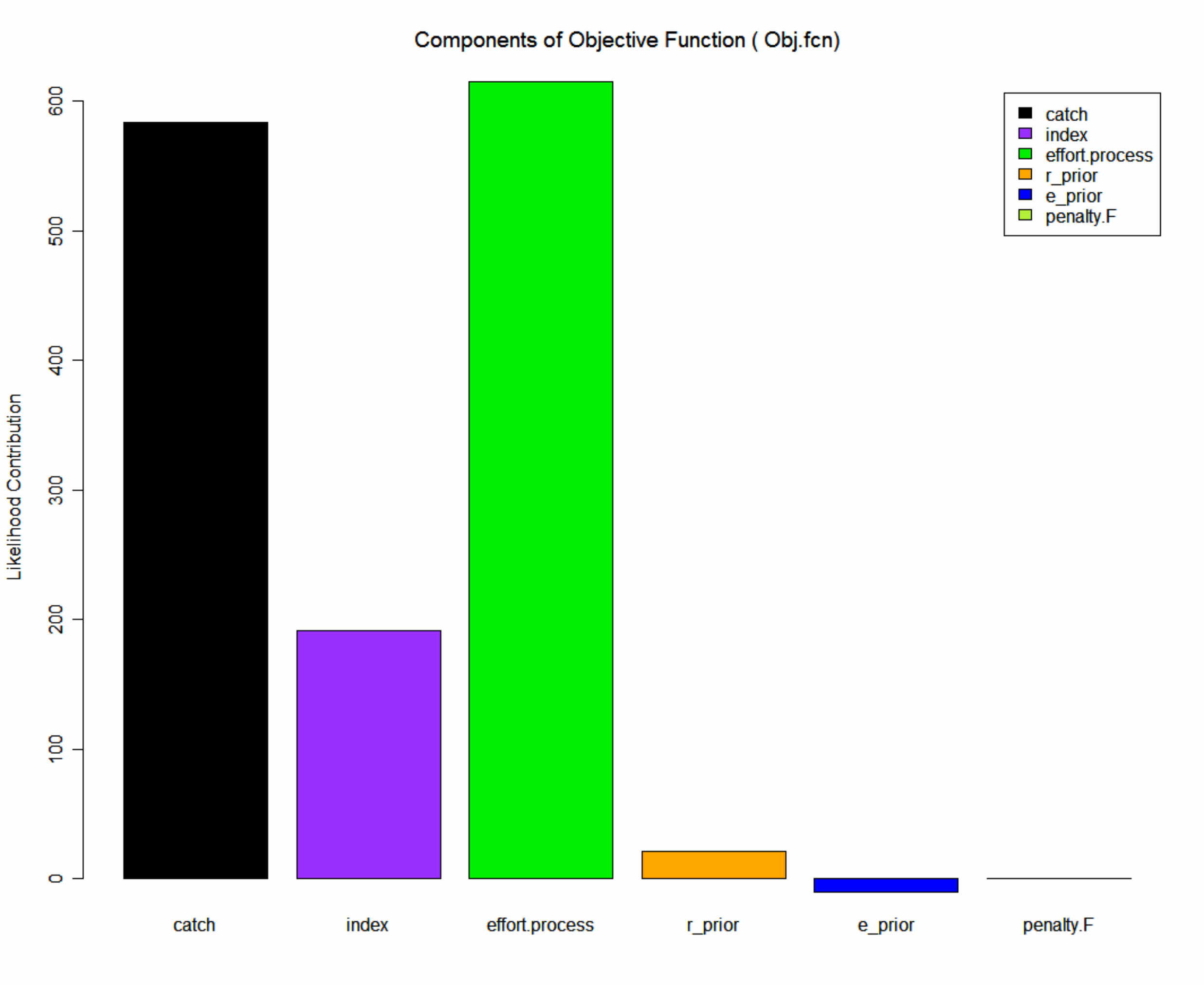


Figure 6.11. (Continued).

Appendix I. Catch rates series used for the small coastal shark complex, Atlantic sharpnose, blacknose, bonnethead, and finetooth sharks. Absolute index is the absolute estimated mean CPUE, relative index is the estimated mean CPUE divided by the overall mean and the CV is the estimated precision of the mean value. Type refers to whether the index is fishery – independent (FI) or fishery-dependent (FD), recreational (R) or commercial (C). Recommendation refers to the recommendation by the Indices Working Group to include the particular index as a base index (Base) or use it for sensitivity runs (Sensitivity).

Small Coastal Shark Complex

					Index		
Document Number	Series Name	Type	Recommendation	Year	Absolute	Relative	CV
SEDAR 13-DW-05	PC LL	FI	Base	1993	0.517	0.843	0.507
				1994	0.235	0.383	0.544
				1995	0.343	0.559	0.483
				1996	1.073	1.750	0.092
				1997	0.594	0.969	0.185
				1998	0.439	0.716	0.378
				1999	1.170	1.908	0.116
				2000	0.534	0.871	0.296
SEDAR 13-DW-06	PC Gillnet	FI	Base	1996	5.091	1.817	0.238
				1997	14.715	5.251	0.144
				1998	1.121	0.400	1.436
				1999	1.174	0.419	1.253
				2000	0.697	0.249	1.294
				2001	1.327	0.474	0.732
				2002	1.167	0.416	1.013
				2003	1.454	0.519	0.531
				2004	0.668	0.238	0.896
				2005	0.611	0.218	0.645
SEDAR 13-DW-09	Gillnet Obs	FD-C	Base	1993	3.014	0.149	0.879
				1994	9.942	0.490	0.172
				1995	10.934	0.539	0.218
				1996			
				1997			
				1998	20.516	1.011	0.130
				1999	12.287	0.606	0.109
				2000	9.998	0.493	0.140
				2001	5.548	0.273	0.220
				2002	72.233	3.560	0.016
				2003	11.597	0.572	0.133
				2004	8.254	0.407	0.180
				2005	58.842	2.900	0.029
SEDAR 13-DW-12	BLLOP	FD-C	Base	1994	0.000	0.068	11.142
				1995	0.004	0.714	1.797
				1996	0.003	0.425	2.412
				1997	0.004	0.595	2.171

				1998	0.006	1.088	1.292
				1999	0.021	3.535	0.890
				2000	0.014	2.346	1.241
				2001	0.009	1.547	1.420
				2002	0.002	0.255	2.922
				2003	0.002	0.357	2.344
				2004	0.003	0.493	2.083
				2005	0.003	0.578	1.346
SEDAR 13-DW-14	SEAMAP - SA	FI	Base	1989	4.138	0.878	0.283
				1990	3.543	0.752	0.285
				1991	4.059	0.861	0.269
				1992	3.530	0.749	0.254
				1993	2.569	0.545	0.293
				1994	2.747	0.583	0.301
				1995	4.433	0.940	0.221
				1996	2.169	0.460	0.306
				1997	4.790	1.016	0.237
				1998	3.817	0.810	0.243
				1999	3.664	0.777	0.252
				2000	4.532	0.961	0.243
				2001	4.998	1.060	0.193
				2002	7.635	1.620	0.165
				2003	7.170	1.521	0.191
				2004	4.576	0.971	0.216
				2005	6.195	1.314	0.218
				2006	10.279	2.181	0.174
SEDAR 13-DW-18	Texas	FI	Base	1975	0.044	0.726	0.710
				1976	0.073	1.206	0.300
				1977	0.021	0.347	0.555
				1978	0.021	0.349	0.555
				1979	0.041	0.669	0.342
				1980	0.062	1.019	0.248
				1981	0.024	0.399	0.371
				1982	0.042	0.699	0.214
				1983	0.077	1.263	0.167
				1984	0.085	1.404	0.149
				1985	0.056	0.915	0.203
				1986	0.084	1.387	0.148
				1987	0.014	0.234	0.444
				1988	0.077	1.272	0.155
				1989	0.053	0.879	0.187
				1990	0.072	1.182	0.162
				1991	0.076	1.244	0.175
				1992	0.050	0.822	0.235
				1993	0.063	1.036	0.198
				1994	0.052	0.859	0.200
				1995	0.046	0.751	0.213

				1996	0.076	1.256	0.150
				1997	0.051	0.844	0.256
				1998	0.058	0.961	0.203
				1999	0.065	1.077	0.165
				2000	0.078	1.282	0.152
				2001	0.082	1.349	0.171
				2002	0.074	1.218	0.181
				2003	0.093	1.536	0.152
				2004	0.084	1.387	0.165
				2005	0.080	1.325	0.161
				2006	0.067	1.103	0.227
SEDAR 13-DW-21	MS Gillnet	FI	Sensitivity	2001	3.399	1.959	0.294
				2002			
				2003	1.401	0.807	0.509
				2004	1.176	0.678	0.298
				2005	1.465	0.844	0.277
				2006	1.235	0.712	0.232
SEDAR 13-DW-22	NMFS LL SE Atlantic	FI	Base	1995	1.977	0.210	0.310
				1996	1.839	0.195	0.335
				1997	2.481	0.263	0.321
				1998			
				1999	1.039	0.110	0.624
				2000	4.819	0.511	0.161
				2001			
				2002	14.822	1.571	0.128
				2003			
				2004	14.495	1.536	0.224
				2005	21.566	2.286	0.310
				2006	21.866	2.318	0.185
SEDAR 13-DW-22	NMFS LL SE GoM	FI	Base	1995	2.141	0.592	0.268
				1996	3.424	0.947	0.272
				1997	1.915	0.530	0.225
				1998		0.000	
				1999	1.799	0.498	0.174
				2000	3.765	1.042	0.162
				2001	2.996	0.829	0.188
				2002	3.723	1.030	0.175
				2003	5.410	1.497	0.146
				2004	5.542	1.533	0.157
				2005	4.330	1.198	0.301
				2006	4.715	1.305	0.183
SEDAR 13-DW-22	NMFS LL SE combined areas	FI	Base	1995	2.394	0.507	0.197
				1996	3.506	0.742	0.216
				1997	2.996	0.634	0.166
				1998			
				1999	1.962	0.415	0.171

				2000	4.133	0.875	0.114
				2001	3.707	0.785	0.176
				2002	5.251	1.111	0.132
				2003	6.868	1.454	0.133
				2004	7.157	1.515	0.132
				2005	7.582	1.605	0.236
				2006	6.414	1.358	0.154
SEDAR 13-DW-26	Gillnet Logs	FD-C	Sensitivity	1998	0.058	0.780	0.870
				1999	0.074	0.995	0.818
				2000	0.063	0.847	0.769
				2001	0.068	0.922	0.752
				2002	0.100	1.356	0.731
				2003	0.053	0.710	0.807
				2004	0.054	0.727	0.917
				2005	0.123	1.664	0.653
SEDAR 13-DW-30	SC Coastspan GN	FI	Base	1998	19.412	0.671	0.365
				1999			
				2000	24.300	0.840	0.293
				2001	30.937	1.070	0.157
				2002	26.974	0.933	0.170
				2003	43.688	1.511	0.127
				2004	29.077	1.006	0.513
				2005	28.029	0.969	0.190
SEDAR 13-DW-30	SCDNR red drum	FI	Base	1998	0.156	0.968	0.726
				1999	0.093	0.576	1.115
				2000	0.149	0.921	1.049
				2001	0.240	1.488	0.797
				2002	0.249	1.538	0.866
				2003	0.197	1.219	0.827
				2004	0.071	0.437	2.644
				2005	0.138	0.852	3.029
SEDAR 13-DW-31	SEAMAP-GoM Extended Summer	FI	Base	1982	0.720	0.925	2.001
				1983	3.042	3.906	1.517
				1984	0.864	1.110	1.952
				1985	1.555	1.997	1.860
				1986	0.720	0.925	1.927
				1987	0.689	0.884	0.439
				1988	0.596	0.765	0.401
				1989	0.651	0.836	0.464
				1990	0.199	0.256	0.540
				1991	0.811	1.041	0.383
				1992	0.576	0.740	0.423
				1993	0.821	1.054	0.400
				1994	0.228	0.292	0.488
				1995	1.072	1.376	0.394
				1996	1.103	1.416	0.382

				1997	0.626	0.803	0.431
				1998	0.473	0.607	0.411
				1999	0.570	0.732	0.423
				2000	0.805	1.033	0.423
				2001	0.427	0.548	0.588
				2002	0.789	1.013	0.405
				2003	0.510	0.654	0.468
				2004	0.428	0.550	0.435
				2005	0.389	0.499	0.467
				2006	0.808	1.037	0.402
SEDAR 13-DW-31	SEAMAP-GoM Extended Fall	FI	Base	1972	0.814	0.956	0.525
				1973	1.229	1.443	0.428
				1974	2.116	2.485	0.417
				1975	1.871	2.197	0.421
				1976	2.046	2.402	0.415
				1977	1.164	1.367	0.430
				1978	0.928	1.089	0.438
				1979	1.192	1.399	0.431
				1980	1.709	2.007	0.429
				1981	1.094	1.285	0.438
				1982	1.215	1.426	0.426
				1983	1.044	1.225	0.463
				1984	0.782	0.918	0.457
				1985	1.268	1.488	0.509
				1986	0.651	0.764	0.846
				1987	0.854	1.002	0.299
				1988	0.518	0.608	0.285
				1989	0.364	0.427	0.316
				1990	0.585	0.687	0.297
				1991	0.355	0.417	0.285
				1992	0.323	0.380	0.304
				1993	0.513	0.603	0.282
				1994	0.629	0.739	0.283
				1995	0.448	0.526	0.293
				1996	0.692	0.812	0.272
				1997	0.556	0.652	0.279
				1998	0.369	0.434	0.315
				1999	0.535	0.628	0.275
				2000	0.590	0.693	0.291
				2001	0.455	0.534	0.284
				2002	0.499	0.585	0.288
				2003	0.610	0.716	0.265
				2004	0.488	0.573	0.290
				2005	0.847	0.994	0.274
				2006	0.457	0.536	0.293
SEDAR 13-DW-34	UNC	FI	Base	1972	3.163	0.856	1.549
				1973	4.983	1.348	0.530
				1974	1.497	0.405	1.608

				1975	2.893	0.782	0.687
				1976	2.183	0.590	0.879
				1977	5.669	1.533	0.359
				1978	4.574	1.237	0.386
				1979	3.865	1.046	0.430
				1980	2.579	0.697	0.484
				1981	1.143	0.309	1.039
				1982	1.538	0.416	0.645
				1983	2.145	0.580	0.462
				1984	2.383	0.644	0.469
				1985	2.116	0.572	0.571
				1986	1.426	0.386	0.958
				1987	2.638	0.713	0.566
				1988	4.012	1.085	0.362
				1989	2.050	0.555	0.733
				1990	2.206	0.597	0.576
				1991	4.629	1.252	0.319
				1992	8.752	2.367	0.246
				1993	4.138	1.119	0.552
				1994	3.981	1.077	0.414
				1995	6.372	1.724	0.234
				1996	4.272	1.156	0.371
				1997	3.443	0.931	0.477
				1998	3.795	1.026	0.382
				1999	3.029	0.819	0.468
				2000	4.197	1.135	0.341
				2001			
				2002	4.831	1.307	0.347
				2003	6.917	1.871	0.288
				2004	6.883	1.862	0.274
				2005			
SEDAR 13-DW-38	MML Gillnet	FI	Base	1995	1.559	0.464	0.171
				1996	1.242	0.370	0.336
				1997	2.793	0.831	0.148
				1998			
				1999	2.441	0.727	0.190
				2000	4.185	1.246	0.197
				2001	5.070	1.509	0.158
				2002	2.978	0.887	0.178
				2003	4.300	1.280	0.190
				2004	5.665	1.686	0.165

Finetooth shark

					Index		
Document Number	Series Name	Type	Recommendation	Year	Absolute	Relative	CV
SEDAR 13-DW-05	PC LL	FI	Sensitivity	1993	0.014	0.418	3.924

				1994	0.046	1.373	0.610
				1995	0.012	0.358	2.759
				1996	0.123	3.672	0.182
				1997	0.057	1.701	0.425
				1998	0.006	0.179	6.800
				1999	0.010	0.299	2.972
				2000	0.000	0.000	0.000
SEDAR 13-DW-06	PC Gillnet	FI	Base	1996	0.479	0.763	0.391
				1997	1.363	2.174	0.291
				1998	0.051	0.081	0.915
				1999	0.840	1.339	0.465
				2000	0.252	0.401	0.833
				2001	0.589	0.940	0.519
				2002	0.451	0.719	0.504
				2003	1.147	1.828	0.361
				2004	0.447	0.712	0.551
				2005	0.654	1.043	0.476
SEDAR 13-DW-09	Gillnet Obs	FD-C	Base	1993	75.596	0.483	1.024
				1994	44.255	0.283	0.897
				1995	30.002	0.192	1.546
				1996			
				1997			
				1998	0.926	0.006	0.999
				1999	44.518	0.284	0.764
				2000	945.377	6.035	0.707
				2001	68.730	0.439	0.718
				2002	77.065	0.492	0.888
				2003	57.723	0.368	1.096
				2004	8.280	0.053	1.115
				2005	370.709	2.366	0.766
SEDAR 13-DW-18	Texas	FI	Base	1976	0.007	0.624	1.069
				1977			
				1978			
				1979	0.005	0.484	1.067
				1980	0.012	1.058	0.579
				1981	0.008	0.704	0.752
				1982	0.012	1.037	0.407
				1983	0.018	1.555	0.354
				1984	0.012	1.093	0.406
				1985	0.010	0.848	0.499
				1986	0.016	1.399	0.351
				1987			
				1988	0.005	0.451	0.752
				1989	0.006	0.556	0.584
				1990	0.024	2.116	0.286
				1991	0.012	1.074	0.445
				1992	0.011	0.974	0.502

				1993	0.003	0.279	1.066
				1994	0.013	1.123	0.407
				1995	0.015	1.293	0.378
				1996	0.026	2.323	0.264
				1997	0.008	0.748	0.752
				1998			
				1999	0.008	0.668	0.499
				2000	0.018	1.584	0.332
				2001	0.003	0.282	1.066
				2002	0.010	0.915	0.499
				2003	0.020	1.730	0.336
				2004	0.012	1.024	0.449
				2005	0.009	0.801	0.499
				2006	0.003	0.255	0.500
SEDAR 13-DW-21	MS Gillnet	FI	Sensitivity	2001	0.180	0.435	0.842
				2002			
				2003	0.562	1.360	0.656
				2004	0.481	1.162	0.626
				2005	0.398	0.962	0.502
				2006	0.447	1.080	0.447
SEDAR 13-DW-26	Gillnet Logs	FD - C	Sensitivity	1998	0.002	0.842	5.796
				1999	0.000	0.141	12.628
				2000	0.001	0.410	5.755
				2001	0.001	0.674	4.470
				2002	0.001	0.413	9.181
				2003	0.003	1.193	4.535
				2004	0.002	0.844	9.364
				2005	0.008	3.483	2.823
SEDAR 13-DW-30	SC Coastspan GN	FI	Base	1998	6.303	0.766	0.851
				1999	4.878	0.593	1.267
				2000	6.423	0.780	0.783
				2001	13.024	1.582	0.284
				2002	12.751	1.549	0.344
				2003	13.754	1.671	0.312
				2004	2.864	0.348	1.994
				2005	5.858	0.712	0.503

Blacknose shark

					Index		
Document Number	Series Name	Type	Recommendation	Year	Absolute	Relative	CV
SEDAR 13-DW-05	PC LL	FI	Sensitivity	1993	0.008	0.212	6.171
				1994	0.076	2.013	0.282
				1995	0.021	0.556	1.332
				1996			

				1997	0.017	0.450	1.201
				1998	0.032	0.848	0.981
				1999	0.052	1.377	0.493
				2000	0.096	2.543	0.294
SEDAR 13-DW-06	PC Gillnet - Adult	FI	Base	1996	0.446	2.164	0.269
				1997	0.161	0.781	0.710
				1998	0.156	0.757	0.724
				1999	0.308	1.494	0.833
				2000	0.025	0.121	5.613
				2001	0.157	0.762	0.971
				2002	0.242	1.174	0.741
				2003	0.216	1.048	0.759
				2004	0.232	1.126	0.763
				2005	0.118	0.573	1.159
SEDAR 13-DW-06	PC Gillnet - juvi	FI	Base	1996	0.168	1.507	0.356
				1997	0.082	0.735	0.351
				1998	0.069	0.619	0.250
				1999	0.086	0.771	0.268
				2000	0.105	0.942	0.282
				2001	0.114	1.022	0.289
				2002	0.124	1.112	0.300
				2003	0.117	1.049	0.296
				2004	0.131	1.175	0.309
				2005	0.119	1.067	0.294
SEDAR 13-DW-09	Gillnet Obs	FD-C	Base	1993	12.832	0.143	1.321
				1994	110.912	1.234	0.801
				1995	14.734	0.164	1.166
				1996			
				1997			
				1998	39.207	0.436	0.991
				1999	55.567	0.618	0.646
				2000	96.643	1.075	0.680
				2001	40.011	0.445	0.639
				2002	143.840	1.601	0.578
				2003	63.992	0.712	0.675
				2004	46.179	0.514	0.658
				2005	251.732	2.801	0.747
SEDAR 13-DW-12	BLLOP	FD-C	Base	1994	17.126	0.305915	0.615
				1995	41.156	0.735152	0.45
				1996	35.776	0.639052	0.459
				1997	13.373	0.238876	0.6
				1998	37.706	0.673526	0.465
				1999	44.055	0.786936	0.582
				2000	130.194	2.325601	0.522
				2001	14.477	0.258597	0.649
				2002	67.202	1.200401	0.368

				2003	34.63	0.618581	0.407
				2004	28.78	0.514085	0.501
				2005	130.604	2.332924	0.468
SEDAR 13-DW-22	NMFS LL SE	FI	Base	1995	0.066	0.287	0.511
				1996	0.177	0.773	0.399
				1997	0.129	0.564	0.317
				1998			
				1999	0.139	0.606	0.307
				2000	0.139	0.606	0.260
				2001	0.251	1.093	0.271
				2002	0.215	0.937	0.248
				2003	0.483	2.105	0.227
				2004	0.347	1.513	0.225
				2005	0.204	0.888	0.540
				2006	0.374	1.628	0.257
SEDAR 13-DW-26	Gillnet Logs	FD-C	Sensitivity	1998	0.001	0.110	2.524
				1999	0.001	0.128	3.298
				2000	0.001	0.123	1.293
				2001	0.004	0.355	1.210
				2002	0.011	1.065	0.850
				2003	0.015	1.430	0.963
				2004	0.014	1.328	1.301
				2005	0.026	2.547	0.981
SEDAR 13-DW-30	SCDNR red drum	FI	Base	1998	0.016	0.690	3.017
				1999	0.008	0.343	5.552
				2000	0.033	1.488	1.803
				2001	0.016	0.722	4.303
				2002	0.035	1.546	1.962
				2003	0.023	1.007	2.136
				2004	0.015	0.677	4.236
				2005	0.034	1.528	3.598
SEDAR 13-DW-34	UNC	FI	Base	1972	3.967	2.564	1.594
				1973	4.233	2.736	0.936
				1974	1.600	1.034	2.293
				1975	3.326	2.149	0.996
				1976	2.490	1.609	1.113
				1977	6.276	4.056	0.344
				1978	4.048	2.616	0.605
				1979	3.115	2.013	0.666
				1980	1.866	1.206	0.859
				1981	0.728	0.470	2.338
				1982	1.503	0.971	0.832
				1983	0.849	0.548	1.670
				1984	1.814	1.172	0.852
				1985	0.953	0.616	1.787
				1986	0.595	0.384	2.992

				1987	1.099	0.710	1.686
				1988	2.135	1.380	1.136
				1989	0.812	0.525	2.507
				1990	0.565	0.365	4.043
				1991	1.052	0.680	2.063
				1992	2.315	1.496	1.385
				1993	1.381	0.893	1.903
				1994	0.819	0.529	2.557
				1995	1.012	0.654	2.286
				1996	1.396	0.902	1.966
				1997	0.419	0.271	4.255
				1998	0.189	0.122	8.969
				1999	0.131	0.085	14.208
				2000	0.194	0.125	9.467
				2001	0.597	0.386	4.604
				2002	0.243	0.157	7.470
				2003	0.100	0.065	16.434
				2004	0.387	0.250	6.553
				2005	0.405	0.262	5.506
SEDAR 13-DW-37	MML LL	FI	Base	2003	0.988	0.624	0.473
				2004	2.548	1.610	0.424
				2005	1.717	1.085	0.473
				2006	1.077	0.680	0.459

Atlantic sharpnose shark

					Index		
Document Number	Series Name	Type	Recommendation	Year	Absolute	Relative	CV
SEDAR 13-DW-05	PC LL	FI	Base	1993	0.481	0.878	0.516
				1994	0.136	0.248	0.882
				1995	0.301	0.549	0.520
				1996	0.951	1.735	0.098
				1997	0.531	0.969	0.196
				1998	0.380	0.693	0.413
				1999	1.160	2.116	0.111
				2000	0.445	0.812	0.337
SEDAR 13-DW-06	PC Gillnet - Adult	FI	Base	1996	0.339	0.517	0.403
				1997	0.679	1.036	0.296
				1998	0.408	0.623	0.429
				1999	0.361	0.551	0.518
				2000	0.616	0.940	0.468
				2001	0.706	1.078	0.382
				2002	1.037	1.583	0.322
				2003	1.091	1.665	0.287

				2004	0.659	1.006	0.382
SEDAR 13-DW-06	PC Gillnet - juvi	FI	Base	1996	1.166	1.103	0.356
				1997	1.401	1.325	0.335
				1998	1.039	0.983	0.430
				1999	1.514	1.432	0.465
				2000	0.852	0.806	0.505
				2001	1.442	1.364	0.399
				2002	1.036	0.980	0.405
				2003	1.117	1.056	0.393
				2004	0.667	0.631	0.449
				2005	0.339	0.321	0.517
SEDAR 13-DW-09	Gillnet Observer combined	FD-C	Base	1993	63.769	0.136	1.458
				1994	520.751	1.114	0.590
				1995	355.170	0.760	1.454
				1996			
				1997			
				1998			
				1999	165.327	0.354	0.484
				2000	27.340	0.058	0.915
				2001	634.326	1.356	0.427
				2002	831.673	1.778	0.420
				2003	814.365	1.741	0.586
				2004	278.853	0.596	0.672
				2005	984.790	2.106	0.670
SEDAR 13-DW-09	Gillnet Observer Atlantic	FD-C	Sensitivity	1993	131.934	0.170	1.286
				1994	853.410	1.103	0.434
				1995	639.344	0.826	1.263
				1996			
				1997			
				1998			
				1999	196.219	0.254	0.355
				2000	47.828	0.062	0.825
				2001	989.642	1.279	0.274
				2002	1190.888	1.539	0.279
				2003	1496.536	1.934	0.404
				2004	403.973	0.522	0.446
				2005	1789.160	2.312	0.431
SEDAR 13-DW-12	BLLOP combined	FD-C	Base	1994	10.534	0.039	0.654
				1995	118.473	0.438	0.561
				1996	107.619	0.398	0.558
				1997	157.065	0.581	0.563
				1998	245.823	0.909	0.543
				1999	760.861	2.815	0.547
				2000	828.94	3.067	0.567
				2001	292.945	1.084	0.551
				2002	272.197	1.007	0.548

				2003	167.911	0.621	0.547
				2004	133.011	0.492	0.558
				2005	148.218	0.548	0.558
SEDAR 13-DW-12	BLLOP Atlantic	FD-C	Sensitivity	1994	36.151	0.111	0.62
				1995	203.128	0.625	0.552
				1996	146.506	0.451	0.55
				1997	177.954	0.548	0.571
				1998	400.443	1.232	0.549
				1999	674.209	2.075	0.582
				2000	977.488	3.008	0.569
				2001	498.29	1.533	0.567
				2002	395.279	1.216	0.573
				2003	98.901	0.304	0.594
				2004	75.067	0.231	0.653
				2005	216.165	0.665	0.597
SEDAR 13-DW-12	BLLOP GoM	FD-C	Sensitivity	1994	0.036	0.000	4.355
				1995	1.533	0.016	0.909
				1996	6.081	0.062	0.828
				1997	167.41	1.695	0.575
				1998	82.08	0.831	0.617
				1999	102.412	1.037	0.526
				2000			
				2001	41.426	0.419	0.677
				2002	92.86	0.940	0.498
				2003	108.793	1.101	0.46
				2004	170.67	1.728	0.463
				2005	313.232	3.171	0.453
SEDAR 13-DW-14	SEAMAP - SA	FI	Base	1990	2.983	0.833	0.305
				1991	3.163	0.884	0.284
				1992	2.908	0.812	0.296
				1993	2.240	0.626	0.325
				1994	1.623	0.453	0.361
				1995	3.052	0.853	0.255
				1996	1.860	0.520	0.347
				1997	3.855	1.077	0.264
				1998	2.679	0.748	0.293
				1999	2.734	0.764	0.290
				2000	3.835	1.071	0.271
				2001	3.385	0.946	0.228
				2002	5.306	1.482	0.207
				2003	5.686	1.588	0.233
				2004	3.851	1.076	0.239
				2005	4.969	1.388	0.269
				2006	6.730	1.880	0.221
SEDAR 13-DW-18	Texas	FI	Base	1975	0.017	1.080	1.063
				1976	0.009	0.554	1.068

				1977	0.008	0.479	1.067
				1978			
				1979	0.016	0.983	0.577
				1980	0.005	0.329	1.058
				1981	0.004	0.278	1.056
				1982	0.003	0.167	1.044
				1983	0.007	0.463	0.576
				1984	0.021	1.316	0.312
				1985	0.017	1.068	0.374
				1986	0.040	2.560	0.218
				1987	0.007	0.474	0.744
				1988	0.034	2.177	0.238
				1989	0.014	0.875	0.376
				1990	0.010	0.653	0.442
				1991	0.017	1.101	0.375
				1992	0.009	0.578	0.577
				1993	0.008	0.531	0.575
				1994	0.011	0.703	0.441
				1995	0.007	0.439	0.575
				1996	0.030	1.891	0.246
				1997	0.011	0.717	0.575
				1998	0.010	0.654	0.497
				1999	0.032	2.035	0.239
				2000	0.025	1.612	0.275
				2001	0.003	0.216	1.047
				2002	0.026	1.658	0.312
				2003	0.029	1.867	0.277
				2004	0.022	1.365	0.333
				2005	0.018	1.140	0.351
				2006	0.016	1.039	0.371
SEDAR 13-DW-19	VA LL	FI	Base	1976	0.036	0.013	1.893
				1977	1.125	0.400	0.728
				1978			
				1979			
				1980	3.406	1.209	0.444
				1981	3.703	1.315	0.261
				1982			
				1983	3.114	1.106	1.049
				1984			
				1985			
				1986			
				1987	5.103	1.812	0.587
				1988	1.765	0.627	1.223
				1989	0.946	0.336	0.533
				1990	2.706	0.961	0.380
				1991	3.147	1.117	0.547
				1992	2.478	0.880	0.434
				1993	3.154	1.120	0.532
				1994			

				1995	2.715	0.964	0.392
				1996	3.201	1.137	0.402
				1997	2.048	0.727	0.471
				1998	3.247	1.153	0.288
				1999	6.057	2.151	0.274
				2000	1.156	0.411	0.382
				2001	2.550	0.905	0.430
				2002	1.850	0.657	0.444
				2003	1.557	0.553	0.939
				2004	1.833	0.651	0.469
				2005	7.879	2.798	0.616
SEDAR 13-DW-21	MS Gillnet - Adult	FI	Sensitivity	2001	1.412	2.335	0.392
				2002			
				2003	0.385	0.637	0.989
				2004	0.460	0.761	0.460
				2005	0.414	0.685	0.407
				2006	0.352	0.582	0.380
SEDAR 13-DW-21	MS Gillnet - juvi	FI	Sensitivity	2001	0.717	1.749	0.515
				2002			
				2003	0.153	0.374	1.307
				2004	0.109	0.266	0.763
				2005	0.199	0.485	0.556
				2006	0.872	2.127	0.303
SEDAR 13-DW-22	NMFS LL SE Atlantic	FI	Sensitivity	1995	1.982	0.212	0.304
				1996	1.820	0.194	0.326
				1997	2.426	0.259	0.320
				1998			
				1999	0.627	0.067	1.018
				2000	4.592	0.490	0.169
				2001			
				2002	14.949	1.596	0.130
				2003			
				2004	14.600	1.559	0.223
				2005	21.693	2.317	0.309
				2006	21.588	2.305	0.186
SEDAR 13-DW-22	NMFS LL SE GoM	FI	Sensitivity	1995	1.893	0.577	0.298
				1996	2.847	0.868	0.320
				1997	1.322	0.403	0.270
				1998			
				1999	1.376	0.420	0.207
				2000	3.515	1.072	0.175
				2001	2.982	0.909	0.200
				2002	3.940	1.201	0.173
				2003	4.902	1.494	0.151
				2004	5.084	1.550	0.173
				2005	4.063	1.239	0.313

				2006	4.155	1.267	0.205
SEDAR 13-DW-22	NMFS LL SE combined	FI	Base	1995	2.120	0.483	0.221
				1996	2.904	0.662	0.256
				1997	2.430	0.554	0.192
				1998			
				1999	1.438	0.328	0.228
				2000	3.837	0.875	0.123
				2001	3.693	0.842	0.196
				2002	5.229	1.192	0.136
				2003	6.258	1.427	0.141
				2004	6.679	1.523	0.147
				2005	7.840	1.788	0.244
				2006	5.811	1.325	0.171
SEDAR 13-DW-26	Gillnet Logs	FD-C	Sensitivity	1998	0.016	0.873	0.261
				1999	0.023	1.216	0.237
				2000	0.018	0.956	0.236
				2001	0.017	0.922	0.243
				2002	0.013	0.721	0.284
				2003	0.015	0.832	0.265
				2004	0.016	0.871	0.259
				2005	0.030	1.610	0.253
SEDAR 13-DW-28	NE Exp LL	FI	Sensitivity	1979	0.713	1.355	4.316
				1980			
				1981			
				1982			
				1983	1.086	2.064	3.781
				1984			
				1985	0.115	0.219	10.572
				1986	0.861	1.636	0.932
				1987			
				1988			
				1989	0.109	0.207	7.822
				1990			
				1991	0.273	0.519	3.069
SEDAR 13-DW-30	SC Coastspan GN	FI	Base	1998	8.280	1.111	0.554
				1999	9.923	1.331	0.704
				2000	5.892	0.791	0.593
				2001	6.140	0.824	0.363
				2002	5.182	0.695	0.344
				2003	14.621	1.962	0.185
				2004	3.570	0.479	1.593
				2005	6.018	0.807	0.357
SEDAR 13-DW-30	SCDNR red drum	FI	Base	1998	0.154	0.983	0.747
				1999	0.090	0.573	1.170

				2000	0.148	0.939	1.070
				2001	0.230	1.463	0.863
				2002	0.227	1.442	0.967
				2003	0.195	1.243	0.826
				2004	0.075	0.479	2.642
				2005	0.138	0.878	3.001
SEDAR 13-DW-31	SEAMAP - GoM Extended Summer	FI	Base	1982	0.855	1.098	2.139
				1983	3.329	4.278	1.557
				1984	1.118	1.436	2.061
				1985	1.550	1.992	1.975
				1986	0.862	1.107	1.936
				1987	0.705	0.906	0.450
				1988	0.649	0.834	0.421
				1989	0.669	0.859	0.476
				1990	0.189	0.243	0.567
				1991	0.810	1.040	0.404
				1992	0.587	0.754	0.439
				1993	0.658	0.846	0.425
				1994	0.232	0.298	0.523
				1995	1.066	1.370	0.409
				1996	1.057	1.358	0.394
				1997	0.537	0.691	0.452
				1998	0.500	0.643	0.427
				1999	0.484	0.622	0.435
				2000	0.786	1.010	0.441
				2001	0.351	0.451	0.633
				2002	0.822	1.057	0.432
				2003	0.410	0.527	0.505
				2004	0.219	0.282	0.497
				2005	0.359	0.461	0.516
				2006	0.651	0.837	0.430
SEDAR 13-DW-31	SEAMAP - GoM Extended Fall	FI	Base	1972	0.424	0.725	0.731
				1973	0.455	0.777	0.656
				1974	1.380	2.357	0.618
				1975	1.193	2.038	0.622
				1976	1.296	2.213	0.619
				1977	0.710	1.212	0.632
				1978	0.661	1.129	0.629
				1979	0.764	1.305	0.628
				1980	1.263	2.156	0.621
				1981	0.836	1.428	0.624
				1982	0.896	1.529	0.624
				1983	0.776	1.324	0.658
				1984	0.623	1.064	0.642
				1985	0.941	1.607	0.688
				1986	0.533	0.909	1.004
				1987	0.781	1.334	0.327
				1988	0.443	0.756	0.334

				1989	0.324	0.554	0.375
				1990	0.474	0.810	0.335
				1991	0.244	0.417	0.368
				1992	0.237	0.404	0.398
				1993	0.417	0.712	0.348
				1994	0.500	0.854	0.340
				1995	0.340	0.581	0.346
				1996	0.565	0.965	0.312
				1997	0.386	0.659	0.336
				1998	0.315	0.538	0.382
				1999	0.406	0.694	0.352
				2000	0.489	0.834	0.371
				2001	0.288	0.492	0.370
				2002	0.286	0.488	0.363
				2003	0.404	0.690	0.333
				2004	0.199	0.340	0.411
				2005	0.380	0.649	0.336
				2006	0.267	0.456	0.401
SEDAR 13-DW-31	SEAMAP-GoM Fall Groundfish	FI	Sensitivity	1972	0.489	0.549	0.381
				1973	0.430	0.483	0.246
				1974	1.609	1.807	0.199
				1975	1.304	1.464	0.173
				1976	1.255	1.409	0.147
				1977	0.704	0.791	0.202
				1978	0.697	0.782	0.207
				1979	0.843	0.946	0.215
				1980	1.415	1.589	0.208
				1981	0.837	0.940	0.242
				1982	0.932	1.047	0.215
				1983	0.770	0.865	0.242
				1984	0.660	0.741	0.373
				1985	1.103	1.238	0.357
				1986	0.310	0.348	0.571
SEDAR 13-DW-31	SEAMAP-GoM Fall SEAMAP	FI	Sensitivity	1987	0.927	2.673	1.053
				1988	0.334	0.961	0.225
				1989	0.298	0.859	0.386
				1990	0.396	1.141	0.346
				1991	0.175	0.504	0.239
				1992	0.166	0.478	0.242
				1993	0.388	1.119	0.341
				1994	0.475	1.369	0.395
				1995	0.236	0.679	0.341
				1996	0.475	1.369	0.241
				1997	0.286	0.826	0.295
				1998	0.219	0.631	0.272
				1999	0.444	1.279	0.372
				2000	0.548	1.581	0.362
				2001	0.281	0.809	0.243

				2002	0.234	0.675	0.402
				2003	0.284	0.820	0.213
				2004	0.142	0.409	0.395
				2005	0.443	1.278	0.424
				2006	0.188	0.541	0.392
SEDAR 13-DW-34	UNC	FI	Base	1973	0.861	0.328	4.135
				1974	0.313	0.119	9.764
				1975	0.653	0.249	3.486
				1976	0.372	0.142	6.784
				1977	0.739	0.282	3.328
				1978	1.366	0.521	1.736
				1979	1.166	0.444	1.862
				1980	1.139	0.434	1.530
				1981	0.594	0.226	2.643
				1982	0.340	0.130	4.363
				1983	1.353	0.516	1.210
				1984	0.922	0.352	1.675
				1985	1.322	0.504	1.312
				1986	1.150	0.438	1.918
				1987	1.735	0.661	1.149
				1988	2.299	0.876	0.761
				1989	1.265	0.482	1.604
				1990	1.750	0.667	1.028
				1991	3.526	1.344	0.593
				1992	6.286	2.397	0.447
				1993	3.141	1.198	0.964
				1994	2.164	0.825	1.096
				1995	5.698	2.172	0.527
				1996	3.101	1.182	0.634
				1997	2.898	1.105	0.773
				1998	3.780	1.441	0.539
				1999	2.865	1.092	0.678
				2000	4.001	1.526	0.544
				2001	.		.
				2002	4.872	1.858	0.463
				2003	6.899	2.630	0.364
				2004	6.449	2.459	0.462
				2005	8.917	3.400	0.246
SEDAR 13-DW-38	MML GN - Adult	FI	Base	1995	2.868	0.204	0.731
				1996	9.140	0.649	0.629
				1997	3.210	0.228	1.500
				1998			
				1999	6.522	0.463	0.677
				2000	5.041	0.358	0.707
				2001	32.431	2.302	0.521
				2002	13.662	0.970	0.574
				2003	35.560	2.524	0.527
				2004	18.350	1.303	0.535

				1995	0.070	0.111	1.837
SEDAR 13-DW-38	MML GN - juvi	FI	Base	1996	0.305	0.485	0.756
				1997	2.971	4.721	0.398
				1998			
				1999	0.423	0.672	0.588
				2000	0.161	0.255	0.765
				2001	0.505	0.803	0.896
				2002	0.897	1.426	0.456
				2003	0.254	0.404	0.757
				2004	0.078	0.124	0.831

Bonnethead shark

					Index		
Document Number	Series Name	Type	Recommendation	Year	Absolute	Relative	CV
SEDAR 13-DW-06	PC Gillnet - Adult	FI	Base	1996	0.563	1.595	0.483
				1997	0.204	0.578	0.728
				1998	0.165	0.467	0.814
				1999	0.374	1.059	0.687
				2000	0.046	0.130	2.407
				2001	0.619	1.754	0.470
				2002	0.504	1.428	0.452
				2003	0.692	1.960	0.381
				2004	0.296	0.839	0.557
				2005	0.067	0.190	1.047
SEDAR 13-DW-06	PC Gillnet - juvi	FI	Base	1996	0.602	1.705	0.554
				1997	0.827	2.343	0.575
				1998	0.622	1.762	0.481
				1999	0.710	2.011	0.598
				2000	0.304	0.861	0.779
				2001	0.390	1.105	0.617
				2002	0.435	1.232	0.590
				2003	0.292	0.827	0.624
				2004	0.166	0.470	0.778
				2005	0.046	0.130	1.536
SEDAR 13-DW-09	Gillnet Obs	FD-C	Base	1994	196.274	1.447	0.619
				1995	12.915	0.095	1.359
				1996			
				1997			
				1998	169.757	1.252	0.841
				1999	102.106	0.753	0.519
				2000	431.009	3.178	0.538
				2001	133.159	0.982	0.530
				2002	67.460	0.497	0.545

				2003	29.868	0.220	0.875
				2004	8.594	0.063	0.882
				2005	163.588	1.206	0.665
SEDAR 13-DW-10	ENP	FD-R	Base	1978	0.436	0.565	0.313
				1979	0.545	0.706	0.341
				1980	0.151	0.196	0.443
				1981	0.395	0.512	0.205
				1982	0.285	0.369	0.222
				1983	0.542	0.702	0.137
				1984	0.944	1.223	0.078
				1985	0.627	0.813	0.114
				1986	0.602	0.780	0.115
				1987	0.631	0.818	0.109
				1988	0.708	0.917	0.112
				1989	0.901	1.168	0.104
				1990	0.818	1.060	0.090
				1991	0.498	0.645	0.130
				1992	0.971	1.258	0.077
				1993	0.931	1.206	0.089
				1994	1.026	1.330	0.077
				1995	1.137	1.473	0.075
				1996	1.102	1.428	0.072
				1997	0.879	1.139	0.083
				1998	0.808	1.047	0.094
				1999	0.940	1.218	0.087
				2000	0.888	1.151	0.088
				2001	0.965	1.251	0.087
				2002	0.881	1.142	0.100
				2003	0.803	1.041	0.101
				2004	0.781	1.012	0.119
SEDAR 13-DW-14	SEAMAP - SA	FI	Base	1989	0.777	0.426	0.543
				1990	1.370	0.751	0.359
				1991	2.100	1.152	0.343
				1992	1.448	0.794	0.323
				1993	1.031	0.565	0.407
				1994	1.563	0.857	0.347
				1995	1.749	0.959	0.324
				1996	0.711	0.390	0.439
				1997	1.578	0.865	0.331
				1998	1.248	0.684	0.356
				1999	1.122	0.615	0.382
				2000	1.644	0.902	0.340
				2001	2.237	1.227	0.277
				2002	3.415	1.873	0.243
				2003	2.936	1.610	0.260
				2004	1.264	0.693	0.343
				2005	2.731	1.498	0.269
				2006	3.901	2.139	0.251

SEDAR 13-DW-18	Texas	FI	Base	1975	0.164	0.192	1.634
				1976	1.578	1.848	0.440
				1977	0.178	0.208	1.091
				1978	0.199	0.233	0.877
				1979	0.559	0.654	0.622
				1980	1.092	1.279	0.405
				1981	0.997	1.168	0.674
				1982	0.645	0.755	0.355
				1983	1.076	1.260	0.281
				1984	1.397	1.636	0.232
				1985	0.453	0.531	0.376
				1986	0.779	0.913	0.284
				1987	0.090	0.105	1.009
				1988	1.222	1.431	0.263
				1989	0.591	0.692	0.338
				1990	1.560	1.827	0.261
				1991	1.042	1.220	0.287
				1992	0.399	0.467	0.431
				1993	0.984	1.152	0.295
				1994	0.661	0.774	0.368
				1995	0.479	0.560	0.407
				1996	0.558	0.654	0.321
				1997	0.495	0.579	0.465
				1998	1.350	1.582	0.308
				1999	0.441	0.517	0.393
				2000	1.340	1.569	0.274
				2001	1.341	1.570	0.243
				2002	1.335	1.564	0.299
				2003	0.927	1.085	0.283
				2004	1.323	1.549	0.273
				2005	1.000	1.171	0.264
				2006	1.071	1.254	0.310
SEDAR 13-DW-26	Gillnet Logs	FD-C	Sensitivity	1998	0.001	0.307	5.975
				1999	0.001	0.261	7.179
				2000	0.002	0.426	5.128
				2001	0.003	0.598	4.448
				2002	0.003	0.698	5.102
				2003	0.004	0.838	5.547
				2004	0.014	3.067	2.233
				2005	0.007	1.560	3.061
SEDAR 13-DW-30	SC Coastspan GN	FI	Base	1998	5.113	0.402	0.925
				1999	13.233	1.040	0.456
				2000	12.370	0.972	0.414
				2001	13.092	1.029	0.236
				2002	10.316	0.811	0.288
				2003	14.299	1.124	0.236
				2004	17.229	1.354	0.713

				2005	16.121	1.267	0.222
SEDAR 13-DW-31	Early SEAMAP-GoM Fall Groundfish	FI	Base	1972	0.182	0.944	0.419
				1973	0.558	2.892	0.258
				1974	0.308	1.599	0.275
				1975	0.164	0.849	0.433
				1976	0.321	1.667	0.254
				1977	0.360	1.864	0.651
				1978	0.102	0.530	0.405
				1979	0.225	1.167	0.556
				1980	0.108	0.561	0.543
				1981	0.038	0.195	0.496
				1982	0.045	0.235	0.404
				1983	0.065	0.339	0.568
				1984			
				1985	0.031	0.158	1.000
				1986			
SEDAR 13-DW-31	Late SEAMAP-GoM Fall SEAMAP	FI	Base	1987	0.072	0.560	0.466
				1988	0.073	0.566	0.412
				1989	0.058	0.451	0.594
				1990	0.107	0.836	0.456
				1991	0.090	0.700	0.324
				1992	0.054	0.419	0.471
				1993	0.112	0.870	0.343
				1994	0.156	1.215	0.462
				1995	0.035	0.270	0.635
				1996	0.148	1.151	0.318
				1997	0.232	1.805	0.412
				1998	0.048	0.373	0.376
				1999	0.139	1.082	0.359
				2000	0.070	0.545	0.336
				2001	0.093	0.723	0.417
				2002	0.165	1.287	0.633
				2003	0.126	0.984	0.452
				2004	0.430	3.354	0.385
				2005	0.215	1.678	0.244
				2006	0.145	1.130	0.400
SEDAR 13-DW-38	MML GN - adult	FI	Base	1995	0.881	0.492	0.217
				1996	0.597	0.333	0.425
				1997	1.179	0.658	0.180
				1998			
				1999	1.409	0.786	0.207
				2000	2.479	1.383	0.192
				2001	2.728	1.523	0.170
				2002	1.695	0.946	0.207
				2003	2.346	1.309	0.226
				2004	2.811	1.569	0.213

SEDAR 13-DW-38	MML GN - juvi	FI	Base	1995	0.493	0.275	0.239
				1996	0.316	0.176	0.403
				1997	1.216	0.679	0.252
				1998			
				1999	0.607	0.339	0.287
				2000	1.350	0.753	0.283
				2001	1.204	0.672	0.180
				2002	0.581	0.324	0.242
				2003	1.110	0.620	0.233
				2004	1.867	1.042	0.246

SEDAR 13

Stock Assessment Report

Small Coastal Shark Complex, Atlantic Sharpnose, Blacknose, Bonnethead, and Finetooth Shark

Section IV: Review Workshop Consensus Summary

Consensus Summary Report

A. Small Coastal Shark Complex
B. Finetooth Shark
C. Blacknose Shark
D. Atlantic Sharpnose Shark
E. Bonnethead Shark

Prepared by the SEDAR 13 (Small Coastal Sharks) Review Panel for:

NOAA/NMFS Highly Migratory Species Management Division

Edited by Joseph E. Powers for

SEDAR 13 (Small Coastal Sharks), 6–10 August 2007
Panama City, FL

Executive summary

The SEDAR 13 Review Panel met from 6 to10 August 2007, in Panama City, FL. A Chair and 3 CIE reviewers made up the panel. The three NMFS scientists responsible for the assessments summarized the outputs from the Data and Assessment Workshops succinctly and accurately.

Overall, the data used in the assessment of the **Small Coastal Shark complex** *were considered the best available at the time, and the assessment of the status of the complex is considered adequate given the data available. However, because the species which comprise the complex have all been assessed separately (as recommended in previous assessments), the Review Panel based its recommendations on the species-specific results rather than on the aggregated small coastal complex results.*

For **finetooth sharks***, the population model and resulting population estimates are considered the best possible given the data available. Stock status was determined from the results of a range of general production model fits reflecting the Panel's uncertainty about life history parameters, catches and indices of abundance. Results indicated that the stock is not overfished and overfishing is not occurring. While it is reasonable to conclude that the stock is not presently overfished, the impact of index choice when so few are applicable (2002 assessment results versus current assessment results) suggest that management should be cautious.*

For **blacknose sharks***, appropriate standard assessment methods based on general production models and on age-structured modeling were used to derive management benchmarks. The current assessment indicates that spawning stock fecundity (SSF) in 2005 and during 2001-2005 is smaller than SSFmsy, i.e. that blacknose shark are overfished. The estimate of fishing mortality rate in 2005 and the average for 2001-2005 is greater than Fmsy, and the ratio is substantially greater than 1 in both cases. Thus, overfishing was occurring and is likely still occurring. However, because of uncertainties in indices, catches and life history parameters, the status of blacknose shark could change substantially in the next assessment in an unpredictable direction.*

For **Atlantic sharpnose sharks***, the Panel concluded that the data used for the analyses were treated appropriately. The assessment does not show the SSF index falling below the threshold over the period considered, but the ratio index shows an almost continuous decline towards it. While it is reasonable to conclude that the stock is not presently overfished, the fact that F is close to, but presently below, Fmsy (i.e. overfishing is not occurring) means that if F is maintained, the stock will continue to decline toward the SSF threshold and will fall below it as F fluctuates around Fmsy. It would therefore be desirable to distinguish between targets and thresholds.*

In terms of **bonnethead sharks***, the Panel accepts the conclusion of the current assessment that it is likely that SSF is greater than SSFmsy, i.e. that bonnethead are not overfished. The estimate of fishing mortality rate in 2005 is less than Fmsy, thus overfishing was not occurring in that year. However, fishing mortality rates in the recent past have fluctuated above and below Fmsy. Thus, there is some probability that fishing mortality rates in 2006 and 2007 have been or will be in excess of Fmsy.*

Recommendations for future research contained in the Data and Assessment Workshop reports were endorsed, and others were added by the Panel. The report closes with a few comments on process, for future consideration.

1. Introduction

1.1 Time and Place

The SEDAR 13 (Small Coastal Sharks) Review Workshop met in Panama City, FL, from 6 to 10 August 2007.

1.2 Terms of Reference for the Review Workshop

1. *Evaluate the adequacy, appropriateness, and application of data used in the assessment.*

2. *Evaluate the adequacy, appropriateness, and application of methods used to assess the stock.*

3. *Recommend appropriate estimates of stock abundance, biomass, and exploitation (if possible).*

4. *Evaluate the methods used to estimate population benchmarks and management parameters; recommend values for management benchmarks (MSY, Fmsy, Bmsy, MSST, MFMT) and provide declarations of stock status*

5. *Evaluate the adequacy, appropriateness, and application of methods used to project future population status; recommend appropriate estimates of future stock condition (if possible).*

6. *Evaluate the adequacy, appropriateness, and application of methods used to characterize uncertainty, considering input data, model fit, and model configuration. Ensure that the implications of uncertainty with regard to status determinations and management values are clearly stated.*

7. *Ensure that the assessment results are clearly and accurately presented in the Stock Assessment Report and that the reported results are consistent with Review Panel recommendations.*

8. *Evaluate the SEDAR Process. Identify any Terms of Reference which were inadequately addressed by the Data or Assessment Workshops; identify any additional information or assistance which will improve Review Workshops; suggest improvements or identify aspects requiring clarification.*

9. *Consider the research recommendations provided by the Data and Assessment workshops and make any additional recommendations warranted. Clearly indicate the research and monitoring needs that may appreciably improve the reliability of future assessments. Recommend an appropriate interval for the next assessment and whether a benchmark or update assessment should be considered.*

10. *Prepare a Consensus Report summarizing the peer review Panel's evaluation of the reviewed stock assessments and addressing these Terms of Reference. (Drafted during the Review Workshop with a final report due two weeks after the workshop ends.)*

1.3 List of Participants

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1.4 Review Workshop working papers

An impressive quantity of documentation was provided before the meeting by the facilitator. Much of this pertained to material provided to either the Data Workshop or Assessment Workshop for each of the review stocks. No new literature or working papers were provided at the meeting.

2. Terms of Reference

2.1 Background

The Review Workshop is the third meeting in the SEDAR process, and this situation pertained to all stocks reviewed during SEDAR 13. The Panel records that the Terms of Reference set for Data Workshops and Assessment Workshops for the Small Coastal Shark complex (SCS) and the four “stocks” were fully met, at least to the extent feasible, a notable achievement given that data for assessing such species are traditionally (worldwide) very poor.

The Panel was impressed by the quantity and quality of the work that had gone into the assessments. The presentations were well structured and clear, and the information provided through the presentations, and in response to questions, gave a sound basis for the Panel’s subsequent deliberations and conclusions.

2.2 Review of the Panel’s deliberations

The deliberations on each species are presented in the form of responses to the terms of reference listing some of the issues and concerns that were raised in discussions, followed by relevant comments on and conclusions from the discussions, and suggestions for future research (the last two non-prioritized).

In several instances the issues to be discussed under the terms of reference were generic to all of the stocks being assessed. Therefore, a general response to those issues is presented in a separate section and referred to under each stock. Specific comments are included in the stock-specific section.

Finally, the 10th term of reference requests a Consensus Summary Report. The report herein is the Review Panel's response to that term of reference. Thus, it is not discussed further in the body of the report.

2.2.1 Note on MFMT and MSST

The Review Panel understands that the current Fishery Management Plan established a Maximum Fishing Mortality Rate Threshold (MFMT) and a Minimum Stock Size Threshold (MSST) for the small coastal complex as a whole, but that currently, these thresholds have not been formally adopted for the individual species. It is the Panel's understanding that for the complex, MFMT=Fmsy and MSST=(1-M)*Bmsy (where M equals the instantaneous natural mortality rate). Therefore, for purposes of presentation the Review Panel is tacitly defining MFMT and MSST as in the FMP definitions for the complex.

2.2.2 General Response to Terms of Reference

7. *Ensure that assessment results are clearly and accurately presented in the Stock Assessment Report and that reported results are consistent with Review Panel recommendations.*

This term of reference is difficult to meet for the Review Panel. The Stock Assessment Report has been written already and approved when the Review Panel meets. It can be modified if errors in facts, in calculations, or in interpretation are discovered but it would not be appropriate for the Review Panel to modify the Assessment Report for style, clarity or consistency with the Review Panel recommendations.

8. *Evaluate the SEDAR Process. Identify any Terms of Reference which were inadequately addressed by the Data or Assessment Workshops; identify any additional information or assistance which will improve Review Workshops; suggest improvements or identify aspects requiring clarification.*

The SEDAR process is a well thought out transparent consensus building process. Given the diversity of data and information sources, particularly for indices of stock size and biological parameters, putting the data together is a major task and it is appropriate to do so through a data workshop where all interested parties can participate. Similarly, analyzing the data through an Assessment Workshop whose tasks are to provide estimates of population parameters and trends as well as estimates of management benchmarks is appropriate. The Review Workshop, whose tasks are to evaluate the assessment methods and results and to provide the status declaration, with support from the assessment teams, provide an independent neutral evaluation of the methods, results and status determination.

The Data Workshop appears to have met the large majority of its terms of reference completely. Term of reference 3 was almost completely met, but the evaluation of how well the indices of stock size represented fishery and population conditions was not complete. For most stocks, at least some indices indicate conflicting trends over time, some increasing and some decreasing, while other indices were variable over time but showed no trends. The three conditions cannot adequately represent the conditions of the stock, assuming that the stock unit is appropriately defined, unless various geographical components of a stock complex behave differently over time. It is not clear if the selection of indices could be further refined at the Data Workshop or whether it would be more appropriately done at the Assessment Workshop, but it is clear that the selection of indices to be used in the modeling has to be further refined.

The Assessment Workshop appears to have successfully and completely met all its relevant terms of reference except that it did not provide research recommendations.

The process as implemented in SEDAR 13 could be improved by structuring the reports and the presentations more explicitly according to the terms of reference. It would also help to provide more details of the exploratory runs, perhaps in a working paper so that the choice of final run can be better understood.

9. *Consider the research recommendations provided by the Data and Assessment workshops and make any additional recommendations warranted. Clearly indicate the research and monitoring needs that may appreciably improve the reliability of future assessments. Recommend an appropriate interval for the next assessment and whether a benchmark or update assessment should be considered.*

General research recommendations from the Data Workshop Report relevant to all species include the following

1. Re-evaluate life history in Atlantic Ocean, spanning the range of the stock.
2. Expand research efforts directed towards tagging of individuals in south Florida and Texas/Mexico border to get better data discerning potential stock mixing.
3. Develop empirically based estimates of natural mortality

.

Additionally, the following recommendations provided in no particular order, deal with the collection of catch rate series data.

The Review Panel encourages the continuation of the fishery-independent surveys reviewed. Some series that were not useful at this time may prove useful in the future with the inclusion of more data and series that were recommended for use at this time may improve with the additional information.

If significant methodological changes are planned, it would be wise to have an overlap period between the gear, design, or vessel changes to all for calibration and quantification of those changes. This will allow for the time series to be maintained as one entity.

As indicated above, there were no recommendations from the Assessment Workshop.

2.2.3. *Small Coastal Shark Complex*

The small coastal shark complex originally included seven species of sharks: finetooth, blacknose, Atlantic sharpnose, bonnethead, smalltail, angel and Caribbean sharpnose sharks. This category was created because catch and catch per unit effort data were aggregated over species, as some fisheries did not distinguish between species when reporting data. Also, the complex included species with similar life history characteristics. The original assessment of the complex was done on the aggregate data, recognizing the risks of assuming that the status of the individual species within the complex may not be reflected by the status of the complex as a whole. Thus, the original management measures were directed at this complex.

In 1999 smalltail, angel and Caribbean sharpnose sharks were removed from the small coastal shark complex, for management purposes, and put in a prohibited species category. This left four species in the complex: finetooth, blacknose, Atlantic sharpnose and bonnethead sharks.

Subsequently, a number of improvements have occurred in the data. Data sets of species-specific catches have been obtained and historical catches by species reconstructed. Additionally, individual research projects have provided species-specific information on relative abundance trends. This allowed individual analyses of the four species within the small coastal shark complex. Of these four species, bonnethead and Atlantic sharpnose sharks comprise approximately 94% of the catch. Thus, the small coastal shark complex is now essentially the aggregation of those two species.

With the development of species-specific data bases, SEDAR 13 used species-specific models for analysis. Nevertheless, for continuity purposes the species aggregated assessments were continued. However, it is the Review Panel’s view that the aggregate analysis of the complex is unlikely to accurately reflect the status of every individual species in the complex and therefore it should not be viewed in isolation from the species-specific assessments. The aggregated results were not inconsistent with the assessment results on bonnethead and Atlantic sharpnose sharks, in particular. Therefore, the results of alternative forms of analysis were examined for differences and similarities in their structure and results, leading to advice on those species. This does not preclude that management of small coastal sharks as a complex may continue into the future; however, the scientific advice now focuses on the individual species within that complex. The Review Panel supports the Assessment Workshop decisions to provide assessment and advice on a species by species basis, rather than on the complex.

2.2.4. *Finetooth Shark*

Terms of reference

1. Evaluate the adequacy, appropriateness, and application of data used in the assessment.

Life History Data

Finetooth sharks (*Carcharhinus isodon*) comprise only a small fraction of the catch (1%) of small coastal sharks and the data on their life history, abundance, and catch is consequently sparse. Some aspects appear to be relatively well understood. Even though life history estimates such as maximum age, and modest tag returns indicated some isolation between the East Coast (EC) and the Gulf of Mexico (GOM), the data workshop stated that they would treat finetooth sharks as a single stock. Thus these data were combined to yield a growth curve that was later used to convert size to age, and scaled up to the catch. Similarly because data is sparse, estimates of fecundity and the assumption of biennial reproduction relies on data from the EC. If in fact the groups are separate, subsequent management decisions could leave one at risk. In contrast, mortality is estimated in a risk-averse manner, by estimating survivorship from maximum age data using a variety of well-known techniques. When applying such methods to finfish, the 95^{th} percentile of age is usually chosen to eliminate spurious outliers. However in a data sparse situation this approach would be less helpful. As done now, it provides a conservative estimate of *M* which may give an optimistic perception of stock status. Another important parameter that is estimated from life-history tables is the intrinsic rate of population increase, *r*. The value of *r* is -0.056 indicating a future decline in population size, based on standard calculations from the available data. Based on calculations of the steepness of the recruitment function, this value of *r* was rejected as being unreasonable. Such a result could arise from misspecification of fecundity-at-age or incorrectness in the assumption of biennial recruitment and these assumptions are worthy of further review.

Catch and Survey Data

Data on CPUE from fishery-independent and fishery-dependent sources is similarly sparse for finetooth sharks. Numbers of landed sharks are calculated as landed weight divided by average weight. The numbers of finetooth sharks are calculated directly by applying their proportion to the total catch weight. The finetooth commercial catch comes from nets, longlines, and handlines in descending order (SEDAR-13-DW). They are also caught recreationally in less than half the amount of the commercial catch since the 1990's. Unlike the other species under review, they are not taken in the shrimp bycatch because their distribution is closer to the shore. The methods for obtaining catch estimates and numbers are reasonable for this species. Commercial catch data have been collected since 1995 and recreational catch data since 1982. These estimates are also reasonable for this species.

Catch rates were standardized using a GLM approach, which is a well-accepted method of standardization. The CPUE time series that provide data for finetooth include the fishery-dependent gillnet observer series, and three fishery-independent surveys including the Panama

City gillnet, Texas, and South Carolina COASTSPAN gillnet. These series occur throughout the range but are not continuous or overlapping. The choice of these indices is reasonable given that they provide the best coverage in time or space for this species.

2. Evaluate the adequacy, appropriateness, and application of methods used to assess the stock.

Given that finetooth sharks are a small portion of the catch and data on their population dynamics is sparse, there is a limited range of stock assessment models that can be applied to them. The Assessment Workshop chose to use two stock production models (SPM), a Bayesian surplus production model and a WinBUGS Bayesian state-space surplus production model. These models allow incorporation of priors. Note that both also rely on an assumption of logistic growth in the population, hence density dependence. A negative *r* precludes the use of these surplus production models. Given a negative value for *r* obtained from finetooth life history, the Data and Assessment Workshops had to assume another value for *r* to run these models. The 2002 value was chosen. The 2002 value is a reasonable choice, but by necessity doesn't reflect the most recent data on this species. When data are sparse it is easy to be in such a situation, but it also indicates that model results should be viewed with caution and that further research is necessary to resolve the issue with *r*.

Both models use standard and well-recognized methods and are frequently used for stock assessments in data-poor situations. Input data to these models starts in 1976, corresponding to the beginning of the Texas series, with the fishery-dependent index starting in 1983. The indices were assigned equal weight in fitting the models. While there are understandable reasons for this, it ignores the fact that some indices provide better coverage or are more adequately designed to assess a given species. Nonetheless, results of the model didn't change substantially when the series were weighted by the inverse CV. With a stock that is data-poor, such as finetooth sharks, other alternate models can be used in conjunction with the surplus production models to check the results. Such models could include size- or stage-based matrix models that incorporate density dependence or simple delay-difference models. Given the problems with *r* for finetooth, such an approach would prevent an overly optimistic view of stock status. This is particularly important because the series are variable and don't show a long-term trend, and without much contrast, SPMs are difficult to fit.

Modeling included sensitivity analyses to test for the effects of CPUE weighting, extension of the catch series back to 1950, adding addition CPUE series, and a lower *r* value (r=0.02). None of the sensitivity simulations gave appreciably different results than obtained with the base model. Additionally, when further analyses were done upon the Review Panel's request (including use of a multivariate t, a uniform prior on r), there were no substantial change in results from the base case. One concern raised during the review was that lognormal priors were used for N_{76}/K, *r*, and C_0, implying that there was some more knowledge of these than was justified. It was suggested that uniform priors be used and simulations be redone. The results of these new simulations were similar to the baseline case, and uniform priors on *r* made little difference.

3. Recommend appropriate estimates of stock abundance, biomass, and exploitation (if possible).

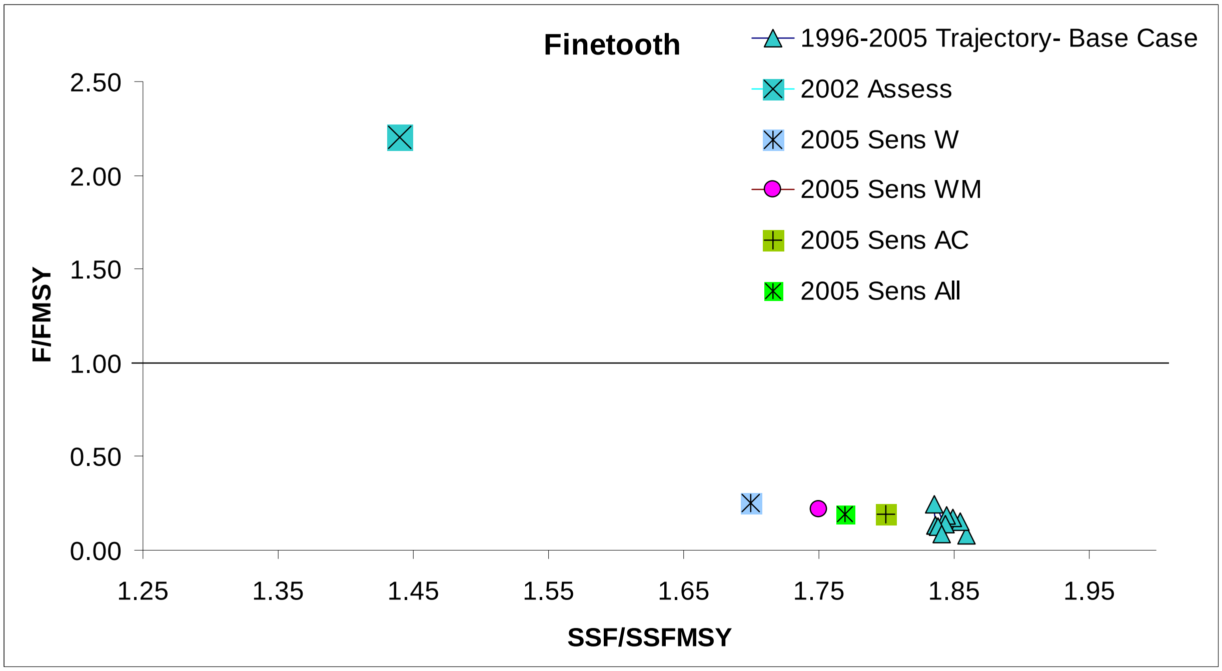
The predicted abundance trend from the surplus production model was relatively flat at approximately 3.7 to 4.1 million. When retrospective analyses were run, these trends were also flat, but differed in magnitude. The reference points of N/N_{msy} were consistently in the range of 1.5 and always above 1. The estimates of F and F/F_{msy} were quite variable from year to year, again reflecting the flat input time series and scarcity of data. However variable, the model rarely estimated F above F_{msy}. Given the constraints mentioned in the previous sections, the model is providing seemingly acceptable estimates.

The Review Panel's concern is that the 2002 assessment showed that there was overfishing in some years, but there is no indication of overfishing in the current assessment. However, it is difficult to compare the two assessments because the 2002 assessment was somewhat *ad hoc* as it included indices based on the choice of one person while the current assessment is based on the collective selection by the Data and Assessment workshops. The differences seem to be due mostly to the change in CPUE indices and the additional few years of catch data. It would be good operating procedure to systematically identify the reasons (differences in data series used, addition of new data, changes in model, or changes in model assumptions) for changes in perception of stock status and stock trends.

4. Evaluate the methods used to estimate population benchmarks and management parameters; recommend values for management benchmarks (MSY, Fmsy, B_{msy}, MSST, MFMT) and provide declarations of stock status.

The methods used to estimate population benchmarks are appropriate for use with surplus production models. B_{msy} and F_{msy} are set as the threshold values in an effort to be precautionary. For finetooth sharks, the estimated values for B fall above 1.0 and for F fall below 1.0. This gives one the feeling that this stock is at least not in decline. However, the change between the 2002 and 2007 assessments due to choice of indices is a cautionary tale. This is a species that is not adequately sampled in the time series of CPUE either from fishery-dependent or fishery-independent indices and small changes in availability or the timing and location of sampling can result in quite different results.

The assessment does not show the biomass index falling below the threshold over the period considered. While it is reasonable to conclude that the stock is not presently overfished and that overfishing is not occurring, the impact of index choice when so few are applicable (2002 versus 2007 assessment results) should result in a cautious management strategy.



5. Evaluate the adequacy, appropriateness, and application of the methods used to project future population status; recommend appropriate estimates of future stock condition (if possible).

Future population status is projected with the surplus production model using a projected value for the current TAC, no TAC, and double the current TAC. Production models do not account for changes in numbers at age or juvenile survival as would an age-structured model. Thus the projections offer less confidence and less insight. However, given the data scarcity for this species, this is an appropriate method for projections. The projections are adequate in so far as the model input has adequately captured the population dynamics. Again, the lack of data sufficient to result in a problematic *r*, the lack of broad spatial or temporal coverage of the input time series, and the substantial variability in these indices gives concerns in relying too heavily on such population projections. Additionally, the projections are for central tendency only (as medians) and don't capture process error and uncertainty.

6. Evaluate the adequacy, appropriateness, and application of methods used to characterize uncertainty, considering input data, model fit, and model configuration. Ensure that the implications of uncertainty with regard to status determinations and management values are clearly stated.

Uncertainty has been characterized in a number of ways in the finetooth stock assessment. A simple estimate of uncertainty is provided in summary statistics (CVs) that show the extent of variability in input data. For finetooth sharks, the data paucity is reflected in very high CVs around mean values of abundance, K, MSY, and catch ratios, among others. Another measure of uncertainty that has been provided is the 80% credibility indices around the Bayesian estimates for N, F, and their ratios in the baseline case and in the sensitivity analyses. The uncertainty in time series is not captured as well. Several of the indices are highly variable over their time course, but also express contradictory values at a point in time to other indices. When the model encounters these types of input data it has difficulty discerning trends and estimating parameter values. In some of the assessments, the models were run by excluding subsets of data series and determining if the exclusion changed the results. Although exclusion of series is a good way to evaluate the uncertainty produced by the selection of time series, this isn't feasible in this case because there were only four input time series to begin with and several of these are sparse in coverage over space or time. So one is precluded from measuring the uncertainty in this way. However an indication of the difference that the inclusion of indices can make to assessment of this species is shown between the 2002 and 2007 assessments which gave quite different results.

7 Ensure that assessment results are clearly and accurately presented in the Stock Assessment Report and that reported results are consistent with Review Panel recommendations.

See Section 2.2.2, above.

8. Evaluate the SEDAR Process. Identify any Terms of Reference which were inadequately addressed by the Data or Assessment Workshops; identify any additional information or assistance which will improve Review Workshops; suggest improvements or identify aspects requiring clarification.

See Section 2.2.2, above. Also, the review of finetooth shark assessment could have benefited by seeing the exploratory analyses of the life tables that were conducted by the assessment team who were very thorough. It would have given the Review Panel more confidence in the results from the input data.

9. Consider the research recommendations provided by the Data and Assessment workshops and make any additional recommendations warranted. Clearly indicate the research and monitoring needs that may appreciably improve the reliability of future assessments. Recommend an appropriate interval for the next assessment and whether a benchmark or update assessment should be considered.

Research recommendations from the Data Workshop Report are given above.

Additionally, the Review Panel has two more recommendations for finetooth shark. The first is to resolve the issue of negative *r* by targeted research on the life history of this species for both the Atlantic Ocean and the Gulf of Mexico. The second is to use an alternate model that is more appropriate to such a data-poor species. This class of model includes length- and stage-based density dependent matrix models or a delay-difference model. The assessment team is to be commended for endeavoring to apply more data-demanding models. However, the Review Panel is concerned that these models may give a misleading sense of confidence that isn't warranted.

Schedule for the next assessment of finetooth: the current stock status indicates that it is not undergoing overfishing and it is not being overfished. It is recommended that no new assessment be undertaken for several years, until such time that basic uncertainties in the data can be resolved; and/or trends in catch or other indices indicate changes in the fishery.

2.2.4. *Blacknose Shark*

Terms of reference

1. Evaluate the adequacy, appropriateness, and application of data used in the assessment.

The assessment of blacknose shark (*Carcharhinus acronotus*) cannot be considered a data rich assessment, but adequate and appropriate data were available and they were used properly in the assessment. Data used in the assessment consist of estimates of life history parameters (such as reproductive rate, growth, maturity and natural mortality (M)), catch data and indices of abundance both from fishery independent and fishery dependent sources.

No direct estimates of M are available and values were derived from published methods that make certain assumptions about the relationship between M and observed maximum age, and knowledge about the life history of the animal. The data workshop chose estimates that corresponded to the highest pup survival (i.e. low M). The values chosen appear plausible but the choice of M has a direct bearing on the estimate of MSY and needs to be considered carefully. Consideration should be given to a plausible range of values on M for sensitivity runs.

The number of pups per female is based on observation (SEDAR 13-DW-17).

The Data Workshop agreed on or calculated data on catches by gear and selected stock size indices, both fishery independent and fishery dependent, to be used in the modeling. The Assessment Workshop reviewed the catch estimates and revised them as considered appropriate by reducing anomalously large shrimp by-catches in 1977 and by allowing an exponential increase in the longline catches during 1981 to 1995 instead of a linear increase as agreed by the Data Workshop. Catch estimates come from various sources, but the main source of removals is the by-catch in the shrimp fishery (between 36 and 70 percent of the total since 1993 when the small coastal shark management plan was implemented). Total estimated removals varied between 39,000 and 128,000 sharks between 1993 and 2005, averaging close to 82,500 for the period.

The Data Workshop selected indices to be used in the base case for blacknose sharks, those that should be used in sensitivities runs, and those that were not considered useful indices of blacknose stock size. Some indices are increasing (Panama City gillnet juvenile (not used in surplus production models), gillnet observers, NMFS SE longline) some are decreasing (Panama City gillnet adult, University of North Carolina), while other indices are variable over time showing no trends (Bottom longline observers, South Carolina Dept. of Natural Resources, Mote Marine Laboratory). Except for the Panama City gillnet juveniles and adults, where the differing trends could be explained by a lag in recruitment, the selected indices cannot all adequately represent the conditions of the stock, if the stock unit is appropriately defined, unless various geographical components of a stock complex behave differently over time. In the next scheduled assessment, subsets of consistent indices should be identified and used in assessment models. If one of those subset cannot be objectively chosen as best representing stock trends, the implications for management of using each of the subsets should be evaluated.

In order to provide estimates of gear selectivity for the state space age-structured model (SPASM), length frequency data from samples were aggregated and converted to age. Gear selectivity parameters were then derived by inspection for maximum age of selection and fitting a logistic or dome curve, depending on gear. This is a relatively crude approach which may be adequate for the purpose but it is difficult to judge without more information on the quantity and quality of the data used. The Data Workshop Report does not provide these details. Whether or not this is an important issue depends on how selectivity information is handled in the SPASM model in the future. For the present, the estimates used can probably be considered adequate as the model results are not likely to be very sensitive to the values.

2. Evaluate the adequacy, appropriateness, and application of methods used to assess the stock.

Three methods were used to assess blacknose shark, a Bayesian Surplus Production model (BSP), a WinBUGS state-space Bayesian surplus production model, and a State-space age structured production model (SPASM). All methods are documented and have been used before in other assessments. SPASM is designed to estimate both observation error and process error. It was the principal assessment tool used to evaluate blacknose shark stock status. All models allow the incorporation of prior information.

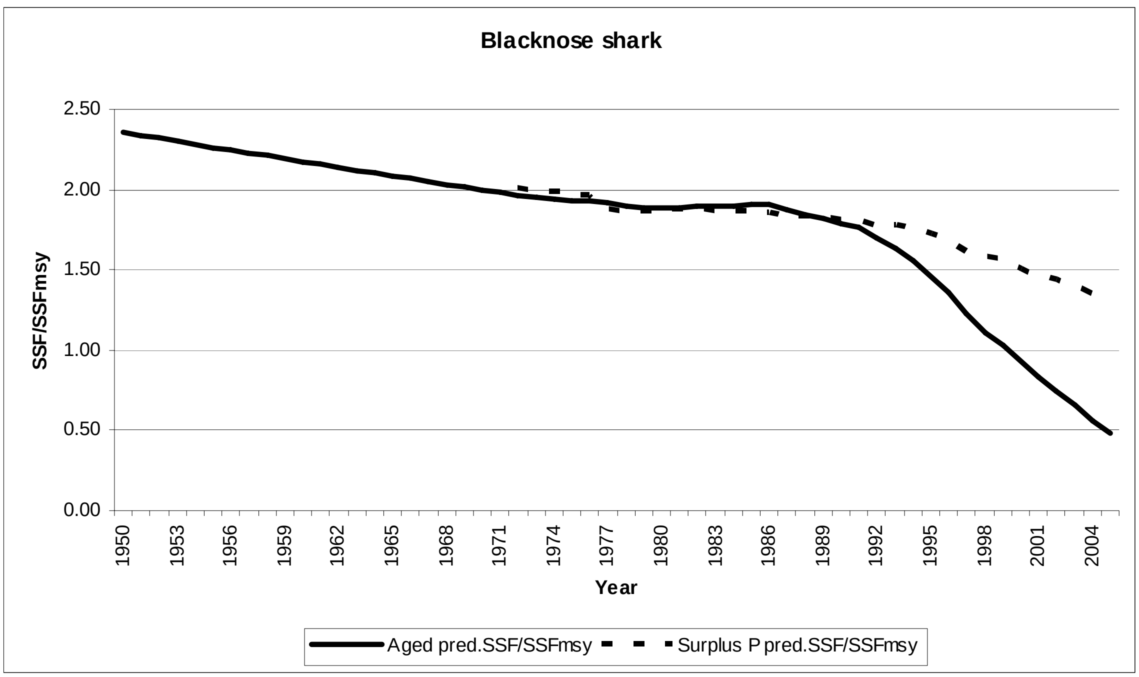
The methods chosen are appropriate for blacknose shark given the data available. The ability to include priors on some of the quantities of interest is important in view of the potentially poor information content in the data, particularly the absence of age structured data. However, care needs to be taken in judging the extent to which choice of priors predetermines the results from the model.

In order to fit the abundance indices that select different age ranges of fish, selectivity parameters were input to the model. These are age-based values that provide catchabilities that in turn mediate between the ‘unseen’ age-structured population generated in the model and the observed indices. Given that selectivity operates primarily as a size process and most of the age data are derived from length samples, it might be preferable to model selectivity as a size rather than age process. This would enable the model to use length data as observations that might offer it more information to help estimate the population size/age structure.

The Assessment Workshop working documents and Assessment Workshop report adequately describes the pros and cons of each method. The general production approach requires less data, runs more rapidly but is less able to capture the biological characteristics of the species. The age-structured approach is considered a preferable approach when appropriate and sufficient data are available. The Assessment Workshop considered that appropriate and sufficient data were available for the age-structured model and chose it to represent stock trends.

3. Recommend appropriate estimates of stock abundance, biomass, and exploitation (if possible).

For blacknose shark, as indicated above, assessments were available using surplus production and age-structured approaches. The Assessment Workshop decided to use the age-structured production model described in SEDAR13-AW-03 as the basis for its assessment because it allowed for the incorporation of age-specific biological and selectivity information which the surplus production models did not. Both approaches used very similar input data and stock size indices, but the age-structured assessment model was able to use a Panama City gillnet juvenile index in addition to the adult series used in the surplus production models. The base surplus production model resulted in population estimates that were approximately 2.5 times larger than those from the age-structured modeling for the first 20 years of the overlapping period but since the early 1990s, the ratio of surplus production estimated numbers to age-structured population numbers has increased. The ratio of spawning stock fecundity to spawning stock fecundity at MSY (Figure below) for both methods have been very similar during 1972 to the early 1990s at about twice the population numbers producing MSY, but since then they have diverged: the surplus production estimates suggest that the stock size is still above that producing MSY while the age-structured results indicate that the stock is at approximately half that producing MSY. The age-structured results are considered more representative of likely stock trends.



Unsurprisingly, because of the divergent trends or lack of trends, neither of the assessment approaches results in good fits to the indices, but the age-structured approach fits almost perfectly to all the catches by gear, except for the by-catch in the shrimp fishery where not all the points are fitted exactly. Figure 4.10 of the Assessment Report shows that the catches and the effort process make by far the largest contribution to the likelihood in the age-structured base assessment model, while the indices contribute less than one tenth the combined contributions of the catches and the effort processes. It is not obvious that the catches are more precisely and more accurately known than at least some of the indices. The Review Panel asked that the model be re-run with more weight given to the indices, but the results were not substantially different, except that the catches were not as well fitted and the indices were only marginally better fitted (again, not necessarily a surprise given that the indices selected either diverge or show no trends). Attempts were made to run the model with effort (and therefore fishing mortality) constrained to change less than in the current parameterization, but it was not possible to achieve a satisfactory run in the time available.

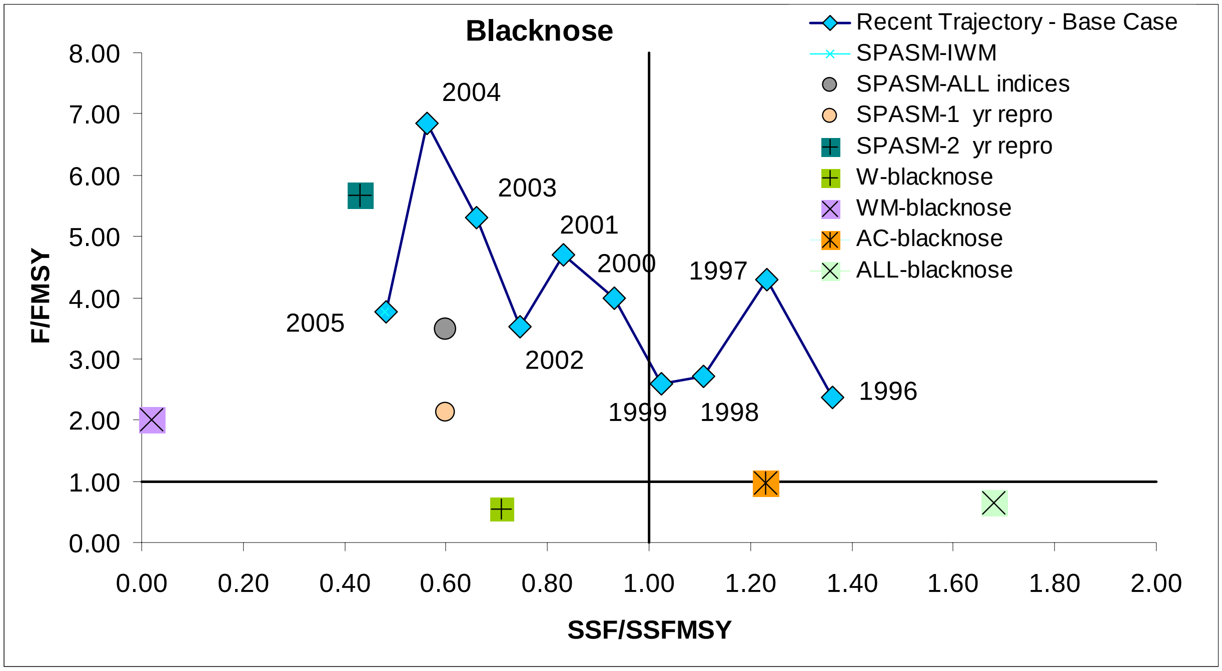
The choice of the age-structured model as the assessment method by the Assessment Workshop is probably appropriate at this stage, but modeling could be improved by developing a length-based model, rather than an age-based one. That would allow fitting yearly indices of stock size at length where the data are sufficient (e.g. Atlantic sharpnose shark). As indicated above, the results of the current modeling approach could change considerably if different subsets of stock size indices were used and if the model was parameterized differently. There is therefore a reasonable probability that the assessment results could change substantially, in an unpredictable direction, in the next assessment.

The base case SPASM assessment produced estimates of the number of blacknose sharks (N), the fecundity of female blacknose sharks (SSF), and the fishing mortality rates throughout the time series (1950-2005). The table below provides the 2005 values and the most recent five year averages for the N, SSF, F and for SSF/SSF_{msy} and F/F_{msy}.

	N	SSF	F	SSF/SSFmsy	F/Fmsy
2005	410,245	223,110	0.245	0.482	3.769
Avg 2001-2005	474,701	262,847	0.314	0.656	4.828

4. E*valuate the methods used to estimate population benchmarks and management parameters; recommend values for management benchmarks (MSY, Fmsy, Bmsy, MSST, MFMT) and provide declarations of stock status.*

For blacknose shark, appropriate standard methods based on general production models and on age-structured modeling were used to derive management benchmarks. The current assessment indicates that SSF in 2005 and during 2001-2005 is smaller than SSF_{msy}, i.e. that blacknose shark are overfished. The estimate of fishing mortality rate in 2005 and the average for 2001-2005 is greater than F_{msy}, and the ratio is substantially greater than 1 in both cases. Thus overfishing was occurring and is likely still occurring. As indicated above, however, the status of blacknose shark could be substantially changed in the next assessment in an unpredictable direction.



5. *Evaluate the adequacy, appropriateness, and application of the methods used to project future population status; recommend appropriate estimates of future stock condition (if possible).*

For blacknose shark, projections were calculated because the species is considered overfished and overfishing is considered to be occurring. The projections were done using Pro-2Box (Porch 2003) with F_{2005} for 2006, 50% of F_{2005} for 2007 through 2009 to account for the expected effects of hurricane Katrina and F=0 thereafter when management action could be implemented. Variability in recruitment was modeled by allowing for process error in the spawner-recruit relationship with lognormal recruitment deviations CV = 0.4 and no autocorrelation for 500 bootstraps. The model and assumptions are considered appropriate for blacknose sharks, but the Review Panel is concerned that the projections do not incorporate all sources of uncertainty.

6. *Evaluate the adequacy, appropriateness, and application of methods used to characterize uncertainty, considering input data, model fit, and model configuration. Ensure that the implications of uncertainty with regard to status determinations and management values are clearly stated.*

As in all modeling exercises, estimates of uncertainty are conditional on the structure of the model, which generally underestimate overall uncertainty. The statistical estimates of variation derived from the fits to the catch and survey indices, depend on a number of structural assumptions.

Uncertainty is characterized in the priors, plots of model fits to the data and likelihood profiles of the principal quantities of interest. Sensitivity analyses also provide some indication of the uncertainty associated with model assumptions. These methods are all standard and appropriate.

The choice of sensitivity runs is limited and was not intended to explore the full range of uncertainty. Given the significance of MSY in the management of fisheries on these stocks it is important to examine sensitivities to those values that influence the calculation of MSY reference points. This will include biological parameters relating to M, maturity, growth, fecundity and the structural assumption about the stock-recruitment curve.

7. *Ensure that assessment results are clearly and accurately presented in the Stock Assessment Report and that reported results are consistent with Review Panel recommendations.*

See Section 2.2.2, above.

8. *Evaluate the SEDAR Process. Identify any Terms of Reference which were inadequately addressed by the Data or Assessment Workshops; identify any additional information or assistance which will improve Review Workshops; suggest improvements or identify aspects requiring clarification.*

   See Section 2.2.2, above.

9. *Consider the research recommendations provided by the Data and Assessment workshops and make any additional recommendations warranted. Clearly indicate the research and monitoring needs that may appreciably improve the reliability of future assessments. Recommend an appropriate interval for the next assessment and whether a benchmark or update assessment should be considered.*

Research recommendations from the Data Workshop Report relevant to blacknose are given above.

Schedule for the next assessment of blacknose: the current stock status indicates that blacknose shark is being overfished and that overfishing is occurring. Thus, it would be wise to reassess this stock within two or three years. Users of the assessment results should be aware that major differences in the estimated status could be expected in the next assessment if consistent subsets of stock size indices were used. In the current assessment, the stock size indices used are conflicting, and the assessment model takes an average of all the indices. If separate assessments were done with the indices that indicated increases, those that indicated stability, and those that indicated decreases, this would show greater uncertainty in stock status and stock trends.

2.2.6. Atlantic Sharpnose Shark

Terms of reference

1. Evaluate the adequacy, appropriateness, and application of data used in the assessment.

Life history data

Data used in the assessment consist of estimates of life history parameters (such as reproductive rate, growth, maturity and natural mortality (M)), catch data and indices of abundance both from fishery independent and fishery dependent sources.

No direct estimates of M are available and values were derived from published methods that make certain assumptions about the relationship between M and observed maximum age, and knowledge about the life history of the animal. The data workshop chose estimates that corresponded to the highest pup survival (i.e. low M). The values chosen appear plausible but it important to appreciate that the choice of M has a direct bearing on the estimate of MSY and needs to be considered carefully. Consideration should be given to a plausible upper value on M for sensitivity runs.

The number of pups per female is based on observation and increases with size (SEDAR 13-DW-08). However a fixed value with age was used in the assessment. This may not be important when F is low and the age structure of the stock remains relatively stable as is apparently the case for this stock. However, it might be expected to affect the value of MSY estimated in the model and a sensitivity run to test this needs to be undertaken.

Specific details of the matrix method used to estimate R_0, r, α and z (steepness) are not provided. However, these parameters are only used in the BSP model that is not used as the main assessment and are not material to the principal results.

Catch data

Most of the catch of Atlantic sharpnose shark is taken as bycatch in the shrimp fishery. The remainder is made up from recreational and commercial fisheries. The catch estimates for the shrimp bycatch and the recreational fisheries have been derived from fishery surveys or bycatch sampling and the estimates will inevitably suffer from sampling error. This means that most of the observed catch used in the assessment model is affected by estimation error of unknown magnitude. While this problem needs to be borne in mind it does not mean the estimates are inappropriate. The approach probably does provide the best available estimate of total catch.

Using trends in human population expansion to raise the recreational catch is probably a good and robust covariate for this purpose.

Selectivities

In order to provide estimates of gear selectivity for the SPASM model length frequency data from samples were aggregated and converted to age. Gear selectivity parameters were then derived by inspection for maximum age of selection and fitting a logistic or dome curve, depending on gear. This is a relatively crude approach which may be adequate for the purpose but it is difficult to judge without more information on the quantity and quality of the data used. The Data Workshop Report does not provide these details. Whether or not this is an important issue depends on how selectivity information is handled in the SPASM model in the future. For the present, the estimates used can probably be considered adequate as the model results are not likely to be very sensitive to the values.

Abundance Indices

A large number of abundance indices are available and tabulated in the Data Workshop Report (SEDAR-13-DW). A subset of these indices were selected on the basis of number of years of observations, area coverage and precision. Of these, two fishery dependent surveys and 11 fishery independent surveys were selected. These series appear to conform to conventional standards for fish stock assessment and are appropriate for the purpose.

2. *Evaluate the adequacy, appropriateness, and application of methods used to assess the stock.*

Three methods were used to assess the stock. These were a Bayesian Surplus Production model (BSP), a WinBUGS state-space Bayesian surplus production model, and a State-space age structured production model (SPASM). All methods are documented and have been used before in other assessments. SPASM is designed to estimate both observation error and process error. It was the principal assessment tool used to evaluate stock status. All models allow the incorporation of prior information.

The methods chosen are appropriate for the species concerned given the data available. The ability to include priors on some of the quantities of interest is important in view of the potentially poor information content in the data, particularly the absence of age structured data. However, care needs to be taken in judging the extent to which choice of priors predetermines the results from the model. In the case of the SPASM model, a uniform prior on Virgin Recruitment and a log normal prior pup survival were used. Neither of these could be considered to unduly bias the model results.

In order to fit the abundance indices that select different age ranges of fish, selectivity parameters were input to the model. These are age based values that provide catchabilities that in turn mediate between the 'unseen' age-structured population generated in the model and the observed indices. Given that selectivity operates primarily as a size process and most of the age data are derived from length samples, it might be preferable to model selectivity as a size rather than age process. This would enable the model to use length data as observations that might offer it more information to help estimate the population size/age structure. There is likely to be a significant computational overhead in doing this which needs to be traded off against any potential improvement in the model performance.

The indices do not show a consistent trend with some series (e.g. UNC) increasing while others are decreasing (e.g. SEMAP-GOM-EF). The only way the model can account for these opposing trends is through the selectivities of the gears. Given the assumption of population mixing, constant selectivity, and a relatively stable population age structure, the model was unable to account for the observed trends in the indices well. This means the overall stock trajectory is influenced most by the catch and is something of a compromise between the various abundance index trends. During the meeting additional runs considered lower relative weighting to the catches but this made little difference to the results.

It is difficult to know if the inclusion of 13 abundance series is the optimum choice and there may be some value in a more systematic analysis of these series outside the assessment model. A simple preliminary analysis would be to examine the cross correlations to see the extent to which the series measure a common signal. If they don't correlate well, then there is a danger of simply using random numbers in the assessment. This is especially important if inverse variance weighting is used since given the large number of series included, there would be a real danger of arbitrarily giving one series high weight when in reality it bore no resemblance to a real trend. In this regard, the decision to use equal weights for the abundance indices would seem to be a sensible approach.

Catch data by fleet were modified by the Assessment Workshop in two important respects. For BLL catches and discards the development of catches in the pre-observation period was modified from a linear increase to an exponential increase. For the gillnet and handline series the 2003 value was modified to correct for an unexpected spike in the catch which appears to be the result of a miscoded reported catch. These modifications appear to be sensible. In particular the gillnet/handline series is likely to distort the model fit for no good reason without the modification.

A notable feature of the model fit is how close the fitted catches are to the observed values. In effect this is close to treating the catches as exact observations. It means that variability in the catches translates directly into variability in the estimates of annual fishing mortality. There must be a concern that the model does not partition observation error in the catches and process error in the fishing mortality well. This, in itself, does not mean the population trajectory, or fishing mortality estimates are inadequate but it is especially relevant in trying to judge stock status because the most recent estimate of F may not in fact be a good indicator of prevailing F over a medium term (3-5 year) time horizon.

Sensitivity runs considered splitting the SEAMAP series, using inverse weighting, separate Atlantic/Gulf assessments and using alternative models (BSP, Winbugs). With regard to the terminal year (2005) these sensitivity tests do not alter the perception of the stock and hence offer some reassurance about the robustness of the results. However, these runs do not consider sensitivity to the biological parameters that can influence the estimate of MSY, namely M, maturity, growth and fecundity. While there is no reason to doubt the validity of the values used in the assessment, there may be some value in extending the sensitivity runs to examine the influence of the assumed biological parameters on the relative position of the stock to MSY reference points.

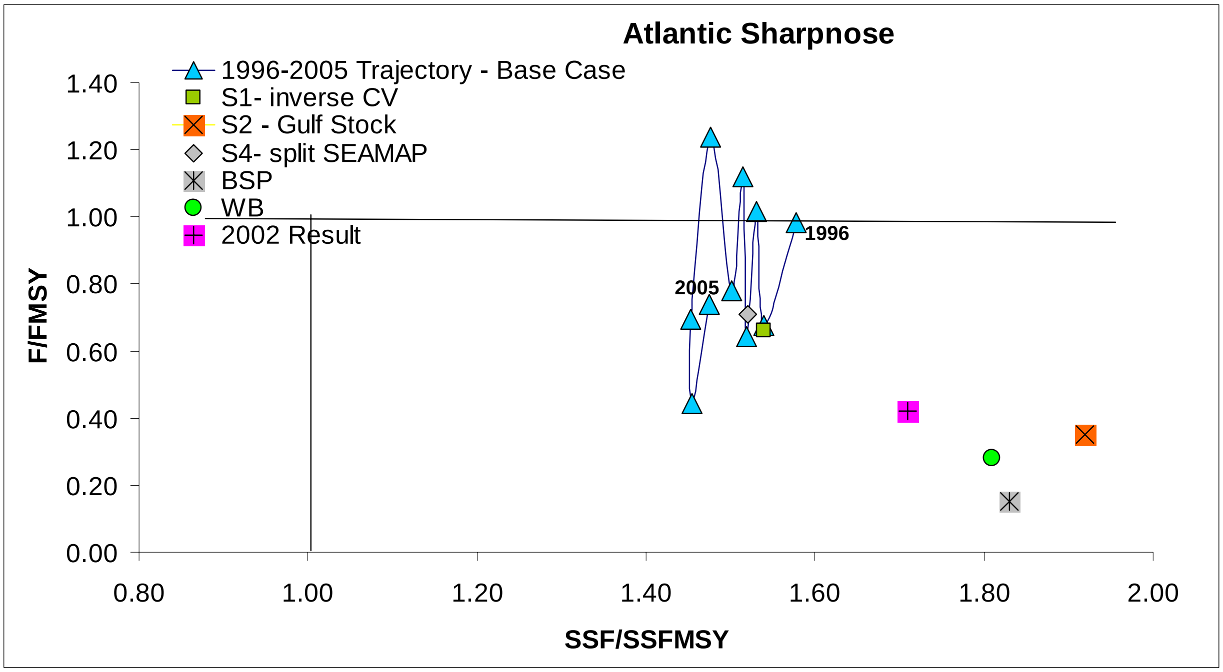
3.Recommend appropriate estimates of stock abundance, biomass, and exploitation (if possible).

The estimates derived from the Base SPASM model should be used to characterize the stock change over time. They give the likely development in stock size and fishing mortality. The preceding section discusses the noisiness of the F estimates and this should be taken into account when both viewing the long term trend and judging the currently prevailing fishing mortality. For the latter, it is probably better to consider the mean value for the most recent 5-10 years as more representative. For projections it is unwise to select single point estimates for the initial conditions. These should be drawn from a distribution. In the case of N_{2005} the probability profile could be used. For F, the distribution could be a taken from the variance of the last 10 annual F values.

4. *Evaluate the methods used to estimate population benchmarks and management parameters; recommend values for management benchmarks (MSY, Fmsy, Bmsy, MSST, MFMT) and provide declarations of stock status.*

The assessment approach adopted for this stock estimates reference points that express the present stock state relative to estimated MSY, ie $F_{current}/F_{msy}$ and (Spawning Stock Fecundity) $SSF_{current}/SSF_{msy}$. This is a desirable choice of reference values as they are relatively insensitive to arbitrary changes in assessments (e.g. revised M, updated catch data etc). The choice of SSF as opposed to the more common SSB appears to be well adapted to the biology of sharks and is likely to be a better measure of reproductive potential than SSB. There is a weakness in respect of the fishing mortality reference point due to the variability in annual estimates of F driven by variability in the catch data. As can be seen in Fig 5.5 of the Assessment Workshop Report, F has periodically exceeded the threshold with no obvious trend. What is clear is that any single year is not representative of the prevailing F. An approach which smoothed out this variability would be desirable. This could be done either by restricting the model fit so that F is smoothed, or simply by taking a mean over recent years. At the Review Workshop phase plots were requested that plotted the reference points over the last 10 years. The plot (Figure below) shows that in the past decade the fishing mortality threshold had been exceeded in 3 years out of 10. This is indicative of the likely proximity of current stock status to an overfishing condition. Thus while the current point estimates for 2005 place the stock in the not overfished/not overfishing status, there may be a modest probability that overfishing is occurring.

The assessment does not show the SSF index falling below the threshold over the period considered, but the ratio index shows an almost continuous decline towards it. While it is reasonable to conclude that the stock is not presently overfished, the fact that F is close to F_{msy} means that if F is maintained, the stock will continue to decline toward the SSF threshold and will fall below it as F fluctuates around F_{msy}. It would therefore be desirable to define thresholds which trigger a management response before such thresholds are reached.



5. *Evaluate the adequacy, appropriateness, and application of the methods used to project future population status; recommend appropriate estimates of future stock condition (if possible).*

The Assessment Workshop considered the stock to be not overfished and that overfishing was not occurring and therefore did not run any forward projections. Given the proximity of F to F_{msy}, its variability and the continuous decline of SSF toward its MSY threshold, there would be some merit in performing a forward projection to evaluate the probability of exceeding the reference points in the medium term. Such projections would need to capture the variability in F and the other major sources of uncertainty. They would provide managers with an indication of developing problems and whether intervention was appropriate.

6. *Evaluate the adequacy, appropriateness, and application of methods used to characterize uncertainty, considering input data, model fit, and model configuration. Ensure that the implications of uncertainty with regard to status determinations and management values are clearly stated.*

Uncertainty is characterized in the priors, plots of model fits to the data and likelihood profiles of the principal quantities of interest. Sensitivity analyses also provide some indication of the uncertainty associated with model assumptions. These methods are all standard and appropriate. The choice of sensitivity runs is quite limited and perhaps does not explore the full range of uncertainty. Given the significance of MSY in the management of these stocks it is particularly important to examine sensitivities to those values that influence the calculation of MSY reference points. This will include biological parameters relating to M, maturity, growth, fecundity and the structural assumption about the stock-recruitment curve. It would be worth exploring alternative stock recruitment functions as robustness tests.

7. Ensure that assessment results are clearly and accurately presented in the Stock Assessment Report and that reported results are consistent with Review Panel recommendations.

This term of reference is difficult to meet for the Review Panel. The Stock Assessment Report is already written and approved. It can be modified if errors in facts, in calculations, or in interpretation are discovered but it would not be appropriate for the Review Panel to modify the Assessment Report for style, clarity or consistency with the Review Panel recommendations.

8. Evaluate the SEDAR Process. Identify any Terms of Reference which were inadequately addressed by the Data or Assessment Workshops; identify any additional information or assistance which will improve Review Workshops; suggest improvements or identify aspects requiring clarification.

See Section 2.2.2, above.

9. Consider the research recommendations provided by the Data and Assessment workshops and make any additional recommendations warranted. Clearly indicate the research and monitoring needs that may appreciably improve the reliability of future assessments. Recommend an appropriate interval for the next assessment and whether a benchmark or update assessment should be considered.

See Section 2.2.2, above. Also, recommendations are only made by the Data Workshop. Those of relevance to Atlantic sharpnose are as follows:

a) Coordinate a biological study for Atlantic sharpnose so that samples are made *at least* monthly, and within each month samples would be made consistently at distinct geographic locations. For example, sampling locations would be defined in the northern Gulf, west coast of Florida, the Florida Keys (where temperature is expected to be fairly constant over all seasons), and also several locations in the South Atlantic, including the east coast of Florida, South Carolina, and North Carolina. This same sampling design could be applied to all small coastal sharks.

b) Population level genetic studies are needed that could lend support to arguments for stock discriminations using new loci and/or methodology that has increased levels of sensitivity.

c) Continuation of the fishery-independent surveys reviewed is encouraged. Some series that were not useful at this time may prove useful in the future with the inclusion of more data and series that were recommended for use at this time may improve with the additional information.

All three recommendations have merit but need to be judged on the basis of resources available and the priority/value of the fishery concerned. If the stock can be evaluated as not overfished and where no overfishing is occurring it is doubtful that increasing the level of sampling and research will change the effectiveness of management. It is also necessary to consider the opportunity costs of allocating resources to this species at the expense of other priorities. Recommendation (b) is only worthwhile if there is a capability to manage the two regions as separate stocks and that the fisheries operating in the two areas are sufficiently separate for this to make sense. For example, if vessels can transfer between areas, separate management may not be effective. A desk study using simulation models could be carried out to explore if a two stock approach is desirable, and if so, the more costly genetic study could be initiated.

With regard to (c), such surveys are often extremely costly and before an open ended commitment is made it would be desirable analyse the value of existing surveys and consider whether a more parsimonious approach might serve the purpose of the assessment without the need to support numerous surveys.

Schedule for the next assessment of Atlantic sharpnose: the current stock status indicates that it is not overfished. While in 2005 it was not undergoing overfishing, in several of the previous years it had been. Thus, it would be wise to reassess this stock within two or three years. However, major differences in the status are unlikely to be detected unless, 1) regulations are implemented; 2) data and indices are improved; or 3) catches change.

2.2.7. Bonnethead Shark

<u>Terms of reference</u>

1. *Evaluate the adequacy, appropriateness, and application of data used in the assessment.*

The basic data used in the assessment included catch time series, CPUE and Survey indices, some size frequencies, and growth and reproduction parameters used for estimating vital life history rates.

The catch series included directed catches (recreational and commercial), discards from the recreational catches, and discarded bycatch in the shrimp trawl fishery. Of these, the shrimp trawl bycatch contributed most to the catch (about 80% in numbers). Additionally, the catch series for 1950 (the first year in the assessment model) through 1972 were reconstructed catches based upon average tendencies, rather than year to year variation.

A large suite of survey and CPUE indices were examined and used in the assessment (PC Gillnet adult, PC Gillnet juvenile, Gillnet Observer Program, Everglades series, SEAMAP SA, Texas Gillnet, SC COASTSPAN, SEAMAP GOM (early years), SEAMAP GOM (later years), Mote Marine Lab Gillnet (adult), Mote Marine Lab Gillnet (juvenile), Gillnet logbook). The indices had various spatial coverages from very localized to coast-wide. Additionally, the time span over which the surveys were conducted varied from a few years to over 30 years.

The biological parameters (growth and reproduction) were obtained from specific field studies conducted by individual shark biologists. The results formed the basis for specifying priors for life history parameters used in the model.

These data were appropriate sets of information to be applied to assessment models. It should be noted that the vital rate parameters were especially important in integrating biological knowledge about bonnethead productivity into the assessment.

While the estimated catch data are adequate for initial assessment analyses they suffer from the fact that they are relatively imprecise. This is translated into uncertainty in the assessment results.

Of the data sets, the CPUE and survey indices are most problematic. There was no strong basis for eliminating indices from the analysis (the Stock Assessment and Data Reviews addressed this previously). However, as mentioned, the spatial and temporal range of the indices varied considerably. Also, several indices purported to measure the same components of the population exhibited different trends. This is a common problem in assessments, but the implications are that as time proceeds and more index data are collected then some indices will become more reliable while others are eliminated from the analysis. This evolution may give a different picture of the dynamics of the stock in the future.

2. *Evaluate the adequacy, appropriateness, and application of methods used to assess the stock.*

The primary assessment method employed in the bonnethead assessment was a State-space, Age-structured Production Model (SPASM). The method used limited size frequency data to define time invariant selectivities for the indices and the catch by fishing sector. This was coupled with the prior distributions on productivity parameters translated into the stock-recruitment relationship. Then the population abundance (at reconstructed age) was projected forward from 1950 to the present such that the observed and predicted catches and index data were optimally fit using Maximum Likelihood criteria.

There are always alternative modeling approaches and the Stock Assessment Panel considered Bayesian surplus production models as another option. However, this option was rejected on several grounds (symmetry of the surplus production curve is not consistent with understanding of the life history information; SPASM allows age specific mortality and reproduction data to be used). Also, a Bayesian surplus production model of the small coastal complex was examined, the results of which would encompass bonnethead dynamics as part of the aggregate.

Perhaps, other alternatives could have been explored (e.g. fitting the model to the selectivity size frequency data directly). However, it is unclear that this approach would be any better. Additionally, all of these modeling options suffer from the same problem mentioned above: that the indices are variable and inconsistent.

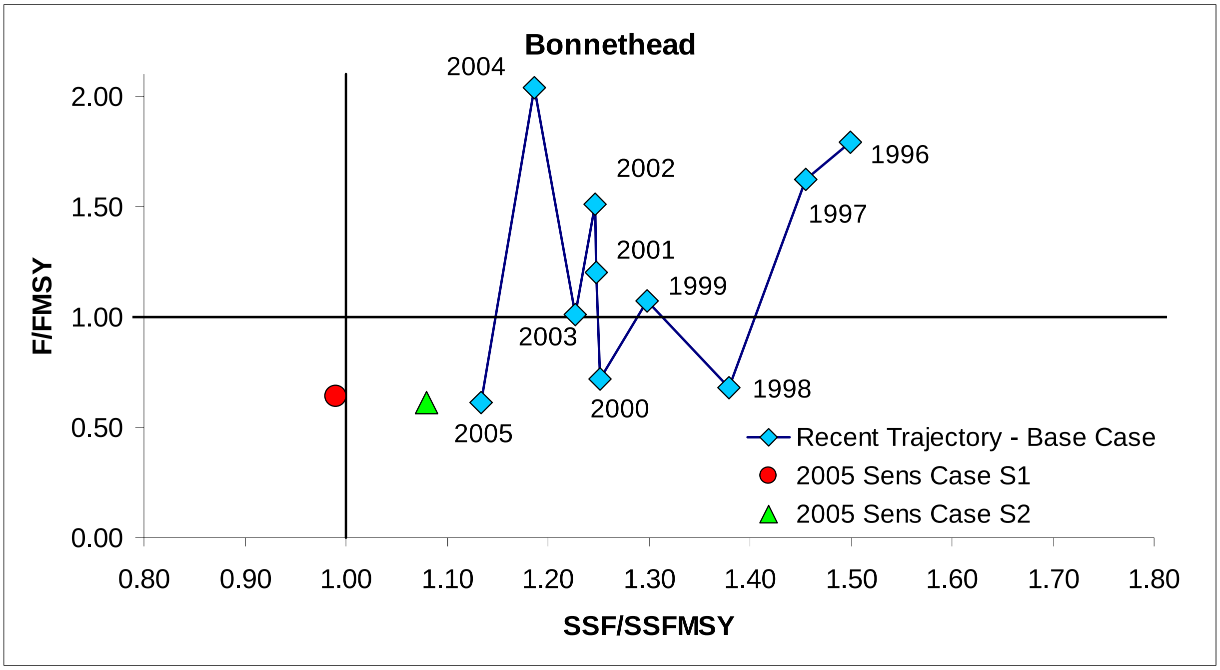
Therefore, it is the Review Panel's conclusion that the methods are appropriate to the application and, thus, are adequate. However, models cannot solve basic weaknesses in the data.

3. *Recommend appropriate estimates of stock abundance, biomass, and exploitation (if possible).*

The base case assessment produced estimates of the number of animals (N), the number of mature females pup production (SSF), the fishing mortality rates throughout the time series (1950-2005). The estimates for the current (2005) statistics are given 1.59 million , 2.26 million and 0.19, respectively. Additionally, two sensitivity tests were conducted, one which used inverse variance weighting of the indices; and the other used all the indices included plus those rejected in the base case. The result of these tests (including the base case) showed a range in N of 1.13 to 1.59 million and the range in SSF of 1.97 to 2.26 million.

4. *Evaluate the methods used to estimate population benchmarks and management parameters; recommend values for management benchmarks (MSY, Fmsy, Bmsy, MSST, MFMT) and provide declarations of stock status*

The methods used to estimate stock status were appropriate for the population model used in the assessment. They allowed the Review Panel to test the impact of alternatives assumptions about the data on the status of the stock.



Note that the estimates of annual fishing mortality rates (Figure above) exhibit considerable annual variability. This probably occurs for two reasons: 1) the major source of fishing mortality for bonnethead is the shrimp trawl bycatch fishery. Since this does not direct at bonnethead shark, catches (and mortality rates) vary from year to year depending on the distribution of bonnethead sharks relative to the shrimp. Therefore, more annual variability in F than normally occurs in directed fisheries is expected; and 2) due to the assessment method (and data), variability in F is probably overestimated, i.e. uncertainties in the model fits are shifted to variability in F. For these reasons, the Review Panel recommends that the $F_{current}/F_{msy}$ metric use a more stable estimate of $F_{current}$ (in the assessment documents $F_{current}$ equals the F in the year 2005). F 2005 is less than F_{msy}, while in the previous ten years the F's varied both above and below F_{msy}. This should be considered when determining the overfishing status.

The current assessment indicates that there is a preponderance of probability that SSF is greater than SSF_{msy}, i.e. that bonnethead sharks are not overfished. The estimate of fishing mortality rate in 2005 is less than F_{msy}, thus there was no overfishing in that year. However, fishing mortality rates in the recent past have fluctuated above and below F_{msy}. Thus, there is some probability that fishing mortality rates in 2006 and 2007 have been in excess of F_{msy}.

5. *Evaluate the adequacy, appropriateness, and application of methods used to project future population status; recommend appropriate estimates of future stock condition (if possible).*

Since the recent fishing mortality rates have fluctuated around F_{msy}, a projection was conducted in which fishing mortality rates in the future were kept at the average of F in the last ten years. Long term projections showed that the median SSF under these conditions remained slightly higher than SSF_{msy}. However, there was some probability that SSF will fall below SSF_{msy} in the future, if current average F's are maintained.

While the projection methodology is adequate for predicting point estimates of future status, it does not characterize all of the uncertainty in the assessment carried through to the projections. Therefore, probability statements about future status are not very precise.

6. *Evaluate the adequacy, appropriateness, and application of methods used to characterize uncertainty, considering input data, model fit, and model configuration. Ensure that the implications of uncertainty with regard to status determinations and management values are clearly stated.*

As in all modeling exercises, estimates of uncertainty are conditional on the structure of the model. Often in these circumstances, uncertainty (variance) is underestimated. This appears to be especially so with bonnethead sharks. The statistical estimates of variation emanating from the fits to the catch and survey indices, depend upon a number of structural assumptions. Given the state of the data, there were no better alternatives. However, when interpreting the probability distributions of status, it is expected that there are higher probabilities in the tails; i.e. that the stock is much better or much poorer than indicated by the analysis.

7. *Ensure that the assessment results are clearly and accurately presented in the Stock Assessment Report and that the reported results are consistent with Review Panel recommendations.*

See Section 2.2.2, above

8. *Evaluate the SEDAR Process. Identify any Terms of Reference which were inadequately addressed by the Data or Assessment Workshops; identify any additional information or assistance which will improve Review Workshops; suggest improvements or identify aspects requiring clarification.*

See Section 2.2.2, above

9. *Consider the research recommendations provided by the Data and Assessment workshops and make any additional recommendations warranted. Clearly indicate the research and monitoring needs that may appreciably improve the reliability of future assessments. Recommend an appropriate interval for the next assessment and whether a benchmark or update assessment should be considered.*

Research recommendations from the Data Workshop Report relevant to bonnethead sharks are given above in the general research recommendation section.

Schedule for the next assessment of bonnethead: the current stock status indicates that it is not overfished. While in 2005 it was not undergoing overfishing, in several of the previous years it had been. Thus, it would be wise to reassess this stock within two or three years. However, major differences in the status are unlikely to be detected unless, 1) regulations are implemented; 2) data and indices are improved or consistent subsets of stock size indices are used; or 3) catches change.

3.0 Recommendations for future SEDAR assessments

Participants and the Review Panel commented throughout the week on the SEDAR assessment process. What follows is a non-prioritized list of the points made:

Sensitivity runs in the assessments should examine the robustness of stock status relative to the biological parameters that determine MSY. These include values for M, growth fecundity selectivity and the form of the stock recruitment curve.

Projection software tools should be developed that can incorporate uncertainty in the initial conditions and capture process error more comprehensively for the forecast period.

The Review workshop identified process error, especially in F, as a problem in determining stock status relative to MSY reference points. Further consideration needs to be given to a more robust means of interpreting stock status than the procedure of simply using the most recent data year. It is also important for managers to know the probability of exceeding reference points in the medium term, even if present stock status is judged satisfactory.

A more detailed and comprehensive analysis of the CPUE series would be desirable to evaluate the utility of many series available. A rigorous and objective scientific protocol should be developed against which CPUE series are evaluated as a basis for inclusion in assessments. This should include, *inter alia*, statistical design, spatial coverage and relevance to target species. The Review Panel envisioned a set of standards that delineated a weighted scoring depending on the attributes of the time series. For example, if the time series was based on a statistically valid sampling design targeted at the specific species, then it would achieve a high score for that standard. If the time series was properly designed for another species and largely covered the distribution in space and time, it would achieve an intermediate score against this standard, and so on. This would avoid vulnerability to personal preference and ad hoc choice of time series to include.

Differences between successive assessments, particularly when different data series or different assessment models are used, should be systematically investigated to assess whether differences are due to changes in data, changes in models, or changes in assumptions.

4.0 Reviewer Statements

The Consensus Report provides an accurate summary of my views on the issues covered in the review. Joseph Powers, Robin Cook, Cynthia Jones, J.-J. Maguire